Minnesota Energy Efficiency Potential Study: 2020–2029

Appendix J: Residential Buildings Primary Data Collection Report

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Introduction

The full report that this appendix supports, *Minnesota Energy Efficiency Potential Study: 2020-2029*, is available for download on the project website.

Minnesota has a thirty-plus year history of leadership in energy efficiency policy and achievements. In order to continue to maximize the benefits of cost-effective energy efficiency resource acquisition by utilities, the project team, consisting of Center for Energy and Environment (CEE), Optimal Energy (Optimal) and Seventhwave, was commissioned to:

- Estimate statewide electric and natural gas energy efficiency and carbon-saving potential for 2020-2029;
- Produce data-driven and stakeholder-informed resources defining market segments, end uses, measures, and programs that could be targeted in the decade ahead to realize the state's cost-effective energy efficiency potential; and
- Engage stakeholders in order to help advance robust energy policies and energy efficiency programs in the state, and to inform future efficiency portfolio goals.

To provide a better empirical basis for estimates of energy-efficiency potential in the residential sector, the project team implemented a statewide telephone survey of residents of single-family homes and conducted site visits to a subsample of survey respondents. This appendix describes the design and execution of that effort.

The objective of the survey and site visits was to elicit information about appliance holdings and other energy-related information for a statewide sample of single-family households. The effort was designed to have an emphasis on collecting information about customers of rural electric cooperatives and small municipal utilities, since data for these customers were generally lacking, and, at the same time, providing statistically-representative estimates for all Minnesota households. The effort was also intended to capture information for a statistically-meaningful sample of low-income households.

Telephone Survey Design

The telephone survey was budgeted for 1,500 total completions. Table 1 shows the overall sample targets by utility type and household income. These targets were intended to provide statistically meaningful results in each of the two principal dimensions, while also yielding useful weighted statewide results. Specifically, the overall sample was designed to provide a sampling margin of error of no more than ±5 percentage points at a 95 percent confidence level, with error margins of ±7 and ±10 percentage points for customers of small/rural utilities and low-income households, respectively.

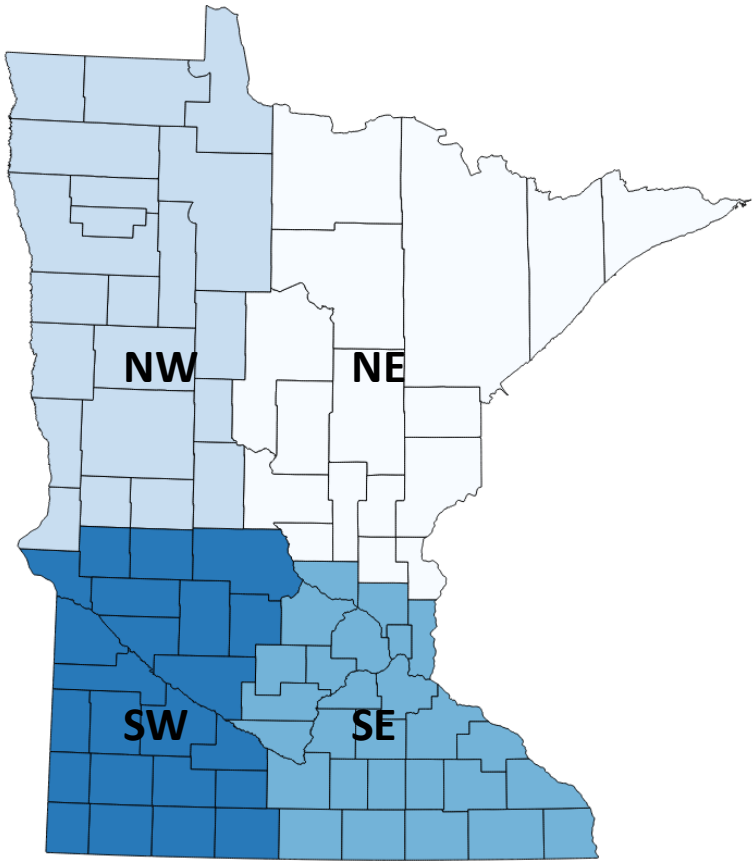
Table 1. Telephone survey sample targets by utility class and household income.

	Small/rural utilities*	Other utilities	Total
Low-income	200	100	300
Non-low-income	800	400	1,200
Total	1,000	500	1,500

*defined as a rural cooperative with fewer than 50 residential customers per square mile, or a municipal utility with fewer than 10,000 customers.

The sample was be geographically stratified in two ways: (1) by region within the state; and, (2) by ZIP code according to the probability that a given household is a customer of a rural utility.
In terms of regions, the state was divided (by county) into four quadrants as shown in Figure 1

Figure 1. County-based quadrants for geographic stratification.

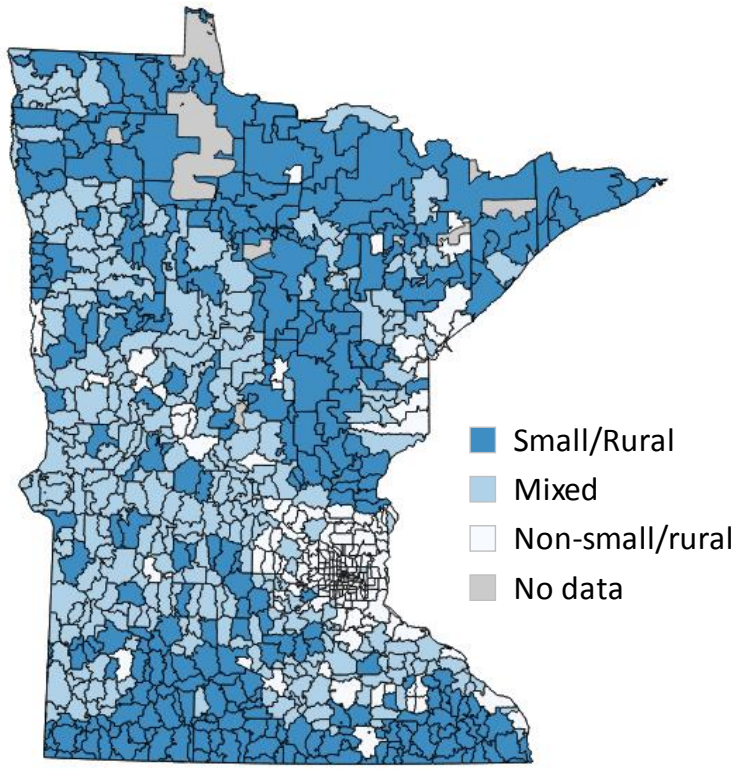


ZIP codes within each quadrant were then grouped into three categories based on the percent of single-family households that are estimated to be customers of a small municipal or rural cooperative utility:

1. *Small/Rural*—80 percent or more;
2. *Non-small/rural*—20 percent or less,
3. *Mixed*—21 to 79 percent

These classifications were derived by intersecting ZIP code boundaries with electric-utility service territory maps, and then apportioning Census estimates of housing units by utility. Figure 2 shows the classification of the roughly 900 Minnesota ZIP codes by these three types. About 39 percent of ZIP codes were classified as small/rural, 27 percent as non-small/rural and 34 percent as mixed. Note however, that due to the higher concentration of homes in cities (especially the Twin Cities metropolitan area), less than 20 percent of all single-family households are estimated to be in ZIP codes that are dominantly served by small/rural utilities, while more than 60 percent are in non-small/rural utility ZIP codes.

Figure 2. Minnesota ZIP code classification by electric-utility type.



The sample was also stratified demographically in terms of household income (above or below 200% of the federal poverty guideline) and household type. Three household types were defined:

1. *Non-senior*—no children and no adults age 65 or more
2. *Children*—families with children
3. *Senior*—no children and at least one household member age 65 or more

These strata were mainly intended to ensure that the final survey sample would be demographically representative of the population of Minnesota households in single-family homes.

Table 2 shows the completion quotas for the survey across the geographic and demographic strata. These quotas were meant to be proportional to the population of single-family households across quadrants and by household type, with low-income household quotas being slightly higher than the expected population proportions. There was an intentional significant oversample of rural-class ZIP codes to achieve the desired number of completions among customers of rural utilities. As described later, case weights were used to ensure that statewide and regional statistics would appropriately reflect the total population of single-family households.

Table 2. Survey completion quotas.

Quadrant	ZIP-code class	Non-Low-income non-senior	Non-Low-income children	Non-Low-income senior	Low-income non-senior	Low-income children	Low-income senior	Total	
SE	Small/rural	95	75	45	10	15	20	260	720
	Mixed	50	45	25	5	10	5	140	
	Non-small/rural	115	100	55	15	20	15	320	
SW	Small/rural	80	50	45	15	15	20	225	290
	Mixed	25	15	10	5	5	5	65	
	Non-small/rural	0	0	0	0	0	0	0	
NW	Small/rural	50	30	25	5	10	15	135	195
	Mixed	15	10	10	5	5	5	50	
	Non-small/rural	5			5			10	
NE	Small/rural	90	55	55	15	20	20	255	295
	Mixed	5	5	5	5			20	
	Non-small/rural	10			10			20	
Total		1,200			300			1,500	

"non-senior" means household with no children and no adults age 65 plus; "children" means any household with children below age 18; "senior" means household with no children and any adult age 65 plus.

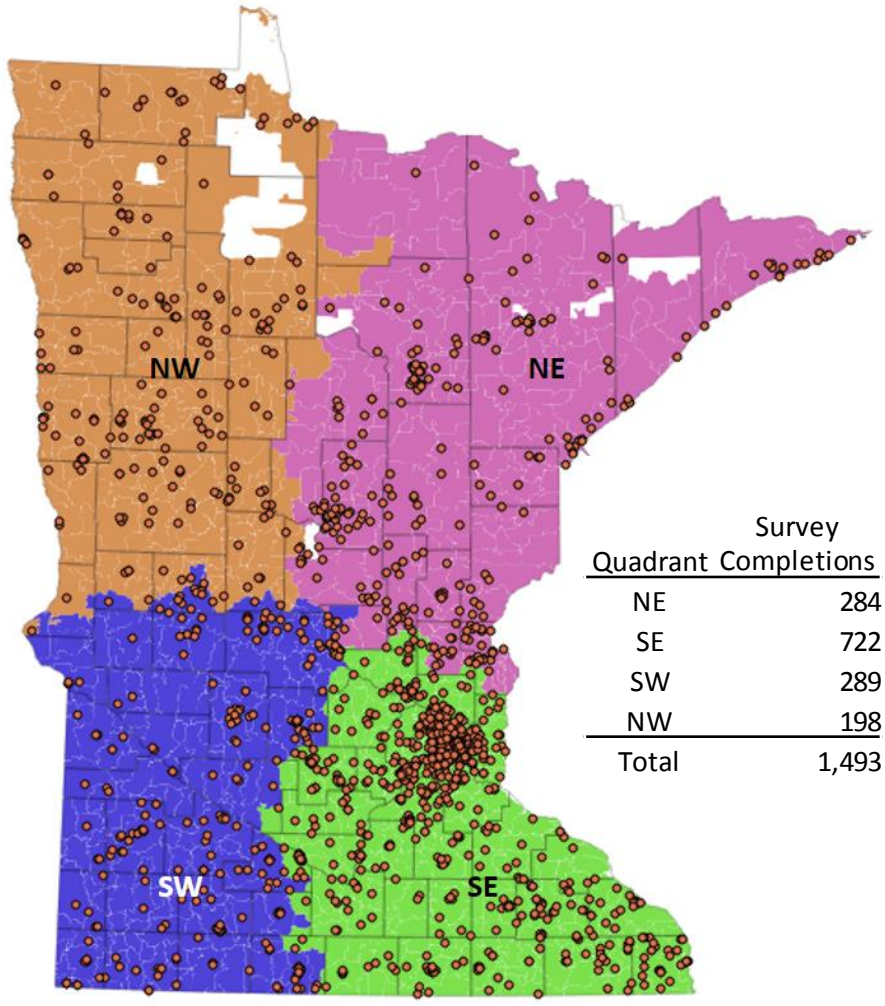
The survey instrument covered the following topics:

- Home characteristics
- Heating and cooling
- Water heating
- Appliances
- Laundry
- Other appliances/equipment
- Lighting
- Energy efficiency program awareness
- Demographics

Survey Implementation

The survey was fielded between July and October 2017 using a purchased (from InfoUSA) statewide sample of Minnesota single-family homes. The survey yielded 1,493 completions and had a response rate of 5.8 percent.[1] Figure 3 shows the distribution of survey respondents around the state. As Table 3 shows, actual completions were fairly close to target values for key subgroups.

Figure 3. Approximate location of survey respondents.



Quadrant	Survey Completions
NE	284
SE	722
SW	289
NW	198
Total	1,493

[1] Response rate is calculated here using the R/(U+IS+R) method put forth by the Marketing Research and Intelligence Association.

Table 3. Target and actual telephone-survey completions.

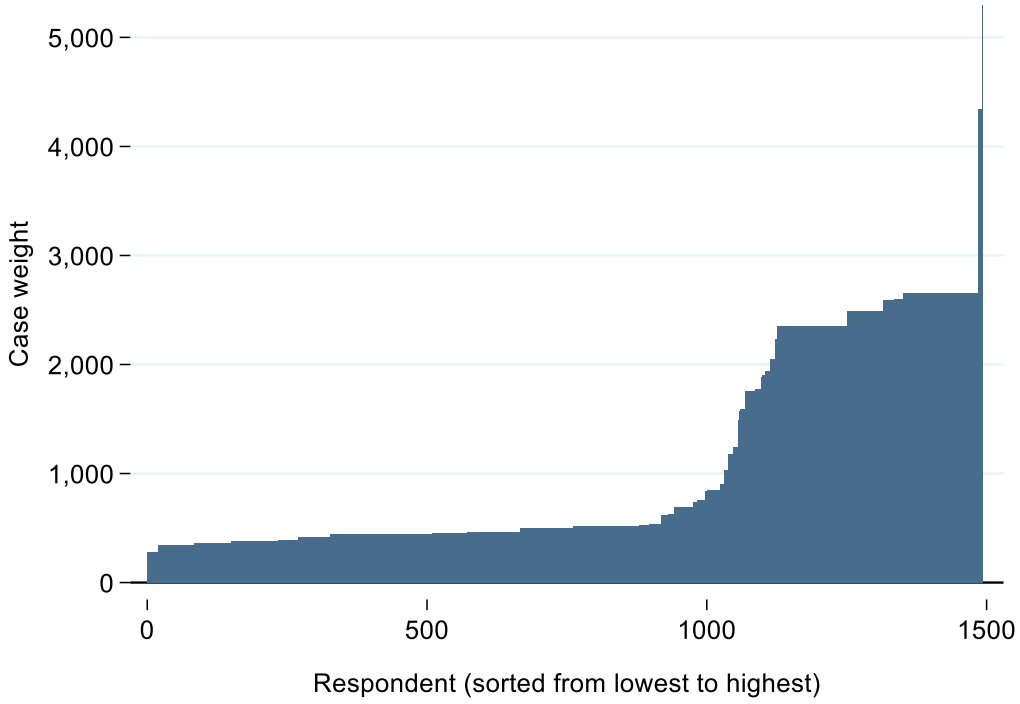
	Small/rural utilities*		Other utilities		Total	
	Target	Actual	Target	Actual	Target	Actual
Low-income	200	208	100	91	300	299
Non-low-income	800	782	400	412	1,200	1,194
Total	1,000	990	500	503	1,500	1,493

*defined as a rural cooperative with fewer than 50 residential customers per square mile, or a municipal utility with fewer than 10,000 customers.

Case weights were developed to ensure that the final survey sample properly reflected the geographic and demographic proportions of single-family homes per Census data.[2] The case weights were designed to sum across the survey sample to the Census-based count of total single-family housing units in the state (1,582,640). Case weights ranged from 276 to 5,293, with a median case weight of 503. Only a handful of cases had case weights of more than 2,700 (Figure 4), which were from non-low-income respondents in the Northeast quadrant of the state.

[2] A case weight is a multiplier applied to each survey respondent to reflect the number of households in the total population represented by that respondent.

Figure 4. Distribution of case weights for single-family telephone survey (n=1,493).



A Microsoft Excel document containing the survey instrument, selected cross-tabulations and anonymized responses is available on the project website.

Site Visits

As part of telephone survey, respondents were asked if they would be willing to allow a field technician to collect more detailed information about their home during a two- to four-hour site visit, with a $100 gift-card as a participation incentive.

Twenty eight percent of survey respondents (n=415) indicated willingness to participate in this follow-up effort. From this pool, 108 households were eventually scheduled and visited, as shown in Table 4.

Table 4. Completed site visits, by state quadrant, type of electric utility and low-income status.

	Rural/small utility customer		Other utility customer		
Quadrant	Non-low-income	Low-income	Non-low-income	Low-income	Total
NE	11	8	2	3	24
NW	6	8	1	1	16
SE	7	6	28	6	47
SW	10	6	4	1	21
Total	34	28	35	11	108

As with the telephone survey, case weights were used to geographically and demographically balance the overall sample to reflect the statewide population.

The site visits were used to collect detailed information about homes that was not amenable to reporting by telephone. Data collection elements included:

- Insulation levels
- Air-leakage rates (blower-door test)
- Window characteristics
- Lighting inventory
- Heating, cooling and domestic hot water system information
- Household appliance characteristics (e.g. refrigerators, clothes washers and clothes dryers)
- Presence and type of selected electronics, such as TVs and computers

Use of Results in the Potential Study

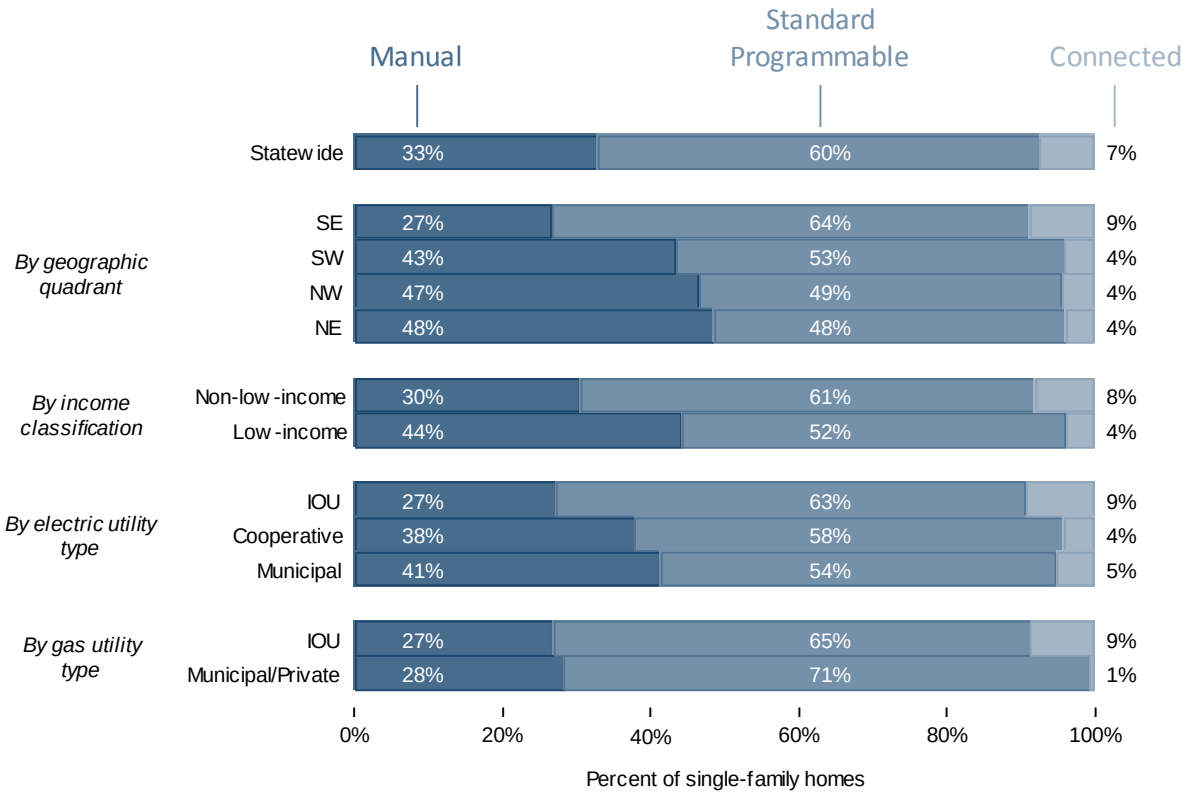
The survey and site-visit data were used in several ways in the potential study. First, the telephone survey data were helpful in the disaggregation of residential electricity and natural gas sales into end-uses in ways that accounted for geographic and demographic variation across utility service territories. For example, the number of refrigerators per home was imputed at the utility level by first fitting an ordered logistic regression model of number of refrigerators as a function of household income, household size and state quadrant—and then applying the model to utility-level Census data. As Table 5 shows, the survey-based model indicates that the fraction of households with multiple refrigerators increases with both income and household size. Similar models (using a variety of survey-based explanatory variables) were developed to impute the distribution of single-family heating, cooling and water heating system type across the state at the utility level. These estimates would not have been possible without a comprehensive statewide survey sample.

Table 5. Model estimates of percent of households with more than one refrigerator as a function of household income and size.

Annual income	Number of household members				
	1	2	3	4	5+
<$20k	22%	26%	30%	31%	43%
$20k-$39k	26%	29%	34%	38%	52%
$40k-$59k	37%	43%	48%	54%	62%
$60k--$79k	38%	42%	47%	54%	62%
$80k-$99k	39%	44%	49%	55%	62%
$100k-$119k	43%	49%	54%	59%	68%
$120k-$139k	40%	49%	55%	60%	73%
$140k+	58%	61%	66%	70%	76%

Second, the telephone survey data provided information about the current saturation of energy efficiency opportunities that were amenable to data gathering via telephone survey. Most notable among these is type of thermostat: they survey data revealed geographic and demographic differences in the proportions of manual, traditional programmable and connected thermostats among subgroups in the state (Figure 5). The survey data were thus used to impute *not-complete* factors for programmable thermostats at the utility-grouping level in the potential study taking these differences into account, and thus provided better geographic and demographic distinction for this measure than would otherwise have been possible.

Figure 5. Type of thermostat.



Similarly, the site visit data were valuable to help establish the existing saturation of high efficiency equipment, such as condensing furnaces and high-efficiency clothes washers. The site visits (along with other data) were also instrumental in helping set the remaining potential for building shell retrofits such as air-sealing and ceiling insulation. For example, Figure 6 shows average blower-door measured air leakage as a function of home age from the site-visit sample.

Figure 6. Mean measured air leakage (air changes per hour @ 50Pa) by home age for site-visit sample.