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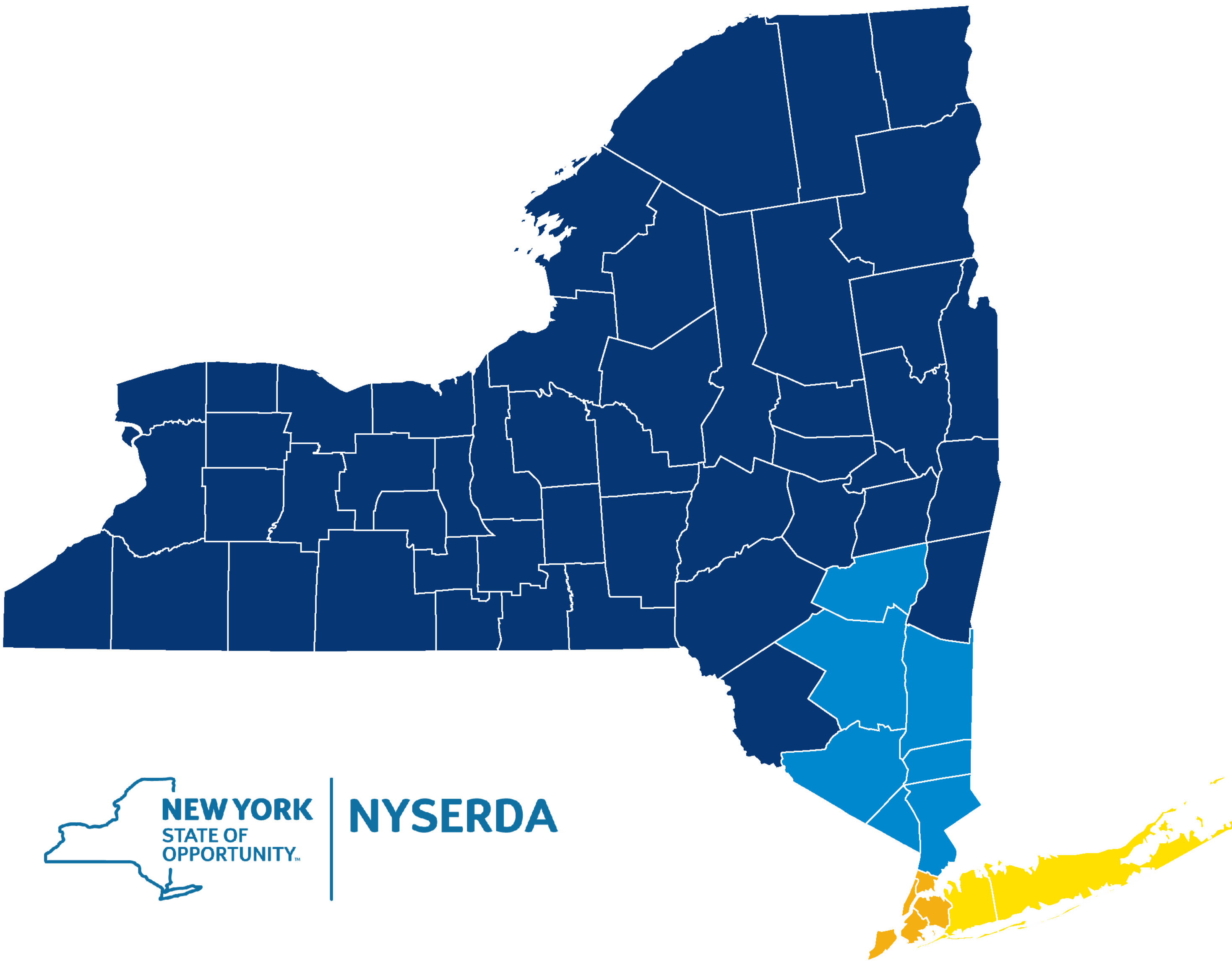

NEW YORK STATE OF OPPORTUNITY | NYSERDA

Assessment of Energy Efficiency Potential in New York State Multifamily Buildings

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Notice

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Acronyms and Abbreviations

AC	Air conditioner
BBtu	Billion British thermal units
BCA	Benefit Cost Analysis
BEEM	Building Efficiency and Electrification Model
CO2	Carbon dioxide
DOE EERE	U.S. Department of Energy, Office of Energy Efficiency and Renewable Technology
DPS	NYS Department of Public Service
EIA	Energy Information Administration
EISA	Energy Independence and Security Act of 2007
EPA	U.S. Environmental Protection Agency
EUL	Effective useful life
GWh	Gigawatt hours
HVAC	Heating, ventilation, and air conditioning
IRR	Internal rate of return
kWh	Kilowatt hours
LED	Light emitting diode
LMI	Low- to moderate-income
MMBtu	Million British thermal units
MW	Megawatt
NYISO	New York Independent System Operator
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
SCC	Social Cost of Carbon
TBtu	Trillion British thermal units
TRM	Technical resource manual

Executive Summary

The New York State Energy Research and Development Authority (NYSERDA) contracted with Cadmus to complete an energy efficiency potential assessment of New York State multifamily buildings. Cadmus designed the study to produce estimates of the energy efficiency resources available in New York State multifamily buildings over a 10-year period, from 2021 to 2030, with an emphasis on calendar years 2023, 2025, and 2030. The primary objective of the study was to identify energy efficiency potential opportunities in multifamily buildings in the state, with secondary objectives to quantify the effects of known codes and standards, to inform the design and planning of energy efficiency interventions, and to make information available to public and private stakeholders as New York State pursues wide-ranging initiatives to advance clean energy and climate goals under the Climate Leadership and Community Protection Act.

Cadmus presents the results of this multifamily potential study in a study report and companion appendices. This report provides an overview of the methodological approach and key findings of the energy efficiency potential study, with attention to technical and economic potential. Separate appendices have further discussion of the methodologies, with attention to achievable potential, and detailed assumptions and study results.

Scope of Analysis

Within the multifamily segment, defined as buildings with five or more housing units, Cadmus segmented the market to analyze energy efficiency potential for the most prominent fuel types in residential multifamily buildings, including electricity, natural gas, fuel oil and propane, and Consolidated Edison district steam. Cadmus considered geography (New York City, Long Island, Hudson Valley, and Upstate), electric utility service territory, building vintage, ownership, building segment (less than or equal to seven stories and greater than seven stories), metering type, and all major residential multifamily end uses. Statewide, this study covers 2.4 million units of multifamily housing, which are geographically concentrated in New York City.

This study includes estimates of technical, economic, and achievable potential. ***Technical potential*** includes all technically feasible efficiency measures, regardless of costs and market barriers. ***Economic potential*** represents a subset of technical potential and consists of measures that meet the cost-effectiveness criteria, set to be consistent with the primary test adopted under the New York State Public Service Commission's Benefit Cost Analysis (BCA) Framework. ***Achievable potential*** represents the portion of technical or economic potential that might reasonably be achievable, after accounting for market barriers that may impede customer adoption.

The energy efficiency potential estimates presented in this report represent savings that energy efficiency programs could achieve beyond those savings resulting from the effects of codes and standards. For this study, Cadmus did not estimate potential from fuel switching or electrification measures (converting fossil fuel-based space and water heating end uses to electric heat pumps).

Summary of Results

This section provides a summary of energy efficiency potential estimates.

Energy Efficiency Potential

Cadmus quantified the amount of energy and coincident peak demand reduction available for multifamily buildings in New York State from 2021 to 2030. Table ES-1 presents the cumulative electric, natural gas, fuel oil and propane, and district steam technical and economic potential estimated through the study. Energy efficiency potentials throughout this report are presented as savings at the customer site. These values represent potentials from energy efficiency measures and do not include potentials from fuel-switching measures.

Table ES-1. Cumulative New York State Multifamily Energy Efficiency Potential, 2021-2030

Fuel Type	2030 Estimated Sales (TBtu)	Technical Potential 2030 (TBtu)	Technical Potential as a Percentage of Sales	Economic Potential 2030 (TBtu)	Economic Potential as a Percentage of Sales
Electricity	91	29	32%	25	27%
Natural Gas	102	43	42%	23	22%
Fuel Oil and Propane	44	18	41%	14	31%
District Steam	3.8	0.7	17%	0.4	9%
Total	**241**	**91**	**38%**	**62**	**26%**

Study results indicate that approximately 91 TBtu of technically feasible energy efficiency potential are available by 2030, with cost-effective measures producing approximately 62 TBtu. These are cumulative savings, representing the total of annual incremental savings that can be achieved during each year of the 10-year study period and accounting for customer decision points based on measure replacement cycles. As a percentage of estimated 2030 sales, cumulative technical potential represents 38% and economic potential represents 26%. The technical and economic potentials correspond to energy savings as a percentage of sales on an annual basis of 4.6% and 2.9%, respectively, across all fuel types.

Cadmus estimated approximately 29 TBtu (more than 8,500 GWh) of technically feasible, cumulative electric energy efficiency potential by 2030, with cost-effective measures producing approximately 25 TBtu. The cumulative technical potential represents about 32% of estimated 2030 sales and economic potential represents 27%; on an annual basis, this corresponds to 3.8% and 3.2% of estimated sales, respectively.

The cumulative, technically feasible natural gas energy efficiency potential is approximately 43 TBtu by 2030, with cost-effective measures producing approximately 23 TBtu. The cumulative technical potential represents 42% of estimated natural gas baseline 2030 sales, and economic potential represents 22%; on an annual basis, this corresponds to 5.3% and 2.5% of estimated sales, respectively.

Fuel oil and propane account for approximately 18 TBtu of cumulative technical potential and 14 TBtu of economic potential, equaling 41% and 31% of estimated baseline 2030 sales, respectively. District steam accounts for approximately 0.7 TBtu of cumulative technical potential and 0.4 TBtu of economic potential, equaling 17% and 9% of estimated baseline 2030 sales, respectively.

Table ES-2 shows the cumulative technical and economic electric coincident peak demand reduction potential for all multifamily buildings in New York State for each geography from 2021 through 2030. Approximately 82% of the technical electric coincident peak demand reduction is cost-effective. Energy efficiency measures that provide substantial coincident peak demand reduction include some of the highest energy-saving measures in the study—such as residential lighting—and also include measures with end-use load shapes that have relatively high coincidence with the New York Independent System Operator peak, such as central air conditioning (AC), ductless heat pumps, air sealing, and energy management systems, among other measures.

Table ES-2. Cumulative New York State Multifamily Electric Peak Demand Reduction Potential, 2021-2030

Region	Technical Potential 2030 (MW)	Economic Potential 2030 (MW)
New York City	982	801
Long Island	67	54
Hudson Valley	94	84
Upstate	209	175
Total	**1,352**	**1,114**

This report's *Technical and Economic Potential* section provides detailed estimates of electric, natural gas, fuel oil and propane, and district steam potential for each New York State geography for the multifamily segment.

Study Findings and Conclusions

The full range of potential estimates generated in this study indicate significant energy efficiency potential in the state's multifamily buildings, with cumulative, cost-effective economic potential equating to approximately 9%, 15%, and 26% of baseline energy estimates in 2023, 2025, and 2030, respectively, for the multifamily market segment (combined across all fuel types).

Cadmus offers several additional conclusions from our analysis:

- ***Conclusion 1: Energy efficiency potential in New York State multifamily buildings is concentrated in New York City.*** New York City accounts for approximately 65% and 64% of 10-year technical and economic potential, respectively. This is unsurprising given the regional distribution of multifamily buildings in the state. Upstate has the second highest multifamily energy efficiency potential, accounting for approximately 22% and 21% of 10-year technical and economic potential, respectively. The Hudson Valley and Long Island regions account for approximately 10% and 5% of 10-year economic potential, respectively.
- ***Conclusion 2: Measures that save electricity and fuel oil or propane are more cost-effective than measures that save natural gas, applying current energy costs and the New York State BCA Framework.*** Approximately 86% of 10-year electric technical potential is economic and 76% of 10-year fuel oil and propane technical potential is economic. By contrast, only 53% of 10-year natural gas technical potential is economic and just 55% of 10-year district steam technical potential is economic. This trend is due to the relatively low forecasted natural gas and district steam avoided costs used in this study.

- ***Conclusion 3: Natural gas energy efficiency economic potential occurs primarily within retrofit measures, as lower natural gas avoided costs render most space heating equipment replacements non-economic.*** Despite the substantial availability of technical potential from replacing multifamily natural gas forced-air furnaces and boilers with more efficient natural gas equipment, the relatively low forecasted natural gas avoided costs used in this study result in low economic potential for equipment replacements. Equipment efficiency improvements—replacing inefficient natural gas boilers, furnaces, and water heaters—represent 9% of the total 10-year economic potential. Four retrofit measures—energy management systems, air sealing, smart thermostatic radiator enclosures, and boiler stack economizers—combine to represent approximately 57% of the total economic natural gas efficiency potential.
- ***Conclusion 4: Domestic hot water improvements represent significant cost-effective energy efficiency savings in multifamily buildings.*** Water heating end-use savings comprise 5% of electric economic potential, 17% of natural gas economic potential, 11% of fuel oil and propane economic potential, and 46% of district steam economic potential. Measures that saved water heating energy were consistently cost-effective. Heat pump water heaters comprise just over half of water heating end-use electric economic potential, with retrofit-style measures such as showerheads and faucet aerators comprising the remainder. Central hot water boiler upgrades account for approximately 45% of water heating end-use natural gas economic potential, with retrofit-style measures comprising the remainder. Water heating equipment and retrofit measures remain a critical component of reducing building thermal load.
- ***Conclusion 5: Ductless heat pumps represent significant cost-effective energy efficiency savings in multifamily buildings with existing electric resistance heat and window AC units.*** Upgrades from electric resistance baseboard and window AC units to ductless heat pumps account for approximately 14% of the 10-year electric economic potential in multifamily buildings. (Cadmus did not estimate potential from fuel switching measures in this study.)
- ***Conclusion 6: Multifamily rental buildings that provide low- to moderate-income (LMI) housing account for 59% of the cumulative 10-year economic energy efficiency potential, which aligns with the share of New York State multifamily housing units that are LMI housing (based on NYSERDA's multifamily building segmentation).*** These buildings constitute a disproportionately high share of the electrically heated buildings in the state. Consequentially, most potential from electric space and water heating equipment comes from multifamily rental buildings that provide LMI housing. Statewide, 84% of ductless heat pump installations, 85% of heat pump water heater installations, and 91% of package terminal heat pump installations that were modelled occurred in these buildings. Conversely, these buildings comprise a disproportionately low share of the natural gas and fuel oil and propane heated buildings in the state.
- ***Conclusion 7: Lighting potential represents significant, highly cost-effective energy efficiency savings in multifamily buildings, but is largely exhausted by 2027.*** LED lighting and lighting controls account for over 42% of 10-year electric economic potential in multifamily buildings. In our modeling methodology, Cadmus assumed that the 2020 Energy Independence and Security Act (EISA) backstop standard will still occur and that it will apply only to standard lighting. Lighting potential would decrease significantly if EISA standards were extended to specialty

bulbs, as initially proposed by the U.S. Department of Energy on January 18, 2017. There are still pending legal challenges and, with the change in presidential administrations, uncertainty remains regarding how this standard will move forward. In addition, market adoption for LEDs continues to be rapid and has implications on the remaining potential. Cadmus assumed a seven-year replacement cycle for LED lighting; when coupled with the high cost-effectiveness of lighting measures, this results in economic lighting potential being exhausted by 2027.

- ***Conclusion 8: Building shell improvements represent significant technical potential, but only air sealing regularly passes the New York State BCA Framework cost-effectiveness test.*** Building shell improvements are a critical component of reducing building thermal load and account for approximately 26% of both natural gas and fuel oil and propane technical potential. However, they account for only 11% of the natural gas economic potential and 6% of the fuel oil and propane economic potential (the lower percentage for fuel oil and propane is due to more measures passing the cost-effectiveness threshold in aggregate). The high cost of window upgrades reduces the cost-effectiveness of the basic shell (air sealing and window upgrades) and the deep shell (air sealing, window upgrades, and ceiling and wall insulation) measure packages modeled in this study. Future potential studies would benefit from assessing additional shell packages (such as ceiling insulation independent of window upgrades) as well as measure packages that combine more costly shell improvements with low-cost measures such as lighting.

This study builds on and complements previous energy efficiency potential studies conducted in New York State. In particular, it complements NYSERDA's *2019 Residential Building Stock Assessment Single-Family Potential Study*, which included an evaluation of the residential single-family segment (defined as buildings with one to four housing units). This study considers multifamily buildings (defined as buildings with five or more housing units, including both tenant and common area spaces). Both studies report energy savings at the customer site.

Overall, Cadmus' assessment of energy efficiency potential in New York State multifamily buildings is that a significant amount of electric, natural gas, and fuel oil and propane energy efficiency potential is available in buildings with five or more housing units.

Introduction

The New York State Energy Research and Development Authority (NYSERDA) contracted with Cadmus to complete an energy efficiency potential assessment of New York State multifamily buildings. Cadmus designed the study to produce estimates of the energy efficiency resources available in New York State multifamily buildings over a 10-year period, from 2021 to 2030, with an emphasis on calendar years 2023, 2025, and 2030. The primary objective of the study was to identify energy efficiency potential opportunities in multifamily buildings in the state, with secondary objectives to quantify the effects of known codes and standards, to inform the design and planning of energy efficiency interventions, and to make information available to public and private stakeholders as New York State pursues wide-ranging initiatives to advance clean energy and climate goals under the Climate Leadership and Community Protection Act.

Cadmus presents the results of this multifamily potential study in a study report and companion appendices. This report provides an overview of the methodological approach and key findings of the energy efficiency potential study, with attention to technical and economic potential. Separate appendices have further discussion of the methodologies, with attention to achievable potential, and detailed input assumptions and results for each measure permutation included in the study.

Multifamily Buildings in New York State

This study considers multifamily buildings, defined as buildings with five or more housing units, including both tenant and common area spaces. Quantifying the building stock is an essential step in any energy efficiency potential study. Cadmus relied on NYSERDA's multifamily building segmentation, referred to as the Resource Potential, which NYSERDA developed alongside the Building Efficiency and Electrification Model (BEEM) tool. The Resource Potential divides the multifamily building stock by a number of differentiating factors, such as heating fuel type, geography, electric utility service territory, building size, vintage, ownership, and metering type. This section provides useful context on the multifamily housing stock in New York State as estimated in the Resource Potential.[1]

The Resource Potential encompasses 2.4 million multifamily housing units in New York State, segmented geographically into four regions:

- **New York City** consists of the Bronx, Kings, Queens, New York, and Richmond counties
- **Long Island** consists of Nassau and Suffolk counties
- **Hudson Valley** consists of Dutchess, Greene, Orange, Putnam, Rockland, Ulster, and Westchester counties
- **Upstate** consists of all other New York State counties

[1] NYSERDA generates the Resource Potential primarily from the following data sources, which have relevant information on the residential building stock in New York State, New York City, or the broader region: U.S. Census *American Community Survey* (2017), U.S. Census *American Housing Survey* (2017), U.S. Department of Energy *Residential Energy Consumption Survey (2015)* data for the Mid-Atlantic region, and New York City Department of Building's *Local Law 87 Audit Database*.

Table 1 shows the distribution of multifamily housing units by region and building size (less than or equal to seven stories and greater than seven stories). Low- and mid-rise multifamily buildings comprise 86% of multifamily housing units in the state, with multifamily buildings greater than seven stories comprising the other 14%. New York City contains 67% of all multifamily housing units in the state.[2]

Table 1. Distribution of New York State Multifamily Housing Units by Region and Stories

Region	Multifamily ≤7 Stories	Multifamily >7 Stories
Hudson Valley	8%	1%
Long Island	4%	0%
New York City	56%	12%
Upstate	18%	1%
Grand Total	**86%**	**14%**

Table 2 shows the distribution of multifamily building vintage by region of the state. Statewide, 43% of multifamily housing units are in a building that was constructed in 1945 or earlier, and 36% are in a building that was constructed between 1946 and 1979.

Table 2. Distribution of New York State Multifamily Housing Units by Region and Building Vintage

Region	Pre-War (up to 1945)	Post-War to 1979	1980 and Later	New Build
Hudson Valley	2%	4%	2%	0.0%
Long Island	1%	2%	2%	0.0%
New York City	35%	22%	10%	0.3%
Upstate	5%	8%	7%	0.1%
Grand Total	**43%**	**36%**	**21%**	**0.4%**

Table 3 shows the distribution of multifamily housing units between owner-occupied, rentals at the market rate, and multifamily rental buildings that provide low- to moderate-income (LMI) housing (including regulated buildings that provide subsidized housing and those that provide unsubsidized LMI housing). Statewide, LMI households comprise 59% of multifamily housing units, highlighting the importance of serving LMI households to further equitable and impactful statewide energy efficiency efforts.

Table 3. Distribution of New York State Multifamily Housing Units by Region and Ownership

Region	Owner Occupied	Market Rate Rental	LMI Household
Hudson Valley	2%	1%	5%
Long Island	2%	1%	2%
New York City	10%	20%	37%
Upstate	1%	5%	14%
Grand Total	**14%**	**27%**	**59%**

Table 4 shows the distribution of heating fuel for multifamily housing units. The housing units with electric heating fuel are disproportionately in multifamily buildings that provide LMI housing, with 87% of electrically heated housing units being LMI households.

[2] The values for New York City from the table (56% and 12%) do not sum to 67% due to rounding.

Table 4. Distribution of New York State Multifamily Housing Units by Region and Heating Fuel

Region	Electric	Natural Gas	Oil/Propane	District Steam
Hudson Valley	2%	4%	3%	-
Long Island	1%	2%	2%	-
New York City	8%	38%	18%	3%
Upstate	5%	12%	2%	-
Grand Total	**16%**	**56%**	**25%**	**3%**

Table 5 shows the distribution of multifamily housing units by heating distribution system type. The overwhelming majority of multifamily housing units are heated by radiator systems (boilers and electric resistance baseboard heaters).

Table 5. Distribution of New York State Multifamily Housing Units by Region and Heating Distribution Type

Region	Radiators	Ducts	Package Terminal Air Conditioner Heating
Hudson Valley	7.8%	0.6%	0.3%
Long Island	4.3%	0.4%	0.1%
New York City	67.1%	0.0%	0.3%
Upstate	16.0%	2.3%	0.9%
Grand Total	**95.1%**	**3.3%**	**1.6%**

Statewide, the distribution of cooling systems for multifamily housing units with radiator heating systems is 84% window air conditioners (ACs), 6% package terminal ACs, and 10% no cooling. The distribution of cooling systems for multifamily housing units with ducted heating systems is 51% central ACs and 49% window ACs.

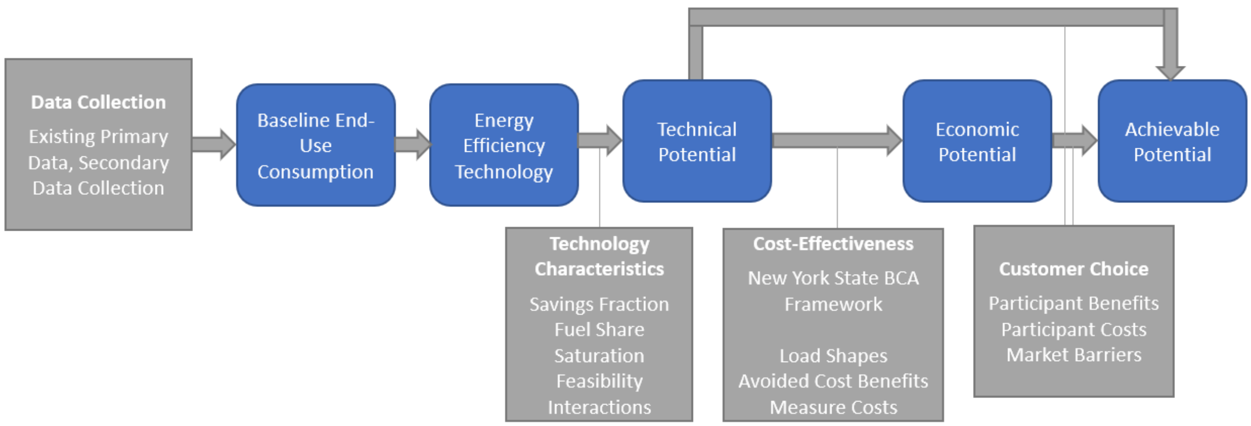
Approach and Scope of Analysis

Cadmus estimated the potential for multifamily building energy savings in New York State from 2021 to 2030. This section describes each step in the assessment process, the scope of the energy efficiency analysis, and the energy efficiency measures Cadmus considered.

Overview of Analysis Methodology

Cadmus' general methodology was a bottom-up approach using NYSERDA's BEEM tool. As shown in Figure 1, we developed baseline end-use consumption forecasts and considered the potential technical impacts of various energy efficiency measures and efficiency practices on each end use. Then we estimated energy efficiency savings impacts based on engineering calculations and accounting for fuel shares, current market saturation, technical feasibility, and costs.

Figure 1. General Methodology for Assessing Energy Efficiency Potential



Cadmus used NYSERDA's multifamily building segmentation, known as the multifamily Resource Potential, to estimate statewide potential for multifamily buildings. Cadmus developed a comprehensive measure database of technology and market data that applied to all multifamily end uses, then we estimated costs, savings, and applicability for a set of energy efficiency measures. This set of measures included existing measures from New York State utility and statewide programs as well as selected emerging technologies. The *Measure Characterization* section of Appendix A includes a list and description of the data sources we used for this study.

Cadmus assessed three types of potential (as illustrated in Figure 1):

- ***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 energy efficiency potential is estimated after accounting for technical constraints. The technical potential approach assumes that measure replacement cycles dictate the timing of when a customer decides whether to upgrade to the efficiency measure.

- ***Economic potential*** represents a subset of technical potential and consists only of measures that meet the cost-effectiveness criteria, set to be consistent with the primary cost-effectiveness test adopted under the New York State Public Service Commission's Benefit Cost Analysis (BCA) Framework. The primary benefit/cost test under the New York State BCA Framework includes the energy-related costs and benefits experienced by the utility system, the incremental costs of energy efficiency measures, and the value of benefits associated with avoided emissions of carbon dioxide and other greenhouse gases. For each energy efficiency measure, Cadmus 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 (DPS) guidance. We only considered measures with a benefit/cost ratio of 1.0 or greater as cost-effective. The *Economic Potential* section of Appendix A includes a detailed description of the benefits and costs we considered.
- ***Achievable potential*** estimates the energy efficiency potential that might be assumed reasonably achievable during the planning horizon, given technical feasibility, project economics, and market barriers that might impede customer participation in New York State. Appendix A includes a more detailed discussion of Cadmus' approach to estimating achievable potential.

Cadmus did not consider program potential, which would require a more detailed examination of rebate levels, marketing and administration expenditures, the possible measure mix that New York State 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's Appendix A can inform program potential through the estimated upper and lower bounds and the identification of which measures could contribute to cost-effectively meeting energy-savings targets, as well as which measures could be bundled in program design to encourage multifamily buildings to undertake comprehensive energy retrofits.

Scope of Energy Efficiency Analysis

Within the multifamily segment, defined as buildings with five or more housing units, Cadmus segmented the market to analyze energy efficiency potential for the most prominent fuel types in residential multifamily buildings, including electricity, natural gas, fuel oil and propane, and Consolidated Edison district steam. Cadmus considered geography (New York City, Long Island, Hudson Valley, and Upstate), electric utility service territory, building vintage, ownership, building size (less than or equal to seven stories and greater than seven stories), metering type, and all major residential multifamily end uses.

The energy efficiency potential estimates presented in this report represent savings that energy efficiency programs could achieve beyond those savings resulting from the effects of codes and standards. For this study, Cadmus did not estimate potential from fuel switching or electrification measures (converting fossil fuel-based space and water heating end uses to electric heat pumps).

As discussed in the *Measure Characterization* section of Appendix A, Cadmus considered measure savings and costs separately for each measure permutation across applicable differentiating factors (such as geography, vintage, and ownership) within the multifamily sector. As shown in Table 6, we examined more than 50,000 energy efficiency measure permutations and 48 unique measures across all fuel types (electric, natural gas, fuel oil and propane, and district steam). Permutations occurred when Cadmus applied a unique measure (such as air sealing) to multiple geographies, multiple building vintages, or to another differentiating factor.

Table 6. Measure Counts and Permutations

Unique Electric Measure Count	Electric Permutations	Unique Fossil Fuel Measure Count	Fossil Fuel Permutations	Total Unique Measure Count	Total Measure Permutations
34	11,697	45	43,248	48	54,945

Energy Efficiency Measures

This study included a comprehensive set of energy efficiency measures, including new and emerging technologies, with measure details drawn from the *2020 New York Technical Resource Manual* (TRM; v8) and additional secondary data sources. After creating a list of electric, natural gas, fuel oil and propane, and district steam energy efficiency measures applicable to New York State multifamily buildings, Cadmus classified energy efficiency measures into measure groups and three categories:

- ***Tenant measures*** are only applicable to tenant space in multifamily buildings, such as tenant lighting or ductless heat pumps.
- ***Common area measures*** are only applicable to common area spaces in multifamily buildings, such as lighting in hallways or stairwells.
- ***Whole-building measures*** are applicable to both tenant and common area spaces in multifamily buildings, such as central boilers or shell improvements.

Table 7 shows the energy efficiency measures Cadmus considered for this study and their corresponding measure group.

Table 7. Energy Efficiency Measures by Measure Group

Measure Name	Measure Group
Common Area: Clothes Washers (Coin-Op)	Appliances
Common Area: Natural Gas Clothes Dryers (Coin-Op)	
Tenant: Dishwashers	
Tenant: Refrigerators	
Tenant: Indirect Energy Feedback	Behavioral
Tenant: Submetering Electricity	
Tenant: Ductless Heat Pumps	Heat Pump
Tenant: Package Terminal Heat Pumps	
Tenant: Central ACs (Residential-Sized)	HVAC Equipment
Tenant: Package Terminal ACs	
Tenant: Window ACs - ENERGY STAR 2020 Most Efficient	
Whole Building: Convert Steam Boilers to Hydronic Boilers	
Whole Building: Improved Boilers/Furnaces	
Tenant: Residential-Sized HVAC Tune-Ups (Central ACs and Furnaces)	HVAC Retrofits
Tenant: Smart Thermostatic Radiator Enclosures	

Measure Name	Measure Group
Whole Building: Boiler Controls - Outside Air Temperature Reset/Cutout Controls	
Whole Building: Boiler Controls - Combustion Optimization	
Whole Building: Energy or Heat Recovery Ventilator	
Whole Building: Energy Management Systems	
Whole Building: Pipe Insulation - HVAC	
Whole Building: Retro-Commissioning or Recommissioning	
Whole Building: Stack Economizers - Boilers	
Whole Building: Steam Retrofit Package	
Whole Building: Strategic Energy Management	
Common Area: Interior Lighting Controls	Lighting
Common Area: Lighting Delamping	
Common Area: Lighting Linear Fluorescents	
Common Area: Lighting Specialty	
Common Area: Lighting Standard	
Common Area: Parking - Covered or Surface Lighting	
Tenant: Lighting Specialty	
Tenant: Lighting Standard	
Whole Building: Exterior Lighting Controls	
Tenant: Plug Load Upgrades	Plug Loads
Whole Building: Air Sealing	Shell Improvements
Whole Building: Basic Shell Upgrades	
Whole Building: Deep Shell Upgrades	
Common Area: Automated Exhaust Variable Frequency Drive Controls - Parking Garage Carbon Monoxide Sensor	Ventilation and Circulation
Whole Building: Boiler Draft Fans - Variable Frequency Drives	
Whole Building: Variable Speed Drives - Water Pumps	
Tenant: Centralized Hot Water Heaters	Water Heat
Tenant: Decentralized Hot Water Heaters	
Tenant: Drain Water Heat Recovery Water Heaters	
Tenant: Faucet Aerators	
Tenant: Heat Pump Water Heaters - Decentralized	
Tenant: Pipe Insulation - Domestic Hot Water	
Tenant: Showerheads	
Whole Building: Pipe Insulation - Hot Water Recirculation	

The HVAC equipment measure group is comprised of efficient heating and cooling equipment, such as an efficient boiler or window AC, while the HVAC retrofit measure group is comprised of measures that impact the HVAC end uses but are not pieces of HVAC equipment (such as boiler controls and tune-ups). The whole building: steam retrofit package measure is comprised of steam trap repair and thermostatic radiator valves.

Cadmus assessed potential for three building shell measures as part of this study: air sealing, basic shell upgrades, and deep shell upgrades. Basic shell is comprised of air sealing and window upgrades, while deep shell is comprised of air sealing, window upgrades, and ceiling and wall insulation.

Cadmus also assessed a behavioral indirect energy feedback measure, in which customers are provided with information via indirect feedback designed to change their usage habits. 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. Indirect energy feedback behaviors include enabling computer sleep settings, enabling game console standby settings, programing an HVAC schedule setback, reducing lighting hours of use, reducing minutes per shower, reducing television brightness, and programing the water heater temperature setback.

Cadmus assumed that all high-efficiency equipment measures would be installed according to the measures' replacement cycle, and therefore we did not assess energy efficiency potential for early replacement.

Measure Baselines

Cadmus compared efficiency measures to baselines to estimate sales and cost differences. We used two different baselines for measures in this study based on income status and type of measure:

- For owner-occupied and market-rate multifamily housing and for all LED lighting measures, we used a counterfactual baseline. Counterfactuals represent the equipment a customer or building would have installed if they had opted not to install the efficiency measure. For an efficient boiler or furnace, the counterfactual would be a federal standard boiler or furnace. The counterfactual and existing conditions are identical for many retrofit-style measures, such as pipe wrap or shell improvements for existing buildings.
- For multifamily rental buildings that provide LMI housing, we used an existing conditions baseline (except for LED lighting measures). These buildings often do not have the available capital to replace failed or failing equipment with the counterfactual option. Cadmus assumed that these buildings would continue to use poorly performing equipment and do everything possible to avoid purchasing costly counterfactual replacements.

In addition to the different baseline assumptions, Cadmus scaled measure costs up by 30% for multifamily rental buildings that provide LMI housing, consistent with NYSERDA's other BEEM work.

Technical and Economic Potential

Energy efficiency potentials throughout this report are presented as savings at the customer site. These values represent potentials from energy efficiency measures and do not include potentials from fuel-switching measures.

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

In addition to the 10-year study horizon from 2021 to 2030, Cadmus estimated technical, economic, and achievable potential for the three- and five-year periods ending in 2023 and 2025, respectively. The study reports cumulative savings, representing the total of annual incremental savings that can be achieved during each year of the 10-year study period and accounting for customer decision points based on measure replacement cycles.

Table 8 shows 2030 estimated baseline sales and cumulative technical and economic potential by fuel type. The study results indicate 91 TBtu of technically feasible energy efficiency (38% of forecasted baseline sales) by 2030, the end of the 10-year study horizon, with an estimated 62 TBtu (26% of forecasted baseline sales) that are cost-effective and technically feasible (known as economic potential). The technical and economic potential correspond to energy savings as a percentage of sales on an annual basis of 4.6% and 2.9%, respectively, across all fuel types.

Table 8. Multifamily Technical and Economic Energy Efficiency Potential by Fuel Type, 2030

Fuel Type	2030 Estimated Sales (TBtu)	Technical Potential 2030 (TBtu)	Technical Potential as a Percentage of Sales	Economic Potential 2030 (TBtu)	Economic Potential as a Percentage of Sales
Electricity	91	29	32%	25	27%
Natural Gas	102	43	42%	23	22%
Fuel Oil and Propane	44	18	41%	14	31%
District Steam	3.8	0.7	17%	0.4	9%
Total	**241**	**91**	**38%**	**62**	**26%**

Table 9 and Table 10 show the estimated baseline sales and cumulative technical and economic potential by fuel type for the periods ending in 2023 and 2025, respectively.

Table 9. Multifamily Technical and Economic Energy Efficiency Potential by Fuel Type, 2023

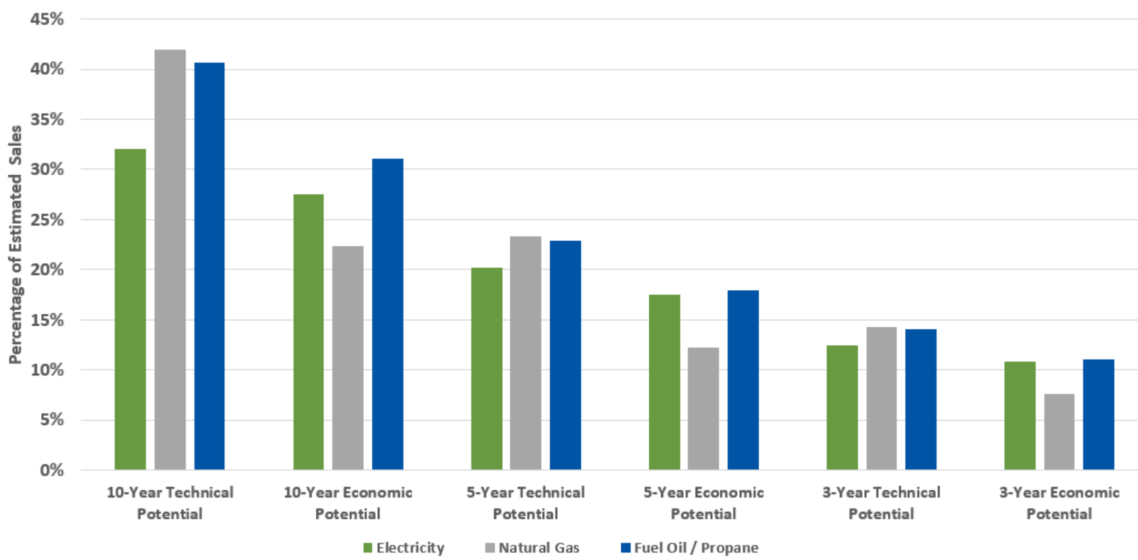
Fuel Type	2023 Estimated Sales (TBtu)	Three-Year Technical Potential (TBtu)	Technical Potential as a Percentage of Sales	Three-Year Economic Potential (TBtu)	Economic Potential as a Percentage of Sales
Electricity	91	11	12%	10	11%
Natural Gas	104	15	14%	8	8%
Fuel Oil and Propane	45	6	14%	5	11%
District Steam	4	0	6%	0	3%
Total	**243**	**33**	**13%**	**23**	**9%**

Table 10. Multifamily Technical and Economic Energy Efficiency Potential by Fuel Type, 2025

Fuel Type	2025 Estimated Sales (TBtu)	Five-Year Technical Potential (TBtu)	Technical Potential as a Percentage of Sales	Five-Year Economic Potential (TBtu)	Economic Potential as a Percentage of Sales
Electricity	91	18	20%	16	18%
Natural Gas	103	24	23%	13	12%
Fuel Oil and Propane	45	10	23%	8	18%
District Steam	4	0	9%	0	5%
Total	**243**	**53**	**22%**	**37**	**15%**

Cadmus calculated potential savings estimates relative to baseline forecasts of future sales, which accounted for the impacts of past energy efficiency programs, but not for the impacts of future energy efficiency codes, standards, and program activities. The baseline sales estimates include modest escalators over time, with cumulative changes of -2% lighting load, +2% plug loads, and -2% space heating loads from 2020 to 2030. The sales estimates do not include improvements from federal standards or state codes. Figure 2 shows technical and economic energy efficiency potential as a percentage of baseline forecasted sales for the multifamily sector.

Figure 2. Multifamily Technical and Economic Energy Efficiency Potential as a Percentage of Estimated Sales by Fuel Type



The following sections report electric, natural gas, fuel oil and propane, and district steam savings potential in aggregate and by major end-use group (for appliances, lighting, plug loads, space heating, space cooling, and water heat). Table 11 provides a summary of each end-use group, including the 2030 baseline forecast and share of forecasted sales. For additional detail on the methods we used to estimate baseline end-use energy consumption, see the *BEEM Energy Sales Estimate* section of Appendix A.

Table 11. Estimated Multifamily Sales by End-Use Group

End-Use Group	2030 Baseline Forecast Consumption (TBtu)	End-Use Group Percentage of 2030 Baseline Forecasted Sales
Appliances	13	5%
Lighting	36	15%
Plug Loads	17	7%
Space Cooling	15	6%
Space Heating	107	44%
Water Heat	54	22%
Total	**241**	**100%**

Electric

The study indicates more than 8,500 GWh of cumulative technically feasible electric energy efficiency potential by 2030, with cost-effective measures producing approximately 7,300 GWh. Economic potential represents 27% of estimated 2030 sales. On an annual basis, the 10-year technical and economic potential savings correspond to savings as a percentage of sales of 3.8% and 3.2%, respectively.

Table 12 summarizes electric technical and economic potential for each region of New York State. New York City accounts for 61% of the total economic electric potential, followed by Upstate, at 25%. Table 13 provides the corresponding electric peak demand reduction potential.

Table 12. Multifamily Electric Technical and Economic Energy Efficiency Potential by Region

Region	2030 Estimated Sales (GWh)	10-Year Technical Potential (GWh)	Technical Potential as a Percentage of Sales	10-Year Economic Potential (GWh)	Economic Potential as a Percentage of Sales
New York City	16,660	5,097	31%	4,463	27%
Long Island	1,225	369	30%	318	26%
Hudson Valley	2,541	866	34%	737	29%
Upstate	6,163	2,181	35%	1,793	29%
Total	**26,589**	**8,513**	**32%**	**7,310**	**27%**

Table 13. Multifamily Electric Technical and Economic Peak Demand Reduction Potential by Region

Region	Technical Potential 2030 (MW)	Economic Potential 2030 (MW)
New York City	978	796
Long Island	67	54
Hudson Valley	93	83
Upstate	207	173
Total	**1,345**	**1,107**

The combined lighting, HVAC retrofits, heat pump, plug load, and shell improvement measure groups account for 85% and 84% of the electric multifamily cumulative technical and economic potential, respectively, as shown in Table 14. Appendix B provides a complete list of electric energy efficiency measures, the measure group, and the measure technical and economic potential.

Table 14. Multifamily Electric Technical and Economic Energy Efficiency Potential by Measure Group

Electric Measure Group	10-Year Technical Potential (GWh)	10-Year Economic Potential (GWh)	Percentage of Total 10-Year Economic Potential
Lighting	3,097	3,095	42%
Heat Pumps	1,083	1,079	15%
HVAC Retrofits	1,318	880	12%
Plug Loads	834	834	11%
Behavioral Changes	545	503	7%
Water Heat	389	389	5%
Shell Improvements	896	275	4%
HVAC Equipment	151	134	2%
Appliances	165	92	1%
Ventilation and Circulation	34	28	0%
Total	**8,513**	**7,310**	**100%**

Table 15 provides the electric peak demand technical and economic energy efficiency potential by measure group.

Table 15. Multifamily Electric Peak Demand Technical and Economic Energy Efficiency Potential by Measure Group

Electric Measure Group	10-Year Technical Potential (MW)	10-Year Economic Potential (MW)	Percentage of Total 10-Year Economic Potential
Lighting	522	522	47%
HVAC Retrofits	391	256	23%
Behavioral Changes	157	151	14%
HVAC Equipment	83	73	7%
Water Heat	41	41	4%
Heat Pumps	36	35	3%
Shell Improvements	95	19	2%
Appliances	23	13	1%
Ventilation and Circulation	4	2	0%
Plug Loads	0	0	0%
Total	**1,352**	**1,114**	**100%**

Table 16 lists the top 10 energy-saving electric multifamily measures based on the cumulative 10-year economic potential. These measures account for approximately 88% of the total economic residential multifamily electric energy efficiency potential. Tenant LED lighting, common area LED lighting, ductless heat pumps, and plug load upgrades represent the top four energy-saving electric multifamily measures over the 10-year study horizon. Table 16 does not include a complete list of all 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 B provides a comprehensive list of electric energy efficiency measures that passed the economic benefit/cost test and all measures with technical potential.

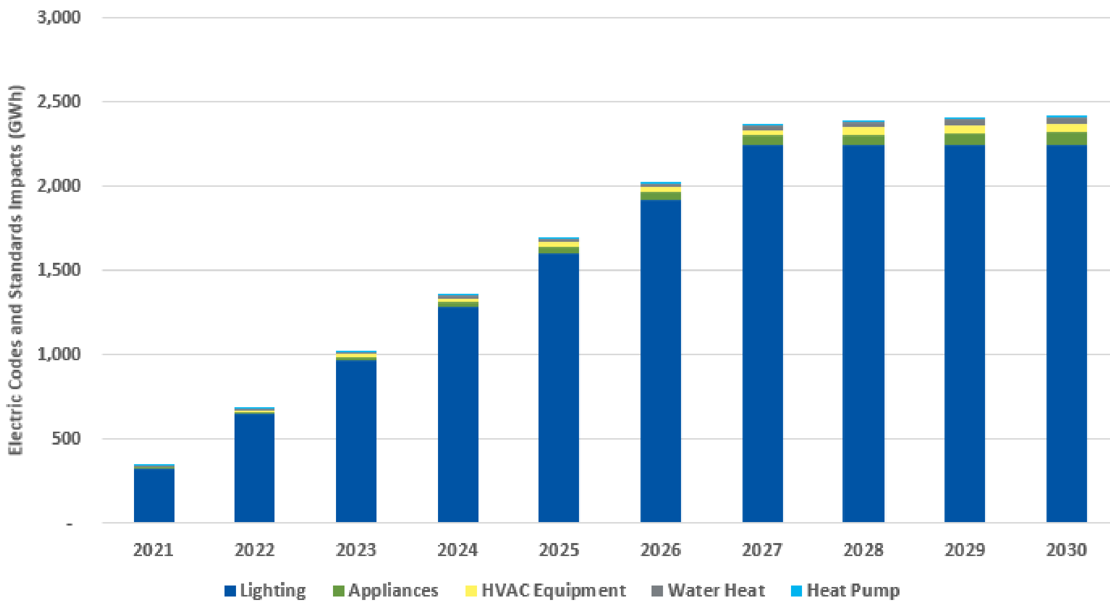
Table 16. Top Multifamily Electric Energy Efficiency Saving Measures, Cumulative in 2030

Multifamily Energy Efficiency Measure Category	Average Societal Cost Test Benefit/Cost Ratio	10-Year Cumulative Electric Economic Potential (GWh)	Percentage of Total 10-Year Economic Potential
Tenant Lighting (Standard and Specialty)	25.2	1,442	20%
Common Area Lighting (Standard, Specialty, Linear Fluorescent)	75.7	1,175	16%
Tenant: Ductless Heat Pumps	1.8	996	14%
Tenant: Plug Load Upgrades	3.1	834	11%
Whole Building: Energy Management System	2.5	558	8%
Tenant: Submetering Electricity	1.5	337	5%
Whole Building: Retro-Commissioning or Recommissioning	1.2	286	4%
Whole Building: Air Sealing	8.4	275	4%
Tenant: Heat Pump Water Heaters - Decentralized	1.6	207	3%
Common Area: Interior Lighting Controls	8.6	233	3%
Total	**-**	**6,343**	**87%**

Cadmus also estimated the cumulative annual electric efficiency savings in New York State resulting from federal equipment standards and state codes; shown in Figure 3, these savings are not reflected in the baseline sales estimate and are not reported in the efficiency potential estimates. For lighting equipment, these savings represent the efficiency gains in any given year that result from replacing less efficient lighting (in the existing condition) with new lighting that meets the minimum federal efficiency standard. For non-lighting equipment, these savings represent the efficiency gains in owner-occupied and market-rate rental buildings in any given year that result from replacing less efficient equipment (in the existing condition) with new equipment that meets the minimum federal efficiency standard or state code requirement. For non-lighting measures that are installed in multifamily rental buildings that provide LMI housing, Cadmus used existing conditions baselines, as discussed in the *Measure Baselines* section of this report.

Over the 10-year study horizon, the cumulative savings are approximately 2,400 GWh.

Figure 3. Electric Codes and Standards Impacts by Measure Group



Natural Gas

Cadmus estimated cumulative, technically feasible natural gas energy efficiency potential of 43 TBtu by 2030, with cost-effective measures producing approximately 23 TBtu. Economic potential represents 22% of estimated 2030 sales. On an annual basis, the 10-year technical and economic potential savings correspond to savings as a percentage of sales of 5.3% and 2.5%, respectively.

Table 17 summarizes natural gas technical and economic potential for each region. New York City accounts for 67% of the total economic natural gas potential, followed by Upstate, at 24%. Table 18 provides the corresponding natural gas peak demand reduction potential. Cadmus assumed that all buildings are on a firm natural gas rate.

Table 17. Multifamily Natural Gas Technical and Economic Energy Efficiency Potential by Region

Region	2030 Estimated Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential as a Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
New York City	65,194	28,389	44%	15,294	23%
Long Island	3,250	1,268	39%	613	19%
Hudson Valley	7,389	2,912	39%	1,551	21%
Upstate	26,623	10,395	39%	5,409	20%
Total	**102,456**	**42,963**	**42%**	**22,867**	**22%**

Table 18. Multifamily Natural Gas Technical and Economic Peak Demand Reduction Potential by Region

Region	Technical Potential 2030 (BBtu/Peak Day)	Economic Potential 2030 (BBtu/Peak Day)
New York City	228	121
Long Island	10	5
Hudson Valley	24	12
Upstate	86	43
Total	**348**	**180**

The HVAC retrofit measure group accounted for 47% and 61% of cumulative natural gas technical and economic potential, respectively, as shown in Table 19. Shell improvements represent 26% and 15% of the total 10-year technical and economic natural gas energy efficiency potential, respectively. Air sealing is the only economic shell measure for natural gas.

Table 19. Multifamily Natural Gas Technical and Economic Energy Efficiency Potential by Measure Group

Natural Gas Measure Group	10-Year Technical Potential (BBtu)	10-Year Economic Potential (BBtu)	Percentage of Total 10-Year Economic Potential
HVAC Retrofits	20,335	13,948	61%
Water Heat	4,571	3,841	17%
Shell Improvements	11,019	3,474	15%
Behavioral Changes	1,343	1,170	5%
HVAC Equipment	4,258	420	2%
Appliances	133	15	0%
Ventilation and Circulation	1,305	-	0%
Total	**42,963**	**22,867**	**100%**

Table 20 provides the natural gas peak demand technical and economic energy efficiency potential by measure group.

Table 20. Multifamily Natural Gas Technical and Economic Peak Demand Energy Efficiency Potential by Measure Group

Natural Gas Measure Group	10-Year Technical Potential (BBtu/Peak Day)	10-Year Economic Potential (BBtu/Peak Day)	Percentage of Total 10-Year Economic Potential
HVAC Retrofits	196	128	71%
Shell Improvements	92	29	16%
Water Heat	15	12	7%
Behavioral Changes	9	8	5%
HVAC Equipment	34	3	2%
Appliances	0	0	0%
Ventilation and Circulation	4	-	0%
Total	**348**	**180**	**100%**

HVAC equipment efficiency improvements—replacing inefficient natural gas boilers and furnaces—represent only 2% of the total 10-year economic potential, reflecting smaller natural gas savings opportunities compared with retrofit-style measures. Appendix B provides a complete list of natural gas energy efficiency measures, the measure group, and the measure technical and economic potential.

Table 21 lists the top 10 energy-saving natural gas multifamily measures. Air sealing and installations of an energy management system and a smart thermostatic radiator enclosure represented the top three natural gas–saving multifamily measures, combining to approximately 47% of the total 10-year economic potential. The top 10 natural gas–saving measures combined account for 93% of the total 10-year economic natural gas potential.

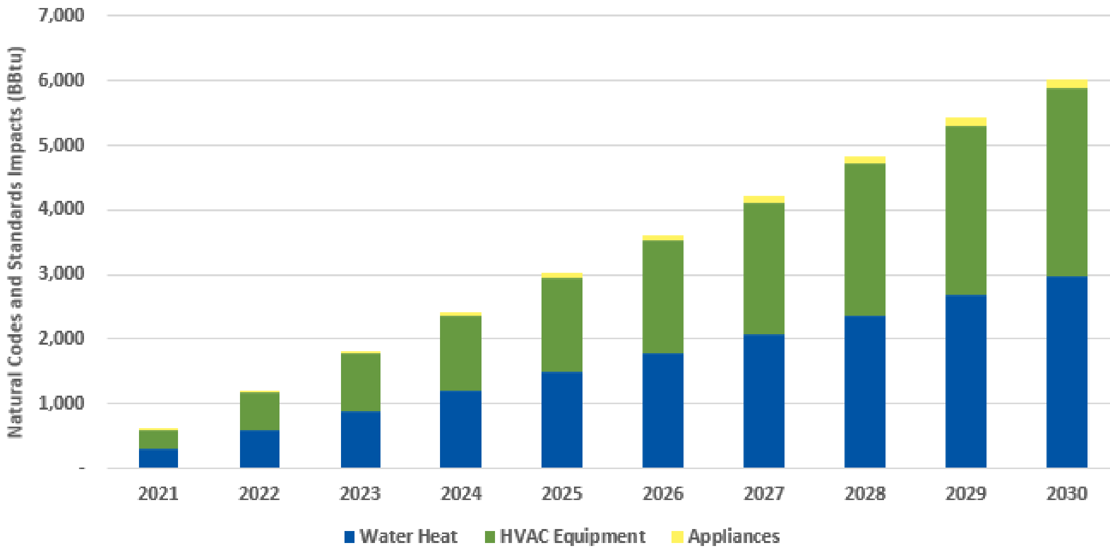
Table 21. Top Multifamily Natural Gas Energy Efficiency Saving Measures, Cumulative in 2030

Multifamily Energy Efficiency Measure Category	Average Societal Cost Test Benefit/Cost Ratio	10-Year Cumulative Economic Potential (BBtu)	Percentage of Total 10-Year Economic Potential
Whole Building: Energy Management Systems	1.7	4,456	19%
Whole Building: Air Sealing	5.5	3,474	15%
Tenant: Smart Thermostatic Radiator Enclosures [a]	1.9	2,804	12%
Whole Building: Stack Economizers - Boilers	2.9	2,208	10%
Tenant: Showerheads and Faucet Aerators	73.5	1,728	8%
Whole Building: Boiler Controls - Outside Air Temperature Resets/Cutout Controls	5.9	1,632	7%
Whole Building: Steam Retrofit Packages	2.1	1,601	7%
Tenant: Centralized Hot Water Heaters	1.2	1,536	7%
Whole Building: Retro-Commissioning or Recommissioning	0.8	1,080	5%
Whole Building: Deep Shell Upgrades	2.1	827	4%
Total	**-**	**21,346**	**93%**

[a] Potential for smart thermostatic radiator enclosures should be interpreted with caution, as this emerging technology is new to market.

Cadmus also estimated the cumulative annual natural gas efficiency savings in New York State resulting from federal equipment standards and state codes; shown in Figure 4, these savings are not reflected in the baseline sales estimate and are not reported in the efficiency potential estimates. These savings represent the efficiency gains in owner-occupied and market-rate rental buildings in any given year that result from replacing less efficient equipment (in the existing condition) with new equipment that meets the minimum federal efficiency standard or state code requirement. For measures that are installed in multifamily rental buildings that provide LMI housing, Cadmus used existing condition baselines, as discussed in the *Measure Baselines* section of this report. Over the 10-year study horizon, the cumulative savings are approximately 6 TBtu.

Figure 4. Natural Gas Codes and Standards Impacts by Measure Group



Fuel Oil and Propane

Cadmus determined cumulative fuel oil and propane energy efficiency potential of more than 18 TBtu of technically feasible energy efficiency potential by 2030, with cost-effective measures producing approximately 14 TBtu. Economic potential represents 31% of forecasted baseline 2030 sales. On an annual basis, the 10-year technical and economic potential savings as a percentage of sales corresponds to 5.1% and 3.6%, respectively.

Table 22 summarizes fuel oil and propane technical and economic potential for each region. New York City accounts for 66% of the total economic fuel oil and propane potential, followed by Hudson Valley, at 16%.

Table 22. Multifamily Fuel Oil and Propane Technical and Economic Energy Efficiency Potential by Region

Region	2030 Estimated Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential as a Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
New York City	30,132	12,207	41%	9,053	30%
Long Island	3,600	1,457	40%	1,095	30%
Hudson Valley	6,480	2,687	41%	2,201	34%
Upstate	4,202	1,724	41%	1,430	34%
Total	**44,415**	**18,074**	**41%**	**13,780**	**31%**

The HVAC retrofits and shell improvements measure groups account for 54% and 26% of fuel oil and propane cumulative technical potential, respectively, as shown in Table 23. Combined, the HVAC retrofits and shell improvements measure groups account for approximately 80% of the total fuel oil and propane economic potential. Economic shell improvements for fuel oil and propane include air sealing (1,557 BBtu) and deep shell (296 BBtu) measures.

Table 23. Multifamily Fuel Oil and Propane Technical and Economic Energy Efficiency Potential by Measure Group

Fuel Oil and Propane Measure Group	10-Year Technical Potential (BBtu)	10-Year Economic Potential (BBtu)	Percentage of Total 10-Year Economic Potential
HVAC Retrofits	9,750	9,119	66%
Shell Improvements	4,769	1,852	13%
Water Heat	1,462	1,462	11%
Behavioral Changes	628	628	5%
Ventilation and Circulation	592	550	4%
HVAC Equipment	854	168	1%
Appliances	18	-	0%
Total	**18,074**	**13,780**	**100%**

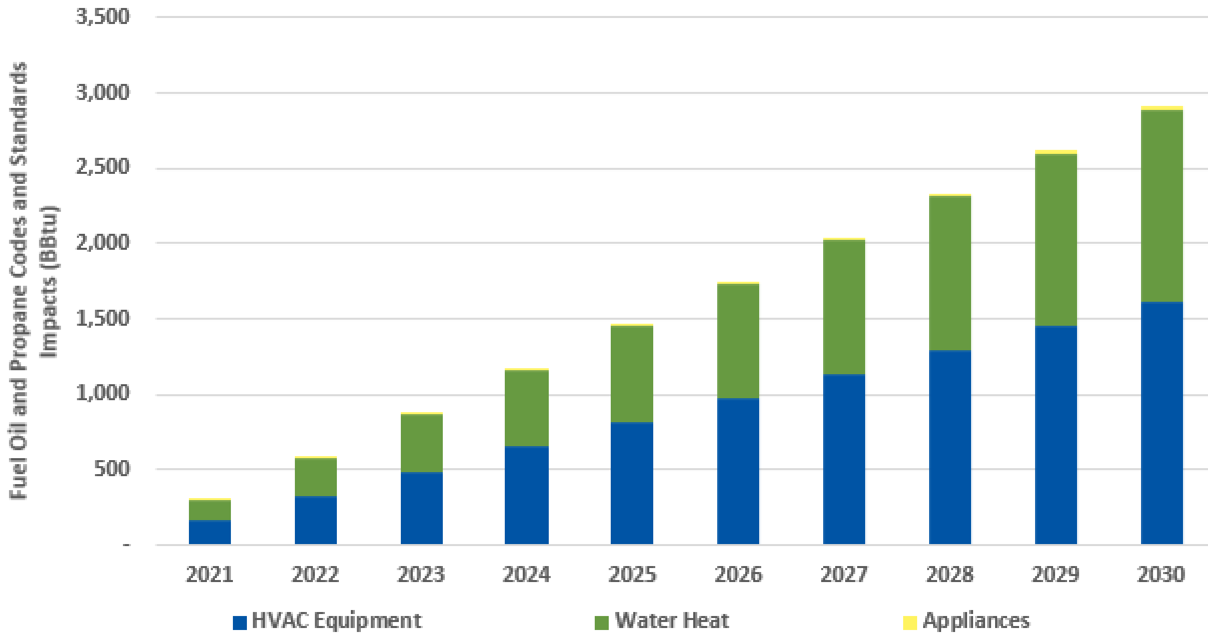
Table 24 lists the top 10 energy-saving fuel oil and propane multifamily measures. Building retro-commissioning or recommissioning, energy management systems, and air sealing represent the top three fuel oil and propane fuel–saving multifamily measures, combining for more than 46% of the total 10-year economic potential.

Table 24. Top Multifamily Fuel Oil and Propane Energy Efficiency Saving Measures, Cumulative in 2030

Multifamily Energy Efficiency Measure Category	Average Societal Cost Test Benefit/Cost Ratio	10-Year Cumulative Economic Potential (BBtu)	Percentage of Total Multifamily Fuel Oil and Propane Economic Potential
Whole Building: Retro-Commissioning or Recommissioning	2.0	2,583	19%
Whole Building: Energy Management Systems	4.1	2,270	16%
Whole Building: Air Sealing	13.7	1,557	11%
Tenant: Smart Thermostatic Radiator Enclosures	4.7	1,357	10%
Whole Building: Stack Economizers - Boilers	7.9	1,109	8%
Tenant: Showerheads and Faucet Aerators	289.8	818	6%
Whole Building: Boiler Controls - Outside Air Temperature Reset/Cutout Controls	14.7	758	6%
Whole Building: Steam Retrofit Packages	5.1	692	5%
Whole Building: Boiler Draft Fans - Variable Frequency Drives	2.0	550	4%
Tenant: Centralized Hot Water Heaters	2.8	395	3%
Total	**-**	**12,088**	**88%**

Cadmus also estimated the cumulative annual fuel oil and propane efficiency savings in New York State resulting from federal equipment standards and state codes; shown in Figure 5, these savings are not reflected in the baseline sales estimate and are not reported in the efficiency potential estimates. These savings represent the efficiency gains in owner-occupied and market-rate rental buildings in any given year that result from replacing less efficient equipment (in the existing condition) with new equipment that meets the minimum federal efficiency standard or state code requirement. For measures that are installed in multifamily rental buildings that provide LMI housing, Cadmus used existing conditions baselines, as discussed in the *Measure Baselines* section of this report. Over the 10-year study horizon, the cumulative savings are approximately 3 TBtu.

Figure 5. Fuel Oil and Propane Codes and Standards Impacts by Measure Group



District Steam

District steam represents steam purchased from Consolidated Edison. Cadmus determined cumulative district steam energy efficiency potential of approximately 3.8 TBtu of technically feasible energy efficiency potential by 2030, with cost-effective measures producing approximately 0.4 TBtu. Economic potential represents 9% of forecasted baseline 2030 sales. On an annual basis, the 10-year technical and economic potential savings as a percentage of sales correspond to 1.7% and 0.8%, respectively. Table 25 summarizes district steam technical and economic potential.

Table 25. Multifamily District Steam Technical and Economic Energy Efficiency Potential by Region

Region	2030 Estimated Sales (BBtu)	10-Year Technical Potential (BBtu)	Technical Potential as a Percentage of Sales	10-Year Economic Potential (BBtu)	Economic Potential as a Percentage of Sales
New York City	3,835	661	17%	363	9%

The shell improvements and water heaters measure groups account for 66% and 25% of multifamily district steam cumulative technical potential, respectively, as shown in Table 26. Combined, the shell improvements and water heaters measure groups account for approximately 85% of the total district steam economic potential.

Table 26. Multifamily District Steam Technical and Economic Energy Efficiency Potential by Measure Group

District Steam Measure Group	10-Year Technical Potential (BBtu)	10-Year Economic Potential (BBtu)	Percentage of Total 10-Year Economic Potential
Water Heat	166	166	46%
Shell Improvements	435	141	39%
Behavioral Changes	56	56	15%
Appliances	4	-	0%
Total	**661**	**363**	**100%**

Table 27 lists the top seven energy-saving district steam multifamily measures. Air sealing, domestic water heater pipe insulation, and low-flow showerheads represented the top three district steam energy-saving multifamily measures, combining to represent more than 78% of the total 10-year economic potential. The seven measures shown here are the only cost-effective district steam measures found in the study.

Table 27. Top Multifamily District Steam Energy Efficiency Saving Measures, Cumulative in 2030

Multifamily Energy Efficiency Measure	Average Societal Cost Test Benefit/Cost Ratio	10-Year Cumulative Economic Potential (BBtu)	Percentage of Total 10-Year Economic Potential
Whole Building: Air Sealing	9.3	141	39%
Tenant: Pipe Insulation - Domestic Hot Waters	175.3	91	25%
Tenant: Showerheads	314.7	53	14%
Tenant: Indirect Energy Feedback	4.6	34	9%
Tenant: Submetering Electricity	1.7	22	6%
Tenant: Faucet Aerators	30.1	19	5%
Whole Building: Pipe Insulation – Hot Water Recirculation	7.8	3	1%
Total	**-**	**363**	**100%**

Cadmus estimated the cumulative annual district steam efficiency savings in New York State resulting from federal appliance standards (for dishwashers and clothes washers) and state codes (for faucet and shower aerators) and found them to be negligible.

Study Findings

The full range of potential estimates generated in this study indicate significant energy efficiency potential in the state's multifamily buildings, with cumulative, cost-effective economic potential equating to approximately 9%, 15%, and 26% of baseline energy estimates in 2023, 2025, and 2030, respectively, for the multifamily market segment (combined across all fuel types).

Cadmus offers several additional conclusions from our analysis:

- ***Conclusion 1: Energy efficiency potential in New York State multifamily buildings is concentrated in New York City.*** New York City accounts for approximately 65% and 64% of 10-year technical and economic potential, respectively. This is unsurprising given the regional distribution of multifamily buildings in the state. Upstate has the second highest multifamily energy efficiency potential, accounting for approximately 22% and 21% of 10-year technical and economic potential, respectively. The Hudson Valley and Long Island regions account for approximately 10% and 5% of 10-year economic potential, respectively.
- ***Conclusion 2: Measures that save electricity and fuel oil or propane are more cost-effective than measures that save natural gas, applying current energy costs and the New York State BCA Framework.*** Approximately 86% of 10-year electric technical potential is economic and 76% of 10-year fuel oil and propane technical potential is economic. By contrast, only 53% of 10-year natural gas technical potential is economic and just 55% of 10-year district steam technical potential is economic. This trend is due to the relatively low forecasted natural gas and district steam avoided costs used in this study.
- ***Conclusion 3: Natural gas energy efficiency economic potential occurs primarily within retrofit measures, as lower natural gas avoided costs render most space heating equipment replacements non-economic.*** Despite the substantial availability of technical potential from replacing multifamily natural gas forced-air furnaces and boilers with more efficient natural gas equipment, the relatively low forecasted natural gas avoided costs used in this study result in low economic potential for equipment replacements. Equipment efficiency improvements—replacing inefficient natural gas boilers, furnaces, and water heaters—represent 9% of the total 10-year economic potential. Four retrofit measures—energy management systems, air sealing, smart thermostatic radiator enclosures, and boiler stack economizers—combine to represent approximately 57% of the total economic natural gas efficiency potential.
- ***Conclusion 4: Domestic hot water improvements represent significant cost-effective energy efficiency savings in multifamily buildings.*** Water heating end-use savings comprise 5% of electric economic potential, 17% of natural gas economic potential, 11% of fuel oil and propane economic potential, and 46% of district steam economic potential. Measures that saved water heating energy were consistently cost-effective. Heat pump water heaters comprise just over half of water heating end-use electric economic potential, with retrofit-style measures such as showerheads and faucet aerators comprising the remainder. Central hot water boiler upgrades account for approximately 45% of water heating end-use natural gas economic potential, with

retrofit-style measures comprising the remainder. Water heating equipment and retrofit measures remain a critical component of reducing building thermal load.

- ***Conclusion 5: Ductless heat pumps represent significant cost-effective energy efficiency savings in multifamily buildings with existing electric resistance heat and window AC units.*** Upgrades from electric resistance baseboard and window AC units to ductless heat pumps account for approximately 14% of the 10-year electric economic potential in multifamily buildings. (Cadmus did not estimate potential from fuel switching measures in this study.)
- ***Conclusion 6: Multifamily rental buildings that provide low- to moderate-income (LMI) housing account for 59% of the cumulative 10-year economic energy efficiency potential, which aligns with the share of New York State multifamily housing units that are LMI housing (based on NYSERDA's multifamily building segmentation).*** These buildings constitute a disproportionately high share of the electrically heated buildings in the state. Consequentially, most potential from electric space and water heating equipment comes from multifamily rental buildings that provide LMI housing. Statewide, 84% of ductless heat pump installations, 85% of heat pump water heater installations, and 91% of package terminal heat pump installations that were modelled occurred in these buildings. Conversely, these buildings comprise a disproportionately low share of the natural gas and fuel oil and propane heated buildings in the state.
- ***Conclusion 7: Lighting potential represents significant, highly cost-effective energy efficiency savings in multifamily buildings, but is largely exhausted by 2027.*** LED lighting and lighting controls account for over 42% of 10-year electric economic potential in multifamily buildings. In our modeling methodology, Cadmus assumed that the 2020 EISA backstop standard will still occur and that it will apply only to standard lighting. Lighting potential would decrease significantly if EISA standards were extended to specialty bulbs, as initially proposed by the U.S. Department of Energy on January 18, 2017. There are still pending legal challenges and, with the change in presidential administrations, uncertainty remains regarding how this standard will move forward. In addition, market adoption for LEDs continues to be rapid and has implications on the remaining potential. Cadmus assumed a seven-year replacement cycle for LED lighting; when coupled with the high cost-effectiveness of lighting measures, this results in economic lighting potential being exhausted by 2027.
- ***Conclusion 8: Building shell improvements represent significant technical potential, but only air sealing regularly passes the New York State BCA Framework cost-effectiveness test.*** Building shell improvements are a critical component of reducing building thermal load and account for approximately 26% of both natural gas and fuel oil and propane technical potential. However, they account for only 11% of the natural gas economic potential and 6% of the fuel oil and propane economic potential (the lower percentage for fuel oil and propane is due to more measures passing the cost-effectiveness threshold in aggregate). The high cost of window upgrades reduces the cost-effectiveness of the basic shell (air sealing and window upgrades) and the deep shell (air sealing, window upgrades, and ceiling and wall insulation) measure packages modeled in this study. Future potential studies would benefit from assessing additional shell packages (such as ceiling insulation independent of window upgrades) as well as measure packages that combine more costly shell improvements with low-cost measures such as lighting.

This study builds on and complements previous energy efficiency potential studies conducted in New York State. In particular, it complements NYSERDA's *2019 Residential Building Stock Assessment Single-Family Potential Study*, which included an evaluation of the residential single-family segment (defined as buildings with one to four housing units). This study considers multifamily buildings (defined as buildings with five or more housing units, including both tenant and common area spaces). Both studies report energy savings at the customer site. Appendix A includes discussion of areas to consider for future analysis of energy efficiency and electrification potential in New York State buildings.

Overall, Cadmus' assessment of energy efficiency potential in New York State multifamily buildings is that a significant amount of electric, natural gas, and fuel oil and propane energy efficiency potential is available in buildings with five or more housing units.

Appendices

Appendix A: Methodology and Achievable Potential

Appendix B: Detailed Assumptions and Energy Efficiency Potential [Excel]