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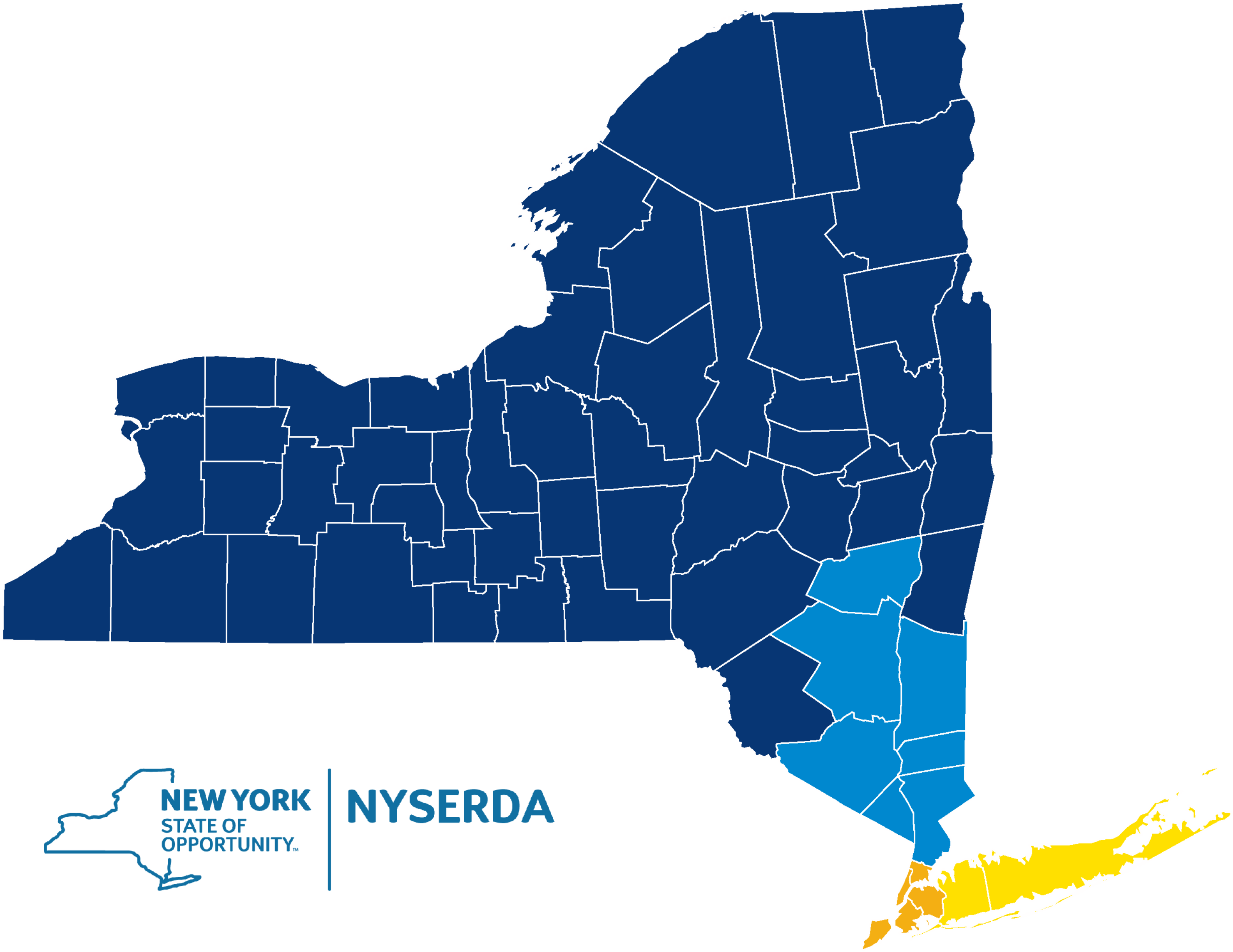

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Appendix A: Methodology and Achievable Potential

Assessment of Energy Efficiency Potential in New York State Multifamily Buildings

June 2021

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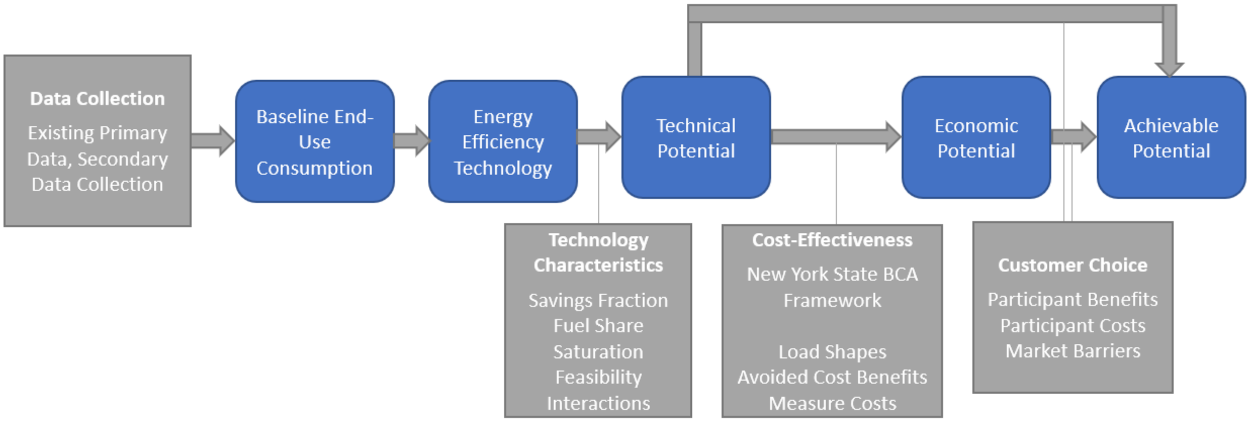
Analysis Methodology

Cadmus estimated the potential for multifamily building energy savings in New York State from 2021 through 2030. This section describes each methodological step in the assessment process in greater detail, while the next section (*Scenario Analysis*) outlines scenario analyses used to estimate achievable potential.

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

Figure 1. General Methodology for Assessing Energy Efficiency Potential



Measure Characterization

Cadmus developed a measure database of technical and market details that apply to all end uses in the multifamily market segment, then we estimated costs, savings, and applicability for a set of energy efficiency measures. Through this process, Cadmus calculated the measure percentage savings to estimate the total end-use savings. These measure end-use percentage savings, when applied to the baseline end-use consumption, produced estimates of energy efficiency potential.

First we developed an initial list of measures using Cadmus' in-house database, which included information from several sources:

- Measures included within the 2020 *New York Technical Resource Manual* (TRM; v8)
- Efficiency tiers from the Consortium for Energy Efficiency and ENERGY STAR
- Measures of interest for multifamily buildings in consultation with NYSERDA program staff
- Measures from Cadmus' extensive database, which includes details from regional and national databases (such as the *California Database for Energy Efficient Resources* and various TRMs)
- Selected emerging technologies and behavioral measures

Upon identifying measures, Cadmus compiled all inputs required to estimate potential. Table 1 shows key inputs and data sources.

Table 1. Key Measure Data Sources

Input	Data Sources
Load and Energy Savings	NYSERDA BEEM multifamily inputs, 2020 New York TRM (v8), ENERGY STAR, DOE EERE,[a] Regional Technical Forum, regional and well-respected TRMs, Cadmus research
Equipment and Labor Costs	NYSERDA BEEM multifamily inputs, RSMeans,[b] ENERGY STAR, DOE EERE, *California Database for Energy Efficient Resources*, Regional Technical Forum, incremental cost studies, regional and well-respected TRMs, online retailers, Cadmus research
Measure Life	NYSERDA BEEM multifamily inputs, 2020 New York TRM (v8), ENERGY STAR, *California Database for Energy Efficient Resources*, regional and well-respected TRMs, Cadmus research
Technical Feasibility	Regional building stock assessments, Cadmus research
Measure Penetration	NYSERDA BEEM multifamily inputs, regional building stock assessments, U.S. Energy Information Administration (EIA) *Residential Energy Consumption Survey*, ENERGY STAR market shipment reports, Cadmus research

[a] U.S. Department of Energy, Office of Energy Efficiency and Renewable Technology (EERE). http://energy.gov/eere/office-energy-efficiency-renewable-energy

[b] RSMeans. Lat updated 2002. "Comprehensive Database for Cost Estimation." https://www.rsmeans.com/products/online.aspx

Measure Baselines

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

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

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

Energy Savings

Cadmus estimated energy savings for each energy efficiency measure: both the savings per unit (kilowatt-hour or MMBtu) and the savings as a percentage of end-use equipment baseline consumption. These estimates also accounted for savings interactions and results across end uses (for example, when efficient cooling equipment is installed, cooling loads for other measures decrease). Cadmus relied on a number of sources to develop savings estimates:

- ***Multifamily inputs from NYSERDA's BEEM tool.*** NYSERDA developed baseline load and savings estimates for a number of end-use equipment and efficiency measures such as boilers, furnaces, and shell measures. Cadmus checked these values and aligned our details with NYSERDA's BEEM inputs wherever possible.

- ***Recent NYSERDA and New York State utility program evaluations, program data, and potential studies.***
- ***The DOE Uniform Methods Project or other standard evaluation protocols.*** The *Uniform Methods Project* set of protocols define standard calculations used to estimate energy savings for a number of measures. Cadmus' savings calculations were consistent with these and other similar industry standards.
- ***ENERGY STAR calculators.*** Cadmus used the U.S. Environmental Protection Agency's (EPA) ENERGY STAR calculators, which provide estimates of per-unit savings for a number of measures, including efficient appliances (such as refrigerators, freezers, and clothes washers) and efficient home electronics (such as televisions, computers, and monitors).
- ***New York TRM (v8).***
- ***Other state and regional TRMs.***
- ***DOE EERE technical support documents.*** The DOE EERE includes estimates of equipment energy consumption in technical support documents for numerous energy-efficient equipment types.

Baseline and Measure Costs

Cadmus estimated equipment, labor, and annual operation and maintenance costs for each energy efficiency measure, then used these costs to calculate benefit/cost ratios to assess measure cost-effectiveness. We relied on a number of sources to develop cost estimates:

- ***RSMeans.*** RSMeans provides construction cost data, including costs for several building retrofits (such as weatherization, windows, and other shell upgrades).
- ***ENERGY STAR.*** The EPA provides current equipment costs for several ENERGY STAR–rated units.
- ***DOE EERE technical support documents.*** The DOE EERE includes estimates of equipment and labor costs in technical support documents for several types of energy-efficient equipment.
- ***Incremental cost studies.*** TRMs often require incremental cost studies that show baseline and efficiency measure costs (such as for labor, equipment, and operation and maintenance). States frequently update these studies to incorporate the most recent cost data. These studies include measures that are most commonly offered through utility-sponsored energy efficiency programs.
- ***Online retailers.*** Cadmus continuously reviewed prices listed on manufacturer or retailer websites. Although online retailers may not provide estimates of installation (labor) or annual operation and maintenance costs, they provide reliable equipment costs.
- ***NYSERDA cost assumptions.*** As part of ongoing NYSERDA work related to the BEEM tool and multifamily program planning, NYSERDA has cost assumptions for a number of BEEM measures (including shell improvements). These cost assumptions are New York–specific and are often derived in consultation with industry experts.

Due to the high level of cost variance across New York State, Cadmus used BEEM's cost-scaling capability to adjust the costs by region (New York City, Long Island, Hudson Valley, and Upstate). This means that the same measure will cost more in New York City than it will elsewhere in the state.

Measure Life and Replacement Cycle

Cadmus used estimates of each measure's effective useful life (EUL) to calculate the lifetime net present value benefits and costs for each energy efficiency measure. Many data sources for measure savings and costs (described above) also provided estimates for measure lifetimes. Cadmus relied on a number of those sources, along with a couple of new sources, to develop measure life estimates:

- 2020 New York TRM (v8)
- EUL studies, including the Northeast Energy Efficiency Partnership's 2007 EUL study and EULs derived by the Association of Home Appliance Manufacturers
- ENERGY STAR
- DOE EERE technical support documents
- Regional TRMs

Cadmus used estimated replacement cycles for each measure to determine the natural rate of measure replacements, assumed to be one divided by the replacement cycle. BEEM models customer decisions when faced with two options: purchase the counterfactual minimum efficiency equipment or purchase the measure equipment. These decision points occur more frequently than the EUL predicts for certain measures, such as shell improvements; therefore, Cadmus used replacement cycles instead of EUL to determine the rate of measure replacements. NYSERDA had created these replacement cycles as part of its ongoing work on the BEEM tool, based on programmatic considerations and professional judgement.

Technical Feasibility

Technical feasibility represents the percentage of homes that could feasibly install an energy efficiency measure. Technical limitations include equipment capability or space limitations. For example, ductless heat pumps could not feasibly be installed in all apartments of high-rise multifamily buildings due to space constraints related to the exterior unit and refrigeration lines. Cadmus relied on two types of sources to develop feasibility estimates:

- ***Energy efficiency program evaluations*** that included research to identify technical barriers to installing energy efficiency measures.
- ***Cadmus research and third-party measure characterization research (including from the Federal Energy Management Program and DOE)*** that identified technical limitations for energy efficiency measures, allowing us to estimate the proportion of homes that would feasibly install each measure. In some instances, Cadmus used engineering judgment to approximate technical constraints.

Measure Saturation

Measure saturation represents the percentage of homes that have already installed an energy efficiency measure. Cadmus relied on a number of sources to develop estimates of measure saturation that account for current saturations of energy-efficient equipment, building energy codes and standards, and the natural adoption of efficiency measures:

- Recent stock assessments and surveys (such as the 2015 EIA *Residential Energy Consumption Survey* and 2018 NYSERDA *Single Family Residential Building Stock Assessment*).
- ENERGY STAR reports.

Energy Efficiency Measure Database

After creating a list of electric, natural gas, fuel oil and propane, and district steam energy efficiency measures applicable to New York State multifamily buildings, Cadmus classified energy efficiency measures into three categories:

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

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

For this study, Cadmus used several relevant inputs for each measure type:

- ***Technical feasibility:*** the percentage of buildings where customers could install a particular measure, accounting for physical constraints.
- ***Energy savings:*** the average annual savings attributable to installing a particular measure, in percentage terms.
- ***Equipment cost:*** the full counterfactual and measure equipment costs.
- ***Labor cost:*** the expense of installing the measure, accounting for differences in labor rates by region, urban versus rural areas, and other variables.
- ***Operation and maintenance cost:*** the annual expense of operating or maintaining the measure. This is only characterized when there is a difference in operation or maintenance costs between the counterfactual and measure cases.
- ***Measure life:*** the expected measure life of the equipment.
- ***Measure saturation:*** the percentage of homes that have already installed a particular energy efficiency measure.

Cadmus used Excel workbooks to characterize underlying measure assumptions and analysis. These measure workbooks contain detailed saving calculations, cost research, EUL data, applicability factor values, and measure assumptions, along with well-documented source descriptions. Cadmus aggregated all measure data into a final master input file for use in the potential model. We provided these detailed measure workbooks in supplemental formats along with this final report.

Codes and Standards

Cadmus accounted for changes in codes and federal standards over the planning horizon. These changes will affect customers' energy-consumption patterns and behaviors and will impact which energy efficiency measures continue to produce energy savings over minimum requirements. Cadmus captured current efficiency requirements, including those enacted but not yet in effect.

Cadmus used the *New York State Energy Conservation Construction Code*, which requires that residential multifamily buildings comply with the 2020 code, as the baseline for the new vintage. The energy efficiency measure savings estimates explicitly assumed 100% code compliance for new multifamily buildings. We measured new building energy efficiency savings relative to the code requirements for each multifamily building component. For example, Cadmus calculated building shell savings in New York City as the increment of energy savings achieved from installing additional insulation or air sealing relative to the energy code requirement for New York City.

We did not attempt to predict how federal standards (or state energy codes) might change in the future; rather, we only factored in legislation that has already been enacted. Notably, this includes the EISA backstop provision that requires higher-efficiency technologies beginning in 2020 (45 lumens per watt or better).[1]

Cadmus also explicitly accounted for several other pending federal standards. The following tables provide lists of recently enacted or pending equipment standards that we accounted for in this study's multifamily segment for electric fuel (Table 2) and for natural gas and other fossil fuels (Table 3). Cadmus also incorporated other standards that became effective for equipment prior to 2021. For measures where a future standard would have a higher efficiency than a current standard counterfactual, we adjusted the baseline to the new federal standard.

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[1] On January 18, 2017, the DOE expanded EISA requirements for previously exempt specialty lamps (such as reflectors, globes, and candelabras) and for higher lumen-standard lamps (greater than 2,600 lumens). On September 5, 2019, however, the DOE's final rule and notice of proposed determination effectively rescinded the EISA 2020 backstop standard. There are still pending legal challenges and, with the change in presidential administrations, uncertainty remains regarding how this standard will move forward. Given the timing of the final rule and uncertainty around its effects, Cadmus modeled savings assuming that the 2020 EISA backstop standard would still occur. For this study, we assumed that standard lamps would be impacted by the EISA backstop provision in 2020, and thus used a baseline of 45 lumen per watt lighting, starting in 2020, as the counterfactual.

Table 2. Current and Pending Electric Equipment Standards by End Use

End-Use Equipment Type	Current (Baseline) Standard	New Standard (Year Effective)
Central Air Conditioner	2015	2023
Clothes Washer	2018	No new standard pending
Room Air Conditioner	2015	No new standard pending
Freezer	2015	No new standard pending
Linear Fluorescent Lamp	2018	No new standard pending
Lighting General Service Lamp	2020	No new standard pending
Package Terminal Air Conditioner	2017	No new standard pending
Refrigerator	2015	No new standard pending
Water Heater GT 55 Gallon	2017	No new standard pending
Water Heater LE 55 Gallon	2017	No new standard pending

Table 3. Current and Pending Natural Gas and Other Fossil Fuel Equipment Standards by End Use

End-Use Equipment Type	Current (Baseline) Standard	New Standard (Year Effective)
Dryer	2015	No new standard pending
Heat Central Fuel Oil Boiler	2012	2021
Heat Central Natural Gas Boiler	2012	2021
Heat Central Natural Gas Furnace	2015	No new standard pending
Heat Central Propane Boiler	2012	2021
Water Heater GT 55 Gallon	2017	No new standard pending
Water Heater LE 55 Gallon	2017	No new standard pending

BEEM and EIA Energy Sales Estimates and Comparison

This report reflects the first deployment of BEEM in a potential study application. To ensure that the results were grounded, Cadmus constructed a rough estimate of multifamily sales based on data from the EIA, then compared this to the multifamily energy sales estimate we determined using the BEEM tool.

BEEM Energy Sales Estimate

Cadmus used BEEM to estimate the whole-building load for each applicable building. We then added up the whole-building load for all multifamily buildings in the study to estimate the statewide multifamily load. Table 4 shows the BEEM multifamily sales estimate by fuel type.

Table 4. BEEM Multifamily Energy Sales Estimate

Fuel Type	Unit	Estimated New York State 2020 Energy Sales Using BEEM Multifamily Data
Electric	GWh	26,589
Natural Gas	BBtu	102,456
Fuel Oil and Propane	BBtu	44,415
District Steam	BBtu	3,835
Total (Excluding District Steam)	**BBtu**	**237,591** [a]

[a] The sum of this column does not equal the total because electric GWh must be converted to BBtu.

EIA Energy Sales Estimate

Cadmus used New York State residential EIA data by fuel type in conjunction with the baseline sales forecast from the *2019 Single-Family Potential Study* to estimate multifamily energy sales.[2] The 2019 residential EIA data by state and by fuel type is available on the EIA website.[3] The *2019 Single-Family Potential Study* included single family and manufactured homes, so Cadmus estimated multifamily sales as the difference between the EIA residential sales and the single family baseline sales. Table 5 shows Cadmus' estimate of New York State EIA multifamily sales by fuel type.

Table 5. EIA Multifamily Energy Sales Estimate

Fuel Type	Unit	Estimated New York State 2020 Energy Sales Using EIA Data		
		All Residential	Single Family (2019 Potential Study)	Multifamily
Electric	GWh	50,141	39,906	10,235
Natural Gas	BBtu	488,900	351,950	136,950
Fuel Oil and Propane	BBtu	134,000	107,688	26,312
District Steam	BBtu	N/A	N/A	N/A
Total (Excluding District Steam) [a]	**BBtu**	**793,981**	**595,797**	**198,184**

[a] The sum of these columns does not equal the total because electric GWh must be converted to BBtu.

Comparison and Conclusions

While the total MMBtu-equivalent is relatively close between the two estimates, and the difference can possibly be attributed to some multifamily building load being captured in the commercial portion of EIA or to imprecision in the estimated single-family baseline sales forecast, the differences are more substantial at the individual fuel level.

For the purposes of this study, Cadmus' comparison of EIA-estimated and BEEM-estimated New York State energy sales for multifamily buildings showed that the BEEM tool produces reasonable overall potential results, though the fuel mix estimated by the BEEM tool differs from that presented in EIA data.

Technical Potential

After fully populating the measure database, Cadmus used measure-level inputs to estimate technical potential over the planning horizon. First we estimated savings from all measures included in the analysis, then we aggregated results to the end use, fuel type, and multifamily segment levels.

Cadmus characterized individual measure savings, first in terms of the percentage of end-use consumption. For each measure, we estimated absolute savings using the following equation:

$$\mathrm{SAVE}_{ijm} = \mathrm{EUI}_{ije} * \mathrm{PCTSAV}_{ijem} * \mathrm{APP}_{ijem}$$

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[2] Cadmus. 2019. *2019 Single-Family Potential Study*. https://www.nyserda.ny.gov/About/Publications/Building-Stock-and-Potential-Studies/Residential-Building-Stock-Assessment

[3] U.S. Energy Information Administration. Last updated 2021. "State Energy Data System (SEDS): 2019 (updates by energy source)." https://www.eia.gov/state/seds/seds-data-fuel.php?sid=NY

Where:

SAVE*ijm* = Annual energy savings for measure *m* and end use *j* in customer segment *i*

EUI*ije* = Calibrated annual end-use energy consumption for equipment *e* and end use *j* in customer segment *i*

PCTSAV*ijem* = The percentage savings of measure *m* relative to base use for the equipment configuration *ije*, accounting for interactions among measures (such as lighting and HVAC), calibrated to annual end-use energy consumption

APP*ijem* = Measure applicability: a fraction representing the combined technical feasibility, existing measure saturation, end-use interaction, and any adjustments used to account for competing measures

For example, wall insulation that saved 10% of space heating consumption would have a final percentage of the end use saved of 5%, assuming an overall applicability of 50%. This value represents the percentage of baseline consumption that the measure saved in an average home.

Capturing all applicable measures, however, would require examining many instances in which multiple measures affect a single end use. To avoid overestimating total savings, Cadmus assessed cumulative impacts and accounted for interactions among various measures—a treatment called measure stacking. The primary method used to account for stacking effects is to establish a rolling, reduced baseline, then apply that baseline sequentially upon assessing measures in the stack.

The following equations illustrate this technique, applying measures 1, 2, and 3 to the same end use:

$$\text{SAVE}\mathit{ij1} = \text{EUIije} * \text{PCTSAV}\mathit{ije1} * \text{APP}\mathit{ije1}$$

$$\text{SAVE}\mathit{ij2} = (\text{EUI}\mathit{ije} - \text{SAVE}\mathit{ij1}) * \text{PCTSAV}\mathit{ije2} * \text{APP}\mathit{ije2}$$

$$\text{SAVE}\mathit{ij3} = (\text{EUI}\mathit{ije} - \text{SAVE}\mathit{ij1} - \text{SAVE}\mathit{ij2}) * \text{PCTSAV}\mathit{ije3} * \text{APP}\mathit{ije3}$$

After iterating all measures in a bundle, the final percentage of the reduced end-use consumption provides the sum of each individual measure’s stacked savings, which Cadmus divided by the original baseline consumption. We ranked the order of the stacked measures in a bundle from the highest to the lowest cost-effective measure, which we had determined prior to conducting the stacking calculation.

Economic Potential

Economic potential represents a subset of technical potential, consisting only of measures that meet cost-effectiveness criteria. Cadmus used the primary cost-effectiveness test adopted under the New York State BCA Framework, which is a societal cost (SCT), to identify cost-effective measures in a manner consistent with the New York State Department of Public Service (DPS) guidance. Table 6 lists the benefits and costs we considered in calculating benefit/cost ratios to develop the economic potential.

Table 6. Summary of Cost and Benefit Components

Type	Component
Costs	Incremental measure equipment costs, which includes equipment, labor, and ongoing annual operation and maintenance costs required to purchase a measure and sustain savings over each measure's EUL.
Benefits	Avoided energy costs, which reflect the direct (primary) and secondary energy savings from installing energy efficiency measures. BEEM estimates the whole-building energy load for each measure, fully accounting for primary and secondary energy savings.
	Deferred capacity costs, which includes the deferred generation and transmission and distribution capacity benefits that accrue from peak-coincident electric energy efficiency measures (and we also included deferred natural gas distribution costs).
	Reduced greenhouse gas emissions, which reflect the economic value of avoided greenhouse gas emissions, including carbon dioxide (CO_2).

In addition to each benefit and cost detailed in Table 6, Cadmus and E3 calculated the net present value of benefits, including utility-specific line loss factors and a discount rate of 6.9% (based on an energy sales-weighted average utility cost of capital).

Data Sources

Cadmus and E3 collected the data required to perform benefit/cost analysis from a variety of sources. Table 7 provides a comprehensive list of these data sources, along with notes regarding their treatment in the potential study.

Table 7. Benefit/Cost Analysis Data Source Summary

Data	Source Data Tool or Model	Agency	Notes
Electricity			
Avoided Energy	Congestion Assessment and Resource Integration Study; Historical hourly prices	New York Independent System Operator (NYISO)	Based the hourly avoided energy costs on the shape of 2016 through 2018 average historical locational-based marginal pricing, scaled by the annual energy cost forecasts from the 2018 Congestion Assessment and Resource Integration Study 2 Base Case Locational Based Marginal Pricing report.
Avoided Generation Capacity	DPS Installed Capacity Model	NYISO; DPS	Developed hourly avoided generation capacity costs by shaping annual capacity costs from the Installed Capacity Model using the value of distributed energy resources alternative 2 allocation methodology.
Avoided Transmission and Distribution Capacity	Utility specific	Utilities	Developed hourly avoided transmission and distribution capacity costs by shaping avoided distribution costs from the marginal cost of service reports using the value of distributed energy resources demand reduction value allocation methodology.
Avoided CO_2 (Electricity)	NYSERDA Renewable Energy Standard	NYSERDA	Determined these values using NYSERDA's Tier 1 renewable energy credit sale price for the 2020 compliance year.
Losses	Utility specific	Utilities	Developed hourly avoided loss costs by applying the losses data from utility tariff leaves to hourly avoided energy costs.
Natural Gas			
Avoided Natural Gas	Federal Energy Regulatory Commission (FERC) tariffs; Citygate prices; EIA forecasts; Hub natural gas prices; Utility filings; Natural gas supply plans	FERC; EIA; Utilities	The avoided cost of natural gas assumptions came from the latest version of the New York Gas Avoided Cost Calculator (September 2020), which E3 developed for NYSERDA and the DPS. There are two energy-related avoided cost of natural gas components: • Upstream supply (fixed) data sources include FERC tariffs, Citygate prices, hub natural gas prices, utility filings, and natural gas supply plans. • Upstream supply (variable) data sources include EIA forecasts, hub natural gas prices, and FERC tariffs.
Avoided Natural Gas Capacity	Utility specific	Utilities	Avoided cost assumptions came from the latest version of the New York Gas Avoided Cost Calculator (September 2020), which E3 developed for NYSERDA and the DPS. The capacity-related avoided cost of natural gas components includes both fixed and variable downstream distribution costs, based on utility filings.
Avoided CO_2 (Natural Gas)	EPA Social Cost of Carbon (SCC)	EPA	Used the EPA SCC values calculated at the 3% discount rate, per the New York State BCA Framework. The CO_2 emissions factor for natural gas also came from the EPA.

Data	Source Data Tool or Model	Agency	Notes
Fuel Oil and Propane			
Avoided Fuel Oil	Historical fuel oil prices; EIA Annual Energy Outlook	NYSERDA; EIA	Developed fuel oil price assumptions based on historical fuel oil prices provided by NYSERDA. Used three-year average (2017 through 2019), region-specific monthly fuel oil prices for both the residential and commercial sectors, and for the Long Island, New York City, Hudson Valley, and Upstate regions.
			Developed scenarios for fuel oil price escalation factors for the residential and commercial sectors based on EIA Annual Energy Outlook values for 2020.
Avoided CO_2	EPA SCC	EPA	Used the EPA SCC values calculated at the 3% discount rate, per the New York State BCA Framework. The CO_2 emissions factor for natural gas also came from the EPA.
District Steam			
Avoided District Steam	Utility specific	Consolidated Edison (Con Edison)	Used the steam rate schedule for Con Edison, pulled from the utility tariff. Projected customer rates to escalate over time at annual inflation rates.
Avoided CO_2	EPA SCC; Con Edison Steam Long Range Plan	EPA; Con Edison	Used the EPA SCC values calculated at the 3% discount rate, per the New York State BCA Framework. The CO_2 emissions factor for district steam came from Con Edison's *Steam Long Range Plan*.

Additional Economic Potential Considerations

The economic potential for a given measure can exceed the technical potential when a second measure, interacting with that measure, fails a benefit/cost screen. For instance, if a homeowner installs an efficient air conditioner that reduces baseline cooling consumption from 1,000 kWh to 900 kWh, then installs a weatherization measure that saves 10% off the baseline cooling consumption, this weatherization measure results in energy efficiency savings, or technical potential, of 90 kWh (900 kWh * 10%). However, if the efficient air conditioner had not been installed first, the baseline consumption would have been 1,000 kWh, and the weatherization measure would have resulted in energy savings, or economic potential, of 100 kWh (1,000 kWh * 10%). In this case, the economic potential (100 kWh) exceeds the technical potential (90 kWh) for the weatherization measure.

Achievable Potential

Achievable potential estimates the energy efficiency that might be assumed as reasonably achievable during the planning horizon given technical feasibility, project economics, and market barriers that might impede customer participation in New York State. Achievable potential is often estimated as a subset of economic potential, constrained by a cost-effectiveness screen; this approach applies generic ramp rates (which are independent of measure economics) to the economic potential to estimate achievable potential. BEEM offers an alternate approach, since its customer adoption functionality is a Bass diffusion adoption model that accounts for the cost-effectiveness of measures from the customer perspective.

In the scenarios reported below, Cadmus estimated achievable potential as a subset of the technical potential that was not constrained by the economic potential (that is, it was unconstrained by the societal cost-effectiveness screen). We estimated achievable potential using BEEM's adoption algorithm, which predicts the annual adoption rate using a Bass diffusion adoption model, then applies the annual adoption rate to the annually applicable sites to estimate the number of achievable installations in a given year.

Adoption Model

This discussion of the BEEM adoption model draws from internal NYSERDA BEEM documentation, particularly a memo from Cadmus and E3 describing the adoption algorithm in detail. The adoption model in BEEM consists of two major components:

- ***Projecting the maximum adoption percentage*** that will ever be achieved as a function of the project return (or corresponding payback). A higher project return corresponds to achieving a higher adoption potential. This component is discussed in the *Scaling the Adoption Percentage Based on Economic Return* section below.
- ***Projecting how adoption percentages will increase over time*** from current, typically low levels to reach the final maximum adoption percentage. E3 modeled this component based on an assessment of barriers to adoption, including customer behavior barriers, technology barriers, and other non-financial barriers. As discussed in the *S-Curve* section below, this component is expressed through a curve that describes how the shape and speed of the adoption level increases over time.

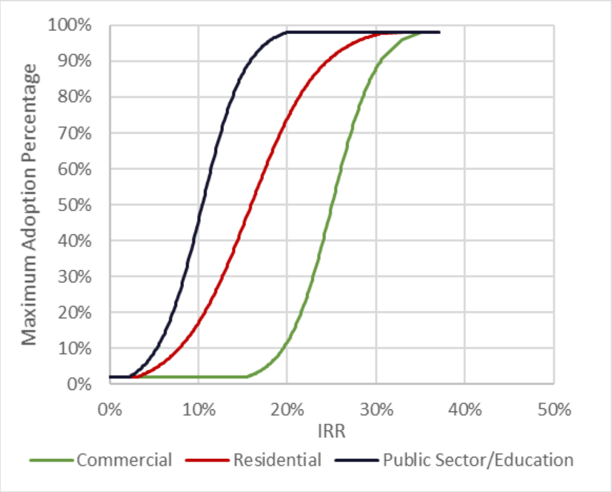
Adoption of the measures under consideration in BEEM tends to be linked to end-of-life replacement cycles. The model therefore applies an annual adoption rate modeling (where adoption is modeled as a percentage of the sites that are ready for end-of-life replacement each year, rather than as a percentage of total building stock). This modeling choice means that it takes longer to achieve a certain level of penetration: getting to 100% penetration requires not only achieving an annual adoption percentage of 100% but also maintaining this adoption level for the number of years equal to the replacement cycle.

Scaling the Adoption Percentage Based on Economic Return

BEEM determines the customer willingness to adopt an energy measure based on project return—specifically the internal rate of return (IRR) indicating the annualized rate of return. This approach links maximum measure adoption to both (1) differences in returns achieved by different measures over time (with or without incentives) and (2) differences in the required return assumed for different customer sectors. For all customers, this approach assumes that the customer's willingness to adopt a measure is heavily influenced by that measures' economic prospects: in other words, payback matters. This assumption is supported by market intelligence and by available customer survey data.[4]

Figure 2 shows the IRR scalar curves used in the BEEM model. For this study, Cadmus and E3 used the residential curve for all multifamily ownership categories: owner-occupied housing, market rate rental housing, unsubsidized low- to moderate-income housing, and regulated multifamily rental buildings that provide subsidized LMI housing. This curve assumes that if a project provides approximately a six-year simple payback (or 16% IRR), then up to half of customers will be willing to adopt it.

Figure 2. Internal Rate of Return Scalar



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[4] As a part of the *2019 Residential Building Stock Assessment Single-Family Potential Study*, Cadmus surveyed residential customers about their willingness to adopt an energy efficiency measure, given varying incentive levels. The surveyed customers become increasingly willing to adopt a measure as incentive levels increased. The most dramatic change in willingness was for air-source heat pumps, where 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.

S-Curve: Shape of Adoption Over Time

The S-curve describes the length of time and shape of the adoption pattern to achieve the maximum adoption percentage. For modeling adoption, BEEM uses the Bass diffusion model, a simple differential equation that describes the S-curve pattern of new product adoption:

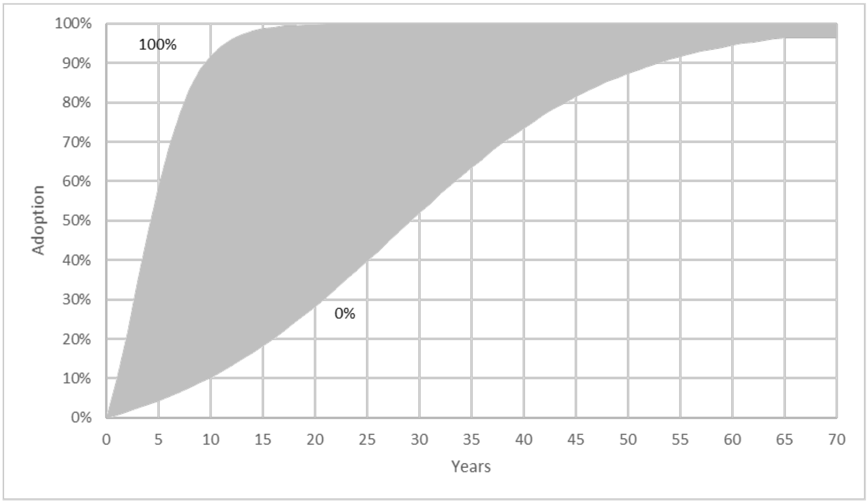
$$Bass\ diffusion\ adoption\ rate(t) = \frac{1 - e^{-(p+q)T}}{1 + (\frac{q}{p})e^{-(p+q)T}}$$

Two coefficients, *p* and *q*, influence the slope and duration of the adoption curve produced by the Bass diffusion model.

- *p* represents the coefficient of innovation
- *q* represents the coefficient of imitation

A significant amount of research has been done to evaluate adoption curves for various products and their associated *p* and *q* values. BEEM draws from a 2011 paper by Daim et al.[5] that analyzes the pace of adoption, cost, value, and efficiency of residential energy management technologies to develop a set of four adoption curves. Cadmus and E3 assumed that the range of adoption curves reflected in Daim et al. (2011) is reasonable for technology uptake where barriers to adoption (such as technology complexity, customer awareness, and supply chain issues) are addressed effectively; but for measures where barriers remain high, the project team extended the duration of the adoption curves. The resulting S-curve range is provided in Figure 3.

Figure 3. BEEM S-Curve Range



Cadmus and E3 used a scoring system to assign measures to S-curves. This scoring matrix allowed us to evaluate measure packages by their reference attributes, or characteristics, that capture the current

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[5] Daim, Tugrul, Ibrahim Iskin, and Daniel Ho. October 2011. "Technology Forecasting for Residential Energy Management Devices." *Foresight* 13(6): 70-87. https://www.researchgate.net/publication/235261177_Technology_forecasting_for_residential_energy_management_devices

state of a technology and a customer's willingness or ability to adopt a measure package. The matrix also provides the option to adjust these reference attributes in scenario modeling due to policy interventions or market developments: we did not employ such adjustments in the scenarios reported for this study. See Table 8 for the scoring matrix reference attributes and weightings.

Table 8. Scoring Matrix

Reference Attributes		
Customer (25% Weight)	**Technology (25% Weight)**	**Barriers (50% Weight)**
Unfavorable; Somewhat Unfavorable; Somewhat Favorable; Favorable	Unfavorable; Somewhat Unfavorable; Somewhat Favorable; Favorable	Unfavorable; Somewhat Unfavorable; Somewhat Favorable; Favorable

Three reference attributes are outlined in the table above:

- The ***customer attribute*** captures the ease and willingness of customers to adopt a measure package (setting aside project economics that are addressed using a scalar, as discussed above). For example, when a measure meets financial requirements, commercial customers may respond more quickly than multifamily customers, who must weigh the impacts of measures across many tenants. The customer scoring in BEEM is based on sector type, with the commercial sector receiving a favorable score, single family a medium score, and multifamily an unfavorable score; further nuances can be captured based on ownership type. Note that this attribute is intended to capture inherent differences between customer types that will not be susceptible to policy interventions: aspects that are or should be expected to be impacted by policy interventions (such as issues around landlord/tenant split incentives) are captured by the barriers attribute.
- The ***technology attribute*** captures aspects of technologies such as transaction costs (hassle factor), technology complexity, depth of renovation or operational change required, and ancillary benefits. For example, lighting would receive a favorable score since it is a relatively simple solution to implement. However, deep shell packages would receive an unfavorable score due to their potentially high level of intrusiveness and their complexity. Scoring is based on the current state of a measure package.
- The ***barriers attribute*** 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. Ranking this characteristic depends on the technology being considered. For example, technologies with less mature markets face greater barriers than those with more mature markets due to workforce limitations. Barriers are also differentiated by customer sector.

Cadmus and E3 used this scoring framework and resulting weighted score to determine the associated p and q values that define each measure's unique S-curve, selecting from the full range shown in Figure 3.

In brief, we determined the annual adoption rate for a given measure by multiplying the adoption percentage from its unique S-curve by the IRR scalar percentage. Then we applied this annual adoption rate to the annually applicable sites to estimate the number of achievable installations in a given year.

Scenario Analysis

Cadmus and NYSERDA identified a series of achievable potential scenarios to investigate for this study.

Scenario Definitions

Table 9 summarizes the scenarios for which results are reported below. Scenarios 1, 2, and 3.0 comprise the base case technical, economic, and achievable scenarios (without incentives), respectively. Scenarios 3.1 and 3.2 comprise additional achievable scenarios and are differentiated by their incentive structures.

In these scenarios, achievable potential estimates energy savings from the adoption of energy efficiency measures that are projected to occur given the measures' technical feasibility, the extent to which measures are cost-effective from the customer's point of view, and market barriers that might impede customer adoption. Where measure adoption—in the absence of incentives or comparable support policies—is assessed to be uneconomic from the customer's point of view, Cadmus estimated the upfront payment that would need to be made in order to deliver an adequate project return to the customer. In this study, the highest modeled incentive corresponds to the payment needed to bring the multifamily customer's simple payback to approximately six years (or 16% IRR) when installing an energy efficiency measure, which is referred to as the "six-year payback incentive." The modeled incentive is less for measures that are close to delivering the threshold project return, and zero for measures that already meet that return. The projections are subject to uncertainties around each of the input assumptions described in this appendix.

Table 9. Scenario Names and Descriptions

#	Scenario	Incentive Structure	SCT Screen
1	**Technical Potential**	**N/A**	**N/A**
2	**Economic Potential**	**N/A**	**Yes**
3.0	**Achievable Potential – Zero Incentive**	**None**	**-**
3.1	**Achievable Potential – Incentive of up to 50% of Incremental Cost (Constrained Incentive)**	Lesser of incentive set to deliver a six-year simple payback or 50% of incremental capital cost	-
3.2	**Achievable Potential – Six-Year Payback Incentive**	Incentive set to deliver a six-year simple payback	-

Scenario Results

This section reports the results for achievable scenarios (3.0, 3.1, and 3.2), where the achievable potential is not constrained by the societal cost-effectiveness screen since New York State energy efficiency programs do not apply the SCT screen at the measure level. Cadmus organized this results section in ascending order of the incentive structure amount. Available achievable potential ranges from 16.8% of total 2030 estimated sales in the zero-incentive scenario (3.0) to 19.0% in the six-year payback incentive scenario (3.2), corresponding to annual savings as percentage of sales ranging from 1.8% to 2.1%.[6]

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

Scenario 3.0 – Achievable Potential with Zero Incentives

Scenario 3.0, the base case, has no incentives and achievable potential is not constrained by the SCT screen. Table 10 shows 2030 estimated baseline sales and cumulative technical, economic, and achievable potential by fuel type for scenario 3.0. The scenario results indicate 41 TBtu of achievable potential by 2030, corresponding to energy savings as a percentage of sales on an annual basis of 1.8%.

Table 10. Scenario 3.0 Cumulative Energy Efficiency Potential, 2021-2030

Fuel Type	2030 Estimated Sales (TBtu)	Technical Potential		Economic Potential		Achievable Potential	
		2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales
Electricity	91	29	32%	25	27%	22	24%
Natural Gas	102	43	42%	23	22%	11	11%
Fuel Oil and Propane	44	18	41%	14	31%	7	17%
District Steam	3.8	0.7	17%	0.4	9%	0.2	5%
Total	**241**	**91**	**38%**	**62**	**26%**	**41**	**16.8%**

In addition to the 10-year study horizon from 2021 to 2030, Cadmus estimated technical, economic, and achievable potential for the three- and five-year periods ending in 2023 and 2025, respectively. Table 11 shows the 2030 estimated baseline sales and the cumulative achievable potential for the three-, five-, and 10-year periods.

Table 11. Scenario 3.0 Cumulative Multifamily Achievable Energy Efficiency Potential

Fuel Type	2030 Estimated Sales (TBtu)	Total Achievable Potential as Percentage of Sales		
		3-Year	5-Year	10-Year
Electricity	91	5.7%	10.1%	23.7%
Natural Gas	102	2.4%	4.5%	11.1%
Fuel Oil and Propane	44	3.1%	6.2%	16.8%
District Steam	3.8	0.9%	1.8%	5.1%
Total	**241**	**3.7%**	**6.9%**	**16.8%**

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[6] Study results indicate that if achievable potential *were constrained by* the SCT, it would fall between 14.0% (no incentive) and 14.6% (incentive bringing typical multifamily customer payback to six years). This indicates that applying the SCT screen at the measure level limits the achievable potential significantly.

This achievable scenario, which has no incentives, represents the natural, market-driven adoption of energy efficiency measures over the study horizon. Overall, 86% of electric economic potential is achievable, compared to 50% of natural gas, 54% of fuel oil and propane, and 54% of district steam economic potential being achievable.

Achievable potential for many mature measures with good customer economics will be fully or nearly exhausted by 2030, such as lighting equipment and plug load upgrades (like ENERGY STAR computers and printers). This means that all or most of the economic potential for these measures is achievable without incentives. Ductless heat pumps that replace inefficient electric heating, another measure with high economic potential, achieved 56% of its economic potential even without incentives.

Scenario 3.1 – Achievable Potential with Incentives up to 50% of Incremental Cost

In scenario 3.1, incentives are equal to the lesser of the six-year payback incentive or 50% of the measures' incremental cost, and achievable potential is not constrained by the SCT screen. In this scenario, a measure for which the project return is favorable (with a simple payback of six years or less without incentives) would not receive any public incentive to decrease the upfront cost. On the other hand, a measure with a long simple payback would receive an incentive that covers up to half its incremental cost (however, even accounting for this incentive, the resulting payback may still be longer than most customers find acceptable). Table 12 shows 2030 estimated baseline sales and cumulative technical, economic, and achievable potential by fuel type for scenario 3.1. The scenario results indicate 42 TBtu of achievable potential by 2030, corresponding to energy savings as a percentage of sales on an annual basis of 1.9%.

Table 12. Scenario 3.1 Cumulative Energy Efficiency Potential, 2021-2030

Fuel Type	2030 Estimated Sales (TBtu)	Technical Potential		Economic Potential		Achievable Potential	
		2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales
Electricity	91	29	32%	25	27%	22	24%
Natural Gas	102	43	42%	23	22%	13	12%
Fuel Oil and Propane	44	18	41%	14	31%	8	17%
District Steam	3.8	0.7	17%	0.4	9%	0.2	5%
Total	**241**	**91**	**38%**	**62**	**26%**	**42**	**17.5%**

Table 13 shows the 2030 estimated baseline sales and the cumulative achievable potential for the three-, five-, and 10-year periods.

Table 13. Scenario 3.1 Cumulative Multifamily Achievable Energy Efficiency Potential

Fuel Type	2030 Estimated Sales (TBtu)	Total Achievable Potential as Percentage of Sales		
		3-Year	5-Year	10-Year
Electricity	91	5.7%	10.2%	23.9%
Natural Gas	102	2.6%	4.9%	12.4%
Fuel Oil and Propane	44	3.2%	6.3%	17.0%
District Steam	3.8	0.9%	1.8%	5.1%
Total	**241**	**3.9%**	**7.1%**	**17.5%**

The difference in achievable potential between this scenario (constrained incentive) and the previous scenario (3.0, zero-incentive base case) is driven by a subset of measures that have significantly more favorable customer economics and subsequently higher uptake in the presence of the incentive. Notable measures driving this difference include improved boilers and furnaces, coin-op natural gas dryers, coin-op clothes washers, HVAC pipe insulation, parking area lighting, VFDs on boiler draft fans, combustion optimization boiler controls, parking garage carbon monoxide sensors and automated exhaust VFD controls, and additional retro- and re-commissioning. Other measures had modest increases in uptake under this scenario, such as basic and deep shell packages and energy and heat recovery ventilators, among others.

Scenario 3.2 – Six-Year Payback Incentive

In scenario 3.2, incentives are equal to the payment needed to deliver approximately a six-year simple payback and achievable potential is not constrained by the SCT screen. Table 14 shows 2030 estimated baseline sales and cumulative technical, economic, and achievable potential by fuel type for scenario 3.2. The scenario results indicate 46 TBtu of achievable potential by 2030, corresponding to energy savings as a percentage of sales on an annual basis of 2.1%.

Table 14. Scenario 3.2 Cumulative Energy Efficiency Potential, 2021-2030

Fuel Type	2030 Estimated Sales (TBtu)	Technical Potential		Economic Potential		Achievable Potential	
		2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales	2030 (TBtu)	As a Percentage of Sales
Electricity	91	29	32%	25	27%	22	24%
Natural Gas	102	43	42%	23	22%	15	15%
Fuel Oil and Propane	44	18	41%	14	31%	8	18%
District Steam	3.8	0.7	17%	0.4	9%	0.2	6%
Total	**241**	**91**	**38%**	**62**	**26%**	**46**	**19.0%**

Table 15 shows the 2030 estimated baseline sales and the cumulative achievable potential for the three-, five-, and 10-year periods.

Table 15. Scenario 3.2 Cumulative Multifamily Achievable Energy Efficiency Potential

Fuel Type	2030 Estimated Sales (TBtu)	Total Achievable Potential as Percentage of Sales		
		3-Year	5-Year	10-Year
Electricity	91	5.7%	10.3%	24.2%
Natural Gas	102	3.0%	5.7%	15.1%
Fuel Oil and Propane	44	3.4%	6.7%	18.4%
District Steam	3.8	0.9%	2.0%	5.8%
Total	**241**	**4.1%**	**7.6%**	**19.0%**

The difference in achievable potential between this scenario (incentive set to deliver a six-year payback) and the previous scenario (3.1, constrained incentive) is driven by a subset of measures that have significantly more favorable customer economics and subsequently higher uptake in the presence of the higher incentive. Notable measures driving this difference include additional uptake of combustion optimization boiler controls and improved boilers and furnaces, basic shell upgrades (air sealing and windows), deep shell upgrades (air sealing, windows, and wall and ceiling insulation), and energy and heat recovery ventilators.

Achievable Potential Findings and Conclusions

The range of achievable potential estimates generated in this study indicate significant energy efficiency potential in the state's multifamily buildings. Cadmus offers several additional findings from our achievable potential scenario analysis:

- Many of the measures included in this study are mature, cost-effective, and offer an adequate project return to the customer even without incentives, such that all or most of the economic potential for these measures is achievable without offering incentives (including lighting, lighting controls, plug load upgrades, low-flow water fixtures, and various HVAC controls). Providing incentives for these measures in isolation may not significantly increase market adoption.
- On the other hand, measures with relatively high upfront costs (such as shell upgrades and energy or heat recovery ventilators) and those with significant market barriers may require incentives that cover more than half the incremental project cost, coupled with complementary market development support, in order to spur a meaningful increase in customer adoption. This category also likely includes electrification measures that fall outside the scope of this study.
- Future analysis and program design would benefit by considering incentives for bundled measure packages that combine deeper, more costly building energy improvements with low-cost measures such as lighting, allowing assessment of the impact on customer adoption.
- Additional scenario analysis is also warranted, as discussed in the *Areas for Future Analysis* section

Study Limitations

This study had two notable limitations: the limited availability of primary multifamily data and savings in instances of measure competition.

Primary Data Collection

In the *2019 Single-Family Potential Study*, site visits conducted as part of the single family *Residential Building Stock Assessment* comprised the highest level of detail used to inform study inputs. Multifamily site visits were not conducted for this potential study due to the COVID-19 pandemic. While NYSERDA has already begun its statewide multifamily baseline study to characterize the multifamily building stock, preliminary results were not available in time for Cadmus to incorporate into this current multifamily potential study. Instead, we relied on many inputs derived from dated or secondary sources to estimate potential, such as fuel shares, equipment shares, and measure saturations.[7] Future multifamily potential studies would benefit considerably from incorporating the forthcoming results of the ongoing NYSERDA statewide multifamily baseline study.

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[7] NYSERDA used fuel shares and equipment saturations to determine the building segmentation within their resource potential estimate.

Measure Competition

The BEEM tool has a mechanism integrated into the adoption algorithm to compare multiple measures. This mechanism is only included for determining achievable potential, so the technical and economic potentials *could* double-count potential for competing measures. Cadmus employed two strategies to avoid this issue:

- ***We limited the number of competing measures in the measure list.*** Of the 48 unique measures Cadmus considered in this potential study, only three compete with each other for the same installation priority: air sealing, basic shell measures (air sealing and window upgrades), and deep shell measures (air sealing, window upgrades, and ceiling and wall insulation). Often, potential studies will consider multiple tiers of efficiency for certain measures to capture the unique cost-effectiveness of each efficiency tier. For example, it is possible for a 95% efficient boiler to be cost-effective while a 98% efficient boiler is not. If a study includes both measures, the technical potential will capture the high savings of the 98% efficient boiler, while the economic potential will reflect the lower savings of the 95% efficient boiler. By contrast, if the study only includes the 98% efficient boiler, the technical potential will capture these savings, but the economic potential for boilers will be zero since the 98% boiler is not cost-effective. This logic can apply to many measures—shell improvements, HVAC improvements, and water heating equipment, among others.
- ***We forced competition shares using the technical feasibility factor.*** As noted in the first strategy above, only three measures in this potential study compete with each other for the same installation priority. Cadmus assumed a share between these three measures based on feasibility assumptions from a 2017 Navigant Consulting potential study (conducted for Con Edison).[8] Cadmus assumed technical feasibility of 50% for air sealing, 30% for basic shell measures, and 15% for deep shell measures. These forced competition shares apply to technical, economic, and achievable potential estimates.

Areas for Future Analysis

Over the course of this study, Cadmus and NYSERDA identified several areas where future analysis could provide interesting or enhanced findings of energy efficiency potential for multifamily buildings in New York State.

- ***Consider alternate approaches to modeling shell measures.*** In this study, window upgrades were packaged with ceiling and wall insulation upgrades. Window upgrades are comparatively less cost-effective than other shell measures, so packaging insulation with window upgrades degrades their cost-effectiveness and therefore their modeled adoption. Modeling insulation as a stand-alone measure would provide a better view of its individual cost-effectiveness and uptake.

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[8] Navigant Consulting. 2017. *2017 Distributed Energy Resources (DER) Potential Study*. Prepared for Consolidated Edison Company of New York. http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B59359020-BA53-4C6D-A79F-C7B5E2BF4BAE%7D

- ***Model measure packages that bundle deeper, more costly measures with highly cost-effective measures.*** For example, bundling building shell improvements with lighting and lighting controls would improve the cost-effectiveness of the bundled building shell measure package and subsequently increase adoption. In this way, total achievable potential could be increased through strategic measure bundling, informed by possible program design considerations.
- ***Model additional scenarios to assess how various policy options could impact adoption of energy saving measures.*** Scenarios could model additional incentive structures, with attention to both setting realistic incentive levels and to incorporating more granular assumptions regarding what economic return is likely to be acceptable for different types of decision makers (e.g., condo owners, rental building owners, tenants). Scenarios also could explicitly model achievable potential when incentives are delivered with complementary policy interventions that reduce market barriers or support technical innovation, as well as the impact of possible new regulatory requirements that could be set for products or buildings. Climate policy also may place upward pressure on the price of fossil gas and other fossil fuels, and such price dynamics could be incorporated into future scenario analysis.
- ***Consider modeling policy options to spur early replacement of inefficient appliances, equipment, and building systems.*** Targeting equipment at its end of life with an energy efficient replacement is an effective way to control costs, but it also takes longer to achieve high levels of penetration for the efficient solution. Alternatively, modeling could estimate achievable energy savings if incentives or regulatory policy options are designed to encourage building decision makers to replace inefficient equipment or upgrade building systems somewhat sooner than end-of-life replacement or other typical investment points.
- ***Consider modeling New York City Local Law 97, which sets annual greenhouse gas emissions limits for energy use in large buildings starting in 2024 and imposes fines on buildings that exceed the limits.*** This law could be modeled as a monetary incentive influencing customer adoption decisions and as an impetus for early upgrades of equipment and building systems.
- ***Integrate energy efficiency and building electrification into the same potential study.*** While energy efficiency and building electrification are often modeled separately as a simplifying assumption, they are inextricably linked. A customer will not simultaneously upgrade their full-sized boiler and convert to a heat pump. Considering how electrification is a critical component of meeting New York State energy goals, modeling electrification in competition with energy efficiency in a holistic manner could provide valuable insights.