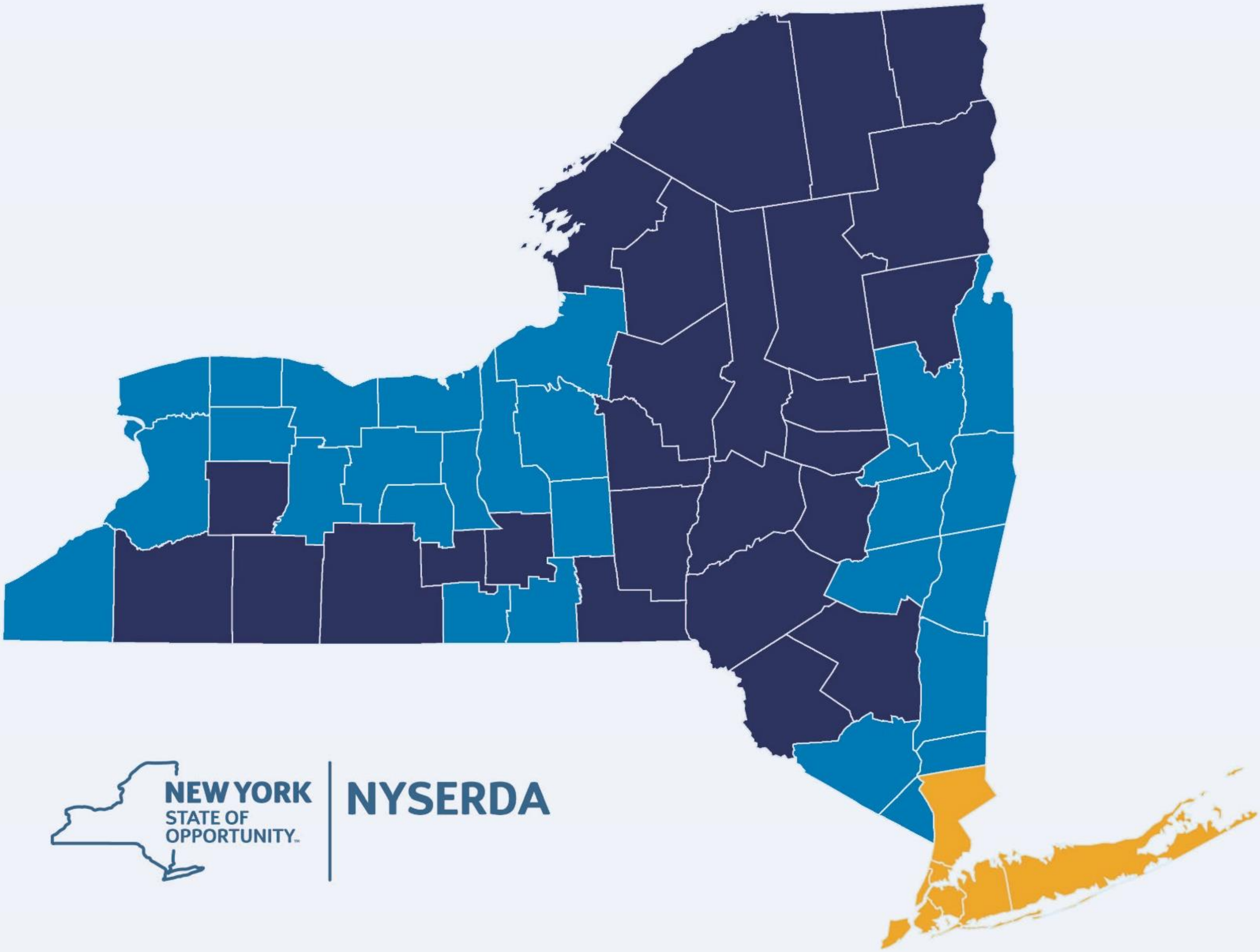

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

2019 SINGLE-FAMILY POTENTIAL STUDY

RESIDENTIAL BUILDING STOCK ASSESSMENT

Prepared for:

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Acronyms and Abbreviations

ACS	American Community Survey
BBtu	Billion British thermal units
BCA	Benefit Cost Analysis
CARIS	Congestion Assessment and Resource Integration Study
CEE	Consortium for Energy Efficiency
CO2	Carbon dioxide
DOE	U.S. Department of Energy
DPS	New York Department of Public Service
EERE	Energy Office of Energy Efficiency
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
EUL	Effective useful life
GPM	Gallons per minute
GWh	Gigawatt hours
kWh	Kilowatt hours
MMBtu	Million British thermal units
NREL	National Renewable Energy Laboratory
NYISO	New York Independent System Operator
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
RBSA	Residential Building Stock Assessment
SCC	Social Cost of Carbon
TBtu	Trillion British thermal units
TRM	Technical reference manual

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Executive Summary

STUDY OBJECTIVES

The New York State Energy Research and Development Authority (NYSERDA) contracted with Cadmus to complete an energy efficiency potential assessment—the 2019 Residential Building Stock Assessment (RBSA) Single-Family Potential Study. Cadmus designed the study to produce estimates of the conservation resources achievable in New York State over a 10-year period, from 2019 to 2028, with an emphasis on calendar years 2021, 2023, and 2028. The primary objective of the study is to identify energy efficiency potential opportunities in the State.

This report presents the single-family potential study's findings in two volumes: this volume provides the methodologies and findings of the energy efficiency potential study. A separate document contains appendices, including detailed study results. In conjunction with this study, Cadmus conducted the 2019 RBSA Single-Family Building Assessment, presented in a separate report.

SCOPE OF ANALYSIS

Within the single-family segment, which the 2019 RBSA defines as including buildings with one to four housing units, Cadmus considered multiple climate zones (defined by the International Energy Conservation Code as Climate Zones 4, 5, and 6),[1] home vintage (new and existing), and all major residential single-family end uses. Cadmus applied these considerations to the most prominent fuel types in residential single-family households, including electricity, natural gas, fuel oil, and propane.

For each fuel type, Cadmus developed a baseline end-use load forecast that assumed no new future programmatic conservation resources. The baseline largely captured savings from building energy codes, equipment standards, and naturally occurring market forces. Cadmus calculated energy efficiency potential estimates by assessing the impacts of each energy conservation measure on this baseline forecast. Therefore, conservation potential estimates presented in this report represent savings that energy efficiency programs could achieve beyond those savings resulting from the effects of codes, standards, and naturally occurring savings from market forces.

As shown in Figure 1, these methods provided estimates for three types of savings potential. Cadmus based these estimates on standard methods and information available at the time of the study.

[1] See Figure B-1 in Appendix B. Baseline Forecast Data for a map of New York State climate zones.

FIGURE 1. TYPES OF POTENTIAL ESTIMATES

Technical potential includes all technically feasible conservation measures, regardless of costs and market barriers, that are generally available at the time of the study. Cadmus used the industry-standard, bottom-up approach to analyze all electric, natural gas, and other fossil fuel measures applicable to single-family homes in New York State. This approach remains consistent with energy efficiency potential studies conducted by Cadmus and other consultants throughout the United States.

Economic potential represents a subset of technical potential and consists of measures meeting the cost-effectiveness criteria, set to be consistent with the primary test adopted under the NYS Public Service Commission's Benefit Cost Analysis (BCA) Framework.

Achievable potential represents the portion of economic potential that might be reasonably achievable, after taking into account market barriers that may impede customer adoption, including limitations in customers' willingness to adopt energy efficiency measures.

Cadmus did not estimate program potential in this study. Program potential is the amount of potential savings NYS utilities and statewide initiatives may realize through the energy efficiency programs formally offered to customers; it accounts for program design, spending on energy efficiency programs, and program implementation barriers. This study's estimates of technical, economic, and achievable potential can serve as a valuable starting point for designing programs and estimating program potential, but final estimates of program potential fall outside the scope of this study.

PRIMARY DATA COLLECTION

The RBSA project featured in-depth primary data collection efforts, which provided essential inputs to the potential study. Primary data collection included the following activities:

- **Detailed survey.** Web and phone surveys collected information on housing characteristics, demographics, and energy-consuming end uses (such as fuel type, equipment type, and equipment age).
- **Site visit.** A site assessment collected extensive information on single-family housing characteristics, energy-consuming end uses (such as HVAC equipment, lighting, and appliances), and equipment efficiencies. In total, Cadmus completed a web or phone survey with 2,419 single-family home occupants and completed site visits to 456 homes distributed throughout the State.

SUMMARY OF RESULTS

This section provides a summary of energy efficiency potential estimates that represent opportunities from energy conservation measures applied to end uses within fuel types; they do not include opportunities from converting from fossil fuel–based space and water heating end uses to electric heat pumps, or vice versa.

Energy Efficiency Potential

This study quantifies the amount of energy and coincident peak demand reduction achievable for all single-family homes in NYS from 2019 to 2028. Table 1 presents the cumulative electric, natural gas, and other fossil fuel (fuel oil and propane) technical and economic potential estimated through the study. Energy efficiency potentials throughout this report are presented as savings at the customer site.[2] These values represent potentials from energy efficiency measures and do not include potential from fuel-switching measures.

TABLE 1. CUMULATIVE ENERGY EFFICIENCY POTENTIAL, 2019–2028

Fuel Type	2028 Forecast Sales (TBtu)	Technical Potential 2028 (TBtu)	Technical Potential Percentage of Sales	Economic Potential 2028 (TBtu)	Economic Potential as a Percentage of Sales
Electricity	126	38	30%	34	27%
Natural Gas	354	144	41%	76	21%
Other Fossil Fuels	106	34	32%	32	30%
Total	**586**	**216**	**37%**	**142**	**24%**

Study results indicate the cumulative accrual of more than 216 trillion British thermal units (TBtu) of technically feasible energy efficiency potential by 2028, with cost-effective measures producing approximately 142 TBtu. Cumulative savings represent the total annual incremental savings that can be achieved during each year of the 10-year study period and account for end-use equipment turnover based on measure lifetimes. As a percentage of baseline forecasted 2028 sales, technical potential represents 37% and economic potential represents 24%, equating to 4.7% and 2.8% of forecasted baseline sales, respectively, on an annual basis. As a percentage of total technical potential, economic potential represents 66%.

This study estimates approximately 38,000 BBtu (more than 11,000 GWh) of technically feasible, cumulative, electric energy efficiency potential by 2028, with cost-effective measures producing approximately 34,000 BBtu. The technical potential represents about 30% of forecasted 2028 sales, and economic potential represents 27%, equating to 3.7% and 3.2% of forecasted sales, respectively, on an annual basis. As a percentage of total technical potential, the economic potential represents 90%.

This study's cumulative natural gas energy efficiency potential totals more than 144,000 BBtu of technically feasible potential by 2028, with cost-effective measures producing approximately 76,000 BBtu. The technical potential represents 41% of forecasted natural gas baseline 2028 sales, and

[2] Electric efficiency savings are converted to Btu directly when calculating site energy savings, using a conversion factor of 3,412 Btu/kWh, which is based on the energy content of a kWh.

economic potential represents 21%, equating to 5.4% and 2.4% of forecasted sales, respectively, on an annual basis. As a percentage of total technical potential, economic potential represents 53%.

Other fossil fuels, including fuel oil and propane, combine to account for about 34,000 BBtu of cumulative technical potential and approximately 32,000 BBtu of economic potential, equaling 32% and 30% of forecasted baseline 2028 sales, respectively.

Table 2 shows the cumulative, technical and economic, electric coincident peak demand reduction potential for all single-family homes in NYS for each climate zone from 2019 through 2028. Approximately 65% of the technical electric coincident peak demand savings are cost-effective. Energy efficiency measures providing substantial coincident peak demand reductions include some of the highest energy-saving measures in the study—including residential lighting—but also include measures with end-use load shapes with relatively high coincidence with the New York Independent System Operator peak, including central air conditioning, smart thermostat, pool pump, air conditioning recycling, among other measures.

TABLE 2. CUMULATIVE PEAK DEMAND POTENTIAL, 2019–2028

Climate Zone	Technical Potential 2028 (MW)	Economic Potential 2028 (MW)
Climate Zone 4	3,847	2,445
Climate Zone 5	2,357	1,546
Climate Zone 6	835	559
Total	**7,039**	**4,550**

This report's *Technical and Economic Potential* section provides detailed estimates of electric, natural gas, and other fossil fuel potential for each NYS climate zone for the residential single-family segment.

Study Findings and Conclusions

The full range of potential estimates generated in this study indicate that the total energy efficiency potential in the state can vary under different circumstances, with combined, cost-effective economic potential equating to nearly 9%, 15%, and 28% of baseline energy forecasts in 2021, 2023, and 2028 for the residential single-family market segment, across all fuel types.

Cadmus offers several additional conclusions from this report's findings:

- **Conclusion: LED lighting represents significant, cost-effective energy efficiency savings in 2019 and perhaps beyond.** Despite the U.S. Department of Energy's (DOE) September 5, 2019, final rule and notice of proposed determination that effectively rescinded the Energy Independence and Security Act (EISA) 2020 backstop standard,[3] substantial uncertainty remains regarding the future of the backstop standard and effect of the DOE final rule on energy-savings potential for LEDs within energy efficiency programs. Given the timing of the final rule and the uncertainty around its effects, Cadmus' modeling methodology assumed that the 2020 EISA backstop

[3] DOE. September 5, 2019. "Energy Conservation Program: Energy Conservation Standards for General Service Lamps." https://s3.amazonaws.com/public-inspection.federalregister.gov/2019-18941.pdf

standard would still occur. This report presents potential savings beyond the savings that would result from that standard. With this assumption, general service LED lighting measures represent almost 11% of the total 10-year electric economic potential for single-family homes, with 57% of general service lighting potential occurring in 2019.

- **Conclusion: Specialty LED lighting, including lamps exempt from the EISA 2020 backstop standard, represent significant, cost-effective energy savings from 2019 through 2028.** These lamps account for almost 14% of the total 10-year electric economic potential for single-family homes.
- **Conclusion: Residential connected load measures—smart thermostats and behavioral energy feedback—offer opportunities and substantial energy savings potential.** According to the potential study, smart thermostat and behavior energy feedback measures will offer substantial savings opportunities in the future.
- **Conclusion: Appliance recycling measures contribute significant, cost-effective energy efficiency potential.** With nearly 1.4 refrigerators and 0.4 stand-alone freezers per single-family home, appliance recycling measures contribute meaningful, cost-effective electric energy efficiency potential in NYS. In fact, the refrigerator and freezer recycling measures combine to account for nearly 25% of the total, 10-year economic electric efficiency potential. A third appliance recycling measure category—room air conditioning—contributes to approximately 1.6% of the total 10-year economic efficiency potential for residential single-family homes.
- **Conclusion: Natural gas energy efficiency economic potential occurs primarily within retrofit measures, as lower natural gas avoided costs render most equipment replacements non-economic.** Despite the substantial availability of technical potential from replacing single-family, natural gas, forced air furnaces and boilers with more efficient gas equipment, the relatively low forecasted natural gas avoided costs used in this study result in low economic potential for within-fuel natural gas equipment replacements; equipment efficiency improvements—replacing inefficient natural gas boilers, furnaces, and water heaters—represent 4% of the total 10-year economic potential. As a result, two retrofit measures—smart/Wi-Fi thermostats and basement wall insulation—together represent more than 40% of the total economic gas efficiency potential.

Recent NYSERDA Potential Studies

NYSERDA completed previous studies to estimate energy efficiency potential in NYS in 2014 (Long-Term Potential Study) and in 2015 (2015-2016 Short-Term Potential Study); the latter study used 2013 as the baseline year and was conducted as part of the 2015 Residential Statewide Baseline Study.[4] Several notable differences emerged between the two studies:

- The Long-Term Potential Study evaluated potential for all sectors, including residential, and employed a top-down approach to estimate energy efficiency potential.
- The Short-Term Potential Study evaluated only the residential sector, including multifamily and single-family, and used a bottom-up methodology to estimate energy efficiency potential.

The primary distinctions between the previous studies is that the RBSA Potential Study:

- Considers only the residential single-family segment.
- Employs a different definition of economic potential, which includes the social cost of carbon, consistent with the PSC Benefit Cost Analysis (BCA) Order.
- Reports energy savings at site, rather than generation, to remain consistent with New York's 2025 statewide energy efficiency target.

Overall, the RBSA single-family potential study estimates that a significant amount of electric, natural gas, oil, and propane energy efficiency potential remains in buildings with one to four housing units in New York State. New efficiency opportunities continue to emerge.

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[4] Optimal Energy, Inc., American Council for an Energy-Efficient Economy, and Vermont Energy Investment Corporation. 2014. "Energy Efficiency and Renewable Energy Potential Study of New York State." NYSERDA Report Number 14-19. https://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/EERE-Potential-Studies
Tetra Tech, GDS Associates, and Performance Systems Development. 2015. "NYSERDA Residential Statewide Baseline Study." NYSERDA Report Number 15-07. https://nyserda.ny.gov/publications

General Approach

This assessment estimates the potential for residential single-family energy savings in NYS from 2019 to 2028. This section describes each step in the assessment process and summarizes the results.

PRIMARY DATA COLLECTION

This study drew heavily on data collected through the RBSA project's building assessment component, which included a detailed web and phone survey and site visits.

Surveys

Cadmus completed a web or phone survey with 2,419 single-family home occupants to provide a larger sample size for many home characteristics than practical with site visits alone and to obtain information about several energy efficiency potential study topics:

- Efficient product awareness and perceptions
- Customers' willingness to adopt and pay for energy efficiency measures
- Demographics

To recruit survey recipients, the study mailed postcards to randomly selected existing and new homes within each of the State's 10 Economic Development Regions (EDRs), drawing primarily on addresses of single-family homes randomly selected from New York State Department of Taxation and Finance tax assessment rolls. Results were weighted by climate zone and home vintage to provide estimates representative of the population of interest. Table 3 provides the number of single-family data collection surveys by climate zone and home vintage.

TABLE 3. DATA COLLECTION SURVEY COUNTS

Vintage	Stratum	Population	Count
Existing Homes	Climate Zone 4	2,516,613	515
	Climate Zone 5	1,945,375	913
	Climate Zone 6	807,178	407
	Total Existing	5,269,166	1,835
New Homes	Climate Zone 4	12,105	38
	Climate Zone 5	18,451	420
	Climate Zone 6	7,169	126
	Total New	37,725	584
Total		**5,306,891**	**2,419**

Site Visits

Site visits provided the highest level of detail to inform this study. These on-site assessments collected extensive information on single-family housing characteristics, energy-consuming end uses (such as HVAC equipment, lighting, and appliances), and equipment efficiencies.

The study recruited site visit participants from the 2,419 survey respondents and set separate targets for completions in existing and new homes in each of the 10 EDRs. The project team visited 456 single-family homes in the fall of 2018, including 361 existing (built prior to 2015) and 95 new homes (built during or after 2015). Cadmus subcontracted to Honeywell and Performance Systems Development to conduct site visits.

Table 4 shows the total population and data collection site visit count for each home vintage and climate zone. Note that the small sample size for new homes in Climate Zone 4 limited the meaningfulness of those results. (As with the 2015 Residential Statewide Baseline Study, the RBSA experienced challenges identifying and recruiting new homes participants in Climate Zone 4, especially in New York City and Long Island.) Accordingly, Cadmus chose, for many new homes' inputs, to use statewide values rather than rely on small sample-size data for Climate Zone 4. Cadmus believes this approach provides the most accurate statewide results for new homes.

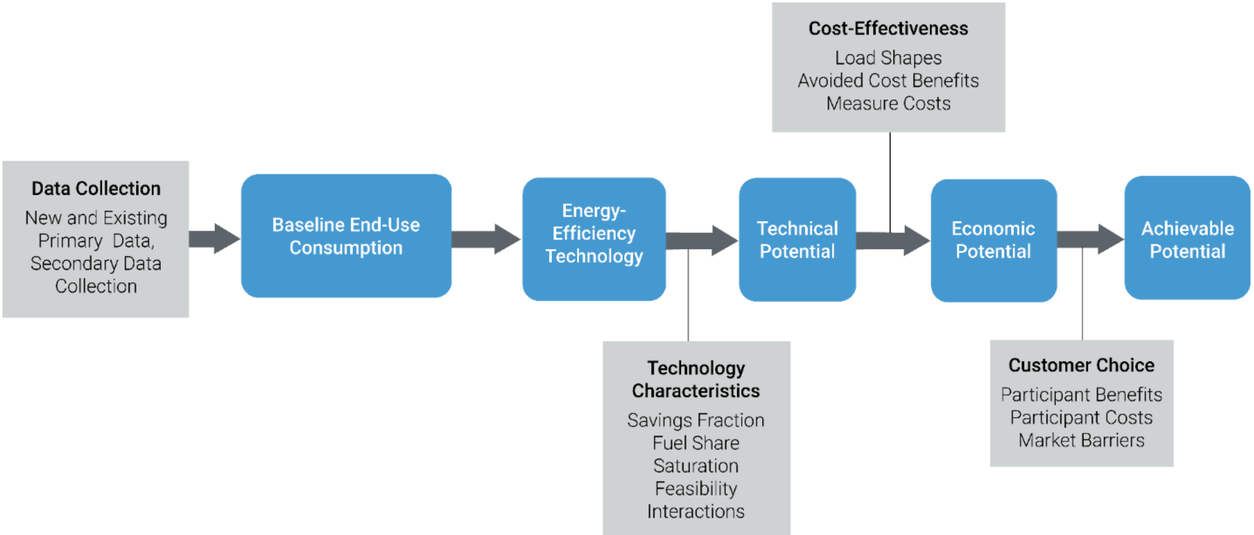
TABLE 4. DATA COLLECTION SITE VISIT COUNTS

Home Vintage	Stratum	Population	Count
Existing Homes	Climate Zone 4	2,516,613	85
	Climate Zone 5	1,945,375	204
	Climate Zone 6	807,178	72
	Total Existing	5,269,166	361
New Homes	Climate Zone 4	12,105	5
	Climate Zone 5	18,451	67
	Climate Zone 6	7,169	23
	Total New	37,725	95
Total		**5,306,891**	**456**

ENERGY EFFICIENCY METHODOLOGY OVERVIEW

Cadmus' general methodology was a bottom-up approach, which relied on the granular, New York State-specific, single-family equipment-level data gathered as part of the RBSA building stock assessment. As shown in Figure 2, Cadmus developed baseline end-use consumption forecasts and considered the potential technical impacts of various energy efficiency measures and conservation practices on each end use. Cadmus then estimated energy efficiency savings impacts based on engineering calculations and accounting for fuel shares, current market saturation, technical feasibility, and costs.

FIGURE 2. GENERAL METHODOLOGY FOR ASSESSING ENERGY EFFICIENCY POTENTIAL



Prior to developing baseline end-use consumption forecasts, Cadmus segmented the statewide, residential, single-family housing stock into three distinct geographies, defined by climate zone. Cadmus then estimated the number of homes served with each major fuel type (electric, natural gas, and other fossil fuels) in each climate zone.

After segmenting the residential single-family housing stock, Cadmus developed annual baseline end-use consumption estimates for each climate zone and fuel type, relying on granular and detailed end-use equipment saturation, fuel share, and efficiency share data gathered in the RBSA and from secondary data sources. The equation below specified the forecast for each end use in the study:

$$EUSE_{jz} = \Sigma_e\, HOMES_z * UPH_z * SAT_{jz} * FSH_{jz} * ESH_{jze} * UEC_{jze}$$

Where:

$EUSE_{jz}$	=	Total energy consumption for end use *j* in climate zone *z*
$HOMES_z$	=	The number of single-family homes in climate zone *z*
UPH_z	=	The units per home in climate zone *z*
SAT_{jz}	=	The share of homes in climate zone *z* with end use *j*
FSH_{jz}	=	The share of electric, gas, or other fossil fuel in end use *j* in climate zone *z*
ESH_{jze}	=	The market share of efficiency level *e* in equipment for end use *j* in climate zone *z*
UEC_{jze}	=	Unit energy consumption for the equipment configuration *jze*

After adjusting for future equipment efficiency standards, Cadmus summed each end-use forecast within each climate zone and fuel-type combination to determine the overall baseline consumption forecast. Baseline consumption forecasts in this report include estimates of energy savings resulting from residential energy codes, federal equipment standards, and naturally occurring savings from market forces. Therefore, energy efficiency potential estimates presented in the report represent only the additional savings attainable through various utility and state energy efficiency programs and initiatives.

As part of this study, Cadmus collected primary data across NYS through site visits and telephone surveys. Cadmus completed 456 single-family site visits and more than 2,400 surveys of single-family homeowners and renters to provide NYS-specific baseline data on housing characteristics, demographics, and energy-consuming end use (such as fuel type, equipment type, and equipment efficiency) and to collect information on customers' attitudes toward energy efficiency and willingness to adopt efficiency measures. This report's Primary Data Collection section provides further details on these data collection activities.

Next, Cadmus developed a comprehensive measure database of technology and market data that applied to all residential single-family end uses and estimated costs, savings, and applicability for a set of energy efficiency measures. The listed measures included existing measures from NYS utility programs as well as selected emerging technologies and behavioral measures. This report's Appendix A. Analysis Methodology section includes a description of data sources used as part of this study.

The study assesses three types of potential (as illustrated in Figure 3):

- **Technical potential** assumes that all technically feasible energy efficiency measures generally available at the time of the study will be implemented, regardless of their costs or of any market barriers. This theoretical upper bound of available conservation potential is estimated after accounting for technical constraints. For energy efficiency resources, technical potential has three distinct classes:
  - Retrofit opportunities in existing homes
  - Equipment replacements in existing homes
  - New homes

  Customers can theoretically implement the first class, which exists in current building stock, at any point in the planning horizon; however, the study assumed that retrofit measure opportunities would be replaced incrementally until 100% of the stock was converted to the efficient measure over the 10-year study horizon. In other words, the annual rate of retrofit measure implementation was 10% of the total, remaining

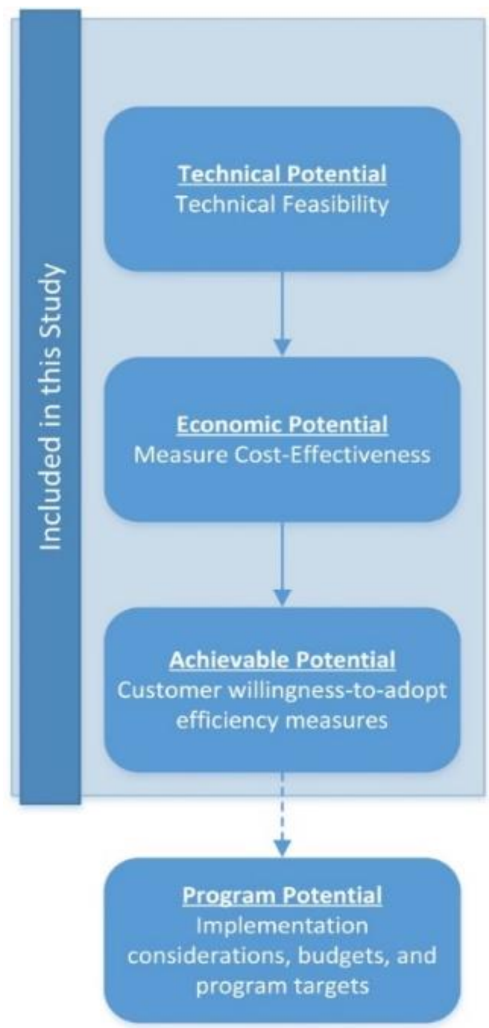


FIGURE 3. TYPES OF POTENTIAL ESTIMATED FOR THIS STUDY

applicable housing stock. Examples of retrofit measures, which reduce the consumption of end-use equipment without modifying or replacing that equipment, include insulation, faucet aerators, and smart/Wi-Fi thermostats. On the other hand, the technical potential model assumes that end-use equipment turnover rates and new homes rates dictate the timing of the other two classes. This report's Appendix A. Analysis Methodology section includes a description of the data sources Cadmus used to estimate these technical constraints for individual measures.

- **Economic potential** represents a subset of technical potential and consists only of measures meeting the cost-effectiveness criteria, set to be consistent with the primary cost-effectiveness test adopted under the NYS Public Service Commission's BCA Framework.[5] The primary benefit/cost test under the NYS BCA Framework includes the cost and benefits experienced by the utility system, plus costs and benefits to program participants, plus valuing the benefits associated with avoided carbon dioxide (CO2) emissions. For each energy efficiency measure, the study structured the benefit/cost test as the ratio of net present values for the measure's benefits and costs, using the benefit and cost inputs following the BCA Framework and subsequent New York Department of Public Service guidance.[6] Only measures with a benefit/cost ratio of 1.0 or greater were deemed cost-effective. This report's Appendix A. Analysis Methodology section includes a detailed description of the benefits and costs considered.
- **Achievable potential** derives from the portion of economic potential that might be assumed reasonably achievable in the course of the planning horizon, given market barriers that might impede customer participation in NYS. As measured in this study, achievable potential can vary greatly, based on assumed program incentive levels (as a proxy for interventions to address market barriers) as well as "ramp rates" (defined as the acquisition rates for specific technologies) that determine the amount of economic potential considered achievable in each year of the study. The use of different incentive levels reflects that achievable potential can be best presented as a range of estimates (rather than as a single-point estimate). This recognizes the uncertainty around customer adoption and the challenges inherent in assessing behavioral factors, which can be difficult to quantify and can change unpredictably over time. Appendix A includes a more detailed discussion of Cadmus' approach to estimating achievable potential.

This report does not consider program potential. Fully estimating program potential would require a more detailed examination of rebate levels, marketing and administration expenditures, the possible measure mix that NYS utilities and statewide initiatives can offer, and steps that can be taken in future program-planning processes. The achievable potential estimates presented in this report can inform

[5] New York State Public Service Commission. January 21, 2016. "Order Establishing the Benefit Cost Analysis Framework." Case 14-M-0101, supra.

[6] NY DPS Office of Clean Energy. May 14, 2018. "Utility-Administered Energy Efficiency BCA Filing Requirement Guidance." Clean Energy Guidance CE-07.

program potential by estimating upper and lower bounds and by identifying which measures most cost-effectively meet those targets.

Cadmus rounded values to whole numbers for better readability when presenting results in this report. Accordingly, component values in each table may not sum exactly to the totals shown for each column. Reported results are accurate and full tables can be found in the appendices.

Technical and Economic Potential

ENERGY EFFICIENCY SCOPE OF ANALYSIS

This study included a comprehensive set of energy efficiency measures, with measures drawn from the 2018 *New York Technical Reference Manual* (TRM) and additional secondary data sources, including new and emerging technologies. Cadmus began by assessing the technical potential for hundreds of unique energy efficiency measures.

As discussed in Appendix A. Analysis Methodology, Cadmus considered measure savings and costs separately for each measure permutation across applicable end uses and homes vintage (new and existing) within the single-family segment. As shown in Table 5, Cadmus examined more than 2,000 energy efficiency measure permutations and 213 unique measures across all fuels (electric, natural gas, fuel oil, and propane), in each of three climate zones. Permutations occur when the study applies a unique measure (such as a smart/Wi-Fi thermostat) to multiple end uses (such as central heating, central cooling, and heat pump), home vintages (existing or new), and/or baseline conditions (replacing manual or programmable thermostats).

TABLE 5. MEASURE COUNTS AND PERMUTATIONS

Area	Unique Electric Measure Count	Electric Permutations	Unique Fossil Fuel Measure Count	Fossil Fuel Permutations
Per Climate Zone	89	914	124	1,131

OVERVIEW OF ENERGY EFFICIENCY RESULTS

In addition to the 10-year study horizon from 2019 to 2028, Cadmus estimated technical, economic, and achievable potential for the three- and five-year periods ending in 2021 and 2023, respectively. Table 6 shows 2028 forecasted baseline sales and cumulative technical and economic potential by fuel type. Study results indicate more than 215,700 BBtu of technically feasible conservation (37% of forecasted baseline sales) by 2028, the end of the 10-year study horizon, with an estimated 142,000 BBtu (24% of forecasted baseline sales) that are cost-effective and technically feasible (i.e., economic potential). The technical and economic potential equate to energy savings as a percentage of sales on an annual basis of 4.7% and 2.8%, respectively, across all fuel types.

TABLE 6. TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY FUEL TYPE, 2028

Fuel Type	2028 Forecast Sales (BBtu)	Technical Potential 2028 (BBtu)	Technical Potential Percentage of Sales	Economic Potential 2028 (BBtu)	Economic Potential Percentage of Sales
Electricity	125,541	37,927	30%	34,096	27%
Natural Gas	353,928	144,177	41%	75,837	21%
Other Fossil Fuels	106,267	33,629	32%	32,091	30%
Total	**585,737**	**215,733**	**37%**	**142,024**	**24%**

Table 7 provides 2023 baseline sales and cumulative five-year potential by fuel type.

TABLE 7. TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY FUEL TYPE, 2023

Fuel Type	2023 Forecast Sales (BBtu)	5-Year Technical Potential (BBtu)	Technical Potential Percentage of Sales	5-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
Electricity	128,388	25,311	20%	22,511	18%
Natural Gas	352,035	78,986	22%	49,635	14%
Other Fossil Fuels	107,043	17,052	16%	10,307	10%
Total	**587,466**	**121,348**	**21%**	**82,453**	**14%**

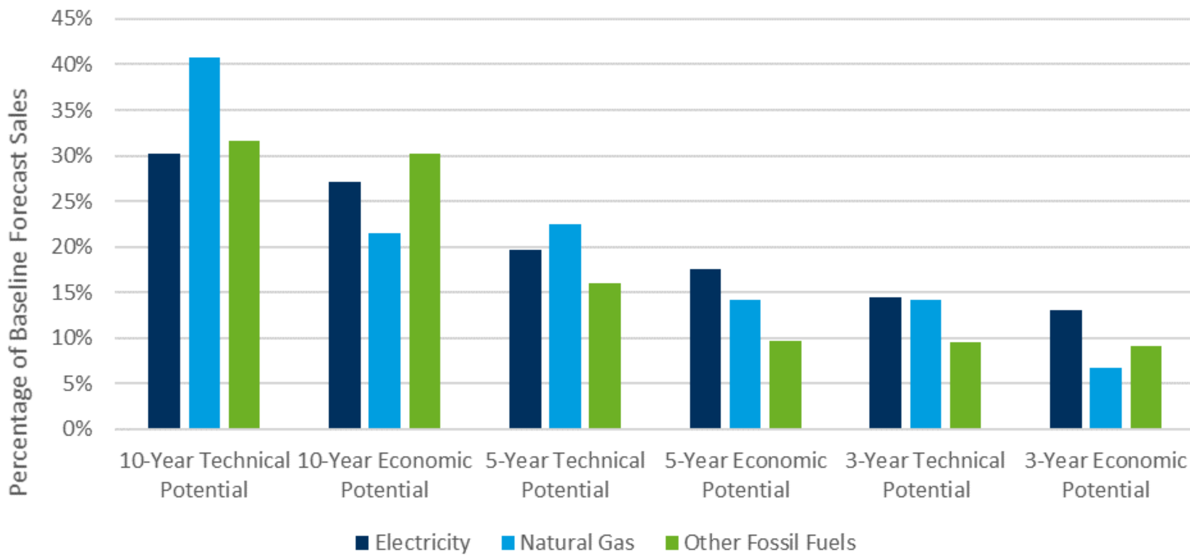
Table 8 provides 2021 baseline sales and three-year cumulative potential by fuel type.

TABLE 8. TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY FUEL TYPE, 2021

Fuel Type	2021 Forecast Sales (BBtu)	3-Year Technical Potential (BBtu)	Technical Potential Percentage of Sales	3-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
Electricity	132,481	19,232	15%	17,217	13%
Natural Gas	351,861	49,635	14%	23,413	7%
Other Fossil Fuels	107,455	10,307	10%	9,823	9%
Total	**591,797**	**79,174**	**13%**	**50,454**	**9%**

Potential savings estimates were calculated relative to baseline forecasts of future consumption, which accounted for impacts of past utility- and NYSERDA-funded energy efficiency measures as well as energy codes and standards, but not impacts of future energy efficiency program activities. The identified estimated potential includes forecasted savings from future program activities. Figure 4 shows technical and economic energy efficiency potential as a percentage of baseline forecasted sales at the single-family segment level.

FIGURE 4. TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL AS A PERCENTAGE OF BASELINE SALES FORECAST BY FUEL TYPE

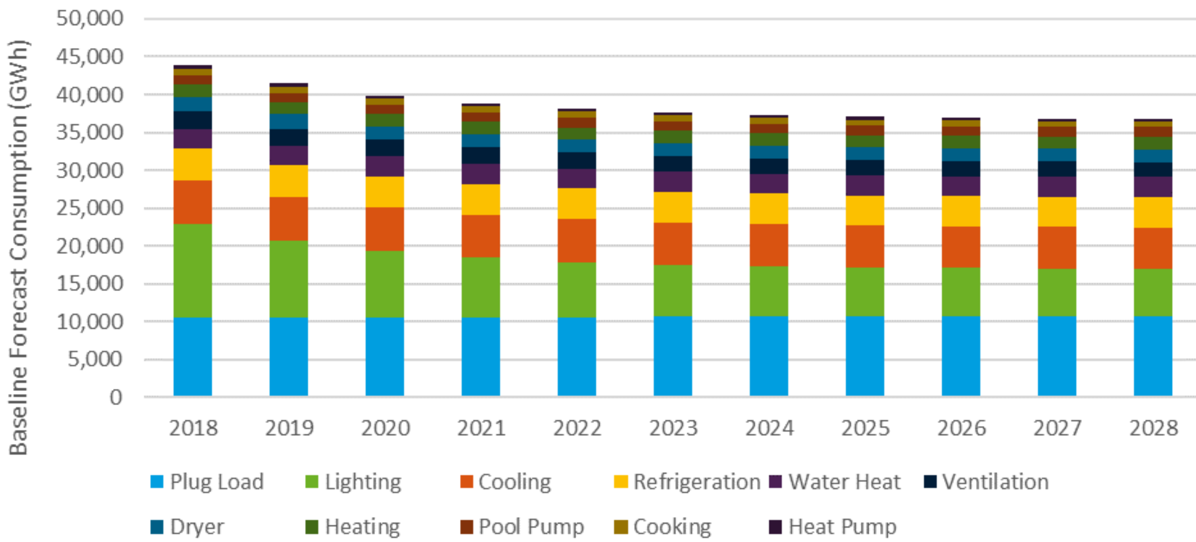


Electric

Prior to estimating electric technical and economic energy efficiency potential, Cadmus developed a bottom-up baseline energy sales forecast for single-family homes in NYS. Figure 5 shows the annual baseline energy sales forecast for the base year (2018) and each year of the study horizon for each electric end-use group. In total, the study included 25 distinct electric end uses that Cadmus categorized into 10 end-use groups.[7] Appendix B provides a complete list of electric end uses and assigned end-use groups.

[7] End-use groups and assigned end uses include: plug load (air purifier, computer, dehumidifier, microwave, plug load other, and TV), lighting (linear fluorescent, standard, specialty), cooling (central and room cooling), refrigeration (freezer and refrigerator), water heat (greater than 55 gallons and less than 55 gallons), ventilation, dryer, heating (central electric furnace and electric room heat), pool pump, cooking (ovens and ranges), and heat pump.

FIGURE 5. ELECTRIC BOTTOM-UP BASELINE ENERGY SALES FORECAST BY END USE GROUP



As Figure 5 reveals, the baseline electric energy sales forecast decreases substantially (11%) from the study's first year (2019) to its last (2028), primarily due to the lighting general service lamp EISA backstop standard, which this study assumed will take effect in 2020. To further illustrate the decreasing electric energy forecast, Table 9 shows the electric bottom-up baseline energy sales forecast by end-use group for the first and last year of the potential study. The 2028 forecasted baseline sales are lower than the 2019 forecasted baseline sales for many end-use groups (such as cooling, refrigeration, and water heat), where portions of baseline equipment stock include "below standard" end-use equipment that, at the end of its useful life, will likely be replaced with minimum federal standard equipment. Appendix A. Analysis Methodology of this report describes in detail the methods used to estimate baseline end-use energy consumption.

TABLE 9. ELECTRIC BOTTOM-UP BASELINE ENERGY SALES FORECAST BY END-USE GROUP, 2019 AND 2028

Electric End Use Group	2019 Baseline Forecasted Sales (GWh)	End-Use Group Percentage of 2019 Baseline Forecasted Sales	2028 Baseline Forecasted Sales (GWh)	End-Use Group Percentage of 2028 Baseline Forecasted Sales
Plug Load	10,607	26%	10,765	29%
Lighting	10,143	24%	6,265	17%
Cooling	5,704	14%	5,441	15%
Refrigeration	4,166	10%	4,045	11%
Water Heat	2,661	6%	2,635	7%
Ventilation	2,233	5%	1,931	5%
Dryer	1,877	5%	1,702	5%
Heating	1,547	4%	1,613	4%
Pool Pump	1,284	3%	1,301	4%
Cooking	868	2%	712	2%
Heat Pump	372	1%	412	1%
Total	**41,463**	**100%**	**36,821**	**100%**

The study indicates more than 11,100 GWh of cumulative technically feasible electric energy efficiency potential by 2028, with cost-effective measures producing approximately 10,000 GWh. Economic potential represents 27% of forecasted 2028 sales. On an annual basis, the 10-year technical and economic potential savings correspond to savings as a percentage of sales of 3.7% and 3.2%, respectively.

Table 10 summarizes electric technical and economic potential for each climate zone. Climate Zone 4 accounts for 51% of the total economic electric potential, followed by Climate Zone 5, at 35%. Table 11 provides the corresponding electric peak demand savings potential.

TABLE 10. TECHNICAL AND ECONOMIC ELECTRIC ENERGY EFFICIENCY POTENTIAL BY CLIMATE ZONE

Climate Zone	2028 Forecast Sales (GWh)	10-Year Technical Potential (GWh)	Technical Potential Percentage of Sales	10-Year Economic Potential (GWh)	Economic Potential Percentage of Sales
Climate Zone 4	18,350	5,677	31%	5,129	28%
Climate Zone 5	12,902	3,844	30%	3,471	27%
Climate Zone 6	5,569	1,603	29%	1,400	25%
Total	**36,821**	**11,124**	**30%**	**10,000**	**27%**

TABLE 11. TECHNICAL AND ECONOMIC ELECTRIC PEAK DEMAND SAVINGS POTENTIAL BY CLIMATE ZONE

Climate Zone	10-Year Technical Potential (MW)	10-Year Economic Potential (MW)
Climate Zone 4	3,847	2,445
Climate Zone 5	2,357	1,546
Climate Zone 6	835	559
Total	**7,039**	**4,550**

The combined lighting, refrigeration, water heating, plug load, and space cooling end-use groups account for 88% and 90% of the electric single-family cumulative technical and economic potential, respectively, as shown in Table 12. Energy efficiency savings accrue to each of these end-use groups through the application of both equipment and retrofit measure types to the baseline forecast end-use loads. For example, the technical and economic potential for the heat pump end use consists of measures replacing inefficient heat pumps with efficient units, and from improvements to the thermal building shell for homes heated and cooled with heat pumps.

Appendix C provides a complete list of electric energy efficiency measures, the end-use group, whether the measure is equipment or retrofit, and the measure’s technical and economic potential.

TABLE 12. SINGLE-FAMILY ELECTRIC TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY END-USE GROUP

Electric End-Use Group	2028 Forecast Sales (GWh)	10-Year Technical Potential (GWh)	Technical Potential, Percentage of Sales	10-Year Economic Potential (GWh)	Economic Potential Percentage of Sales
Cooking	712	0	0%	0	0%
Cooling	5,441	2,049	38%	1,782	33%
Dryer	1,702	36	2%	36	2%
Heat Pump	412	157	38%	140	34%
Heating	1,613	404	25%	284	18%
Lighting	6,265	3,031	48%	2,742	44%
Plug Load	10,765	819	8%	770	7%
Pool Pump	1,301	548	42%	548	42%
Refrigeration	4,045	2,525	62%	2,542	63%
Ventilation	1,931	142	7%	0	0%
Water Heat	2,635	1,413	54%	1,157	44%
Total	**36,821**	**11,124**	**30%**	**10,000**	**27%**

Table 13 provides the electric peak demand technical and economic energy efficiency potential by end-use group.

TABLE 13. SINGLE-FAMILY ELECTRIC PEAK DEMAND TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY END-USE GROUP

Electric End-Use Group	10-Year Technical Potential (MW)	10-Year Economic Potential (MW)
Cooking	0	0
Cooling	3,292	1,677
Dryer	124	82
Heat Pump	93	42
Heating	102	37
Lighting	2,508	2,181
Plug Load	213	114
Pool Pump	363	228
Refrigeration	271	151
Ventilation	0	0
Water Heat	74	38
Total	**7,039**	**4,550**

Table 14 lists the top 15 energy-saving, electric, single-family measures, based on the cumulative 10-year economic potential. These measures account for approximately 84% of the total economic, residential, single-family, electric energy efficiency potential. The removal of secondary refrigerators and the installation of LED lighting, pool pumps with Variable Speed Drive (VSD), and enhanced central air conditioners represent the top four energy-saving, electric, single-family measures over the 10-year study horizon. Although Table 14 provides a list of the top 15 energy-saving, electric, single-family measures, it does not include a complete list of electric, energy efficiency measures that passed the economic benefit/cost test, nor does it include all measures with technical potential that did not pass the economic benefit/cost test. Appendix C provides a comprehensive list of electric energy efficiency measures that passed the economic benefit/cost test and all measures with technical potential that passed the economic benefit/cost test.

The study considered several early retirement measures, including the removal of secondary refrigerators, stand-alone freezers, and room air conditioning units, with room air conditioners being recycled. Cadmus developed per-unit energy savings estimates by applying the 2018 New York TRM methodology for each of these early retirement measures. Furthermore, for each of these end uses—room air conditioning, freezers, and refrigerators—Cadmus estimated the energy efficiency potential from improving the efficiency of the end-use equipment. For example, refrigeration equipment measures included ENERGY STAR, Consortium for Energy Efficiency (CEE) Tier 2, and CEE Tier 3 refrigerators, each of which represent an incremental efficiency improvement compared with refrigerators meeting only the minimum 2015 federal standard efficiency requirements.

TABLE 14. TOP ELECTRIC ENERGY EFFICIENCY SAVING FOR SINGLE-FAMILY MEASURES, CUMULATIVE IN 2028

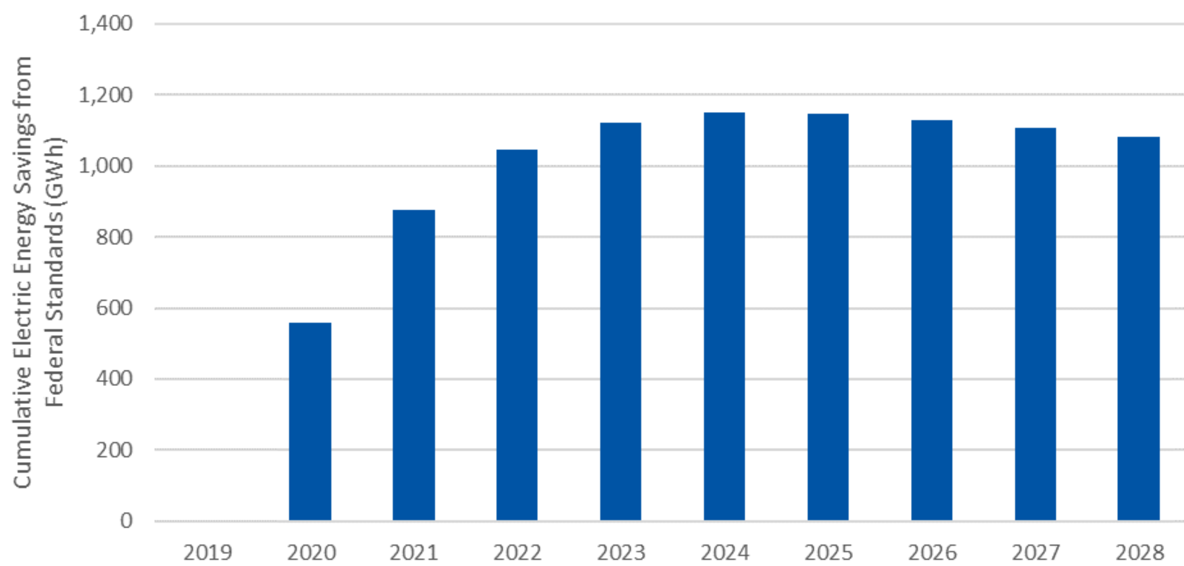
Single-Family Electric Energy Efficiency Measure	10-Year Cumulative Electric Economic Potential (GWh)	Percentage of Total 10-Year Electric Economic Potential
Refrigerator—Removal of Secondary	1,967	19.7%
Lighting Specialty Lamp—CEE Tier 2 LED	1,415	14.2%
Lighting General Service Lamp—CEE Tier 2 LED	1,099	11.0%
Pool Pump—– VSD	548	5.5%
Central Air Conditioner—Enhanced	521	5.2%
Freezer - Removal of Stand-Alone	520	5.2%
Direct Energy Feedback Devices (In Home Display)—HVAC Schedule Setback	460	4.6%
Smart Wi-Fi Thermostat	338	3.4%
Faucet Aerator Low Flow—Bathroom	300	3.0%
Low-Flow Showerhead	291	2.9%
Tier 1 Advanced Power Strip	275	2.7%
Thermostatic Shower Restriction Valve	200	2.0%
Heat Pump Water Heater—Enhanced Efficiency	195	1.9%
Room AC Recycling	159	1.6%
Air Purifier—ENERGY STAR	148	1.5%
Total	**8,436**	**84.4%**

As Table 14 shows, substantial energy efficiency savings remain for residential lighting technologies. Cadmus separated residential lighting into three distinct end uses: (1) standard lighting (such as general service lamps); (2) specialty lighting (such as EISA-exempt lamps); and (3) linear fluorescent lighting. Substantial savings exist for the specialty lighting end use, as it is unaffected by the EISA 2020 backstop standard. Incandescent and halogen lamps account for approximately 70% of specialty lighting, although the saturation is relatively low (11 per home).

If the study began in 2020 rather than 2019, the savings for the standard lighting end use would be much lower; 57% of the total 10-year savings from the standard lighting end use occur in 2019 alone—the last year prior to the assumed EISA 2020 backstop standard. However, substantial savings occur after the 2020 EISA backstop standard because, even though the difference in energy usage is relatively small (~ 3 kWh) between the EISA 2020 standard and the most efficient standard lighting end-use measure, a CEE Tier 2 LED, the saturation of standard lighting (general service) lamps is relatively high (62 per home), and there are approximately 5.3 million existing single-family homes in NYS.

Cadmus also estimated the cumulative annual electric efficiency savings in New York State resulting from the EISA 2020 backstop standard; shown in Figure 6, these savings are reflected in the baseline sales forecast but are not reported in the efficiency potential estimates. These savings represent the efficiency gains in any given year from replacing all below-standard (i.e., incandescent/halogen/CFL) general service lighting lamps with lamps meeting the EISA 2020 backstop minimum efficiency standard. Over the ten-year study horizon, the cumulative savings are more than 1,000 GWh.

FIGURE 6. CUMULATIVE ENERGY SAVINGS FROM 2020 EISA BACKSTOP LIGHTING STANDARD



Natural Gas

Similar to the electric forecast, Cadmus developed a bottom-up, baseline, natural gas sales forecast for single-family homes in NYS. The bottom-up, baseline, natural gas sales forecast excludes any adjustments to lost sales resulting from switching from natural gas space and water heating equipment to electric heat pump technologies. Figure 7 shows the annual baseline natural gas sales forecast for the base year (2018), each year of the study horizon, and each end use. In total, the study included six distinct natural gas end uses.

FIGURE 7. NATURAL GAS BOTTOM-UP BASELINE ENERGY SALES FORECAST BY END USE

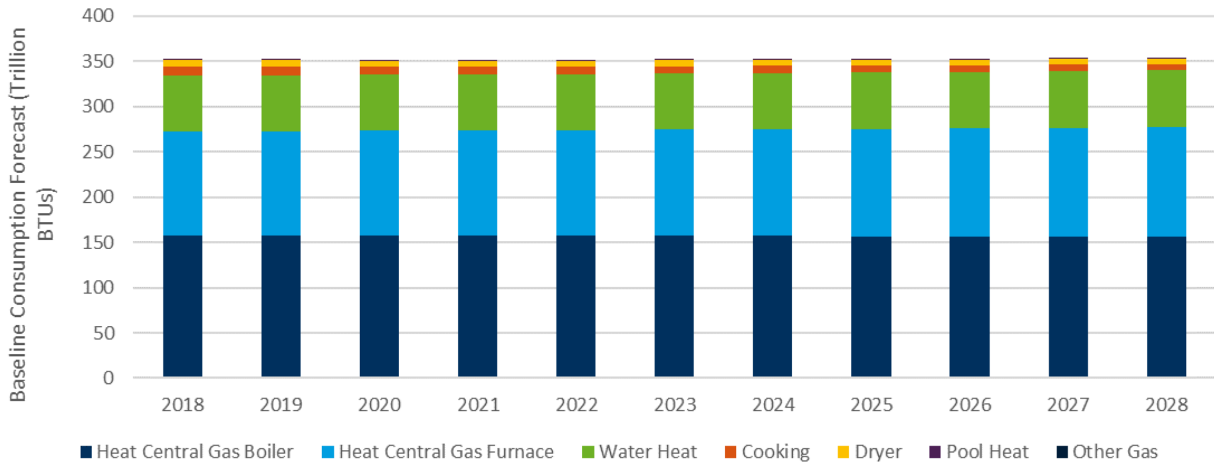


Table 15 shows the natural gas, bottom-up, baseline energy sales forecast by end use for the first and last year of the potential study. After accounting for the effects of future federal equipment standards, the natural gas forecast baseline sales increase only slightly over the 10-year horizon, by about 0.5%. Central heating, provided by natural gas boilers and furnaces, accounts for approximately 78% of the total residential, single-family natural gas usage, following by the water-heating end use, at 18%. Cooking, dryers, and pool heat account for the remaining natural gas consumption.

TABLE 15. NATURAL GAS BOTTOM-UP BASELINE ENERGY SALES FORECAST BY END USE, 2019 AND 2028

Natural Gas End Use	2019 Baseline Forecasted Sales (BBtu)	End Use Percentage of 2019 Baseline Forecasted Sales	2028 Baseline Forecasted Sales (BBtu)	End Use Percentage of 2028 Baseline Forecasted Sales
Heat Central Gas Boiler	157,706	45%	156,492	44%
Heat Central Gas Furnace	114,866	33%	120,624	34%
Water Heat	61,696	18%	62,852	18%
Cooking	9,659	3%	7,026	2%
Dryer	7,108	2%	5,797	2%
Pool Heat	1,014	< 1%	1,138	< 1%
Total	**352,049**	**100%**	**353,928**	**100%**

The study indicates cumulative, technically feasible, natural gas energy efficiency potential of more than 144,100 BBtu by 2028, with cost-effective measures producing approximately 75,800 BBtu. Economic potential represents 21% of forecasted 2028 sales. On an annual basis, the 10-year technical and economic potential savings correspond to savings as a percentage of sales of 5.4% and 2.4%, respectively.

Table 16 summarizes natural gas technical and economic potential for each climate zone. Climate Zone 4 accounts for 49% of the total economic natural gas potential, followed by Climate Zone 5, at 39%.

TABLE 16. TECHNICAL AND ECONOMIC SINGLE-FAMILY NATURAL GAS ENERGY EFFICIENCY POTENTIAL BY CLIMATE ZONE

Climate Zone	2028 Forecast Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
Climate Zone 4	181,389	78,468	43%	37,368	21%
Climate Zone 5	132,240	49,759	38%	29,893	23%
Climate Zone 6	40,300	15,950	40%	8,576	21%
Total	**353,928**	**144,177**	**41%**	**75,837**	**21%**

The heat central natural gas boiler and heat central natural gas furnace end uses accounted for 49% and 25% of single-family, natural gas, cumulative technical potential, respectively, as shown in Table 17. Combined, the heat central natural gas boiler and heat central natural gas furnace end uses account for approximately 37% of the cumulative economic potential. The water heating end use represents 56% and 39% of the total 10-year technical and economic natural gas energy efficiency potential, respectively.

TABLE 17. SINGLE-FAMILY NATURAL GAS TECHNICAL AND ECONOMIC ENERGY EFFICIENCY POTENTIAL BY END USE

End-Use Group	2028 Forecast Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential, Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential, Percentage of Sales
Heat Central Gas Boiler	156,492	71,274	46%	27,484	18%
Heat Central Gas Furnace	120,624	36,573	30%	23,212	19%
Water Heat	62,852	35,440	56%	24,364	39%
Cooking	7,026	0	0%	0	0%
Dryer	5,797	121	2%	0	0%
Pool Heat	1,138	768	68%	777	68%
Total	**353,928**	**144,177**	**41%**	**75,837**	**21%**

Equipment efficiency improvements—replacing inefficient natural gas boilers, furnaces, and water heaters—represent only 5.3% of the total 10-year economic potential, reflecting smaller natural gas savings opportunities compared with retrofit measures. Appendix C provides a complete list of measures that this study considered for natural gas retrofit potential, including measures in the following categories:

- Behavioral measures (direct and indirect energy feedback)
- Building shell improvements (air sealing; insulation for ceilings, floors, walls, and basements; doors; and windows)
- Heating system improvements (boiler controls, smart/Wi-Fi thermostats, boiler and furnace tune-ups, and duct sealing)
- Water heating (low-flow faucet aerators and showerheads, pipe insulation, clothes washers, and dishwashers)
- Other (solar pool covers, solar hot water heating with natural gas backup)

The study employs behavioral "energy feedback" measures, which provide users with information designed to change their usage habits via both direct and indirect feedback. Indirect energy feedback measures assume that customers receive an informative home energy report that provides normative comparisons of energy use and suggestions for conserving energy. In contrast, direct energy feedback measures employ some type of direct, visible display of metered energy consumption to customers. The direct and indirect energy feedback measures encompass the following:

- Enable computer sleep settings,
- Enable game console standby settings,
- HVAC schedule setback,
- Lighting hours-of-use reduction,
- Minutes per shower reduction,
- Reduce television brightness, and
- Water heater temperature setback.

Table 18 lists the top 15 energy-saving, natural gas, single-family measures. Smart/Wi-Fi thermostats, basement wall insulation, and HVAC schedule setbacks prompted by direct energy feedback devices represented the top three natural gas–saving, single-family measures, combining for more than 54% of the total, 10-year economic potential. The top 15 natural gas–saving measures combine to account for all of the total 10-year economic natural gas potential.

TABLE 18. TOP NATURAL GAS ENERGY EFFICIENCY SAVING SINGLE-FAMILY MEASURES, CUMULATIVE IN 2028

Single-Family Energy Efficiency Measure	10-Year Cumulative Economic Potential (BBtu)	Percentage of Total Single-Family Natural Gas Economic Potential
Smart Wi-Fi Thermostat	18,579	24.5%
Basement Wall Insulation	12,921	17.0%
Direct Energy Feedback Devices (In Home Display)—HVAC Schedule Setback	9,895	13.0%
Faucet Aerator Low Flow—Bathroom	8,369	11.0%
Low-Flow Showerhead	8,105	10.7%
Thermostatic Shower Restriction Valve	5,147	6.8%
Wall Insulation	3,392	4.5%
Gas Furnace—Tier 3 High Efficiency	3,297	4.3%
Programmable Thermostat	1,472	1.9%
Faucet Aerator Low Flow—Kitchen	1,423	1.9%
Indirect Energy Feedback—Water Heat Temperature Setback	874	1.2%
Solar Pool Cover	777	1.0%
Gas Boiler - Tier 1 High Efficiency	726	1.0%
Indirect Energy Feedback - Minutes per Shower Reduction	445	0.6%
Duct Sealing	410	0.5%
Total	**75,834**	**100.0%**

Other Fossil Fuels

Cadmus developed a bottom-up baseline sales forecast for fossil fuels other than natural gas (fuel oil and propane combined) for single-family homes in NYS. Figure 8 shows the annual baseline sales forecast for other fossil fuels in the base year (2018) and for each year and each end use of the study horizon. In total, the study included five distinct "other" fossil fuel end uses.

FIGURE 8. OTHER FOSSIL FUELS BOTTOM-UP BASELINE SALES FORECAST BY END USE

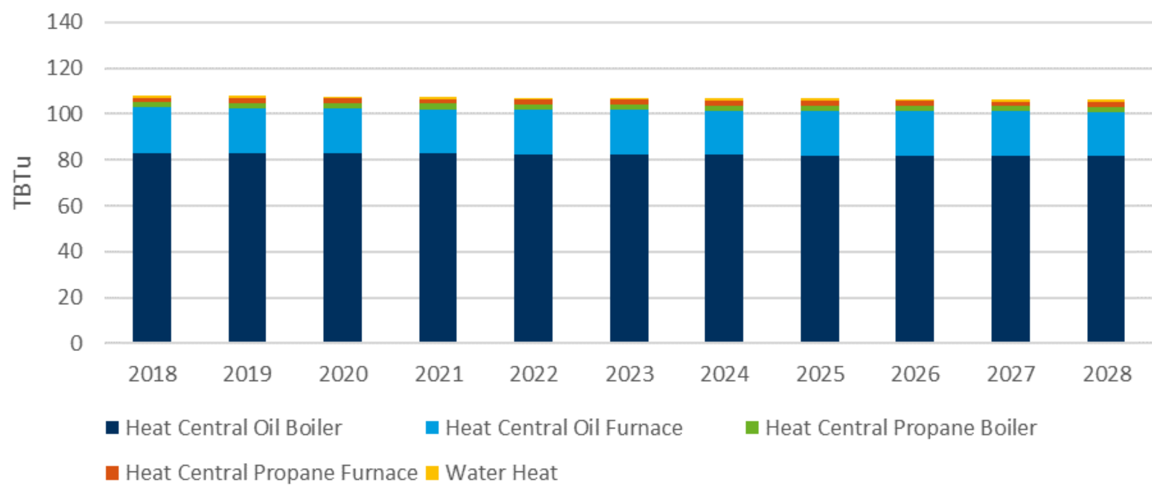


Table 19 shows the bottom-up baseline energy sales forecast for other fossil fuels by end use for the first and last year of the potential study. After accounting for the effects of future federal equipment standards, the other fossil fuels forecast baseline sales decrease slightly over the 10-year horizon, by 1.5%. Central heating, provided by fuel oil and propane boilers and furnaces, accounts for 99% of the total residential, single-family, other fossil fuel usage.

TABLE 19. OTHER FOSSIL FUEL BOTTOM-UP BASELINE ENERGY SALES FORECAST BY END USE, 2019 AND 2028

Other Fossil Fuels End Use	2019 Baseline Forecasted Sales (BBtu)	End Use Group Percentage of 2019 Baseline Forecasted Sales	2028 Baseline Forecasted Sales (BBtu)	End Use Group Percentage of 2028 Baseline Forecasted Sales
Heat Central Oil Boiler	82,978	77%	81,741	77%
Heat Central Oil Furnace	19,594	18%	19,257	18%
Heat Central Propane Boiler	2,322	2%	2,281	2%
Heat Central Propane Furnace	2,122	2%	2,120	2%
Water Heat	877	1%	868	1%
Total	**107,893**	**100%**	**106,267**	**100%**

The study indicates cumulative, other fossil fuel (fuel oil and propane), energy efficiency potential of more than 33,600 BBtu of technically feasible energy efficiency potential by 2028, with cost-effective measures producing approximately 32,100 BBtu. Economic potential represents 32% of forecasted baseline 2028 sales. On an annual basis, the 10-year technical and economic potential savings as a percentage of sales corresponds to 3.9% and 3.7%, respectively.

Table 20 summarizes other fossil fuel, technical and economic potential for each climate zone. Climate Zone 4 accounts for 61% of the total economic other fossil fuel potential, followed by Climate Zone 5, at 23%.

TABLE 20. TECHNICAL AND ECONOMIC SINGLE-FAMILY OTHER FOSSIL FUEL ENERGY EFFICIENCY POTENTIAL BY CLIMATE ZONE

Climate Zone	2028 Forecast Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential, Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential, Percentage of Sales
Climate Zone 4	65,866	20,636	31%	19,705	30%
Climate Zone 5	23,913	7,652	32%	7,267	30%
Climate Zone 6	16,488	5,341	32%	5,119	31%
Total	**106,267**	**33,629**	**32%**	**32,091**	**30%**

The heat central oil boiler and heat central oil furnace end uses account for 77% and 16% of single-family, other fossil fuel, cumulative technical potential, respectively, as shown in Table 21. Combined, the heat central oil boiler and oil furnace end uses account for approximately 93% of the total, other fossil fuel economic potential.

TABLE 21. SINGLE-FAMILY OTHER FOSSIL FUEL TECHNICAL AND ECONOMIC POTENTIAL BY END-USE GROUP

Fuel Type	2028 Forecast Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential, Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential, Percentage of Sales
Heat Central Oil Boiler	81,741	26,048	32%	25,051	31%
Heat Central Oil Furnace	19,257	5,407	28%	4,949	26%
Heat Central Propane Boiler	2,281	1,037	45%	1,029	45%
Heat Central Propane Furnace	2,120	648	31%	598	28%
Water Heat	868	490	56%	464	53%
Total	**106,267**	**33,629**	**32%**	**32,091**	**30%**

Table 22 lists the top 15 energy saving, other fossil fuel, single-family measures. Smart/Wi-Fi thermostats, basement wall insulation, and HVAC schedule setbacks prompted by direct energy feedback devices represented the top three other fossil fuel–saving single-family measures, combining for more than 54% of the total, 10-year economic potential.

TABLE 22. TOP OTHER FOSSIL FUEL ENERGY EFFICIENCY SAVING SINGLE-FAMILY MEASURES, CUMULATIVE IN 2028

Single-Family Other Fossil Fuel Energy Efficiency Measure	10-Year Cumulative Economic Potential (BBtu)	Percentage of Total 10-Year Single-Family Other Fossil Fuel Economic Potential
Smart Wi-Fi Thermostat	7,444	23.2%
Basement Wall Insulation	5,320	16.6%
Wall Insulation	4,820	15.0%
Air Sealing—Reduction of Existing Conditions	4,228	13.2%
Boiler—Controls	3,589	11.2%
Direct Energy Feedback Devices (In Home Display)—HVAC Schedule Setback	3,369	10.5%
Exterior Door	1,046	3.3%
Programmable Thermostat	541	1.7%
Ceiling Insulation	521	1.6%
Combination Propane Space and Water Heat	377	1.2%
Tune-up—Furnace (Oil)	141	0.4%
Water Heater—CEE Tier 2 Tankless—92%	97	0.3%
Faucet Aerator Low Flow—Bathroom	90	0.3%
Low-Flow Showerhead	88	0.3%
Duct Sealing	83	0.3%
Total	**31,755**	**99.0%**

Study Findings

The full range of potential estimates generated in this study also indicates that the total energy efficiency potential in the state can vary under different circumstances, with combined, cost-effective economic potential contributing savings of nearly 9%, 15%, and 28% of baseline energy forecasts in 2021, 2023, and 2028 for the residential, single-family market segment, across all fuel types.

In addition to these findings, Cadmus identified several measures that offer significant cost-effective energy efficiency savings potential:

- Refrigerator recycling of secondary units (electric)
- LED general service and specialty lamps (electric)
- Smart and Wi-Fi thermostat (electric, natural gas, and other fossil fuels)
- Direct and indirect energy feedback (electric, natural gas, and other fossil fuels)
- Pool pumps with variable speed drives (electric)
- Freezer recycling (electric)
- Basement wall and wall insulation (natural gas and other fossil fuels)

In addition to the study findings, Cadmus offers several conclusions from this report's findings:

- **Conclusion: LED lighting represents significant, cost-effective energy efficiency savings in 2019 and perhaps beyond.** Despite U.S. DOE's September 5, 2019, final rule and notice of proposed determination that effectively rescinded the EISA 2020 backstop standard,[8] substantial uncertainty remains regarding the future of the backstop standard and effect of DOE's final rule on energy savings potential for LEDs within energy efficiency programs. Given the timing of the final rule and uncertainty around its effects, Cadmus' modeling methodology assumed that the 2020 EISA backstop standard would still occur. This report presents potential savings beyond the savings that would result from that standard. With this assumption, general service LED lighting measures represent almost 11% of the total 10-year electric economic potential for single-family homes, with 57% of the general service lighting potential occurring in 2019.
- **Conclusion: Specialty LED lighting, including lamps that are exempt from the EISA 2020 backstop standard, represent significant, cost-effective energy savings from 2019 through 2028.** These lamps account for almost 14% of the total 10-year electric economic potential for single-family homes.
- **Conclusion: Residential connected load measures—smart thermostats and behavioral energy feedback—offer opportunities and substantial energy savings potential.** According to the

[8] DOE. September 5, 2019. "Energy Conservation Program: Energy Conservation Standards for General Service Lamps." https://s3.amazonaws.com/public-inspection.federalregister.gov/2019-18941.pdf

potential study, smart thermostat and behavior energy feedback measures will offer substantial savings opportunities in the future, across all fuel types.

- **Conclusion: Appliance recycling measures contribute significant, cost-effective energy efficiency potential.** With nearly 1.4 refrigerators and 0.4 stand-alone freezers per single-family home, appliance recycling measures contribute meaningful, cost-effective, electric energy efficiency potential in NYS. In fact, these two measures combine to account for nearly 24% of the total 10-year electric economic potential. A third appliance recycling measure—room air conditioning—contributes to approximately 1.5% of the total 10-year economic efficiency potential for residential single-family homes.
- **Conclusion: Natural gas energy efficiency economic potential occurs primarily within retrofit measures, as lower natural gas avoided costs render equipment replacements non-economic.** Despite the substantial availability of technical potential from replacing single-family, natural gas, forced air furnaces and boilers with more efficient natural gas equipment, the decline in forecasted natural gas avoided costs from the 2016 Congestion Assessment and Resource Integration Study (CARIS) 2 estimates to the updated 2018 CARIS 2 estimates used in this study results in minimal economic potential (4% of the 10-year natural gas total) for within-fuel natural gas equipment replacements. As a result, two retrofit measures—smart/Wi-Fi thermostats and basement wall insulation—together represent more than 40% of the total economic gas efficiency potential.

Overall, the RBSA single-family potential study estimates that a significant amount of electric, natural gas, oil, and propane energy efficiency potential remains in buildings with one to four housing units in New York State. New efficiency opportunities continue to emerge.