Data-Driven Decarbonization: Cost-Effective Strategies for Electrifying New York's Multifamily Housing Stock

Maruti Anumulapalli, ICF
David Pudleiner, ICF
Nilus Klingel, NYSERDA
Ke Wei, NYSERDA

ABSTRACT

New York State's decarbonization goals require scalable and cost-effective strategies tailored to its diverse multifamily building stock. This study, commissioned by the New York State Energy Research and Development Authority (NYSERDA), evaluates energy-efficiency and electrification pathways for ten representative multifamily archetypes across downstate and upstate regions. Archetypes were developed using the NYSERDA Statewide Multifamily Building Stock Assessment and RetrofitNY Market Characterization Study, supplemented by New York City Local Law 87/84 audit data and NYSERDA Multifamily Performance Program records, capturing variations in building size, vintage, system type, and climate.

For each archetype, a suite of individual and bundled measures was modeled, including insulation upgrades, air sealing, boiler controls, and heat-recovery technologies. Multiple electrification pathways were assessed, including centralized (building-level) air-to-water air-source heat pumps (ASHPs), hybrid ASHP-boiler configurations, ground-source heat pumps (GSHPs), and decentralized in-unit heat-pump technologies. Scenarios were evaluated both with and without prior efficiency upgrades to quantify interactive effects, heating-load reduction, and implications for heat-pump performance.

Preliminary results indicate that electrification pathways achieved ~30-60% site-energy reductions depending on region, system configuration, and climate severity, while packaged efficiency measures alone provided ~20-35% savings. However, operating-cost (OpEx) outcomes did not consistently track energy savings. Tariff structure significantly influenced cost performance, with modeled OpEx impacts ranging from savings to increases even under similar energy-reduction levels. In several cases, shifting from direct-metered to master-metered tariffs increased OpEx savings by ~10-20%, underscoring the importance of rate design in electrification economics.

The practical guidance that emerges is twofold. First, because no single pathway is cost-effective across the stock, programs should be prepared to support a wide range of retrofit types matched to building typology. Second, metering configuration and utility rate design are decisive to whether electrification produces operating-cost savings or increases, so rate and metering policy warrant explicit consideration alongside technology selection. This detailed analysis offers data-driven support for policymakers, utilities, and building owners on designing cost-effective electrification pathways across New York's multifamily housing stock.

Introduction

New York State has established some of the most ambitious climate and decarbonization targets in the United States through the Climate Leadership and Community Protection Act (CLCPA), which mandates an economy-wide reduction in greenhouse gas (GHG) emissions of at least 85% by 2050 relative to 1990 levels (New York State 2019). Achieving these goals requires substantial emissions reductions from the building sector, which remains one of the largest sources of on-site fossil fuel combustion in the state (EIA 2023).

Multifamily buildings represent a critical segment of New York's building stock. They account for a significant share of residential floor area and energy use, particularly in dense downstate regions, while also housing a large proportion of low- and moderate-income households (NYSERDA 2022). At the same time, the multifamily sector presents unique challenges for decarbonization, including a large variety of building vintages, centralized and shared heating systems, split incentives between owners and tenants, and constraints related to capital planning and affordability.

Electrification of space and water heating, combined with targeted energy-efficiency improvements, has emerged as a central strategy for reducing building-sector emissions (Berrill et al. 2022). High-efficiency heat pump technologies, advanced controls, and envelope improvements can significantly reduce fossil fuel consumption while improving occupant comfort and resilience. However, the performance and cost-effectiveness of these measures vary widely across the multifamily stock. Differences in climate, existing system configurations, envelope conditions, building height, and regional market conditions all influence achievable savings and investment outcomes (NREL 2023).

To address this complexity, policymakers and program administrators increasingly rely on stock-based and archetype-driven modeling approaches to evaluate decarbonization pathways across large and diverse building populations (Reinhart and Davila 2016). Archetype modeling enables detailed representation of typical buildings while maintaining scalability, allowing analysts to assess individual and bundled measures, explore alternative technology pathways, and estimate energy, emissions, and cost impacts. When grounded in empirical building data, such approaches show how strategies perform across building types and regions and how programs can reflect realistic equipment lifetimes, capital planning cycles, and phased retrofits (Pudleiner et al. 2018).

This paper presents results from the NYSERDA's Multifamily Decarbonization Pathway Study, which applies an archetype-based building energy modeling framework to evaluate electrification and energy-efficiency strategies across New York State's multifamily housing stock. Ten representative archetypes were developed to capture variation in building size, vintage, system configuration, and geographic location across both downstate and upstate regions. The archetypes were informed by detailed datasets from NYSERDA Statewide Multifamily Building Stock Assessment, New York City Local Law 87 audit and Local Law 84 benchmarking submissions, and NYSERDA's Multifamily Performance Program (NYC Mayor's Office 2021; NYSERDA 2022; NYSERDA 2023).

Using these archetypes, the study evaluates standalone efficiency upgrades, partial (hybrid) electrification, and full electrification scenarios. Measures analyzed include envelope improvements, air sealing, advanced controls, heat-recovery technologies, and air-to-water air-source, in-unit mini-split, and ground-source heat pump configurations. Importantly, the analysis also considers phased and hybrid pathways that align with realistic equipment replacement timelines and capital planning cycles, recognizing that most multifamily buildings will transition incrementally rather than through a single comprehensive retrofit (Moe and Gibbs 2023).

By quantifying energy savings and cost impacts across these pathways, this study seeks to inform the design of cost-effective and scalable multifamily decarbonization strategies in New York State. Because this paper reports results through energy, operating-cost analysis and simple payback periods, cost-effectiveness in this study refers specifically to tariff-informed operating-cost outcomes, providing a data-driven view of how electrification strategies perform under real utility rate conditions.

Methodology

This study evaluates electrification and energy-efficiency pathways for New York State's multifamily building stock using an archetype-based simulation approach. The methodology is organized into four steps: (1) archetype and pathway development; (2) baseline and measure-level energy modeling; (3) operating cost (OpEx) analysis under alternative tariff structures; and (4) Financial modeling. This sequence mirrors how program designers and building owners typically move from building characterization to technology selection and then to economic decision-making.

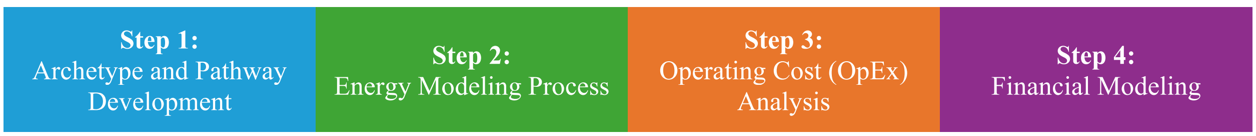

Figure 1. Summary of steps in the approach utilized to perform multi-family decarbonization pathway study

Step 1: Archetype and Pathway Development

First, archetype development began with statewide multifamily stock characterization resources and targeted datasets that provide higher-resolution building system information. Building stock characterization was derived from the 2022 NYSERDA Statewide Multifamily Building Stock Assessment (SMBS), which compiled multifamily building and equipment characteristics through surveys and site visits conducted across New York State (NYSERDA 2022). Building population counts by size category and climate zone were extracted directly from Section 1 of the report, documenting approximately 129,611 multifamily buildings across four IECC climate zones. To reframe the stock on a dwelling-unit basis, average unit counts per building were derived for each size tier, calibrated to the reported statewide total of approximately 2.6 million dwelling units (approximately 9, 22, and 89 units per building for low-, mid-, and high-rise, respectively). These derived unit counts were applied to the NYSERDA building population counts to produce the dwelling-unit-weighted distributions reported throughout this analysis.[1]

Across all climate zones, low-rise buildings (1-3 stories) represent the largest share of the multifamily building stock by count, accounting for approximately 52% of buildings statewide. However, when characterized on a dwelling-unit basis, a more meaningful metric for assessing decarbonization scale and retrofit impact, the distribution shifts dramatically. Mid-rise buildings account for approximately 46% of all multifamily dwelling units statewide (compared to 42% of buildings), followed by high-rise buildings at roughly 31% (compared to just 7% of buildings), while low-rise buildings, despite being the most numerous building type, represent only about

[1] Dwelling-unit distributions were estimated by applying derived average unit counts to NYSERDA SMBS 2022 building population counts (page 29, Section 1), calibrated to the reported statewide total of approximately 2.6 million multifamily dwelling units. Unit counts are derived estimates; unit-level breakdowns by building size and climate zone are not directly reported in the NYSERDA SMBS.

23% of total dwelling units (compared to 52% of buildings). This inversion, where high-rise buildings constitute just 7% of the building stock yet house nearly a third of all multifamily residents, underscores the outsized importance of taller building types in any statewide decarbonization strategy.

Regional differences are equally pronounced on both a building count and dwelling-unit basis. New York City alone accounts for approximately 76% of all statewide multifamily dwelling units. Within NYC, mid-rise buildings represent roughly 62% of buildings but 54% of dwelling units, while high-rise buildings account for 11% of buildings yet 37% of dwelling units. Low-rise buildings, which make up 27% of NYC buildings, account for less than 10% of dwelling units within the city. In contrast, upstate climate zones present a markedly different profile: low-rise buildings account for approximately 90% of buildings and roughly 72% of dwelling units within the zone, with mid-rise and high-rise buildings representing only 19% and 9% of units respectively.

Building vintage further differentiates the stock. Pre-1940 construction constitutes a substantial share of mid- and high-rise buildings, particularly in downstate regions, whereas post-war construction dominates much of the low-rise upstate stock. Among 4-7 story buildings statewide, pre-1940 construction accounts for the majority, while post-1980 represents a small share. These trends reflect the prevalence of older, centrally heated multifamily buildings downstate and newer, lower-rise configurations upstate.

Downstate archetype selection emphasized NYC-relevant building types and vintages. To strengthen downstate characterization, statewide stock data were triangulated with NYC-specific Local Law 87 audit and Local Law 84 benchmarking datasets to identify representative, high-prevalence typologies (NYSERDA 2022; NYC Open Data 2025). Upstate archetypes relied primarily on statewide stock characterization and Cadmus survey and site-visit-based system data for Climate Zones 5 and 6, supplemented by NYSERDA Multifamily Performance Program (MPP) data (NYSERDA 2016; NYSERDA 2022). Where an upstate archetype closely matched a downstate typology in physical form and system configuration, the downstate geometry and assumptions were adapted using region-specific weather files and calibration targets.

Based on this quantitative stock characterization, ten representative multifamily archetypes were selected to capture dominant combinations of region, building height, vintage, and heating system type across the state. Collectively, these archetypes reflect the majority of multifamily buildings by count and encompass the system configurations most relevant to near-term decarbonization policy and program design. A standalone archetype figure is omitted for space; Figure 2 in the following section presents the ten archetypes and their evaluated pathways.

Step 1.1 Defining Pathway Terminology

Centralized (building-level) pathways replace or supplement a building's central heating plant and deliver heating (and cooling) to multiple dwelling units through shared hydronic distribution. In this study, the centralized electrification pathways use air-to-water (air-source) heat pumps (ASHPs)-and, in two upstate cases, ground-source heat pumps (GSHPs)-that produce hot or chilled water circulated through the building's existing or converted hydronic loop. Throughout this paper, "ASHP" therefore refers to an air-to-water (air-source) heat pump serving central hydronic distribution, rather than a unitary air-to-air system. The centralized pathways comprise the hybrid ASHP+boiler configuration, the full low-temperature ASHP (100%), and the GSHP.

For the steam-heated archetypes (Archetypes 1 and 6), both the hybrid and the full low-temperature ASHP pathways assume conversion of the existing steam distribution to a low-temperature hot-water loop, because an air-to-water heat pump cannot serve steam emitters. In the hybrid case, the boiler remains on the converted loop for peak and cold-snap capacity. For the archetypes already served by hot-water hydronic distribution (Archetypes 4 and 9), the hybrid pathway instead uses the boiler for thermal lift, raising the ASHP's low-temperature hot water to the existing setpoint so the distribution and terminal units can be reused. Only the full low-temperature ASHP (100%) pathway operates the loop at low supply temperature and therefore assumes distribution and terminal-unit upgrades.

Decentralized (in-unit) pathways install equipment in or serving individual dwelling units and are typically tenant-metered. These include ductless mini-splits, cold-climate packaged terminal heat pumps (ccPTHPs), saddle window heat pumps, and, for converted single-family homes, a whole-home heat pump.

For each archetype, four to five decarbonization pathways were defined using market-ready technologies matched to its distribution system, unit configuration, and retrofit constraints. Centralized pathways apply where building level shared steam or hydronic distribution exists, with GSHP limited to the upstate hydronic mid-rises where ground-loop siting is plausible. Decentralized options follow unit and facade characteristics. Ductless mini-splits serve units with adequate interior wall space, though line-set routing and outdoor-unit siting can be constraints in larger buildings, while saddle window heat pumps, an emerging option with strong market interest that serve space-constrained units, including the electric-baseboard archetypes. Where existing through-wall sleeves or fan-coil closets can be reused, ccPTHPs apply, and the converted single-family archetype uses a whole-home heat pump. Figure 2 illustrates the electrification strategies evaluated across the ten multifamily building archetypes.

Archetype	Sq Ft	Stories	CENTRALIZED PATHWAYS			DECENTRALIZED PATHWAYS			
			ASHP Hybrid (Boiler at Peak / High Temp)	Full Low-Temp ASHP (100%)	GSHP	Ductless Mini-Split	Saddle Window Heat Pump	ccPTHP	Whole-Home Heat Pump
DOWNSTATE **1. Pre-war steam** 1-Pipe Steam | Boiler | Window AC	32,500	5 (mid-rise)	✓	✓	–	✓	–	–	–
DOWNSTATE **2. Post-war 2-pipe steam** 2-Pipe Steam | Boiler | Window AC	32,500	5 (mid-rise)	✓	✓	–	–	✓	–	–
DOWNSTATE **3. Post-war hot-water hydronic** Hot Water | Boiler | Thru-wall AC	32,500	5 (mid-rise)	✓	✓	–	–	–	✓	–
DOWNSTATE **4. Post-war fan-coil** Terminal Unit w/ Fan Coil | Boiler | DX	130,263	15 (high-rise)	✓	✓	–	–	–	✓	–
DOWNSTATE **5. Post-war electric-baseboard** Electric Baseboard | Window ACs	96,259	12 (high-rise)	–	–	–	✓	✓	–	–
UPSTATE **6. Pre-war steam (CZ5)** 1-Pipe Steam | Boiler | Window ACs	32,500	5 (mid-rise)	✓	✓	–	✓	–	–	–
UPSTATE **7. Converted single-family home** Forced Air | Furnace | Window ACs	4,000	3 (low-rise)	–	–	–	Hybrid + Mini-Split ✓	–	–	✓
UPSTATE **8. Electric-baseboard apartments** Electric Baseboard | Window ACs	15,000	3 (low-rise)	–	–	–	✓	✓	–	–
UPSTATE **9. Post-war hot-water hydronic** Hot Water | Boiler | Window ACs	32,500	5 (mid-rise)	✓	✓	✓	✓	–	–	–
UPSTATE **10. Post-war hydronic (very cold, CZ6)** Hot Water | Boiler | Window ACs	32,500	5 (mid-rise)	✓	✓	✓	✓	–	–	–

✓ Centralized pathway evaluated ✓ Decentralized pathway evaluated Hybrid + Mini-Split = Hybrid Mini-Split with Furnace

Figure 2. Multifamily Building Archetypes and Evaluated Decarbonization Pathways

Step 2. Energy Modeling Process

Step 2.1 Baseline model characterization and calibration

For each archetype, a baseline energy model was developed to represent existing (pre-retrofit) conditions. Baseline models incorporated archetype-specific geometry, envelope thermal performance, occupancy and internal gains assumptions, HVAC system type and efficiency, ventilation and exhaust configurations, and domestic hot water (DHW) system characteristics. These baseline conditions were intended to reflect typical multifamily building performance at the archetype level, rather than replicating any individual building.

Downstate baseline calibration relied on NYC benchmarking and audit-derived datasets-Local Law 87 energy audit data and Local Law 84 benchmarking records-to align modeled site energy use intensity (EUI) and end-use distributions (space heating, DHW, and common-area electricity) with observed ranges for comparable typologies (NYC Open Data 2025). For upstate archetypes, baseline targets were informed by statewide stock characterization and system saturation data from NYSERDA's Statewide Multifamily Building Study, supplemented by available Multifamily Performance Program (MPP) data (NYSERDA 2016; NYSERDA 2022). Where an upstate archetype closely matched a downstate type in form and system configuration, the downstate model was adapted using an appropriate upstate weather file and region-specific EUI and system assumptions.

Envelope thermal assumptions including baseline wall and roof construction types, insulation levels, and vintage-dependent performance were aligned with typology-level guidance from the NYSERDA RetrofitNY Market Characterization Study to ensure consistency with New York-specific multifamily construction profiles and feasible retrofit conditions (NYSERDA 2020).

Calibration in this study was not intended to replicate ASHRAE Guideline 14-style utility bill calibration for individual buildings. Instead, baseline models were tuned to align with archetype-level EUI and end-use expectations derived from the referenced datasets and program records, ensuring that baseline performance was representative of typical existing conditions and suitable for comparative assessment of efficiency and decarbonization pathways.

Step 2.2 Standalone Energy Efficiency (EE) Measures

A suite of standalone energy efficiency (EE) measures was modeled to quantify energy savings attributable to envelope, controls, and heat-recovery improvements prior to electrification or fuel-switching. Each measure was first applied individually to the calibrated baseline to quantify its marginal effect on site energy use, end-use consumption, reduced loads, and heating demand, enabling comparison of the relative effectiveness of these strategies across building vintages, forms, and system types. The measures modeled were:

- Wall insulation
    - Internal insulation approaches for pre-war buildings with no wall cavity
    - Cavity insulation for post-war construction with nominal 2 to 3-inch cavities
    - Over-cladding strategies for high-rise configurations where applicable
- Roof insulation
- Air sealing (infiltration reduction)

- Boiler smart controls
- Exhaust heat recovery (applied to high-rise archetypes where appropriate)
- Packaged efficiency (wall + roof + air sealing + boiler controls + heat recovery, as applicable).

Following the individual simulations, all applicable EE measures for each archetype were modeled as a packaged bundle to capture interactive effects among measures. These interactions include, for example, improvements to building envelope reducing overall heating and cooling loads such that upgraded mechanical systems operate at lower capacity factors, or combined infiltration and insulation upgrades jointly reducing internal heat gains and peak cooling demand more effectively than either measure in isolation. The packaged EE bundle therefore represents a realistic deep-efficiency retrofit scenario consistent with market practice.

The resulting packaged EE pathway served as the efficiency-optimized baseline for subsequent electrification and decarbonization pathways evaluated in later steps. By applying HVAC electrification measures both with and without prior EE upgrades, the analysis was able to assess tradeoffs between efficiency-first and HVAC-first strategies, including impacts on energy savings, equipment sizing, capital costs, and operating costs.

Step 2.3 Packaged Energy Efficiency and HVAC (Electrification) Pathways

Following the standalone energy efficiency analysis, HVAC electrification measures were evaluated both in combination with the packaged EE bundle and directly on the calibrated baseline to assess combined and HVAC-only decarbonization pathways. This approach captures key interactive effects, such as reduced HVAC capacity from envelope and infiltration improvements, while isolating the impacts of fuel switching and equipment efficiency alone.

This framework enables direct comparison among three strategy types: standalone energy efficiency (EE), HVAC-only electrification-first pathways, and packaged EE + HVAC efficiency-first pathways. Comparing these cases highlights differences in energy savings, equipment sizing, capital costs, and operating-cost outcomes. Additionally, it provides insight into the tradeoffs between pursuing electrification without prior load reduction versus sequencing efficiency and electrification to reduce peak loads, right-size replacement equipment, and improve overall retrofit economics.

Step 3: Operating Cost (OpEx) Analysis

Operating costs were evaluated using representative utility rate structures reflecting common multifamily metering arrangements. Under direct metering, each dwelling unit has its own electric meter billed to the tenant under residential volumetric service (NY Engineers 2025), while common-area and central-plant electricity is metered separately and billed to the building owner under general (commercial) service. Under master metering (multiple-dwellings redistribution), the entire building is served by one owner-held electric meter-typically on a demand-based rate with the owner paying all electricity and allocating costs to tenants through submetering. Direct metering is treated as the reference configuration because the 2022 NYSERDA Statewide Multifamily Building Stock Assessment found that approximately 82% of multifamily dwelling units statewide are direct-metered for electricity (NYSERDA 2022).

This metering boundary governs how each retrofit shifts costs between owners and tenants. Decentralized pathways place in-unit heating and cooling electricity on tenant meters, whereas centralized pathways concentrate the incremental electricity in owner-metered common areas, so the metering configuration interacts strongly with pathway type. Because residential volumetric rates differ from demand-based rates, the same modeled energy use can produce materially different operating costs under the two configurations, an effect examined directly in the results.

Tariff inputs were sourced from publicly available utility rate schedules and service classification documentation. Electric utility rates for downstate archetypes were based on Consolidated Edison Company of New York tariff schedules (Con Edison 2025). Upstate electric rates were based on Niagara Mohawk Power Corporation (NMPC 2025) and New York State Electric & Gas Corporation (NYSEG 2025) tariff schedules by service territory. Natural gas[2] rates for both downstate and upstate archetypes were based on National Grid (National Grid 2025) tariff schedules. By distinguishing direct- and master-metered configurations and their associated rate structures, the analysis isolates the contribution of tariff type and demand charges to overall operating cost outcomes, separate from consumption-driven effects.

Step 4: Financial Modeling

Capital costs were developed from an all-in installed-cost perspective (equipment, labor, demolition and removal, construction and integration, and design and engineering fees) and normalized per square foot to support cross-archetype comparison. Operating-cost savings were computed on two bases consistent with the metering configurations defined in Step 3: a direct-meter basis, comparing each pathway to the direct-metered baseline (the configuration applicable to the approximately 82% of dwelling units that are direct-metered), and a meter-switch basis, comparing the direct-metered baseline to the pathway operated under master metering, which represents an owner who converts to master metering at the time of electrification.

From these inputs, simple payback was calculated as capital cost divided by first-year operating-cost savings on each basis, with no payback reported where savings are non-positive. Together, these metrics compare each pathway from a building-owner perspective on first cost and operating-cost recovery.

Results Discussion:

The Results Discussion section focuses on five representative multifamily archetypes selected from the broader modeling set to illustrate decarbonization outcomes across New York State.

- Downstate pre-war steam (Archetype 1)
- Upstate pre-war steam in CZ5 (Archetype 6)-Direct Comparison to Archetype 1
- Downstate very-high-rise hydronic with fan coil units (Archetype 4)
- Upstate post-war mid-rise hydronic in CZ5 (Archetype 9)-Similar Comparison to Archetype 4
- Upstate low-rise “converted home” with in-unit forced-air furnace (Archetype 7).

These archetypes were chosen because they represent predominant building types within their respective climate zones and collectively capture a wide range of system configurations and

[2] This analysis considers natural gas as the sole fossil fuel source across all archetypes evaluated. Other fossil fuel types-including fuel oil and steam-will be incorporated in future work.

building scales, including downstate and upstate locations, steam and hydronic distribution systems, centralized and in-unit heating, and low-, mid-, and very-high-rise forms. Together, the selected archetypes reflect a substantial share of multifamily floor area and energy use while exhibiting distinct baseline energy drivers, peak demand characteristics, and retrofit constraints. Constraints include existing distribution type, envelope conditions and the space for new equipment. Results for archetypes not shown in detail follow similar directional trends. These five cases illustrate the range of technical and economic responses observed across the analysis.

Baseline Energy Performance and Energy Efficiency (EE) Results

Baseline site EUIs across the five archetypes range from 78.5 to 107 kBtu/sf, driven primarily by space heating, which represents 41-58% of baseline EUI depending on climate and system type, with domestic hot water contributing a consistent secondary load of approximately 15-20%. These two end uses together explain why electrification strategies targeting both space heat and DHW consistently produce the largest site-EUI reductions.

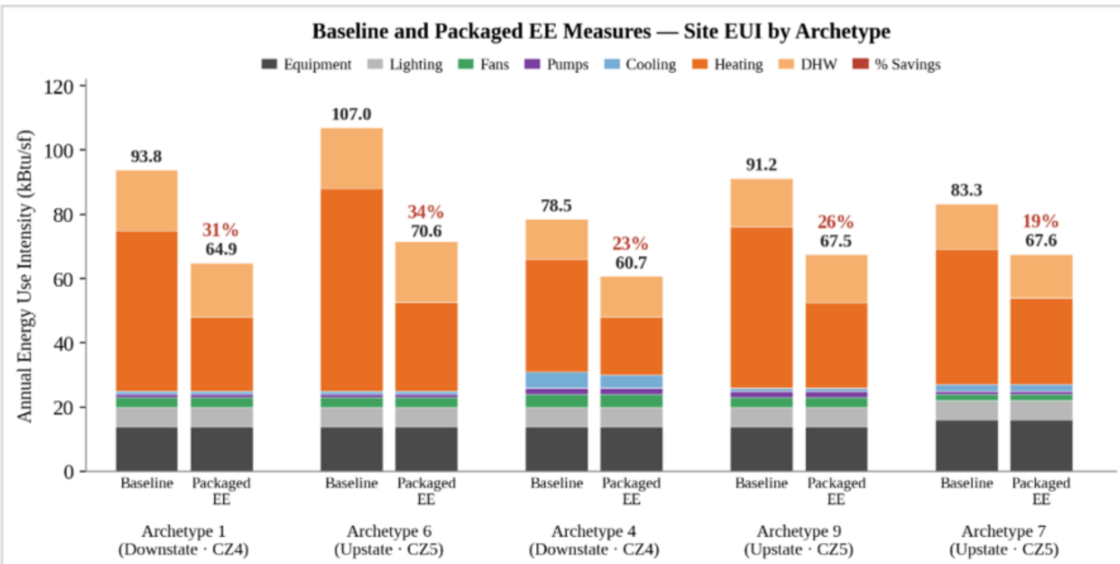

Figure 3. Baseline vs Packaged EE measure energy across selected five archetypes.

Standalone EE measures deliver meaningful but incremental savings, whereas the packaged bundle achieve 20-35% site EUI reductions depending on building type and climate (Figure 3). Among individual measures, air sealing produces the most consistent savings across archetypes (13-18%), particularly in steam and hydronic buildings, while insulation and boiler smart controls contribute more modest incremental gains. Packaged efficiency measures outperform individual measures but yield savings that are lower than the simple sum of standalone estimates because each measure reduces the available savings baseline for the next. Overall, efficiency measures are most effective at reducing site EUI when implemented as coordinated packages, particularly in older and colder-climate buildings. Results for the individual measures in each archetype are reported in full study. Envelope and air-sealing measures also deliver non-energy benefits, including improved thermal comfort and reduced drafts and outside noise. While EE alone does not achieve deep decarbonization, it plays a critical supporting role by reducing heating demand and improving the performance and reliability of electrification pathways examined in the following section.

Electrification pathways

Electrification produces considerably deeper savings than efficiency alone. Whereas the packaged EE bundle reduces site EUI by 20-35%, the electrification pathways reach 30-60% relative to baseline, depending on archetype and pathway (Figure 4). Sequencing efficiency ahead of electrification adds a further 8-12 percentage points beyond the electrification-only result.

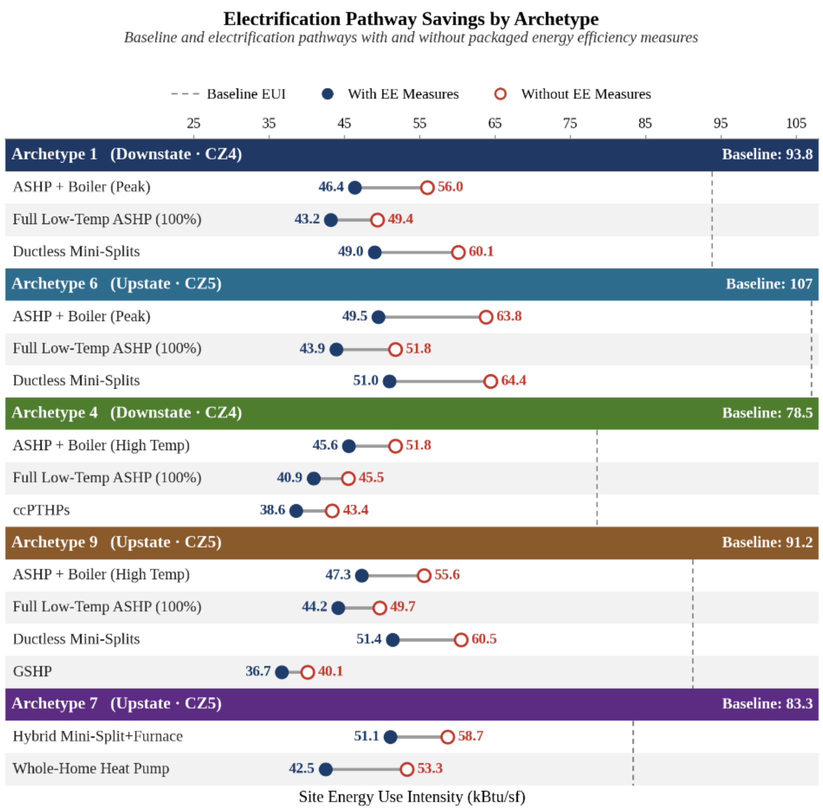

Figure 4. Electrification pathway measure savings for each archetype over its baseline.

The compounding effect of EE on electrification performance is most pronounced in steam systems (Archetypes 1 and 6), where hydronic conversion to low-temperature hot water reduces heating load by 10-18%, directly curtailing backup boiler operation in hybrid configurations. Upstate steam (Archetype 6) achieves the highest savings ceiling of any archetype evaluated, with the 100% low-temperature ASHP pathway reaching 59% site EUI reduction with EE. The upstate mid-rise hydronic building (Archetype 9) shows the widest pathway spread, with GSHP reaching 60% savings while mini-splits trail at 44%-illustrating that pathway selection matters as much as building type in colder climates.

Two archetypes stand out at opposite ends of the performance range. In the high-rise fan coil building (Archetype 4), ccPTHPs achieve savings competitive with full ASHP conversion (51% vs. 48% with EE), suggesting that the least disruptive retrofit option need not compromise performance. At the other end, the converted home archetype (Archetype 7) consistently shows the lowest savings ceiling, where EE investment has a proportionally larger impact on outcomes than pathway selection alone.

Operating cost (OpEx) results

Across the five representative archetypes, operating-cost (OpEx) outcomes diverge from site energy savings because cost impacts depend on fuel price differentials, tariff structure, and peak demand, not energy use alone. Results are reported against a single reference (the direct-metered baseline defined in Step 3) under two configurations: a direct-meter case, in which the retrofit remains direct-metered (the status quo for roughly 82% of dwelling units), and a meter-switch case, in which the building converts to master metering at the time of electrification.

As shown in Figures 5-7, the most consequential finding is that under direct metering, every electrification pathway in every archetype increases annual operating cost. With packaged EE, the increases range from roughly 5% to 8% for the centralized pathways in the downstate archetypes (Archetypes 1 and 4), to 13% to 19% in the upstate steam building (Archetype 6), and about 25% for the centralized pathways in the upstate mid-rise (Archetype 9), and they are larger still without EE. Energy efficiency consistently offsets roughly half of the direct-meter penalty; for example, the ASHP+boiler hybrid in Archetype 1 improves from -19.2% to -5.4%. The decentralized mini-split pathways show the largest direct-meter increases of all (-22% to -40% with EE), reflecting in-unit electricity billed at residential volumetric rates. Because direct metering is the configuration most of the stock currently uses, this result indicates that electrification under prevailing residential rates raises operating costs across the board.

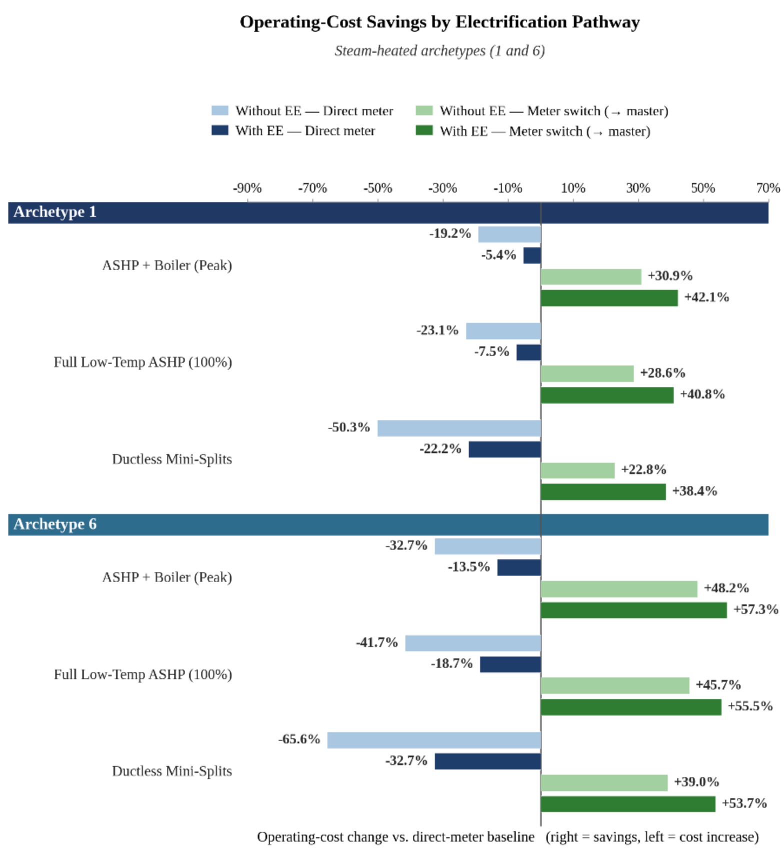

Figure 5. Operating cost savings for steam buildings with electrification pathways.

Metering structure emerges as a material driver of the economic case for electrification. Benchmarking master-meter costs against the direct-meter baseline reflects the full benefit of converting to master metering and electrifying simultaneously.

The meter-switch case turns every pathway into a substantial operating-cost saving relative to the direct-meter baseline, with roughly 38% to 42% savings with EE in the downstate steam building, 54% to 57% in the upstate steam building, 39% to 44% in the downstate high-rise, and 51% to 64% in the upstate mid-rise (with the upstate GSHP pathway the strongest at 64%). The swing between the two configurations-on the order of 50 to 90 percentage points for most pathways-shows that the direct-to-master transition, rather than the equipment pathway, is the dominant lever on operating-cost outcomes, and that metering and rate design warrant explicit treatment in electrification planning.

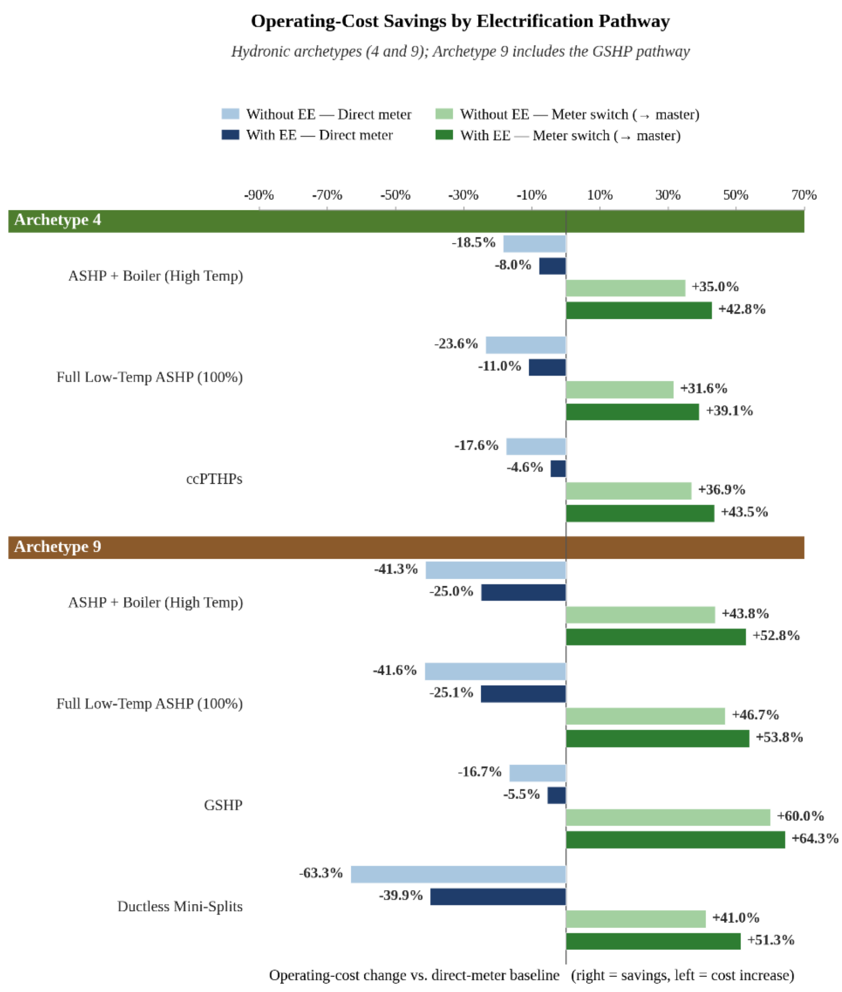

Figure 6. Operating cost savings for hydronic buildings with electrification pathways.

Archetype 7-representing a converted home with an in-unit furnace-is the most adverse case and is reported on a direct-metered basis only, as master metering does not apply to this building type (Figure 7). Operating cost increases under both pathways with and without EE-from 42% to 60% with EE-driven by the higher residential electricity rate that replaces lower-cost gas in a building with a high exterior-surface-to-floor-area ratio. The EE measures still deliver their own savings, but cannot offset the rate and fuel-cost penalty that electrification imposes in this configuration.

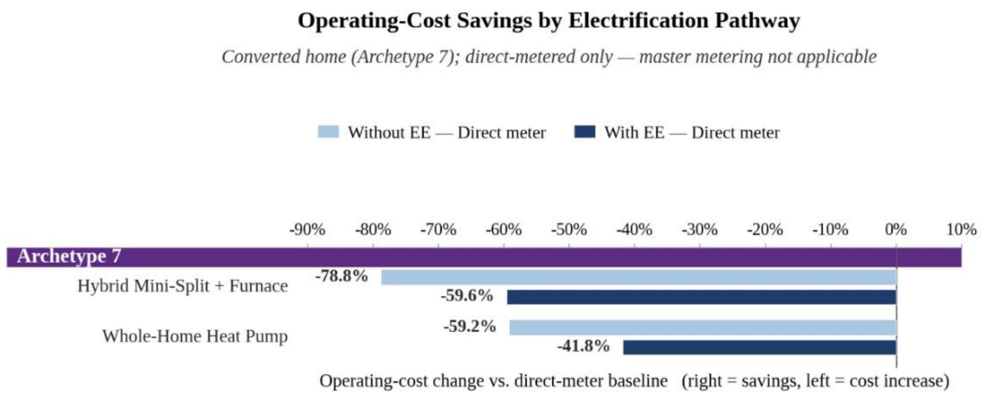

Figure 7. Operating cost savings for single-family style building with electrification pathways.

Financial Modeling:

Capital costs were developed from an all-in installed-cost perspective using prior project experience, cost-estimator input, and published unit-cost data, and are reported per square foot to support cross-archetype comparison. Actual retrofit costs vary widely with building condition, site access, and market factors. Installed costs span a wide range (Figure 8). The steam-heated archetypes (Archetypes 1 and 6) carry high costs-roughly $65 to $76/sf with EE for the centralized pathways-because the steam-to-hydronic conversion is a major cost element, consistent with field experience that steam buildings are among the costliest to electrify. The full 100% ASHP retrofit of the downstate high-rise (Archetype 4) is the most capital-intensive option at about $104/sf, while the lowest-cost centralized retrofit is the ASHP-and-boiler hybrid in the upstate mid-rise (Archetype 9) at roughly $24/sf, which reuses the existing hydronic distribution. Decentralized pathways are generally less capital-intensive than full centralized conversions. Adding the packaged EE bundle raises installed cost by a broadly consistent increment across archetypes.

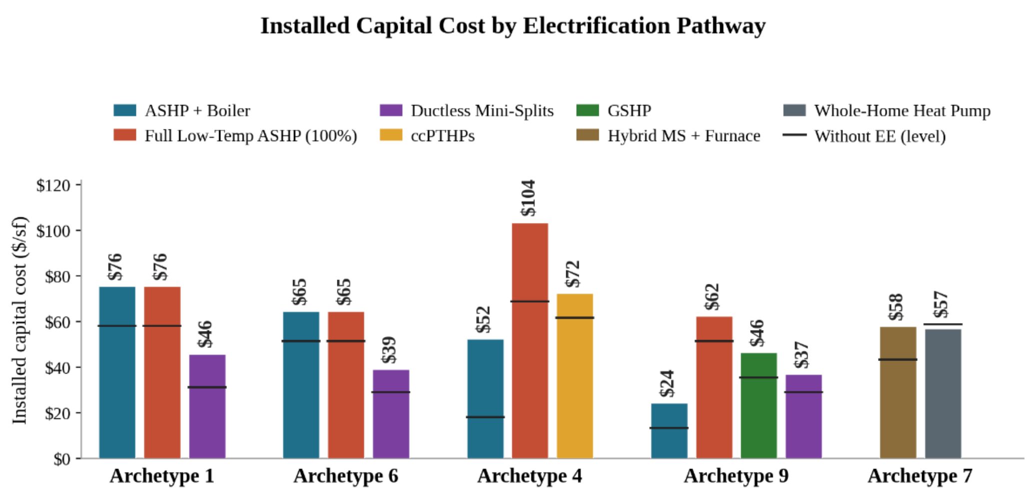

Figure 8. Installed capital cost ($/sf) for pathways with & without energy efficient measures.

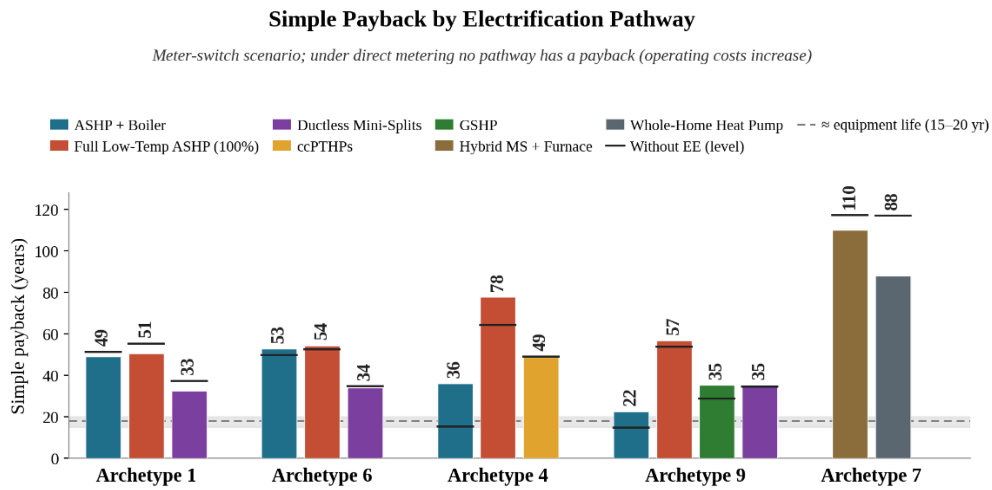

Figure 9. Simple payback analysis based on CapEx ($/sf) and OpEx Savings ($/sf) from Meter-switch scenario.

Because operating costs increase under direct metering for every pathway (Step 3), no pathway has a simple payback on the direct-meter basis; payback exists only under the meter-switch scenario (Figure 9). Even then, periods are long: most exceed 20 years, and many exceed the expected 15-20 year service life of heat-pump equipment by a factor of three or more (roughly 49-55 years for the centralized steam-archetype pathways and 88-110 years for the converted home). The shortest paybacks track the lowest-capital retrofits: about 15-22 years for the upstate mid-rise ASHP-and-boiler hybrid and roughly 33-35 years for the in-unit and ground-source options. Simple payback excludes maintenance and mid-life replacement, so these figures are upper-bound indicators of relative pathway economics rather than investment guidance. The standalone EE bundle carries no fuel-switching penalty and, under the meter-switch scenario, recovers its cost far sooner than the electrification pathways.

Conclusion:

This study demonstrates that archetype-based modeling can characterize the technical and economic complexity of multifamily decarbonization at scale. The analysis of five representative archetypes points to two conclusions that hold across the cases examined. First, no single electrification pathway is best for all buildings: energy savings, capital cost, and operating cost vary with climate zone, distribution system, and building scale, so the most appropriate strategy differs by archetype. Efficiency measures play a consistent supporting role, reducing heating demand and improving heat-pump performance, but on their own do not determine the economic outcome. Analyzed in isolation, the efficiency bundle carries no fuel-switching penalty, and paired with a change in metering, recovers its cost far sooner than the electrification pathways reported here.

Second, and more consequential, metering configuration and rate design are decisive for the economics of electrification. Under the direct-metered residential rates that apply to most of the stock, every electrification pathway examined increases annual operating cost, and the packaged efficiency bundle reduces but does not reverse that increase. However, converting to master metering at the time of electrification turns the same retrofits into substantial operating-cost savings. Capital costs are high, and the resulting simple paybacks, applicable only under the meter-switch scenario, generally exceed the service life of the equipment, so these pathways are not justified by utility-bill savings alone under current conditions.

The utility-bill lens, however, is not the only one that matters. In New York City, Local Law 97 imposes escalating penalties on building emissions above tightening intensity limits, and the CLCPA establishes comparable statewide decarbonization expectations (NYC LL97 2019; New York State 2019). The pathways modeled here cut building emissions substantially, moving buildings below the intensity thresholds that would otherwise trigger penalties. Viewed this way, the relevant economic question shifts from utility-bill payback toward avoided carbon penalties and compliance value. Such policies, together with any available incentives and rebates for electrification and decarbonization that lower net capital cost and shorten paybacks, can act as a catalyst that moves marginal pathways from net cost toward net benefit.

New York State's multifamily stock is diverse (in age, system type, and ownership structure), meaning that uniform decarbonization mandates may create unintended consequences; in practice, solutions must be tailored to each building and site. This study offers a basis for utilities, policymakers, and building owners to work from the same data, recognizing that energy analysis and detailed financial modeling are foundational to whether electrification pencils out in practice. The analysis presented here is a subset of a larger study; expanded results across all archetypes and pathways, with detailed financial modeling and incentive analysis, will be available in a forthcoming NYSERDA report.

References

Berrill, P., E. J. H. Wilson, J. L. Reyna, A. D. Fontanini, and E. G. Hertwich. 2022. "Decarbonization pathways for the residential sector in the United States." Nature Climate Change 12 (8): 712-718. https://doi.org/10.1038/s41558-022-01429-y

EIA (Energy Information Administration). 2023. State Energy Data System (SEDS): New York. Washington, DC: EIA. https://www.eia.gov/state/seds/seds-data-complete.php?sid=NY

Moe, A., and P. Gibbs. 2023. Equitable Electrification Analysis for Existing Buildings in Richmond, California. Golden, CO: National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy23osti/86954.pdf

New York City Mayor's Office of Climate & Environmental Justice. 2021. Local Law 87 Energy Audit Data. New York, NY. https://data.cityofnewyork.us/Environment/LL87-Energy-Audit-Data/au6c-jqvf

New York State. 2019. Climate Leadership and Community Protection Act. Albany, NY. https://climate.ny.gov/

NREL (National Renewable Energy Laboratory). 2023. ResStock and ComStock Methodology Documentation. Golden, CO. ResStock: https://resstock.nrel.gov/
ComStock: https://www.nrel.gov/buildings/comstock

NYSERDA (New York State Energy Research and Development Authority). 2022. Statewide Multifamily Building Study. Albany, NY.

https://www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Building-Stock-and-Potential-Studies/Statewide-Multifamily-Building-Study

NYSERDA (New York State Energy Research and Development Authority). 2023. Multifamily Performance Program Impact Evaluation. Albany, NY. https://www.nyserda.ny.gov/About/Publications/Evaluation-Reports/Multifamily

Pudleiner, D., A. Bennett, and A. Grossberg. 2018. "A customizable framework for large-scale portfolio analysis through cloud-based building energy modeling." In Proceedings of the 2018 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, DC: ACEEE. https://www.aceee.org/files/proceedings/2018/data/papers/12_011.pdf

Reinhart, C. F., and C. Cerezo Davila. 2016. "Urban building energy modeling-A review of a nascent field." Building and Environment 97: 196-202. https://doi.org/10.1016/j.buildenv.2015.12.001

NYC Open Data. 2025. "LL87 Energy Audit Data." https://data.cityofnewyork.us/Environment/LL87-Energy-Audit-Data/au6c-jqvf

NYSERDA. (New York State Energy Research and Development Authority). 2020. RetrofitNY Market Characterization Study: Building Stock Assessment and Architectural Profiles of Predominant New York State Multifamily Building Types. Report 20-20. https://www.nyserda.ny.gov/-/media/Project/Nyserda/files/Programs/RetrofitNY/20-20-NYSERDA-Market-Characterization-Report-SU-Pratt.pdf

NYSERDA (New York State Energy Research and Development Authority). 2016. Multifamily Performance Program. Albany, NY. https://www.nyserda.ny.gov/ny/MPP-Existing-Buildings/Document-Library/

NY(NEARBY) Engineers. 2025. Overview of Electricity Rates in NYC, New York City, NY. https://www.ny-engineers.com/blog/overview-of-electricity-rates-in-nyc

Con Edison (Consolidated Edison Company of New York). 2025. "Rates & Tariffs" https://www.coned.com/en/rates-tariffs/rates

National Grid.2025. "Service Rates" https://www.nationalgridus.com/NY-Home/Bills-Meters-and-Rates/Service-Rates

NMPC (Niagara Mohawk Power Corporation), 2025, PSC Tariff Supplements https://ets.dps.ny.gov/ets_web/search/presearch.cfm

NYSEG (New York State Electric& Gas Corporation), 2025, PSC Tariff Supplements https://ets.dps.ny.gov/ets_web/search/presearch.cfm

NYC LL97 (New York city Local Law 97), 2019, NYC Buildings, New York, NY. https://www.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2022GAP_Chapter3_MaintenanceWBwm.pdf&section=conscode_2022#page=31