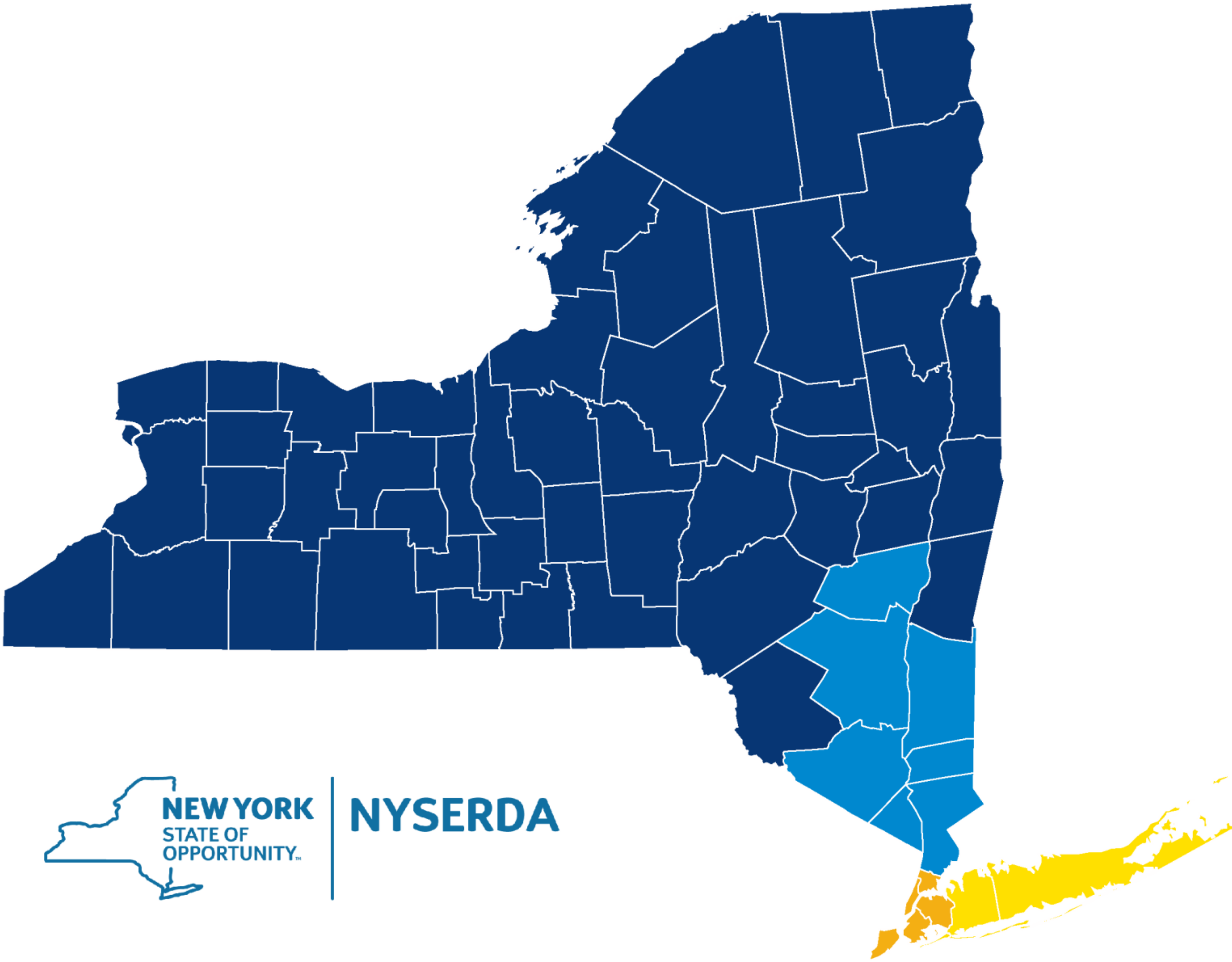

Assessment of Energy Efficiency and Electrification Potential in New York State Residential and Commercial Buildings

April 2023

Prepared for:

New York State Energy Research and
Development Authority

Prepared by:

Cadmus
with Energy + Environmental Economics
and Industrial Economics Incorporated

Record of Revision

Document Title
Assessment of Energy Efficiency and Electrification Potential in New York State Residential and Commercial Buildings February 2023

Revision Date	Description of Change	Revision on Page(s)
	Added minor copy edits for brevity or clarity.	
April 7, 2023	Amended text in executive summary to include a summary of and key finding for economic potential results.	1-2, 1-5, 1-7
April 7, 2023	Added key finding related to economic potential to Section 1.3 and Section 9.	1-7, 9-65
April 7, 2023	Made minor revisions to Table 2.1 Overview of Building Codes and Equipment Standards in Scenario 1. Baseline to align with methodology appendix.	2-14
April 7, 2023	Corrected a rounding error in Table 5.1 2030 Regional Energy Efficiency and Electrification Potential (TBtu) by Region.	5-42
April 7, 2023	Added Chapter 8: Statewide Energy Efficiency and Electrification Economic Potential, which describes statewide energy efficiency and electrification economic potential, focusing on 2030 estimates.	8-54 to 8-63
April 7, 2023	Updated Table 2-1 to align with the Methodology Appendix	2-14

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
ASHP	Air-source heat pump
BBtu	Billion British thermal units
BCA	Benefit/cost analysis
BEEM	Building Efficiency and Electrification Model
CEE	Consortium for Energy Efficiency
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
Commission	New York State Public Service Commission
COP	Coefficient of performance
DOE EERE	U.S. Department of Energy, Office of Energy Efficiency and Renewable Technology
DPS	New York State Department of Public Service
EISA	Energy Independence and Security Act
GAL	Gallon
GHG	Greenhouse gas
gpm	Gallons per minute
GSHP	Ground-source heat pump
HCR	New York State Homes and Community Renewal
HPWH	Heat pump water heater
HVAC	Heating, ventilation, and air conditioning
IEC	Industrial Economics Incorporated
IRR	Internal rate of return
$kgCO_2e$	kilograms of carbon dioxide equivalent
kWh	Kilowatt hours
LED	Light emitting diode
LMI	Low- and moderate-income
MMBtu	Million British thermal units
MW	Megawatt
N/A	Not applicable
NYS	New York State
NYSEG	New York State Electric & Gas
NYSERDA	New York State Energy Research and Development Authority
PSEG	Public Service Enterprise Group
RG&E	Rochester Gas and Electric
SASE	Seasonal average system efficiency
SCC	Social cost of carbon
TBtu	Trillion British thermal units
TDSE	Temperature derated system efficiency
TRM	Technical reference manual
UEF	Uniform energy factor
USD	United States Dollars
VFD	Variable frequency drive
VRF	Variable refrigerant flow
VSD	Variable speed drive

1 Executive Summary

The New York State Public Service Commission (Commission) directed the New York State Energy Research and Development Authority (NYSERDA), in consultation with the New York State Department of Public Service (DPS) staff as well as the New York State investor-owned utilities, the Long Island Power Authority, and the New York Power Authority (referred to as the NYS utilities), to conduct a comprehensive statewide potential study encompassing energy efficiency and electrification for the residential and commercial building sectors in New York State. NYSERDA contracted with Cadmus, Energy + Environmental Economics (E3), and Industrial Economics Incorporated (IEC)—collectively referred to as Cadmus throughout this report—to complete the study.

This study estimates energy efficiency and electrification savings potential over a 20-year period, from 2023 to 2042. The main objective of the study is to identify and explore energy efficiency and electrification potential opportunities in New York State's buildings sector statewide. A secondary objective is to inform the design and planning of energy efficiency and electrification interventions, though the study scope does not include estimating program potential that any prospective energy efficiency program could attain. The study makes information available to public and private stakeholders, in support of New York State's initiatives to advance clean energy and climate goals under the Climate Leadership and Community Protection Act (see Box 1).

This executive summary describes the scope of analysis, summary of results, key findings, and areas for future analysis. Further discussion of the methodologies, detailed assumptions, and study results is provided in the following report and appendices.

Box 1. The Climate Act and the Statewide Potential Study for Buildings

The New York State Climate Leadership and Community Protection Act (Climate Act) is one of the most ambitious climate laws in the nation. It commits New York State to a 40% reduction in greenhouse gas (GHG) emissions by 2030 and an 85% reduction by 2050, from 1990 levels. The Climate Act also required the development of the New York State Climate Action Council Scoping Plan,[1] under the direction of a 22-member Climate Action Council, which advances recommendations on how New York State can reduce GHG emissions, achieve net-zero emissions, increase renewable energy usage, and ensure climate justice. The Climate Act goals and specific strategies recommended in the Scoping Plan inform this study.

1.1 Scope of Analysis

The study analyzes the energy and demand impacts of energy efficiency measures installed in place of less efficient, business-as-usual options, which are based on federal equipment standards, existing energy codes for new construction, or common market practice. The study also analyzes electrification

1 For more information about New York State Climate Action Council's Scoping Plan, published December 2022, access the website at climate.ny.gov/resources/scoping-plan/.

measures, in which efficient electric equipment is installed instead of business-as-usual gas, oil, or propane equipment or to replace electric resistance heating.

Energy efficiency measures considered in this study include building shell upgrades; high-efficiency heating, ventilation, and air conditioning (HVAC) equipment, as well as improved HVAC controls and tune-ups; appliance and plug load upgrades; and several behavioral measures like home energy reports and multifamily tenant submetering. Electrification measures in this study include cold-climate air-source heat pumps and ground-source heat pumps for space and water heating. Measure packages are also modeled (for example, heat pump and shell improvements installed together), and the study accounts for interactive effects between measures.

This study breaks out the impacts of energy efficiency and electrification (separately and combined) and reports results for technical, economic, and achievable potential. **Technical potential** represents the total potential that could be achieved if energy efficiency and electrification measures are adopted by customers over typical replacement cycles.[2] Technical potential is estimated without consideration of cost or non-technical market barriers.

Economic potential is a subset of technical potential that represents only measures that pass the societal cost-effectiveness screen established under the Commission's Benefit/Cost Analysis (BCA) Framework. This study reports economic potential for two cases: one that incorporates values for the social cost of carbon (SCC) estimated at a 3% discount rate and the other for the SCC estimated at a 2% discount rate.[3]

Achievable potential is expressed through the development of illustrative scenarios that analyze the adoption potential for measures given real-world customer motivations and constraints, including, for example, the impact of cost considerations, customer behavior, supply chain barriers, and the extent to

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2 The assumed replacement cycles vary by measure and sector. This analysis assumed that all high-efficiency equipment measures would be installed according to the measures' replacement cycle, and therefore it did not assess energy efficiency potential for early replacement of equipment (i.e., replacement before end of useful life), which may unlock additional potential. The analysis assumed that shell upgrade packages are considered every 10 years in residential buildings (roughly corresponding to the sale or refinancing of a building) and every 25 years in commercial buildings (on a cycle for major capital improvements).

3 A key input for the BCA Framework—the greenhouse gas reduction value—is determined based on the SCC. The New York State Department of Environmental Conservation publishes values for the SCC, which vary depending on the real discount rates used (following a methodology used by the federal government). For example, the social cost of carbon dioxide (CO_2) emitted in 2030, discounted to 2020 dollars, is $62 and $137 per metric ton of CO_2 at the 3% and 2% discount rates, respectively. For more information, see Establishing a Value of Carbon; Guidelines for Use by State Agencies from the New York State Department of Environmental Conservation, published June 2021. In benefit/cost analysis, incorporating SCC values at the 3% discount rate is aligned with the Commission's 2016 Order Establishing the Benefit/Cost Analysis Framework, while using SCC values at the 2% discount rate is consistent with the central value of carbon recommended in the Department of Environmental Conservation guidance and, subsequently, the values used in analysis conducted for the New York State Climate Action Council.

which government programs overcome such barriers and constraints. Notably, achievable potential is not a subset of economic potential.

This report presents three adoption scenarios to explore achievable potential.[4] First, the Baseline Scenario describes a case that is inclusive of enacted federal, state, and local policies, as well as anticipated advancements in New York State codes for new construction (as recommended in the Scoping Plan). Scenarios 2 and 3 carry forward the core Baseline Scenario assumptions and apply different approaches for upfront financial incentives to encourage adoption of energy efficiency and electrification measures. Each scenario is described below.

- **Scenario 1. Baseline:** This study incorporates statewide building energy codes and federal equipment standards into forecasted business-as-usual energy sales and equipment consumption estimates. The Baseline Scenario builds on this by incorporating state appliance and equipment efficiency standards, and the enacted New York City Local Laws 97 and 154. In alignment with the Scoping Plan, this scenario also assumes that new building energy codes will take effect for new construction, which require highly efficient, zero-emission new construction starting in 2025 for single-family buildings and 2028 for multifamily and commercial buildings. These anticipated code adjustments will, in effect, expand the phase-out of fossil fuel systems in new buildings—which is already required under New York City Local Law 154—across all of New York State. This scenario does not model any new upfront financial incentives for consumers beyond currently available tax credits. The Baseline Scenario establishes a case to which additional interventions can be compared.
- **Scenario 2. CapEx Incentives:** The CapEx Incentives Scenario includes the elements modeled for the Baseline Scenario. It adds sustainability guidelines that New York State Homes and Community Renewal (HCR) has established for new construction of subsidized affordable housing for low-income households. The scenario assumes that consumers receive an incentive amount calculated at 50% of the measure incremental cost after applicable tax credits, which is an incentive design commonly used by program administrators in New York State. Incentives are modeled for all measures (except measures subject to state and federal codes or standards). Incentive caps are applied to each measure, expressed on a maximum amount per dwelling unit basis for residential sites or on a per square foot of floor space basis for commercial sites.
- **Scenario 3. Reasonable Return Incentives:** The Reasonable Return Incentives Scenario includes the elements modeled for the Baseline Scenario and the HCR sustainability guidelines. Like Scenario 2, this scenario models incentives that encourage households and businesses to adopt energy efficiency and electrification measures (unless measures are subject to state and federal codes and standards). Scenario 3 applies a more tailored approach to setting incentives, in which the incentive offered is equal to the upfront amount required to achieve a reasonable

[4] This study did not consider program potential for programs that could be offered by New York State utilities and statewide initiatives. This would require a more detailed examination of planning for incentive levels, the possible eligible measure mix, and marketing and administration expenditures.

customer rate of return on the measure's incremental lifetime cost.[5] Measures that are highly cost-effective in the Baseline Scenario (such as commercial lighting) receive little or no upfront incentive in this scenario, while measures that do not initially offer a reasonable project return (as is often the case for heat pumps) see higher incentives. As such, incentives may exceed 50% of the incremental cost. Like Scenario 2, this scenario applies an incentive cap to each measure, expressed on a maximum amount per dwelling unit basis for residential sites or on a per square foot of floor space basis for commercial sites.

The selection of measures and the adoption methodology significantly shape the study findings. Across all scenarios, electrification measures modeled for the single-family residential sector (defined as buildings with one to four housing units) include both full-load and partial-load heat pumps for space heating and cooling. Electrification measures modeled in the multifamily residential (buildings with five or more housing units) and commercial sectors represent comprehensive retrofits to meet the building's full heating load with electricity; that is, partial-electrification measures are not considered in the multifamily or commercial sectors. Additional detail on measure definition is provided in Chapter 3 of this report.

1.2 Summary of Results

This section summarizes study results, focusing on potential that can be achieved through 2030 (long-term results through 2042 are discussed in the main body of the report). The energy efficiency and electrification potential estimates presented here represent energy savings that New York State could achieve beyond the impacts of federal equipment standards and currently enacted building energy codes. Results throughout this report are presented as savings at the customer site.

There is significant energy savings potential from energy efficiency and electrification in New York. As detailed in Table 1-1, the analysis shows that there are significant technical potential savings for energy efficiency (306 trillion British thermal units [TBtu], or 24% of estimated sales in 2030[6]) and electrification (165 TBtu, or 13% of estimated sales in 2030) from measures adopted from 2023 through 2030. For energy efficiency, the majority of technical potential accrues in the gas sector (160 TBtu), followed closely by electricity (106 TBtu). With substantially smaller overall sales, fuel oil and propane and steam also offer relatively smaller savings technical potential (39.1 TBtu and 1.6 TBtu, respectively). To avoid double-counting, the model first accounts for energy efficiency savings that reduce building heating and cooling loads before estimating the available savings from electrification.

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5 Specifically, the incentive is set such that subsidized affordable multifamily buildings, public sector buildings, and certain large commercial building types achieve an internal rate of return of 10% (corresponding to a project payback period of nine to ten years) and other residential or commercial customers see an internal rate of return of 16% (corresponding to roughly a six-year payback period).

6 The sales forecast accounts for federal standards, as well as current energy code for new construction, but excludes adoption of efficiency and electrification measures that go beyond these minimum standards.

The analysis of electrification shows that the majority of technical potential savings comes from transitioning natural gas (177 TBtu) to electricity, followed by transitioning fuel oil and propane, then steam to electricity (39.0 TBtu and 1.1 TBtu, respectively). Notably, the net electricity savings in the electrification analysis are negative (-52.5 TBtu), reflecting *the increase* in electricity use due to fuel switching.

Table 1-1. 2030 Statewide Energy Efficiency and Electrification Potential Savings (TBtu)

Fuel Type	2030 Estimated Sales (TBtu)	2030 TBtu (from measure installations between 2023 and 2030) [a]			
		Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Energy Efficiency					
Electricity	410	106	27.5	30.5	29.9
Natural Gas	720	160	70.1	78.8	83.2
Fuel Oil and Propane	163	39.1	16.8	19.7	19.5
District Steam	11.8	1.6	0.6	0.7	0.6
Total	**1,305**	**306**	**115**	**130**	**133**
Electrification					
Electricity	410	-52.5	-2.9	-3.7	-11.4
Natural Gas	720	177	13.9	17.3	42.8
Fuel Oil and Propane	163	39.0	4.2	9.0	10.2
District Steam	11.8	1.1	0.3	0.4	0.6
Total	**1,305**	**165**	**15.5**	**23.1**	**42.3**

[a] Negative numbers in this table indicate an increase in electric load, which occurs when electric equipment is installed instead of counterfactual fossil fuel equipment.

The analysis also shows that a significant portion of the technical potential savings is economic based on a societal cost-effectiveness screen. The 2030 economic potential for energy efficiency ranges from 182 TBtu (SCC at 3% discount rate) to 201 TBtu (SCC at 2% discount rate), or 14% to 15% of estimated sales in 2030 across all fuels from measures adopted from 2023 through 2030. Consistent with technical potential, the majority of economic potential for energy efficiency accrues in the gas sector (97.5 TBtu to 106 TBtu), followed by electricity (60.4 TBtu to 69.7 TBtu). The 2030 economic potential for electrification ranges from 66.6 TBtu (SCC at 3% discount rate) to 112 TBtu (SCC at 2% discount rate), or 5% to 9% of estimated sales in 2030. The choice of the SCC discount rate has the greatest impact on economic potential savings from converting to electricity from natural gas (51.7 TBtu to 110 TBtu with the SCC at 3% or at 2%, respectively). Combined across energy efficiency and electrification potential, the single-family sector accounts for the majority (141 TBtu) of the 2030 economic potential across all building sectors, followed by the commercial sector (75 TBtu) and the multifamily sector (32 TBtu), for results using an SCC at the 3% discount rate.

This study explores achievable potential by analyzing adoption scenarios, which estimate statewide energy efficiency savings ranging from 115 TBtu (Baseline Scenario) to 133 TBtu (Scenario 3) from 2023 through 2030. For electrification, Scenario 3 has a more pronounced impact on adoption (42.3 TBtu) relative to Scenario 2 (23.1 TBtu) or the Baseline Scenario (15.5 TBtu).

Table 1-2 illustrates the end-use groups that offer the greatest savings potential (highlighted green) in New York State. Building shell improvements (in single-family and multifamily residential), efficiency and electrification of space heating (across all sectors), space cooling (in commercial), and improved energy efficiency of water heating (in single-family and multifamily residential) yield the greatest savings potential in New York over the coming years. Notably, lighting measures show limited opportunity for energy savings above federal standards. This is because the federal Energy Independence and Security Act of 2007 (EISA) requires retailers to transition to an all-LED market.

Table 1-2. 2030 Statewide Energy Efficiency and Electrification Potential in Adoption Scenarios by Measure Group and Sector (TBtu)

End-Use Group		Single-Family				Multifamily				Commercial			
		Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3	Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3	Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Energy Efficiency	Lighting	0.4	0.3	0.3	0.3	2.2	1.3	1.4	1.3	5.5	1.7	2.1	2.2
	Appliances and Plug Loads	2.9	1.8	1.9	1.8	1.6	0.6	0.9	0.7	6.7	4.0	4.1	4.2
	Building Shell	108	5.4	9.7	17.7	21.9	3.1	3.5	4.3	25.3	2.8	2.7	2.8
	Space Cooling	11.5	1.2	1.6	1.8	1.3	0.3	0.4	0.4	26.4	12.5	13.5	13.4
Energy Efficiency	Space Heating	133	28.1	31.5	27.2	19.8	10.9	12.1	11.6	49.5	12.5	13.6	13.6
Electrification			5.3	10.2	23.0		1.7	1.8	3.6		5.8	7.5	9.9
Energy Efficiency	Water Heating [a]	38.1	22.3	23.4	23.2	12.4	5.2	5.9	5.5	5.3	1.2	1.2	1.2
Electrification			0.3	0.5	2.5		1.0	1.2	1.4		1.4	1.9	2.0
Total		**294**	**64.5**	**78.9**	**97.5**	**59.3**	**24.2**	**27.2**	**28.8**	**119**	**41.8**	**46.7**	**49.3**

NOTE: This table shows both electric and fossil fuel savings potential. This means that electrification potential includes both electric load increases and fossil fuel savings from heat pump measures.

[a] Savings from low-flow water fixtures are the primary contributor to these water heating savings. The final efficiency standards, published after modeling was completed, were lower than the assumptions used in this analysis. Thus, actual savings will be lower than the estimates presented in this study.

In addition to energy savings, the study estimated peak summer electric and peak winter gas reduction potential. The analysis shows significant potential to reduce summer and winter peaks. As Table 1-3 shows, through 2030 the scenario potential estimates for electric summer peak reduction range from a 2,670 MW to 3,000 MW and from 463 BBtu-day to 719 BBtu-day for gas winter peak reduction.

Table 1-3. 2030 Statewide Energy Efficiency and Electrification Demand Impact Potential

Fuel Type	Unit Definition	Estimated 2030 Peak	Demand Reduction			
			Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Electricity	MW - Summer Peak	33,450	7,380	2,670	2,960	3,000
Natural Gas	BBtu-Day - Winter Peak	4,765	2,000	463	532	719

1.3 Key Findings

The following section describes key findings from the study, including a discussion of the potential to reduce fossil fuel use, increase deployment of shell and electrification measures, and deploy other measures that offer significant potential for heating and cooling savings. These findings also include a discussion of how adoption of energy efficiency and electrification measures responds to alternative incentive structures.

The technical opportunity exists to cut fossil fuel use nearly in half in New York's buildings through 2030. By 2030, fossil fuel energy efficiency and electrification technical potential accounts for roughly 47% of business-as-usual estimated sales for gas, oil, propane, and district steam (excluding electricity). Statewide technical potential further increases to a 64% reduction in fossil fuel use in buildings by 2042, as building HVAC and hot water systems are assumed to be replaced when equipment is retired. Notably, the end-of-life replacement cycle spans 20 years (in the residential sector) to 25 years (in the commercial sector) for space heating equipment. Because most systems will be replaced only once between now and 2042, it is especially important to ensure that market signals are in place in the near term to drive adoption of energy efficiency and electrification measures.

Significant economic potential exists for energy efficiency and electrification in New York. This study finds that more than half of the total energy efficiency and electrification technical potential is cost-effective in New York State by 2030, based on a societal benefit/cost screen that incorporates values for the social cost of carbon (SCC) at either the 3% or a 2% discount rate. Compared to the statewide technical potential, the 2030 economic potential ranges from 59% to 65% (182 TBtu to 201 TBtu) for energy efficiency and from 40% to 68% (66.6 TBtu to 112 TBtu) for electrification measures, with an SCC at the 3% or 2% discount rate, respectively. Compared to business-as-usual estimated sales for fossil fuels (gas, oil, propane, and district steam), 2030 economic potential across energy efficiency and electrification ranges from approximately 24% (SCC at 3% discount rate) to 31% (SCC at 2% discount rate). The choice of the SCC discount rate has a pronounced effect on the economic potential results for electrification of buildings using natural gas.

New York State has the potential to achieve meaningful savings from the Baseline Scenario voluntary adoption and state and local codes and standards. In the Baseline Scenario, the strong majority (76%)

of the energy savings potential results from voluntary customer adoption, indicating that many measures included in this study are mature and offer an adequate return to the customer. Importantly, voluntary adoption accounts for available state and federal tax credits but does not offer customers additional upfront incentives. State equipment standards and building energy codes informed by the Scoping Plan, as well as New York City Local Law 154, account for the remainder of savings (approximately 24%) in the Baseline Scenario. Codes and equipment standards are modeled to require adoption of certain high-efficiency measures starting at dates that vary by major sector.

To drive significant savings above federal standards, energy efficiency incentive programs must transition away from lighting—and toward deeper savings measures like building shell and space heating. Historically, lighting measures have driven considerable savings in state- and utility-administered energy efficiency programs. However, as the federal Energy Independence and Security Act of 2007 (EISA) requires retailers to transition to an all-LED market, lighting measures will have minimal impact on program savings in the future. Over the coming decade, the measures with greatest potential for energy reductions include building shell and space heating, which are closely linked to building system replacement cycles and new construction.

The Reasonable Return Incentive structure drives the greatest adoption of deeper savings measures. As illustrated in Table 1-1 and Table 1-2 above, potential savings respond differently to the CapEx and Reasonable Return Incentives scenarios. Though both incentive structures drive greater adoption for deep energy savings measures like heat pumps and deep shell improvement packages, the Reasonable Return Incentives structure has a greater impact on adoption for such measures. This is logical because to achieve the target return on investment, the Reasonable Return incentive for deep-savings measures is often greater than the 50% of the incremental cost offered by the CapEx Incentives Scenario.

Moreover, for measures that meet the desired return on investment (or are close to it) without incentives, the study shows that an additional incentive does not significantly increase market adoption. This is the case for relatively low-cost energy efficiency measures including HVAC tune-ups, commissioning, and distribution improvements; thermostats and boiler controls; and higher-efficiency boilers and furnaces, where adoption is strong and comparable across the Baseline Scenario, the CapEx Incentives Scenario, and the Reasonable Return Incentives Scenario for such measures. On the other hand, the CapEx Incentives Scenario sees a slight decrease in adoption relative to the Baseline Scenario for certain deep energy savings measures, notably packages that bundle deep shell and heat pumps, because the flat incentive structure favors competing measures.

In single-family homes, adoption of heat pumps and shell upgrades is responsive to incentives. As the modeled incentives improve return on investment, the single-family sector sees a significant increase in adoption of (and energy savings potential from) basic shell upgrade packages comprising air sealing and insulation, partial-load and full-load heat pumps for space heating and cooling, packages that bundle basic shell upgrades and full-load heat pumps, and heat pump water heaters. While incentives equal to 50% of incremental capital cost increase shell and electrification adoption substantially, even higher incentives under the Reasonable Return Incentives result in significant acceleration of basic shell and heat pump adoption. Importantly, the results show that the impact of incentives is most pronounced in the single-family sector as compared to the multifamily and commercial sectors.

The multifamily sector is generally less responsive to incentives than the single-family sector, reflecting higher barriers to the adoption of heat pumps and deeper shell upgrades. In the Baseline Scenario, modeling shows that the majority of electrification savings in the multifamily sector occurs due to codes requiring highly efficient, all-electric new construction. Voluntary heat pump adoption in existing multifamily buildings sees a meaningful increase only under the Reasonable Return Incentives, which typically exceed 50% of the incremental cost to install a full-load heat pump or a heat pump bundled with shell upgrades. Uptake of deeper-saving shell packages (comprising air sealing, insulation, and energy-efficient windows) in existing multifamily buildings increases modestly with Reasonable Return Incentives, though adoption is constrained by non-financial barriers.

The commercial sector is responsive to electrification incentives but sees minimal uptake of shell measures. In the commercial sector, the analysis assumes that heat pump adoption occurs either in new construction or as part of a major capital upgrade to an existing building, such that heat pumps are bundled with additional efficiency measures (such as energy recovery ventilation and more efficient lighting, appliances, and plug loads) in a manner that benefits energy savings and project returns. Meaningful electrification of commercial space heating occurs in the Baseline Scenario, with increased uptake under CapEx Incentives and still higher electrification savings with Reasonable Return Incentives. In contrast, because incentive caps are applied, commercial shell packages do not reach a desired return on investment under any incentive scenario modeled and their adoption remains low.

In commercial buildings, HVAC controls and distribution improvement measures offer significant potential for heating and cooling energy savings. In the commercial buildings sector, the top energy savings measure packages in the Baseline Scenario include HVAC controls, distribution improvements (such as insulating pipes and repairing ducts or steam traps), and the commissioning and tune-up of HVAC systems. These energy efficiency measures are typically low-cost, mature, and offer both heating and cooling savings; as a result, additional incentives do not significantly increase their adoption. An exception is that certain non-thermostat HVAC controls (for example, variable speed drives and economizers) do see higher savings with incentives.

1.4 Areas for Future Analysis

The Commission noted that this statewide potential study, or components thereof, may warrant interim updates and shall be conducted no less than every four years. Areas for future work include these:

- **Supplementary adoption scenarios.** New insights could be drawn from an adoption scenario in which heat pumps, building shell, and other targeted measures are offered incentives, but high-efficiency fossil fuel equipment measures do not receive incentives. Similarly, it would be beneficial to conduct additional scenario analyses that directly examine the impacts of policy initiatives (other than incentives) to address market barriers such as consumer awareness and workforce development.

- **Partial and phased electrification.** This study focused primarily on deeper energy savings measures, including heat pumps and building shell measures. It did not focus on certain incremental measures like partial electrification in commercial and multifamily buildings. Future work will include designing measures that reflect partial and incremental electrification in larger buildings, as well as attention across building sectors to how usage patterns for partial-load heat pumps may impact realized energy savings.
- **State equipment standards.** Recent data indicate that some statewide equipment standards have lower efficiencies than initially assumed in this study, meaning savings from these measures (particularly low-flow water fixtures) have been over-estimated. In any future updates, this study will revisit the impact of equipment standards to align with up-to-date adopted requirements.
- **Winter electric peak.** Given that estimates of winter electric peaks will grow in importance over time as New York realizes higher levels of electrification, any future iterations of this study will include winter electric peak impact estimates.

2 Introduction

The New York State Public Service Commission (Commission) directed the New York State Energy Research and Development Authority (NYSERDA), in consultation with New York State Department of Public Service (DPS) staff as well as the New York State investor-owned utilities, the Long Island Power Authority, and the New York Power Authority (referred to as the NYS utilities), to conduct a comprehensive statewide potential study encompassing energy efficiency and electrification for the residential and commercial building sectors in New York State. NYSERDA contracted with Cadmus, Energy + Environmental Economics, and Industrial Economics Incorporated (IEC)—collectively referred to as Cadmus throughout this report—to complete the study.

This section presents an overview of the potential study objectives, types of potential identified, adoption scenarios, and consultative engagement process. The methodology appendix provides additional details on the levels of potential, scenarios, and modeling inputs and data sources.

2.1 Study Objectives

This study estimates energy efficiency and electrification savings potential over a 20-year period, from 2023 to 2042. The main objective of the study is to identify and explore energy efficiency and electrification potential opportunities in New York State's buildings sector statewide. A secondary objective is to inform the design and planning of energy efficiency and electrification interventions, though the study scope does not include estimating the program potential that any prospective energy efficiency program could attain. The study makes information available to public and private stakeholders, in support of New York State's initiatives to advance clean energy and climate goals under the Climate Leadership and Community Protection Act (explained in Box 2).

Box 2. The Climate Act and the Statewide Potential Study for Buildings

The New York State Climate Leadership and Community Protection Act (Climate Act) is one of the most ambitious climate laws in the nation. It commits New York State to a 40% reduction in greenhouse gas (GHG) emissions by 2030 and an 85% reduction by 2050, from 1990 levels. The Climate Act also required the development of the New York State Climate Action Council Scoping Plan,[7] under the direction of a 22-member Climate Action Council, which advances recommendations on how New York State can reduce GHG emissions, achieve net-zero emissions, increase renewable energy usage, and ensure climate justice. The Climate Act goals and specific strategies recommended in the Scoping Plan inform this study.

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7 For more information about New York State Climate Action Council's Scoping Plan, published December 2022, access the website at climate.ny.gov/resources/scoping-plan/.

2.2 Levels of Potential and Scenarios

This potential study estimates the energy and demand impacts of adopting energy efficiency and electrification measures in New York State. This study calculated these impacts for three levels of potential: technical, economic, and achievable scenarios.

2.2.1 Technical and Economic Potential

Technical potential assumes that the highest-saving, technically feasible energy efficiency and electrification 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 energy savings 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 to upgrade to the efficiency measure.

Economic potential represents a subset of technical potential and consists only of measures that are cost-effective according to the NYS Public Service Commission's Benefit/Cost Analysis (BCA) Framework. The BCA Framework includes the energy-related costs and benefits experienced by the utility system, the incremental costs of energy efficiency and electrification measures, and the value of benefits associated with avoided emissions of greenhouse gases and air pollutants. For each energy efficiency and electrification measure, the study structured the benefit/cost test as the ratio of net present value for the measure's societal benefits and costs, using a nominal societal discount rate of 5.76%. This study considered measures with a societal benefit/cost ratio of 1.0 or greater as cost-effective in the economic potential estimates, which will be presented in an addendum to this report in March 2023. The methodology appendix includes a detailed description of the benefits and costs elements.

The study did not consider program potential, which would require a more detailed examination of rebate levels, marketing and administration expenditures, and the possible measure mix that NYS utilities and statewide initiatives can offer, including measures that are not cost-effective.

2.2.2 Achievable Potential Scenarios

Achievable potential is expressed through the development of illustrative scenarios that analyze the potential for adoption of measures given real-world customer motivations and constraints, including, for example, the impact of cost considerations, customer behavior, supply chain barriers, and the extent to which government programs overcome such barriers and constraints. This study determines achievable potential as a subset of technical potential. Unless subject to codes and standards, measure adoption is voluntary and is determined based on project return as experienced by the customer and non-economic barriers to adoption. This study does not require that measures pass a societal benefit/cost screen (as is applied to estimate economic potential) to be included in achievable potential estimates.

This report presents three adoption scenarios to explore achievable potential.[8] First, the Scenario 1. Baseline describes a case that is inclusive of enacted federal, state, and local policies, as well as anticipated advancements in New York State codes for new construction (as recommended in the Scoping Plan). Scenario 2. CapEx Incentives and Scenario 3. Reasonable Return Incentives carry forward the core Baseline Scenario assumptions and apply different approaches for upfront financial incentives to encourage adoption of energy efficiency and electrification measures. Each scenario is described below.

Scenario 1. Baseline

This study incorporates statewide building energy codes and federal equipment standards into estimated business-as-usual energy sales and equipment consumption estimates. The Baseline Scenario builds on this by incorporating state appliance and equipment efficiency standards and the enacted New York City Local Laws 97 and 154. In alignment with the Scoping Plan, this scenario also assumes that new building energy codes will take effect for new construction, requiring highly efficient, zero-emission new construction starting in 2025 for single-family buildings and 2028 for multifamily and commercial buildings. These anticipated code adjustments will, in effect, expand the phase-out of fossil fuel systems in new buildings—which is already required under New York City Local Law 154—across all of New York State.

Table 2-1 provides a summary of the building codes and equipment standards included in the Baseline Scenario. This scenario does not model any new upfront financial incentives for consumers beyond currently available federal tax credits from the 2022 Inflation Reduction Act and a New York State geothermal tax credit for homeowners. The Baseline Scenario establishes a case to which additional interventions can be compared.

[8] This study did not consider program potential for programs that could be offered by New York State utilities and statewide initiatives. This would require a more detailed examination of planning for incentive levels, the possible eligible measure mix, and marketing and administration expenditures.

Table 2-1. Overview of Building Codes and Equipment Standards in Scenario 1. Baseline

Measure	Statewide [a]	New York City Local Law 154
Shell (New Construction)	High-performance shell (approximately Passive House level) • 2025: single-family • 2028: multifamily and commercial	Though Local Law 154 does not specify shell requirements, New York City has adopted a stretch energy code. Therefore, for new construction buildings in New York City, high-performance shell measures are modeled as adopted concurrently with cold-climate heat pumps: • 2024: residential buildings ≤7 stories • 2027: all other building types
Space Heating (New Construction)	Installation of electric, cold-climate heat pumps for space heating • 2025: single-family • 2028: multifamily and commercial	No combustion with >25 $kgCO_2e$/MMBtu within building (modeled as installation of electric, cold-climate heat pumps for space heating) • 2024: Buildings ≤7 stories • 2027: Buildings >7 stories
Hot Water (New Construction)	Heat pump water heaters • 2025: single-family • 2028: multifamily and commercial	No combustion with >25 $kgCO_2e$/MMBtu within building (modeled as installation of electric, cold-climate heat pump water heater) • 2024: single-family 1 or 2 units • 2027: all other building types
Appliances/ Products	2024: standard for appliances/ products not preempted by federal standards. The list of such appliances/products is presented in the methodology appendix.	Local Law 154 does not specify appliance and product standards, therefore, buildings in New York City follow the statewide requirements as stated on this table.

[a] 100% compliance is assumed to occur on the third year after building code is in effect, with compliance increasing incrementally from 70% in the first year of the building code. Cold-climate heat pumps include air-source and ground-source technologies. For appliances and product standards 100% compliance is assumed in the first year of the standard.

Scenario 2: CapEx Incentives

The CapEx Incentives Scenario includes the elements modeled for the Baseline Scenario. It adds sustainability guidelines that New York State Homes and Community Renewal (HCR) has established for the new construction of housing for low-income households, which is modeled as a requirement that new construction of subsidized affordable multifamily buildings adopts high-performance shell and heat pumps from 2024 onward (with incentives provided through 2027). The scenario assumes that consumers receive an incentive amount calculated at 50% of the measure incremental cost after applicable tax credits. This incentive design is commonly used by program administrators in New York State. Incentives are modeled for all measures (except those subject to state and federal codes or standards). Incentive caps are applied to each measure, up to a maximum of $30,000 per single-family dwelling unit, $35,000 per multifamily dwelling unit, and $20 per square foot in commercial spaces.

Scenario 3: Reasonable Return Incentives

The Reasonable Return Incentives Scenario includes the elements modeled for the Baseline Scenario and the HCR sustainability guidelines. Like Scenario 2, this scenario models incentives that encourage households and businesses to adopt energy efficiency and electrification measures (unless measures are subject to state and federal codes and standards). Scenario 3 applies a more tailored approach to setting incentives, in which the incentive is equal to the upfront amount required to achieve a reasonable customer rate of return on the measure's incremental lifetime cost.[9] Measures that are highly cost-effective in the Baseline Scenario (such as commercial lighting) receive little or no upfront incentive in this scenario, while measures that do not initially offer a reasonable project return (as is often the case for heat pumps) see higher incentives and may even exceed 50% of the incremental cost. Like Scenario 2, this scenario applies an incentive cap to each measure, up to a maximum of $30,000 per single-family dwelling unit, $35,000 per multifamily dwelling unit, and $20 per square foot in commercial spaces.

2.2.3 Analysis Tool

The study used the NYSERDA in-house Building Efficiency and Electrification Model (BEEM). The BEEM toolset encompasses a specific set of measure packages selected to represent the most common energy and efficiency measures that can be installed in buildings. BEEM predicts annual adoption of measures or measure groups based on a combination of return on investment and non-economic barriers to adoption, as described in Chapter 3 of this report and in the methodology appendix. To model the scenarios, the study leveraged two key features of BEEM:

- The ***predetermined adoption feature*** requires certain measures to be adopted at specific levels over time (to model regulatory requirements rather than voluntary adoption of measures).
- The ***incentive feature*** provides an upfront financial incentive to impact voluntary adoption; this upfront incentive is either set as a percentage of incremental measure cost or set to the level needed to meet a specified rate of return.

2.3 Consultative Engagement

NYSERDA and Cadmus consulted with DPS staff and NYS utilities (consultative study partners) throughout the potential study through eight project-wide webinars, multiple one-on-one meetings, and direct communication. The purpose of this engagement was the following:

- Gather input and feedback to shape the potential study scope and scenarios
- Answer questions about the technical aspects of the study
- Keep consultative study partners informed of developments throughout the study timeframe

Consultative study partners included representatives from the DPS, the Long Island Power Authority, the New York Power Authority, Central Hudson, Con Edison, PSEG Long Island, National Fuel, National Grid, New York State Electric & Gas (NYSEG) and Rochester Gas and Electric (RG&E), and Orange and Rockland

[9] Specifically, the incentive is set such that subsidized affordable multifamily buildings, public sector buildings, and certain large commercial building types achieve an internal rate of return (IRR) of 10% (corresponding to a project payback period of nine to ten years) and other residential or commercial customers see an internal rate of return of 16% (corresponding to roughly a six-year payback period).

Utilities.[10] The consultative study partners provided valuable feedback about data inputs and assumptions, scenario design, and interim modeling outputs. The NYS utilities provided information specific to their service territory such as customer counts, loads, load forecasts, retail rates, and background studies. NYSERDA and Cadmus welcome additional input from DPS staff, the NYS utilities, and interested stakeholders on the analysis and results presented in this report, including areas for refinement and future work.

2.4 Areas for Future Analysis

The Commission noted that this statewide potential study, or components thereof, may warrant interim updates and shall be conducted no less than every four years. Areas for future work include:

- **Supplementary adoption scenarios.** New insights could be drawn from an adoption scenario in which heat pumps, building shell, and other targeted measures are offered incentives, but high-efficiency fossil fuel equipment measures do not receive incentives. Similarly, it would be beneficial to conduct additional scenario analyses that directly examine the impacts of policy initiatives (other than incentives) to address market barriers such as consumer awareness and workforce development.
- **Partial and phased electrification.** This study focused primarily on deeper energy savings measures, including heat pumps and building shell measures. It did not focus on certain incremental measures like partial electrification in commercial and multifamily buildings. Future work will include designing measures that reflect partial and incremental electrification in larger buildings, as well as attention across building sectors to how usage patterns for partial-load heat pumps may impact realized energy savings.
- **State equipment standards.** Recent data indicate that some statewide equipment standards have lower efficiencies than initially assumed in this study, meaning that savings from these measures (particularly low-flow water fixtures) have been over-estimated. In any future updates, this study will revisit the impact of equipment standards to align with up-to-date adopted requirements.
- **Winter electric peak.** Given that estimates of winter electric peaks will grow in importance over time as New York realizes higher levels of electrification, any future iterations of this study will include winter electric peak impact estimates.
- **Measure stack perspective.** BEEM currently determines the order in which buildings adopt measures from a societal cost perspective. A future refinement to the model could offer to determine the measure adoption order (measure stacking) from a participant perspective, using either the participant internal rate of return (IRR) or a participant cost test.

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[10] Central Hudson Gas & Electric Corp. Consolidated Edison Company of New York, Inc. (Con Edison), Public Service Enterprise Group (PSEG) Long Island, National Fuel Gas Distribution Corporation, Niagara Mohawk Power Corporation d/b/a National Grid, KeySpan Gas East Corporation d/b/a National Grid, and The Brooklyn Union Gas Company d/b/a National Grid NY (collectively, National Grid), New York State Electric & Gas/Rochester Gas and Electric Corporation, and Orange and Rockland Utilities.

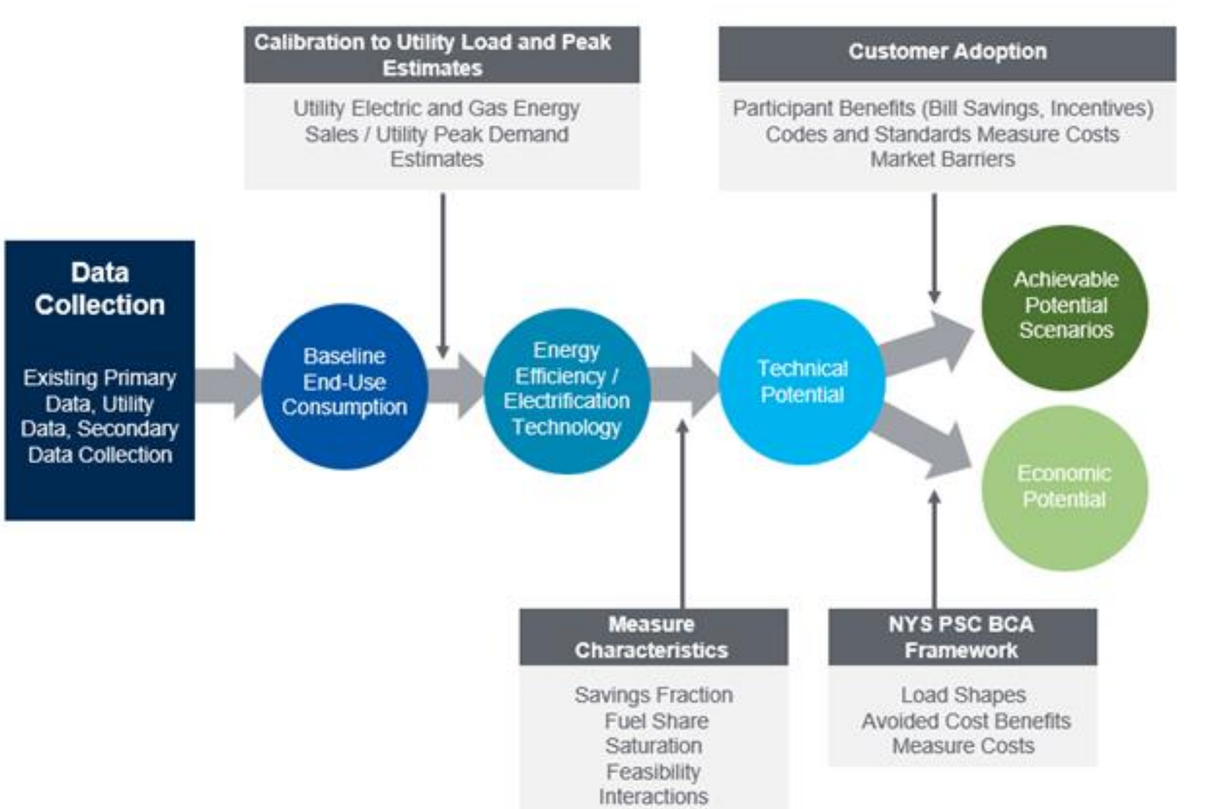
3 Overview of Analysis Methodology

As shown in Figure 3-1, this study developed end-use consumption forecasts through a bottom-up approach then aggregated the consumption forecasts to estimate utility, regional, and statewide energy sales. The estimated sales values were then calibrated to individual utility load data.

Subsequently, the study team calculated energy efficiency and electrification potential for each subset of the building stock (based on the segmentations described below) and aggregated these results to estimate the regional and statewide potentials.

The study estimated energy efficiency and electrification savings impacts accounting for fuel shares, current market saturation and market barriers, technical feasibility, and costs. The analysis assumes that energy efficiency and electrification measures are adopted by customers over typical replacement cycles.[11]

Figure 3-1. General Methodology for Assessing Energy Efficiency and Electrification Potential



[11] The assumed replacement cycles vary by measure and sector. This analysis assumed that all high-efficiency equipment measures would be installed according to the measures' replacement cycle and therefore did not assess energy efficiency potential for early replacement of equipment (that is, replacement before end of useful life), which may unlock additional potential. The analysis assumed that shell upgrade packages are considered every 10 years in residential buildings (roughly corresponding to the sale or refinancing of a building) and every 25 years in commercial buildings (on a cycle for major capital improvements).

3.1 Building Sectors

The study estimated energy efficiency and electrification measure adoption impacts in three sectors: single-family, multifamily, and commercial. Each building sector was further broken down into size categories, building vintages, and ownership models. For example, the commercial sector was segmented into nine business types—office/government, food service, retail, grocery/convenience, warehouse, education, lodging/hospitality, health services, and hospitals.

Table 3-1 shows the building sectors, size categories, and vintages in this potential study.

Table 3-1. Building Sectors, Sizes, Types, Vintages, Income Strata, and Ownership

Sector	Size	Building Types	Vintage	Income Strata	Ownership
Single-Family (1 to 4 units)	1 unit, 2 to 4 units	N/A	Pre-1980, post-1980, new build	Market-rate, LMI	Owner-occupied, renter-occupied
Multifamily (5+ units)	Less than or equal to 7 stories, more than 7 stories	N/A	Pre-war (up to 1945), post-war (up to 1979), post-1980, new build	Market-rate, LMI	Owner-occupied, renter-occupied, subsidized
Commercial	Small/medium commercial (<= 100,000 sq. ft.), large commercial (>100,000 sq ft)	Office/government, food service, retail, grocery/ convenience, warehouse, education, lodging/ hospitality, health services, hospitals	Pre-1980, post-1980, new build	N/A	Private owner, private leased, public owner, public leased

LMI = low- and moderate-income

Configurations by region, space and water heating fuel, HVAC distribution configurations, and water distribution are other differentiating factors used to further segment the building stock data. Regions include New York City, Long Island, Hudson Valley, and Upstate. 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.

The space and water heating fuels include natural gas, oil/propane, electricity, and district steam purchased from Con Edison.

3.2 Energy Efficiency and Electrification Measures

This potential study included a comprehensive set of energy efficiency and electrification measures, with measure details drawn from the 2020 New York State Technical Resource Manual (TRM) (v8) and additional data sources such as NYSERDA's 2019 Residential Baseline Stock Assessment. This section includes an overview of the measure groups included in this study, and further details are provided in the methodology appendix.

The study modeled energy efficiency and electrification measures as individual measures and as measure packages. For example, the single-family appliances measure package consists of ENERGY

STAR® refrigerators, clothes dryers, freezers, and electric cooking equipment. Energy impacts, costs, and customer adoption for these measures were modeled as a single measure package, rather than as individual measures. Another example is for HVAC measures installed together with building shell upgrades, such as in the single-family basic shell and ground-source heat pump (GSHP) measure package.

The study accounted for interactive effects between measures in three ways:

- The study accounted for **interactions between measures in the same measure package** by ensuring that multiple measure components that impact the same end use account for the cumulative impact of all other applicable measure components (that is, accounting for measure "stacking" between different measures within the same measure package). Specifically, for building shell measure components interacting with space heating and cooling equipment or retrofit measure components, the model applies building shell savings first to reduce the building heating and cooling loads before applying the non-shell measure components. This approach accounts for interactive effects within each measure package in the per-unit savings and the technical, economic, and achievable potentials.
- The study accounted for **interactions between different measure packages within the same fuel** by stacking measure packages that interact in the order of their societal cost-effectiveness and reducing the end-use load by the savings of the preceding measure packages in the stack, assuming customers will install the most cost-effective measures first. This approach accounts for interactive effects in the technical, economic, and achievable potentials.
- The study accounted for **interactions between electrification measure packages and subsequently installed energy efficiency measure packages**. An adjustment is necessary because the model does not dynamically adjust the fuel type or heating coefficient of performance (COP) of a building after it has been electrified. Without an adjustment, a gas-heated building in which a heat pump has been installed in one year and a shell improvement in a subsequent year would still produce gas savings as if it were heated by a gas furnace. To account for this, the analysis tracked the percentage of buildings that electrified in each year for each portion of the building segmentation and reduced the fossil fuel potential for the applicable installations of non-equipment measures accordingly. At the same time, the analysis increased the electric potential for those measures to account for the fact that they should save electricity if they were installed after building electrification. The analysis converted the lost fossil fuel efficiency potential into electricity efficiency potential using COP ratios between gas equipment and heat pumps. This adjustment was applied to estimate technical potential but not achievable potential; for the adoption scenarios, the impact was assessed to be minor due to the relatively low heat pump adoption as a proportion of the total building stock.

The following tables list the measure packages in each building sector modeled for the potential study. Table 3-2 shows the single-family energy efficiency and electrification measures packages considered for this study, along with their corresponding measure grouping, and identifies which measure packages are electrification measure packages.

Table 3-2. Single-Family Energy Efficiency and Electrification Measures by Measure Group

<table>
<tr><th>Measure Group</th><th colspan="2">Measure Package Name</th><th>Description/Included Measures</th><th>Category</th></tr>
<tr><td>Appliances</td><td colspan="2">Appliances</td><td>ENERGY STAR refrigerators, clothes dryers, freezers, and electric cooking equipment</td><td>Efficiency</td></tr>
<tr><td>Behavioral</td><td colspan="2">Indirect energy feedback</td><td>Home energy reports</td><td>Efficiency</td></tr>
<tr><td rowspan="4">Heat Pump</td><td colspan="2">Ground-source heat pump</td><td>Heating SASE 338%, Heating TDSE 288%, Cooling SASE 634%, Cooling TDSE 539% [a]</td><td>Electrification</td></tr>
<tr><td colspan="2">Partial-load ductless heat pump</td><td rowspan="2">Heating SASE 250%, Heating TDSE 188%, Cooling SASE 469%, Cooling TDSE 352% [a]</td><td>Electrification</td></tr>
<tr><td colspan="2">Whole-house ductless heat pump</td><td>Electrification</td></tr>
<tr><td colspan="2">Whole-house ducted air-source heat pump</td><td>Heating SASE 216%, Heating TDSE 162%, Cooling SASE 441%, Cooling TDSE 331% [a]</td><td>Electrification</td></tr>
<tr><td rowspan="3">HVAC Equipment and Retrofits</td><td colspan="2">Improved HVAC</td><td>High efficiency central air conditioner and furnace, boiler (gas, oil, propane)</td><td>Efficiency</td></tr>
<tr><td colspan="2">Window air conditioner</td><td>ENERGY STAR</td><td>Efficiency</td></tr>
<tr><td colspan="2">Thermostats, tune-ups, distribution improvements, and boiler controls</td><td>Smart Wi-Fi thermostats, HVAC tune-ups, duct insulation, duct sealing, and boiler pipe insulation, boiler reset controls</td><td>Efficiency</td></tr>
<tr><td rowspan="10">Shell and HVAC Equipment</td><td rowspan="5">Basic shell and</td><td>Air-to-water heat pump</td><td rowspan="5">Basic shell:
Pre-1980 buildings: Air sealing; Wall, ceiling, and floor insulation.
Post-1980: Air sealing; Ceiling insulation</td><td>Electrification</td></tr>
<tr><td>Ground-source heat pump</td><td>Electrification</td></tr>
<tr><td>Improved HVAC</td><td>Efficiency</td></tr>
<tr><td>Whole-house ducted air-source heat pump</td><td>Electrification</td></tr>
<tr><td>Whole-house ductless heat pump</td><td>Electrification</td></tr>
<tr><td rowspan="5">Deep shell and</td><td>Air-to-water heat pump</td><td rowspan="5">Deep shell:
air sealing, R-20 Wall insulation, floor insulation, R-60 ceiling insulation, window upgrades</td><td>Electrification</td></tr>
<tr><td>Ground-source heat pump</td><td>Electrification</td></tr>
<tr><td>Improved HVAC</td><td>Efficiency</td></tr>
<tr><td>Whole-house ducted air-source heat pump</td><td>Electrification</td></tr>
<tr><td>Whole-house ductless heat pump</td><td>Electrification</td></tr>
<tr><td>Lighting</td><td colspan="2">Lighting</td><td>LED specialty lamps (Tier 2), general service ENERGY STAR LED lamps, TLED linear lamp</td><td>Efficiency</td></tr>
<tr><td>Plug Loads</td><td colspan="2">Plug loads</td><td>Advanced power strips, ENERGY STAR air purifier, computer, dehumidifier, TV, and variable speed pool pumps, federal standard microwaves</td><td>Efficiency</td></tr>
<tr><td rowspan="2">Shell Improvements</td><td colspan="2">Basic shell</td><td rowspan="2">See above</td><td>Efficiency</td></tr>
<tr><td colspan="2">Deep shell</td><td>Efficiency</td></tr>
<tr><td rowspan="3">Water Heating</td><td colspan="2">Heat pump water heater (HPWH)</td><td>Advanced efficiency (No Resistance/Split System) HPWH ≤ 55 GAL - UEF 3.1</td><td>Electrification</td></tr>
<tr><td colspan="2">Efficient hot water heater</td><td>Water heater Consortium for Energy Efficiency (CEE) Tier 2 tankless (Replacing ≤ 55 GAL) - UEF 0.92</td><td>Efficiency</td></tr>
<tr><td colspan="2">Low-flow water fixtures</td><td>Bathroom and kitchen aerators, low-flow shower head</td><td>Efficiency</td></tr>
</table>

SASE = seasonal average system efficiency – system efficiency accounting for distribution losses; TDSE = temperature derated system efficiency – system efficiency accounting for distribution losses and reflecting reduced performance from climate conditions at the time of peak load; UEF = uniform energy factor; LED = light emitting diode

Table 3-3 shows the multifamily measures considered for this study, along with their corresponding measure group, and identifies which measures are electrification measures. In multifamily buildings, different measures may apply to tenants or to whole buildings. The measure names indicate the space to which they apply. Measures labeled "tenant," such as tenant lighting or ductless heat pumps, affect tenant space only (in green). Measures labeled "whole building," such as central boilers and shell improvements, affect both tenant and common area space (in blue).

Table 3-3. Multifamily Energy Efficiency and Electrification Measures by Measure Group

Measure Group	Measure Package Name	Measure Description	Electrification
Appliances	Tenant appliances	ENERGY STAR refrigerator, clothes dryers, freezers. Electric oven, range	Efficiency
Behavioral	Tenant indirect energy feedback	Home energy reports	Efficiency
	Tenant electricity submetering	Submetering electricity for individual apartments	Efficiency
Heat Pump	Tenant ducted air-source heat pump	Heating SASE 230%, heating TDSE 173%, cooling SASE 469%, cooling TDSE 352% [a]	Electrification
	Tenant ductless heat pump	Heating SASE 250%, heating TDSE 188%, cooling SASE 469%, cooling TDSE 352% [a]	Electrification
	Tenant package terminal heat pump	Heating SASE 270%, cooling SASE 379%, cooling TDSE 345% [a]	Electrification
	Whole building air-to-water heat pump	Heating SASE 200%, heating TDSE 150%, cooling SASE 470%, cooling TDSE 350% [a]	Electrification
	Whole building ground-source heat pump	Heating SASE 360%, heating TDSE 306%, cooling SASE 674%, cooling TDSE 573% [a]	Electrification
	Whole building variable refrigerant flow	Heating SASE 200%, heating TDSE 150%, cooling SASE 450%, cooling TDSE 338% [a]	Electrification
HVAC Equipment	Whole building convert steam boiler to Hydronic boiler	Gas or oil/propane hydronic boiler - advanced efficiency	Efficiency
	Improved HVAC	Whole building improved boiler, furnace, and central air conditioner	Efficiency
HVAC Retrofits	Whole building steam retrofit package	Thermostatic radiator valves and steam trap repair	Efficiency
	Whole building boiler control	Outside air temperature reset/cutout control	Efficiency
	Whole building energy management system	Installation of energy management system	Efficiency
	Whole building retro-commissioning and re-commissioning	Building retro-commissioning and re-commissioning	Efficiency
	Tenant smart thermostatic radiator enclosure	Smart thermostatic radiator enclosure	Efficiency
	Whole building boiler optimization	Heat recovery from boiler flue gases to preheat boiler feed water, variable frequency drive (VFD) boiler draft fan, and boiler linkageless controls and oxygen trim controls	Efficiency
Lighting	Common area lighting	LED specialty and ENERGY STAR general service lamps, TLED linear lamps, occupancy sensors and lighting controls	Efficiency
	Tenant LED lighting	LED specialty and ENERGY STAR general service lamps, TLED linear lamps	Efficiency
Plug Loads	Tenant plug loads	Advanced power strips, ENERGY STAR dehumidifiers, air purifiers, computers, and TVs, and microwaves	Efficiency

Measure Group	Measure Package Name	Measure Description	Electrification
Shell Improvements	Whole building air-sealing (basic shell)	Shell package improvements – Basic (air sealing from the apartment interior)	Efficiency
	Whole building medium shell	Shell package improvements - Medium (air sealing, double-pane windows, R-40 roof insulation)	Efficiency
	Whole building high-performance shell	Shell package improvements – high-performance	Efficiency
Shell and HVAC Equipment	Each shell package—whole building air-sealing (basic shell), whole building medium shell, and whole building deep shell—can be paired with the heat pump/HVAC measures listed below:		
	Tenant ducted air-source heat pump	See individual descriptions throughout	Electrification
	Tenant ductless heat pump		Electrification
	Tenant package terminal heat pump		Electrification
	Whole building air-to-water heat pump		Electrification
	Whole building ground-source heat pump		Electrification
	Whole building improved HVAC		Efficiency
	Whole building variable refrigerant flow		Efficiency
Water Heating	Central hot water heater	Gas or oil/propane storage water heater - advanced efficiency	Efficiency
	Tenant heat pump water heater	Residential sized heat pump water heater - 240% SASE	Electrification
	Tenant low-flow water fixtures	Kitchen and bathroom aerators, efficient showerheads and thermostatic shower restriction valve	Efficiency
	Whole building central heat pump water heater	Commercial sized heat pump water heater - 240% SASE	Electrification

[a] SASE = seasonal average system efficiency – system efficiency accounting for distribution losses

TDSE = temperature derated system efficiency – system efficiency accounting for distribution losses and reflecting reduced performance from climate conditions at the time of peak load

Table 3-4 shows the commercial energy efficiency and electrification measures considered for this study, along with their corresponding measure group, and identifies which measures are electrification measures.

Table 3-4. Commercial Energy Efficiency and Electrification Measures by Measure Group

Measure Group	Measure Package	Measure Description	Electrification
Appliances	Appliances/plug loads	Commercial appliances and plug loads	Efficiency
Heat Pump	Air-source heat pump	Commercial air-source heat pump [a]	Electrification
	Ground-source heat pump	Commercial ground-source heat pump	Electrification
HVAC Equipment	Improved HVAC	Efficient boilers, efficient furnaces	Efficiency
HVAC Retrofits	Commissioning and tune-up	This study applied the following components to applicable HVAC configurations: [b] Commissioning, continuous commissioning, re-commissioning, retro-commissioning, boiler maintenance, chiller tune-up, direct expansion tune-up and diagnostic, furnace and heat pump tune-ups	Efficiency
	HVAC controls – non-thermostat	This study applied the following components to applicable HVAC configurations: [a] Thermostatic radiator valves, roof-top unit supply fan VFD and controller, economizer controller, and CO_2 sensor (full advanced rooftop controls), CO sensors Rooftop unit with automated fault detection and diagnostics capability economizer, boiler controls – high, turndown burners, linkageless, boiler controls, boiler reset controls, VFD boiler draft fan, add oxygen trim controls to boiler (TEMP-A-TRIM), additional control features, variable speed drive (VSD) for secondary chilled water loop, chilled water temperature reset, install economizer, HVAC fan system installation with VSD, air-side economizer, optimize economizer	Efficiency
	HVAC controls - thermostat	Installation of emergency management system, Wi-Fi thermostat (learning type) and learning type with seasonal savings)	Efficiency
	Distribution improvements	This study applied the following components to applicable HVAC configurations: [a] Above-code boiler and chiller pipe, code hot water pipe insulation, duct repair and sealing, hot water circulation insulation, duct insulation, steam trap repair	Efficiency
Lighting	Lighting controls	Advanced lighting and control design, occupancy sensors, daylight controls, continuous dimming, 3-step dimming, time clock	Efficiency
	Lighting equipment	Commercial lighting	Efficiency
Refrigeration	Refrigeration system upgrades	Added doors, anti-sweat controls, case replacement, refrigeration defrost, electronically commutated motor evaporator fans, display case LEDs, display case motion sensors, display case ac motor, electronically commutated motor evaporator fan controller, floating condenser head pressure controls, mechanical subcooling, night covers for display cases, no heat case covers, commissioning/recommission, strip curtains for walk-ins, economizers added to walk-in cooler	Efficiency
Shell Improvements	Code minimum shell	Code minimum shell: air sealing, wall and roof insulation to the 2018 energy code, and double-pane windows	Efficiency
	Basic shell	Basic shell: Pre-1980 buildings: air sealing plus double-pane windows Post-1980 buildings: air sealing	Efficiency

Measure Group	Measure Package	Measure Description	Electrification
Shell Improvements and HVAC	Each shell package-basic shell, code minimum shell, and high-performance shell—can be paired with the following improvements and HVAC: Air-source heat pump Ground-source heat pump Improved HVAC	See individual descriptions throughout	Electrification
Water Heating	Heat pump water heater (commercial sized)	Commercial sized heat pump water heater	Electrification
	Water heater usage and controls	Drain water heat recovery water heater, low-flow faucet aerators, low-flow pre-rinse spray valves - CEE Tier 2, low-flow showerheads, ultrasonic faucet control, water heater setback thermostat	Efficiency

[a] The BEEM toolset models a variation of air-source heat pump (ASHP) technology for each commercial building type based on the most common HVAC configuration. For example, the ASHP technology for small offices or small grocery stores is a variable refrigerant flow (VRF) system with energy recovery ventilator, whereas large hotels are considered to install a two-pipe air-to-water heat pump with water-cooled chillers. In the commercial sector, heat pumps for space conditioning are bundled with additional efficiency measures that may include more efficient lighting, appliances, plug loads, and water heating equipment.
[b] The study applied measures only to appropriate HVAC distribution configurations (for example, boiler maintenance applied only to sites with boilers).

3.3 Measure Permutations

This study segmented the market to analyze energy efficiency and electrification potential for the most prominent fuel types in residential and commercial buildings, including electricity, natural gas, fuel oil and propane, and district steam purchased from Con Edison. This study considered region (New York City, Long Island, Hudson Valley, and Upstate), electric utility service territory, building vintage, ownership, building size (for example less than or equal to seven stories and greater than seven stories for multifamily), metering type, and all major residential and commercial end uses.

This study considered measure savings and costs separately for each measure permutation across applicable differentiating factors (such as geographic area, vintage, and ownership) within the single-family, multifamily, and commercial sectors. As shown in Table 3-5, this study examined 96 unique measures, hence more than 135,472 energy efficiency and electrification measure permutations across all fuel types (electric, natural gas, fuel oil and propane, and district steam). Permutations occurred when applying a unique measure (such as air sealing) to multiple geographic areas, multiple building vintages, or to another differentiating factor. (The methodology appendix contains further information.)

Table 3-5. Measure Counts and Permutations

Sector	Total Unique Measure Package Count	Total Measure Package Permutations
Single-Family	24	45,493
Multifamily	47	47,043
Commercial	25	42,936
Total	96	135,472

3.4 Energy and Demand Impacts and Costs

This potential study estimated energy savings for each energy efficiency and electrification measure: both the savings per unit (kWh or MMBtu) and the savings as a percentage of end-use equipment baseline consumption. These estimates account for savings interactions and results across end uses (for example, when efficient cooling equipment is installed, cooling loads for other measures decrease). This study also estimated peak demand impacts for each measure using 8,760 end-use load shapes for each sector.

The study estimated equipment, labor, and annual operation and maintenance costs for each measure. These costs then fed into the calculation of benefit/cost ratios and the return on investment (considering available incentives and tax credits where applicable) to assess measure adoption. The study team relied on multiple sources, such as RSMeans, ENERGY STAR, incremental cost studies, and others.

Because costs vary widely across New York State, the study team used BEEM's cost-scaling capability to adjust costs by region (New York City, Long Island, Hudson Valley, and Upstate). For low- and moderate-income (LMI) housing, the analysis scaled measure costs up by 10% for single-family LMI and 20% for multifamily LMI to reflect higher likelihood of deferred maintenance as well as requirements applicable to subsidized affordable housing.

3.5 Measure Counterfactual Baselines

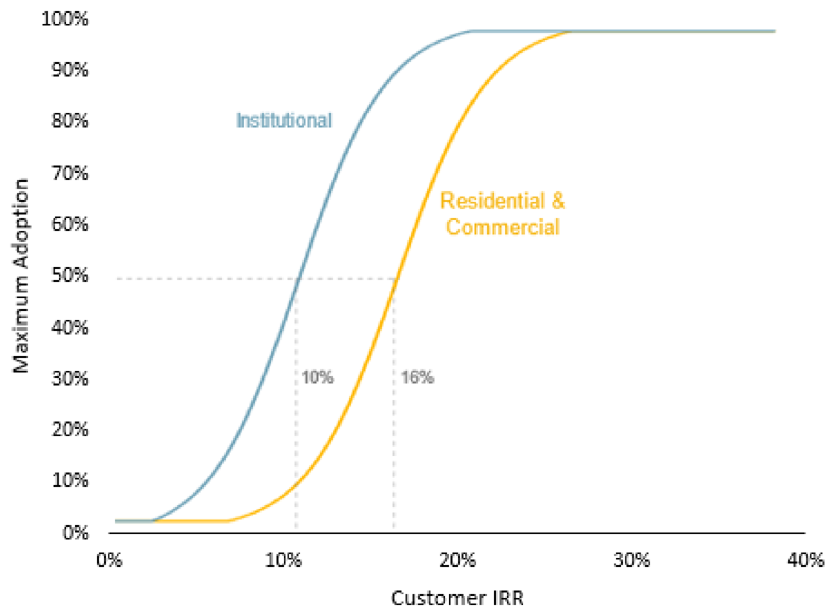
This study compared measure cost and energy consumption to a counterfactual baseline. Counterfactuals represent the equipment a customer or building would have installed if they had opted not to install the efficiency measure. For an efficient boiler or furnace, for example, the counterfactual is a federal standard boiler or furnace. For new construction, the counterfactual reflects the current energy code. The counterfactual baseline condition for many retrofit-style measures, such as pipe wrap or shell improvements, is the existing condition.

3.6 Voluntary Measure Adoption

This study modeled voluntary measure adoption based on a combination of the project return as experienced by the customer and non-economic barriers to adoption. The analysis determines the customer's willingness to adopt a measure based on project return on investment, expressed here as internal rate of return (IRR), on the incremental capital cost of the measure under consideration compared to the counterfactual alternative. For each customer type, a correlation is established between the measure IRR and a resulting maximum adoption rate.

As shown in Figure 3-2, the vertical value of a curve sets the maximum fraction of customers who would adopt a technology for a given IRR. The dashed lines demonstrate that maximum adoption by half of the institutional customers (public sector buildings and subsidized affordable multifamily buildings) would require an IRR of 10%, while a similar fraction of residential or commercial customers would adopt given an IRR of 16%. The correlations between IRR and maximum adoption rate used here are broadly consistent with those used in prior NYSERDA analyses.[12]

Figure 3-2. Maximum Adoption Rate as a Function of Internal Rate of Return



The analysis estimates the annual adoption from the maximum annual adoption percentage (from Figure 3-2) and a series of s-curves that are derived for each measure package and market segment based on specific measure attributes. As shown in Figure 3-3, each s-curve describes how adoption rates increase over time as technologies evolve from nascency to maturity. Table 3-6 shows the assignment of each measure to a corresponding s-curve by assessing customer, technology, and market barrier attributes.

In brief, the sales share adoption of a measure in a given year is set by the product of the IRR maximum adoption percentage discussed above and the value derived from placement on an s-curve. A measure that has attributes of complex or invasive technology, limited customer awareness, and other unaddressed barriers to adoption would fall on a curve closer to the bottom of the shaded region in Figure 3-3, resulting in low near-term adoption even with a strong project return on investment. The methodology appendix provides further details on the measure adoption methodology.

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12 As a part of NYSERDA's 2019 Residential Building Stock Assessment Single-Family Potential Study, residential customers were surveyed about their willingness to adopt an energy efficiency measure given varying incentive levels. The surveyed customers became increasingly willing to adopt a measure as incentive levels increased. The most dramatic change in willingness was for air-source heat pumps, which 30% of residential customers were willing to adopt with no incentive and 60% were willing to adopt for an incentive covering 100% of the measure incremental cost.

Figure 3-3. Adoption S-Curve Range

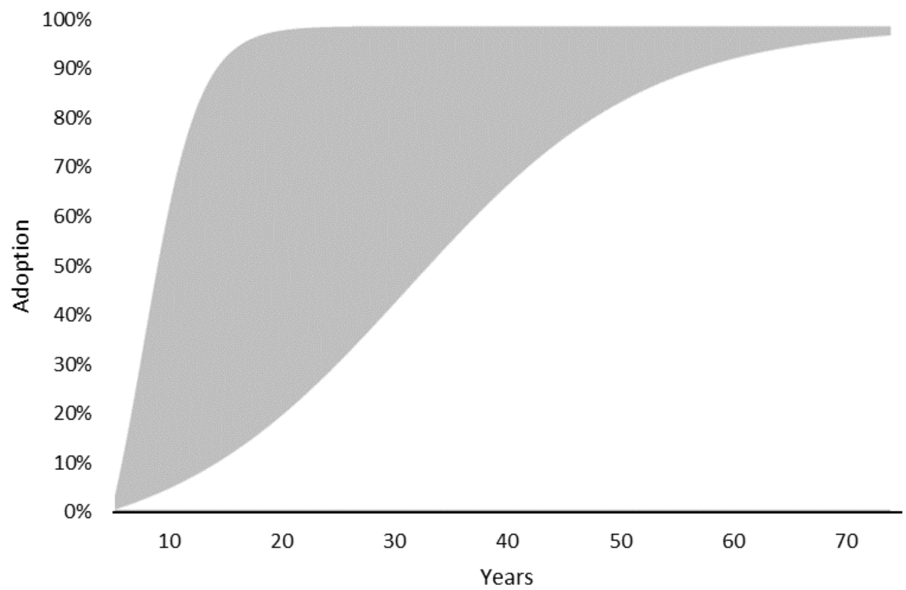


Table 3-6. Measure Attributes

Reference Attributes		
Customer	**Technology**	**Barriers**
Captures the ease and willingness of customers to adopt a measure package (setting aside project return)	Captures aspects of technologies such as transaction costs (hassle factor), technology complexity, depth of renovation or operational change required, and ancillary benefits.	Captures other characteristics that limit the adoption of measure packages, such as customer awareness and confidence, supply chain and workforce development, availability of finance solutions, and landlord/tenant split-incentive issues

4 Statewide Energy Efficiency and Electrification Potential

This chapter describes statewide energy efficiency and electrification potential. It provides results for technical and achievable potentials, focusing on 2030 estimates (that is, representing the estimated energy savings impact in 2030 from measures installed from 2023 through 2030). The statewide results provide estimated energy savings potential by fuel, building sector, and end-use group, which are presented throughout this report as energy savings at the customer site. Potential estimates are provided as energy, peak demand, and greenhouse gas (GHG) reduction and represent savings that New York State could achieve beyond the impacts of federal equipment standards and currently enacted statewide building energy codes.

Table 4-1 shows statewide energy efficiency and electrification potential savings as compared to the estimated 2030 site energy sales (in TBtu) for electricity, natural gas, fuel oil and propane, and Con Edison district steam. Estimated sales include regular equipment stock turnover from existing equipment to counterfactual equipment (federal appliance standards) using the same fuel but absent any efficiency or electrification measure installations.

Table 4-1. 2030 Statewide Energy Efficiency and Electrification Potential Savings (TBtu)

Fuel Type	2030 Estimated Sales (TBtu)	2030 TBtu (from measure installations between 2023 and 2030) [a]			
		Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Energy Efficiency					
Electricity	410	106	27.5	30.5	29.9
Natural Gas	720	160	70.1	78.8	83.2
Fuel Oil and Propane	163	39.1	16.8	19.7	19.5
District Steam	11.8	1.6	0.6	0.7	0.6
Total	**1,305**	**306**	**115**	**130**	**133**
Electrification					
Electricity	410	-52.5	-2.9	-3.7	-11.4
Natural Gas	720	177	13.9	17.3	42.8
Fuel Oil and Propane	163	39.0	4.2	9.0	10.2
District Steam	11.8	1.1	0.3	0.4	0.6
Total	**1,305**	**165**	**15.5**	**23.1**	**42.3**

[a] Negative numbers in this table indicate an increase in electric load, which occurs when electric equipment is installed instead of counterfactual fossil fuel equipment.

As detailed in this table, the analysis shows that there are significant technical potential savings for energy efficiency (306 TBtu, or 24% of estimated sales in 2030[13]) and electrification (165 TBtu, or 13% of estimated sales in 2030) from measures adopted from 2023 through 2030. For energy efficiency, the

[13] The sales forecast accounts for federal standards, as well as current energy code for new construction, but excludes adoption of efficiency and electrification measures that go beyond these minimum standards.

majority of energy efficiency technical potential accrues in the gas sector (160 TBtu), followed closely by electricity (106 TBtu). With substantially smaller overall sales, fuel oil and propane and steam also offer relatively smaller savings technical potential (39.1 TBtu and 1.6 TBtu, respectively). To avoid double-counting, the model first accounts for energy efficiency savings that reduce building heating and cooling loads before estimating the available savings from electrification.

The analysis of electrification shows that the majority of technical potential savings comes from transitioning natural gas (177 TBtu) to electricity, followed by transitioning fuel oil and propane, and steam to electricity (39.0 TBtu and 1.1 TBtu, respectively). Notably, the net electricity savings in the electrification analysis are negative (-52.5 TBtu), reflecting *the increase* in electricity use due to fuel switching.

Summing across energy efficiency and electrification potential for fossil fuel savings in particular, the analysis finds that by 2030, the technical potential accounts for roughly 47% of estimated sales for gas, oil, propane, and district steam (excluding electricity).

This study explores achievable potential by analyzing adoption scenarios, which estimate statewide energy efficiency savings ranging from 115 TBtu (Baseline Scenario) to 133 TBtu (Scenario 3) from 2023 through 2030. For electrification, Scenario 3 has a more pronounced impact on electrification adoption (42.3 TBtu) relative to Scenario 2 (23.1 TBtu) or the Baseline Scenario (15.5 TBtu).

The data show that New York State has the potential to achieve meaningful savings from the Baseline Scenario voluntary adoption and state and local codes and standards. In the Baseline Scenario, the strong majority (76%) of the energy savings potential results from voluntary customer adoption, indicating that many measures included in this study are mature and offer an adequate return to the customer. Importantly, voluntary adoption accounts for available state and federal tax credits but does not offer customers additional upfront incentives. State code and equipment standards account for the remainder of savings in the Baseline Scenario, as described in Chapter 7.

The results also show that estimated energy savings potentials for the various fuels respond differently to incentives offered under Scenario 2 and Scenario 3. Notably, net impacts from electrification (heat pumps) see a 45% increase in Scenario 2 and a 192% increase in Scenario 3 (across all fuels), indicating that higher incentives spur significant acceleration in heat pump adoption. Potentials for specific measure packages across scenarios are discussed in more detail in Chapter 6.

Figure 4-1 shows in graphical form the data presented in Table 4-1, above.

Figure 4-1. 2030 Statewide Energy Efficiency and Electrification Potential (TBtu)

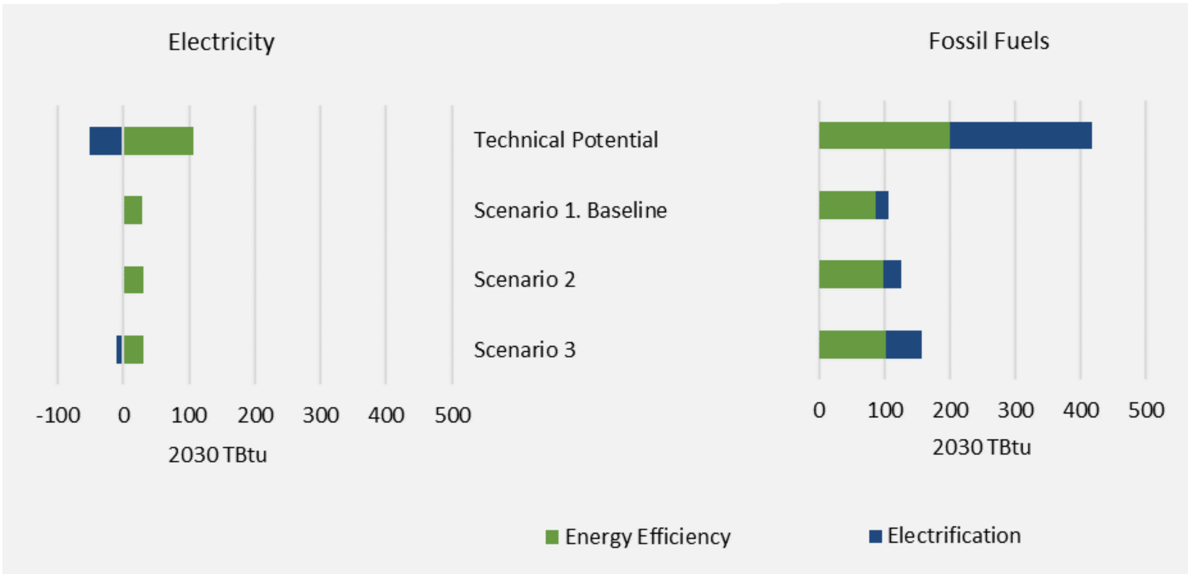
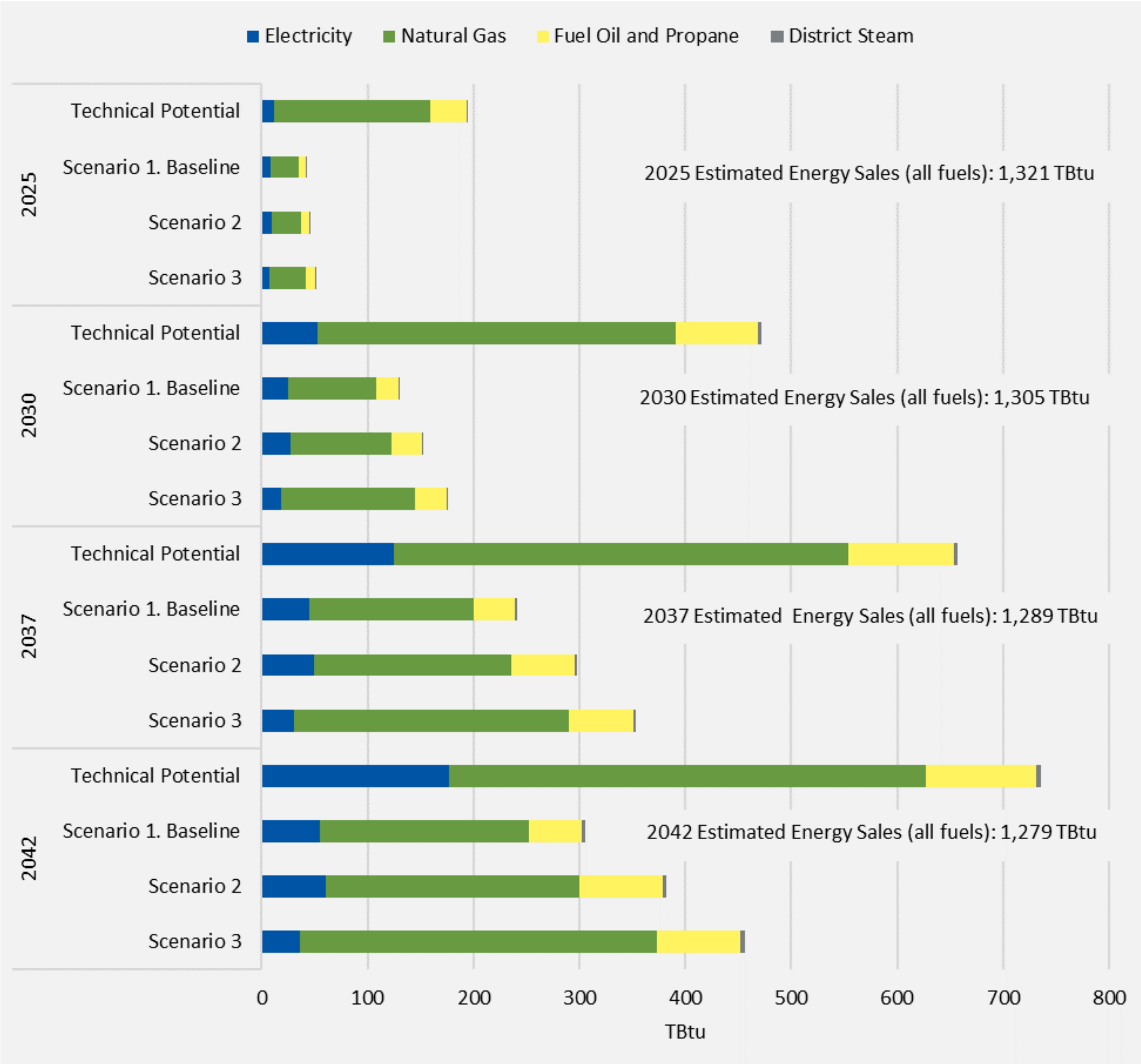


Figure 4-2 shows statewide energy efficiency and electrification potential by scenario and fuel for 2025, 2030, 2037, and 2042. By 2042, technical potential equals approximately 58% of estimated energy sales (all fuels) and 64% of fossil fuel estimated sales (natural gas, fuel oil and propane, and district steam). Technical potential increases over time as building systems are assumed to be replaced when equipment is retired and as retrofits are considered at points in a building's lifecycle. For example, the end-of-life replacement cycle spans 20 years (in the residential sector) to 25 years (in the commercial sector) for space heating equipment. The analysis assumes that shell upgrade packages are considered every 10 years in residential buildings (roughly corresponding to the sale or refinancing of a building) and every 25 years in commercial buildings (on a cycle for major capital improvements).

Relative to the Baseline scenario, growth rates for Scenario 2 and Scenario 3 increase significantly after 2030, a trend that is driven by an increase in shell and heat pump installations. Shell and heat pump measures enter the higher-adoption portion of their adoption curves in the middle years of the study, meaning incentives (as modeled in Scenario 2 and Scenario 3), or other market signals that improve project return on investment, have a larger relative impact in the later years compared to the early years.

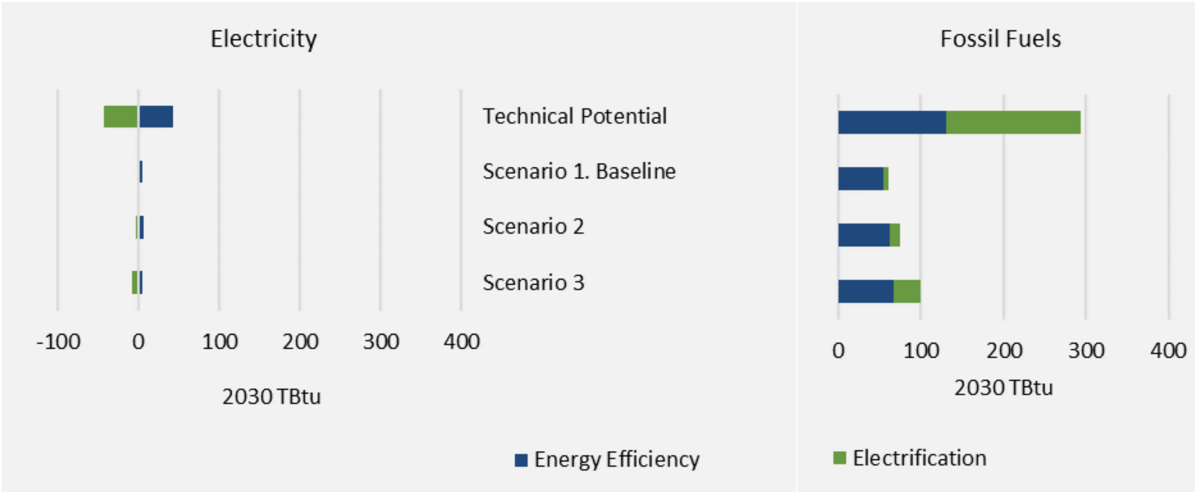
Figure 4-2. 2025, 2030, 2037, and 2042 Statewide Energy Efficiency and Electrification Potential by Scenario and Fuel (TBtu)



4.1 Statewide Energy Efficiency and Electrification Potential by Building Sector

This section presents the estimated energy savings potential results by sector. Figure 4-3 through Figure 4-6 show energy efficiency and electrification potential for single-family, multifamily, and commercial sectors.

Figure 4-3. 2030 Statewide Single-Family Energy Efficiency and Electrification Potential (TBtu)



Sixty-two percent of the total 2030 technical potential occurs in the single-family residential sector (defined as buildings with one to four housing units), which likewise contributes a large share of the total estimated energy savings in each scenario, ranging from 49% (Scenario 1. Baseline) to 56% (Scenario 3). As shown Figure 4-3, electrification represents 41% of single-family technical potential and energy efficiency accounts for the remaining 59% (across all fuels). Space and water heating electrification contribute 9% of the single-family estimated energy savings under the Baseline Scenario, which grows to 14% in Scenario 2 and 26% in Scenario 3. The growth in energy savings from electrification between scenarios indicates the importance of heat pumps in achieving deep savings in the single-family sector as well their responsiveness to incentives.

The multifamily residential sector (defined as buildings with five or more housing units) comprises 13% of the total 2030 technical potential, 19% of the Baseline Scenario, 18% of Scenario 2, and 16% of Scenario 3 potential. As shown in Figure 4-4, energy efficiency represents 87% of the multifamily technical potential and electrification the remaining 13%. Of the total estimated energy savings in the multifamily sector, space and water heating electrification form 11% of the Baseline Scenario, 14% of Scenario 2, and 17% of Scenario 3 potential estimates.

Electricity impacts from electrification appear to be relatively small in the multifamily sector. This is an artifact of categorizing measures as electrification or energy efficiency. All heat pumps are counted as electrification, even when they are installed in buildings with electric counterfactual heating fuel. Similarly, improvements in cooling efficiency due to a heat pump are counted as electrification potential. The added load from new electric heating is offset by improved efficiency in buildings with electric counterfactual heating fuel and improved cooling efficiency. This effect is present in all sectors but is noticeable only in the multifamily sector due to a high prevalence of electric heating.

Figure 4-4. 2030 Statewide Multifamily Energy Efficiency and Electrification Potential (TBtu)

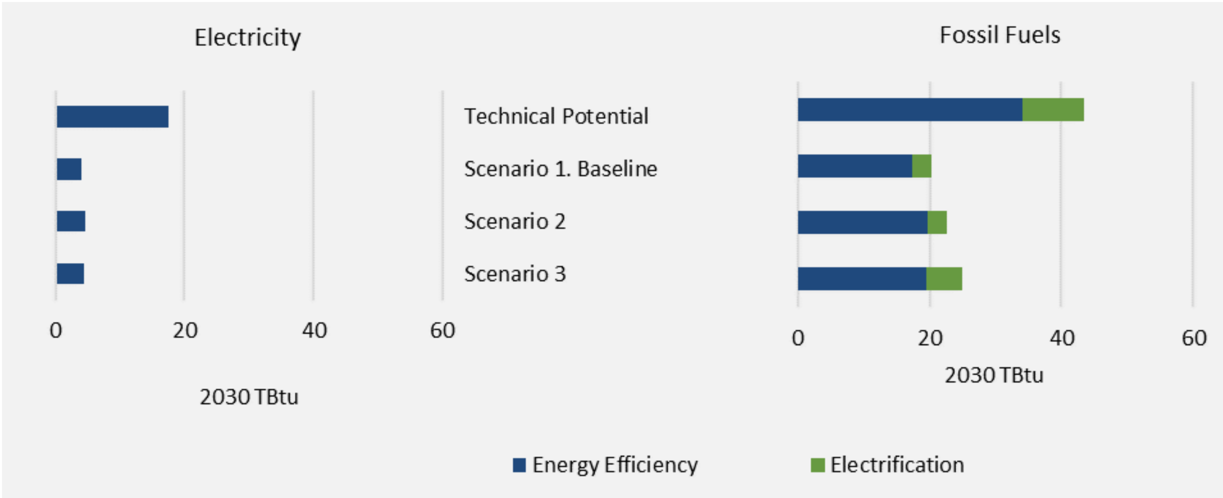
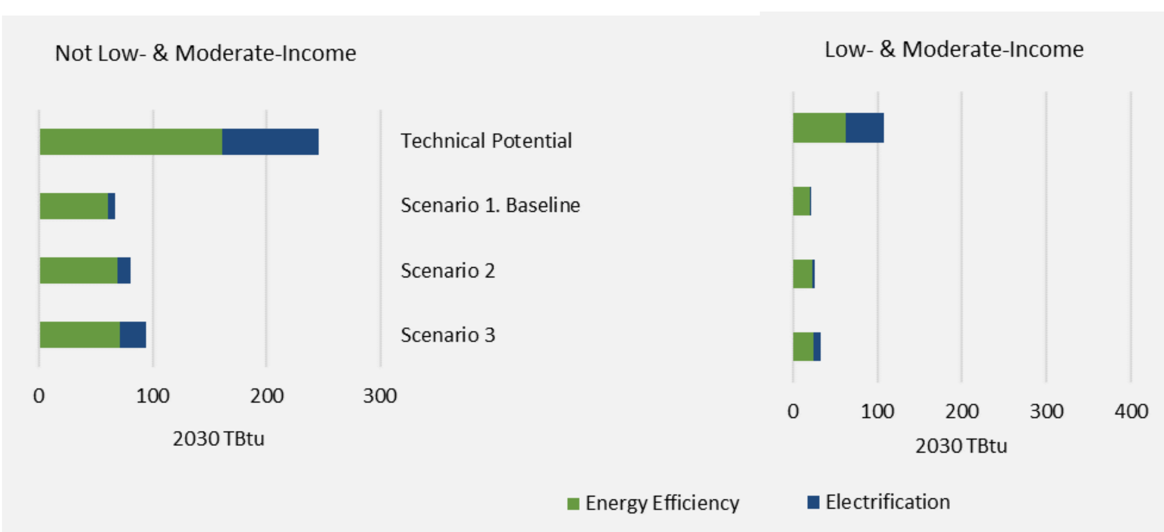


Figure 4-5 shows estimated energy savings potential in the residential sector by income-level. The low- and moderate-income (LMI) residential sector (in both single-family and multifamily households) comprises 30% of the total 2030 residential technical residential potential, 25% of the Baseline Scenario, 25% of Scenario 2, and 26% of Scenario 3 potential. Electrification comprises a greater share of the technical potential in LMI households compared to non-LMI households (41% to 34%, respectively) but a smaller share of the adoption scenario potential in LMI households compared to non-LMI households.

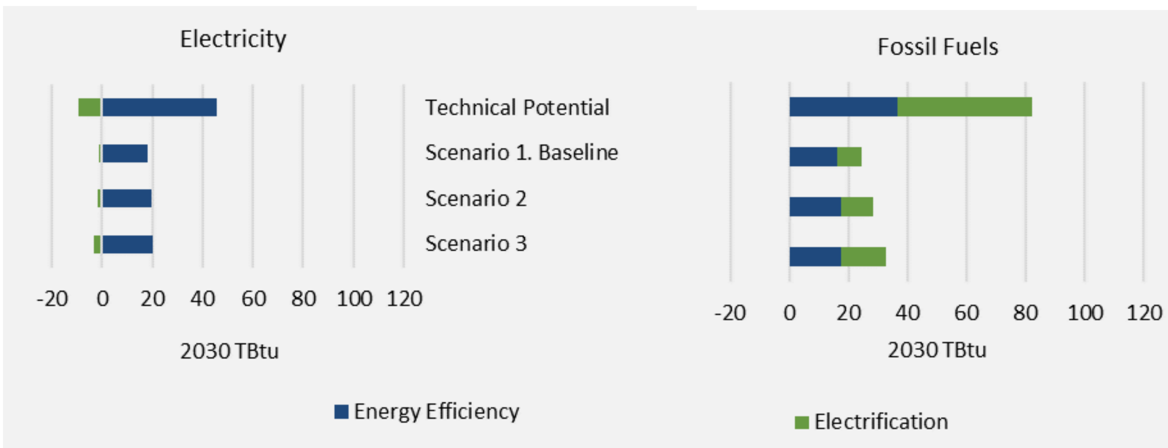
These patterns reflect that LMI households are more likely to live in multifamily buildings and that LMI households face higher barriers to adoption of energy efficiency and electrification measures. This analysis does not model the potential for programs focused on serving LMI households, which could offer higher incentives as well as focused community-based engagement and technical support.

Figure 4-5. 2030 Statewide Low- and Moderate-Income Energy Efficiency and Electrification (Single-Family and Multifamily)



The commercial sector makes up 25% of the total 2030 technical potential and 32% of the Baseline scenario, 31% of Scenario 2, and 28% of Scenario 3 potential estimates. Figure 4-6 presents the estimated energy savings potential in 2030 from commercial sector. Electrification represents 31% of commercial technical potential and 17% of the Baseline scenario, 20% of Scenario 2, and 24% of Scenario 3 achievable potential estimates. The commercial trend in electrification is similar to the single-family trend and highlights the importance of heat pumps in achieving deep savings in the commercial sector.

Figure 4-6. 2030 Statewide Commercial Energy Efficiency and Electrification Potential (TBtu)



4.2 *Statewide Energy Efficiency and Electrification Impacts Potential by Measure Group*

Historically, lighting measures have driven savings in energy efficiency programs; however, as the Energy Independence and Security Act (EISA) requires retailers to transition to an all-LED market, lighting measures will have minimal impact on program savings in the future. Over the coming decade, the measures with greatest potential for energy and carbon reductions include building shell and space heating, which are closely linked to building system replacement cycles and new construction.

Through 2030, building shell and space heating comprise 82% and 70% of technical potential for single-family and multifamily, respectively. Water heating comprises 13% and 21% of technical potential for single-family and multifamily, respectively. For commercial, space heating, shell, and space cooling are 42%, 21%, and 22% of technical potential, respectively.

Table 4-2 shows 2030 statewide energy efficiency and electrification potential by measure group and sector. Lighting potential is low across all sectors, reflecting the EISA backstop requirement and high LED saturations. Single-family and multifamily water heating potential is largely driven by low-flow faucet aerators, showerheads, and thermostatic shower restriction valve—modeled as required by state standards starting in 2024.

Table 4-2. 2030 Statewide Achievable Energy Efficiency and Electrification Potential by Measure Group and Sector (TBtu)

End-Use Group		Single-Family				Multifamily				Commercial			
		Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3	Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3	Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Energy Efficiency	Lighting	0.4	0.3	0.3	0.3	2.2	1.3	1.4	1.3	5.5	1.7	2.1	2.2
	Appliances and Plug Loads	2.9	1.8	1.9	1.8	1.6	0.6	0.9	0.7	6.7	4.0	4.1	4.2
	Building Shell	108	5.4	9.7	17.7	21.9	3.1	3.5	4.3	25.3	2.8	2.7	2.8
	Space Cooling	11.5	1.2	1.6	1.8	1.3	0.3	0.4	0.4	26.4	12.5	13.5	13.4
Energy Efficiency	Space Heating	133	28.1	31.5	27.2	19.8	10.9	12.1	11.6	49.5	12.5	13.6	13.6
Electrification			5.3	10.2	23.0		1.7	1.8	3.6		5.8	7.5	9.9
Energy Efficiency	Water Heating [b]	38.1	22.3	23.4	23.2	12.4	5.2	5.9	5.5	5.3	1.2	1.2	1.2
Electrification			0.3	0.5	2.5		1.0	1.2	1.4		1.4	1.9	2.0
Total		**294**	**64.5**	**78.9**	**97.5**	**59.3**	**24.2**	**27.2**	**28.8**	**119**	**41.8**	**46.7**	**49.3**

[a] This table shows both electric and fossil fuel savings potential. This means that electrification potential includes both electric load increases and fossil fuel savings from heat pump measures.
[b] Savings from low-flow water fixtures are the primary contributor to these water heating savings. The final efficiency standards, published after modeling was completed, were lower than the assumptions used in this analysis. Thus, actual savings will be lower than the estimates presented in this study.

Single-Family Potential by End-Use Group

In single-family homes, adoption of heat pumps and shell upgrades is responsive to incentives. As modeled incentives improve the return on investment, the single-family sector sees a significant increase in adoption of (and energy savings potential from) basic shell upgrade packages comprising air sealing and insulation, partial-load and full-load heat pumps for space heating and cooling, packages that bundle basic shell upgrades and full-load heat pumps, and heat pump water heaters. The impact of incentives is most pronounced on measures that have a poor project return under the Baseline (no-incentive) Scenario.

In particular, as noted above, shell and heat pump measures respond particularly well to Scenario 3 incentives. For example, single-family building shell potential increased 80% in Scenario 2 and 231% in Scenario 3, relative to the Baseline Scenario. Space heating savings from electrification measures increased 91% in Scenario 2 and 333% in Scenario 3, relative to the Baseline Scenario. Water heating savings from electrification measures increased 79% in Scenario 2 and 798% in Scenario 3, relative to the Baseline Scenario.

By contrast, space heating savings from efficiency measures—which already meet the desired return on investment (or are close to it) without incentives—increased 12% in Scenario 2 and *decreased* 3% in Scenario 3. This decrease is due to low changes in adoption in Scenario 3 and to interactive effects with measures that see larger changes in adoption in Scenario 3.

Multifamily Potential by End-Use Group

In the Baseline Scenario, modeling shows that the majority of electrification savings in the multifamily sector occurs due to codes requiring highly efficient, all-electric multifamily buildings for new construction. Voluntary heat pump adoption in existing multifamily buildings sees a meaningful increase only under the Reasonable Return incentives in Scenario 3, which typically exceed 50% of the incremental cost to install a full-load heat pump or a heat pump bundled with shell upgrades. Uptake of deeper-saving shell packages (comprising air sealing, insulation, and energy-efficient windows) in existing multifamily buildings increases modestly with Reasonable Return incentives, though adoption is constrained by non-financial barriers.

Specifically, multifamily building shell potential increased 13% in Scenario 2 and 38% in Scenario 3, relative to the Baseline Scenario. Space heating savings from electrification measures increased 2% in Scenario 2 and 107% in Scenario 3, relative to the Baseline Scenario. Water heating savings from electrification measures increased 25% in Scenario 2 and 39% in Scenario 3, relative to the Baseline Scenario. Space heating savings from efficiency measures—which already meet the desired return on investment (or are close to it) without incentives— increased 11% in Scenario 2 and 7% in Scenario 3, relative to the Baseline Scenario.

Overall, heat pumps are less responsive to incentives in multifamily buildings than in single-family buildings for three primary reasons. First, heat pumps in multifamily buildings offer a lower project return than in single-family homes.[14] Second, multifamily buildings face more significant non-financial barriers to electrify than single-family homes, as modeled through slower-ramping adoption curves. Lastly, heat pumps in the multifamily sector have lower starting annual adoption than in the single-family sector, meaning these heat pumps start the study in the low-adoption portion of their adoption curves. This effectively stunts heat pump adoption in the multifamily sector throughout the study horizon compared to the single-family sector.

Commercial Potential by End-Use Group

In the commercial sector, the analysis assumes that heat pump adoption is considered either in new construction or as part of a major capital upgrade to an existing building, by bundling heat pumps with additional efficiency measures (such as energy recovery ventilation and more efficient lighting, appliances, and plug loads) to benefit energy savings and project returns. Meaningful electrification of commercial space heating occurs in the Baseline Scenario, with increased uptake with Scenario 2 and still higher electrification savings with Scenario 3.

In contrast, because incentive caps are applied, commercial shell packages do not reach a desired return on investment under any incentive scenario modeled and their adoption remains low. Specifically, commercial building shell potential decreased 2% in Scenario 2 and increased 0.3% in Scenario 3, relative to the Baseline Scenario. These counterintuitive results are driven by poor project returns even with incentives reaching the incentive cap of $20 per square foot and shifts in measure competition between incentive scenarios. Stand-alone HVAC equipment (heat pumps and efficient boilers and furnaces) compete with shell and HVAC equipment packages. When all measures receive incentives equal to 50% of their incremental capital cost, less expensive measures receive a bigger boost in cost-effectiveness relative to more costly measures; therefore, less expensive measures are more likely to be adopted.

When CapEx Incentives are applied, stand-alone HVAC equipment measures have higher adoption than in the Baseline Scenario, partly because those measures are taking installations away from more expensive competing measure packages (shell and HVAC equipment). Because fewer shell and HVAC equipment packages are being adopted with CapEx Incentives than in the Baseline Scenario, the building shell savings are lower. Though similar effects occur in all sectors for all measure packages that directly compete, the impact is minor overall and is most visible in the building shell results for the commercial building sector.

Electrification measures in commercial buildings are responsive to incentives, while efficiency measures are considerably less responsive to incentives. For example, space heating savings from efficiency measures in commercial buildings—which already meet or approach the desired return on investment without incentives— increased 9% in Scenario 2 and 9% in Scenario 3, relative to the Baseline Scenario. By contrast, space heating savings from electrification measures increased 30% in Scenario 2 and 70% in

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[14] The exception is packaged terminal heat pumps, which are generally cost-effective without incentives. However, their feasibility is limited to the buildings with existing packaged terminal air conditioners.

Scenario 3, and water heating savings from electrification measures increased 33% in Scenario 2 and 44% in Scenario 3 relative to the Baseline case. The relative responsiveness of electrification measures to incentives in the commercial sector occurs because incentives meaningfully improve the project return on investment for heat pumps (which as noted above are bundled with efficiency measures).

Potentials for specific measure packages across scenarios are discussed in more detail in Chapter 6.

4.3 Statewide Energy Efficiency and Electrification Demand Potential Results

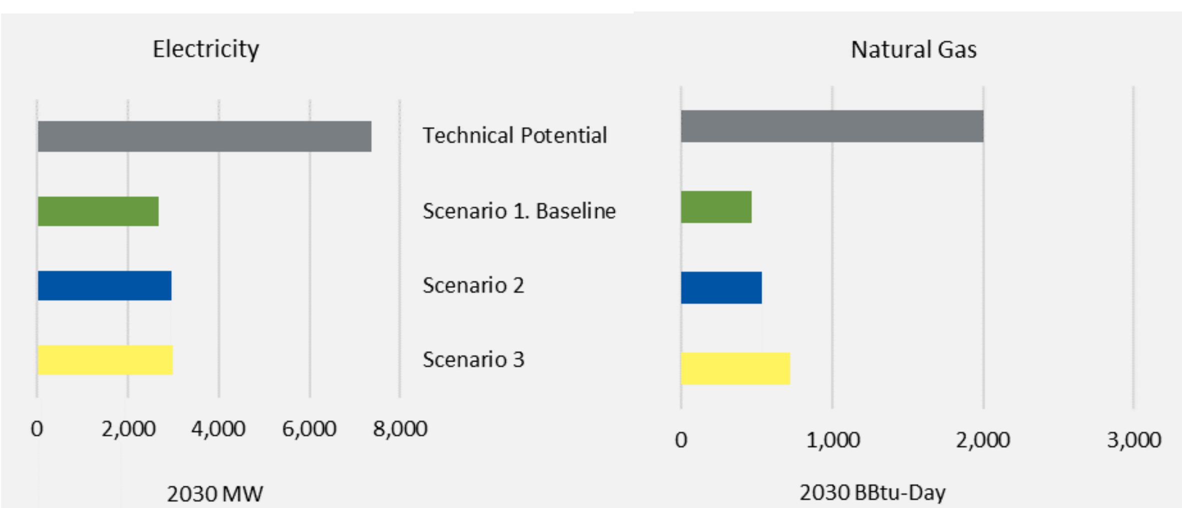
In addition to energy savings, the study estimated peak summer electric and peak winter gas reduction potential. Table 4-3 shows the 2030 statewide demand impact potential by fuel from energy efficiency and electrification measures modeled in this analysis. Figure 4-7 depicts this demand impact in graphical form. The analysis shows significant potential to reduce summer electricity and winter gas peaks.

Through 2030, the scenario potential estimates for electric summer peak reduction range from a 2,670 MW to 3,000 MW reduction and from 463 BBtu-day to 719 BBtu-day for gas winter peak reduction. Because the saturation of cooling is already quite high in all sectors, the increase in load from additional cooling with the adoption of heat pumps is offset by efficiency savings (from buildings replacing inefficient air conditioners with efficient heat pumps). Building electrification, however, does have a substantial impact on the winter heating peak for both natural gas and electricity (not shown).

Table 4-3. 2030 Statewide Energy Efficiency and Electrification Demand Impact Potential

Fuel Type	Unit Definition	Estimated 2030 Peak	Demand Reduction			
			Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Electricity	MW - Summer Peak	33,450	7,380	2,670	2,960	3,000
Natural Gas	BBtu-Day - Winter Peak	4,765	2,000	463	532	719

Figure 4-7. 2030 Statewide Energy Efficiency and Electrification Demand Impact Potential by Fuel (Electricity Summer Peak in MW and Gas Winter Peak in BBtu-Day)

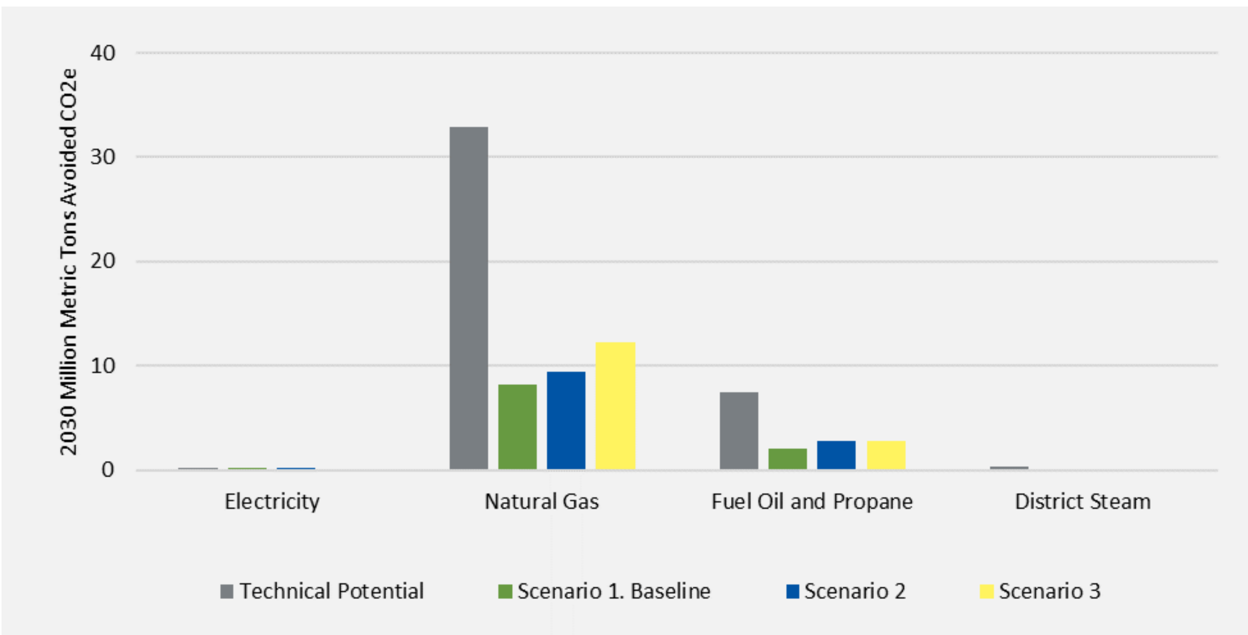


4.4 Statewide Greenhouse Gas Emissions Reduction Potential

Figure 4-8 shows 2030 statewide energy efficiency and electrification GHG emissions reduction potential by fuel (in million metric tons of avoided CO_2e). The GHG emissions impacts presented for 2030 show the impacts of energy efficiency and electrification measures installed between 2023 and 2030. As shown in Figure 4-8, the GHG emissions reduction potential is almost exclusively from fossil fuels (primarily natural gas) in 2030.

Due to the (anticipated) decrease in carbon intensity of the electrical grid, GHG emissions impacts from electricity are almost completely absent in 2030. As the electrical grid becomes less carbon-intensive, electrification measures realize greater GHG emissions reductions, while the GHG reduction benefits of electric energy efficiency measures eventually vanish (though efficiency remains important to manage electricity demands).

Figure 4-8. 2030 Statewide Energy Efficiency and Electrification GHG Emissions Reduction Potential (Million Metric Tons of Avoided CO_2e)



5 Regional Energy Efficiency and Electrification Potential Results

This chapter provides energy efficiency and electrification potential broken out by geographic region in New York State: Long Island, New York City, the Hudson Valley, and Upstate. It provides results for technical and achievable potentials, focusing on 2030 results. Potential estimates are provided for energy and peak demand. Unless otherwise stated, all potentials represent the annual impact in 2030 of potential savings from measures installed from 2023 through 2030.

5.1 Regional Energy Efficiency and Electrification Potential

Figure 5-1 shows 2030 energy efficiency and electrification potential by region. As illustrated in the figure, Upstate New York has the greatest technical and scenarios potential, followed by New York City, Long Island, and the Hudson Valley.

Figure 5-1. 2030 Energy Efficiency and Electrification Potential (TBtu) by Region

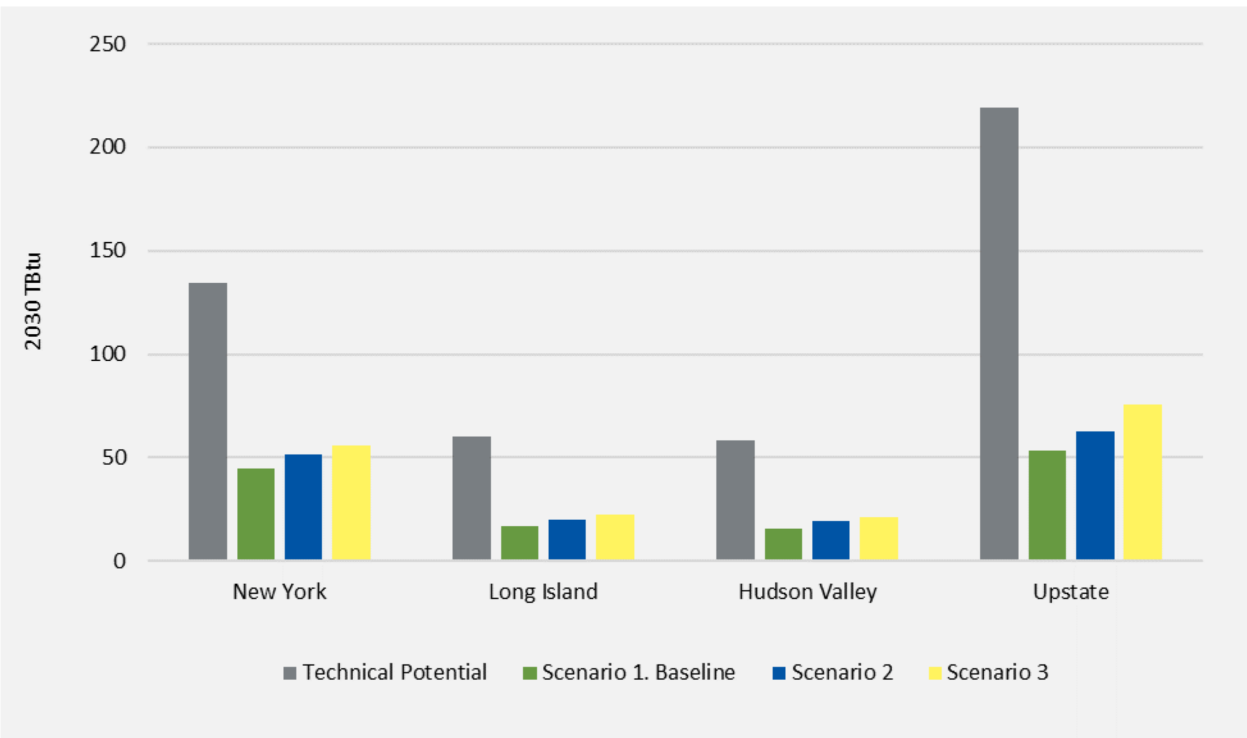


Table 5-1 shows 2030 energy efficiency and electrification potential by region. Across scenarios, the Hudson Valley has 12% of statewide technical and scenarios energy savings, Long Island has 13% of savings, New York City has 29% to 34% of savings, and Upstate has 41% to 46% of savings. Generally, regional trends follow statewide trends. Differences in trends between regions are due to differences in the building stock between the regions, including types of buildings and prevalence of heating fuel and equipment types.

Table 5-1. 2030 Regional Energy Efficiency and Electrification Potential (TBtu) by Region

Fuel Type	2030 TBtu			
	Technical Potential	Scenario 1. Baseline	Scenario 2	Scenario 3
Energy Efficiency				
Hudson Valley	37.3	14.0	16.3	16.2
Long Island	40.9	15.3	17.1	17.7
New York	92.4	39.5	43.9	44.4
Upstate	136	46.2	52.3	55.1
Total	**306**	**115**	**130**	**133**
Electrification				
Hudson Valley	20.7	1.8	3.1	5.3
Long Island	19.3	1.7	2.6	4.8
New York	42.0	4.9	7.4	11.7
Upstate	83.0	7.0	10.0	20.6
Total	**165**	**15.5**	**23.1**	**42.3**

Figure 5-2 through Figure 5-4 show 2030 energy efficiency and electrification potential by region for electricity, natural gas, and fuel oil and propane, respectively. These figures also illustrate the difference in regional building heating fuels.

New York City has a disproportionately large share of the electric savings, reflecting the unique composition of its building stock, which includes much of the state's multifamily buildings. Multifamily buildings, more so than the other building sectors, have a relatively high prevalence of electric heating. New York City also has a disproportionately high share of the state's commercial building electricity load. Upstate has a disproportionate share of the natural gas savings, and Long Island and the Hudson Valley have disproportionately higher shares of the fuel oil and propane savings.

Figure 5-2. 2030 Electric Energy Efficiency and Electrification Potential (TBtu) by Region

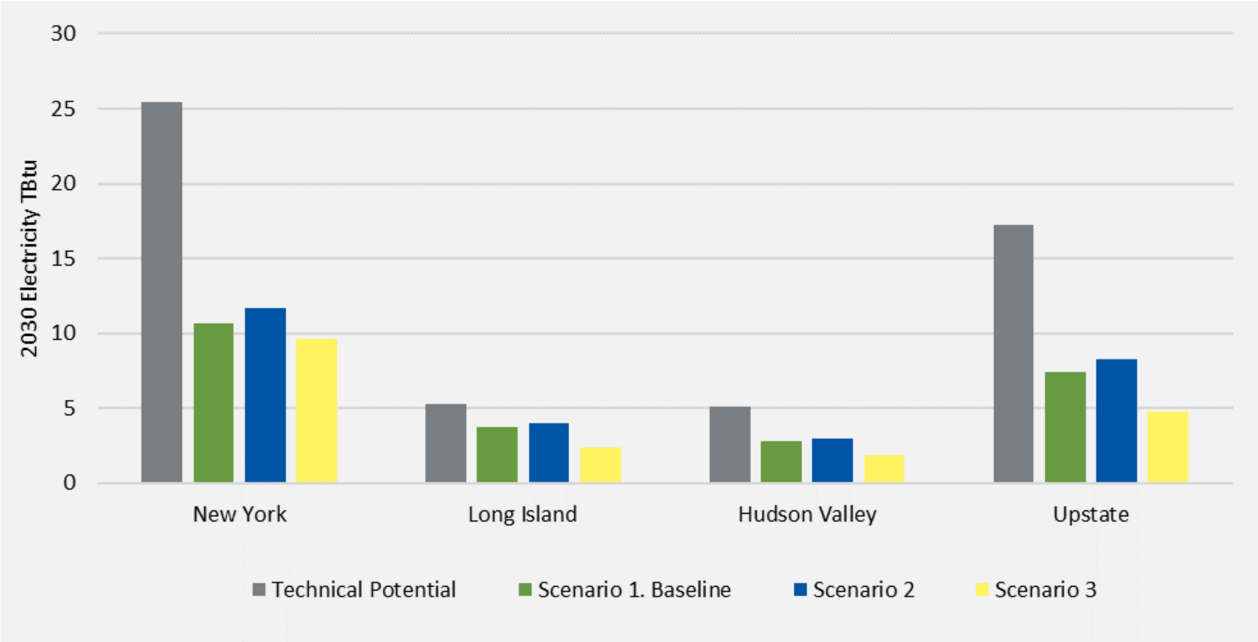


Figure 5-3. 2030 Natural Gas Energy Efficiency and Electrification Potential (TBtu) by Region

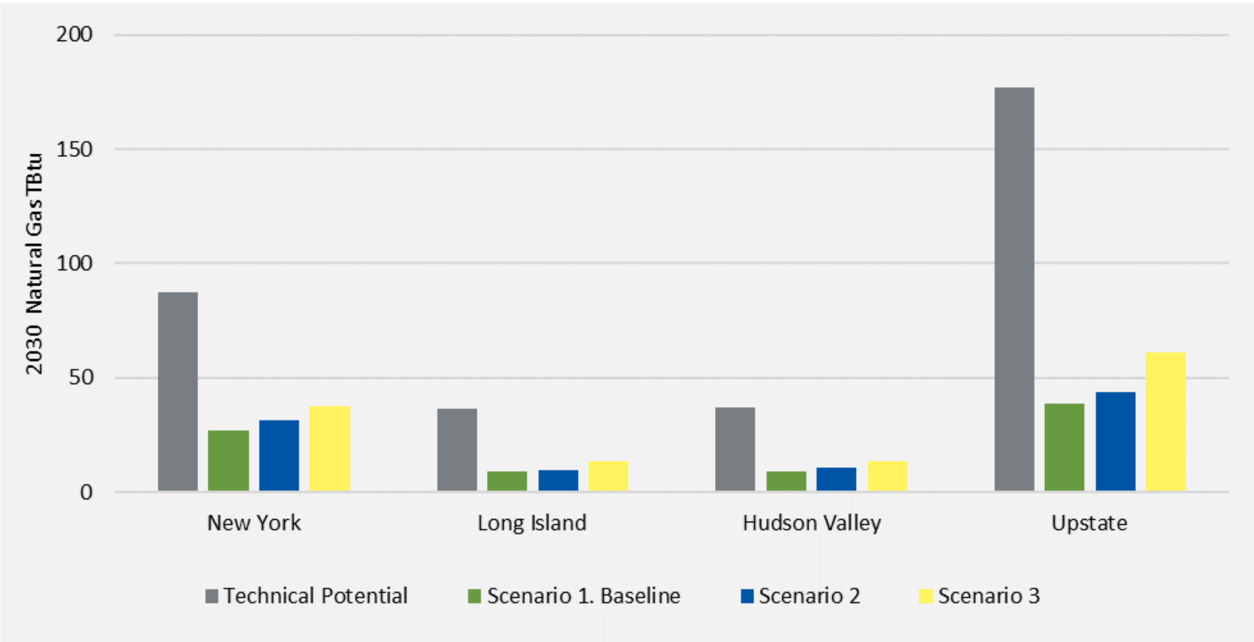
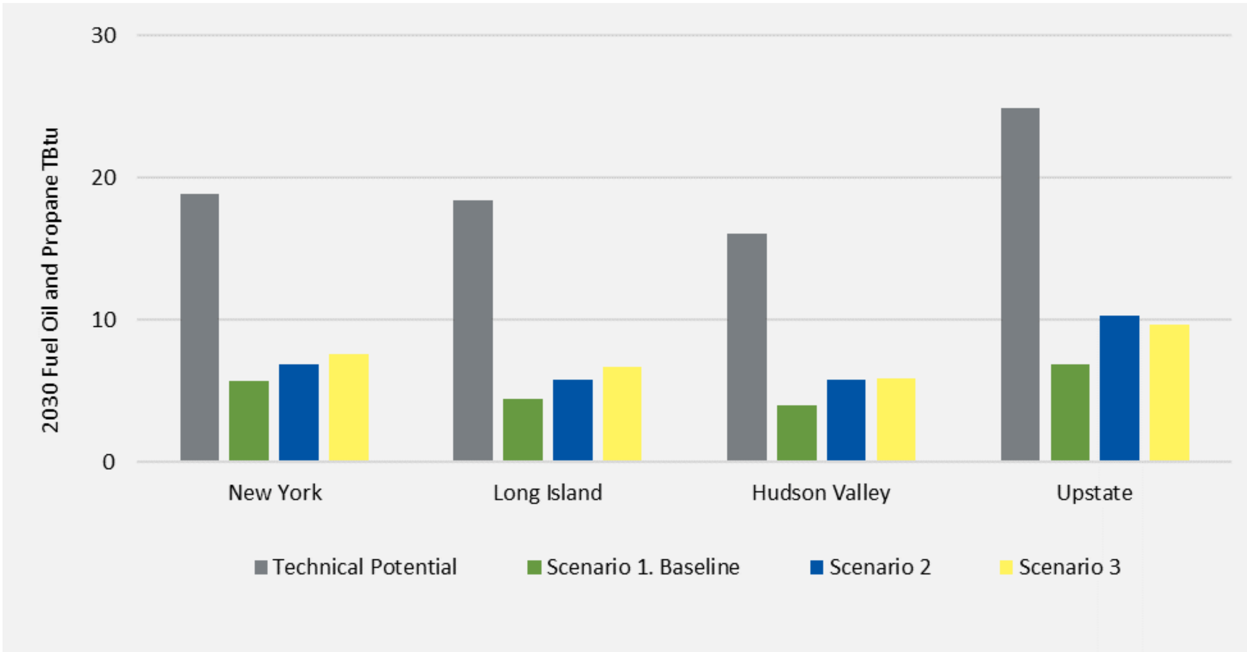


Figure 5-4. 2030 Fuel Oil and Propane Energy Efficiency and Electrification Potential (TBtu) by Region



5.2 Regional Electric and Natural Gas Demand Potential Results

Figure 5-5 shows 2030 regional electric peak demand reduction. This trend largely follows the regional electricity energy savings trend shown in Figure 5-2, with New York City having a disproportionately large share of the statewide summer peak demand savings. Unlike in Figure 5-2, Long Island also has a disproportionate share of statewide summer peak demand savings. This difference is due to Long Island and New York City having higher cooling loads than the Hudson Valley and Upstate regions.

Figure 5-5. 2030 Regional Electric Summer Peak Demand Reduction (MW)

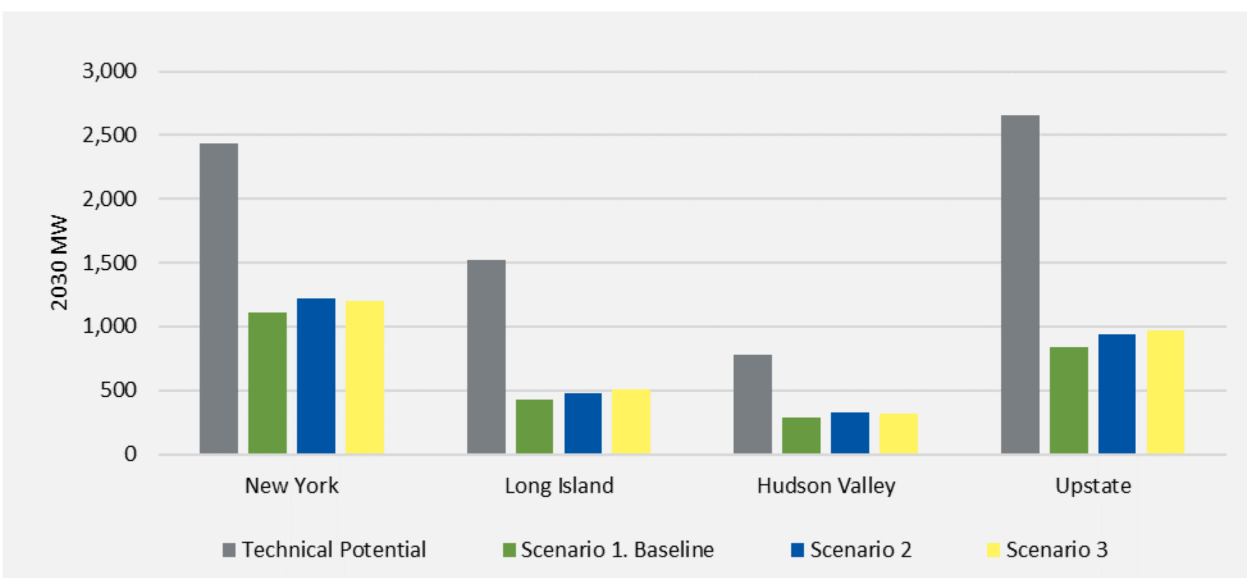
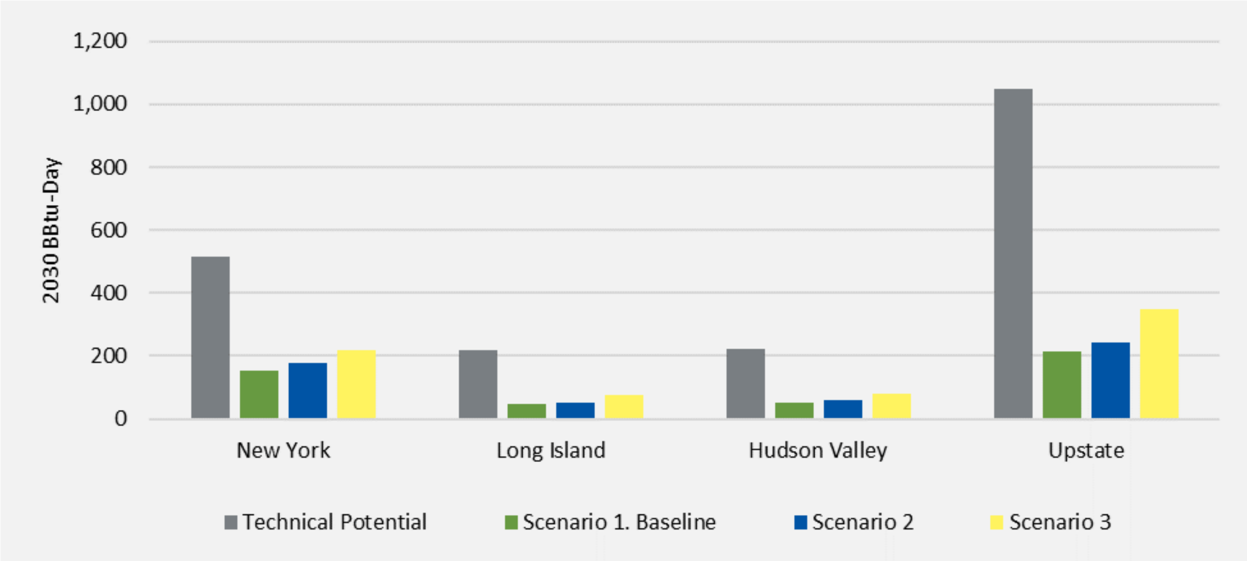


Figure 5-6 shows 2030 regional natural gas peak demand reduction. This trend closely follows the regional natural gas energy savings trend shown in Figure 5-3, with Upstate having a disproportionate share of the natural gas savings.

Figure 5-6. 2030 Regional Natural Gas Winter Peak Demand Reduction (BBtu-Day)



6 Most Adopted Measures

This chapter presents the list of measures with the greatest energy savings potential in the single-family, multifamily, and commercial sectors. The following tables report the top-saving measures for each incentive scenario and indicate the change in energy savings from each measure relative to the Baseline Scenario.

Results for all measures, including measures not shown or discussed in this chapter, are available in the detailed results appendix (Excel workbook).

6.1 2030 Top Measures – Single-Family

Table 6-1 shows the top single-family sector measures for Scenarios 2 and 3 in 2030, the 2030 estimate of energy savings, and the percentage change in savings relative to the Baseline Scenario (for example, 0% means no change and 100% means that savings double).

Table 6-1. 2030 Top Single-Family Measures

Measure Group	2030 Potential (TBtu)	% Increase from Baseline
Scenario 2		
Thermostat, HVAC Tune-Up, Distribution Improvements, and Boiler Controls	22.0	12%
Low-Flow Fixtures [a]	20.0	0%
Improved HVAC	8.5	7%
Partial-Load Minisplit Ductless Heat Pump	6.8	204%
Basic Shell	5.3	184%
Deep Shell and Heat Pump (Whole-house)	3.4	-3%
Efficient Hot Water Heater	3.0	53%
Basic Shell and Improved HVAC	1.9	347%
Indirect Energy Feedback (Home energy reports)	1.7	12%
Heat Pump (Whole-house)	1.5	31%
Scenario 3		
Low-Flow Fixtures [a]	20.0	0%
Thermostat, HVAC Tune-Up, Distribution Improvements, and Boiler Controls	19.8	1%
Partial-Load Minisplit Ductless Heat Pump	14.5	547%
Basic Shell	10.5	469%
Improved HVAC	6.3	-21%
Basic Shell and Heat Pump (Whole-house)	4.6	402%
Heat Pump (Whole-house)	4.5	300%
Deep Shell and Heat Pump (Whole-house)	3.6	2%
Efficient Hot Water Heater	2.8	44%
Basic Shell and Improved HVAC	2.6	522%

[a] Low-flow fixtures are not incentivized after 2024, and because this study assumes they are required by state product standards starting in 2024, potential does not change noticeably between scenarios. This study modeled low-flow water fixtures assuming higher efficiencies than those adopted by New York State in December 2022. The savings for this measure group are, therefore, likely overstated. Potential estimates for low-flow fixtures will be updated in future work.

As illustrated in Table 6-1, CapEx Incentives impacts the voluntary adoption of measures across the board (relative to the Baseline), but the impacts vary significantly between measures. In this scenario, mature measures that have good project returns without incentives are favored over competing measures that are more expensive and less well established. For example, savings from basic shell and improved HVAC (boiler/furnace) increase 347% in Scenario 2, while competing measures, such as heat pumps (not shown), basic shell and heat pumps (not shown), and deep shell and heat pumps experience much smaller or negative growth (31%, 31%, and -3%, respectively). Deep shell and heat pump is a top-saving measure only because of the assumption (applied to all three scenarios) that codes will require single-family new construction to start phasing in deep shell and heat pump measures in 2025; by contrast, voluntary adoption of deep-saving shell and electrification measures remains low (although not zero) in Scenario 2.

Savings for basic shell and partial-load minisplit heat pumps increase by 184% and 204%, respectively, under Scenario 2 relative to the Baseline Scenario. These measures offer significant per-household energy bill savings, which, combined with an incentive covering 50% of their incremental capital cost, make them economically appealing. Altogether, CapEx Incentives do spur a significant increase in heat pump and shell adoption, though adoption of the deepest-saving measures decreases because the flat CapEx incentive widens the gap in project return between the deepest- and shallowest-saving measures.

Savings for thermostats (and grouped HVAC tune-up and controls measures) and home energy reports each increase by approximately 12% in Scenario 2 relative to the Baseline Scenario. These measures are economically appealing in the absence of incentives and are well established. As a result, additional incentives have a minimal impact on adoption.

Scenario 3 applies a more tailored approach to incentives than Scenario 2, which is reflected in the adoption rates. Deeper-saving measures such as whole-house heat pumps and basic shell and heat pumps (whole-house) see large increases in adoption in Scenario 3. Savings for these measures increased by 300% and 402%, respectively. Furthermore, savings for basic shell and partial-load minisplit heat pumps increased by 469% and 547%, respectively, with Reasonable Return Incentives (relative to the Baseline Scenario).

In addition to significant adoption in the incentive scenarios, the single-family basic shell package and in particular the partial-load minisplit heat pump measure have high technical potential.[15] This is due to high heating and cooling end-use savings, as well as the 10-year replacement cycle assumed for these measures. In fact, the partial-load minisplit is the only heating equipment measure with a replacement cycle shorter than 20 years (across all sectors). This means that the customer decision point to install the measure occurs twice as often for partial-load minisplit heat pumps as compared to whole-house heat pumps or efficient boilers and furnaces.

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15 The study assumes that partial-load minisplit heat pumps serve 40% of the home heating load and 100% of the home cooling load, consistent with the New York TRM version 10. This measure accounts for roughly one-third of the 2030 single-family technical potential.

It is notable that recent evaluations of heat pump incentive programs in New York State and in the Northeast show that ductless minisplits used for partial-load heating achieve lower realization rates than are estimated here. In particular, while partial-load heat pump uptake has been promising, program evaluations have found that, on average, partial-load heat pumps provide less heating (over fewer hours) than estimated, because homeowners have continued to use (preexisting) boilers or furnaces more frequently than anticipated.[16] While this study assumes that heat pump realization rates will increase—and therefore estimates potential associated with greater usage of heat pumps than seen in recent evaluations—achieving this potential will likely require greater investment in educational, outreach, and installation best practices for partial-load heat pumps.

Finally, savings for improved HVAC decrease in Scenario 3 relative to the Baseline Scenario. This is because the difference in project return between the improved HVAC and competing heat pump measures vanishes with Scenario 3, and, as a result, more customers opt to install a heat pump instead of an efficient boiler or furnace. That said, savings for basic shell and improved HVAC increased 522% relative to the Baseline Scenario, indicating that efficient boilers and furnaces retain a meaningful market share through 2030, even when heat pumps compete on a level economic playing field.

6.2 2030 Top Measures – Multifamily

Table 6-2 shows the top multifamily sector measures for Scenarios 2 and 3 in 2030, the 2030 estimate of energy savings, and the percentage change in savings relative to the Baseline Scenario.

The multifamily sector is generally less responsive to incentives than the single-family sector. The top four measures in both incentive scenarios are largely driven by state standards (low-flow fixtures) as well as by mature measures that have good project returns even without incentives (retro-commissioning, energy management systems, and boiler optimization).

High-performance shell and heat pump is a top-saving measure because of the assumption that multifamily new construction will be required to meet this standard under New York City local laws, state codes, and (in the incentives scenarios) sustainability guidelines that apply to subsidized affordable multifamily buildings, with these requirements phasing in over the study period.

Heat pumps in existing multifamily buildings are responsive to incentives, though typically they require higher incentive levels as modeled in Scenario 3. Compared to the Baseline Scenario, savings for the heat pump, the air sealing and heat pump, and the medium shell and heat pump measures in Scenario 3 increase by 124%, 278%, and 148%, respectively, elevating them to the sixth, ninth, and eleventh (not shown) highest-saving measures. Furthermore, the centralized heat pump water heater becomes the eighth highest-saving measure in Scenario 3. As discussed in the *Multifamily Potential by End-Use Group* section of this report, heat pump adoption in the multifamily sector is less responsive to incentives than comparable measures in the single-family sector due to both cost and non-financial considerations.

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16 DNV. *Heat Pump Impact Evaluation Final Report.* April 2022. Prepared for NYSERDA. www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Clean-Heating-Cooling

Table 6-2. 2030 Top Multifamily Measures

Measure Group	2030 Achievable (TBtu)	% Increase from Baseline
Scenario 2		
Tenant: Low-Flow Fixtures [a]	4.3	0%
Whole Building: Retro-commissioning or Re-Commissioning	3.0	12%
Whole Building: Energy Management System	2.6	8%
Whole Building: Boiler Optimization	2.6	0%
High-Performance Shell and Heat Pump	2.1	8%
Whole Building: Steam Retrofit Package	1.3	4%
Tenant: Smart Thermostatic Radiator Enclosure (TRE)	1.2	124%
Heat Pump Water Heater - Centralized	1.0	17%
Common Area: LED Lighting	1.0	0%
Centralized Hot Water Heater	1.0	256%
Scenario 3		
Tenant: Low-Flow Fixtures [a]	4.3	0%
Whole Building: Retro-commissioning or Re-Commissioning	3.0	10%
Whole Building: Energy Management System	2.6	9%
Whole Building: Boiler Optimization	2.6	0%
High-Performance Shell and Heat Pump	2.1	9%
Heat Pump	1.4	124%
Whole Building: Steam Retrofit Package	1.2	0%
Heat Pump Water Heater - Centralized	1.2	36%
Air Sealing and Heat Pump	1.2	278%
Common Area: LED Lighting	1.0	2%

[a] Tenant: Low-flow fixtures are not incentivized after 2024 and, because this study assumes they are required by state product standards starting in 2024, potential does not change noticeably between scenarios. This study modeled low-flow water fixtures assuming higher efficiencies than those currently adopted by New York State. The savings for this measure group are, therefore, likely overstated. Potential estimates for low-flow fixtures will be updated in future work.

Shell measures respond modestly to incentives in the multifamily sector, though they are not shown among the top 10 measures above. In Scenario 2, the low-cost air sealing (basic shell) measure outcompetes the medium shell package. However, as Reasonable Return incentives level the economic playing field, adoption of the medium shell package (not shown) more than doubles in Scenario 3 compared to the Baseline Scenario.

6.3 2030 Top Measures – Commercial

Table 6-3 shows the top commercial sector measures for Scenarios 2 and 3 in 2030, the 2030 estimate of energy savings, and the percentage change in savings relative to the Baseline Scenario.

Table 6-3. 2030 Top Commercial Measures

Measure Group	2030 Achievable (TBtu)	% Increase from Baseline
Scenario 2		
HVAC Controls		
HVAC Controls - Thermostat	7.3	1%
HVAC Controls - Non-Thermostat	6.0	20%
Distribution Improvements	6.2	4%
Commercial Heat Pump [a]	5.8	55%
Commissioning and Tune-Up	4.8	10%
Refrigeration System Upgrade	2.8	0%
Heat Pump Water Heater - Commercial Sized	1.9	33%
Code-Minimum Shell	1.6	-2%
Improved HVAC	1.6	24%
Water Heat Usage and Controls	1.4	6%
Scenario 3		
HVAC Controls		
HVAC Controls - Thermostat	7.3	0%
HVAC Controls - Non-Thermostat	6.6	32%
Commercial Heat Pump [a]	8.7	132%
Distribution Improvements	6.1	1%
Commissioning and Tune-Up	4.5	3%
Refrigeration System Upgrade	2.8	0%
HP Water Heater - Commercial Sized	2.0	44%
Code-Minimum Shell	1.5	-4%
Basic Shell	1.4	6%
Water Heat Usage and Controls	1.3	1%

[a] Commercial sector heat pump measures for space heating and cooling are bundled with additional energy efficiency upgrades.

The commercial sector is generally less responsive to incentives than the single-family sector, though there are some notable areas of impact. Savings from commercial heat pump measures (which, as noted previously, are bundled with energy efficiency upgrades) increase 55% in Scenario 2 and 132% in Scenario 3 compared to the Baseline Scenario. Air-source heat pump measures comprise the strong majority of this modeled adoption, accounting for 80% (Scenario 2) to 85% (Scenario 3) of the associated savings. Savings from commercial-sized heat pump water heaters increased by 33% in Scenario 2 and 44% in Scenario 3 compared to the Baseline Scenario.

Unintuitively, commercial shell savings overall decrease in Scenario 2 and increase only negligibly in Scenario 3 compared to the Baseline Scenario (as shown in Table 4-2, in *Chapter 4 Statewide Energy Efficiency and Electrification Potential*). The primary reason for this outcome is that high project costs for the modeled commercial shell packages and the shell and heat pump packages (not shown in Table 4-2) result in very poor project returns even when incentives reach the cap of $20 per square foot. Measure competition and interactive effects also contribute to this result.

In both incentive scenarios, four of the top five highest-saving measure packages comprise HVAC efficiency measures, which affect the heating and cooling end uses. Of these four, only non-thermostat HVAC controls (for example, variable speed drives and economizers) demonstrate a noteworthy response to incentives, with 20% and 32% higher savings in Scenarios 2 and 3, respectively. By contrast, thermostat HVAC controls, distribution improvements (such as insulating pipes and repairing ducts or steam traps), and the commissioning and tune-up of HVAC systems have good project returns without incentives and, as a result, have a muted response to incentives in the model.

Results for all measures, including measures not shown or discussed in this chapter, are available in the detailed results appendix (Excel workbook).

7 Impact of Codes and Equipment Standards on Measure Adoption

The modeled Baseline Scenario as well as the incentive scenarios include several building code and equipment standard assumptions, which are described in greater detail in the methodology appendix. The baseline building code assumption is that new construction will phase in deep shell and heat pump measures starting in 2025 for single-family homes and 2028 for multifamily and commercial buildings (thus expanding the phase-out of fossil fuel systems in new buildings, required under New York City Local Law 154, throughout the state). The baseline also assumes that state law will require efficiency standards for various products and appliances not covered by federal standards starting in 2024.

As illustrated in Table 7-1, the energy savings impacts of the code and equipment standards assumptions are significant, accounting for approximately 24% of the Baseline Scenario, 21% of Scenario 2, and 18% of Scenario 3.

Table 7-1. 2030 Impact of Code and Equipment Standards Compared to Voluntary Adoption (TBtu)

Measure Category	Baseline Code and Equipment Standards [a]	Voluntary Adoption		
		Scenario 1. Baseline	Scenario 2	Scenario 3
HVAC	0.0	40.8	44.5	41.6
Heat Pump	0.0	7.4	14.4	28.6
Basic Shell	0.0	5.4	9.0	14.1
Basic Shell and Heat Pump	0.0	3.4	3.7	7.7
Basic Shell and HVAC	0.0	2.2	3.7	4.5
Deep Shell and Heat Pump	5.1	0.6	0.6	0.7
Deep Shell	0.0	1.2	1.2	2.5
Medium Shell	0.0	0.3	0.3	0.7
Medium Shell and Heat Pump	0.0	0.2	0.2	0.6
Medium Shell and HVAC	0.0	0.2	0.2	0.5
Deep Shell and HVAC	0.3	0.3	0.3	0.5
Controls	0.0	19.7	22.0	19.8
Appliances/Products	22.2	4.7	5.0	4.8
Behavioral [b]	0.0	4.8	5.2	5.0
Heat Pump Water Heater	1.2	1.4	2.2	4.5
Water Heater	0.0	3.5	5.3	4.7
Lighting	0.5	2.2	2.5	2.5
Refrigeration	2.6	0.1	0.1	0.1
Total	**31.9**	**98.6**	**120.5**	**143.5**

[a] Savings from code and equipment standards in the Baseline Scenario. Savings from code and equipment standards vary slightly for the other achievable scenario, based on changes in measure adoptions and interactions when incentives are provided.
[b] Behavioral measures include home energy reports, indirect energy feedback, tenant submetering, and energy management systems.

The equipment standards drive significant savings in all building vintages, primarily through the adoption of low-flow water fixtures. This study assumed that the state equipment standards would reflect stringent specifications and full compliance with the standard. Specific assumptions included these requirements: showerheads of 1.5 gallons per minute (gpm) or lower, kitchen faucet aerators of 1.0 gpm or lower, bathroom faucet aerators of 0.5 gpm or lower, and the presence of a thermostatic shower restriction valve.

Equipment standards that were adopted by New York State in December 2022 (to take effect by July 2023) are less stringent than the study assumptions, and compliance may be significantly lower given the ability for customers to buy a water fixture from other states and install it themselves.

Table 7-1 also shows the significant impact of New York City Local Law 154 and statewide codes that affect new construction projects. The assumed codes provide 87% to 89% of the savings for the heat pump and deep (high-performance) shell measures across scenarios, which is one of the study’s most impactful measures.

As discussed in previous chapters, the table also shows the significant impact of incentives on the adoption of heat pumps and basic shell measures, which in existing buildings are not modeled as required by codes or equipment standards.

8 Statewide Energy Efficiency and Electrification Economic Potential

This chapter describes statewide energy efficiency and electrification economic potential, focusing on 2030 estimates (that is, energy savings impact in 2030 from measures installed from 2023 through 2030). The statewide results provide estimated energy savings potential by fuel, building sector, and top economic measures.

Economic potential is a subset of technical potential that represents only measures that pass the societal cost-effectiveness screen established under the NYS Public Service Commission's Benefit/Cost Analysis (BCA) Framework. A key input for the BCA Framework—the greenhouse gas reduction value—is determined based on the social cost of carbon (SCC). The New York State Department of Environmental Conservation publishes values for the SCC, which vary depending on the discount rates used (following a methodology used by the federal government). This chapter reports economic potential for two cases: one that incorporates SCC values estimated at a 3% discount rate and the other for SCC values estimated at a 2% discount rate.[17]

Table 8-1 shows statewide energy efficiency and electrification potential savings relative to estimated 2030 site energy sales (in TBtu) for electricity, natural gas, fuel oil and propane, and Con Edison district steam. Estimated sales include regular equipment stock turnover from existing equipment to counterfactual equipment (federal appliance standards) using the same fuel but absent any efficiency or electrification measure installations.

[17] For example, the social cost of carbon dioxide (CO_2) emitted in 2030, discounted to 2020 dollars, is $62 and $137 per metric ton of CO_2 at the 3% and 2% discount rates, respectively. For more information, see *Establishing a Value of Carbon; Guidelines for Use by State Agencies* from the New York State Department of Environmental Conservation, published June 2021.

Table 8-1. 2030 Statewide Technical and Economic Potential Savings (TBtu)

Fuel Type	2030 Estimated Sales (TBtu)	2030 Potential Savings (TBtu)		
		Technical Potential	Economic Potential, SCC at 3% Discount Rate	Economic Potential, SCC at 2% Discount Rate
Energy Efficiency				
Electricity	410	106	60.4	69.7
Natural Gas	720	160	97.5	106
Fuel Oil and Propane	163	39.1	23.5	24.2
District Steam	11.8	1.6	0.3	0.4
Total	**1,305**	**306**	**182**	**201**
Electrification				
Electricity	410	-52.5	-23.4	-38.6
Natural Gas	720	177	51.7	110
Fuel Oil and Propane	163	39.0	38.1	40.1 [a]
District Steam	11.8	1.1	0.2	0.5
Total	**1,305**	**165**	**66.6**	**112**

SCC = social cost of carbon

[a] Economic potential exceeds electrification technical potential for fuel oil and propane due to changes in the mix of measures affecting stacking interactions with energy efficiency measures.

The analysis shows that there are significant economic potential savings for energy efficiency (182 TBtu to 201 TBtu, or 59% to 65% of technical potential in 2030) and electrification (66.6 TBtu to 112 TBtu, or 40% to 68% of technical potential in 2030) from measures adopted from 2023 through 2030. Moreover, the analysis shows that when compared to estimated sales for fossil fuels (gas, oil, propane, and district steam), the combined economic potential for energy efficiency and electrification ranges from approximately 24% (SCC at 3% discount rate) to 31% (SCC at 2% discount rate).

The SCC estimate used to assess societal cost-effectiveness has a notable impact on the economic potential for electrification measures, especially in buildings heated with natural gas. For example, 29% of natural gas electrification technical potential is economic with the SCC at a 3% discount rate, increasing to 62% with the SCC at a 2% discount rate. On the other hand, electrification measures for buildings heated with fuel oil or propane are almost entirely economical with either SCC estimate for the societal cost-effectiveness screen. This outcome reflects differences in modeled fuel prices, where the avoided cost of gas is lower than that for oil or propane.

Figure 8-1 shows in graphical form the data presented above in Table 8-1.

Figure 8-1. 2030 Statewide Technical and Economic Potential (TBtu)

SCC = social cost of carbon; DR = discount rate

Figure 8-2 shows statewide technical and economic potential by fuel for 2025, 2030, 2037, and 2042. Technical and economic potential increase over time as building systems are assumed to be replaced when equipment is retired and as retrofits are considered at some points in a building's lifecycle. Economic potential increases over time from approximately 101 TBtu to 123 TBtu in 2025 (or approximately 52% to 63% of technical potential) to 442 TBtu to 558 TBtu in 2045 (or approximately 60% to 76% of technical potential).

Figure 8-2. 2025, 2030, 2037, and 2042 Statewide Technical and Economic Potential by Fuel (TBtu)

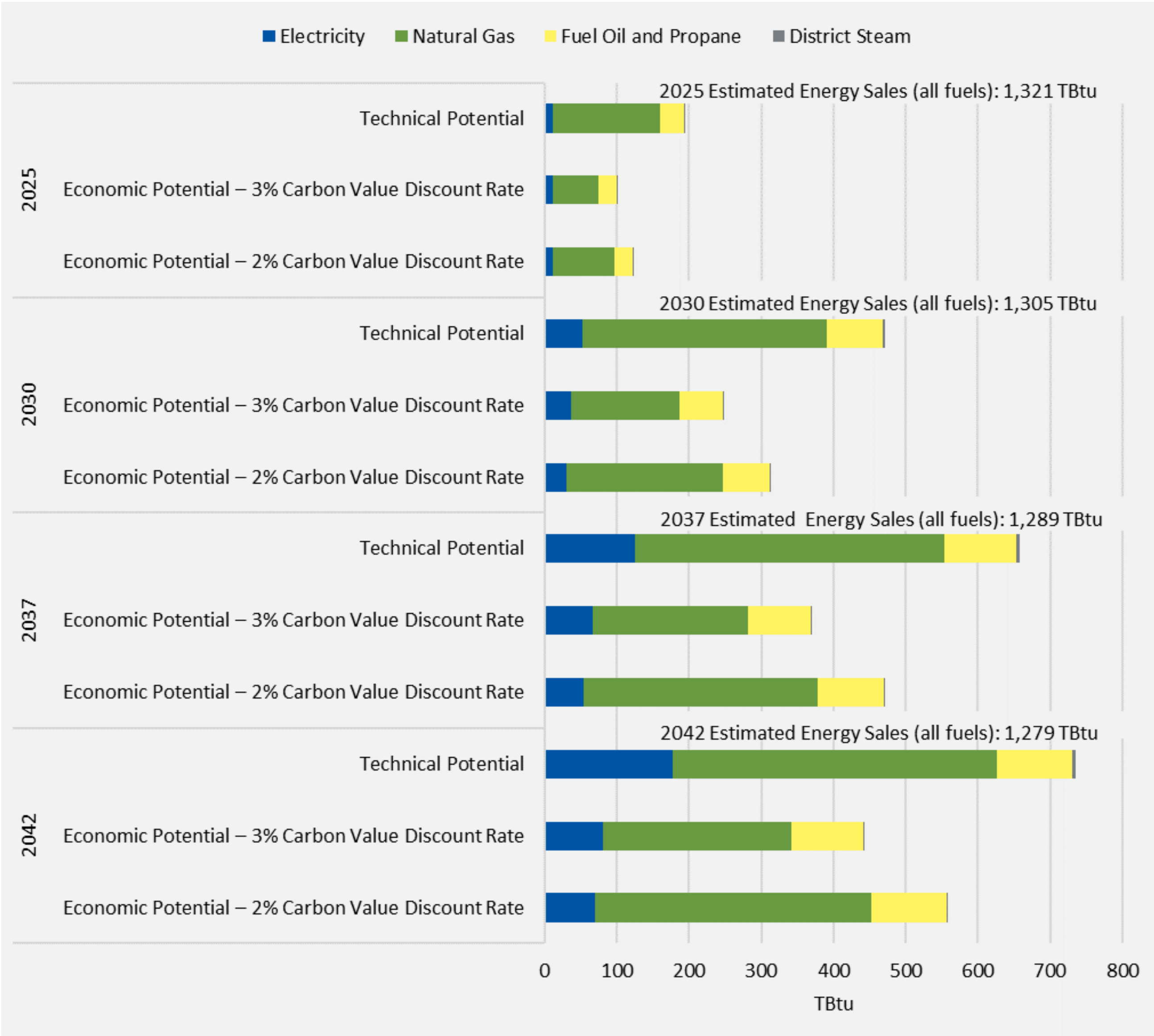


Table 8-2 shows technical and economic potential by region of New York State. Upstate shows the greatest technical and economic potential for energy efficiency and electrification, followed closely by New York City. Together, these two regions make up 75% and 76% of the statewide energy efficiency and electrification economic potential, respectively.

Table 8-2. 2030 Technical and Economic Energy Efficiency and Electrification Potential by Region

Region	2030 Potential Savings (TBtu)		
	Technical Potential	Economic Potential – 3% Carbon Value Discount Rate	Economic Potential – 2% Carbon Value Discount Rate
Energy Efficiency			
Hudson Valley	37.3	23.5	24.5
Long Island	40.9	22.8	28.1
New York	92.4	55.5	60.6
Upstate	136	79.8	87.5
Total	**306**	**182**	**201**
Electrification			
Hudson Valley	20.7	8.7	14.4
Long Island	19.3	7.5	10.1
New York	42.0	25.6	36.9
Upstate	83.0	24.7	50.2
Total	**165**	**66.6**	**112**

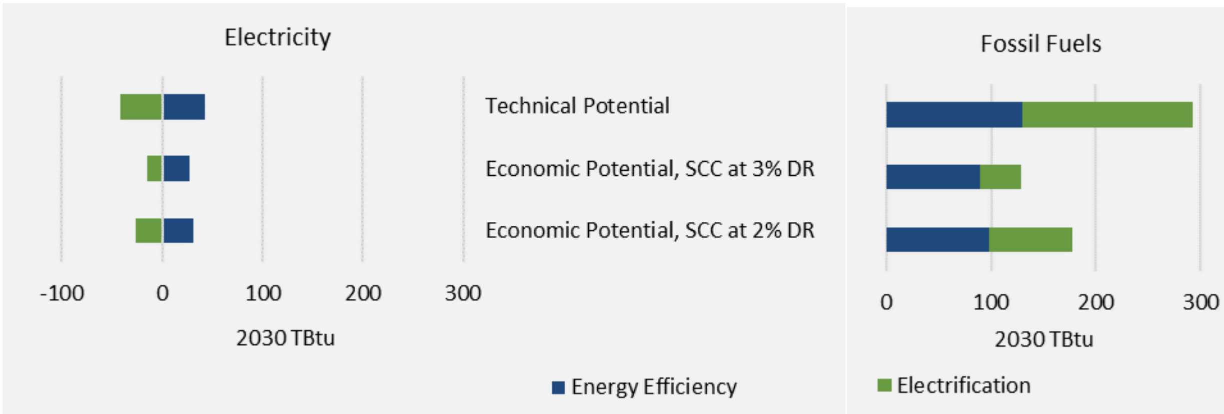
8.1 Statewide Energy Efficiency and Electrification Economic Potential by Sector

This section presents the estimated economic potential results by sector. Figure 8-3 through Figure 8-5 show economic potential for energy efficiency and electrification in the single-family, multifamily, and commercial sectors, assuming the SCC has a 3% and 2% discount rate. These figures also include the technical potential estimate. Table 8-3 through Table 8-5 show the top-saving economic measures by sector.

8.1.1 Single-Family Sector

Figure 8-3 illustrates the breakdown of energy efficiency and electrification technical and economic potential for electricity and fossil fuels in the single-family sector (defined as buildings with one to four housing units). The single-family sector accounts for 57% to 58% of the total economic potential across all building sectors (single-family, multifamily, and commercial). Across all fuels, energy efficiency represents 83% to 71% of the total single-family economic potential, assuming an SCC at a 3% and 2% discount rate, respectively.

Figure 8-3. 2030 Statewide Single-Family Technical and Economic Potential (TBtu)



SCC = social cost of carbon; DR = discount rate

Table 8-3 details the single-family measures that offer the greatest economic potential.

Table 8-3. 2030 Top Economic Single-Family Measures

2030 Top Economic Potential Measure Group, SCC at 3% DR	2030 Economic Potential, SCC at 3% DR (TBtu)	2030 Top Economic Potential Measure Group, SCC at 2% DR	2030 Economic Potential, SCC at 2% DR (TBtu)
Basic Shell	45.1	Basic Shell	55.9
Thermostat, HVAC Tune-Up, Distribution Improvements, and Boiler Controls	25.6	Part Load Minisplit	42.5
Part Load Minisplit	18.2	Thermostat, HVAC Tune-Up, Distribution Improvements, and Boiler Controls	25.9
Low-Flow Fixtures	18.0	Low-Flow Fixtures	18.0
Basic Shell + Improved HVAC	16.4	Basic Shell + Improved HVAC	12.7
Basic Shell + Heat Pump	3.7	Basic Shell + Heat Pump	9.8
Heat Pump	3.5	Heat Pump Water Heater	5.3
Improved HVAC	3.1	Heat Pump	3.0
Heat Pump Water Heater	1.8	Hot Water Heater	2.6
Plug Loads	1.8	Plug Loads	1.9

SCC = social cost of carbon; DR = discount rate

Several key trends can be observed related to the choice of SCC. Specifically, the SCC value has the most pronounced impact on the cost-effectiveness of electrification measures in the single-family sector. This is apparent, for example, for the economic potential for heat pump and basic shell + heat pump (combined, 7.2 TBtu at with SCC at the 3% discount rate and 12.8 TBtu with SCC at the 2% discount rate), part load minisplits (18.2 TBtu with SCC at 3% and 42.5 TBtu with SCC at 2%), and heat pump water heater (1.8 TBtu with SCC at 3% and 5.3 TBtu with SCC at 2%). The difference in the SCC value drives a 77%, 134%, and 195% increase in economic potential across these three electrification measures, respectively.

The following discussion describes notable trends and includes a discussion of economic potential within context of the available technical potential.

Standalone shell measure trends. Basic shell packages make up the majority of cost-effective shell packages. The technical potential for standalone shell upgrades is 92.6 TBtu, which is entirely comprised of deep shell upgrades. Though deep shell measures offer substantial energy saving potential, their high upfront cost prevents them from passing the BCA cost-effectiveness test. Therefore, basic shell packages (lesser energy savings, but lower upfront costs) make up the majority of economic potential for standalone shell packages.

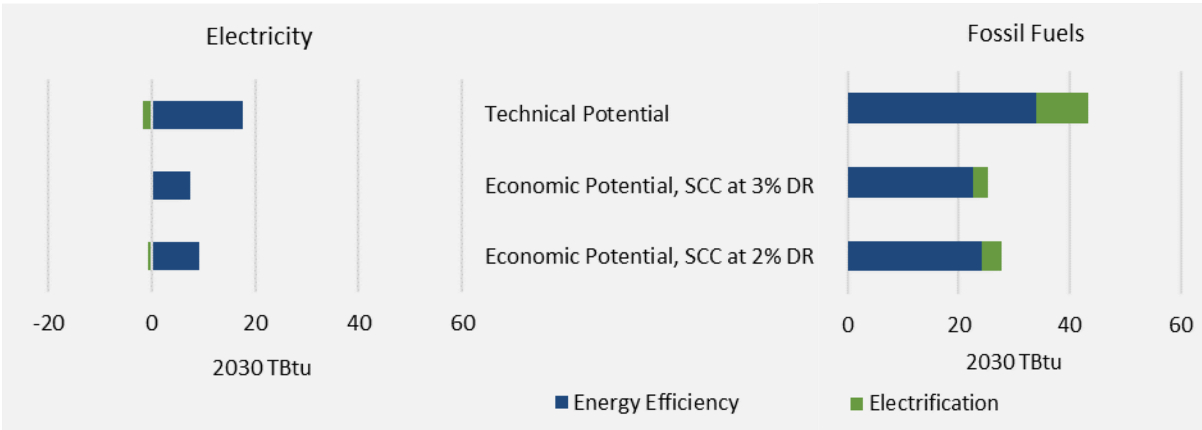
Space heating and cooling trends. The technical potential for space heating and cooling end uses (not shown in Table 8-3) is predominately represented by deep shell and deep shell + ground-source heat pump (GSHP) measures. However, deep shell and GSHP measures cost substantially more than lower-saving measures like basic shell and ASHPs or improved HVAC equipment so do not achieve cost-effectiveness in most cases. Therefore, the single-family economic potential results are predominately represented by air-source heat pump (ASHP), improved HVAC, basic shell + ASHP, and shell + improved HVAC measures. Overall, heat pump and improved HVAC and their combinations with basic shell measures contribute to 26.7 TBtu of economic potential with the SCC at 3% discount rate.

Other measure trends. Almost all applications of the low-flow fixtures, plug loads, and thermostat, HVAC tune-up, distribution improvements, and boiler controls measures are cost-effective in both the SCC at 3% and 2% discount rate cases; that is, their economic potential is equal to (or nearly equal to) their technical potential.

8.1.2 Multifamily Sector

Figure 8-4 illustrates the breakdown of energy efficiency and electrification technical and economic potential for electricity and fossil fuels in the multifamily sector (defined as buildings with five or more housing units). The multifamily sector accounts for 13% to 11% (32.4 TBtu to 36.2 TBtu) of the total economic potential across all building sectors (single-family, multifamily, and commercial), assuming an SCC at 3% or 2%, respectively. Across all fuels, energy efficiency represents approximately 93% of the total multifamily economic potential.

Figure 8-4. 2030 Statewide Multifamily Technical and Economic Potential (TBtu)



SCC = social cost of carbon; DR = discount rate

Though the choice of SCC discount rate has a modest 12% impact on the total multifamily economic potential, it has a 43% impact on cost-effectiveness of electrification measures in the multifamily sector.

Table 8-4 details the multifamily measures that offer the greatest economic potential.

Table 8-4. 2030 Top Economic Multifamily Measures

2030 Top Economic Potential Measure Group, SCC at 3% Discount Rate	2030 Economic Potential, SCC at 3% Discount Rate (TBtu)	2030 Top Economic Potential Measure Group, SCC at 2% Discount Rate	2030 Economic Potential, SCC at 2% Discount Rate (TBtu)
Whole Building: Energy Management System (EMS)	4.8	Whole Building: Energy Management System (EMS)	4.8
Tenant: Low-Flow Fixtures	3.9	Whole Building: Retrocommissioning or Recommissioning	4.0
Whole Building: Air Sealing + Whole Building: Improved HVAC	3.1	Tenant: Low-Flow Fixtures	3.9
Whole Building: Air Sealing (Basic Shell)	2.6	Whole Building: Air Sealing + Whole Building: Improved HVAC	2.9
Whole Building: Boiler Optimization	2.4	Air Sealing + Heat Pump	2.8
Tenant: Centralized Hot Water Heater	2.3	Whole Building: Air Sealing (Basic Shell)	2.7
Tenant: Smart Thermostatic Radiator Enclosure (TRE)	2.2	Whole Building: Boiler Optimization	2.4
Whole Building: Retrocommissioning or Recommissioning	2.0	Tenant: Centralized Hot Water Heater	2.3
Air Sealing + Heat Pump	1.9	Tenant: Smart Thermostatic Radiator Enclosure (TRE)	2.2
Common Area: LED Lighting	1.6	Common Area: LED Lighting	1.6

The following discussion describes notable trends and includes a discussion of economic potential within the context of the available technical potential.

Stand-alone shell measure trends. Standalone air sealing (basic shell) is a top-saving economic potential measure, with 2.6 TBtu of economic potential with SCC at the 3% discount rate. Though technical potential is significant for high-performance shell (16.1 TBtu), applications of this measure are largely not cost-effective due to the high upfront cost of high-performance shell relative to the potential for energy savings over time.

Space heating and cooling trends. For space heating and cooling, the top economic measures are energy efficiency improvements that are modeled to be cost-effective across all, or nearly all, cases at both the SCC at 3% and 2% discount rates. Specific measures include energy management systems, boiler optimization, smart thermostatic radiator enclosure, steam retrofit package, and steam boiler to hydronic boiler conversions. These measures make up about 36% of the multifamily economic potential and offer economic potential close to, or equal to, their technical potential.

Retrocommissioning or recommissioning also has substantial economic potential, though its applications are less consistently cost-effective than other top economic measures. The technical potential for this measure is 6.3 TBtu with economic potential ranging from 2.1 TBtu to 4.2 TBtu and, therefore, this measure is either the seventh highest-saving (SCC at the 3% discount rate) or second highest-saving (SCC at the 2% discount rate) economic measure.

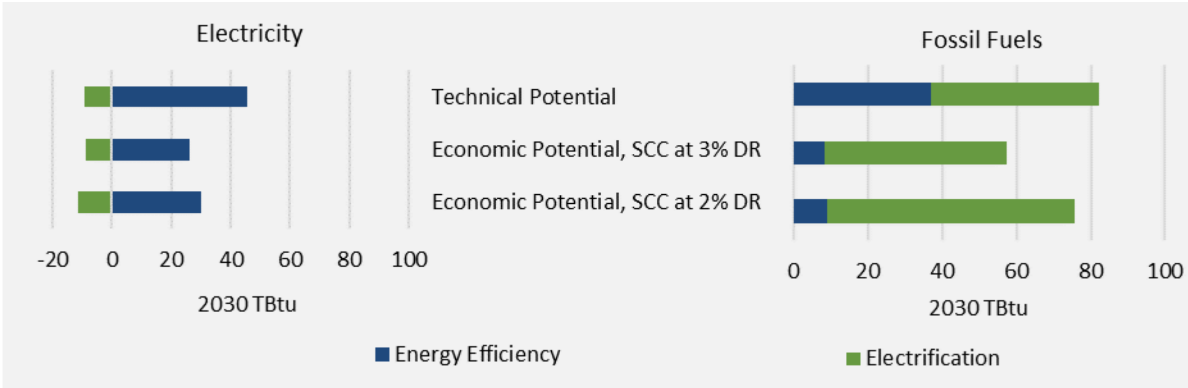
Finally, most multifamily buildings have a cost-effective HVAC upgrade option under both SCC discount rates. For HVAC equipment upgrades (both stand-alone and packaged with shell improvements), economic potential consists primarily of air sealing + improved HVAC or air sealing + heat pump. Though the greatest technical potential for HVAC upgrade measures consists of medium shell + heat pump and deep shell + heat pump packages, these measures are not modeled to be cost-effective due to high upfront costs.

Other measure trends. Several other top measures (low-flow fixtures, common area LED lighting, and centralized hot water heater) offer economic potential close to, or equal to, their technical potential. That is, these measures are cost-effective in all or nearly all modeled applications at both the SCC at 3% and 2% discount rates.

8.1.3 Commercial Sector

Figure 8-5 illustrates the breakdown of energy efficiency and electrification technical and economic potential for electricity and fossil fuels. The commercial sector accounts for 30% of the total economic potential across all three building sectors (single-family, multifamily, and commercial), assuming the SCC discount rate is set at either 3% or 2%. Across all fuels, energy efficiency represents 41% to 46% of the total commercial economic potential, assuming an SCC at the 3% and 2% discount rate, respectively.

Figure 8-5. 2030 Statewide Commercial Technical and Economic Potential (TBtu)



SCC = social cost of carbon; DR = discount rate

Table 8-5 details the commercial measures that offer the best economic potential. The discussion that follows describe notable trends, including a discussion of economic potential within the context of the available technical potential.

Table 8-5. 2030 Top Economic Commercial Measures

2030 Top Economic Potential Measure Group, SCC at 3% DR	2030 Economic Potential, SCC at 3% Discount Rate (TBtu)	2030 Top Economic Potential Measure Group, SCC at 2% Discount Rate	2030 Economic Potential, SCC at 2% Discount Rate (TBtu)
Heat Pump[a]	37.7	Heat Pump	46.3
Distribution Improvements	7.8	Basic shell + Heat Pump	8.8
HVAC Controls - Thermostat	7.4	Distribution Improvements	7.8
Commissioning and Tune-Up	6.3	HVAC Controls - Thermostat	7.4
HP Water Heater - Commercial Sized	4.6	Commissioning and Tune-Up	6.3
HVAC Controls - Non-Thermostat	3.1	HP Water Heater - Commercial Sized	5.0
Basic shell + Heat Pump	2.8	HVAC Controls - Non-Thermostat	4.9
Refrigeration System Upgrade	1.7	Refrigeration System Upgrade	2.5
Improved HVAC	1.2	Code-min Shell + Heat Pump	1.8
Water Heat Usage and Controls	1.0	Lighting Controls	1.1

[a] Commercial sector heat pump measures for space heating and cooling are bundled with additional energy efficiency upgrades.

Standalone shell measure trends. No standalone shell measures are represented among the top-saving economic potential measures. While substantial technical potential exists among standalone shell measures, the majority is not cost-effective.

Space heating and cooling trends. Heat pumps are the top-savings measure for economic potential, ranging from 37.7 TBtu to 46.3 TBtu of savings. Similarly, basic shell + heat pump and improved HVAC are all high scoring measures assuming an SCC at the 3% discount rate. As seen in other building sectors, the choice of SCC discount rate has a pronounced impact on the cost-effectiveness of commercial electrification measures. This is apparent, for example, when viewing the economic potential for heat pump (37.7 TBtu for SCC at the 3% discount rate and 46.3 TBtu for SCC at the 2% discount rate) and basic shell + heat pump (2.8 TBtu at 3% and 8.8 TBtu at 2%) measures. In total, the difference in the SCC estimate drives a 23% and 217% increase in economic potential for those two electrification measures, respectively.

Other measure trends. Several top economic measures are cost-effective in all or nearly all modeled applications in both the SCC at 3% and 2% discount rate cases. These measures include distribution improvements, HVAC controls – thermostat, commissioning and tune-up, and HP water heater – commercial sized. In addition, 50% or more of the refrigeration system upgrade (1.7 TBtu to 2.5 TBtu) and water heat usage and controls measures (~1.0 TBtu) are cost-effective.

9 Key Findings

Key findings from the study are reviewed below and include a discussion of the potential to reduce fossil fuel use, increase deployment of shell and electrification measures, and deploy other measures that offer significant potential for heating and cooling savings. These findings also revisit how adoption of energy efficiency and electrification measures responds to alternative incentive structures.

The technical opportunity exists to cut fossil fuel use nearly in half in New York's buildings through 2030. By 2030, fossil fuel energy efficiency and electrification technical potential accounts for roughly 47% of business-as-usual estimated sales for gas, oil, propane, and district steam (excluding electricity). Statewide technical potential further increases to a 64% reduction in fossil fuel use in buildings by 2042, as building HVAC and hot water systems are assumed to be replaced when equipment is retired. Notably, the end-of-life replacement cycle spans 20 years (in the residential sector) to 25 years (in the commercial sector) for space heating equipment. Because most systems will be replaced only once between now and 2042, it is especially important to ensure that market signals are in place in the near term to drive adoption of energy efficiency and electrification measures.

Significant economic potential exists for energy efficiency and electrification in New York. This study finds that more than half of the total energy efficiency and electrification technical potential is cost-effective in New York State by 2030, based on a societal benefit/cost screen that incorporates values for the social cost of carbon (SCC) at either the 3% or the 2% discount rate. Compared to the statewide technical potential, the 2030 economic potential ranges from 59% to 65% (182 TBtu to 201 TBtu) for energy efficiency and from 40% to 68% (66.6 TBtu to 112 TBtu) for electrification measures, with an SCC at the 3% or 2% discount rate, respectively. Compared to business-as-usual estimated sales for fossil fuels (gas, oil, propane, and district steam), 2030 economic potential across energy efficiency and electrification ranges from approximately 24% (SCC at 3% discount rate) to 31% (SCC at 2% discount rate). The choice of the SCC discount rate has a pronounced effect on the economic potential results for electrification of buildings using natural gas.

New York State has the potential to achieve meaningful savings from the Baseline Scenario voluntary adoption and state and local codes and standards. In the Baseline Scenario, the strong majority (76%) of the energy savings potential results from voluntary customer adoption, indicating that many measures included in this study are mature and offer an adequate return to the customer. Importantly, voluntary adoption accounts for available state and federal tax credits but does not offer customers additional upfront incentives. State equipment standards and building energy codes informed by the Scoping Plan, as well as New York City Local Law 154, account for the remainder of savings (approximately 24%) in the Baseline Scenario. Codes and equipment standards are modeled to require adoption of certain high-efficiency measures starting at dates that vary by major sector.

To drive significant savings above federal standards, energy efficiency incentive programs must transition away from lighting—and toward deeper savings measures like building shell and space heating. Historically, lighting measures have driven considerable savings in state- and utility-administered energy efficiency programs. However, as the federal Energy Independence and Security

Act of 2007 (EISA) requires retailers to transition to an all-LED market, lighting measures will have minimal impact on program savings in the future. Over the coming decade, the measures with greatest potential for energy reductions include building shell and space heating, which are closely linked to building system replacement cycles and new construction.

In single-family homes, adoption of heat pumps and shell upgrades is responsive to incentives. As the modeled incentives improve return on investment, the single-family sector sees a significant increase in adoption of (and energy savings potential from) basic shell upgrade packages comprising air sealing and insulation, partial-load and full-load heat pumps for space heating and cooling, packages that bundle basic shell upgrades and full-load heat pumps, and heat pump water heaters. While incentives equal to 50% of incremental capital cost increase shell and electrification adoption substantially, even higher incentives under the Reasonable Return Incentives result in significant acceleration of basic shell and heat pump adoption. Importantly, the results show that the impact of incentives is most pronounced in the single-family sector as compared to the multifamily and commercial sectors.

The multifamily sector is generally less responsive to incentives than the single-family sector, reflecting higher barriers to the adoption of heat pumps and deeper shell upgrades. In the Baseline Scenario, modeling shows that the majority of electrification savings in the multifamily sector occurs due to codes requiring highly efficient, all-electric new construction. Voluntary heat pump adoption in existing multifamily buildings sees a meaningful increase only under the Reasonable Return Incentives, which typically exceed 50% of the incremental cost to install a full-load heat pump or a heat pump bundled with shell upgrades. Uptake of deeper-saving shell packages (comprising air sealing, insulation, and energy-efficient windows) in existing multifamily buildings increases modestly with Reasonable Return Incentives, though adoption is constrained by nonfinancial barriers.

The commercial sector is responsive to electrification incentives but sees minimal uptake of shell measures. In the commercial sector, the analysis assumes that heat pump adoption occurs either in new construction or as part of a major capital upgrade to an existing building, such that heat pumps are bundled with additional efficiency measures (such as energy recovery ventilation and more efficient lighting, appliances, and plug loads) in a manner that benefits energy savings and project returns. Meaningful electrification of commercial space heating occurs in the Baseline Scenario, with increased uptake under CapEx Incentives and still higher electrification savings with Reasonable Return Incentives. In contrast, because incentive caps are applied, commercial shell packages do not reach a desired return on investment under any incentive scenario modeled and their adoption remains low.

In commercial buildings, HVAC controls and distribution improvement measures offer significant potential for heating and cooling energy savings. In the commercial buildings sector, the top energy savings measure packages in the Baseline Scenario include HVAC controls, distribution improvements (such as insulating pipes and repairing ducts or steam traps), and the commissioning and tune-up of HVAC systems. These energy efficiency measures are typically low-cost, mature, and offer both heating and cooling savings; as a result, additional incentives do not significantly increase their adoption. An exception is that certain non-thermostat HVAC controls (for example, variable speed drives and economizers) do see higher savings with incentives.

The Reasonable Return Incentive structure drives the greatest adoption of deeper savings measures. Measure adoption and potential savings respond differently to the CapEx and Reasonable Return Incentives scenarios explored in this study. Though both incentive structures drive greater adoption for deep energy savings measures like heat pumps and deep shell improvement packages, the Reasonable Return Incentives structure has a greater impact on adoption for such measures. This is logical because to achieve the target return on investment the Reasonable Return incentive for deep-savings measures is often greater than the 50% of the incremental cost offered by the CapEx Incentives Scenario.

Moreover, for measures that meet the desired return on investment (or are close to it) without incentives, the study shows that an additional incentive does not significantly increase market adoption. This is the case for relatively low-cost energy efficiency measures (including HVAC tune-ups, commissioning, and distribution improvements; thermostats and boiler controls; and higher-efficiency boilers and furnaces) for which adoption is strong and comparable across the Baseline, CapEx Incentives, and Reasonable Return Incentives scenarios for such measures. On the other hand, the CapEx Incentives Scenario sees a slight decrease in adoption relative to the Baseline Scenario for certain deep energy savings measures, notably packages that bundle deep shell and heat pumps, because the flat incentive structure favors competing measures.

Building upon these insights, future work could include additional adoption scenarios, such as a scenario in which heat pumps, building shell, and other targeted measures are offered incentives, but high-efficiency fossil fuel equipment measures do not receive incentives. It also would be beneficial to conduct additional scenario analyses that directly examine the impacts of policy initiatives (other than incentives) to address market barriers such as consumer awareness and workforce development.