Evaluating energy efficiency potential in low-income households: a flexible and granular approach

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Abstract

This study presents a new approach to evaluating energy efficiency potential that provides a more accurate, granular, and flexible estimate of the cost-effective energy efficiency potential in households of various income ranges.

Results from this work estimate that in U.S. single-family households with income less than 200% of the federal poverty level, energy efficiency packages tailored to maximize net present value could result in an estimated $13 billion per year in energy cost savings, or $670 per year for an average household, corresponding to about 1 EJ (0.9 quads) of annual primary energy savings. These types of metrics can be estimated for other geographies (regions, states, and counties) and for other ranges of household income.

These results can be used by policymakers and program designers to improve the cost-effectiveness of income-qualified programs and to improve the equity of non-income-qualified programs. The results can also be used to understand how energy efficiency opportunities differ between urban and rural areas, as well as how energy efficiency can spur economic development in areas that have had high poverty rates for decades.

Keywords: energy efficiency potential, cost-effectiveness, energy modeling, building stock modeling, weatherization, low-income housing

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1. Introduction

In the United States, low-income households spend an estimated 16.3% of their household income on energy used in the home, compared to 3.5% spent by non-low-income households (Eisenberg, 2014).[1] While average U.S. residential electricity prices increased 39% between 2004 and 2014, U.S. average adjusted income only grew by 0.9% during the same period (Drehobl and Ross, 2016). This increasing *energy burden*—housing energy expenditures as a percentage of household income—means that these households often must cut back on healthcare, transportation, groceries, and childcare expenses to pay their energy bills (DOE, 2017). Customers' inability to pay energy bills can lead to higher costs for all utility ratepayers due to the logistical cost of shutoffs, debt collection, or debt cancellation (Drehobl and Ross, 2016). For these reasons, addressing high energy costs in low-income households is of interest to non-profit organizations, utility companies, and federal, state, and local governments. Additionally, such organizations recognize that saving energy in low-income households is a key component of their energy or greenhouse gas emissions goals, and that the low-income sector faces several significant barriers to investment (e.g., lack of up-front funds or financing, and a split incentive in renter-occupied housing (Levinson and Niemann, 2004)).

The goal of this work is to provide an improved understanding of the energy efficiency potential (and associated co-benefits) in U.S. households with low- and moderate-incomes and living in single-family detached housing. Instead of relying upon projections based on historical energy savings, this work uses an analysis tool that leverages new data sources, physics-based simulation, and modern computing resources to provide a more accurate, granular, and flexible estimate of the energy efficiency potential across the diversity of the U.S. housing stock inhabited by low- and moderate-income households. The results are *accurate* in that they account for correlations between household income and energy-related building characteristics (e.g., floor area or presence of central air conditioning). The results are *granular* in that they can be provided for individual U.S. counties and for household seg-

[1]The statistic in this sentence uses <200% of the federal poverty level to define "low-income." However, in this article we do not use a specific definition for "low-income" or "moderate-income"; our methodology allows for flexibility in definition based on the needs of the analysis.

ments within each county, accounting for the characteristics of each county's housing stock, such as the prevalence of older housing in urban core counties or propane heating in rural counties. The results are *flexible* in that they can be provided for whatever range of household incomes is relevant for a particular application (e.g., 0%–80% of area median income (AMI) for households eligible for U.S. Department of Housing and Urban Development assistance programs or percent increments of the Federal Poverty Level (FPL), which is used for the U.S. federal Weatherization Assistance Program (WAP) and Low Income Home Energy Assistance Program (LIHEAP).

2. Background and literature review

U.S. electric and gas utilities invested $8.0 billion in energy efficiency programs in 2015, but only 9%[2] of those funds were devoted to low-income programs (CEE, 2017). As a point of reference, households below 200% FPL comprise 23% of electricity and 22% of natural gas use (EIA, 2013). This begs the question of how much potential for energy efficiency remains in low- and moderate-income households.

Attempts to quantify energy efficiency potential in low-income households are typically limited in several ways:

1. They are based on historical savings numbers (Hoffman, 2017; Barbose et al., 2013; Drehobl and Ross, 2016). While it is useful to have estimates that are realistic, projections based on historical savings are inherently limited to estimating future savings based on the technologies, policies, and housing stock of past initiatives.
2. They do not account for housing characteristics specific to different ranges of household income (Hoffman, 2017). For example, the savings potential in households with less than 200% of the FPL should not be extrapolated to household in the 200%–300% range, who may live in different areas and in homes of different vintages, sizes, heating/cooling equipment, etc.
3. They are often geographically coarse. Historical savings are often national or regional aggregations. Estimates based on modeling often use

[2]This figure is calculated as an expenditure-weighted average of 6% of $6.7 billion spent by electric utilities and 27% of $1.29 billion spent by gas utilities, derived from data in Figures 4, 5, 9, and 10 of the report from Consortium for Energy Efficiency (CEE), 2017.

a handful of prototypical buildings in a handful of regions (Bradshaw et al., 2014). Both approaches are limited in their ability to provide guidance on which energy efficiency measures are most cost-effective for a particular state, county, climate zone, or housing type. These limitations can lead to sub-optimal investments. Differences in the housing stock between urban, suburban, and rural areas (e.g., propane use in rural areas) can have a large impact on measure prioritization and cost-effectiveness, which is important when developing programs for these varying socioeconomic contexts.

The methodology described in Section 3 aims to address these limitations and provide estimates of energy efficiency potential in low- and moderate-income households that are more accurate, granular, and flexible.

3. Methods and data

This work seeks to evaluate the applicability and potential impact of various energy efficiency upgrades on households across the U.S. as a function of various household demographic parameters related to income. Highly geographically-resolved household-level statistical data that incorporate the household characteristics of interest were derived from multiple data sources. These data were processed and applied to results from a residential building stock model to derive the desired results regarding the effect of the energy efficiency upgrades considered in this work.

3.1. Modeling the residential building stock

ResStock, a bottom-up, engineering-based, residential building stock model, is used to estimate the energy savings potential of various energy efficiency upgrades. ResStock represents the approximately 80 million single-family detached homes using a set of 350,000 building archetypes (Wilson et al., 2016, 2017). These representative archetypes are based on statistical analysis of the characteristics of the residential building stock to capture the wide variability in construction types, equipment and appliance configurations, climate conditions, and other factors that influence building energy use. The resulting model represents the stock with much higher granularity and specificity than other approaches in the literature. For full details on the ResStock methodology, see Wilson et al. (2017). In this work, the inherent granularity in the results from ResStock, along with the enhancements described below, facilitate the county-level analysis of the energy use impacts of a range of building efficiency upgrades across various bins of household income.

3.2. Modeling scope and limitations

ResStock modeling capabilities are currently limited to single-family detached structures in the 48 contiguous U.S. states. Following the definition used by the U.S. Energy Information Administration (EIA), "single-family detached" includes site-assembled manufactured housing units, but does not include true mobile homes that are "built on a movable chassis and moved to the site." (EIA, 2018). Incorporating single-family attached and low-rise multifamily apartment buildings into ResStock is an area of active work.

The underlying data for ResStock are derived from an array of sources that generally lag five to ten years behind the current year. As a result, upgrades to homes completed in that period, and the resulting reductions in energy use and economic potential are not explicitly accounted for in these results. U.S. Department of Energy's Weatherization Assistance Program (WAP) reaches approximately 35,000 homes per year, which represents roughly 0.1% of eligible households, thus the results in this study might not fully account for improvements made to between 0.5%–1% of WAP-eligible homes. These results also do not account for energy efficiency upgrades made to non-WAP-eligible homes during the same period.

Sources for ResStock building characteristics data generally do not have large enough sample sizes to include Alaska, Hawaii, and U.S. territories in analyses. Caution should be taken when using ResStock results for counties partially or wholly within American Indian reservations. ResStock data sources generally do not capture the differences in housing characteristics and energy use on tribal lands compared to surrounding areas.

3.3. Identifying housing characteristics correlated with income

To estimate which energy-related housing characteristics are most correlated to household income, a multiple linear regression (MLR) analysis was applied to various datasets. The MLR analysis develops linear models for describing the relationship between a dependent or response variable (household income) and a set of independent or explanatory variables (house size, vintage, heating fuel, etc.). This relationship is determined by calculating a regression equation intercept and set of coefficients such that the residuals between the fitted line and observed data are minimized in the least-squares sense. Specifically, the output from the R software's MLR program consists of both coefficient estimates and probability values for the independent variables included in the regression (The R Development Core Team, 2012). While a coefficient's magnitude and sign reflect its corresponding variable's relative impact on household income, the probability value can be interpreted to measure the level of significance in predicting household income. Additionally, the R^2 and adjusted R^2 values are output for each regression. These statistics give a sense for how close the actual data are to the predicted data. See Heaney and Polly (2015) for more information on MLR in the context of building energy use.

For this analysis, observed values from three sets of data were used to develop an MLR model for each of three datasets: 1) 2009 Residential Energy Consumption Survey (RECS) (EIA, 2013), 2) the American Community Survey (ACS) (Manson et al., 2017), and 3) the American Housing Survey (AHS) (U.S. Census Bureau, 2013).

Results from the RECS MLR are shown in Table 1. The RECS MLR included the dependent variable "household income" and the independent variables were vintage, size (floor area), reportable domain, heating system type, heating fuel type, heating system age, heating setpoint, cooling system type, cooling system age, cooling setpoint, type of window glass, and number of household members (EIA, 2013). See Table D.17 and Table D.18 of Appendix D for results from the AHS MLR and PUMS MLR.

3.4. Data sources

Based on the MLR results, the household characteristics related to household income, including income itself, were sought for households in the U.S. so that they could be applied on top of ResStock results. To obtain all of these parameters, two datasets were required—the American Community Survey (ACS) and the American Housing Survey (AHS), both collected by the U.S. Census Bureau, though the latter is funded by the U.S. Department of Housing and Urban Development (HUD).

ACS and AHS provide the major parameters of interest for this work by location. Using geographically-resolved data enables investigation of the impacts of various efficiency upgrades as a function of location, since income-linked household characteristics vary by location. All of the data used for this study were restructured onto a census tract basis, though only the parameters available from ACS were originally specified by census tract. Since the AHS data are only available at lower geographic resolution, and the sample size in

Table 1: RECS dataset MLR model output[a,b,c]

Variable	Estimate	Std. Error	t value	$Pr(>\|t\|)$
size=3500+	44,842	2,396	18.717	7.09E-75
size=2500-3499	31,111	2,166	14.360	1.37E-45
size=1500-2499	15,876	1,725	9.202	5.61E-20
nhsldmem	3,792	475	7.989	1.78E-15
reportable_domain=21	26,556	3,449	7.699	1.74E-14
reportable_domain=26	31,529	4,273	7.378	1.95E-13
reportable_domain=4	35,766	5,005	7.146	1.07E-12
reportable_domain=14	32,526	4,957	6.562	6.02E-11
reportable_domain=13	28,387	4,541	6.251	4.52E-10
temphome	-1,209	200	-6.044	1.64E-09
reportable_domain=5	29,614	4,909	6.032	1.77E-09
vintage=2000s	14,818	2,774	5.342	9.75E-08
reportable_domain=24	24,284	4,704	5.163	2.55E-07
reportable_domain=3	30,758	6,071	5.066	4.25E-07
reportable_domain=17	17,690	3,744	4.725	2.38E-06
reportable_domain=1	50,695	11,096	4.569	5.06E-06
typeglass=2+ Pane	7,314	1,605	4.558	5.33E-06
reportable_domain=6	19,720	4,395	4.486	7.45E-06
reportable_domain=7	17,772	4,012	4.430	9.67E-06
reportable_domain=22	38,318	8,688	4.410	1.06E-05
equipm=Steam or Hot Water System	32,652	8,626	3.785	1.56E-04
reportable_domain=8	20,322	5,420	3.749	1.80E-04
vintage=1990s	10,070	2,697	3.733	1.92E-04
vintage=1980s	10,469	2,812	3.722	2.00E-04
reportable_domain=2	40,836	11,232	3.636	2.81E-04
reportable_domain=18	13,594	3,796	3.581	3.46E-04
reportable_domain=10	16,494	4,797	3.438	5.91E-04
reportable_domain=25	20,169	6,089	3.313	9.33E-04
(Intercept)	74,321	23,871	3.114	1.86E-03
equipm=Heat Pump	22,959	7,661	2.997	2.75E-03
reportable_domain=12	11,625	4,603	2.526	1.16E-02
agecenac=15-19 yrs	9,586	3,841	2.496	1.26E-02
equipm=Central Warm-Air Furnace	15,443	7,361	2.098	3.60E-02
reportable_domain=19	9,577	4,589	2.087	3.70E-02
reportable_domain=11	9,771	5,209	1.876	6.07E-02
reportable_domain=27	13,672	7,428	1.841	6.57E-02
reportable_domain=20	7,461	4,093	1.823	6.84E-02
equipm=Built-In Electric Units	16,745	9,463	1.770	7.69E-02
vintage=1970s	4,652	2,748	1.692	9.06E-02
equipage=20+ yrs	5,895	3,520	1.675	9.41E-02
agecenac=10-14 yrs	5,146	3,245	1.586	1.13E-01
agecenac=2-4 yrs	5,631	3,588	1.570	1.17E-01
equipm=Other Equipment	17,584	11,517	1.527	1.27E-01
equipage=5-9 yrs	5,150	3,430	1.501	1.33E-01
reportable_domain=9	10,500	7,069	1.485	1.38E-01
equipage=2 yrs	5,627	4,179	1.347	1.78E-01
fuelheat=Natural Gas	11,937	9,222	1.294	1.96E-01

[a] $R^2 = 0.257$, Adjusted $R^2 = 0.245$

[b] Variables with $Pr > 0.20$ were truncated from this table.

[c] Refer to the 2009 RECS Microdata Variable and Response Codebook for variable name meanings. Heated/Cooled floor area was binned into four bins with units of "ft^2". The "temphome" variable, representing the temperature when someone is home during the day (winter), is a continuous variable with units of "degrees Fahrenheit"; all other variables are categorical. Categorical variables included in the intercept reference are: size=0-1499, vintage=1960s, reportable_domain=15, equipm=Floor or Wall Pipeless Furnace, fuelheat=Other Fuel, typeglass=1 pane, equipage=15-19 yrs, agecenac=20+ yrs.

ACS is too small to support robust results at the census tract level, results from this analysis are presented at the county level.[3]

In the U.S., government programs typically use one of several metrics to normalize household income[4], including *federal poverty level* (FPL) (HHS, 2017b; 2017a), developed by the U.S. Census Bureau for the Department of Health and Human Services (HHS), and *area median income* (AMI) and *state median income* (SMI) (HUD, 2017), developed by HUD. FPL is the same for the entire continental U.S., with separate rates for Alaska and Hawaii. Conversely, AMI is specified by county and/or metropolitan statistical area (MSA), and SMI is specified by state. These income metrics are typically specified as a percentage, where the nominal level is set to 100%. There are significant differences in the cost of living between states and between urban and rural areas within states; AMI tracks these variations whereas FPL does not. Low-income programs often use a household income less than 200% of FPL as the eligibility criterion for receiving assistance. The Low Income Housing Tax Credit for affordable housing investments is one example of a program that uses a percentage of AMI for eligibility. For most of the results shown in this work, FPL is adopted for the normalized income thresholds, though results can be aggregated into either FPL or AMI bins.

The ACS data employed for this analysis were derived from the 2011–2015 ACS 5-Year tables. Because 2012–2015 ACS data use the 2010 ACS Public Use Microdata Areas (PUMAs), derived from the 2010 Census, whereas 2011 ACS data uses 2000 PUMAs, data from 2011 were discarded. The ACS 5-Year tables provided household income, building vintage (age of structure), structure type, number of household occupants, and owner/renter parameters for each census tract. Each of these parameters are categorical; for example, building vintage is specified as "before 1940," "1940–1959," "1960–1979," "1980–1999," "2000–2009," and "after 2010." The tables with these parameters include no more than three parameters simultaneously, e.g., census tract,

[3]Census tracts are subdivisions of counties and states (U.S. Census Bureau, 2017b); as a point of comparison, there are 73,057 census tracts (U.S. Census Bureau, 2017a) and 3,141 counties (U.S. Geological Survey, 2017) in the 50 states comprising the U.S.

[4]For the purposes of this analysis, "normalized income" metrics represent gross income as a function of the number of individuals in a household. These metrics better represent the impact that dependents have on income needs, and thus eliminate household size-dependence on disposable income, which can influence energy-related housing characteristics (e.g., housing unit size or cooling system type).

household income, and owner/renter status; therefore, cross-tabulations had to be generated to obtain the relationships between the ACS variables of interest for individual households.

3.5. Preparing household characteristics data

Iterative proportional fitting (IPF) was employed to develop these cross-tabulations of the ACS data. IPF is a method by which a cross-tabulation of multiple parameters can be calculated using the independent distributions of each of the parameters and an initial guess of the cross-tabulation (Deming and Stephan, 1940). For example, in a dataset with a population of individuals, if the number of individuals in decadal age bins and in eye colors are known, but the distribution of individuals by eye color within each age bin (the cross-tabulation of the two parameters) is not known, IPF can be used to calculate an estimate of those distributions. In the case of the ACS data, available cross-tabulations included, for example, census tract–owner/renter status–building vintage and census tract–housing tenure–household income, which could then be combined using IPF to yield a cross-tabulation with census tract, housing tenure, building vintage, and household income. Because IPF requires that all of the margins have identical sums (the samples in each cross-tabulation combined must be exactly the same size), all of the ACS tables used to obtain the desired parameters were derived from tables in the "occupied housing units" universe. Each of the ACS tables containing one or more parameters of interest for this analysis were thus combined together using IPF until a single cross-tabulation with all of the parameters of interest was obtained. The required ACS cross-tabulation for this analysis was obtained from DOE's Low-income Energy Affordability Data (LEAD) tool (DOE, 2017). The data tables in the LEAD tool were generated using IPF.

AHS data were used to obtain the two parameters of interest not available from ACS—floor area and cooling system type. The AHS data are provided as microdata, which obviates the need for IPF to obtain the desired cross-tabulation. For privacy reasons, households in the AHS microdata are specified with limited, and varying, geographic resolution. Most households in major cities are specified by their MSA; households outside MSAs are specified by census division, with the South Atlantic and East South Central, and Mountain and Pacific census divisions merged, thus yielding seven census divisions. To combine these data with the ACS data, the AHS microdata were converted to a cross-tabulation with the parameters common to both datasets—location, housing tenure, building vintage, household income, and number of household occupants—and the parameters available only from the AHS data. The common parameters were categorized using the same bins as those employed in the ACS data. Finally, for each combination of the common parameters, the household counts for each unique combination of cooling system type and floor area range were converted into weights.

Following preparation of the AHS and ACS data into cross-tabulations containing the desired parameters from each source, the two cross-tabulations were merged to yield an estimate of the full cross-tabulated relationships between all of the parameters. To reduce the computational burden of combining the data, the household income and number of household occupants parameters were first combined and replaced with FPL or AMI. Both household income metrics were specified in bins; in the case of FPL, 50% FPL size bins from 0%–300% FPL (e.g., 0%–50%, 50%–100%), and a top bin for households over 300% FPL; and for AMI, the bins largely matched those used by HUD but added a 100% threshold: 0%–30%, 30%–50%, 50%–80%, 80%–100%, 100%–120%, and over 120%.

In addition, to support combination of the AHS and ACS cross-tabulations, the AHS-sourced data were remapped to a census tract basis. For census tracts within an MSA included in the AHS-sourced data, it was assumed that the data from AHS for that MSA applied to the census tract. If no MSA applied, the data from AHS for the applicable census division were used. This remapping facilitates joining of the cross-tabulations from the AHS and ACS on their common parameters, but does not fundamentally improve the geographic resolution of the AHS-sourced data. Because of this shortcoming in the AHS-sourced cross-tabulation, those data were used only as weights for the distribution of households across the parameters derived from the AHS data—household totals for each of the common parameters were taken from the ACS-derived cross-tabulations. The final cross-tabulation combining the parameters obtained from the AHS and ACS data specifies the household count and the household weights for each combination of FPL or AMI and housing tenure, for each census tract, building vintage, floor area, and cooling system type.

3.6. Simulations

The ResStock workflow was used to run over 20 million detailed subhourly-timestep annual EnergyPlus™[5] building energy simulations on high-performance computing nodes. These simulations included a baseline run of the 350,000 representative home models, and runs of the 350,000 models (or applicable subsets) for around 50 single-upgrade, package, and reference scenarios. Energy savings are calculated as the difference in energy use between results from a simulation with an upgrade applied and the reference simulation where either nothing changes from the baseline (typical for enclosure upgrades) or equipment is upgraded to federal minimum efficiency standards at wear out (typical for equipment upgrades). See Wilson et al. (2017) for further details.

3.7. Mapping simulation results to income distributions

For ResStock analyses of the approximately 80 million single-family detached homes, each of the 350,000 models has a weighting factor of around 230, meaning that each represents around 230 real single-family homes. For each home model, the weighting factor of 230 was distributed into FPL or AMI (and housing tenure) bins so that savings metrics can be aggregated for various FPL or AMI ranges (and/or housing tenure groups). Table A.2 shows an example table used to distribute weighting factors into FPL and housing tenure bins, while accounting for census tract, vintage, house size, heating fuel type, and AC type. A network dependency graph showing the relationship between FPL/AMI and other parameters is included in Appendix B.

Each of the 350,000 models was matched to the rows in the cross-tabulations described in Section 3.5. The parameters used for matching were building vintage, floor area, and cooling system type, as well as the climate subregion (N=216) containing each census tract. This matching process between the simulation results and household characteristics cross-tabulations avoided the need to run multiple EnergyPlus simulations for otherwise identical households having different incomes or located in different census tracts within a climate subregion, dramatically improving the computational efficiency of the analysis.

[5] EnergyPlus™ is a whole-building energy simulation program that engineers, architects, and researchers use to model energy consumption. Its development is funded by the U.S. Department of Energy's (DOE) Building Technologies Office (BTO). See https://energyplus.net/.

3.8. Economic calculations

Electricity rates were assumed to be flat volumetric charges ($/kWh) and were derived from EIA Form 861 sales and revenue data for 2013 (EIA, 2017a). Marginal $/kWh rates were estimated by assuming $8 per month in fixed customer charges along with average monthly electricity consumption, and were applied at the county level based on utility service territories reported on EIA Form 861 (EIA, 2017a). Rates for on-site natural gas, propane, and fuel oil use were derived from data from EIA (2017b; 2017c), and were applied by state.

As described in Wilson et al. (2017), upgrade costs were primarily from the National Residential Efficiency Measures Database (Roberts, 2012). Net present value calculations were from the building owners' perspective. For renter-occupied housing, it is assumed that either the building owner pays the utility bills or rent can be increased by an amount equal to utility bill savings. Thirty years of future cash flows (energy cost savings, equipment replacement at end of life, and residual value) were brought to the present using a 3% real discount rate.

3.9. Future work

There are several areas in which the methodology could be improved. First, field measurements have shown that low-income households live in homes with enclosure air leakage rates 50% higher than other homes (Chan et al., 2012). Currently, our model does not explicitly capture this relationship, though it does account for the fact that older homes are leakier and low-income households are more likely to live in older homes.

Secondly, the current model does not explicitly model the relationship between number of occupants and household income, though analysis of 2009 RECS microdata shows that low-income households are more likely to have a higher number of occupants (EIA, 2013). There are likely other examples of housing characteristics that are correlated with income and not captured in the current model that might warrant further investigation.

Finally, the methodology could be expanded to account for home health risks, which have been correlated with lower income levels (Office of the Surgeon General (U.S.), 2009, Chapter 2). Home health risks are an important factor for low-income programs because remediation of these risks (mold, radon, pests, etc.) can greatly increase the costs of home retrofits and are thus a barrier to program implementation. Conversely, the economic benefits of mitigating these health risks—increased wages and productivity due to reduced medical absences, as well as reduced medical bills—can be significant, and if quantified as co-benefits, can increase the cost-effectiveness of programs (Tonn et al., 2014).

4. Results and discussion

4.1. Overview of results

The analysis methodology described in Section 3 results in the ability to estimate potential annual energy and cost savings for 50+ upgrades and packages, for all 3,107 counties in the 48 contiguous U.S. states.[6] Results can be filtered by various cost-effectiveness criteria, so that energy and cost savings are only counted when they result from an upgrade in a household where the criterion is met. The results presented below all use "net present value > 0" as the criteria for *economic potential*.

To accommodate varying definitions of low- and moderate-income households, the results are flexible: they can be filtered for seven FPL bins (0%–50%, 50%–100%, 100%–150%, 150%–200%, 200%–250%, 250%–300%, and 300+%) and six AMI bins (0%–30%, 30%–50%, 50%–80%, 80%–100%, 100%–120%, and 120+%), or aggregations thereof. They can also be separated by housing tenure (i.e., owner-occupied and renter-occupied).

4.2. County-level maps

The choropleth maps presented in this section show examples of county-level results that may be relevant for policymakers or energy efficiency program administrators.

To compare how effective an upgrade or package is at reducing energy consumption or expenditures in a given income bin and county of interest, the savings values are normalized as a percentage of the consumption or expenditures in that income bin and county:

$$\text{savings } \% = \frac{\sum_{i=1}^{m}(N_i E_{i,upgrade} - N_i E_{i,ref})}{\sum_{j=1}^{n} N_j E_{j,ref}} \times 100,$$

where E is each simulated home's annual energy use or energy cost, N is the number of households that the simulated home represents within this

[6] Results from this analysis are presented at the county level because sample size in ACS is expected to be too small to support robust results at the census tract level. Further investigation might determine that census tract level results have adequate certainty.

income bin and county, n is the set of all simulated homes representing the income bin and county of interest, and m is a subset of n where the upgrade is applicable and meets the NPV>0 criteria. In other words, for each county and income bin:

$$\text{savings \%} = \frac{\text{energy savings from applicable and NPV>0 upgrades}}{\text{total energy use for single-family homes}} \times 100,$$

It should be noted that these percentage savings maps are best suited for comparing *relative* savings between counties, as opposed to determining where the largest savings potential exists within a state. County maps of *absolute* savings (i.e., total dollars or kWh) would be less useful because absolute savings is primarily a function of the number of homes in a county, which varies greatly between urban and rural counties. Because of the large population differences between counties, these maps show percent savings not absolute savings, and thus one should avoid the temptation to "visually sum" the colored areas on the maps to estimate total savings potential for multiple counties or an entire state. State totals are more appropriately presented as tabular results. Appendix C presents state total absolute savings (energy costs, electricity, on-site fuel, and primary energy) for NPV-optimized packages for three FPL bins. We also include results for aggregations of counties associated with seven regional economic development commissions as well as an aggregation of all U.S. counties categorized as "persistent poverty counties."

Figure 1 shows the percentage energy cost savings for each county in six states, resulting from packages tailored to maximize NPV in each simulated home (including enclosure, equipment, appliance, and lighting upgrades; see Wilson et al., 2017 for details). There are several reasons why some counties have higher percentages than others, including:

1. Older vintages of housing stock, which provides more opportunity for upgrades
2. More homes using propane, fuel oil, or electric resistance for heating (which are typically more expensive per unit of heat than natural gas or electric heat pumps)
3. Higher electricity or fuel costs
4. More severe heating or cooling climates

These factors get conflated, making it difficult to identify distinct causes without more closely examining how housing characteristics vary between counties.

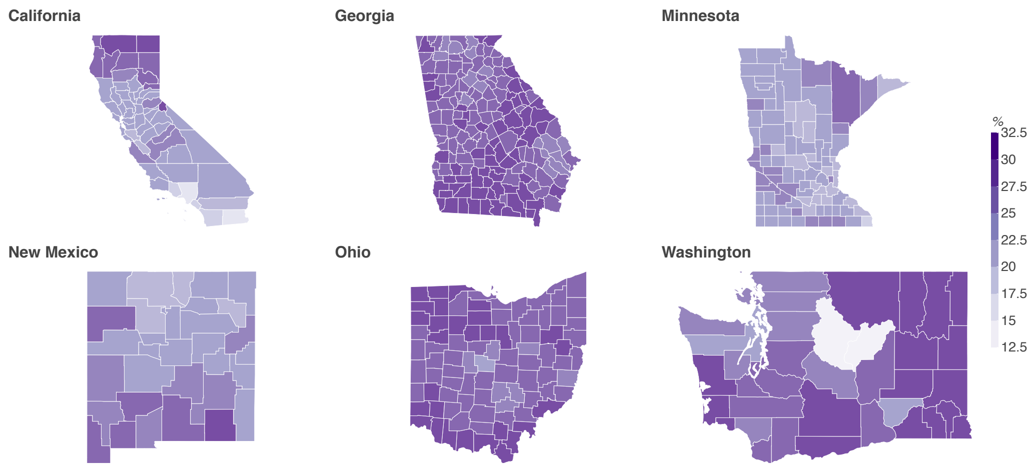

Figure 1: Percentage primary (source) energy savings resulting from packages tailored to maximize NPV in each simulated home, by county in six U.S. states

One can also examine differences in savings potential between different income bins. Figure 2 illustrates how in the state of Tennessee, the percentage energy cost savings resulting from adding R-13 insulation to empty wall cavities (upgrades with positive net present value only) is highest in the <200% FPL bin, and decreases as one moves to higher income bins. This suggests that across all counties, lower-income households tend to live in older homes that have uninsulated walls (reason 1 above). This result is reflective of the findings from our preliminary regressions that lower income households are often located in older homes, which in turn have less insulation and thus higher savings potential than higher income homes. As might be expected, the counties containing established urban areas (Memphis, Nashville, Chattanooga, Knoxville, and Johnson City–Kingsport–Bristol) consistently have higher primary energy savings potentials than surrounding suburban counties and counties with recent growth (e.g., Murfreesboro).

Figure 3 provides further insights by breaking down the savings potential within the lowest income bin of Figure 2 into owner-occupied and renter-occupied homes. In some counties, the percentage savings is higher in renter-occupied homes, but the opposite is true in other counties.

Figure 4 shows percentage energy cost savings for a different upgrade in Tennessee: upgrading electric furnaces to high-efficiency variable-speed heat pumps (SEER 22, HSPF 10). As with the wall insulation upgrade,

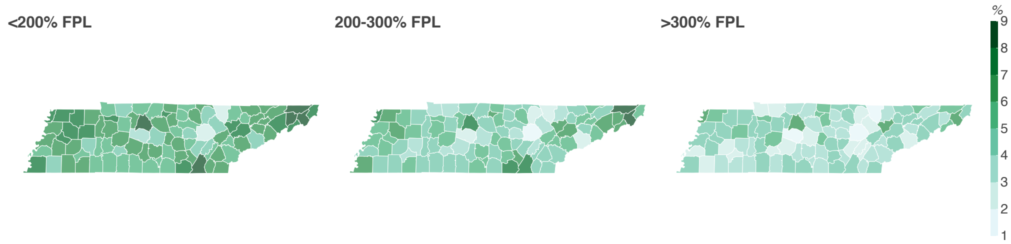

Figure 2: Percentage energy cost savings resulting from adding R-13 insulation to empty wall cavities (upgrades with positive net present value only), by county and income bin, in the U.S. state of Tennessee

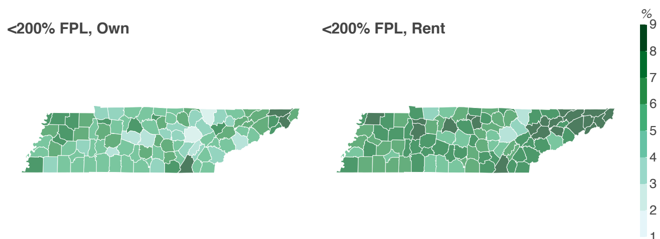

Figure 3: Percentage energy cost savings resulting from adding R-13 insulation to empty wall cavities (upgrades with positive net present value only), by county and owner/renter status (<200% FPL households only), in the U.S. state of Tennessee

the percentage savings decrease for higher income bins. Unlike the wall insulation upgrade, the highest savings are in the eastern and south-central parts of the state, where electric heating is more common. Whereas the wall insulation upgrade is typical of weatherization work, the high-efficiency heat pump is less commonly included in typical weatherization projects (Head, 2017). Thus, it is useful to highlight the fact that it is an important upgrade opportunity for lower-income households. Additionally, the high upfront cost of the measure is a market barrier that especially affects low- and moderate-income households, meaning it would particularly benefit from inclusion in financing programs, especially those targeted towards low- and moderate-income households in the eastern and south-central parts of the state.

Figure 5 presents percentage energy cost savings in the state of Ohio for an upgrade that is often a target of utility efficiency rebate program incentives: high-efficiency central air conditioners. The figure shows that the savings potential is higher in the >300% FPL bin and lower in the lower income bins. This reflects the fact that in Ohio, which has significant summer cooling loads but is not a cooling-dominated climate, the presence of central air

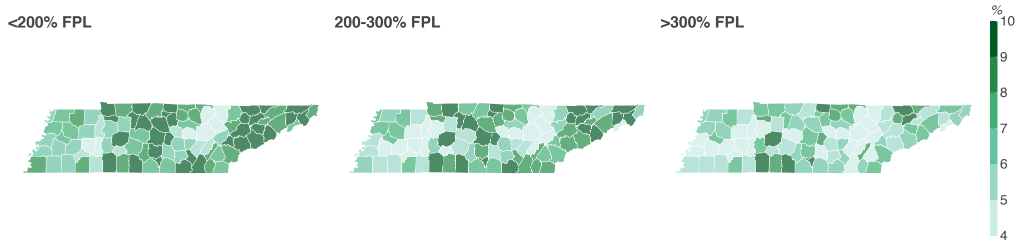

Figure 4: Percentage energy cost savings resulting from upgrading electric furnaces to SEER 22 HSPF 10 variable-speed heat pumps at wear out (upgrades with positive net present value only), by county and income bin, in the U.S. state of Tennessee

conditioning is correlated with higher household income. This is an example of an incentive where the participant benefits are regressively distributed. Nevertheless, energy efficiency improvements such as this benefit all utility ratepayers through system-wide cost savings (e.g., reduced peak demand) (Taylor et al., 2015).

In a complementary fashion, Figure 6 shows how the savings potential of room air conditioner (i.e., "window unit") upgrades is higher in the lower income bins. While the potential savings of room air conditioners is lower than that of central air conditioner upgrades, efficiency program designers might decide to make incentives available for both technologies to improve program reach across income groups.

4.3. Comparison of AMI and FPL potential

Previous studies have examined how U.S.-wide energy efficiency potential in low-income households varies based on how "low-income" is defined (Hoffman, 2017). The analysis presented here enables comparison at a more granular, county level. For example, Figure 7 compares the aggregate utility bill savings potential between <80% AMI households and <200% FPL households, for packages tailored to maximize NPV in each simulated home. A higher ratio of <80% AMI to <200% FPL potential is associated with higher population metropolitan areas. This result is intuitive because metropolitan areas have higher costs of living, which is reflected in AMI but not FPL, and thus, across a given multi-county MSA, more households fall into the <80% AMI category. However, there are many rural areas, such as Wyoming, North Dakota, and other parts of the upper Midwest U.S., where the <80% AMI threshold includes more eligible households than the 200% FPL threshold. According to the ACS data used in this analysis, these rural areas have a

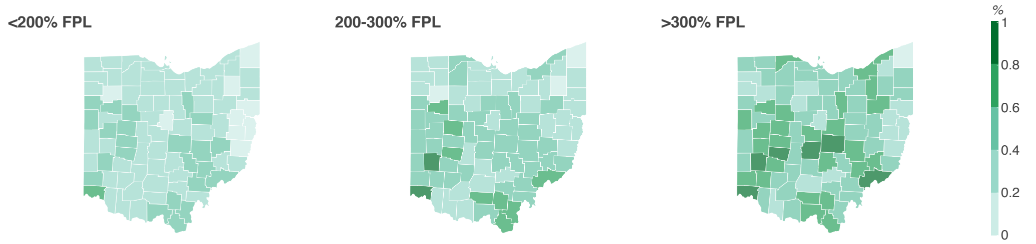

Figure 5: Percentage energy cost savings resulting from upgrading central air conditioners to SEER 18 units at wear out (upgrades with positive net present value only), by county and income bin, in the U.S. state of Ohio

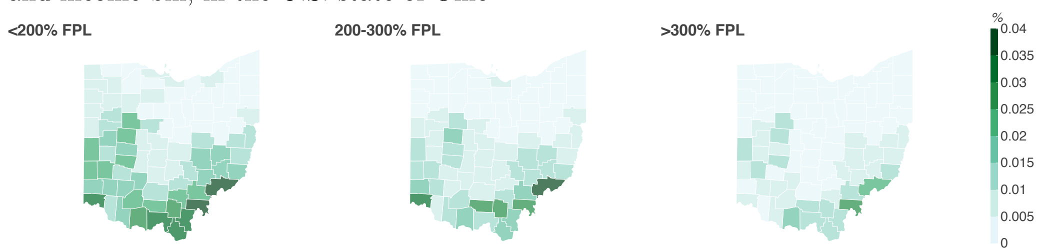

Figure 6: Percentage energy cost savings resulting from upgrading room air conditioners to ENERGY STAR-qualified (SEER 12) units at wear out (upgrades with positive net present value only), by county and income bin, in the U.S. state of Ohio

smaller percentage of households with income less than 200% of FPL, which reduces the savings potential of the <200% FPL category.

4.4. Economic development potential

In addition to estimating economic potential energy and energy cost savings, these analysis capabilities can be used to estimate the potential revenue for local businesses installing energy efficiency measures in states and counties. For example, we find that there exists $12.7 billion of potential revenue[7] that would result from implementation of all cost-effective energy efficiency packages in single-family homes in the state of Tennessee. Potential revenue corresponds to the total upfront costs of energy efficiency measure implementation. The average revenue per home upgraded in Tennessee is about

[7] Revenue from equipment improvements would accrue over 30 years of equipment turnover. Revenue from enclosure improvements does not depend on turnover and can begin accruing immediately.

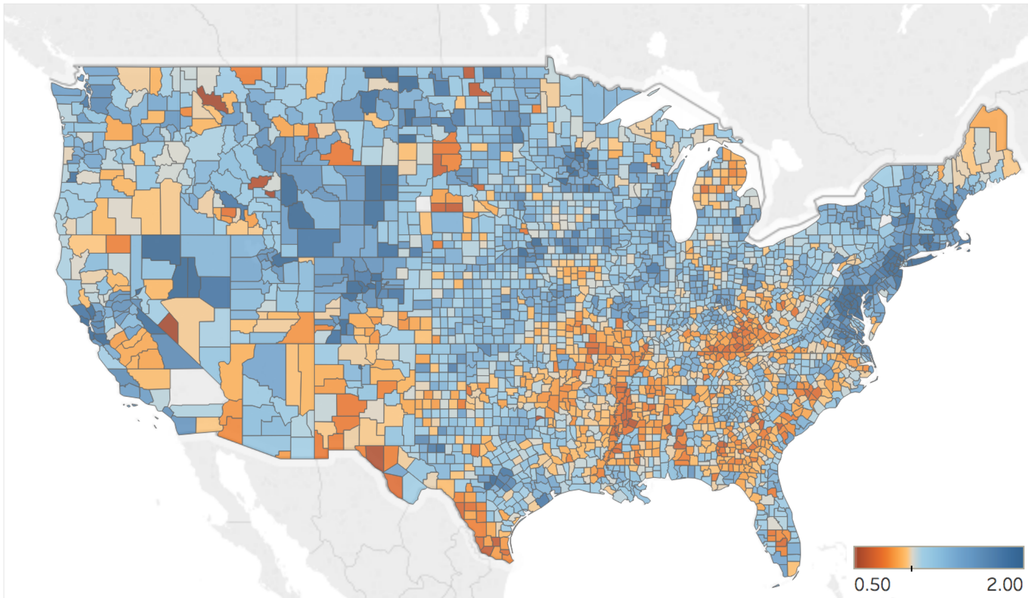

Figure 7: Ratio of <80% AMI to <200% FPL aggregate utility bill savings potential for packages tailored to maximize NPV in each simulated home, by U.S. county.

\$7,260 (with annual energy bill savings of \$1,030).[8] Aggregate results for other states are included in Appendix C. Some measures, such as air sealing or attic insulation have a high labor-to-material cost ratio and therefore will result in a larger portion of the revenue staying in the local economy in the form of wages. On the other hand, measures with a lower labor-to-material cost ratio, such as heating and cooling equipment installation, will result in less of the revenue staying in the local economy. However, the revenue potential of these measures would be relevant if any of the equipment is manufactured within the region of interest.

[8]As a point of comparison, DOE's Weatherization Assistance Program, which funds upgrades for households at or below 200% FPL, reports national average weatherization measure costs (excluding administrative, training, and health and safety costs) of \$2,846 per unit (\$283 in annual energy cost savings) (Tonn et al., 2014). This indicates that there may be more potential for energy savings and economic development than has been achieved in the past, notwithstanding other program barriers.

5. Conclusions and policy implications

In contrast to historical approaches, our methodology uses new data sources, physics-based simulation, and modern computing resources to provide a more accurate, granular, and flexible estimate of the cost-effective energy efficiency potential in low- and moderate-income households. Using this approach we estimate that in households with income less than 200% of the federal poverty level, energy efficiency packages tailored to maximize net present value (NPV) could result in an estimated $13 billion per year in energy cost savings ($726 per year median household savings). This corresponds to 77 TWh per year electricity savings and 371 PJ (352 TBtu) per year on-site fuel savings, or about 1 EJ (0.9 quads) per year of primary energy. The revenue for local businesses implementing these packages is estimated to be $152 billion. Similar figures can be estimated for other geographies (regions, states, and counties) and for other ranges of household income, many of which are included in Appendix C. All of these savings result from upgrade packages with positive NPV; the simple payback period ranges from 13 to 19 years (10–90 percentile range), with a median value of 16 years.[9]

Beyond these high-level savings estimates, this analysis can provide insight to policymakers and program managers at different stages of design and implementation. Without making specific recommendations, we have identified several types of policy questions that this analysis could address.

Understanding residential energy efficiency potential for ranges of household income offers multiple opportunities to support policy and program design. Policymakers looking to create or expand energy efficiency programs with income-based eligibility requirements in a state or region can use this analysis to identify high-value measures to implement in a program. The U.S. Department of Energy's Weatherization Assistance Program (WAP), for example, provides states with funds to weatherize homes with household incomes less than or equal to 200 percent of FPL (DOE, 2018). The WAP-eligible measures with the highest savings opportunity in these homes can vary by state, and even within a state (see Figure 1). The implications of these results extend to utility-run efficiency programs as well. While it is generally expected that market rate programs deliver greater energy savings, as noted by the Environmental Defense Fund (EDF, 2018), savings from

[9] Alternative packages could be constructed to optimize return on investment, simple payback period, or other metrics, but this was not done for this study.

low-income homes can be greater as a result of their higher energy savings potential.

Results on the relative savings opportunities between low, moderate, and higher income households may also be of interest when designing and implementing programs with no income requirements (see Figures 5 and 6). Research has indicated that some efficiency program designs may attract a participant population more affluent than the full eligible population, which could mean that some of the program benefits are regressively distributed (Frank and Nowak, 2016). Prioritizing measures with high potential in low- and moderate-income homes could improve the likelihood of more low and moderate income households participating while maintaining cost-effectiveness (see Figure 2). For example, eligibility requirements for the Federal Low Income Housing Tax Credit and New Markets Tax Credit identify census tracts with high densities of households below certain levels of Area Median Income. Marketing programs in these communities, as well as focusing on measures with a high likelihood of increasing energy affordability for low- and moderate-income homes, could improve the equity of programs even if they do not require income verification.

Breaking down potential by county also has several applications. The measures with the greatest potential saving opportunities in rural counties can be very different from the opportunities in urban counties. For example, rural areas often use propane, fuel oil, or electric resistance heating, which tend to be more expensive than heating with electric heat pumps or natural gas, which improves the cost-effectiveness of insulation and heating equipment measures (see Figure 4). Additionally, policymakers and program managers may be interested in choosing an AMI or FPL income threshold that maximizes the savings potential in a particular state or county (see Figure 7)

Several economic and employment metrics are measured at the county level and are used to identify priority areas for economic development efforts. Congress has established several regions of the United States with their own entities to prioritize economic development, beginning with the Appalachian Regional Commission in 1935 and adding six others since (Appalachian Regional Commission, 2018). These commissions are made up of counties across several states (with the exception of the Denali Commission in Alaska), making state-level efficiency potential studies less helpful for understanding potential impacts in these jurisdictions. Results from this work providing both county level energy efficiency potential by income level, as well as potential revenue for local businesses installing measures, can serve as the basis for quantifying economic development potential for counties specifically in these regions (see Section 4.4). Congress has also identified "persistent poverty counties" experiencing multi-decade stretches of high poverty rates as targets for federal funding (Dalaker, 2017). Estimates of single-year energy bill savings, primary energy, electricity, and fuel savings, and potential revenue for these regional commissions and for persistent poverty counties are tabulated in Appendix C. Future work using the results presented here could quantify the energy efficiency savings opportunities, and associated potential to grow the local workforce, with sustained support for efficiency investments in these counties.

Presenting results in owner-occupied homes versus rentals can also inform program administrators. Due to the well-documented split-incentive barrier to energy efficiency investment in rented households[10], understanding the differentiated potential can help administrators identify and market the highest opportunity measures for homeowners, and target different measures for programs specifically designed for the rental market (see Figure 3).

Finally, understanding savings opportunities at granular levels of income and geography can support future analysis into the role of targeting energy efficiency investments to reduce energy burden, or the share of a household budget that is spent on energy services. Greater understanding of the energy consumption and other characteristics of low- and moderate-income homes could inform policymakers on how to target energy efficiency activities, or pair them with other energy technologies to reduce energy burden in communities with diverse needs.

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[10]Further description of this barrier, as well as current strategies for addressing it, can be found at https://www6.eere.energy.gov/alliance/activities/market-solutions-teams/leasing-split-incentive

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Appendix A. Example Cross-tabulation

Table A.2: Example Federal Poverty Level table combining data from AHS and ACS to provide fractional household weights by location (census tract), age of home, size of home, heating fuel type, and cooling system type for each combination of FPL bin and tenure status, as described in section 3.5.[a]

Census Tract	Vintage	House Size	AC Type	Heating Fuel	Count	Owner 0-50	Owner 50-100	Owner 100-150	Owner 150-200	Owner 200-250	Owner 250-300	Owner 300+	Renter 0-50	Renter 50-100	Renter 100-150	Renter 150-200	Renter 200-250	Renter 250-300	Renter 300+
G4100010950100	<1940	0-1499	Central	Elec.	0.4596	0	0.0115	0.4035	0	0.0568	0	0.0725	0.0512	0.2735	0.0857	0	0	0	0.0448
G4100010950100	<1940	0-1499	Central	Elec.	2.4076	0	0.0115	0.4035	0	0.0568	0	0.0725	0.0512	0.2735	0.0857	0	0	0	0.0448
G4100010950100	<1940	0-1499	None	Elec.	0.6517	0	0	0	0.0747	0.0400	0	0.3173	0.0361	0.3544	0.1233	0	0	0.0014	0.0524
G4100010950100	<1940	0-1499	None	Elec.	3.4140	0	0	0	0.0747	0.0400	0	0.3173	0.0361	0.3544	0.1233	0	0	0.0014	0.0524
G4100010950100	<1940	0-1499	Room	Elec.	0.4068	0	0	0.3411	0	0.0641	0	0.3492	0.0578	0	0.1073	0.0407	0.0156	0	0.0237
G4100010950100	<1940	0-1499	Room	Elec.	2.1314	0	0	0.3411	0	0.0641	0	0.3492	0.0578	0	0.1073	0.0407	0.0156	0	0.0237
G4100010950100	<1940	1500-2499	Central	Elec.	0.5897	0	0.0128	0.1331	0.2667	0.0442	0.2307	0.2490	0.0399	0	0	0.0165	0.0066	0	0
G4100010950100	<1940	1500-2499	Central	Elec.	3.0892	0	0.0128	0.1331	0.2667	0.0442	0.2307	0.2490	0.0399	0	0	0.0165	0.0066	0	0
G4100010950100	<1940	1500-2499	None	Elec.	0.3398	0.0579	0.0183	0	0	0.0768	0	0.7353	0.0693	0	0	0	0	0.0011	0.0409
G4100010950100	<1940	1500-2499	None	Elec.	1.7802	0.0579	0.0183	0	0	0.0768	0	0.7353	0.0693	0	0	0	0	0.0011	0.0409
G4100010950100	<1940	1500-2499	Room	Elec.	0.0875	0	0	0	0	0.2983	0	0.4326	0.2690	0	0	0	0	0	0
G4100010950100	<1940	1500-2499	Room	Elec.	0.4585	0	0	0	0	0.2983	0	0.4326	0.2690	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	Central	Elec.	0.1679	0	0	0	0	0.1555	0	0.7041	0.1402	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	Central	Elec.	0.8796	0	0	0	0	0.1555	0	0.7041	0.1402	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	None	Elec.	0.1435	0	0.0478	0	0	0.1818	0	0.6062	0.1640	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	None	Elec.	0.7522	0	0.0478	0	0	0.1818	0	0.6062	0.1640	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	Room	Elec.	0.0496	0	0	0	0	0.5257	0	0	0.4742	0	0	0	0	0	0
G4100010950100	<1940	2500-3499	Room	Elec.	0.2601	0	0	0	0	0.5257	0	0	0.4742	0	0	0	0	0	0
G4100010950100	<1940	3500+	Central	Elec.	0.0952	0	0	0	0	0.2741	0	0.4785	0.2472	0	0	0	0	0	0
G4100010950100	<1940	3500+	Central	Elec.	0.4989	0	0	0	0	0.2741	0	0.4785	0.2472	0	0	0	0	0	0
G4100010950100	<1940	3500+	None	Elec.	0.0911	0	0	0	0	0.2864	0	0.4552	0.2583	0	0	0	0	0	0
G4100010950100	<1940	3500+	None	Elec.	0.4776	0	0	0	0	0.2864	0	0.4552	0.2583	0	0	0	0	0	0
G4100010950100	<1940	3500+	Room	Elec.	0.0613	0	0	0	0	0.4254	0	0	0.3836	0	0	0.1908	0	0	0
G4100010950100	<1940	3500+	Room	Elec.	0.3215	0	0	0	0	0.4254	0	0	0.3836	0	0	0.1908	0	0	0
G4100010950100	<1940	0-1499	Central	Fuel Oil	0.0899	0	0	0.0097	0.0648	0	0.1571	0	0.1132	0.0156	0.1130	0.1748	0.1649	0.1863	0
G4100010950100	<1940	0-1499	Central	Fuel Oil	0.4712	0	0	0.0097	0.0648	0	0.1571	0	0.1132	0.0156	0.1130	0.1748	0.1649	0.1863	0
G4100010950100	<1940	0-1499	None	Fuel Oil	0.2126	0	0	0.0041	0.0274	0.5770	0.0664	0	0.0479	0.0066	0.0478	0.0739	0.0697	0.0788	0
G4100010950100	<1940	0-1499	None	Fuel Oil	1.11414	0	0	0.0041	0.0274	0.5770	0.0664	0	0.0479	0.0066	0.0478	0.0739	0.0697	0.0788	0
G4100010950100	<1940	0-1499	Room	Fuel Oil	0.0923	0.0256	0	0.0094	0.0631	0	0.1531	0	0.1103	0.0152	0.1101	0.1703	0.1607	0.1815	0
G4100010950100	<1940	0-1499	Room	Fuel Oil	0.4836	0.0256	0	0.0094	0.0631	0	0.1531	0	0.1103	0.0152	0.1101	0.1703	0.1607	0.1815	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
G4100710031000	>2010	0-1499	Central	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	0-1499	None	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	0-1499	Room	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	1500-2499	Central	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	1500-2499	None	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	1500-2499	Room	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	2500-3499	Central	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	2500-3499	None	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	2500-3499	Room	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	3500+	Central	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	3500+	None	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0
G4100710031000	>2010	3500+	Room	Propane	0.1770	0.0090	0.0046	0.0146	0.0138	0.0174	0.0234	0.9169	0	0	0	0	0	0	0

[a] Additional columns that indicate the EnergyPlus Weather file (EPW) location and county corresponding to each row is excluded for brevity.

Appendix B. Dependency Graph

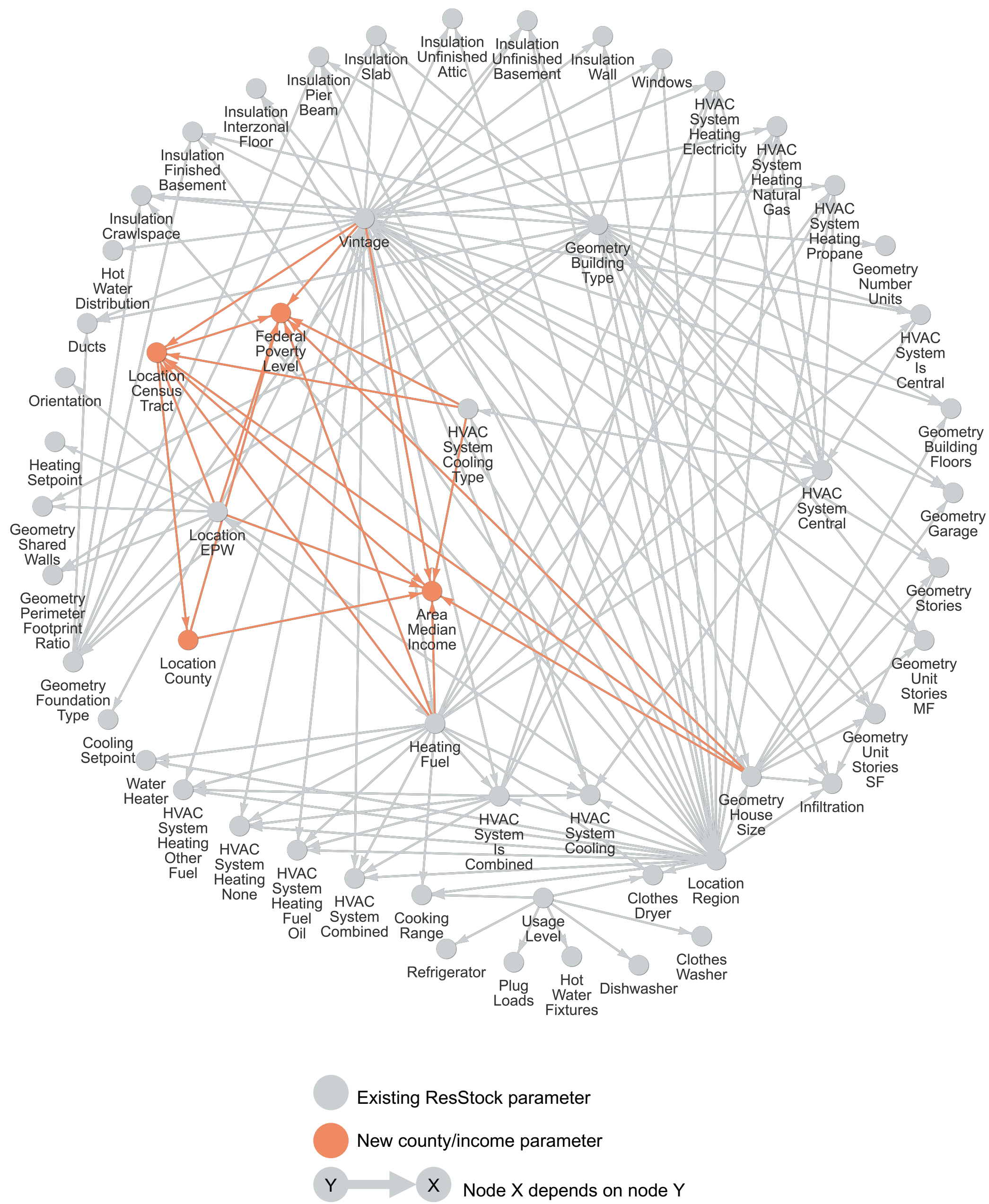

Figure B.8: This dependency graph illustrates the relationship between the conditional probability distributions used to describe the U.S. residential building stock. Red color indicates the parameters and dependencies added to enable aggregation by county and household income.

Appendix C. Tabular Results by State and for Regional Commission Counties

Table C.3: Single-year economic potential energy bill savings (million $/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference expenditures
Alabama	336	429	516	366	539	958	3,321
Arizona	189	240	307	224	357	670	3,582
Arkansas	182	231	279	187	281	519	1,958
California	750	969	1,178	945	1,449	2,696	14,776
Colorado	117	161	206	169	278	502	2,796
Connecticut	212	294	380	367	575	973	3,535
Delaware	50	69	88	79	125	232	742
District of Columbia	5	6	7	9	13	24	77
Florida	628	829	1,021	739	1,143	2,228	9,594
Georgia	489	634	777	553	840	1,445	5,780
Idaho	50	67	85	59	93	172	887
Illinois	378	491	615	497	792	1,394	6,772
Indiana	386	510	646	462	738	1,279	5,127
Iowa	135	184	235	178	301	521	2,515
Kansas	139	189	239	177	279	502	2,192
Kentucky	292	378	466	317	487	902	3,186
Louisiana	140	175	207	154	220	417	2,110
Maine	149	194	233	181	284	519	1,919
Maryland	210	290	370	404	628	1,123	3,562
Massachusetts	327	426	535	529	830	1,460	5,113
Michigan	641	829	1,027	778	1,220	2,120	8,963
Minnesota	207	280	361	302	514	915	4,374
Mississippi	204	254	305	194	286	544	2,059
Missouri	334	441	542	404	621	1,097	4,528
Montana	33	43	55	41	64	126	673
Nebraska	72	99	125	97	157	275	1,304
Nevada	67	89	113	82	134	252	1,369
New Hampshire	73	101	129	126	202	373	1,464
New Jersey	215	291	383	417	671	1,291	5,317
New Mexico	84	107	129	91	134	269	1,240
New York	676	918	1,174	1,047	1,670	3,145	11,697
North Carolina	662	865	1,062	746	1,145	2,107	6,708
North Dakota	25	36	47	35	58	108	534
Ohio	774	1,015	1,264	915	1,450	2,558	9,422
Oklahoma	246	312	380	275	409	721	2,688
Oregon	171	227	288	209	327	551	1,964
Pennsylvania	789	1,071	1,360	1,083	1,731	3,158	9,974
Rhode Island	66	88	113	94	153	267	973
South Carolina	301	386	474	330	507	920	3,068
South Dakota	30	41	53	37	64	116	622
Tennessee	360	467	575	389	599	1,030	4,075
Texas	837	1,075	1,296	992	1,501	2,685	12,528
Utah	50	70	94	70	117	206	1,235
Vermont	57	74	91	77	120	221	815
Virginia	356	473	597	514	808	1,489	5,221
Washington	230	308	395	324	511	838	3,233
West Virginia	147	191	236	154	239	453	1,473
Wisconsin	197	269	351	281	466	849	4,754
Wyoming	15	20	26	24	37	72	379
Total	13,080	17,204	21,431	16,721	26,164	47,289	192,199
All U.S. persistent poverty counties (no AK, HI)	940	1,152	1,353	860	1,245	2,378	9,354

Table C.4: Single-year economic potential energy bill savings (million $/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference expenditures
ARC[a] - AL	230	294	354	252	373	655	2,216
ARC - GA	157	207	262	183	286	485	1,936
ARC - KY	111	137	164	93	139	276	931
ARC - MD	21	28	34	26	39	72	203
ARC - MS	45	56	67	41	60	117	444
ARC - NC	159	209	259	172	269	504	1,474
ARC - NY	86	115	144	109	173	310	1,066
ARC - OH	198	257	324	210	337	633	2,152
ARC - PA	546	731	916	688	1,069	1,821	5,687
ARC - SC	89	116	146	97	152	255	806
ARC - TN	187	241	296	192	296	512	1,986
ARC - VA	57	74	93	58	91	172	524
ARC - WV	147	191	236	154	239	453	1,473
ARC - Total	2,032	2,657	3,293	2,273	3,523	6,266	20,898
NBRC[b] - ME	101	128	154	105	163	305	1,089
NBRC - NH	20	26	31	25	38	72	269
NBRC - NY	78	107	134	101	165	307	1,114
NBRC - VT	17	21	25	20	30	52	199
NBRC - Total	215	282	345	251	396	736	2,670
SBRC[c] - AZ	152	192	246	184	293	540	3,015
SBRC - CA	306	394	476	359	548	1,082	7,010
SBRC - NM	29	37	44	28	41	86	332
SBRC - TX	215	271	319	212	320	579	2,765
SBRC - Total	702	894	1,086	783	1,202	2,286	13,121
SCRC[d] - AL	74	96	116	86	126	227	848
SCRC - FL	628	829	1,021	739	1,143	2,228	9,594
SCRC - GA	332	427	515	369	554	960	3,844
SCRC - MS	67	85	105	67	101	198	735
SCRC - NC	504	656	803	575	877	1,603	5,234
SCRC - SC	212	270	328	232	355	665	2,262
SCRC - VA	299	398	504	456	717	1,317	4,697
SCRC - Total	2,115	2,762	3,391	2,523	3,872	7,198	27,213
DRA[e] - AL	37	46	54	33	47	89	303
DRA - AR	98	123	148	97	144	266	967
DRA - IL	22	29	36	25	39	73	278
DRA - KY	28	37	46	31	47	86	368
DRA - LA	103	127	150	111	157	291	1,482
DRA - MO	55	70	84	51	81	151	568
DRA - MS	103	126	149	96	138	255	984
DRA - TN	87	108	129	91	131	227	936
DRA - Total	533	666	795	535	785	1,439	5,884
NGPR[f] - IA	135	184	235	178	301	521	2,515
NGPR - MN	207	280	361	302	514	915	4,374
NGPR - MO	280	371	458	352	540	946	3,960
NGPR - ND	25	36	47	35	58	108	534
NGPR - NE	72	99	125	97	157	275	1,304
NGPR - SD	30	41	53	37	64	116	622
NGPR - Total	750	1,011	1,279	1,001	1,633	2,881	13,310

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.5: Single-year economic potential electricity savings (GWh/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
Alabama	2,280	2,953	3,587	2,509	3,775	6,968	23,039
Arizona	1,489	1,892	2,424	1,771	2,831	5,344	24,943
Arkansas	1,378	1,762	2,143	1,416	2,148	4,139	14,777
California	4,147	5,358	6,499	5,142	7,882	14,701	69,317
Colorado	706	970	1,252	974	1,641	3,038	14,876
Connecticut	337	468	607	598	942	1,642	9,575
Delaware	216	293	373	334	555	1,023	3,714
District of Columbia	27	32	37	47	64	116	385
Florida	5,507	7,282	8,970	6,481	10,036	19,620	74,535
Georgia	3,731	4,886	6,022	4,253	6,484	11,208	39,424
Idaho	322	428	558	395	608	1,122	5,772
Illinois	2,183	2,809	3,538	2,766	4,492	8,149	35,963
Indiana	2,469	3,242	4,111	2,911	4,657	8,291	29,418
Iowa	684	929	1,183	871	1,496	2,726	12,703
Kansas	769	1,036	1,304	965	1,526	2,844	11,535
Kentucky	2,287	2,982	3,677	2,475	3,832	7,266	23,086
Louisiana	1,256	1,572	1,876	1,391	2,004	3,897	17,999
Maine	180	235	274	222	338	669	5,059
Maryland	1,043	1,469	1,873	2,033	3,204	5,751	20,131
Massachusetts	691	905	1,140	1,106	1,764	2,943	15,179
Michigan	2,723	3,545	4,335	3,261	5,088	9,135	37,298
Minnesota	1,037	1,397	1,804	1,501	2,575	4,754	21,197
Mississippi	1,507	1,887	2,265	1,434	2,134	4,131	14,940
Missouri	2,161	2,857	3,518	2,575	3,971	7,294	27,860
Montana	171	231	301	236	365	698	3,753
Nebraska	421	575	736	557	934	1,732	7,725
Nevada	450	610	786	558	925	1,788	8,649
New Hampshire	123	170	218	209	329	622	3,929
New Jersey	737	974	1,277	1,377	2,181	4,173	20,437
New Mexico	558	712	858	597	886	1,772	7,148
New York	1,454	1,932	2,498	2,187	3,495	6,623	34,988
North Carolina	4,558	6,014	7,379	5,096	7,969	14,899	46,154
North Dakota	111	165	225	146	265	565	2,955
Ohio	4,334	5,626	7,019	4,974	7,961	14,436	49,872
Oklahoma	1,989	2,508	3,056	2,206	3,281	5,867	19,699
Oregon	1,310	1,714	2,186	1,568	2,389	3,859	14,627
Pennsylvania	2,038	2,716	3,538	2,674	4,465	8,232	41,869
Rhode Island	83	117	152	117	198	372	2,477
South Carolina	2,021	2,623	3,245	2,214	3,491	6,535	20,289
South Dakota	153	210	278	183	333	650	3,415
Tennessee	3,372	4,364	5,342	3,652	5,596	9,488	32,466
Texas	7,241	9,321	11,261	8,619	13,109	23,699	95,883
Utah	332	468	626	461	771	1,384	7,633
Vermont	67	86	108	95	148	289	1,943
Virginia	2,294	3,080	3,848	3,353	5,337	10,210	35,676
Washington	2,011	2,662	3,410	2,752	4,271	6,799	27,222
West Virginia	821	1,081	1,331	868	1,366	2,722	10,200
Wisconsin	882	1,210	1,584	1,265	2,134	4,098	20,673
Wyoming	75	105	138	128	197	397	2,027
Total	76,733	100,460	124,766	93,521	146,440	268,677	1,074,430
All U.S. persistent poverty counties (no AK, HI)	6,429	7,889	9,265	5,762	8,381	16,367	61,397

Table C.6: Single-year economic potential electricity savings (GWh/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
ARC[a] - AL	1,549	2,017	2,452	1,720	2,606	4,770	15,552
ARC - GA	1,189	1,590	2,015	1,400	2,195	3,731	13,305
ARC - KY	839	1,059	1,270	704	1,071	2,194	6,854
ARC - MD	84	112	136	99	160	325	1,268
ARC - MS	344	432	518	312	465	924	3,399
ARC - NC	1,054	1,405	1,739	1,124	1,796	3,376	9,917
ARC - NY	187	243	298	228	340	598	3,707
ARC - OH	941	1,226	1,550	990	1,624	3,180	11,472
ARC - PA	1,205	1,577	2,041	1,373	2,284	4,160	23,324
ARC - SC	584	771	983	633	1,031	1,760	5,292
ARC - TN	1,719	2,207	2,697	1,765	2,712	4,606	15,628
ARC - VA	373	493	608	371	599	1,189	3,737
ARC - WV	821	1,081	1,331	868	1,366	2,722	10,200
ARC - Total	10,889	14,212	17,638	11,585	18,249	33,534	123,656
NBRC[b] - ME	116	148	170	119	177	362	2,716
NBRC - NH	26	34	41	33	48	98	686
NBRC - NY	153	206	270	193	329	594	3,485
NBRC - VT	20	25	31	26	39	69	473
NBRC - Total	315	413	512	371	593	1,123	7,359
SBRC[c] - AZ	1,227	1,548	1,991	1,487	2,377	4,428	21,364
SBRC - CA	1,843	2,371	2,859	2,144	3,273	6,485	34,546
SBRC - NM	205	260	315	197	295	622	2,131
SBRC - TX	1,794	2,266	2,679	1,783	2,690	4,876	20,371
SBRC - Total	5,069	6,444	7,844	5,612	8,635	16,411	78,412
SCRC[d] - AL	534	694	847	616	921	1,713	5,829
SCRC - FL	5,507	7,282	8,970	6,481	10,036	19,620	74,535
SCRC - GA	2,543	3,296	4,007	2,853	4,289	7,477	26,119
SCRC - MS	470	603	741	465	714	1,446	5,080
SCRC - NC	3,505	4,610	5,640	3,972	6,173	11,523	36,237
SCRC - SC	1,437	1,852	2,262	1,581	2,460	4,775	14,998
SCRC - VA	1,921	2,586	3,240	2,982	4,738	9,021	31,938
SCRC - Total	15,916	20,923	25,708	18,949	29,330	55,575	194,736
DRA[e] - AL	230	284	336	203	292	570	1,955
DRA - AR	733	923	1,110	718	1,072	2,066	7,258
DRA - IL	145	189	236	164	256	490	1,683
DRA - KY	217	284	349	233	355	683	2,540
DRA - LA	915	1,142	1,356	996	1,430	2,700	12,644
DRA - MO	389	500	601	368	572	1,086	3,954
DRA - MS	772	950	1,124	726	1,058	1,964	7,238
DRA - TN	846	1,053	1,251	891	1,282	2,185	7,693
DRA - Total	4,247	5,325	6,364	4,298	6,318	11,743	44,965
NGPR[f] - IA	684	929	1,183	871	1,496	2,726	12,703
NGPR - MN	1,037	1,397	1,804	1,501	2,575	4,754	21,197
NGPR - MO	1,772	2,357	2,917	2,207	3,399	6,208	23,906
NGPR - ND	111	165	225	146	265	565	2,955
NGPR - NE	421	575	736	557	934	1,732	7,725
NGPR - SD	153	210	278	183	333	650	3,415
NGPR - Total	4,177	5,632	7,142	5,466	9,001	16,634	71,902

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.7: Single-year economic potential on-site fuel savings (PJ/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
Alabama	4.5	5.6	6.6	4.9	7.0	11.3	40.7
Arizona	1.5	2.0	2.5	1.8	2.8	5.0	33.6
Arkansas	3.4	4.3	5.1	3.7	5.4	8.9	38.5
California	14.0	18.2	22.3	19.4	29.7	54.5	325.1
Colorado	5.2	7.2	9.0	8.3	13.3	22.7	110.3
Connecticut	11.2	15.6	20.2	19.1	30.3	52.2	100.5
Delaware	0.9	1.2	1.5	1.4	2.2	3.8	13.7
District of Columbia	0.1	0.2	0.2	0.3	0.5	0.8	2.3
Florida	1.0	1.3	1.6	1.2	1.9	3.5	22.6
Georgia	5.3	6.7	8.0	6.0	9.2	15.3	77.6
Idaho	2.1	2.9	3.6	2.5	4.1	7.5	36.2
Illinois	20.8	27.2	33.8	28.7	44.4	74.8	327.1
Indiana	14.7	19.3	24.3	18.1	28.0	46.1	183.2
Iowa	6.1	8.6	11.1	8.5	14.0	23.8	98.2
Kansas	5.1	7.1	9.2	6.9	10.7	18.1	68.5
Kentucky	6.2	8.1	10.0	7.0	10.7	19.1	67.7
Louisiana	2.4	2.9	3.5	2.6	3.7	6.5	32.4
Maine	9.0	11.6	13.9	10.8	17.1	32.8	64.8
Maryland	2.8	3.8	4.9	5.6	8.5	14.7	59.5
Massachusetts	16.0	20.9	26.6	26.0	41.2	74.5	165.8
Michigan	34.6	44.6	56.1	43.0	68.0	116.9	377.6
Minnesota	9.8	13.7	17.8	14.6	24.9	45.2	168.4
Mississippi	2.6	3.2	3.8	2.4	3.5	6.3	26.1
Missouri	10.4	14.0	17.1	13.2	20.2	34.1	123.2
Montana	1.8	2.5	3.1	2.3	3.8	7.1	31.5
Nebraska	3.8	5.3	6.5	5.4	8.1	13.2	55.7
Nevada	1.3	1.8	2.2	1.8	2.8	4.9	33.1
New Hampshire	4.5	6.2	8.0	7.6	12.5	24.0	45.9
New Jersey	9.7	13.2	17.5	19.6	31.3	60.4	204.2
New Mexico	2.0	2.6	3.1	2.3	3.3	6.1	33.4
New York	34.9	47.8	61.3	54.1	86.6	163.0	411.9
North Carolina	6.7	8.6	10.4	7.9	11.7	19.1	90.1
North Dakota	1.2	1.8	2.4	1.9	3.0	5.5	24.8
Ohio	28.2	37.6	46.4	35.2	54.4	91.7	324.3
Oklahoma	5.6	7.2	8.9	6.6	9.9	16.8	59.9
Oregon	3.9	5.3	6.6	4.8	8.1	15.0	54.1
Pennsylvania	27.1	36.5	46.1	37.4	58.5	100.1	298.5
Rhode Island	3.0	4.1	5.3	4.2	7.0	13.4	27.0
South Carolina	2.7	3.5	4.1	3.0	4.4	7.0	34.3
South Dakota	1.4	2.0	2.5	1.8	3.0	5.5	25.7
Tennessee	4.6	6.2	7.9	5.0	8.0	14.7	74.3
Texas	9.8	12.7	15.1	12.1	17.9	29.4	174.7
Utah	2.1	2.8	3.7	2.9	4.6	7.5	43.9
Vermont	3.3	4.3	5.2	4.4	6.9	13.3	25.3
Virginia	4.9	6.5	8.3	7.4	11.4	19.5	90.3
Washington	4.2	5.4	6.9	6.0	9.8	18.3	78.9
West Virginia	3.0	3.8	4.8	3.2	4.9	8.4	33.9
Wisconsin	11.0	15.1	19.8	15.8	26.0	47.8	205.1
Wyoming	0.8	1.1	1.4	1.3	2.1	3.9	16.3
Total	371.3	494.0	620.0	510.1	801.3	1414.3	5060.6
All U.S. persistent poverty counties (no AK, HI)	17.8	21.8	25.6	17.3	24.8	44.2	159.2

Table C.8: Single-year economic potential on-site fuel savings (PJ/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
ARC[a] - AL	4.2	5.2	6.2	4.7	6.6	10.3	29.3
ARC - GA	2.0	2.5	3.1	2.3	3.5	5.8	25.9
ARC - KY	2.3	2.8	3.3	1.9	2.8	5.2	16.6
ARC - MD	0.8	1.0	1.2	0.9	1.3	2.3	4.6
ARC - MS	0.8	0.9	1.1	0.7	1.0	1.9	6.6
ARC - NC	2.6	3.3	4.1	2.9	4.4	8.1	20.6
ARC - NY	4.3	5.9	7.5	5.7	9.1	16.5	44.2
ARC - OH	7.1	9.1	11.3	7.7	11.9	20.6	59.3
ARC - PA	25.8	34.4	42.8	33.4	50.5	81.7	187.1
ARC - SC	1.4	1.8	2.1	1.6	2.2	3.4	10.6
ARC - TN	2.8	3.7	4.6	2.9	4.5	8.4	38.2
ARC - VA	1.0	1.3	1.6	1.0	1.6	2.7	6.3
ARC - WV	4.7	6.1	7.5	4.9	7.6	13.2	33.9
ARC - Total	59.8	78.0	96.6	70.5	107.2	180.1	483.1
NBRC[b] - ME	4.6	5.8	7.0	4.8	7.4	13.9	36.5
NBRC - NH	0.8	1.1	1.3	1.0	1.6	2.9	8.0
NBRC - NY	3.9	5.5	6.8	5.1	8.2	15.4	43.9
NBRC - VT	0.7	0.9	1.1	0.9	1.3	2.1	6.0
NBRC - Total	10.0	13.2	16.1	11.8	18.4	34.3	94.4
SBRC[c] - AZ	1.1	1.4	1.8	1.3	2.0	3.4	23.6
SBRC - CA	3.9	5.1	6.1	4.6	7.0	13.9	132.3
SBRC - NM	0.4	0.5	0.6	0.4	0.6	1.0	5.2
SBRC - TX	1.9	2.4	2.9	2.1	3.1	5.1	32.5
SBRC - Total	7.3	9.4	11.3	8.4	12.7	23.4	193.6
SCRC[d] - AL	1.0	1.2	1.5	1.1	1.6	2.4	8.7
SCRC - FL	1.3	1.7	2.0	1.5	2.3	4.3	22.6
SCRC - GA	4.3	5.4	6.3	4.8	7.2	11.9	51.7
SCRC - MS	0.9	1.1	1.3	0.9	1.2	2.1	6.8
SCRC - NC	7.9	10.0	12.2	9.3	13.5	22.3	69.4
SCRC - SC	2.7	3.3	3.9	2.9	4.1	6.6	23.7
SCRC - VA	6.6	8.6	11.2	9.9	15.4	26.2	84.0
SCRC - Total	24.6	31.3	38.4	30.5	45.4	75.9	266.9
DRA[e] - AL	0.6	0.7	0.9	0.6	0.8	1.3	3.3
DRA - AR	2.1	2.7	3.2	2.2	3.2	5.4	17.4
DRA - IL	0.6	0.8	1.0	0.8	1.1	1.8	7.1
DRA - KY	0.8	1.0	1.3	0.9	1.3	2.2	9.6
DRA - LA	1.9	2.4	2.8	2.1	2.9	5.0	23.1
DRA - MO	1.2	1.6	1.8	1.1	1.8	3.2	10.4
DRA - MS	1.7	2.1	2.5	1.6	2.2	3.9	14.3
DRA - TN	1.2	1.5	1.8	1.2	1.8	3.3	16.8
DRA - Total	10.3	12.8	15.2	10.4	15.2	26.1	102.1
NGPR[f] - IA	5.4	7.6	9.7	7.6	12.2	19.7	98.2
NGPR - MN	7.6	10.6	13.7	11.1	18.6	32.3	168.4
NGPR - MO	9.1	12.0	14.7	11.7	17.7	28.5	112.8
NGPR - ND	1.1	1.6	2.2	1.7	2.7	4.8	24.8
NGPR - NE	3.7	5.2	6.5	5.3	8.1	12.9	55.7
NGPR - SD	1.1	1.6	2.0	1.5	2.5	4.2	25.7
NGPR - Total	28.1	38.5	48.7	39.0	61.7	102.3	485.6

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.9: Single-year economic potential on-site fuel savings (TBtu/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
Alabama	4.2	5.3	6.3	4.7	6.7	10.7	38.5
Arizona	1.4	1.9	2.4	1.7	2.6	4.7	31.8
Arkansas	3.3	4.1	4.9	3.5	5.2	8.5	36.5
California	13.3	17.3	21.1	18.4	28.1	51.7	308.1
Colorado	4.9	6.8	8.5	7.9	12.6	21.5	104.5
Connecticut	10.6	14.8	19.2	18.1	28.7	49.4	95.3
Delaware	0.8	1.1	1.4	1.4	2.1	3.6	12.9
District of Columbia	0.1	0.2	0.2	0.3	0.5	0.8	2.2
Florida	1.0	1.3	1.5	1.2	1.8	3.3	21.4
Georgia	5.0	6.4	7.6	5.7	8.7	14.5	73.5
Idaho	2.0	2.7	3.4	2.4	3.9	7.1	34.3
Illinois	19.7	25.8	32.0	27.2	42.1	70.9	310.0
Indiana	13.9	18.3	23.0	17.2	26.5	43.7	173.6
Iowa	5.8	8.2	10.5	8.1	13.3	22.6	93.1
Kansas	4.8	6.8	8.7	6.5	10.2	17.2	64.9
Kentucky	5.9	7.7	9.5	6.6	10.1	18.1	64.2
Louisiana	2.3	2.8	3.3	2.4	3.5	6.2	30.8
Maine	8.6	11.0	13.2	10.3	16.2	31.1	61.4
Maryland	2.7	3.6	4.6	5.3	8.0	13.9	56.4
Massachusetts	15.2	19.8	25.2	24.6	39.0	70.6	157.2
Michigan	32.8	42.3	53.1	40.7	64.5	110.8	357.9
Minnesota	9.3	13.0	16.9	13.8	23.6	42.8	159.6
Mississippi	2.4	3.0	3.6	2.3	3.4	6.0	24.7
Missouri	9.9	13.3	16.3	12.5	19.2	32.3	116.8
Montana	1.7	2.3	2.9	2.2	3.6	6.8	29.9
Nebraska	3.6	5.0	6.2	5.1	7.7	12.5	52.8
Nevada	1.3	1.7	2.1	1.7	2.6	4.6	31.4
New Hampshire	4.2	5.9	7.5	7.2	11.8	22.8	43.5
New Jersey	9.1	12.5	16.6	18.6	29.6	57.3	193.6
New Mexico	1.9	2.5	2.9	2.2	3.1	5.8	31.7
New York	33.1	45.3	58.1	51.3	82.1	154.5	390.4
North Carolina	6.3	8.1	9.8	7.5	11.1	18.1	85.4
North Dakota	1.1	1.7	2.2	1.8	2.8	5.3	23.5
Ohio	26.8	35.7	44.0	33.4	51.6	86.9	307.4
Oklahoma	5.3	6.9	8.4	6.3	9.4	15.9	56.8
Oregon	3.7	5.0	6.3	4.5	7.7	14.3	51.3
Pennsylvania	25.7	34.6	43.7	35.5	55.5	94.8	283.0
Rhode Island	2.8	3.9	5.0	4.0	6.6	12.7	25.6
South Carolina	2.6	3.3	3.9	2.9	4.2	6.7	32.5
South Dakota	1.3	1.9	2.4	1.7	2.9	5.3	24.4
Tennessee	4.4	5.9	7.4	4.8	7.6	13.9	70.5
Texas	9.3	12.0	14.3	11.5	17.0	27.9	165.6
Utah	2.0	2.7	3.5	2.7	4.3	7.1	41.6
Vermont	3.1	4.1	4.9	4.1	6.5	12.6	24.0
Virginia	4.6	6.1	7.8	7.0	10.8	18.5	85.6
Washington	4.0	5.1	6.6	5.7	9.3	17.4	74.8
West Virginia	2.8	3.6	4.5	3.0	4.6	8.0	32.1
Wisconsin	10.4	14.3	18.8	14.9	24.7	45.3	194.4
Wyoming	0.8	1.0	1.3	1.2	2.0	3.7	15.5
Total	351.9	468.2	587.7	483.5	759.5	1,340.5	4,796.8
All U.S. persistent poverty counties (no AK, HI)	16.9	20.7	24.3	16.4	23.6	41.9	150.9

Table C.10: Single-year economic potential on-site fuel savings (TBtu/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
ARC[a] - AL	4.0	5.0	5.9	4.4	6.2	9.8	27.7
ARC - GA	1.9	2.4	3.0	2.1	3.3	5.5	24.5
ARC - KY	2.2	2.6	3.1	1.8	2.6	4.9	15.7
ARC - MD	0.7	0.9	1.1	0.9	1.3	2.2	4.3
ARC - MS	0.7	0.9	1.1	0.7	1.0	1.8	6.2
ARC - NC	2.5	3.2	3.9	2.8	4.2	7.6	19.6
ARC - NY	4.1	5.6	7.1	5.4	8.6	15.6	41.9
ARC - OH	6.7	8.6	10.7	7.3	11.3	19.5	56.2
ARC - PA	24.5	32.6	40.6	31.6	47.9	77.4	177.4
ARC - SC	1.3	1.7	2.0	1.5	2.1	3.2	10.0
ARC - TN	2.6	3.5	4.4	2.7	4.3	8.0	36.2
ARC - VA	1.0	1.2	1.6	1.0	1.5	2.5	6.0
ARC - WV	4.5	5.7	7.1	4.7	7.2	12.6	32.1
ARC - Total	56.6	74.0	91.6	66.8	101.6	170.7	457.9
NBRC[b] - ME	4.3	5.5	6.6	4.5	7.0	13.1	34.6
NBRC - NH	0.8	1.0	1.2	1.0	1.5	2.8	7.6
NBRC - NY	3.7	5.2	6.4	4.9	7.8	14.6	41.6
NBRC - VT	0.7	0.8	1.0	0.8	1.2	2.0	5.7
NBRC - Total	9.5	12.5	15.3	11.2	17.5	32.5	89.5
SBRC[c] - AZ	1.0	1.3	1.7	1.2	1.9	3.2	22.4
SBRC - CA	3.7	4.8	5.8	4.4	6.6	13.2	125.4
SBRC - NM	0.4	0.5	0.6	0.4	0.6	1.0	4.9
SBRC - TX	1.8	2.3	2.7	2.0	3.0	4.8	30.8
SBRC - Total	6.9	8.9	10.7	8.0	12.0	22.2	183.5
SCRC[d] - AL	0.9	1.2	1.4	1.1	1.5	2.3	8.2
SCRC - FL	1.2	1.6	1.9	1.5	2.2	4.1	21.4
SCRC - GA	4.1	5.1	6.0	4.5	6.8	11.2	49.0
SCRC - MS	0.8	1.0	1.2	0.8	1.2	2.0	6.4
SCRC - NC	7.5	9.5	11.5	8.8	12.8	21.1	65.8
SCRC - SC	2.5	3.1	3.7	2.7	3.9	6.3	22.5
SCRC - VA	6.3	8.2	10.6	9.4	14.6	24.9	79.6
SCRC - Total	23.3	29.7	36.4	28.9	43.1	71.9	252.9
DRA[e] - AL	0.6	0.7	0.8	0.5	0.7	1.3	3.2
DRA - AR	2.0	2.5	3.0	2.1	3.1	5.1	16.5
DRA - IL	0.6	0.7	0.9	0.7	1.0	1.7	6.7
DRA - KY	0.7	1.0	1.2	0.8	1.2	2.1	9.1
DRA - LA	1.8	2.2	2.6	2.0	2.7	4.7	21.9
DRA - MO	1.2	1.5	1.7	1.1	1.7	3.0	9.9
DRA - MS	1.6	2.0	2.3	1.5	2.1	3.7	13.6
DRA - TN	1.1	1.4	1.7	1.2	1.7	3.1	16.0
DRA - Total	9.7	12.1	14.4	9.9	14.4	24.7	96.7
NGPR[f] - IA	5.1	7.2	9.2	7.2	11.6	18.7	93.1
NGPR - MN	7.2	10.0	13.0	10.6	17.6	30.6	159.6
NGPR - MO	8.6	11.3	13.9	11.1	16.7	27.0	106.9
NGPR - ND	1.1	1.5	2.0	1.6	2.6	4.5	23.5
NGPR - NE	3.5	4.9	6.1	5.0	7.6	12.3	52.8
NGPR - SD	1.1	1.5	1.9	1.4	2.3	3.9	24.4
NGPR - Total	26.6	36.5	46.2	36.9	58.5	97.0	460.2

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.11: Single-year economic potential primary energy savings (PJ/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
Alabama	27.5	35.4	42.8	30.1	44.9	81.7	258.9
Arizona	15.8	20.1	25.8	18.8	30.1	56.7	261.7
Arkansas	16.6	21.2	25.7	17.1	25.8	49.1	168.1
California	38.8	50.2	60.9	48.4	74.2	138.7	647.8
Colorado	9.1	12.5	16.0	12.7	21.2	39.2	189.7
Connecticut	12.0	16.8	21.6	20.8	32.6	55.3	194.7
Delaware	3.4	4.6	5.8	5.2	8.3	15.3	47.8
District of Columbia	0.3	0.4	0.5	0.6	0.8	1.5	4.7
Florida	57.9	76.6	94.3	68.2	105.6	206.2	778.9
Georgia	42.0	54.8	67.5	47.8	72.7	125.4	433.4
Idaho	3.3	4.4	5.6	3.9	6.1	11.3	51.5
Illinois	28.6	37.0	46.6	36.7	59.5	107.1	461.7
Indiana	31.6	41.8	53.1	37.7	60.5	107.0	374.1
Iowa	10.3	14.0	17.8	13.3	22.8	40.3	173.2
Kansas	10.1	13.6	17.2	12.7	20.2	37.4	148.0
Kentucky	28.0	36.3	44.7	30.3	46.7	87.8	272.5
Louisiana	14.5	18.1	21.5	16.0	22.9	44.3	198.4
Maine	8.6	11.1	13.4	10.5	16.2	29.5	112.3
Maryland	15.4	21.4	27.3	29.6	46.2	82.6	252.6
Massachusetts	16.8	21.9	27.6	27.4	42.8	74.9	264.5
Michigan	39.4	51.2	63.0	47.4	74.5	131.5	516.7
Minnesota	16.1	21.6	27.8	23.3	39.9	71.6	301.3
Mississippi	18.1	22.6	27.1	17.2	25.5	48.9	169.3
Missouri	28.5	37.7	46.3	34.0	52.5	95.7	354.2
Montana	1.8	2.4	3.1	2.3	3.6	7.2	35.1
Nebraska	5.5	7.6	9.6	7.3	12.2	22.2	95.4
Nevada	4.9	6.6	8.4	5.9	9.8	18.8	88.1
New Hampshire	4.2	5.9	7.5	7.3	11.6	21.5	83.1
New Jersey	12.2	16.4	21.6	23.4	37.7	72.1	287.3
New Mexico	6.3	8.0	9.7	6.8	10.0	20.2	80.2
New York	31.6	43.1	54.9	49.3	79.0	148.6	539.9
North Carolina	58.0	76.1	93.4	65.0	100.7	186.9	548.0
North Dakota	2.1	3.0	3.9	2.8	4.8	9.3	41.5
Ohio	57.9	75.6	94.6	67.3	107.8	194.5	643.3
Oklahoma	23.0	29.0	35.4	25.5	37.9	67.6	222.5
Oregon	12.0	15.9	20.2	14.6	22.5	36.8	121.4
Pennsylvania	46.5	63.2	80.7	63.2	102.8	188.0	637.7
Rhode Island	3.5	4.7	6.0	5.0	8.1	14.1	49.8
South Carolina	25.1	32.4	39.9	27.5	42.8	78.9	236.6
South Dakota	2.6	3.5	4.5	3.1	5.4	10.0	47.5
Tennessee	37.7	48.9	59.9	40.9	62.7	106.9	362.6
Texas	75.2	96.7	116.7	89.4	135.7	244.5	982.9
Utah	3.1	4.4	5.9	4.3	7.3	13.3	67.3
Vermont	3.2	4.1	5.0	4.3	6.6	12.1	43.6
Virginia	31.1	41.4	52.0	45.0	71.0	132.6	429.7
Washington	17.9	24.0	30.7	24.8	38.8	62.2	221.1
West Virginia	12.5	16.4	20.2	13.2	20.6	39.6	128.6
Wisconsin	13.4	18.2	23.9	19.0	31.9	59.4	290.3
Wyoming	0.8	1.1	1.5	1.3	2.1	4.1	20.2
Total	984.9	1,293.4	1,609.0	1,228.2	1,925.6	3,510.5	12,940.0
All U.S. persistent poverty counties (no AK, HI)	76.6	93.9	110.2	69.3	100.3	193.7	690.1

Table C.12: Single-year economic potential primary energy savings (PJ/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
ARC[a] - AL	19.0	24.5	29.6	20.9	31.4	56.6	175.9
ARC - GA	13.6	18.1	23.0	16.0	25.0	42.5	147.5
ARC - KY	10.5	13.1	15.6	8.8	13.2	26.7	80.5
ARC - MD	1.6	2.1	2.6	2.0	3.0	5.7	17.3
ARC - MS	4.2	5.2	6.3	3.8	5.6	11.1	38.8
ARC - NC	13.7	18.2	22.5	14.7	23.2	43.5	119.4
ARC - NY	4.2	5.6	6.9	5.2	8.3	14.7	53.5
ARC - OH	14.7	19.2	24.2	15.5	25.3	48.3	153.8
ARC - PA	31.2	41.9	52.7	38.5	61.1	106.2	365.1
ARC - SC	7.4	9.7	12.2	8.0	12.8	21.6	62.3
ARC - TN	19.4	24.9	30.5	19.9	30.6	52.4	175.2
ARC - VA	5.1	6.6	8.2	5.1	8.1	15.5	44.7
ARC - WV	12.5	16.4	20.2	13.2	20.6	39.6	128.6
ARC - Total	157.0	205.3	254.5	171.7	268.3	484.5	1,562.9
NBRC[b] - ME	5.9	7.6	9.1	6.3	9.6	17.7	64.0
NBRC - NH	1.2	1.5	1.9	1.5	2.3	4.3	15.9
NBRC - NY	3.9	5.4	6.7	5.1	8.4	15.4	56.1
NBRC - VT	1.0	1.2	1.4	1.2	1.7	3.0	11.0
NBRC - Total	12.0	15.7	19.1	14.0	22.0	40.4	147.1
SBRC[c] - AZ	12.9	16.3	21.0	15.7	25.0	46.5	223.0
SBRC - CA	16.9	21.7	26.2	19.7	30.1	59.6	318.2
SBRC - NM	2.2	2.8	3.4	2.2	3.2	6.8	23.0
SBRC - TX	18.4	23.2	27.4	18.3	27.5	49.8	207.5
SBRC - Total	50.4	64.0	78.0	55.8	85.9	162.7	771.6
SCRC[d] - AL	6.1	7.9	9.6	7.0	10.4	19.2	63.9
SCRC - FL	57.9	76.6	94.3	68.2	105.6	206.2	778.9
SCRC - GA	28.4	36.7	44.5	31.8	47.7	82.8	285.9
SCRC - MS	5.6	7.2	8.8	5.6	8.5	16.9	57.0
SCRC - NC	44.2	57.9	70.9	50.3	77.4	143.4	428.6
SCRC - SC	17.8	22.8	27.7	19.4	29.9	57.2	174.3
SCRC - VA	26.0	34.8	43.8	39.9	62.9	117.1	384.9
SCRC - Total	186.0	243.8	299.7	222.2	342.4	642.9	2,173.7
DRA[e] - AL	2.9	3.6	4.2	2.6	3.7	7.0	22.5
DRA - AR	8.9	11.2	13.4	8.7	12.9	24.7	82.3
DRA - IL	1.9	2.4	3.0	2.1	3.3	6.3	21.3
DRA - KY	2.7	3.5	4.4	2.9	4.4	8.4	31.0
DRA - LA	10.6	13.2	15.6	11.5	16.4	30.9	139.7
DRA - MO	5.2	6.7	8.0	4.9	7.7	14.6	50.4
DRA - MS	9.3	11.4	13.5	8.7	12.6	23.4	82.4
DRA - TN	9.4	11.7	13.9	9.9	14.2	24.3	85.2
DRA - Total	50.8	63.7	76.1	51.3	75.4	139.7	514.9
NGPR[f] - IA	10.3	14.0	17.8	13.3	22.8	40.3	173.2
NGPR - MN	16.1	21.6	27.8	23.3	39.9	71.6	301.3
NGPR - MO	23.3	31.0	38.3	29.1	44.8	81.1	303.8
NGPR - ND	2.1	3.0	3.9	2.8	4.8	9.3	41.5
NGPR - NE	5.5	7.6	9.6	7.3	12.2	22.2	95.4
NGPR - SD	2.6	3.5	4.5	3.1	5.4	10.0	47.5
NGPR - Total	59.9	80.5	101.9	78.8	129.8	234.5	962.7

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.13: Single-year economic potential primary energy savings (TBtu/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
Alabama	26.1	33.5	40.6	28.6	42.6	77.5	245.4
Arizona	15.0	19.1	24.4	17.8	28.5	53.8	248.1
Arkansas	15.8	20.1	24.4	16.2	24.5	46.5	159.3
California	36.8	47.5	57.7	45.9	70.3	131.5	614.1
Colorado	8.6	11.8	15.2	12.1	20.1	37.2	179.8
Connecticut	11.4	15.9	20.5	19.7	30.9	52.4	184.6
Delaware	3.2	4.3	5.5	4.9	7.9	14.5	45.3
District of Columbia	0.3	0.4	0.4	0.6	0.8	1.4	4.4
Florida	54.9	72.6	89.4	64.6	100.1	195.5	738.3
Georgia	39.8	52.0	64.0	45.3	68.9	118.8	410.8
Idaho	3.1	4.2	5.3	3.7	5.8	10.7	48.8
Illinois	27.1	35.0	44.2	34.8	56.4	101.5	437.6
Indiana	30.0	39.6	50.3	35.7	57.3	101.4	354.6
Iowa	9.8	13.2	16.8	12.6	21.6	38.2	164.2
Kansas	9.6	12.9	16.3	12.1	19.1	35.4	140.3
Kentucky	26.5	34.4	42.4	28.7	44.2	83.2	258.3
Louisiana	13.7	17.1	20.4	15.1	21.7	42.0	188.0
Maine	8.2	10.6	12.7	9.9	15.3	28.0	106.5
Maryland	14.6	20.3	25.9	28.1	43.8	78.3	239.4
Massachusetts	16.0	20.8	26.2	26.0	40.6	71.0	250.7
Michigan	37.4	48.5	59.7	45.0	70.6	124.6	489.7
Minnesota	15.3	20.5	26.4	22.1	37.8	67.9	285.6
Mississippi	17.1	21.4	25.7	16.3	24.1	46.4	160.5
Missouri	27.0	35.7	43.9	32.2	49.8	90.7	335.8
Montana	1.7	2.3	2.9	2.2	3.4	6.8	33.3
Nebraska	5.2	7.2	9.1	6.9	11.5	21.1	90.4
Nevada	4.6	6.2	8.0	5.6	9.3	17.8	83.5
New Hampshire	4.0	5.5	7.1	6.9	11.0	20.4	78.8
New Jersey	11.6	15.6	20.5	22.2	35.7	68.4	272.3
New Mexico	6.0	7.6	9.2	6.4	9.5	19.2	76.0
New York	30.0	40.9	52.1	46.7	74.9	140.8	511.7
North Carolina	54.9	72.1	88.5	61.6	95.4	177.2	519.5
North Dakota	2.0	2.8	3.7	2.6	4.5	8.8	39.3
Ohio	54.9	71.7	89.6	63.8	102.2	184.3	609.8
Oklahoma	21.8	27.5	33.5	24.1	35.9	64.0	210.9
Oregon	11.4	15.0	19.1	13.9	21.3	34.9	115.1
Pennsylvania	44.1	59.9	76.5	59.9	97.4	178.2	604.4
Rhode Island	3.4	4.4	5.7	4.8	7.7	13.3	47.2
South Carolina	23.8	30.7	37.8	26.0	40.5	74.8	224.3
South Dakota	2.4	3.3	4.2	2.9	5.1	9.5	45.1
Tennessee	35.8	46.3	56.8	38.7	59.4	101.3	343.7
Texas	71.2	91.6	110.6	84.7	128.6	231.8	931.7
Utah	3.0	4.2	5.6	4.1	6.9	12.6	63.7
Vermont	3.0	3.9	4.7	4.1	6.2	11.4	41.4
Virginia	29.4	39.2	49.3	42.6	67.3	125.7	407.3
Washington	17.0	22.7	29.1	23.6	36.8	58.9	209.6
West Virginia	11.8	15.5	19.1	12.5	19.5	37.6	121.9
Wisconsin	12.7	17.3	22.6	18.0	30.2	56.3	275.2
Wyoming	0.8	1.1	1.4	1.3	2.0	3.9	19.2
Total	933.5	1,226.0	1,525.1	1,164.2	1,825.3	3,327.5	12,265.4
All U.S. persistent poverty counties (no AK, HI)	72.6	89.0	104.5	65.7	95.1	183.6	654.1

Table C.14: Single-year economic potential primary energy savings (TBtu/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes	Reference consumption
ARC[a] - AL	18.0	23.2	28.1	19.9	29.8	53.6	166.8
ARC - GA	12.9	17.2	21.8	15.2	23.7	40.3	139.8
ARC - KY	9.9	12.4	14.8	8.4	12.6	25.3	76.3
ARC - MD	1.5	2.0	2.5	1.8	2.8	5.4	16.4
ARC - MS	4.0	5.0	6.0	3.6	5.3	10.6	36.8
ARC - NC	13.0	17.2	21.3	13.9	22.0	41.3	113.2
ARC - NY	4.0	5.3	6.6	5.0	7.9	13.9	50.7
ARC - OH	13.9	18.2	22.9	14.7	23.9	45.8	145.8
ARC - PA	29.6	39.7	49.9	36.5	57.9	100.6	346.1
ARC - SC	7.0	9.2	11.6	7.6	12.1	20.5	59.1
ARC - TN	18.4	23.6	28.9	18.9	29.0	49.7	166.0
ARC - VA	4.8	6.3	7.8	4.8	7.7	14.7	42.4
ARC - WV	11.8	15.5	19.1	12.5	19.5	37.6	121.9
ARC - Total	148.8	194.6	241.2	162.8	254.3	459.2	1,481.4
NBRC[b] - ME	5.6	7.2	8.6	5.9	9.1	16.8	60.7
NBRC - NH	1.1	1.5	1.8	1.4	2.2	4.1	15.1
NBRC - NY	3.7	5.1	6.3	4.8	7.9	14.6	53.2
NBRC - VT	0.9	1.1	1.4	1.1	1.6	2.8	10.4
NBRC - Total	11.3	14.9	18.1	13.3	20.8	38.3	139.4
SBRC[c] - AZ	12.2	15.4	19.9	14.8	23.7	44.1	211.3
SBRC - CA	16.0	20.6	24.8	18.7	28.5	56.5	301.6
SBRC - NM	2.1	2.7	3.3	2.1	3.1	6.4	21.8
SBRC - TX	17.4	22.0	26.0	17.3	26.1	47.2	196.7
SBRC - Total	47.7	60.7	73.9	52.9	81.4	154.3	731.4
SCRC[d] - AL	5.8	7.5	9.1	6.7	9.9	18.2	60.6
SCRC - FL	54.9	72.6	89.4	64.6	100.1	195.5	738.3
SCRC - GA	26.9	34.8	42.2	30.1	45.2	78.5	271.0
SCRC - MS	5.3	6.8	8.3	5.3	8.0	16.0	54.1
SCRC - NC	41.9	54.9	67.2	47.6	73.4	135.9	406.3
SCRC - SC	16.9	21.6	26.2	18.4	28.4	54.2	165.2
SCRC - VA	24.6	33.0	41.5	37.8	59.6	111.0	364.8
SCRC - Total	176.3	231.1	284.0	210.6	324.6	609.3	2,060.3
DRA[e] - AL	2.7	3.4	4.0	2.4	3.5	6.7	21.3
DRA - AR	8.4	10.6	12.7	8.2	12.3	23.4	78.0
DRA - IL	1.8	2.3	2.9	2.0	3.1	6.0	20.2
DRA - KY	2.6	3.3	4.1	2.8	4.2	8.0	29.4
DRA - LA	10.0	12.5	14.8	10.9	15.6	29.3	132.5
DRA - MO	4.9	6.4	7.6	4.7	7.3	13.8	47.8
DRA - MS	8.8	10.8	12.8	8.3	12.0	22.2	78.1
DRA - TN	8.9	11.1	13.1	9.3	13.5	23.0	80.8
DRA - Total	48.2	60.3	72.1	48.6	71.4	132.4	488.0
NGPR[f] - IA	9.8	13.2	16.8	12.6	21.6	38.2	164.2
NGPR - MN	15.3	20.5	26.4	22.1	37.8	67.9	285.6
NGPR - MO	22.1	29.4	36.3	27.5	42.5	76.9	288.0
NGPR - ND	2.0	2.8	3.7	2.6	4.5	8.8	39.3
NGPR - NE	5.2	7.2	9.1	6.9	11.5	21.1	90.4
NGPR - SD	2.4	3.3	4.2	2.9	5.1	9.5	45.1
NGPR - Total	56.8	76.3	96.6	74.7	123.0	222.3	912.5

[a] ARC = Appalachian Regional Commission
[b] NRBC = Northern Border Regional Commission
[c] SBRC = Southwest Border Regional Commission
[d] SCRC = Southeast Crescent Regional Commission
[e] DRA = Delta Regional Authority
[f] NGPR = Northern Great Plains Regional Authority

Table C.15: Single-year economic potential revenue (million $/yr), by state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes
Alabama	4,074	5,193	6,254	4,436	6,544	11,510
Arizona	2,176	2,758	3,494	2,553	4,008	7,327
Arkansas	2,235	2,838	3,428	2,295	3,455	6,341
California	8,166	10,561	12,816	10,364	15,840	29,138
Colorado	1,455	2,009	2,554	2,130	3,497	6,209
Connecticut	2,089	2,906	3,750	3,635	5,716	9,771
Delaware	494	677	860	779	1,237	2,260
District of Columbia	52	63	75	103	147	252
Florida	7,800	10,283	12,663	9,168	14,170	27,334
Georgia	5,965	7,741	9,469	6,741	10,189	17,246
Idaho	671	902	1,147	794	1,246	2,323
Illinois	4,760	6,195	7,741	6,318	10,027	17,421
Indiana	4,583	6,058	7,671	5,522	8,771	15,126
Iowa	1,694	2,325	2,975	2,257	3,787	6,497
Kansas	1,670	2,279	2,903	2,162	3,392	6,007
Kentucky	3,688	4,778	5,896	4,010	6,177	11,440
Louisiana	1,743	2,161	2,561	1,905	2,710	5,036
Maine	1,361	1,767	2,140	1,668	2,629	4,913
Maryland	2,183	3,030	3,882	4,272	6,651	11,892
Massachusetts	3,283	4,281	5,394	5,341	8,412	14,929
Michigan	7,447	9,617	11,975	9,120	14,327	24,907
Minnesota	2,465	3,357	4,344	3,620	6,153	10,997
Mississippi	2,401	2,986	3,581	2,280	3,359	6,314
Missouri	4,176	5,519	6,782	5,046	7,763	13,673
Montana	434	578	730	549	872	1,703
Nebraska	948	1,303	1,641	1,299	2,073	3,607
Nevada	733	972	1,240	904	1,472	2,709
New Hampshire	683	958	1,227	1,196	1,941	3,662
New Jersey	2,426	3,292	4,348	4,774	7,658	14,740
New Mexico	900	1,143	1,368	964	1,419	2,802
New York	6,998	9,558	12,294	10,919	17,477	33,063
North Carolina	7,497	9,785	11,982	8,456	12,925	23,380
North Dakota	310	444	591	448	734	1,382
Ohio	8,938	11,768	14,644	10,650	16,866	29,642
Oklahoma	3,091	3,910	4,761	3,447	5,129	8,992
Oregon	2,178	2,907	3,674	2,688	4,223	7,134
Pennsylvania	8,244	11,183	14,218	11,383	18,178	32,989
Rhode Island	624	829	1,078	885	1,464	2,621
South Carolina	3,449	4,417	5,402	3,772	5,793	10,379
South Dakota	383	523	674	476	823	1,479
Tennessee	4,513	5,854	7,193	4,897	7,509	12,726
Texas	10,017	12,853	15,447	11,803	17,822	30,940
Utah	675	940	1,253	937	1,553	2,722
Vermont	523	682	836	710	1,116	2,107
Virginia	4,100	5,441	6,869	5,930	9,288	16,869
Washington	2,920	3,901	4,983	4,144	6,521	10,764
West Virginia	1,712	2,233	2,760	1,804	2,811	5,292
Wisconsin	2,419	3,304	4,321	3,460	5,730	10,341
Wyoming	190	261	337	307	492	955
Total	151,537	199,322	248,223	193,323	302,093	541,865
All U.S. persistent poverty counties (no AK, HI)	10,880	13,321	15,623	9,964	14,403	27,189

Table C.16: Single-year economic potential revenue (million $/yr), by regional commission and state

Location	<200% FPL	<250% FPL	<300% FPL	<80% AMI	<120% AMI	All incomes
ARC[a] - AL	2,764	3,536	4,263	3,035	4,502	7,834
ARC - GA	1,859	2,466	3,109	2,182	3,384	5,624
ARC - KY	1,376	1,710	2,042	1,159	1,729	3,440
ARC - MD	228	296	363	272	418	779
ARC - MS	539	673	808	490	724	1,393
ARC - NC	1,731	2,285	2,829	1,874	2,938	5,443
ARC - NY	884	1,187	1,496	1,130	1,807	3,297
ARC - OH	2,233	2,907	3,652	2,383	3,822	7,156
ARC - PA	5,721	7,628	9,572	7,241	11,236	19,017
ARC - SC	964	1,255	1,578	1,057	1,653	2,735
ARC - TN	2,324	2,997	3,680	2,394	3,690	6,330
ARC - VA	630	824	1,020	636	1,003	1,880
ARC - WV	1,712	2,233	2,760	1,804	2,811	5,292
ARC - Total	22,964	29,997	37,170	25,656	39,716	70,220
NBRC[b] - ME	900	1,148	1,387	942	1,473	2,816
NBRC - NH	175	232	285	225	348	671
NBRC - NY	813	1,128	1,409	1,064	1,732	3,271
NBRC - VT	153	192	235	188	284	500
NBRC - Total	2,042	2,700	3,316	2,419	3,837	7,258
SBRC[c] - AZ	1,788	2,249	2,856	2,135	3,341	5,968
SBRC - CA	3,311	4,281	5,152	3,873	5,873	11,386
SBRC - NM	310	393	475	301	450	920
SBRC - TX	2,402	3,024	3,563	2,402	3,608	6,372
SBRC - Total	7,810	9,947	12,046	8,712	13,271	24,645
SCRC[d] - AL	930	1,195	1,446	1,067	1,568	2,789
SCRC - FL	7,800	10,283	12,663	9,168	14,170	27,334
SCRC - GA	4,106	5,276	6,360	4,560	6,805	11,623
SCRC - MS	786	1,000	1,225	784	1,184	2,305
SCRC - NC	5,766	7,500	9,153	6,582	9,986	17,937
SCRC - SC	2,486	3,162	3,824	2,715	4,140	7,644
SCRC - VA	3,470	4,617	5,848	5,294	8,285	14,990
SCRC - Total	25,344	33,034	40,520	30,168	46,139	84,621
DRA[e] - AL	446	544	639	397	560	1,045
DRA - AR	1,203	1,509	1,806	1,181	1,751	3,231
DRA - IL	263	341	425	303	468	855
DRA - KY	359	469	583	391	596	1,097
DRA - LA	1,273	1,575	1,859	1,368	1,941	3,507
DRA - MO	691	890	1,061	654	1,030	1,909
DRA - MS	1,201	1,468	1,735	1,116	1,615	2,932
DRA - TN	1,132	1,407	1,673	1,187	1,710	2,874
DRA - Total	6,566	8,201	9,782	6,597	9,670	17,450
NGPR[f] - IA	1,694	2,325	2,975	2,257	3,787	6,497
NGPR - MN	2,465	3,357	4,344	3,620	6,153	10,997
NGPR - MO	3,486	4,630	5,721	4,392	6,732	11,764
NGPR - ND	310	444	591	448	734	1,382
NGPR - NE	948	1,303	1,641	1,299	2,073	3,607
NGPR - SD	383	523	674	476	823	1,479
NGPR - Total	9,285	12,582	15,945	12,492	20,302	35,727

[a] ARC = Appalachian Regional Commission
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Appendix D. Additional Regression Results

The AHS MLR used household income as the dependent variable and the independent variables were vintage, size, heating type, heating fuel, air conditioner type, and census division.

The PUMS MLR used household income as the dependent variable and the independent variables were vintage, heating fuel, and number of rooms.

Table D.17: AHS dataset MLR model output[a,b,c]

Variable	Estimate	Std. Error	t value	$Pr(>\|t\|)$
size=3500+	74,556	1,672	44.581	0
size=2500-3499	45,820	1,349	33.961	2.14E-248
size=1500-2499	18,514	1,024	18.075	1.15E-72
division=Mountain - Pacific	17,790	1,369	12.994	1.65E-38
division=New England	31,708	2,511	12.626	1.85E-36
vintage=1990s	19,351	1,622	11.931	9.56E-33
actype=Central	17,028	1,444	11.793	4.93E-32
division=Middle Atlantic	20,463	1,802	11.352	8.24E-30
heatingfuel=Natural Gas	15,119	1,371	11.028	3.15E-28
vintage=2000s	16,586	1,544	10.739	7.42E-27
vintage=1980s	16,650	1,688	9.866	6.29E-23
heatingfuel=Fuel Oil	12,319	2,464	5.000	5.76E-07
vintage=1970s	5,075	1,450	3.500	4.65E-04
heatingfuel=Propane	5,435	2,196	2.475	1.33E-02
division=West North Central	4,030	1,803	2.236	2.54E-02
division=West South Central	2,986	1,506	1.982	4.74E-02
division=East North Central	2,785	1,447	1.925	5.42E-02
heatingtype=Steam or hot water system	30,573	19,175	1.594	1.11E-01
heatingtype=None	33,187	21,093	1.573	1.16E-01
heatingtype=Electric heat pump	27,603	19,187	1.439	1.50E-01
heatingtype=Built-in electric units	27,585	19,307	1.429	1.53E-01
actype=None	1,979	1,786	1.108	2.68E-01
heatingtype=Warm-air furnace	20,550	19,113	1.075	2.82E-01
heatingtype=Other	21,537	21,184	1.017	3.09E-01
heatingtype=Stoves	18,430	19,744	0.933	3.51E-01
heatingtype=Portable electric heaters	13,450	19,477	0.691	4.90E-01
heatingtype=Fireplaces with inserts	14,331	20,987	0.683	4.95E-01
heatingtype=Fireplaces without inserts	16,054	24,493	0.655	5.12E-01
heatingtype=Floor, wall, or other built-in hot-air units w/out ducts	11,131	19,240	0.579	5.63E-01
vintage=1950s	713	1,518	0.470	6.39E-01
heatingtype=Room heaters with flue	5,844	19,676	0.297	7.66E-01
heatingtype=Room heaters without flue	5,321	19,494	0.273	7.85E-01
heatingfuel=Other Fuel	886	3,627	0.244	8.07E-01
(Intercept)	-823	19,123	-0.043	9.66E-01
vintage=1960s	60	1,559	0.039	9.69E-01

[a] $R^2 = 0.141$, Adjusted $R^2 = 0.140$

[b] Refer to the AHS 2013 Table Specifications for variable name meanings.

[c] Categorical variables included in the intercept reference are: size=0-1499, vintage=<1950, actype=Room, heatingtype=Cooking stove, heatingfuel=Electricity, division=South Atlantic - East South Central.

Table D.18: PUMS dataset MLR model output[a,b,c]

Variable	Estimate	Std. Error	t value	$Pr(>\|t\|)$
vintage=1970s	9,668	134	71.994	0
vintage=1980s	22,480	143	156.886	0
vintage=1990s	28,309	137	207.231	0
vintage=2000s	28,477	137	207.470	0
heatingfuel=Fuel Oil	22,445	254	88.476	0
heatingfuel=Natural Gas	18,398	217	84.907	0
rooms=6	27,678	714	38.791	0
rooms=7	41,840	715	58.524	0
rooms=8	57,971	717	80.837	0
rooms=9	90,291	716	126.120	0
vintage=1960s	5,311	141	37.716	3.09E-311
vintage=1950s	4,161	135	30.871	3.13E-209
heatingfuel=None	15,286	546	28.016	1.09E-172
heatingfuel=Electricity	6,158	223	27.629	5.20E-168
rooms=5	16,681	714	23.354	1.30E-120
(Intercept)	14,763	736	20.047	2.15E-89
heatingfuel=Propane/LPG	4,872	259	18.815	5.69E-79
rooms=4	9,390	724	12.975	1.70E-38
rooms=1	11,267	1,225	9.196	3.73E-20
rooms=3	3,794	781	4.860	1.17E-06

[a] $R^2 = 0.148$, Adjusted $R^2 = 0.148$
[b] Refer to the PUMS 2011 Data Dictionary for variable name meanings
[c] Categorical variables included in the intercept reference are: heatingfuel=Other Fuel, vintage=<1950, rooms=2.

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