# Programmable Thermostats Installed into Residential Buildings: Predicting Energy Saving Using Occupant Behavior & Simulation

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## Background

During the past several years the California Statewide Residential Energy Efficiency programs administered by the Investor Owned Utilities (IOUs) and others have been offering rebates or incentives for residential customers to install programmable thermostats. These types of rebate and incentive programs are authorized by the California Public Utilities Commission based upon the expectation that, for the average customer, there will be a reduction in the customer's energy use after the installation of programmable thermostats. The inclusion of the programmable thermostat energy efficiency measure (EEM) into the residential energy efficiency program proposals by the IOUs and others, and the decision by the CPUC to approve these program elements, was based, in part, on the savings for that EEM as found in the California DEER database. The DEER value for this EEM was produced during the 2001 DEER update. The energy savings resulting from the installation of programmable thermostats into residential buildings, calculated using the DEER EEM value, results in this single measure accounting for more than one-fifth of the total statewide residential energy efficiency program savings for the IOUs.

When the methodology and assumptions used to develop the current DEER residential programmable thermostat EEM values were investigated, it was found that this DEER EEM was defined and modeled with a base case of "no heating or cooling thermostat setback." Such a base case then implicitly assumes only one set point behavior, i.e., the unit is "on" all times. In particular, defining such a base case for this DEER EEM leads to the maximum savings that would be expected from the application of the EEM. For a DEER value to be used directly in the analysis of "reportable" savings for IOU energy efficiency programs it must be: 1) the average expected savings for a California residential building that has the EEM newly installed; 2) a saving value for this EEM must be the savings for a residential building with the EEM newly installed relative to the same building without the technology of the EEM but in full compliance with Title 24. The current DEER value for this EEM, in other words, is the upper limit on the savings that can be expected from this EEM rather than the average saving that can be expected given a population distribution of set point behavior. It was deemed necessary to develop a methodology to model this EEM so that the value is the appropriate one to use for the analysis of the savings potential for residential energy efficiency programs.

The 2001 DEER residential analysis methodology appears to do a good job at describing the average California residential building construction of a specified "vintage" in a specified "location" and then performing the energy savings calculations using the DOE-2 program. The methodology takes into account the regionally varying physical elements such as floor plan, directional orientation, wall/window/roof constructions, and weather. The residential building are grouped into several "vintages" that span the pre- and post- Title 24 time period to capture the changes to the minimum Title 24 requirements relative to construction parameters. The analysis is done with several residential building models facing different directions and with varying floor plans including single and two story houses. Simulations of each of the building models is performed and then the results from each model are aggregated into an "average" resultant value by weighting each single building result into the final value based upon survey data that provides the population frequency of occurrence for each of the basic models. The simulations are done across the 16 California climate zone to capture weather variations.

The2001 DEER analysis methodology can take into account occupant behavior variations in a manner that is appropriate to predict average energy savings for EEMs that are NOT very strongly influenced by behavior assumptions of the model; the 2001 DEER analysis for EEMs, however, does not include these behavioral variations. For many EEMs the variations of occupancy behavior are important to the absolute energy use estimates but are less important to the savings estimates. For example, occupancy behavior has a strong influence in the energy consumption of a house; the occupants can choose to run or not run their heater or air-conditioner. However, some EEMs cannot be directly influenced by this behavior. For example, after installing more efficient lighting or air-conditioning the occupants cannot, by their behavior, directly affect the efficiency of the EEM, only when the device is used and how much it is used. It is true that the installation of the EEM, resulting in less cost per unit of use, may cause some fraction of the population to use the device more often (due to affordability), however, their patterns of use cannot change, to a measurable degree, the efficiency of the device when it is in use. Thus for this category of EEM, the occupancy behavior has a secondary affect on the saving; the model of the EEM may have the schedule of use increased in the EEM case as compared to the non-EEM (base) case.

The energy savings performance of EEMs such as the residential programmable thermostat EEM is strongly influenced by occupant behavior. In fact, for this type of EEM, the occupant behavior is the primary parameter that influences the EEM performance; the occupant behavior, as translated into a range of base case and EEM case thermostat schedules for the DOE-2 building models, is the primary parameter that characterizes the EEM and leads directly to the results. The current DEER analysis methodology can, but currently DOES NOT, take into account occupant behavior variations in a manner that is appropriate to predict average energy savings for EEMs that are very strongly influenced by behavior assumptions of the model. In the case of EEMs that are strongly influenced by occupant behavior it is necessary to characterize the range of behavior variations into behavior groups for both the base case and the EEM case, model each of these behavior groups, and build up an average result for the EEM by weighting each behavior group result based upon population frequency. This methodology mirrors the methodology already used in the DEER analysis for construction variations; the methodology is extended to include behavioral variations.

It should be noted that it is not clear that the behavioral variation for the programmable thermostat EEM is greatly changed by Title 24. Title 24 requires, since the first version in 1978, that all residential buildings with heating and/or cooling systems have a clock thermostat with a minimum of two periods with separate setpoints for heating and cooling. The existence of this type of thermostat in a residence does not necessarily influence the behavior of the occupants relative to thermostat setpoints and heating/cooling system operation. Although the fact that the thermostat is installed makes the automatic control of setpoints easier, it does not provide any assurance that multiple setpoints will be used. The occupants can manually operate the heating/cooling system to have the same multiple set point control that a 5-1-1 fully programmable thermostat offers; so the effect of this EEM is more one of convenience and consistency than one of assured savings. There will be cases where the occupants install the programmable thermostat to allow better comfort and actually incur an increase in energy use; this would happen when the programmable thermostat is installed by the occupant who was doing both daytime and nighttime setback but desires the setback to be automatically terminated earlier in the morning and evening so that the home is more comfortable when they get up in the morning or return from work in the evening. For this reason the variation in the base case analysis and the EEM case analysis, in terms of the range of behavior, may contain the same number and detail of behavior groups with the difference being the fractional population in each of these population groups.

In summary, for the programmable thermostat EEM there are two very significant shortcomings of the DEER analysis that prevents the use of the current DEER savings values for this EEM in energy efficiency programs. First, the EEM was not defined and modeled to represent the average savings relative to a fully Title 24 compliant building without the “added” (above Title 24 requirements) technology of the EEM. Second, the DEER analysis methodology for this EEM, and probably other EEMs, does not properly take into account the variations of occupant behavior that strongly effect the savings that would result from the EEM. This project developed, tested, and implemented a methodological improvement to the DEER analysis to provide corrected savings estimates for the residential programmable thermostat EEM; this methodology can then be incorporated into the current DEER Update project and easily extended into other EEM, that are similarly strongly influenced by occupant behavior.

## Methodology Improvement

As was mentioned in the above section, the current DEER analysis methodology already provides a mechanism to allow population variation to be incorporated into the DOE-2 models and "build up" a population average result by weighting the individual results based upon population frequency. Two improvements are implemented here to allow proper analysis of the programmable thermostat EEM. The first improvement is to use the Residential Appliance Saturation Survey (RASS) to quantify how homes with and without programmable thermostats use their thermostat. The RASS database-derived thermostat tables will specify both the thermostat set point and set point movement throughout the day.

Both thermostat set point and movement are important when simulating energy use of the building, especially when attempting to capture the diversity of a large number of homes. To appreciate this, one can imagine a number of homes with similar architectural features and orientation (not uncommon in large developments), all with the same cooling thermostat set point of 76F at 6:00 PM. Just based on thermostat ***movement***, some homes may have no cooling demand at this time while others are operating at full capacity. A house with a thermostat set point of 74F during the day that ***increased*** the set point to 76F at 6:00 PM may have no cooling demand at all, while another house that had a cooling set point of 82F during the day and just ***lowered*** the set point to 76F may run at full capacity for the entire hour.

The second improvement is to greatly expand the number of simulation models to include all the thermostat scenarios considered during the RASS database analysis. Instead of simulating a base case and EEM case for each vintage/climate zone combination, all possible thermostat settings are simulated for each vintage/climate zone. The weights determined from the statistical analysis of the RASS database are then applied to each thermostat scenario to determine the difference in energy use implied by the difference in the thermostat schedules associated with households with and without programmable thermostats.

## RASS Database Analysis

The RASS database includes respondent's indication of thermostat set point for heating and cooling for four periods during the day: morning, day, evening and night. For the RASS survey, *Morning* is defined as 6 AM till 9 AM, *day* is from 9 AM till 5 PM, *evening* is from 5 PM till 9 PM, and *night* is from 9 PM till 6 AM. The respondent also indicated if they have a manual thermostat (with a temperature set point and an off position set by the user) or a programmable thermostat. No details on the level of programmability are included in the survey.

The objective of this RASS database analysis is to discern how thermostat setpoints differ between households with manual thermostats and households with programmable thermostats. The difference in thermostat set points will then be translated into energy savings using DOE2 simulations.

The analysis is done separately for cooling thermostats and heating thermostats.

### *Grouping of RASS respondents into Regions*

The number of responses in the RASS database from each of the 16 CEC climate zones that include cooling or heating thermostat information varies significantly. For example, there is only one respondent with a programmable cooling thermostat in CZ01, while there are 1464 respondents with standard heating thermostats in CZ03. This variation, combined with the lack of a significant number of respondents in some climate zones, was the main factor which leads to the grouping responses regionally rather than creating separate thermostat tables for each of the 16 climate zones.

Table 1 summarizes the number of RASS respondents from each of the 16 climate zones, along with an extended description of each climate zone.

**Table 1. Weather Summary and Number of Respondents by Climate Zone**

| | | | | | Un-Weighted Count (Respondents) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cooling T-Stat type | | Heating T-Stat type | |
| City | T24-CZ | Region | $CDD_{70}$ | $HDD_{65}$ | Prog | Std | Prog | Std |
| Arcata | CZ01 | North Coast | 0 | 4085 | 1 | 2 | 46 | 80 |
| Santa Rosa | CZ02 | North Coast | 179 | 2890 | 151 | 56 | 320 | 343 |
| Oakland | CZ03 | North Coast | 4 | 2541 | 113 | 40 | 836 | 1464 |
| Sunnyvale | CZ04 | North Coast | 35 | 2414 | 322 | 85 | 567 | 534 |
| Santa Maria | CZ05 | North Coast | 5 | 2277 | 15 | 5 | 121 | 180 |
| Los Angeles | CZ06 | South Coast | 63 | 1475 | 235 | 184 | 560 | 1090 |
| San Diego | CZ07 | South Coast | 117 | 1344 | 191 | 138 | 453 | 793 |
| El Toro | CZ08 | South Coast | 357 | 1316 | 388 | 385 | 484 | 1060 |
| Pasadena | CZ09 | South Inland | 534 | 1260 | 601 | 620 | 710 | 1330 |
| Riverside | CZ10 | South Inland | 716 | 1636 | 664 | 573 | 753 | 945 |
| Red Bluff | CZ11 | Central Valley | 741 | 2656 | 255 | 162 | 330 | 318 |
| Sacramento | CZ12 | Central Valley | 453 | 2648 | 859 | 381 | 1045 | 728 |
| Fresno | CZ13 | Central Valley | 1233 | 2228 | 426 | 304 | 468 | 519 |
| China Lake | CZ14 | Desert | 965 | 3113 | 175 | 142 | 207 | 274 |
| El Centro | CZ15 | Desert | 2817 | 845 | 81 | 80 | 88 | 85 |
| Mount Shasta | CZ16 | Mountain | 36 | 5529 | 81 | 64 | 152 | 196 |

The first three columns present the representative city, the Title-24 climate zone and the general region. The next two columns indicate the cooling degree-days (base 70) and the heating degree-days (base 65) for the climate zone. These values are a relative indicator of cooling and heating that might be required for a residence in these climate zones. The last four columns present the unweighted count, or number of respondents, for the various types of thermostats.

It is clear that there are a few climate zones that do not have enough respondents to conduct a robust analysis of the cooling thermostat set point and movement. Climate zone CZ01 has only three total respondents with cooling thermostats. The two respondents with standard thermostats indicate that the thermostat is “Off” at all times and the sole respondent with a programmable thermostat indicates that it is set to “Medium” at all times. Since the simulation analysis of cooling in this climate zone indicates that no cooling is actually required (it’s a surprising cool climate), the RASS-data cooling thermostat tables for this climate zone are actually irrelevant. However, climate zone CZ05 does have a significant cooling load, and the number of respondents with cooling thermostats is not enough to conduct a statistically robust analysis.

A number of alternative groupings were evaluated before it was determined that using the regional groupings, which were also integral in the 2001 DEER Update building definitions, provided the most robust possible analysis. Appendix A contains a discussion of some of this process and the statistical justification for this grouping.

### *Derivation of RASS database Thermostat Tables*

To analyze the cooling thermostat set points, the RASS database of responses were filtered by house type, geographic region and thermostat type for all households that indicated they had central air conditioning. These data were then presented as the weighted frequency of occurrence of every possible combination of cooling thermostat set point. An example of this reporting format is shown below:

**Table 2. Example of RASS cooling thermostat data**

| Cooling Thermostat Set Point | | | | Weighted Frequency | Percent |
|---|---|---|---|---|---|
| Morning | Day | Evening | Night | | |
| OFF | OFF | OFF | OFF | 4878.13 | 9.59 |
| OFF | OFF | BELOW 70 F | OFF | 1539.44 | 3.03 |
| OFF | OFF | 70-73 F | OFF | 585.04 | 1.15 |
| OFF | OFF | 70-73 F | 70-73 F | 165.93 | 0.33 |
| OFF | OFF | 70-73 F | 74-76 F | 186.16 | 0.37 |
| OFF | OFF | 74-76 F | OFF | 3806.04 | 7.48 |
| Etc. | | | | | |

The first four columns of table 2 indicate the sequence of thermostat set points while the fifth column indicates their weighted frequency of occurrence as reported in the RASS database[1]. The last column of this table is the weighted percentage and is calculated as the weighted frequency of that row divided by the total weighted frequency times 100. Since there are five possible thermostat positions for each of the four periods, there are $5^4$, or 625, potential rows for each of these tables. As it turns out, not all combinations of thermostat set points are encountered for each of the filtered data sets, but there may be 300 – 400 rows in a particular table.

For the heating thermostat data, the same analysis and data formatting are done, with the exception that there are six possible thermostat positions, leading to a maximum of 1296 rows for each table.

[1] Every RASS respondent is assigned a sample weight, so that the survey results are representative of the larger population. See section 2.4 of the "California Statewide Residential Appliance Saturation Study" for an explanation of how the weights were determined.

At this point, 625 cooling thermostat schedules and 1296 heating thermostat schedules could be included in a residential model and simulated using DOE2, for each of the climate zones, for each of the thermostat types, for each of the building vintages and for each of the building types. This would lead to nearly a half million simulations for single-family residences and nearly 3 million simulations for multi-family residences. While not an entirely unreasonable task, the number of necessary thermostat schedules is greatly reduced by recognizing that the energy use during any period of the day is largely a function of the thermostat set point during that period and the thermostat set point during the previous period. For example, the energy use for the evening period is only a function of the evening thermostat set point and the day thermostat set point. Energy use during the evening is not affected by the thermostat set point of any later period, and is insensitive to the thermostat set point two periods prior.

This dependency on the current thermostat set point and the prior thermostat set point forms the basis of the "RASS-data thermostat tables" used in this analysis. These tables indicate the percentage of homes that have a particular thermostat setting and thermostat movement for the standard periods throughout the day. Thermostat movement is indicated by whether the set point remained the same, was increased, or was decreased compared to the previous period. Table 3 shows a RASS-data cooling thermostat table for households with a programmable thermostat for the South Inland region.

**Table 3. RASS-data Cooling Thermostat Table (Programmable Thermostat, South Inland Region)**

| | T-stat Setting | | Period (kWh) | | | |
|---|---|---|---|---|---|---|
| Row | Current | Previous | Morning | Day | Evening | Night |
| 1 | Off | any | 42.5% | 23.7% | 11.3% | 40.0% |
| 2 | Very Low | Very Low | 10.2% | 14.1% | 19.4% | 12.0% |
| 3 | Very Low | Low | 0.7% | 0.4% | 1.8% | 1.2% |
| 4 | Very Low | Medium | 1.7% | 1.1% | 0.2% | 0.6% |
| 5 | Very Low | High | 0.0% | 0.1% | 0.1% | 0.0% |
| 6 | Very Low | Off | 5.1% | 8.0% | 4.5% | 1.2% |
| 7 | Low | Very Low | 0.7% | 0.7% | 0.6% | 1.6% |
| 8 | Low | Low | 8.4% | 9.9% | 19.5% | 13.5% |
| 9 | Low | Medium | 1.3% | 3.4% | 1.5% | 0.2% |
| 10 | Low | High | 0.0% | 0.1% | 1.2% | 0.0% |
| 11 | Low | Off | 1.4% | 10.0% | 5.4% | 0.6% |
| 12 | Medium | Very Low | 0.1% | 0.3% | 0.2% | 1.0% |
| 13 | Medium | Low | 2.2% | 1.0% | 1.5% | 3.2% |
| 14 | Medium | Medium | 16.4% | 16.2% | 21.4% | 19.2% |
| 15 | Medium | High | 0.5% | 1.7% | 0.7% | 0.1% |
| 16 | Medium | Off | 3.0% | 4.4% | 6.6% | 0.1% |
| 17 | High | Very Low | 0.0% | 0.0% | 0.0% | 0.0% |
| 18 | High | Low | 0.0% | 0.1% | 0.0% | 0.2% |
| 19 | High | Medium | 0.6% | 0.3% | 0.2% | 1.7% |
| 20 | High | High | 4.8% | 3.0% | 3.0% | 3.7% |
| 21 | High | Off | 0.2% | 1.6% | 1.2% | 0.0% |

The first two columns of table 3 describe all of the possible thermostat scenarios of set point and movement. The last four columns indicate the percentage of households that are associated with each scenario for the four time periods. Rows 12 through 16, for example, indicate the percentage of households that have a “medium” cooling thermostat set point. In the morning, 3.0% of the households have a medium set point coming from an “off” set point while 16.4% of households have a medium set point in the morning coming from a medium set point the previous period. Each of the last four columns sums to 100%, since the thermostat setting during each period is required to correspond to one the described scenarios. For thermostat settings of “Off”, the thermostat movement is not indicated since the energy use associated with the “Off” position is independent of the previous period’s set point (i.e. it is zero).

The cell values of this table are derived by adding the percentage values from table 2 for all rows that meet the criteria of the RASS-data thermostat table cell. For example, in order to fill in row 1 of the “morning” column of table 3, the “percent” column of table 2 is added up for each row of table 2 that shows an “OFF” in the morning. In this case, the percentages add up to 42.5%. Likewise, the value for row 6 of the same column in table 3 is determined by adding up all the percentages of table 2 with values of “Very Low” in the morning and “OFF” at night (the previous period).

The temperature ranges in table 2 are translated into the descriptions in table 3 by the following mapping:

**Table 4. Mapping of RASS Temperature Bins to Descriptions and Simulation Values.**

**Cooling Thermostat**

| RASS Bin | Description | Sim Value |
|---|---|---|
| Off | Off | Off |
| <= 73 F | Very Low | 72 F |
| 74 to 76 F | Low | 75 F |
| 77 to 80 F | Medium | 78 F |
| > 80F | High | 82 F |

**Heating Thermostat**

| RASS Bin | Description | Sim Value |
|---|---|---|
| "Off" & < 55 F | Off | 53 F |
| 55 to 60 F | Very Low | 58 F |
| 61 to 65 F | Low | 63 F |
| 66 to 70 F | Medium | 68 F |
| 71 - 75 F | High | 73 F |
| >75 F | Very High | 76 F |

The results of the RASS analysis include thermostat tables for programmable and standard thermostats by climate region, for cooling and for heating (5 climate regions x 2 thermostat types x 2 operation modes = 20 thermostat tables). Each table is based on the RASS respondents from that particular climate region and with that particular thermostat type. Appendix B contains the entire set of RASS-data thermostat tables derived for this analysis.

### *Summary of RASS reported Thermostat Set Points*

The RASS data thermostat tables described above and listed in appendix B can be distilled down to single estimates of thermostat set points for each period and for each region and thermostat type by assigning the temperature ranges a value (as in table 4) and adding up the weighted temperatures for each thermostat table.

**Table 5. Average Cooling Thermostat Set Points (°F)**

| | Standard Thermostat | | | | Change due to Prog T-stat | | | |
|---|---|---|---|---|---|---|---|---|
| Region | Morn | Day | Evening | Night | Morn | Day | Evening | Night |
| NC | 74.9 | 74.6 | 74.4 | 75.0 | **0.1** | **0.5** | **0.4** | **0.6** |
| SC | 74.2 | 74.0 | 74.1 | 74.6 | **0.6** | **1.2** | **0.2** | **0.2** |
| SI | 74.4 | 74.5 | 74.3 | 74.7 | **0.9** | **0.7** | **0.7** | **0.7** |
| CV | 75.9 | 75.5 | 75.5 | 76.1 | **0.9** | **1.2** | **0.8** | **0.8** |
| DE | 76.4 | 76.4 | 75.9 | 76.8 | **0.4** | **0.9** | **0.9** | 0.0 |

Table 5 shows the average cooling set point by region and time-of-day for the standard thermostat and the change in the average thermostat set point due to the use of a programmable thermostat. The data used to calculate these average temperatures exclude the "Off" category and demonstrate that when cooling thermostats are "On", programmable thermostats are, on average, set to a slightly higher temperature (on the order of a fraction to one degree Fahrenheit).

On the surface, it would seem that programmable thermostats should lead to consistently lower cooling energy use (i.e. across all regions and time periods). However, a summary of the percent of cooling thermostats set to "Off" shows that this may not be the case:

**Table 6. Percent of Cooling Systems set to "Off"**

| | Standard Thermostat | | | | Change due to Prog T-stat | | | |
|---|---|---|---|---|---|---|---|---|
| Region | Morn | Day | Evening | Night | Morn | Day | Evening | Night |
| NC | 49% | 28% | 13% | 56% | -2% | **3%** | **7%** | -2% |
| SC | 63% | 43% | 42% | 65% | -13% | -6% | -16% | -17% |
| SI | 48% | 25% | 23% | 47% | -13% | -5% | -9% | -10% |
| CV | 43% | 24% | 11% | 40% | -10% | -9% | -3% | -3% |
| DE | 37% | 14% | 10% | 35% | -8% | 0% | -4% | -10% |

Table 6 shows the average number of cooling thermostats set to "Off" by region and time-of-day and the increase in percentage of thermostats set to "Off' due to the use of a programmable thermostat. Note that the right columns of table 6 show the change in percentage, not the percent change. For example, 49% of standard cooling thermostats are set to "Off" in the North Coast Region in the morning, while [49% - 2%], or 47%, of programmable thermostats are set to "Off". Likewise, 35% of standard cooling thermostats are set to "Off" in the Desert Region at night, while only 25% of programmable thermostats are set to "Off".

In almost all regions and at all times of day, a smaller percentage of programmable cooling thermostats are set to "Off" than are standard thermostats. This, of course, will have a significant effect on the calculated energy use comparison.

The same data for heating thermostats do not exhibit this ambiguity of savings potential; programmable thermostat set points are consistently ***higher*** and a lower percentage of programmable thermostats are set to "Off". Both of these trends point toward higher energy use associated with programmable thermostats.

**Table 7. Average Heating Thermostat Set Points (°F)**

| | Standard Thermostat | | | | Change due to Prog T-stat | | | |
|---|---|---|---|---|---|---|---|---|
| Region | Morn | Day | Evening | Night | Morn | Day | Evening | Night |
| NC | 65.9 | 65.2 | 66.5 | 64.3 | 0.6 | **-0.3** | 0.8 | **-0.6** |
| SC | 67.9 | 66.5 | 68.0 | 65.8 | **-0.3** | **-1.1** | 0.0 | **-0.9** |
| SI | 67.6 | 66.9 | 67.7 | 66.7 | 0.9 | 0.8 | 0.9 | 0.6 |
| CV | 67.5 | 67.4 | 68.0 | 66.5 | 0.3 | **-0.2** | 0.7 | **-0.7** |
| DE | 67.0 | 66.6 | 67.7 | 65.1 | 2.2 | 2.0 | 1.9 | 2.3 |

**Table 8. Percent of Heating Systems set to "Off"**

| | Standard Thermostat | | | | Change due to Prog T-stat | | | |
|---|---|---|---|---|---|---|---|---|
| Region | Morn | Day | Evening | Night | Morn | Day | Evening | Night |
| NC | 29% | 45% | 19% | 53% | -12% | -17% | -11% | -13% |
| SC | 40% | 57% | 35% | 54% | -15% | -15% | -16% | -17% |
| SI | 30% | 44% | 26% | 36% | -10% | -12% | -12% | -7% |
| CV | 19% | 37% | 19% | 39% | -10% | -15% | -12% | -10% |
| DE | 27% | 34% | 23% | 35% | -17% | -11% | -14% | -11% |

While a large fraction of standard heating thermostats are set to "Off", far less programmable heating thermostats are. In the North Coast Region, for example, 45% of standard thermostats are set to "Off" in the daytime, while only 28% of programmable thermostats are in that mode.

## DOE2 Simulation Analysis

The residential models used in the DEER 2001 update include realistic single-story and two-story multi-zone models with differing orientations, as shown in figure 1. The descriptions of each house model, including total area, insulation levels, average number of stories, amount of glass, etc. vary by region and by vintage of the house. These values where derived from a separate survey analysis conducted for the 2001 report.

The five regions are: North Coast, South Coast, Central Valley, South Inland and Desert. The Title-24 climates zones associated with these regions are shown in table 1. The four vintages are described as: very old, old, recent and new. These correspond to homes built before 1978, between 1978 and 1992, between 1992 and 1998 and after 1998.

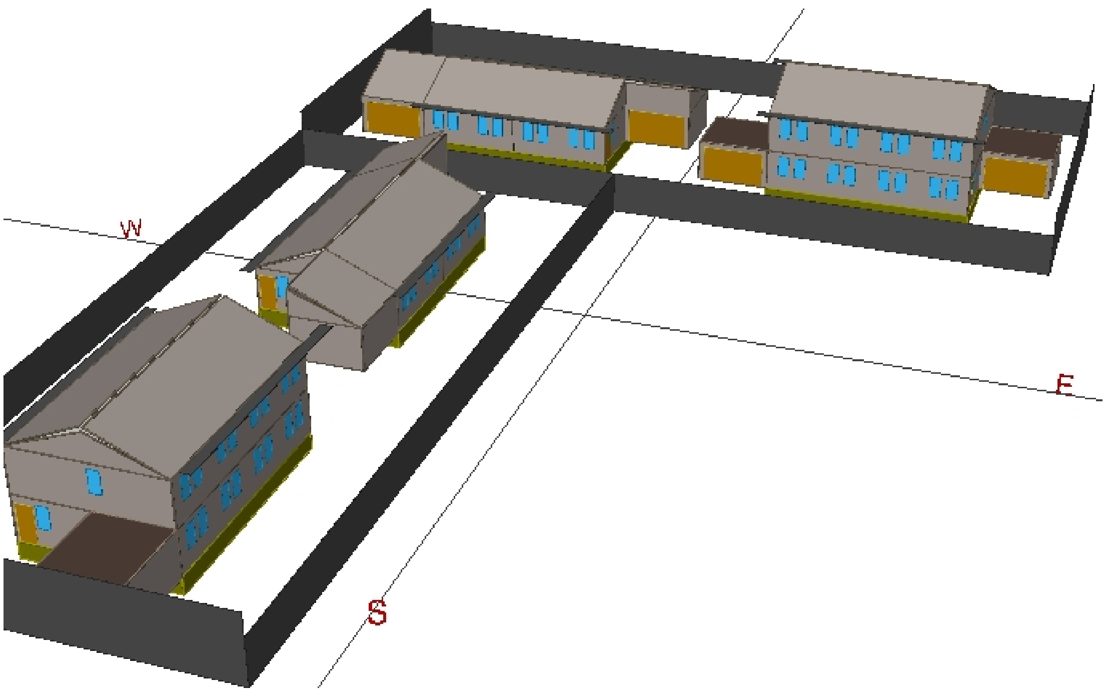


**Figure 1. 2001 DEER Single-Family Residential Simulation Model**

Multi-family dwellings were also included in the 2001 DEER update, represented by two, two-story, 12-unit apartment building, as shown in figure 2. The physical characteristics of the apartment building were derived using the same region and vintage definitions as was used for the single-family residence.

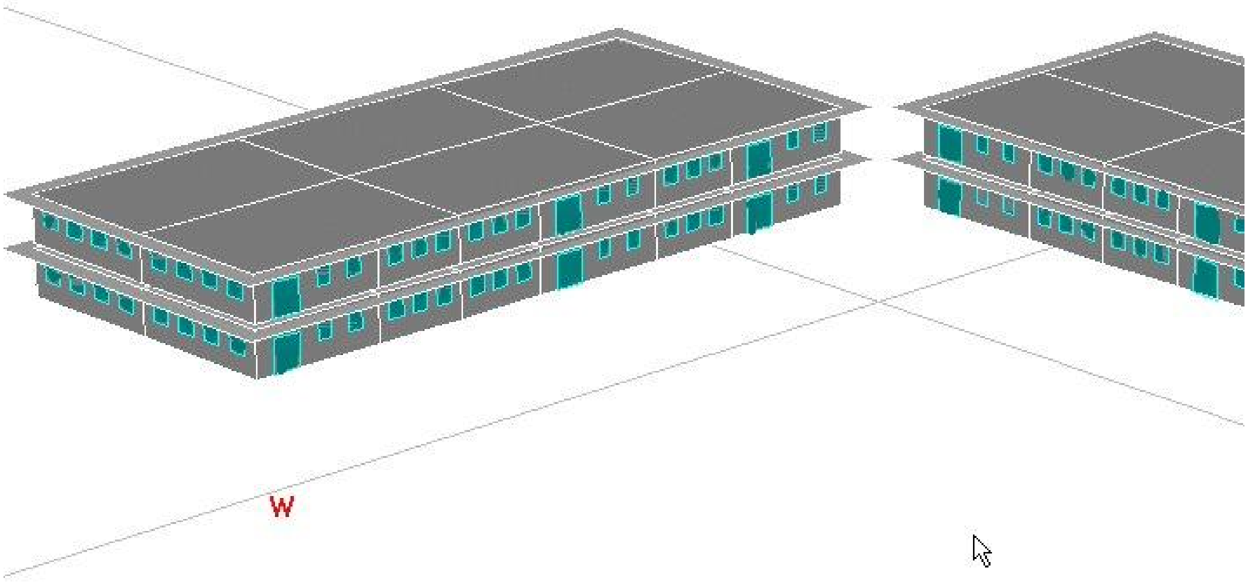


**Figure 2. 2001 DEER Multi-Family Residential Simulation Model**

The simulation part of this analysis expands the 2001 DEER residential update to include all of the thermostat schedules described by the newly created RASS-data thermostat tables. Cooling energy use must be simulated for the setpoint scenario of every cell in table 3. For example, there will be a simulation that uses a morning cooling setpoint of “Low” (or 75°F) and a cooling thermostat setpoint control set to “Off” at night, and a simulation that uses a morning cooling setpoint of “Med” (or 78°F) and a cooling thermostat setpoint control set to “Off” at night, etc.

For every simulation conducted for the 2001 analysis, there are now 24 simulations run using varying cooling thermostat schedules and 35 simulations run with varying heating thermostat schedules. This results in a requirement to run slightly more than 100,000 residential simulations; this number of simulations is a practical task in terms of both required computer run-time and data manipulation.

The residential prototypes include only natural gas, forced-air heating systems. Energy savings associated with programmable thermostats used with heat pumps is outside of the scope of this analysis.

The results of the DOE2 simulations provide heating and cooling energy use by time period (morning, day, evening, night) for every combination of climate zone, vintage and thermostat schedule. For example, there is a DOE2 simulation for climate zone CZ10 that reports the average cooling energy used by a typical “old” house in that region in the evening period, and which has an evening cooling thermostat set point of "Low" and a day thermostat set point of "Medium".

The simulation results are compiled into a table that brings together all of the cooling energy use results for a particular climate zone and vintage. Table 9 shows all of the estimated cooling energy use values for a typical "Old" residence in climate zone CZ11.

**Table 9. Cooling Electricity Use (kWh/yr) by Thermostat Schedule (Single-Family unit, "Old" Vintage, Climate Zone CZ11)**

| | T-stat Setting | | Period (kWh) | | | |
|---|---|---|---|---|---|---|
| Row | Current | Previous | Morning | Day | Evening | Night |
| 1 | Off | any | 0 | 0 | 0 | 0 |
| 2 | Very Low | Very Low | 340 | 3933 | 1551 | 338 |
| 3 | Very Low | Low | 390 | 4114 | 1838 | 538 |
| 4 | Very Low | Medium | 420 | 4212 | 2084 | 733 |
| 5 | Very Low | High | 448 | 4259 | 2332 | 902 |
| 6 | Very Low | Off | 501 | 4269 | 2567 | 965 |
| 7 | Low | Very Low | 142 | 3100 | 1027 | 99 |
| 8 | Low | Low | 173 | 3292 | 1303 | 186 |
| 9 | Low | Medium | 195 | 3414 | 1583 | 353 |
| 10 | Low | High | 217 | 3490 | 1894 | 538 |
| 11 | Low | Off | 255 | 3509 | 2250 | 661 |
| 12 | Medium | Very Low | 46 | 2296 | 569 | 17 |
| 13 | Medium | Low | 62 | 2476 | 798 | 42 |
| 14 | Medium | Medium | 76 | 2605 | 1058 | 91 |
| 15 | Medium | High | 92 | 2698 | 1408 | 265 |
| 16 | Medium | Off | 114 | 2741 | 1885 | 418 |
| 17 | High | Very Low | 5 | 1373 | 171 | 1 |
| 18 | High | Low | 9 | 1519 | 289 | 1 |
| 19 | High | Medium | 14 | 1634 | 468 | 5 |
| 20 | High | High | 21 | 1730 | 750 | 30 |
| 21 | High | Off | 33 | 1809 | 1348 | 204 |

Similar tables are produced for heating electricity (supply fan use during heating) and heating natural gas use (see table 10). In all, data for 384 tables are produced that give the expected energy use by thermostat setting, thermostat movement and by time of day (16 climates x 4 vintages x 3 end-uses x 2 building types).

**Table 10. Heating Gas Use (therms/yr) by Thermostat Schedule (Single-Family unit, "Old" Vintage, Climate Zone CZ11)**

| | T-stat Setting | | Period | | | |
|---|---|---|---|---|---|---|
| row | Current | Previous | Morning | Day | Evening | Night |
| 1 | Off | any | 0 | 0 | 0 | 0 |
| 2 | Very Low | Off | 72 | 40 | 22 | 134 |
| 3 | Very Low | Very Low | 52 | 28 | 15 | 124 |
| 4 | Very Low | Low | 15 | 13 | 3 | 95 |
| 5 | Very Low | Medium | 1 | 6 | 0 | 65 |
| 6 | Very Low | High | 0 | 3 | 0 | 41 |
| 7 | Very Low | Very High | 0 | 3 | 0 | 32 |
| 8 | Low | Off | 149 | 90 | 60 | 257 |
| 9 | Low | Very Low | 131 | 84 | 54 | 255 |
| 10 | Low | Low | 85 | 57 | 35 | 230 |
| 11 | Low | Medium | 36 | 35 | 13 | 187 |
| 12 | Low | High | 7 | 21 | 2 | 141 |
| 13 | Low | Very High | 1 | 17 | 0 | 118 |
| 14 | Medium | Off | 237 | 151 | 116 | 409 |
| 15 | Medium | Very Low | 224 | 151 | 111 | 409 |
| 16 | Medium | Low | 182 | 133 | 93 | 400 |
| 17 | Medium | Medium | 124 | 97 | 65 | 362 |
| 18 | Medium | High | 64 | 67 | 32 | 305 |
| 19 | Medium | Very High | 35 | 55 | 17 | 269 |
| 20 | High | Off | 311 | 230 | 191 | 578 |
| 21 | High | Very Low | 307 | 230 | 187 | 578 |
| 22 | High | Low | 284 | 226 | 172 | 577 |
| 23 | High | Medium | 231 | 196 | 145 | 554 |
| 24 | High | High | 165 | 150 | 107 | 502 |
| 25 | High | Very High | 125 | 125 | 80 | 463 |
| 26 | Very High | Off | 347 | 287 | 243 | 684 |
| 27 | Very High | Very Low | 346 | 287 | 240 | 684 |
| 28 | Very High | Low | 333 | 287 | 228 | 684 |
| 29 | Very High | Medium | 295 | 268 | 203 | 672 |
| 30 | Very High | High | 233 | 220 | 165 | 626 |
| 31 | Very High | Very High | 191 | 189 | 136 | 588 |

### Combining the RASS Analysis with the DOE2 Simulation Results

It is not coincidental that the format of table 9 is exactly the same as table 3. Table 9 presents the expected energy use by time-of-day and by thermostat setting while table 3 provides the weighted percentage of households by the same time-of-day and thermostat settings criteria. When the values in table 9 ("old" vintage, single-family cooling electricity use in CZ11) are multiplied by the corresponding weights in table 3 (programmable thermostat, South Inland region) and then summed across the entire table, the expected annual energy use results. For the specific values presented in tables 3 and 9, the total represents the expected cooling electricity use for an "old" household in climate zone CZ11 with a programmable thermostat. For this case, the values sum to 3943.6 kWh/year.

If table 3 is substituted with the RASS-data thermostat table for ***standard*** thermostats instead of ***programmable*** thermostats, the new summed value is 4005.5 kWh/year. The implied savings for typical old homes in climate zone 11 due to the use of programmable thermostat is (4005.5 – 3843.6), or 61.8 kWh/year. Using this calculation procedure, the expected savings for all vintages in all climate zones can be determined.

DOE2 estimates of heating and cooling energy use were determined for all vintages and all climate zones, though the cooling energy for all periods and all vintages in climate zone CZ01 is essentially zero. As noted earlier, the RASS-data thermostat tables for climate zones are combined into larger geographic regions to produce more statistically robust results. The same dynamic thermostat table is therefore used with multiple DOE2 climate-zone specific results.

The results of applying the DOE2 estimates of energy use to the RASS-data thermostat tables to determine energy savings are shown in tables 11 through 13 for cooling electricity savings, heating electricity savings and heating natural gas savings.

**Table 11. Cooling Electricity Savings (kWh/yr) by Climate Zone, Vintage and Dwelling Type**

| | Single-Family | | | | Multi-Family | | | |
|---|---|---|---|---|---|---|---|---|
| T24-CZ | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 |
| CZ01* | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| CZ02 | **222.7** | **177.6** | **224.3** | **227.4** | **142.0** | **83.0** | **70.3** | **69.5** |
| CZ03 | **111.7** | **88.5** | **139.6** | **144.4** | **84.9** | **51.8** | **47.1** | **47.2** |
| CZ04 | **218.3** | **177.6** | **225.4** | **228.3** | **144.7** | **87.7** | **74.7** | **73.9** |
| CZ05 | **106.3** | **88.3** | **135.4** | **138.8** | **83.5** | **53.3** | **45.4** | **45.7** |
| CZ06 | -2.5 | **24.7** | -25.4 | -24.7 | -15.1 | **4.9** | -1.3 | -1.9 |
| CZ07 | -29.2 | **0.5** | -49.4 | -49.7 | -35.7 | -6.4 | -11.7 | -12.6 |
| CZ08 | -103.1 | -63.1 | -125.1 | -123.1 | -90.9 | -32.5 | -33.8 | -33.9 |
| CZ09 | -0.7 | -2.2 | -20.0 | -18.2 | -21.5 | **8.2** | **6.8** | **7.9** |
| CZ10 | -48.2 | -43.2 | -54.5 | -53.1 | -52.1 | -9.8 | -3.5 | -2.2 |
| CZ11 | **61.8** | **45.4** | **89.8** | **92.3** | **19.2** | **51.5** | **46.4** | **48.7** |
| CZ12 | **91.2** | **77.3** | **116.2** | **116.1** | **34.5** | **61.6** | **56.9** | **59.9** |
| CZ13 | **5.4** | -7.8 | **43.1** | **51.2** | -25.7 | **29.0** | **30.0** | **35.2** |
| CZ14 | **274.2** | **217.4** | **182.8** | **217.2** | **181.9** | **110.1** | **72.4** | **68.9** |
| CZ15 | **91.9** | **65.7** | **68.4** | **64.7** | **121.1** | **46.4** | **19.6** | **15.5** |
| CZ16 | **165.8** | **129.8** | **178.8** | **179.8** | **113.4** | **63.3** | **55.2** | **55.0** |

* For the DEER 2001 Update climate zone CZ01 was prescribed to have no residential cooling load

Table 11 shows that significant electricity savings associated with programmable thermostats can be expected in some climate zones, while in other climate zones increases in electricity use can also be expected.

**Table 12. Heating Electricity Savings (kWh/yr) by Climate Zone, Vintage and Dwelling Type**

| | Single-Family | | | | Multi-Family | | | |
|---|---|---|---|---|---|---|---|---|
| T24-CZ | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 |
| CZ01* | -67.3 | -38.4 | -54.2 | -41.6 | -26.1 | -3.6 | -3.1 | -2.3 |
| CZ02 | -54.7 | -26.4 | -38.5 | -29.1 | -21.9 | -1.9 | -1.8 | -1.3 |
| CZ03 | -48.2 | -24.4 | -32.6 | -23.8 | -19.4 | -2.1 | -1.8 | -1.3 |
| CZ04 | -46.0 | -21.7 | -29.4 | -21.4 | -19.2 | -1.7 | -1.5 | -1.0 |
| CZ05 | -39.5 | -16.9 | -22.5 | -15.6 | -16.6 | -1.1 | -1.0 | -0.6 |
| CZ06 | -12.9 | -2.4 | **1.1** | **2.2** | -7.3 | **0.5** | **0.4** | **0.3** |
| CZ07 | -9.4 | **0.1** | **2.2** | **2.7** | -6.3 | **0.5** | **0.3** | **0.3** |
| CZ08 | -12.1 | -2.4 | -0.2 | **0.9** | -7.5 | **0.2** | **0.2** | **0.2** |
| CZ09 | -29.7 | -17.6 | -15.6 | -11.4 | -11.4 | -2.4 | -1.0 | -0.7 |
| CZ10 | -31.0 | -18.1 | -16.4 | -12.0 | -11.8 | -2.4 | -1.0 | -0.7 |
| CZ11 | -36.3 | -27.3 | -20.4 | -17.9 | -16.1 | -3.7 | -1.9 | -1.6 |
| CZ12 | -32.0 | -23.0 | -17.0 | -14.9 | -14.2 | -2.9 | -1.4 | -1.1 |
| CZ13 | -24.3 | -16.6 | -12.0 | -10.4 | -11.2 | -1.9 | -0.8 | -0.6 |
| CZ14 | -56.1 | -37.5 | -22.6 | -21.4 | -35.8 | -8.7 | -2.9 | -2.0 |
| CZ15 | -22.1 | -9.7 | -3.3 | -2.3 | -18.7 | -1.8 | -0.3 | -0.2 |
| CZ16 | -126.1 | -75.6 | -105.4 | -80.9 | -47.7 | -9.2 | -8.3 | -6.7 |

**Table 13. Heating Fuel Savings (therms/yr) by Climate Zone, Vintage and Dwelling Type**

| | Single-Family | | | | Multi-Family | | | |
|---|---|---|---|---|---|---|---|---|
| T24-CZ | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 |
| CZ01* | -73.2 | -37.7 | -35.9 | -33.3 | -30.3 | -6.2 | -5.3 | -4.2 |
| CZ02 | -60.0 | -26.5 | -25.8 | -23.6 | -25.0 | -3.4 | -3.1 | -2.3 |
| CZ03 | -52.1 | -24.2 | -21.8 | -19.4 | -22.4 | -3.8 | -3.2 | -2.3 |
| CZ04 | -50.1 | -21.8 | -19.8 | -17.6 | -22.0 | -3.0 | -2.5 | -1.8 |
| CZ05 | -42.8 | -17.1 | -15.3 | -13.1 | -18.9 | -2.0 | -1.7 | -1.2 |
| CZ06 | -12.6 | -2.1 | **0.5** | **1.3** | -8.2 | **0.5** | **0.4** | **0.3** |
| CZ07 | -9.3 | -0.2 | **1.2** | **1.6** | -6.9 | **0.5** | **0.4** | **0.3** |
| CZ08 | -11.8 | -2.0 | -0.3 | **0.4** | -8.3 | **0.2** | **0.2** | **0.2** |
| CZ09 | -36.1 | -19.4 | -13.7 | -11.5 | -18.9 | -3.8 | -1.7 | -1.2 |
| CZ10 | -37.5 | -19.9 | -14.2 | -12.0 | -19.5 | -3.8 | -1.8 | -1.2 |
| CZ11 | -57.1 | -35.4 | -24.5 | -20.5 | -27.3 | -7.4 | -4.1 | -3.3 |
| CZ12 | -50.6 | -30.0 | -20.7 | -17.4 | -24.2 | -5.9 | -3.1 | -2.4 |
| CZ13 | -38.6 | -21.9 | -14.8 | -12.3 | -19.1 | -3.9 | -1.9 | -1.4 |
| CZ14 | -122.5 | -72.5 | -42.8 | -43.1 | -64.7 | -17.1 | -6.4 | -4.6 |
| CZ15 | -51.2 | -20.3 | -7.1 | -5.3 | -33.3 | -3.7 | -0.7 | -0.4 |
| CZ16 | -139.5 | -75.5 | -71.2 | -65.4 | -55.0 | -15.0 | -13.4 | -11.2 |

Households with programmable heating thermostats appear to consistently use more energy than households with standard thermostats. A clear indication of this trend is evident in the RASS responses to thermostat settings. In climate zone CZ03, for example, twice the percentage of respondents with standard thermostats reported their heating thermostat to be “Off” during all periods of the day compared to respondents with programmable thermostats.

The results presented in tables 11 - 13 are summarized for each climate zone by weighting the vintage-specific results. The weights currently used are based on full-year occupied, single-dwelling units with either a standard or a programmable thermostat (see appendix C). Other sets of weights could be used to, for example, project the change in energy use if the current population of single-dwelling units with central air conditioning changed from a standard to a programmable thermostat.

Tables 14 and 15 present the weighted energy savings by climate zone and by energy end-use. The last row of this table is the weighted average for all climate zones.

**Table 14. Single-Family Dwelling: Energy Savings by Climate Zone**

| | Manual T-Stat Energy Use | | | | Prog T-Stat Energy Savings | | | | | Percent Savings | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Climate Zone | Clg kWh | Htg kWh | Total KWh | Htg therms | Clg kWh | Htg kWh | Total kWh | Htg therms | Source[2] MBTU | Total kWh | Htg therms | Source Energy |
| CZ01 | 0 | 258 | 258 | 260 | 0.0 | -55.3 | -55.3 | -54.8 | -6.0 | -21% | -21% | -21% |
| CZ02 | 2046 | 203 | 2250 | 217 | **204.2** | -43.8 | **160.4** | -46.2 | -3.0 | **7%** | -21% | -7% |
| CZ03 | 882 | 186 | 1067 | 197 | **112.6** | -42.2 | **70.5** | -44.0 | -3.7 | **7%** | -22% | -12% |
| CZ04 | 1980 | 177 | 2158 | 191 | **211.2** | -39.8 | **171.4** | -42.3 | -2.5 | **8%** | -22% | -6% |
| CZ05 | 780 | 131 | 911 | 138 | **101.3** | -31.2 | **70.0** | -32.1 | -2.5 | **8%** | -23% | -11% |
| CZ06 | 1286 | 94 | 1380 | 84 | **0.3** | -8.3 | -8.0 | -8.2 | -0.9 | -1% | -10% | -4% |
| CZ07 | 1496 | 72 | 1568 | 63 | -26.7 | -3.9 | -30.6 | -4.1 | -0.7 | -2% | -7% | -3% |
| CZ08 | 1980 | 86 | 2066 | 78 | -94.7 | -8.4 | -103.1 | -8.1 | -1.9 | -5% | -10% | -6% |
| CZ09 | 3021 | 98 | 3119 | 119 | -3.1 | -26.0 | -29.0 | -30.7 | -3.4 | -1% | -26% | -8% |
| CZ10 | 3673 | 82 | 3755 | 95 | -47.2 | -21.2 | -68.4 | -23.9 | -3.1 | -2% | -25% | -6% |
| CZ11 | 3603 | 232 | 3834 | 324 | **63.3** | -28.6 | **34.8** | -40.0 | -3.6 | **1%** | -12% | -5% |
| CZ12 | 2843 | 216 | 3059 | 314 | **91.3** | -26.1 | **65.2** | -38.1 | -3.1 | **2%** | -12% | -5% |
| CZ13 | 4696 | 156 | 4852 | 228 | **11.4** | -19.0 | -7.5 | -27.7 | -2.9 | 0% | -12% | -4% |
| CZ14 | 4422 | 107 | 4530 | 213 | **218.3** | -38.8 | **179.5** | -77.3 | -5.9 | **4%** | -36% | -9% |
| CZ15 | 9356 | 23 | 9379 | 50 | **74.3** | -12.3 | **62.0** | -27.4 | -2.1 | **1%** | -55% | -2% |
| CZ16 | 1496 | 512 | 2007 | 521 | **155.1** | -102.2 | **52.9** | -104.8 | -9.9 | **3%** | -20% | -14% |
| Average[1] | 3112 | 142 | 3254 | 169 | **32.8** | -25.8 | **6.9** | -30.8 | -3.0 | **0%** | -18% | -6% |

1: weighted average by residence population in the climate zone (see Appendix C)
2: source energy = (site kWh x 10239 + site therms * 100,000) / 1,000,000

**Table 15. Multi-Family Dwelling: Energy Savings by Climate Zone**

| | Manual T-Stat Energy Use | | | | Prog T-Stat Energy Savings | | | | | Percent Savings | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Climate Zone | Clg kWh | Htg kWh | Total KWh | Htg therms | Clg kWh | Htg kWh | Total kWh | Htg therms | Source MBTU | Total kWh | Htg therms | Source Energy |
| CZ01 | 0 | 80 | 80 | 97 | 0.0 | -16.7 | -16.7 | -20.1 | -2.2 | -21% | -21% | -21% |
| CZ02 | 829 | 55 | 884 | 66 | **85.4** | -11.5 | **73.8** | -13.8 | -0.6 | **8%** | -21% | -4% |
| CZ03 | 453 | 70 | 523 | 83 | **60.3** | -15.3 | **45.0** | -17.9 | -1.3 | **9%** | -22% | -10% |
| CZ04 | 844 | 47 | 892 | 56 | **93.0** | -10.3 | **82.7** | -12.2 | -0.4 | **9%** | -22% | -3% |
| CZ05 | 354 | 53 | 407 | 62 | **46.5** | -11.7 | **34.8** | -13.5 | -1.0 | **9%** | -22% | -10% |
| CZ06 | 626 | 34 | 660 | 37 | -2.0 | -4.2 | -6.2 | -4.7 | -0.5 | -1% | -13% | -5% |
| CZ07 | 748 | 24 | 772 | 26 | -18.0 | -2.6 | -20.6 | -2.9 | -0.5 | -3% | -11% | -5% |
| CZ08 | 940 | 31 | 971 | 34 | -49.1 | -4.3 | -53.4 | -4.7 | -1.0 | -5% | -14% | -8% |
| CZ09 | 1815 | 38 | 1853 | 62 | -6.9 | -8.4 | -15.3 | -13.9 | -1.5 | -1% | -22% | -6% |
| CZ10 | 2024 | 29 | 2053 | 47 | -24.7 | -6.2 | -30.8 | -10.1 | -1.3 | -2% | -21% | -5% |
| CZ11 | 1538 | 83 | 1621 | 142 | **47.7** | -9.8 | **37.8** | -17.2 | -1.3 | **2%** | -12% | -4% |
| CZ12 | 1421 | 55 | 1476 | 96 | **52.7** | -6.5 | **46.2** | -11.6 | -0.7 | **3%** | -12% | -3% |
| CZ13 | 2363 | 52 | 2415 | 89 | **8.1** | -6.1 | **2.0** | -10.7 | -1.0 | **0%** | -12% | -3% |
| CZ14 | 2255 | 47 | 2302 | 84 | **113.8** | -14.9 | **98.9** | -28.0 | -1.8 | **4%** | -33% | -6% |
| CZ15 | 5492 | 27 | 5519 | 46 | **78.4** | -10.6 | **67.8** | -19.2 | -1.2 | **1%** | -42% | -2% |
| CZ16 | 751 | 131 | 881 | 166 | **78.3** | -25.5 | **52.9** | -31.9 | -2.6 | **6%** | -19% | -10% |
| Average* | 1600 | 45 | 1645 | 62 | **12.6** | -8.3 | **4.2** | -11.5 | -1.1 | **0%** | -19% | -5% |

Statewide, electricity use is not expected to change significantly due to the introduction of programmable thermostats, while natural gas for heating can be expected to increase.

It is not clear whether the cooling energy savings variation between climate zones is the result of climate driven differences in behavior and energy use or if it is the result of expected statistical variation in the various data samples used. Heating energy, on the other hand, shows a strong trend of increasing with the use of programmable thermostats.

Instead of weighting the results across all climate zones to arrive at a statewide estimate, the climate zone-specific results presented in tables 14 and 15 can be "rolled up" for each investor-owned utility included in the RASS database. Table 16 uses the territory mapping found in appendix C to weight the results by utility territory.

**Table 16. Energy Savings by Utility Territory**

| Climate Zone | Cooling kWh | Heating kWh | Total kWh | Heating therms | Source MBTU |
|---|---|---|---|---|---|
| Single-Family Dwellings | | | | | |
| PG&E | **93.2** | -34.6 | **58.6** | -40.8 | -3.5 |
| SCE | **3.3** | -22.0 | -18.7 | | -0.2 |
| LADWP | -4.0 | -19.4 | -23.4 | | -0.2 |
| SDG&E | -31.2 | -9.5 | -40.8 | -10.7 | -1.5 |
| SCG | | | | -27.5 | -2.8 |
| Multi-Family Dwellings | | | | | |
| PG&E | **46.9** | -11.3 | **35.6** | -14.6 | -1.1 |
| SCE | -0.2 | -6.6 | -6.8 | | -0.1 |
| LADWP | -7.0 | -7.3 | -14.4 | | -0.1 |
| SDG&E | -20.8 | -3.4 | -24.2 | -4.3 | -0.7 |
| SCG | | | | -10.2 | -1.0 |

### *Comparison of Savings Estimates with 2001 DEER Update Savings*

The 2001 DEER Update study provides a savings estimate for a "Programmable Thermostat" EEM. It is important to note that the stated base case for this EEM is "no heating or cooling thermostat setback" (i.e. constant heating and cooling set points) and that the measure implemented an aggressive setback/setup schedule. The measure uses a 5-degree heating setback from 10 p.m. till 6 a.m. every day and from 9 a.m. till 4 p.m. on weekdays and a cooling setup to 85 F. The DEER 2001 savings estimate is, therefore, only applicable to a theoretical case where the occupant changes behavior in this way based on acquisition of a programmable thermostat.

The RASS data analyzed for this project suggest that, on average, occupant behavior with regard to cooling thermostat set points changes very little whether a standard or programmable thermostat is used. For the case of the heating thermostat, the data points to programmable thermostats consistently having a ***higher*** average set point, leading to in increase in energy use.

Table 17 presents the results from the 2001 DEER Update Study for the programmable thermostat EEM. Because of the EEM definition, the savings are always positive and are consistent across most climate zones. Electricity savings (cooling and heating combined) vary from 7% to 34% and gas savings vary from 23% to 68%.

While the 2001 DEER study used forecasting climate zones and this study uses the CEC standard climate zones, there is significant overlap in weather files that were used for both studies. Table 18 maps the standard CEC climate zones into the forecasting climate zones used in table 17 and present the same type of EEM savings estimates. The estimates of average savings for a programmable thermostat vary between 6% to –25% for electricity, and between –7% and –62% for natural gas.

Though the reporting format encourages comparing the data of tables 17 and 18, it is not necessarily a fair and useful comparison to make, as the two tables are intended to answer different questions. The 2001 DEER results present the savings estimate for a specific scenario of before and after behavior associated with installation of a programmable thermostat. No estimate is given for what fraction of the population these answers are applicable to. The results presented from the current analysis, in contrast, are the aggregate of dozens of assumed behaviors; each weighted by data derived from the RASS database, and is intended to represent an average response.

**Table 17. Results from the 2001 DEER Update Study**

| | | Forecasting Climate Zones | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vintage | 1 | 2,6 | 3,7 | 4 | 5 | 8,11 | 9,12,16 | 10 | 13 | 1 (clg) | 15 |
| **Energy Savings per Household** | | | | | | | | | | | | |
| Electricity | Pre-1978 | 98.8 | 313.6 | 382.1 | 351.7 | 179.4 | 326.9 | 422.2 | 350.5 | 384.6 | 266.7 | 439.9 |
| KWh | 1978-1992 | 68.1 | 275.1 | 330.0 | 266.7 | 118.5 | 267.0 | 342.8 | 290.0 | 287.9 | 198.6 | 332.9 |
| | 1992-1998 | 63.2 | 214.1 | 288.0 | 267.5 | 159.2 | 256.2 | 255.8 | 213.3 | 349.2 | 198.4 | 196.9 |
| | Post-1998 | 46.8 | 187.6 | 253.6 | 242.5 | 143.3 | 227.5 | 248.4 | 239.8 | 319.9 | 181.1 | 231.8 |
| Gas | Pre-1978 | 110 | 108 | 87 | 103 | 122 | 97 | 112 | 130 | 97 | 99 | 94 |
| Therms | 1978-1992 | 74 | 67 | 60 | 67 | 76 | 59 | 69 | 66 | 63 | 55 | 43 |
| | 1992-1998 | 45 | 48 | 36 | 44 | 51 | 34 | 33 | 31 | 38 | 34 | 12 |
| | Post-1998 | 42 | 40 | 30 | 38 | 44 | 25 | 25 | 25 | 26 | 30 | 7 |
| **Percent Savings** | | | | | | | | | | | | |
| Electricity | Pre-1978 | 23% | 19% | 12% | 26% | 28% | 27% | 23% | 16% | 32% | 19% | 7% |
| | 1978-1992 | 27% | 19% | 12% | 29% | 33% | 28% | 22% | 17% | 34% | 22% | 7% |
| | 1992-1998 | 29% | 18% | 11% | 27% | 30% | 25% | 19% | 15% | 30% | 19% | 7% |
| | Post-1998 | 29% | 18% | 11% | 25% | 31% | 24% | 18% | 14% | 28% | 19% | 7% |
| Gas | Pre-1978 | 23% | 25% | 25% | 29% | 28% | 34% | 35% | 37% | 42% | 25% | 45% |
| | 1978-1992 | 29% | 29% | 28% | 36% | 36% | 45% | 46% | 47% | 53% | 32% | 60% |
| | 1992-1998 | 30% | 29% | 28% | 39% | 39% | 53% | 55% | 52% | 59% | 32% | 63% |
| | Post-1998 | 30% | 30% | 28% | 40% | 40% | 54% | 57% | 56% | 59% | 33% | 68% |

**Table 18. Results from the RASS Thermostat Study, Equivalent Climate Zones as Table 12.**

| | | CEC Climate Zones | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vintage | CZ01 | CZ12 | | CZ04 | CZ03 | | CZ09 | CZ10 | CZ07 | CZ02 | CZ15 |
| **Energy Savings per Household** | | | | | | | | | | | | |
| Electricity | Pre-1978 | -67.3 | 59.2 | | 172.4 | 63.5 | | -30.5 | -79.2 | -38.6 | 168.0 | 69.8 |
| KWh | 1978-1992 | -38.4 | 54.3 | | 155.8 | 64.0 | | -19.8 | -61.3 | 0.6 | 151.2 | 55.9 |
| | 1992-1998 | -54.2 | 99.2 | | 195.9 | 107.0 | | -35.6 | -71.0 | -47.2 | 185.8 | 65.1 |
| | Post-1998 | -41.6 | 101.2 | | 206.9 | 120.7 | | -29.6 | -65.1 | -47.1 | 198.3 | 62.4 |
| Gas | Pre-1978 | -73 | -51 | | -50 | -52 | | -36 | -38 | -9 | -60 | -51 |
| Therms | 1978-1992 | -38 | -30 | | -22 | -24 | | -19 | -20 | 0 | -26 | -20 |
| | 1992-1998 | -36 | -21 | | -20 | -22 | | -14 | -14 | 1 | -26 | -7 |
| | Post-1998 | -33 | -17 | | -18 | -19 | | -11 | -12 | 2 | -24 | -5 |
| **Percent Savings** | | | | | | | | | | | | |
| Electricity | Pre-1978 | -21% | 2% | | 8% | 6% | | -1% | -2% | -2% | 7% | 1% |
| | 1978-1992 | -22% | 2% | | 9% | 9% | | -1% | -2% | 0% | 8% | 1% |
| | 1992-1998 | -22% | 4% | | 8% | 8% | | -1% | -2% | -3% | 7% | 1% |
| | Post-1998 | -23% | 4% | | 9% | 9% | | -1% | -2% | -3% | 8% | 1% |
| Gas | Pre-1978 | -21% | -12% | | -22% | -22% | | -25% | -23% | -10% | -21% | -52% |
| | 1978-1992 | -21% | -12% | | -24% | -24% | | -30% | -27% | 0% | -22% | -58% |
| | 1992-1998 | -21% | -12% | | -24% | -24% | | -34% | -30% | 5% | -22% | -58% |
| | Post-1998 | -22% | -12% | | -25% | -25% | | -37% | -33% | 8% | -23% | -60% |

## Conclusions and Recommendations

- Energy savings associated with programmable thermostats is highly dependent on user behavior. This study shows that cooling energy use associated with the introduction of a programmable thermostat can just as easily increase as decrease based on how occupants used the manual thermostat and how they utilize the programmable thermostat.
- The use of programmable thermostats appears to lead to greater heating energy use than standard thermostats in all climate zones. Still, heating energy use associated with the introduction of a programmable thermostat is highly variable and behavior driven.
- This study compares “Standard” thermostats with “Programmable” thermostats, as described in the RASS data survey. Standard in this case translates to a manual thermostat, not a Title-24 compliant thermostat. The results of this study, therefore, are not directly applicable to programs that promote more sophisticated programmable thermostats over Title-24 compliant programmable thermostats. With supporting data that is not yet available, a similar approach as reported here could be used to assess potential savings due to differing levels of programmable thermostats.
- No distinction has been made between weekday and weekend thermostat schedules, since the RASS data does not provide such a data. If data regarding weekday/weekend thermostat usage become available in the future, the approach presented here for dealing with differences in thermostat usage behavior could be expanded to deal with the greater level of detail.
- The approach developed in this analysis utilizes detailed thermostat schedules to capture the reported behavior of RASS respondents. These detailed schedules lead to the requirement of running 59 simulations to capture the effect of thermostat variation for any specific building model. While the total required simulations was not prohibitive for this analysis (approximately 300,000 building simulations), using 59 thermostat schedules to assess typical behavior would be prohibitively time consuming for a general EEM analysis.

  Future work will assess the impact of simplifying the structure of the thermostat tables, and thus the number of required simulations, on energy use predictions. If a dozen or so simulations can adequately capture much of the thermostat behavior variations observed here, their use as a tool to account for user behavior in simulation models may become practical.

## Appendix A – Analysis of the Aggregation of Climate Zones to Regions.

### INTRODUCTION

This appendix examines a necessary methodological decision made by the study authors – to use RASS 2003 data on temperature settings aggregated to the Regional level (North Coast, South Coast, Southern Inland, Central Valley, and Desert) rather than aggregated to the more detailed (and sometimes sparsely sampled) Title 24 Climate Zones. We find that the gain in robustness from this approach was at very little cost in terms of "lost information" about geographical determinants of thermostat behavior, because models using the more detailed geography (16 zones versus 5) account for very little more variation in this behavior.

### BACKGROUND

This study relies upon 2003 California RASS data (KEMA, 2003) as an adjunct to detailed energy simulation using DOE2.2. Quite briefly, taking cooling control as an example that generalizes easily to heating control:

1. For RASS sample residences with full year occupancy, central air-conditioning and reported thermostat setpoints, weighted tabulations were created, by California Title 24 climate zone (CZT24) and programmable vs. standard thermostat, on unique combinations of morning, daytime, evening, and nighttime settings observed in the RASS data. The population weights were those supplied by KEMA with RASS, and each case's population weight is essentially the inverse of the effective sampling fraction for the study population stratum from which it is drawn. From these somewhat voluminous tabulations, frequency distributions were created for each of the four periods of day, and for each climate zone and thermostat type (programmable or standard), that indicate the approximate temperature setting transition into that time of day – for example: Off to Very Low, Medium to High, etc. The programmable thermostat (PROG) vs. standard thermostat (STD) difference in distributions was fundamental to estimating the effect of "moving" from a standard thermostat (and the average behavioral patterns of its users) to a programmable thermostat (and the average behavioral patterns of its users). The assumption made here is that RASS sample households with programmable thermostats provide reasonable proxies for the setpoint behavior of households that acquire programmable thermostats through point of sale programs.

2. For RASS sample residences with full year occupancy, central air-conditioning, programmable or standard thermostats, and single detached dwellings, the distribution over CZT24s was derived. Also, an estimate of the percentage distribution of building vintages within each CZT24 was created. The latter was important in weighting region-specific DOE2 models to represent vintage characteristics, while the former was quite simply necessary in aggregating final estimates up to statewide and utility-specific geographies.

3. DOE2 models were run for a variety of dwelling configurations and vintages within each CZT24 (01 through 16). RASS-based vintage distributions were used to weight results to represent the age of dwellings in the CZT24.

4. Results of DOE-2 runs provided estimates, per CZT24 and vintage, of estimated annualized cooling consumption in each cooling period (morning, day, evening, night). Within each cooling period, vintage, and CZT24, the estimates were *disaggregated according to thermostat setting schedule transition. Estimates of the impact of programmable thermostat versus standard thermostat derive from the differences in the distribution of morning, day, evening, and nighttime "transitions" between RASS respondents with programmable thermostats and RASS respondents with standard thermostats (RASS items C4 and C5).*

5. The estimate of the programmable/standard "delta" entailed developing weighted averages, over CZT24s, of consumption, applying "behavioral" distributions on 84 temperature setting transitions (21 unique transition possibilities x four periods of the day). The PROG distribution yields one weighted average, the STD distribution another, and the difference between the two results is the estimated impact of PROG vs. STD for the climate zone. *An issue relating to the source of the two behavioral distributions surfaced: at what level of geographical aggregation is it appropriate to estimate the separate PROG and STD behavioral or T-Stat distributions?*

## REGIONS VS. CZT24s AS THE SOURCE FOR PROG/STD T-STAT DISTRIBUTIONS FROM RASS 2003

As the study was structured, in order to reliably estimate *differences* in distributions between PROG and STD over 84 setting transitions, it is plainly desirable to have T-STAT data from several times as many households as there are distinct transitions within periods. For this reason, after careful consideration, the decision was made to estimate distinct PROG/STD distributions on cooling thermostat setting transitions at the Regional level, rather than at the level of constituent CZT24s. Table A-1, adapted from the main report text, indicates the mapping of CZT24s to the Regional scheme which was used in data collection supporting the 2001 DEER update study. It also indicates the paucity of reporting households, particularly those with central A/C and PROG or STD thermostats, in certain CZT24s. The RASS survey, with an achieved sample of more than 22,000 households statewide, provides reliable estimates of the fraction of households in a particular CZT24 with central A/C, but where that well-estimated fraction is low, as in coastal and/or northern CZT24s, the base of available (rare) households for estimating a schedule distribution is quite small – see, with respect to cooling, CZT24s 01, 02, 03, 04, 05, 16, 07, 14, and 15.

The Regional solution adopted reasonably solves the "low n" problem faced with respect to cooling and a few marginal heating subsamples. Effectively, the authors opted, in estimating CZT24-specific impacts, to use PROG and STD schedule distributions taken from RASS responses for the entire Region in which a given CZT24 belongs, and apply them to the specific CZT24 DOE-2 results. Although other aggregation solutions could have been entertained, this one was sensible in light of its continuity with previous work on DEER and the aggregation level used in characterizing dwelling by prototypical type in the current study. It also offered advantages in maintaining geographical contiguity, and assembling reasonably homogeneous groupings with respect to climate.

Given the necessity of a solution of the type adopted, the next and final section provides empirical evidence on its reasonableness with respect to variations in temperature setting schedules among California households.

**Table A-1. CDD/HDD Summary and RASS T-TSTAT Respondents per Region and CZT24**

| | | | | | Un-Weighted Count (Respondents) | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Cooling T-Stat type | | Heating T-Stat type | |
| City | T24-CZ | Region | CDD70 | HDD65 | Prog | Std | Prog | Std |
| Arcata | CZ01 | North Coast | 0 | 4085 | 1 | 2 | 46 | 80 |
| Santa Rosa | CZ02 | North Coast | 179 | 2890 | 151 | 56 | 320 | 343 |
| Oakland | CZ03 | North Coast | 4 | 2541 | 113 | 40 | 836 | 1464 |
| Sunnyvale | CZ04 | North Coast | 35 | 2414 | 322 | 85 | 567 | 534 |
| Santa Maria | CZ05 | North Coast | 5 | 2277 | 15 | 5 | 121 | 180 |
| Mount Shasta | CZ16 | North Coast | 36 | 5529 | 81 | 64 | 152 | 196 |
| | | *REGION SUM* | | | *683* | *252* | *2042* | *2797* |
| Los Angeles | CZ06 | South Coast | 63 | 1475 | 235 | 184 | 560 | 1090 |
| San Diego | CZ07 | South Coast | 117 | 1344 | 191 | 138 | 453 | 793 |
| El Toro | CZ08 | South Coast | 357 | 1316 | 388 | 385 | 484 | 1060 |
| | | *REGION SUM* | | | *814* | *707* | *1497* | *2943* |
| Pasadena | CZ09 | South Inland | 534 | 1260 | 601 | 620 | 710 | 1330 |
| Riverside | CZ10 | South Inland | 716 | 1636 | 664 | 573 | 753 | 945 |
| | | *REGION SUM* | | | *1265* | *1193* | *1463* | *2275* |
| Red Bluff | CZ11 | Central Valley | 741 | 2656 | 255 | 162 | 330 | 318 |
| Sacramento | CZ12 | Central Valley | 453 | 2648 | 859 | 381 | 1045 | 728 |
| Fresno | CZ13 | Central Valley | 1233 | 2228 | 426 | 304 | 468 | 519 |
| | | *REGION SUM* | | | *1540* | *847* | *1843* | *1565* |
| China Lake | CZ14 | Desert | 965 | 3113 | 175 | 142 | 207 | 274 |
| El Centro | CZ15 | Desert | 2817 | 845 | 81 | 80 | 88 | 85 |
| | | *REGION SUM* | | | *256* | *222* | *295* | *359* |

## STATISTICAL EVIDENCE ON THE REASONABLENESS OF A REGIONAL GROUPING FOR TEMPERATURE SETTING DISTRIBUTIONS

In this section, we examine whether individual differences in temperature setting behavior are substantially better "explained" or accounted for by identifying a household's CZT24, rather than its more aggregate Region. To the extent that the difference in explained variation is minimal, the loss of information due to aggregation of settings distributions is also minimal, and the *necessary* aggregation decision becomes even more sensible and justifiable.

The approach is quite simple. For cooling, we return to RASS 2003, selecting the same set of residential respondent households used to estimate distributions on 84 thermostat transitions (21 per cooling day). Similarly, we select from RASS the households used in the heating distribution estimation.

We are going to examine the explanatory advantage of CZT24 versus the simpler Regional scheme in accounting for settings reported by respondents in each period of a cooling day, and take a similar approach for heating reports.

### A MULTINOMIAL LOGIT APPROACH

We structure the data in order to be able to perform a maximum likelihood multinomial logit model. The model considers each respondent/day setting as a response with several alternatives (OFF, Very Low, etc.). The model accounts for the logged odds of a respondent reporting that her household uses a particular setting - odds of setting X vs. arbitrarily adopted reference setting "OFF," during a particular period of the cooling day. [The choice of the reference category is immaterial for current purposes.] We are less interested in individual coefficients predicting these settings, than in summary measures of the explanatory power of the complex and simplified geographies.

The variability of the "null model" in accounting for the settings "responses" is indicated by a chi-square statistic calculated over all response categories r:

$$LRXX = -2 * f_r \Sigma \log(F_r/f_r) ,$$

where $f_r$ is an observed frequency, and $F_r$ an "expected frequency" – in this case an expectation that the frequency will equal the geometric average of the frequencies observed over all categories. The LRXX values (referred to a the "Likelihood Ratio Chi Square" or "-2 x the likelihood ratio") for the model improve (become smaller) as information is added to the model which better accounts for cell frequencies over all categories by improving the "expected frequencies" that are produced by the model. We may consider LRXX a rough indicator of "residual variation" unaccounted for by a particular model. We use LRXX values from models, including null models, CZT24 models, and Region models, to assess how much more information is really added by knowledge of a respondent's CZT24 as opposed to simply knowing Region.

Consider cooling. Table A-2 provides the summary statistics from

> (a) a null model describing the variability in cooling settings over respondents and periods,
> (b) a model which accounts for temperature settings using Region, period, and terms allowing for period of the day to have different effects within different regions (region * period)
> (c) a "highly saturated" model which accounts for settings using CZT24 in place of Region, both "additively" and in interaction with period.

As compared to the overall variability in response settings among customers, region/period/region*period (model a) accounts for about 11.4 percent of variability. Adding a great deal more information about geography and its interaction with period of the day (moving from 80 to 256 model parameters), increases the explained variation to 12.6 percent: **a trivial**

**improvement of 1.2 percent in our ability to account for settings behavior**. Two things should be taken from this summary: (1) a great deal of household settings behavior is not related to geography and/or period of the day, and (2) very little information about settings behavior is "at risk" in using the more parsimonious Regional scheme, which allows for the creation of more reliable estimates of PROG and STD settings distributions in the population.

**Table A-2: Multinomial Logit Model Results (CATMOD): Cooling Settings**

| MODEL DESCRIPTION | Model DF | LRXX (model "residual") | Propn. of null model residual explained |
|---|---|---|---|
| (a) Null model | 1 | 45357148 | 0 |
| (b) Region, period, region*period | 80 | 40188129 | 0.113962611 |
| (c) CZT24, period, CZT24*period | 256 | 39616423 | 0.126567151 |
| Rsquare analog -- proportional improvement (c) vs. (b) | | | 0.01260454 |

Turning to heating, Table A-3 indicates that the sixteen zone system does very little better, with an "Rsquare" change of about .01 (or a 1 percent increase in variability accounted for). Note that while we see evidence that geography accounts for heating settings more than it does cooling settings, there is again no basis in the findings for questioning the use of a Regional rather than CZT24 aggregation for heating settings.

**Table A-3: Multinomial Logit Model Results (CATMOD): Heating Settings**

| MODEL DESCRIPTION | Model DF | LRXX (model "residual") | Propn. of null model residual explained |
|---|---|---|---|
| (a) Null model | 1 | 109526130 | 0 |
| (b) Region, period, region*period | 100 | 91561961 | 0.164017198 |
| (c) CZT24, period, CZT24*period | 320 | 90477678 | 0.173916964 |
| Rsquare analog -- proportional improvement (c) vs. (b) | | | 0.009899765 |

## LINEAR (ORDINARY LEAST SQUARES) REGRESSION RESULTS

For those more comfortable with a regression approach, we also offer some findings on a simpler approach. Here, we simply score the respondent's period-specific response using a midpoint scoring procedure, and then entertain a simple Regional model versus a CZT24 model in attempting to account for variation in the scores. The approach is open to criticism with respect to our imputing a particular temperature to "off" in this exercise (53 deg. F for heating, and 83 deg. F for cooling). However, it provides rough confirmation of the more methodologically appropriate multinomial logit results. Table A-4 indicates that, for cooling settings, there is a less than one half percent improvement in variance explained by the more complicated geographical scheme and its interaction with periods of the day.

**Table A-4: General Linear Model Results: Cooling Settings**

| MODEL DESCRIPTION | Model DF | Model Rsquare |
|---|---|---|
| (b) Region, period, region*period | 19 | 0.044546 |
| (c) CZT24, period, CZT24*period | 63 | 0.049831 |
| Explained variance improvement: (c)-(a) | | 0.005285 |

Similarly, with respect to heating, Table A-5 indicates that greater geographical detail increases explanatory power by a very trivial amount – again the decision to use a more robust, climatically and geographically consistent approach like the Regional scheme.

**Table A-5: General Linear Model Results: Heating Settings**

| MODEL DESCRIPTION | Model DF | Model Rsquare |
|---|---|---|
| (b) Region, period, region*period | 19 | 0.092315 |
| (c) CZT24, period, CZT24*period | 63 | 0.095964 |
| Explained variance improvement: (c)-(a) | | 0.003649 |

## Appendix B – RASS-data Thermostat Tables

All of the thermostat tables derived from the RASS data are presented here.

**North Coast**
**Manual Cooling Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 49.2% | 28.1% | 13.2% | 56.3% |
| Off -> Vlo | 5.2% | 11.2% | 12.3% | 0.6% |
| Remain Vlo | 16.6% | 20.4% | 28.3% | 19.8% |
| Low -> Vlo | 0.0% | 0.0% | 1.2% | 0.2% |
| Med -> Vlo | 0.3% | 0.2% | 0.0% | 0.0% |
| High -> Vlo | 0.0% | 0.0% | 0.1% | 0.0% |
| Off -> Low | 6.0% | 9.0% | 2.0% | 0.3% |
| Vlo -> Low | 0.2% | 0.5% | 0.7% | 0.6% |
| Remain Low | 3.9% | 9.9% | 17.2% | 4.0% |
| Med -> Low | 0.3% | 0.5% | 1.0% | 0.0% |
| High -> Low | 0.2% | 0.0% | 0.2% | 0.0% |
| Off -> Med | 0.2% | 1.8% | 4.0% | 0.0% |
| Vlo -> Med | 0.3% | 0.0% | 0.0% | 0.0% |
| Low -> Med | 0.2% | 0.2% | 1.0% | 0.8% |
| Remain Med | 15.4% | 16.0% | 16.7% | 15.4% |
| High-> Med | 0.6% | 0.2% | 0.8% | 0.4% |
| Off -> High | 0.0% | 0.6% | 0.4% | 0.0% |
| Vlo -> High | 0.1% | 0.0% | 0.0% | 0.0% |
| Low -> High | 0.0% | 0.2% | 0.0% | 0.2% |
| Med -> High | 0.6% | 0.0% | 0.4% | 0.8% |
| Remain High | 0.7% | 1.3% | 0.8% | 0.6% |

**South Coast**
**Manual Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 63.4% | 43.5% | 42.0% | 65.4% |
| Off -> Vlo | 6.2% | 12.1% | 9.4% | 0.8% |
| Remain Vl( | 12.4% | 16.7% | 19.3% | 15.0% |
| Low -> Vlo | 0.5% | 1.2% | 2.0% | 0.5% |
| Med -> Vlo | 0.0% | 0.1% | 0.2% | 0.7% |
| High -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 2.6% | 7.3% | 4.0% | 0.2% |
| Vlo -> Low | 0.3% | 0.8% | 0.6% | 0.7% |
| Remain Lo | 5.6% | 7.2% | 9.1% | 7.0% |
| Med -> Lov | 1.4% | 1.4% | 1.9% | 0.2% |
| High -> Lov | 0.1% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 0.6% | 2.1% | 1.9% | 1.1% |
| Vlo -> Med | 0.0% | 0.2% | 0.7% | 0.2% |
| Low -> Me( | 0.4% | 1.4% | 2.3% | 1.6% |
| Remain Me | 4.7% | 4.1% | 4.8% | 5.0% |
| High-> Me( | 0.1% | 0.3% | 0.1% | 0.0% |
| Off -> High | 0.0% | 0.3% | 0.3% | 0.0% |
| Vlo -> High | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Hig | 0.0% | 0.1% | 0.0% | 0.1% |
| Med -> Hig | 0.1% | 0.1% | 0.1% | 0.3% |
| Remain Hi( | 1.5% | 1.3% | 1.4% | 1.4% |

**North Coast**
**Programmable Cooling Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 47.3% | 31.5% | 19.8% | 54.2% |
| Off -> Vlo | 6.1% | 4.6% | 6.5% | 0.1% |
| Remain Vlo | 13.9% | 17.0% | 21.5% | 16.4% |
| Low -> Vlo | 0.6% | 2.6% | 2.8% | 0.8% |
| Med -> Vlo | 0.1% | 0.1% | 0.5% | 0.2% |
| High -> Vlo | 0.1% | 0.1% | 0.1% | 0.0% |
| Off -> Low | 4.5% | 9.8% | 6.1% | 0.0% |
| Vlo -> Low | 2.7% | 0.8% | 0.5% | 1.1% |
| Remain Low | 7.6% | 12.0% | 17.6% | 8.7% |
| Med -> Low | 0.7% | 0.6% | 2.7% | 1.3% |
| High -> Low | 1.2% | 1.1% | 0.1% | 0.1% |
| Off -> Med | 0.6% | 4.8% | 3.7% | 0.0% |
| Vlo -> Med | 0.1% | 0.4% | 0.1% | 0.3% |
| Low -> Med | 0.2% | 0.7% | 2.4% | 2.4% |
| Remain Med | 8.4% | 7.7% | 10.4% | 7.9% |
| High-> Med | 1.4% | 0.6% | 0.7% | 0.0% |
| Off -> High | 0.3% | 0.4% | 0.1% | 0.0% |
| Vlo -> High | 0.0% | 0.1% | 0.0% | 0.3% |
| Low -> High | 0.0% | 1.2% | 0.0% | 1.3% |
| Med -> High | 0.1% | 1.4% | 0.1% | 0.7% |
| Remain High | 3.9% | 2.6% | 4.4% | 4.3% |

**South Coast**
**Programmable Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 50.0% | 37.3% | 26.4% | 48.5% |
| Off -> Vlo | 3.9% | 6.3% | 10.9% | 1.4% |
| Remain Vl( | 15.6% | 13.1% | 16.9% | 18.7% |
| Low -> Vlo | 0.8% | 1.6% | 2.8% | 2.0% |
| Med -> Vlo | 0.1% | 0.1% | 0.8% | 0.1% |
| High -> Vlo | 0.0% | 0.0% | 0.1% | 0.0% |
| Off -> Low | 1.8% | 5.6% | 4.2% | 1.3% |
| Vlo -> Low | 2.1% | 4.2% | 0.5% | 1.2% |
| Remain Lo | 9.6% | 10.2% | 16.1% | 12.7% |
| Med -> Lov | 0.8% | 0.5% | 7.3% | 0.4% |
| High -> Lov | 0.1% | 0.0% | 0.3% | 0.0% |
| Off -> Med | 0.5% | 3.3% | 2.2% | 0.1% |
| Vlo -> Med | 0.1% | 0.7% | 0.1% | 0.3% |
| Low -> Me( | 2.3% | 2.2% | 0.5% | 3.8% |
| Remain Me | 8.8% | 11.1% | 7.7% | 5.8% |
| High-> Me( | 1.6% | 0.3% | 1.6% | 0.0% |
| Off -> High | 0.0% | 0.1% | 0.2% | 0.0% |
| Vlo -> High | 0.0% | 0.1% | 0.0% | 0.0% |
| Low -> Hig | 0.1% | 0.1% | 0.0% | 0.2% |
| Med -> Hig | 0.0% | 1.5% | 0.1% | 2.0% |
| Remain Hi( | 1.8% | 1.5% | 1.4% | 1.5% |

**South Inland**
**Manual Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 48.0% | 24.7% | 23.2% | 46.9% |
| Off -> Vlo | 5.4% | 10.7% | 6.1% | 2.4% |
| Remain Vl( | 20.5% | 22.5% | 28.3% | 22.1% |
| Low -> Vlo | 0.8% | 1.4% | 2.9% | 0.2% |
| Med -> Vlo | 0.1% | 0.1% | 0.3% | 0.1% |
| High -> Vlc | 0.0% | 0.0% | 0.1% | 0.0% |
| Off -> Low | 1.4% | 8.3% | 3.9% | 0.5% |
| Vlo -> Low | 0.3% | 2.7% | 1.4% | 1.9% |
| Remain Lo | 11.0% | 11.5% | 16.0% | 12.3% |
| Med -> Lov | 0.8% | 1.0% | 1.1% | 0.1% |
| High -> Lo\ | 0.1% | 0.1% | 0.7% | 0.0% |
| Off -> Med | 0.6% | 4.3% | 2.1% | 0.9% |
| Vlo -> Med | 0.1% | 0.2% | 0.0% | 0.1% |
| Low -> Me( | 0.8% | 0.2% | 1.0% | 0.8% |
| Remain Me | 5.9% | 6.2% | 9.3% | 7.7% |
| High-> Me( | 0.2% | 2.5% | 0.3% | 0.1% |
| Off -> High | 0.1% | 2.0% | 0.1% | 0.6% |
| Vlo -> High | 0.0% | 0.0% | 0.0% | 0.1% |
| Low -> Hig | 0.6% | 0.1% | 0.1% | 0.6% |
| Med -> Hig | 0.9% | 0.2% | 0.8% | 0.9% |
| Remain Hi( | 2.5% | 1.3% | 2.3% | 1.8% |

**Central Valley**
**Manual Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 42.5% | 23.7% | 11.3% | 40.0% |
| Off -> Vlo | 5.1% | 8.0% | 4.5% | 1.2% |
| Remain Vl( | 10.2% | 14.1% | 19.4% | 12.0% |
| Low -> Vlo | 0.7% | 0.4% | 1.8% | 1.2% |
| Med -> Vlo | 1.7% | 1.1% | 0.2% | 0.6% |
| High -> Vlo | 0.0% | 0.1% | 0.1% | 0.0% |
| Off -> Low | 1.4% | 10.0% | 5.4% | 0.6% |
| Vlo -> Low | 0.7% | 0.7% | 0.6% | 1.6% |
| Remain Lo | 8.4% | 9.9% | 19.5% | 13.5% |
| Med -> Lov | 1.3% | 3.4% | 1.5% | 0.2% |
| High -> Lo\ | 0.0% | 0.1% | 1.2% | 0.0% |
| Off -> Med | 3.0% | 4.4% | 6.6% | 0.1% |
| Vlo -> Med | 0.1% | 0.3% | 0.2% | 1.0% |
| Low -> Me( | 2.2% | 1.0% | 1.5% | 3.2% |
| Remain Me | 16.4% | 16.2% | 21.4% | 19.2% |
| High-> Me( | 0.5% | 1.7% | 0.7% | 0.1% |
| Off -> High | 0.2% | 1.6% | 1.2% | 0.0% |
| Vlo -> High | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Hig | 0.0% | 0.1% | 0.0% | 0.2% |
| Med -> Hig | 0.6% | 0.3% | 0.2% | 1.7% |
| Remain Hi( | 4.8% | 3.0% | 3.0% | 3.7% |

**South Inland**
**Programmable Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 35.3% | 19.7% | 13.8% | 36.6% |
| Off -> Vlo | 4.2% | 8.6% | 5.3% | 0.5% |
| Remain Vl( | 18.4% | 21.2% | 27.4% | 20.4% |
| Low -> Vlo | 1.0% | 1.5% | 0.8% | 0.8% |
| Med -> Vlo | 0.2% | 0.1% | 0.6% | 0.6% |
| High -> Vlc | 0.0% | 0.0% | 0.1% | 0.0% |
| Off -> Low | 1.5% | 4.2% | 2.6% | 0.1% |
| Vlo -> Low | 0.5% | 1.3% | 0.7% | 3.5% |
| Remain Lo | 13.2% | 10.6% | 15.4% | 12.3% |
| Med -> Lov | 0.5% | 0.9% | 3.5% | 2.8% |
| High -> Lo\ | 0.1% | 0.1% | 0.1% | 0.0% |
| Off -> Med | 2.1% | 4.6% | 3.4% | 0.1% |
| Vlo -> Med | 0.1% | 0.4% | 0.0% | 0.2% |
| Low -> Me( | 2.2% | 3.0% | 0.3% | 2.1% |
| Remain Me | 13.7% | 18.1% | 20.7% | 13.1% |
| High-> Me( | 2.9% | 2.2% | 1.0% | 0.3% |
| Off -> High | 0.1% | 0.3% | 0.1% | 0.0% |
| Vlo -> High | 0.0% | 0.1% | 0.0% | 0.1% |
| Low -> Hig | 0.1% | 0.1% | 0.1% | 0.1% |
| Med -> Hig | 0.5% | 1.2% | 1.9% | 2.8% |
| Remain Hi( | 3.4% | 1.7% | 2.0% | 3.6% |

**Central Valley**
**Programmable Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 32.3% | 14.5% | 8.7% | 36.7% |
| Off -> Vlo | 2.2% | 5.8% | 3.8% | 0.2% |
| Remain Vl( | 9.9% | 10.3% | 14.2% | 11.1% |
| Low -> Vlo | 0.5% | 0.6% | 0.9% | 0.7% |
| Med -> Vlo | 0.2% | 0.1% | 1.1% | 0.4% |
| High -> Vlo | 0.1% | 0.0% | 0.1% | 0.0% |
| Off -> Low | 1.7% | 5.0% | 1.3% | 0.1% |
| Vlo -> Low | 0.6% | 0.6% | 0.6% | 0.8% |
| Remain Lo | 11.5% | 13.8% | 17.7% | 12.5% |
| Med -> Lov | 3.3% | 1.9% | 3.3% | 0.4% |
| High -> Lo\ | 0.2% | 0.3% | 1.4% | 0.0% |
| Off -> Med | 3.7% | 7.8% | 4.3% | 0.0% |
| Vlo -> Med | 0.1% | 1.5% | 0.4% | 0.4% |
| Low -> Me( | 0.9% | 2.1% | 2.1% | 3.9% |
| Remain Me | 18.9% | 20.2% | 29.0% | 20.7% |
| High-> Me( | 2.6% | 3.9% | 2.7% | 0.2% |
| Off -> High | 1.9% | 1.3% | 0.3% | 0.1% |
| Vlo -> High | 0.1% | 0.0% | 0.0% | 0.0% |
| Low -> Hig | 0.0% | 0.3% | 0.0% | 0.6% |
| Med -> Hig | 0.7% | 3.0% | 0.6% | 5.9% |
| Remain Hi( | 8.8% | 7.1% | 7.5% | 5.3% |

**Desert**
**Manual Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 37.0% | 13.8% | 9.5% | 34.9% |
| Off -> Vlo | 4.2% | 10.7% | 1.9% | 0.3% |
| Remain Vlo | 8.6% | 8.8% | 13.2% | 6.0% |
| Low -> Vlo | 0.4% | 0.0% | 0.4% | 3.7% |
| Med -> Vlo | 0.7% | 0.2% | 0.3% | 0.4% |
| High -> Vlo | 0.0% | 0.0% | 3.0% | 0.0% |
| Off -> Low | 0.6% | 4.7% | 6.6% | 0.0% |
| Vlo -> Low | 0.2% | 3.4% | 0.7% | 4.0% |
| Remain Lo | 10.0% | 8.0% | 20.9% | 7.7% |
| Med -> Lov | 6.7% | 2.8% | 3.8% | 0.4% |
| High -> Lov | 0.0% | 3.0% | 3.1% | 2.6% |
| Off -> Med | 1.3% | 2.6% | 2.9% | 0.0% |
| Vlo -> Med | 0.2% | 1.2% | 0.0% | 0.2% |
| Low -> Mec | 0.7% | 6.1% | 0.3% | 9.4% |
| Remain Me | 20.2% | 19.3% | 27.0% | 23.8% |
| High-> Mec | 0.4% | 2.7% | 0.5% | 0.0% |
| Off -> High | 0.2% | 6.2% | 0.1% | 0.2% |
| Vlo -> High | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Hig | 2.6% | 3.0% | 0.0% | 2.9% |
| Med -> Hig | 0.0% | 0.2% | 0.2% | 2.9% |
| Remain Hig | 6.1% | 3.1% | 5.8% | 0.7% |

**Desert**
**Programmable Cooling Thermostat**

| T-stat Setti | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 29.0% | 13.6% | 5.4% | 25.0% |
| Off -> Vlo | 0.8% | 4.9% | 1.0% | 0.2% |
| Remain Vlo | 4.5% | 6.2% | 10.1% | 4.9% |
| Low -> Vlo | 2.0% | 0.5% | 0.5% | 0.4% |
| Med -> Vlo | 0.0% | 0.0% | 0.0% | 2.7% |
| High -> Vlo | 0.0% | 0.0% | 0.1% | 0.1% |
| Off -> Low | 0.5% | 1.3% | 2.7% | 0.0% |
| Vlo -> Low | 0.8% | 0.1% | 0.2% | 2.5% |
| Remain Lo | 17.5% | 15.1% | 16.2% | 16.8% |
| Med -> Lov | 0.1% | 0.3% | 0.6% | 3.9% |
| High -> Lov | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 2.0% | 11.4% | 6.5% | 0.0% |
| Vlo -> Med | 0.1% | 0.7% | 0.2% | 0.0% |
| Low -> Mec | 0.8% | 0.8% | 0.0% | 0.6% |
| Remain Me | 33.4% | 29.1% | 40.9% | 36.7% |
| High-> Mec | 4.4% | 0.1% | 11.8% | 0.0% |
| Off -> High | 2.4% | 0.8% | 0.0% | 0.1% |
| Vlo -> High | 0.0% | 0.0% | 0.0% | 0.1% |
| Low -> Hig | 0.0% | 0.1% | 0.0% | 0.0% |
| Med -> Hig | 0.1% | 11.0% | 0.1% | 2.7% |
| Remain Hig | 1.6% | 3.9% | 3.7% | 3.4% |

**North Coast**
**Manual Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 29.0% | 45.1% | 18.6% | 53.3% |
| Off -> Vlo | 3.9% | 1.0% | 1.8% | 0.8% |
| Remain Vlo | 3.7% | 4.5% | 3.7% | 2.8% |
| Low -> Vlo | 0.3% | 1.7% | 0.2% | 2.6% |
| Med -> Vlo | 0.4% | 1.3% | 0.0% | 4.6% |
| High -> Vlo | 0.0% | 0.1% | 0.0% | 0.6% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 10.1% | 1.2% | 7.6% | 1.2% |
| Vlow -> Low | 2.9% | 0.4% | 1.8% | 0.2% |
| Remain Low | 8.4% | 12.8% | 13.3% | 8.6% |
| Med -> Low | 1.1% | 3.8% | 1.1% | 5.6% |
| High -> Low | 0.2% | 0.6% | 0.0% | 0.5% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 13.1% | 1.4% | 14.9% | 1.5% |
| Vlow -> Med | 2.8% | 0.6% | 2.2% | 0.1% |
| Low -> Med | 4.8% | 2.1% | 4.8% | 1.4% |
| Remain Med | 10.8% | 17.6% | 20.0% | 11.5% |
| High-> Med | 0.1% | 0.4% | 0.3% | 1.1% |
| Vhi-> Med | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> High | 2.9% | 0.1% | 3.4% | 0.2% |
| Vlow -> High | 0.4% | 0.1% | 0.1% | 0.0% |
| Low -> High | 0.6% | 0.3% | 0.3% | 0.0% |
| Med -> High | 0.9% | 0.3% | 0.7% | 0.1% |
| Remain High | 2.0% | 3.2% | 3.8% | 2.6% |
| Vhi -> High | 0.0% | 0.6% | 0.0% | 0.1% |
| Off -> Vhi | 0.8% | 0.2% | 0.4% | 0.0% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.1% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| High -> Vhi | 0.0% | 0.0% | 0.4% | 0.3% |
| Remain Vhi | 0.6% | 0.4% | 0.6% | 0.4% |

**South Coast**
**Manual Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 40.3% | 56.7% | 34.9% | 54.2% |
| Off -> Vlo | 1.2% | 0.4% | 1.8% | 0.9% |
| Remain Vlo | 3.2% | 2.3% | 1.7% | 1.8% |
| Low -> Vlo | 0.2% | 1.2% | 0.1% | 2.9% |
| Med -> Vlo | 0.1% | 2.1% | 0.0% | 2.6% |
| High -> Vlo | 0.0% | 0.1% | 0.3% | 0.3% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.2% |
| Off -> Low | 2.4% | 0.5% | 4.0% | 1.3% |
| Vlow -> Low | 1.7% | 0.4% | 1.6% | 0.3% |
| Remain Low | 5.4% | 4.8% | 5.6% | 4.9% |
| Med -> Low | 0.7% | 3.3% | 0.2% | 4.5% |
| High -> Low | 0.1% | 0.5% | 0.0% | 0.5% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 9.7% | 0.6% | 10.3% | 2.3% |
| Vlow -> Med | 2.4% | 0.4% | 2.6% | 0.1% |
| Low -> Med | 3.9% | 0.5% | 3.2% | 0.7% |
| Remain Med | 12.0% | 14.7% | 15.3% | 12.7% |
| High-> Med | 0.7% | 2.2% | 0.7% | 1.2% |
| Vhi-> Med | 0.0% | 0.2% | 0.0% | 0.0% |
| Off -> High | 6.6% | 1.8% | 5.8% | 2.4% |
| Vlow -> High | 0.3% | 0.2% | 0.1% | 0.0% |
| Low -> High | 0.4% | 0.2% | 0.5% | 0.1% |
| Med -> High | 1.1% | 0.4% | 2.3% | 0.8% |
| Remain High | 3.8% | 4.4% | 5.6% | 4.5% |
| Vhi -> High | 0.0% | 1.3% | 0.0% | 0.3% |
| Off -> Vhi | 2.6% | 0.0% | 1.8% | 0.3% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| High -> Vhi | 0.6% | 0.1% | 1.2% | 0.0% |
| Remain Vhi | 0.5% | 0.6% | 0.4% | 0.3% |

**North Coast**
**Programmable Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 17.2% | 27.9% | 8.1% | 39.9% |
| Off -> Vlo | 2.5% | 0.9% | 0.8% | 0.2% |
| Remain Vlo | 4.3% | 3.6% | 2.8% | 2.5% |
| Low -> Vlo | 0.4% | 5.2% | 0.6% | 4.5% |
| Med -> Vlo | 0.1% | 5.4% | 0.1% | 10.9% |
| High -> Vlo | 0.0% | 0.7% | 0.0% | 0.9% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.1% |
| Off -> Low | 7.7% | 0.7% | 5.2% | 0.7% |
| Vlow -> Low | 5.6% | 1.3% | 4.7% | 0.6% |
| Remain Low | 7.2% | 10.5% | 9.8% | 5.0% |
| Med -> Low | 1.6% | 9.5% | 1.2% | 12.8% |
| High -> Low | 0.4% | 0.3% | 0.0% | 1.3% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 12.9% | 1.7% | 10.7% | 0.7% |
| Vlow -> Med | 7.8% | 0.7% | 7.6% | 0.0% |
| Low -> Med | 10.4% | 2.8% | 11.3% | 2.1% |
| Remain Med | 9.7% | 18.0% | 20.9% | 9.5% |
| High-> Med | 0.4% | 1.2% | 0.6% | 1.8% |
| Vhi-> Med | 0.4% | 0.0% | 0.0% | 0.0% |
| Off -> High | 3.8% | 0.9% | 2.3% | 0.2% |
| Vlow -> High | 0.9% | 0.1% | 0.7% | 0.0% |
| Low -> High | 1.3% | 0.5% | 0.5% | 0.0% |
| Med -> High | 1.6% | 0.4% | 1.7% | 0.4% |
| Remain High | 2.8% | 7.1% | 7.9% | 3.9% |
| Vhi -> High | 0.4% | 0.1% | 0.0% | 0.7% |
| Off -> Vhi | 0.0% | 0.0% | 1.8% | 0.0% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.0% | 0.5% | 0.0% | 0.0% |
| High -> Vhi | 0.4% | 0.0% | 0.1% | 0.0% |
| Remain Vhi | 0.0% | 0.0% | 0.6% | 1.2% |

**South Coast**
**Programmable Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 25.4% | 41.9% | 18.6% | 37.1% |
| Off -> Vlo | 0.6% | 0.3% | 0.4% | 0.4% |
| Remain Vlo | 3.6% | 4.2% | 2.0% | 1.7% |
| Low -> Vlo | 0.8% | 3.1% | 0.1% | 1.5% |
| Med -> Vlo | 0.7% | 1.9% | 0.0% | 7.0% |
| High -> Vlo | 0.0% | 0.2% | 0.0% | 0.6% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 2.3% | 1.2% | 1.7% | 1.9% |
| Vlow -> Low | 2.2% | 0.4% | 3.7% | 0.0% |
| Remain Low | 5.3% | 4.4% | 5.3% | 5.5% |
| Med -> Low | 1.2% | 10.0% | 0.2% | 13.5% |
| High -> Low | 0.1% | 1.5% | 0.0% | 1.3% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 10.0% | 0.4% | 17.0% | 0.9% |
| Vlow -> Med | 4.1% | 0.4% | 3.7% | 0.1% |
| Low -> Med | 13.3% | 1.7% | 10.5% | 1.1% |
| Remain Med | 15.2% | 19.0% | 20.4% | 17.4% |
| High-> Med | 0.1% | 3.4% | 0.2% | 4.1% |
| Vhi-> Med | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> High | 5.1% | 0.9% | 4.5% | 0.8% |
| Vlow -> High | 1.2% | 0.0% | 0.2% | 0.0% |
| Low -> High | 1.2% | 0.2% | 1.0% | 0.0% |
| Med -> High | 2.3% | 0.3% | 4.0% | 0.7% |
| Remain High | 4.0% | 3.8% | 4.9% | 3.3% |
| Vhi -> High | 0.0% | 0.0% | 0.0% | 0.1% |
| Off -> Vhi | 0.3% | 0.0% | 0.5% | 0.0% |
| Vlow -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| High -> Vhi | 0.0% | 0.0% | 0.1% | 0.0% |
| Remain Vhi | 0.8% | 0.8% | 0.8% | 0.8% |

**South Inland**
**Manual Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 29.9% | 44.3% | 25.9% | 36.0% |
| Off -> Vlo | 0.9% | 0.2% | 2.7% | 1.2% |
| Remain Vlo | 3.7% | 2.8% | 3.0% | 3.6% |
| Low -> Vlo | 0.6% | 1.3% | 0.7% | 1.0% |
| Med -> Vlo | 0.1% | 0.9% | 0.0% | 1.7% |
| High -> Vlo | 0.0% | 0.3% | 0.2% | 0.4% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 3.0% | 1.2% | 3.6% | 1.7% |
| Vlow -> Low | 0.9% | 0.2% | 1.4% | 0.5% |
| Remain Low | 8.7% | 8.0% | 7.8% | 8.7% |
| Med -> Low | 1.6% | 2.9% | 1.4% | 4.5% |
| High -> Low | 0.1% | 1.4% | 0.0% | 1.1% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.1% |
| Off -> Med | 7.5% | 1.7% | 7.8% | 3.1% |
| Vlow -> Med | 1.7% | 0.4% | 0.7% | 0.1% |
| Low -> Med | 3.9% | 1.3% | 4.3% | 1.5% |
| Remain Med | 17.2% | 18.4% | 18.4% | 17.3% |
| High-> Med | 1.0% | 2.3% | 0.4% | 2.2% |
| Vhi-> Med | 0.0% | 0.1% | 0.0% | 0.0% |
| Off -> High | 4.1% | 0.9% | 6.0% | 2.5% |
| Vlow -> High | 0.5% | 0.3% | 0.4% | 0.0% |
| Low -> High | 0.9% | 0.1% | 0.6% | 0.4% |
| Med -> High | 2.5% | 0.9% | 3.2% | 0.8% |
| Remain High | 9.0% | 8.3% | 9.1% | 9.6% |
| Vhi -> High | 0.3% | 0.3% | 0.0% | 0.3% |
| Off -> Vhi | 0.5% | 0.1% | 0.9% | 0.1% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.0% | 0.0% | 0.1% | 0.0% |
| High -> Vhi | 0.1% | 0.3% | 0.1% | 0.5% |
| Remain Vhi | 1.1% | 1.0% | 1.3% | 0.9% |

**Central Valley**
**Manual Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 19.3% | 36.9% | 19.1% | 38.9% |
| Off -> Vlo | 3.0% | 0.3% | 1.2% | 0.4% |
| Remain Vlo | 2.6% | 2.1% | 1.5% | 1.0% |
| Low -> Vlo | 0.2% | 0.8% | 0.3% | 2.7% |
| Med -> Vlo | 0.2% | 0.8% | 0.1% | 2.8% |
| High -> Vlo | 0.0% | 0.4% | 0.0% | 0.5% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 3.8% | 1.0% | 4.1% | 1.1% |
| Vlow -> Low | 1.8% | 1.1% | 1.1% | 0.1% |
| Remain Low | 8.7% | 7.7% | 10.1% | 6.9% |
| Med -> Low | 0.7% | 4.6% | 0.7% | 6.9% |
| High -> Low | 0.1% | 0.3% | 0.0% | 1.4% |
| Vhi -> Low | 0.0% | 0.1% | 0.0% | 0.0% |
| Off -> Med | 13.8% | 1.8% | 11.8% | 3.7% |
| Vlow -> Med | 2.0% | 0.8% | 1.0% | 0.0% |
| Low -> Med | 5.9% | 1.2% | 3.9% | 0.8% |
| Remain Med | 21.8% | 23.9% | 25.1% | 19.0% |
| High-> Med | 0.2% | 1.5% | 0.5% | 3.4% |
| Vhi-> Med | 0.0% | 0.4% | 0.0% | 0.1% |
| Off -> High | 3.3% | 1.1% | 2.8% | 0.7% |
| Vlow -> High | 0.6% | 0.2% | 0.4% | 0.0% |
| Low -> High | 0.9% | 0.2% | 0.5% | 0.0% |
| Med -> High | 0.6% | 2.2% | 2.2% | 0.7% |
| Remain High | 5.0% | 6.3% | 8.7% | 4.9% |
| Vhi -> High | 0.1% | 0.3% | 0.5% | 0.1% |
| Off -> Vhi | 1.4% | 0.1% | 0.7% | 0.5% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.1% | 0.4% | 0.0% |
| High -> Vhi | 0.5% | 0.1% | 0.1% | 0.1% |
| Remain Vhi | 3.1% | 3.5% | 3.2% | 3.2% |

**South Inland**
**Programmable Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 19.8% | 31.9% | 13.9% | 28.5% |
| Off -> Vlo | 2.7% | 1.2% | 1.9% | 1.3% |
| Remain Vlo | 1.8% | 2.5% | 1.8% | 1.3% |
| Low -> Vlo | 0.6% | 0.7% | 0.6% | 1.2% |
| Med -> Vlo | 0.5% | 1.3% | 0.1% | 3.4% |
| High -> Vlo | 0.0% | 0.2% | 0.0% | 1.0% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 2.1% | 1.0% | 2.6% | 1.0% |
| Vlow -> Low | 1.2% | 0.8% | 1.0% | 0.6% |
| Remain Low | 5.6% | 5.4% | 6.5% | 5.0% |
| Med -> Low | 0.9% | 5.8% | 1.3% | 9.8% |
| High -> Low | 0.1% | 1.1% | 0.0% | 2.4% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.1% |
| Off -> Med | 8.2% | 1.3% | 10.7% | 1.3% |
| Vlow -> Med | 3.6% | 0.2% | 2.4% | 0.0% |
| Low -> Med | 8.6% | 1.3% | 5.4% | 1.8% |
| Remain Med | 17.6% | 21.8% | 23.8% | 19.2% |
| High-> Med | 0.7% | 3.9% | 1.5% | 1.7% |
| Vhi-> Med | 0.0% | 0.1% | 0.0% | 0.0% |
| Off -> High | 2.6% | 0.2% | 3.5% | 0.8% |
| Vlow -> High | 0.9% | 0.1% | 0.2% | 0.0% |
| Low -> High | 2.6% | 0.1% | 1.5% | 0.0% |
| Med -> High | 2.7% | 1.3% | 2.8% | 1.2% |
| Remain High | 9.6% | 12.1% | 12.2% | 10.3% |
| Vhi -> High | 1.6% | 0.5% | 0.1% | 0.5% |
| Off -> Vhi | 0.2% | 0.0% | 0.6% | 1.0% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| High -> Vhi | 0.9% | 0.5% | 0.6% | 1.2% |
| Remain Vhi | 5.0% | 4.4% | 4.9% | 5.4% |

**Central Valley**
**Programmable Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 9.6% | 21.7% | 7.1% | 28.9% |
| Off -> Vlo | 1.8% | 0.2% | 0.4% | 0.1% |
| Remain Vlo | 2.7% | 2.5% | 1.1% | 1.0% |
| Low -> Vlo | 0.4% | 1.9% | 0.3% | 1.7% |
| Med -> Vlo | 0.0% | 4.5% | 0.6% | 9.7% |
| High -> Vlo | 0.0% | 0.1% | 0.0% | 1.7% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 5.1% | 0.4% | 2.9% | 0.8% |
| Vlow -> Low | 2.8% | 0.4% | 1.7% | 0.1% |
| Remain Low | 8.6% | 9.2% | 7.8% | 5.5% |
| Med -> Low | 1.8% | 6.2% | 0.4% | 12.1% |
| High -> Low | 0.1% | 0.4% | 0.0% | 2.2% |
| Vhi -> Low | 0.0% | 0.1% | 0.0% | 0.0% |
| Off -> Med | 10.2% | 1.0% | 9.9% | 0.2% |
| Vlow -> Med | 8.2% | 1.3% | 5.8% | 0.5% |
| Low -> Med | 10.2% | 2.5% | 7.9% | 1.1% |
| Remain Med | 18.1% | 26.6% | 28.0% | 16.8% |
| High-> Med | 0.1% | 1.6% | 0.3% | 2.8% |
| Vhi-> Med | 0.1% | 0.5% | 0.0% | 0.6% |
| Off -> High | 2.9% | 1.3% | 2.9% | 0.6% |
| Vlow -> High | 0.5% | 0.2% | 0.2% | 0.0% |
| Low -> High | 0.9% | 0.3% | 0.6% | 0.1% |
| Med -> High | 1.7% | 1.5% | 3.4% | 0.7% |
| Remain High | 7.2% | 8.5% | 10.8% | 6.1% |
| Vhi -> High | 0.9% | 0.0% | 0.1% | 0.5% |
| Off -> Vhi | 1.2% | 0.0% | 0.1% | 0.0% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.1% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.0% | 0.6% | 0.0% |
| High -> Vhi | 0.0% | 1.5% | 0.1% | 0.7% |
| Remain Vhi | 4.9% | 5.6% | 7.0% | 5.3% |

**Desert**
**Manual Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 26.8% | 33.8% | 23.1% | 35.5% |
| Off -> Vlo | 5.8% | 0.2% | 0.6% | 4.6% |
| Remain Vlo | 5.9% | 5.4% | 4.9% | 4.7% |
| Low -> Vlo | 0.1% | 0.6% | 0.5% | 1.5% |
| Med -> Vlo | 0.1% | 1.0% | 0.2% | 4.3% |
| High -> Vlo | 0.0% | 2.2% | 0.0% | 0.8% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 3.3% | 2.4% | 4.4% | 4.1% |
| Vlow -> Low | 1.6% | 2.7% | 1.0% | 0.5% |
| Remain Low | 10.3% | 10.4% | 10.6% | 7.6% |
| Med -> Low | 1.1% | 1.7% | 0.4% | 4.2% |
| High -> Low | 0.0% | 0.4% | 0.0% | 2.4% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 7.6% | 2.4% | 8.5% | 0.7% |
| Vlow -> Med | 1.7% | 0.3% | 1.2% | 0.1% |
| Low -> Med | 1.9% | 2.9% | 4.2% | 0.5% |
| Remain Med | 11.0% | 13.7% | 17.9% | 12.5% |
| High-> Med | 0.6% | 2.6% | 0.3% | 2.6% |
| Vhi-> Med | 0.0% | 1.9% | 0.0% | 1.9% |
| Off -> High | 5.5% | 0.6% | 2.6% | 0.3% |
| Vlow -> High | 1.1% | 0.0% | 2.0% | 0.0% |
| Low -> High | 2.3% | 0.4% | 0.5% | 0.0% |
| Med -> High | 4.7% | 0.3% | 2.6% | 0.7% |
| Remain High | 4.3% | 10.0% | 8.2% | 8.1% |
| Vhi -> High | 0.0% | 0.1% | 2.0% | 0.1% |
| Off -> Vhi | 2.0% | 0.1% | 2.1% | 1.9% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.0% | 0.0% | 0.0% |
| High -> Vhi | 2.0% | 1.8% | 0.1% | 0.1% |
| Remain Vhi | 0.2% | 2.2% | 2.0% | 0.1% |

**Desert**
**Programmable Heating Thermostat**

| T-stat Setting | Morn | Day | Evening | Night |
|---|---|---|---|---|
| Off | 10.0% | 22.5% | 9.4% | 24.2% |
| Off -> Vlo | 0.4% | 0.2% | 0.6% | 0.1% |
| Remain Vlo | 0.9% | 0.9% | 1.0% | 1.6% |
| Low -> Vlo | 0.1% | 0.5% | 1.0% | 1.0% |
| Med -> Vlo | 0.1% | 2.6% | 0.2% | 3.6% |
| High -> Vlo | 0.1% | 0.3% | 0.0% | 0.6% |
| Vhi -> Vlo | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Low | 3.1% | 0.0% | 0.6% | 0.5% |
| Vlow -> Low | 1.5% | 0.2% | 0.6% | 0.1% |
| Remain Low | 6.8% | 7.2% | 4.8% | 3.7% |
| Med -> Low | 2.4% | 2.9% | 0.2% | 12.6% |
| High -> Low | 0.0% | 0.2% | 0.0% | 5.5% |
| Vhi -> Low | 0.0% | 0.0% | 0.0% | 0.0% |
| Off -> Med | 8.5% | 2.8% | 7.4% | 0.3% |
| Vlow -> Med | 1.8% | 0.2% | 2.6% | 0.0% |
| Low -> Med | 12.3% | 3.2% | 2.5% | 0.3% |
| Remain Med | 20.0% | 29.3% | 34.8% | 19.5% |
| High-> Med | 0.2% | 4.1% | 0.1% | 3.6% |
| Vhi-> Med | 0.0% | 0.0% | 0.0% | 0.2% |
| Off -> High | 2.9% | 0.0% | 3.2% | 0.1% |
| Vlow -> High | 2.6% | 0.1% | 0.5% | 0.0% |
| Low -> High | 3.2% | 0.2% | 1.9% | 0.0% |
| Med -> High | 1.0% | 0.5% | 4.0% | 0.8% |
| Remain High | 11.0% | 10.8% | 11.7% | 10.3% |
| Vhi -> High | 0.0% | 1.4% | 0.0% | 3.9% |
| Off -> Vhi | 1.6% | 0.2% | 2.1% | 0.0% |
| Vlow -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Low -> Vhi | 0.0% | 0.0% | 0.0% | 0.0% |
| Med -> Vhi | 0.1% | 0.1% | 0.0% | 0.0% |
| High -> Vhi | 1.9% | 0.1% | 1.4% | 0.0% |
| Remain Vhi | 7.4% | 9.5% | 9.5% | 7.4% |

## Appendix C – RASS database Weights

This appendix presents the weights derived from the RASS database to aggregate climate-zone and vintage specific results into non-vintage or non-climate zone specific results.

Tables C-1 and C-2 report the weights for each climate zone/vintage combination. These tables are used to roll up the vintage specific results for each climate zone. Table C-1 is used to aggregate the cooling energy results; table C-2 is used for heating energy.

Within the RASS database, each survey response is weighted to reflect the probability of the respondent being selected in the sample and also includes an adjustment for non-respondents within each sample. These tables are created by summing the weights of each respondent within the specified climate zone that reports the specified vintage. The selection criteria for respondents that make up these tables are the same as for the tables that make up the basis of the "RASS-data Thermostat Tables": full-year occupied, residential units with a standard or programmable thermostat and with either central air-conditioning or central heating.

**Table C-1. Households with Central A/C: Weights by Vintage, Climate Zone & House Type**

| | Single-Family Dwellings | | | | Multi-Family Dwellings | | | |
|---|---|---|---|---|---|---|---|---|
| CZ | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 |
| 1 | 171 | 0 | 0 | 0 | 119 | 0 | 0 | 0 |
| 2 | 16189 | 17814 | 4112 | 3977 | 1250 | 6808 | 2693 | 855 |
| 3 | 14991 | 13452 | 9211 | 2871 | 4247 | 7521 | 547 | 2562 |
| 4 | 62651 | 23363 | 7318 | 13712 | 6125 | 22081 | 9925 | 960 |
| 5 | 4841 | 3606 | 326 | 304 | 166 | 0 | 5141 | 0 |
| 6 | 50077 | 34597 | 10493 | 17293 | 20100 | 36412 | 16107 | 3957 |
| 7 | 35405 | 27641 | 22443 | 6632 | 13758 | 16982 | 772 | 7956 |
| 8 | 80339 | 44752 | 15637 | 9667 | 17274 | 31137 | 6705 | 6726 |
| 9 | 190879 | 78776 | 22773 | 9017 | 83688 | 66974 | 5242 | 9190 |
| 10 | 105538 | 207851 | 48117 | 62424 | 22980 | 35283 | 1339 | 3526 |
| 11 | 38754 | 35501 | 13466 | 11682 | 1338 | 10015 | 279 | 434 |
| 12 | 158967 | 135170 | 42711 | 34809 | 33367 | 57490 | 12054 | 5809 |
| 13 | 84189 | 79893 | 40838 | 19001 | 24049 | 32816 | 4397 | 1053 |
| 14 | 11981 | 100053 | 15948 | 4982 | 961 | 8146 | 851 | 0 |
| 15 | 11241 | 17694 | 5218 | 1504 | 13291 | 11498 | 3402 | 0 |
| 16 | 18633 | 11726 | 3716 | 325 | 1165 | 2433 | 187 | 0 |

The weights in table C-1 total nearly 2.2 million and reflect the total number of investor-owned-utility customers that meet the selection criteria (which includes central air conditioning) and had a response to the "Age of House" (vintage) question. The weights in table C-2, which require a central heating system along with other criteria, total more than 3.5 million customers.

**Table C-2. Households with Central Heating: Weights by Vintage, Climate Zone & House Type**

| | Single-Family Dwellings | | | | Multi-Family Dwellings | | | |
|---|---|---|---|---|---|---|---|---|
| CZ | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 | Pre-1978 | 1978-1992 | 1992-1998 | Post-1998 |
| 1 | 6606 | 2517 | 1221 | 2587 | 4405 | 576 | 2502 | 0 |
| 2 | 69759 | 39039 | 5317 | 3791 | 20839 | 13359 | 7132 | 1730 |
| 3 | 274944 | 69120 | 28953 | 8378 | 245752 | 56225 | 9258 | 10647 |
| 4 | 192961 | 47948 | 7947 | 13409 | 79879 | 63953 | 16190 | 2806 |
| 5 | 30736 | 10693 | 7187 | 2448 | 12973 | 783 | 5141 | 0 |
| 6 | 182253 | 56456 | 22894 | 27297 | 142866 | 69859 | 20419 | 4913 |
| 7 | 119133 | 91483 | 30020 | 15939 | 65248 | 66901 | 2288 | 8235 |
| 8 | 148438 | 50417 | 15637 | 12319 | 94932 | 51829 | 13441 | 3923 |
| 9 | 259535 | 75758 | 23669 | 7048 | 253649 | 106808 | 7836 | 7344 |
| 10 | 156843 | 224996 | 52290 | 63547 | 32765 | 38215 | 1604 | 6274 |
| 11 | 38810 | 42033 | 14639 | 12154 | 15462 | 14686 | 279 | 434 |
| 12 | 219190 | 149295 | 43555 | 36745 | 53317 | 88344 | 12054 | 6308 |
| 13 | 109471 | 76178 | 35422 | 18165 | 34308 | 34446 | 4901 | 1214 |
| 14 | 25165 | 104382 | 13179 | 5270 | 4486 | 13370 | 851 | 0 |
| 15 | 11320 | 18097 | 5396 | 1504 | 13503 | 12103 | 184 | 0 |
| 16 | 31437 | 28453 | 6858 | 668 | 2460 | 2988 | 365 | 0 |

Table C-3 presents the weights used to "roll up" cooling and heating energy results across all climate zones. The total weights are slightly greater than for tables C-1 and C-2 since no response was required for "Age of House".

**Table C-3. Data used to weight the Climate Zone specific results**

| | Single-Family Dwellings | | | | Multi-Family Dwellings | | | |
|---|---|---|---|---|---|---|---|---|
| | Cooling | | Heating | | Cooling | | Heating | |
| CZ | Prog | Standard | Prog | Standard | Prog | Standard | Prog | Standard |
| 1 | 109 | 181 | 12727 | 21686 | 119 | 0 | 10534 | 165 |
| 2 | 50850 | 15306 | 101355 | 129266 | 4880 | 7073 | 36328 | 12766 |
| 3 | 54748 | 12665 | 344585 | 673710 | 7498 | 7683 | 338641 | 53444 |
| 4 | 138891 | 35871 | 227318 | 287806 | 15978 | 24015 | 134383 | 37109 |
| 5 | 10063 | 4614 | 32259 | 73731 | 0 | 5307 | 15355 | 4171 |
| 6 | 125293 | 68493 | 235440 | 458325 | 47667 | 40612 | 228009 | 68425 |
| 7 | 84386 | 78461 | 179753 | 379093 | 35393 | 19781 | 142965 | 34669 |
| 8 | 131771 | 152010 | 173240 | 511142 | 60443 | 33525 | 188286 | 44894 |
| 9 | 261934 | 272150 | 305382 | 673593 | 120975 | 61546 | 352754 | 58429 |
| 10 | 340691 | 278389 | 371652 | 447834 | 53674 | 32334 | 79299 | 31890 |
| 11 | 80572 | 58790 | 108661 | 111313 | 8184 | 5351 | 26412 | 6513 |
| 12 | 404294 | 179400 | 470141 | 384266 | 54221 | 69747 | 118681 | 73995 |
| 13 | 197965 | 182039 | 210779 | 261406 | 70687 | 15534 | 83984 | 15877 |
| 14 | 99469 | 65903 | 110642 | 123632 | 17540 | 7798 | 32662 | 8463 |
| 15 | 34345 | 40156 | 38108 | 38565 | 24023 | 9908 | 22000 | 12435 |
| 16 | 32145 | 30796 | 65710 | 77847 | 3603 | 6584 | 5512 | 6961 |

Tables C-4 and C-5 present the percentage of utility customers that fall within each climate zone for single-family and multi-family dwellings. These data were derived from the RASS database of respondents used in this report

**Table C-4. Single-Family Utility Territory Weights**

| Climate | Central Air-Conditioning | | | | | Central Heating | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Zone | PG&E | SCE | LADWP | SDG&E | SCG | PG&E | SCE | LADWP | SDG&E | SCG |
| CZ01 | 0.0% | | | | | 0.9% | | | | |
| CZ02 | 4.7% | | | | | 6.8% | | | | |
| CZ03 | 4.5% | | | | | 26.8% | | | | |
| CZ04 | 11.8% | | | | | 14.5% | | | | |
| CZ05 | 0.9% | 0.0% | | | 0.0% | 2.9% | 0.1% | | | 0.1% |
| CZ06 | | 7.9% | 8.5% | 10.8% | 7.9% | | 16.5% | 10.9% | 9.0% | 16.1% |
| CZ07 | | | | 44.3% | | | | | 60.2% | |
| CZ08 | | 13.6% | 1.4% | 3.0% | 13.0% | | 20.1% | 26.5% | 1.4% | 20.5% |
| CZ09 | | 23.9% | 90.1% | | 26.8% | | 22.3% | 62.6% | | 25.2% |
| CZ10 | | 32.8% | | 40.2% | 31.3% | | 22.6% | | 28.5% | 21.0% |
| CZ11 | 11.0% | | | | | 6.6% | | | | |
| CZ12 | 44.0% | | | | | 27.7% | | | | |
| CZ13 | 21.0% | 4.8% | | | 4.6% | 11.9% | 3.3% | | | 3.1% |
| CZ14 | | 12.2% | | 0.7% | 11.7% | | 9.4% | | 0.6% | 8.7% |
| CZ15 | | 3.0% | | 1.0% | 2.9% | | 1.9% | | 0.4% | 1.8% |
| CZ16 | 2.1% | 1.8% | | | 1.7% | 1.7% | 3.8% | | | 3.5% |

**Table C-5. Multi-Family Utility Territory Weights**

| Climate | Central Air-Conditioning | | | | | Central Heating | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Zone | PG&E | SCE | LADWP | SDG&E | SCG | PG&E | SCE | LADWP | SDG&E | SCG |
| CZ01 | 0.0% | | | | | 1.1% | | | | |
| CZ02 | 4.1% | | | | | 5.1% | | | | |
| CZ03 | 5.2% | | | | | 40.7% | | | | |
| CZ04 | 13.6% | | | | | 17.8% | | | | |
| CZ05 | 1.8% | 0.0% | | | 0.0% | 1.9% | 0.1% | | | 0.1% |
| CZ06 | | 20.8% | 5.8% | 4.2% | 17.4% | | 32.0% | 12.0% | 6.2% | 26.0% |
| CZ07 | | | | 58.9% | | | | | 73.2% | |
| CZ08 | | 23.7% | 1.0% | 4.4% | 18.5% | | 23.9% | 13.6% | 3.2% | 20.9% |
| CZ09 | | 21.3% | 93.2% | | 37.7% | | 22.6% | 74.4% | | 38.0% |
| CZ10 | | 14.9% | | 32.4% | 11.5% | | 9.1% | | 17.4% | 6.4% |
| CZ11 | 4.6% | | | | | 3.4% | | | | |
| CZ12 | 42.2% | | | | | 20.0% | | | | |
| CZ13 | 28.3% | 0.8% | | | 0.6% | 9.8% | 0.7% | | | 0.5% |
| CZ14 | | 6.8% | | 0.0% | 5.2% | | 5.4% | | 0.0% | 3.8% |
| CZ15 | | 9.1% | | 0.0% | 7.0% | | 4.5% | | 0.0% | 3.2% |
| CZ16 | 0.1% | 2.6% | | | 2.0% | 0.0% | 1.6% | | | 1.1% |