# Independent Initial Check on the 2009 RECS End-Use Breakout

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Previous extensive work by EPMI on commercial sector energy use, that included analysis of data from both the State Energy Data System (SEDS) and Commercial Buildings Energy Consumption Survey (CBECS) of the US Energy Information Administration (EIA) of the US Department of Energy, demonstrated that:

1. The end-use breakout of electric space heating energy in CBECS appears internally highly inconsistent over several cycles of the CBECS (viz., total national electric space heating energy use divided by the floor area of buildings heated by electricity, or national electric space-heat energy use index, has varied wildly, by a factor of four over several decades, which is nonsensical from a building science standpoint, as large populations of buildings do not change drastically over time)
2. Independent analysis of national commercial sector energy use based on SEDS data to derive heating-degree-day (HDD) and cooling-degree-day (CDD) dependence of the commercial sector energy for 2012, the same year as the latest CBECS data, demonstrated good agreement between CBECS end use energy estimates and SEDS-derived CDD-dependent energy use, but a large discrepancy for HDD-dependent energy. The large HDD-dependent energy use discrepancy led to the determination that the national total electric space-heating energy use in CBECS was not reasonable when reduced to simple engineering figures of merit, and was almost certainly low by a factor of 10 or more.

The 2012 CBECS results indicate that the electric space-heating energy use index (EUIsph) in the entire population of commercial buildings, on a site energy basis, was 2.0 kBtu/sq-ft. This value is unacceptably low for the entire sector, since even highly-efficient commercial buildings would typically have an electric EUIsph of four or more. Over 26 billion square feet of commercial floor space has electricity as the primary space-heating source (30% of all floor area), and total site energy use for this floor area is only 0.05 quads. Reasonableness checks on EUI strongly indicate that the total space-heating energy use is low by about one order of magnitude.

Independent analysis of energy use dependence on HDD and CDD, using the SEDS data, confirms that HDD-dependent energy use in the commercial sector has been the fastest growing category of energy use over several decades, and again strongly indicates the national CBECS space heating energy use is way too low. Checking all fuels, natural gas and other fossil fuel consumption for space heating did not appear to be underestimated.

For further detail readers can consult the chapter on "End-Use Energy" in the report: *Understanding Commercial and Service Sector Energy Use* (http://epminst.us/commercial/Understanding%20commercial%20and%20service%20sector%20energy%20use.pdf).

Reaching out to the CBECS program in 2016 (November), led to a reply that they were looking into the electric space heating estimates, but no feedback on any findings has yet been provided.

After waiting a year, this researcher began to wonder if there might be similar issues with the end use estimates in the RECS data, and the initial findings on that inquiry are presented in this short paper.

A further potential area of concern is whether any issues with estimating electricity end use breakouts extend to the National Energy Modeling System (NEMS).

## SEDS Analysis of 2009 Residential Electricity Use

A multivariate regression analysis of the SEDS 2009 residential sector electricity use was conducted. SEDS has data for 50 states and the District of Columbia. Previous extensive work on the residential and commercial sector SEDS data has led to the development of several highly-significant regression models of energy use on HDD, CDD, and population, where the independent parameters are some form of:

1. Population of each state (# of people)
2. Population-weighted heating degree-days (HDD) of each state times the number of people in the state (PHDD)
3. Population-weighted cooling degree-days (CDD) of each state times the number of people in the state (PCDD)

For the SEDS residential electricity data for 2009, an initial regression using these three parameters indicated that population was not a significant parameter (Pr > |t| = 0.74). After removing population, the following results were obtained:

| | | | | |
|---|---|---|---|---|
| 1 | Dependent Parameter (4.66 quads total) | | **Total site electricity use in 2009** | |
| 2 | # of observations | | 51 | |
| | Model adjusted R-square | | 0.93 | |
| | Model F Statistic | | 342 | |
| | Model Significance | | < 0.0001 | |
| 3 | **Parameter** | **Model Coefficients** | **T value** | **Significance** |
| | Intercept | 16214 Billion Btu (BBtu) | 3.23 | 0.0023 |
| | PHDD (2009) | 1.272 kBtu/person-HDD | 9.16 | < 0.0001 |
| | PCDD (2009) | 5.365 kBtu/person-CDD | 21.78 | < 0.0001 |

Based on these results, the total US non-degree-day-dependent residential electricity use would be 51 x 16214 BBtu = 0.83 quads (site energy use).

Summing PHDD and PCDD for all 51 data points, and then dividing by US population of 306.8 million in the year 2009, leads to a population-weighted HDD value of 4,400 and a CDD value of 1,284 for the entire country.

Total US PHDD-dependent energy use = 1.272 x 306.8 million people x 4400 HDD = 1.72 quads

Total US PCDD-dependent energy use = 5.365 x 306.8 million people x 1284 HDD = 2.11 quads (and all three sum to 4.66 quads)

## RECS 2009 Electricity End-Use Breakout

Using the V4 SAS microdata set, downloaded from the RECS website in November 2017, the electricity end use breakouts from the 2009 RECS were calculated using the main weighting parameter, NWEIGHT.

This is a fairly simple tabulation of national totals for the parameters: *btuel, btuelsph, btuelwth, btuelcol, btuelrfg,* and *btueloth*. The calculated totals, in kBtu, must be divided by one trillion to arrive at quads. The resulting totals are shown below:

| Calculated weighted sum of site electricity, quads, 2009 V4 microdata | | | | | |
|---|---|---|---|---|---|
| TOTAL | space heat | water heating | cooling | refrigeration | other |
| 4.39 | 0.41 | 0.43 | 0.64 | 0.48 | 2.43 |

These space heat and cooling totals are a lot less than the PHDD- and PCDD-values derived from SEDS. The SEDS national total is 4.66 quads for 2009, while the RECS total is 4.4 quads, and this difference is due to some lack of coverage for renewable electricity and some small differences in how RECS covers the entire sector. Comparison of RECS and SEDS-derived values is next.

## Comparison of End-Use Values

The SEDS end-use breakout will be divided into the same categories as the RECS, as shown above. To keep things simple, the SEDS-derived baseload will be assigned to the "other" category, water heating will be subtracted from the HDD-dependent load, and refrigeration will be subtracted from the CDD-dependent load. This method is probably not exact, but it will illustrate the main points:

1. The RECS electricity end-use breakout cannot be verified using an independent empirical method based on a different EIA data set
2. The SEDS analysis indicates that electricity used for space heat and cooling appears to be highly underestimated by RECS, while "other" electricity use appears to be highly overestimated
3. This pattern of over- and under-estimation is similar to what was found for the 2012 CBECS data

The calculated RECS and SEDS electricity end-use energy totals are shown in the table below.

**Calculated site electricity breakouts**

| | Total | space heat | water heating | cooling | refrigeration | other |
|---|---|---|---|---|---|---|
| **RECS quads** | 4.39 | 0.41 | 0.43 | 0.64 | 0.48 | 2.43 |
| **RECS %** | 100% | 9% | 10% | 15% | 11% | 55% |
| **SEDS quads** | 4.66 | 1.28 | 0.44 | 1.61 | 0.50 | 0.83 |
| **SEDS %** | 100% | 27% | 9% | 35% | 11% | 18% |

The major differences for space heating with electricity (27% vs 9%) and cooling (35% vs 15%) indicate that the RECS end-use breakouts may not be calculated acceptably. The "other" electricity use diverges the other way (18% vs 55% in RECS). This pattern of diminishing space conditioning energy and enhancing "other" energy was also found in CBECS, only for CBECS the space heating discrepancies were worse and were also found to violate reasonableness checks of basic engineering figures of merit, while cooling and refrigeration energy in CBECS matched well with the SEDS results. The same extreme is not found for RECS heating energy, but the divergence for heating and cooling energy is a significant concern. The discrepancies found here should be a concern for anyone attempting to set policy or research agendas based on end-use breakouts.