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Residential Energy Consumption Survey (RECS):

Using the 2015 microdata file to compute estimates and standard errors (RSEs)

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Overview

EIA makes available a public-use microdata file for each RECS survey cycle. The 2015 file is a valuable tool for users conducting detailed analysis of home energy use. This document provides some background on the RECS design, as well as useful tips and examples that will guide users through the use of the RECS microdata.

RECS sample design

The RECS sample was designed to estimate energy characteristics, consumption, and expenditures for the national stock of occupied housing units and the households that live in them. The 2015 RECS allows for separate estimation for Census regions and divisions. (The return to the traditional sample size for the 2015 RECS does not allow for state-level estimation, as was available for the expanded 2009 RECS.) To produce estimates for these geographies and the total U.S., the sample cases were properly weighted to represent the population, including the residences not in the sample. In a sense, a case's weight indicates the number of households that the particular case represents.

Base sampling weights, which are the reciprocal of the probability of being selected for the RECS sample, were first calculated for each sampled housing unit. The base weights were adjusted to account for survey nonresponse and ratio adjustments were used to ensure that the RECS weights add up to Census Bureau estimates of the number of occupied housing units for 2015. The variable **NWEIGHT** in the data file represents the *final sampling weight*, accounting for different probabilities of selection and rates of response, and being adjusted for the Census Bureau housing unit estimates. NWEIGHT is the number of households in the population that the observation represents. For example, if NWEIGHT for a household is 10,000, that household represents itself and 9,999 other non-sampled households. More details about the sample design can be found in the *RECS 2015 Technical Documentation – Summary*.

Sampling error

Estimates from a sample survey like RECS are not exact but are statistical estimates with some associated sampling error in each direction—the result of generating estimates based on a sample rather than a census of the entire population. Sampling error provides a measure of the accuracy of a particular estimate for a characteristic based on how common and variable it is in the population, given a particular sample size.

Standard errors are used in conjunction with survey estimates to measure sampling error, construct confidence intervals, or perform hypothesis tests. A relative standard error (RSE) is defined as the standard error (square root of the variance) of a survey estimate, divided by the survey estimate, and multiplied by 100. In other words, the RSE is the standard error relative to the survey estimate on a scale from zero to 100. The larger the RSE, the less precise the survey estimate is of the true value in the population. An RSE is shown for each estimate in the RECS tables.

Fay's balanced repeated replication (BRR) method of estimating standard error

RECS uses Fay's method of the balanced repeated replication (BRR) technique for estimating standard errors. This method uses replicate weights to repeatedly estimate the statistic of interest and calculate the differences between these estimates and the full-sample estimate.

See Fay (1989), Heeringa, West, and Berglund (2010), Judkins (1990), Lee and Forthofer (2006), Roa and Shao (1999), Rust (1985), and Wolter (2007) for technical details.

If θ is a population parameter of interest, let $\hat{\theta}$ be the estimate from the full sample for θ. Let $\widehat{\theta_r}$ be the estimate from the r-th replicate subsample by using replicate weights and let ε be the Fay coefficient, $0 \leq \varepsilon < 1$. The variance of $\hat{\theta}$ is estimated by:

$$\hat{V}(\tilde{\theta}) = \frac{1}{R(1-\varepsilon)^2} \sum_{r=1}^{R} (\widehat{\theta_r} - \hat{\theta})^2$$

For the 2015 RECS, R=96 (the number of replicate subsamples) and ε = 0.5. The formula for calculating the RSE is:

$$\left(\frac{\sqrt{\hat{V}(\hat{\theta})}}{\hat{\theta}} \right) X\ 100$$

Examples: Using final weights (NWEIGHT) and replicate weights to calculate estimates and RSEs

The following instructions are examples for calculating any RECS estimate using the final weights (NWEIGHT) and the associated RSE using the replicate weights (BRRWT1 – BRRWT96). We have provided instructions for Excel users and users with access to statistical software. Software packages like SAS/STAT, R, Stata, SUDAAN, and WesVar can process replicate weights to calculate RSEs. Note that while EXCEL can be used to calculate point estimates, it cannot process replicate weights to calculate RSEs for RECS or other complex sample designs with varying probabilities of selection. EIA recommends calculating standard errors or RSEs in conjunction with estimates to account for sampling error.

For Excel Users (estimates only, no RSEs)

Excel Example 1: Calculate the frequency of households that used natural gas as their main space heating fuel (Table HC6.1)

A simple count of households can be estimated using the sum of NWEIGHTS for a specified subset of cases within the RECS data file. For this example, filter the file for all cases where natural gas space heating was used as the main heating fuel (FUELHEAT= 1). There are 2,790 cases with FUELHEAT = 1. By adding the NWEIGHT column for these 2,790 cases, the estimated number of households that used natural gas as main heating fuel was approximately 57,667,485. This is equal to 49% of all homes, or 57.7 million/118.2 million (the sum of NWEIGHT for all cases in RECS.)

Table HC6.1 Space heating in U.S. homes by housing unit type, 2015[1]

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Revised date: May 2018

	Number of housing units (million)					
		Housing unit type				
	Total U.S.[2]	Single-family detached	Single-family attached	Apartment (2- to 4-unit building)	Apartment (5 or more unit building)	Mobile home
All homes	118.2	73.9	7.0	9.4	21.1	6.8
Space heating equipment						
Use space heating equipment	113.1	72.1	6.7	8.9	18.9	6.5
Have space heating equipment but do not use it	3.6	1.2	0.2	0.3	1.6	Q
Do not have space heating equipment	1.6	0.5	Q	Q	0.6	Q
Main heating fuel and equipment						
Natural gas	57.7	40.2	4.2	4.6	7.3	1.4

Excel Example 2: Calculate energy intensity by the number of household members in the South (Table CE1.4)

To find the energy intensity by the number of household members, first filter the microdata file for households in the South (REGIONC = 3). There should be 2,010 cases. In a new column, calculate the weighted number of household members (NHSLDMEM × NWEIGHT) for each case and sum the column to get 112,316,570. In a separate column, calculate the weighted total fuel consumption (TOTALBTU × NWEIGHT) for each case and sum the column to get 3,063,515,106,263. Divide the sum of the weighted total fuel consumption by the sum of the weighted number of household members. The result should be 27,275 thousand Btu or 27.3 million Btu as shown in Table CE1.4.

Release date: May 2018

Table CE1.4 Summary annual household site consumption and expenditures in the South—totals and intensities, 2015

	Number of housing units (million)	Site energy consumption[1]				Energy expenditures[1]			
	Total South[2]	Total (trillion Btu)	Per household (million Btu)	Per household member (million Btu)	Per square foot (thousand Btu)	Total (billion dollars)	Per household (dollars)	Per household member (dollars)	Per square foot (dollars)
All homes	44.4	3,064	68.9	27.3	35.6	85.19	1,917	758	0.99

SAS Example 1: Calculate the frequency and RSE of households that used natural gas as their main space heating fuel (Table HC6.1)

Create a new variable to flag the records we are interested in - households that used natural gas as their main space heating fuel. This new variable NG_MAINSPACEHEAT is equal to 1 if the household used natural gas as their main space heating fuel, and 0 otherwise.

```
DATA RECS15;
   SET RECS2015_PUBLIC_V3;
   IF FUELHEAT=1 THEN NG_MAINSPACEHEAT =1; ELSE
   NG_MAINSPACEHEAT =0;
RUN;
```

Use the variable NWEIGHT in the WEIGHT statement and the variable NG_MAINSPACEHEAT in the TABLES statement in PROC SURVEYFREQ. To get the sampling error (RSE) associated with the estimate, we can use PROC SURVEYFREQ to process the replicate weights.

```
PROC SURVEYFREQ DATA=RECS15 VARMETHOD=BRR(FAY);
   REPWEIGHTS BRRWT1-BRRWT96;
   WEIGHT NWEIGHT;
   TABLES NG_MAINSPACEHEAT;
RUN;
```

The estimated number of households that used natural gas as their main space heating fuel is 57,667,485. The standard deviation of the frequency is 155,229 and the calculation for the RSE is: (1,317,409 / 57,667,485)*100 = 2.3. This means that the sampling error is about 2.3% of the estimate, relatively small.

Table of NG_MAINSPACEHEAT

NG_MAINSPACEHEAT	Frequency	Weighted Frequency	Std Err of Wgt Freq	Percent	Std Err of Percent
0	2896	60540765	1317409	51.2153	1.1145
1	2790	57667485	1317409	48.7847	1.1145
Total	5686	118208250	0.03206	100.000	

SAS Example 2: Calculate total and average natural gas space heating consumption by region, and associated RSEs, for households that used natural gas as their main space heating fuel

To calculate total and average consumption for a specified subset of households in SAS, use the SURVEYMEANS procedure. For this example, use BTUNGSPH in the VAR statement, and the newly created variable NG_MAINSPACEHEAT in the DOMAIN statement. For a further breakout of consumption, add a second dimension to the DOMAIN statement. For this example, Census region (REGIONC) is added. The WEIGHT and REPWEIGHT variables are the same as the PROC SURVEYFREQ example above. Use the options *sum*, *clsum*, *mean*, and *clm* to request the sum, confidence interval for the sum, mean, and confidence limit of the mean, respectively, of the variable BTUNGSPH. Note that this code calculates an average natural gas space heating consumption, by region, only for those households who used natural gas as their main space heating fuel.

```
PROC SURVEYMEANS DATA=RECS15 VARMETHOD=BRR(FAY) SUM CLSUM MEAN CLM;
   REPWEIGHTS BRRWT1-BRRWT96;
   WEIGHT NWEIGHT;
   DOMAIN NG_MAINSPACEHEAT * REGIONC;
   VAR BTUNGSPH;
RUN;
```

The table of output shows the natural gas consumption by region (in thousand Btu), the standard deviation (error), and confidence intervals for the average and total natural gas space heating consumption. Note that the estimates for NG_MAINSPACEHEAT = 0 reflect consumption for homes that use natural gas as a secondary space heating fuel.

The SURVEYMEANS Procedure

Domain Statistics in NG_MAINSPACEHEAT*REGIONC

NG_MAINSPACEHEAT	REGIONC	Variable	Mean	Std Error of Mean	95% CL for Mean		Sum	Std Error of Sum	95% CL for Sum	
0	1	BTUNGSPH	339.091355	225.372178	-108.2689	786.4516	3257032722	2221002247	-1.15162E9	7665687338
	2	BTUNGSPH	594.306743	208.953195	179.5379	1009.0756	4560484807	1606695741	1371218969	7749750646
	3	BTUNGSPH	126.138872	29.593730	67.3958	184.8820	3880726434	900222776	2093798347	5667654520
	4	BTUNGSPH	226.544718	78.187112	71.3445	381.7449	2831006655	927632456	989670782	4672342527
1	1	BTUNGSPH	56365	1688.670928	53012.9420	59716.9126	642636844076	46690961919	5.49956E11	7.35318E11
	2	BTUNGSPH	61678	1265.814292	59165.8623	64191.1053	1.1532713E12	42883873848	1.06815E12	1.2384E12
	3	BTUNGSPH	35805	1908.199668	32017.1002	39592.5930	489683780100	35490018552	4.19237E11	5.60131E11
	4	BTUNGSPH	27175	1282.809247	24628.8390	29721.5514	377505435244	28422701678	3.21087E11	4.33924E11

The first set of columns below shows the average natural gas space heating consumption, the standard error, and 95% confidence limits. The average natural gas main space heating consumption in the northeast is 56.4 million Btu. The RSE for the average is (1,265.8 / 56,365)*100 = 2.1%. The lower 95% confidence limit is 53.0 million Btu and the upper 95% confidence limit is 59.7 million Btu. This means that if the sample were repeatedly taken and the confidence intervals were constructed from each sample, then 95% of the time, those confidence intervals would cover the true population mean.

Domain Statistics in NG_MAINSPACEHEAT*REGI

NG_MAINSPACEHEAT	REGIONC	Variable	Mean	Std Error of Mean	95% CL for Mean	
0	1	BTUNGSPH	339.091355	225.372178	-108.2689	786.4516
	2	BTUNGSPH	594.306743	208.953195	179.5379	1009.0756
	3	BTUNGSPH	126.138872	29.593730	67.3958	184.8820
	4	BTUNGSPH	226.544718	78.187112	71.3445	381.7449
1	1	BTUNGSPH	56365	1688.670928	53012.9420	59716.9126
	2	BTUNGSPH	61678	1265.814292	59165.8623	64191.1053
	3	BTUNGSPH	35805	1908.199668	32017.1002	39592.5930
	4	BTUNGSPH	27175	1282.809247	24628.8390	29721.5514

The second set of columns below shows the total natural gas space heating consumption, the standard error, and 95% confidence limits. For the Northeast, this results in a total natural gas main space heating consumption of 0.643 quadrillion Btu, an RSE of 7.3%, and a 95% confidence interval of 0.550 quadrillion Btu to 0.735 quadrillion Btu.

NG_MAINSPACEHEAT	REGIONC	Variable	ONC Sum	Std Error of Sum	95% CL for Sum	
0	1	BTUNGSPH	3257032722	2221002247	-1.15162E9	7665687338
	2	BTUNGSPH	4560484807	1606695741	1371218969	7749750646
	3	BTUNGSPH	3880726434	900222776	2093798347	5667654520
	4	BTUNGSPH	2831006655	927632456	989670782	4672342527
1	1	BTUNGSPH	642636844076	46690961919	5.49956E11	7.35318E11
	2	BTUNGSPH	1.1532713E12	42883873848	1.06815E12	1.2384E12
	3	BTUNGSPH	489683780100	35490018552	4.19237E11	5.60131E11
	4	BTUNGSPH	377505435244	28422701678	3.21087E11	4.33924E11

SAS Example 3: Calculate energy intensity by the number of household members by region and U.S. (Table CE1.1)

To calculate the energy intensity in SAS, use the SURVEYMEANS procedure. For this example, use REGIONC in the DOMAIN statement and TOTALBTU and NHSLDMEM in the RATIO statement to calculate the intensity per household member. The WEIGHT and REPWEIGHT variables are the same as the examples above. Use the *sum* option to request the sums of both TOTALBTU and NHSLDMEM.

```
PROC SURVEYMEANS DATA=RECS15 VARMETHOD=BRR(FAY) SUM;
   REPWEIGHTS BRRWT1-BRRWT96;
   WEIGHT NWEIGHT;
   DOMAIN REGIONC;
   RATIO TOTALBTU/NHSLDMEM;
RUN;
```

To find the intensities, refer to the *Ratio Analysis* tables in the output. The first *Ratio Analysis* table shows the intensity for all U.S. homes. The national level of energy intensity per household member is 30,270 thousand Btu or 30.3 million Btu, as shown in Table CE1.1.

Ratio Analysis			
Numerator	Denominator	Ratio	Std Err
TOTALBTU	NHSLDMEM	30270	388.366666

The regional intensity per household member can be found in the *Domain Ratio in REGIONC* table. The total consumption per household member in the Midwest (REGIONC = 2) is 37,800 thousand Btu or 37.8 million Btu, as shown in Table CE1.1.

Domain Ratio in REGIONC				
REGIONC	Numerator	Denominator	Ratio	Std Err
1	TOTALBTU	NHSLDMEM	38067	733.288676
2	TOTALBTU	NHSLDMEM	37800	877.753024
3	TOTALBTU	NHSLDMEM	27276	729.528912
4	TOTALBTU	NHSLDMEM	22297	546.867192

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Table CE1.1 Summary annual household site consumption and expenditures in the U.S.—totals and intensities, 2015

	Number of housing units (million)	Site energy consumption[1]				Energy expenditures[1]			
	Total U.S.[2]	Total (trillion Btu)	Per household (million Btu)	Per household member (million Btu)	Per square foot (thousand Btu)	Total (billion dollars)	Per household (dollars)	Per household member (dollars)	Per square foot (dollars)
All homes	118.2	9,114	77.1	30.3	38.4	219.34	1,856	728	0.92
Census region and division									
Northeast	21.0	1,984	94.4	38.1	45.2	47.66	2,269	915	1.09
New England	5.6	547	97.3	40.3	44.5	14.31	2,541	1,054	1.16
Middle Atlantic	15.4	1,436	93.4	37.3	45.5	33.36	2,169	866	1.06
Midwest	26.4	2,486	94.3	37.8	41.4	46.42	1,760	706	0.77
East North Central	18.1	1,755	97.0	38.1	43.1	31.88	1,762	693	0.78

Notes to consider when using the microdata file and replicate weights

1. *Publication standards:* EIA does not publish RECS estimates where the RSE is higher than 50 or the count of households used for the calculation is less than 10 (indicated by a "Q" in the data tables). These are EIA's recommended guidelines for custom analysis using the public use microdata file.

2. *Imputation variables:* Most variables were imputed for "Don't Know" and "Refuse" responses. The "Z variables", also referred to as "imputation flags", are included in the public use microdata file. The imputation flag indicates whether the corresponding non-Z variable was based upon reported data (Z variable = 0) or was imputed (Z variable = 1). There are no corresponding "Z variables" for variables from the RECS questionnaire that were not imputed, variables where there was no missing data, and variables that are not from the questionnaire. EIA recommends using the imputed data, where available, to avoid biased estimation.

3. *Standardized coding:* Variables that were not imputed use the response codes -9 for "Don't Know" and -8 for "Refuse". Variables that are not asked of all respondents use the response code -2 for "Not Applicable". For example, if a respondent said they did not use any televisions at home (TVCOLOR = 0) then they were not asked what size of television is most used at home, thus TVSIZE1 = -2. Use caution when performing calculations on variables that may have -2, -8, or -9 responses.

4. *Indicator variables:* The microdata file contains variables to indicate the use of major fuels and specific end uses within each housing unit for 2015. These variables are derived from answers given by each respondent and indicate whether the respondent had access to and actually used the fuel and engaged in the end-use. All indicators are either a 0 or 1 for each combination of major fuel and end-use. For example, a respondent who says they heated their home with electricity in 2015 will have the derived variable ELWARM = 1. If a respondent says they have equipment but did not use it the corresponding indicator will be 0. As an example, a respondent in a cool climate might have air-conditioning equipment but did not use it in 2015. For this case, ELCOOL would be 0.

5. *Confidentiality:* The 2015 RECS was collected under the authority of the Confidential Information Protection and Statistical Efficiency Act (CIPSEA). EIA, project staff and its contractors and agents are personally accountable for protecting the identity of individual respondents. The following steps were

taken to avoid disclosure of personally identifiable information on the public use microdata file.

Local geographic identifiers of sampled housing units, such as zip codes, were removed.

- Building America Climate Regions with few sample cases ("Very Cold" and "Mixed- Dry") were combined with the most similar region.
- The variable indicating on-site wind generation (WIND) was removed due to too few responses.
- The variable HHAGE (age of the householder) was top-coded at 85.
- Weather and climate (HDD and CDD) values were inoculated with random errors. Adjustments were minor and will not result in significant differences than those estimates displayed in data tables.

References

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