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2024 Steam Decarbonization Study
& Implementation Plan

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i. Executive Summary

2024 Steam Decarbonization Study & Implementation Plan

1. Steam System Decarbonization Background

In order to decarbonize the steam system in a way that is cost-effective and that meets the needs of Steam customers, the City, and the State of New York, Consolidated Edison Company of New York, Inc. ("Con Edison" or "the Company") needs to draw on a range of potential steam-generation technologies, while still maintaining the flexibility to adapt to long-range uncertainty in customer demand and technological advancement.

Currently, Con Edison's district energy system is – as identified in New York City's Local Law 97 ("LL97") – the energy source with the lowest emissions per unit of energy delivered. This is due to the system's use of natural-gas boilers and cogeneration as the primary sources of steam production at six generating stations, including the Brooklyn Navy Yard, which provides the Company with steam through a contract with Brooklyn Navy Yard Cogeneration Partners.

Over the next 25 years, these emissions are expected to be driven down even further, through decarbonization investments made by Con Edison in order to meet Climate Leadership and Community Protection Act ("CLCPA") goals and LL97 mandates. The Company has adopted these targets into its own Clean Energy Commitment:

- Zero Scope 1 emissions (i.e., direct greenhouse-gas emissions) for company-owned electric-generating units on the steam system by 2040, and
- Overall net-zero Scope 1 emissions from Company operations by 2050.

As part of the Joint Proposal from the 2022 Steam Rate Case (Case no. 22-S-0659), and to support the development of future strategies regarding steam- and- electric-generation decarbonization investment, the Company was approved to conduct a Steam Operations Decarbonization Study ("Steam Decarbonization Study" or "the Study"), and to create an Implementation Plan based on the Study's findings. The purpose of the Study was to explore the ability of the steam system to meet the requirements of existing climate policies and legislation, and thus determine the potential role of steam in New York's clean energy future.

2. The Study: The Future Steam System

The Steam Decarbonization Study considered various steam customer demand scenarios adapted from the Gas System Long-Term Plan (GSLTP). They varied from a deep electrification scenario where the peak demand declines 26% by 2050 to a new growth scenario where the steam peak demand grows 35% by 2050. The Steam Growth Scenario was selected as the basis for projected customer demand throughout the study, as it would confirm the limit of feasibility by designing around a larger system capacity and reflect our commitment to business development.

Twenty-four clean-energy technologies were initially identified, and each was evaluated using an extensive set of technical, regulatory, and system-focused criteria. A final set of core technologies was identified and used to model potential decarbonization pathways going forward.

Over the course of conducting the study modeling utilizing the Steam Growth Scenario, Con Edison determined that there are many potential pathways for decarbonizing the steam system by migrating to carbon-free sources of steam generation.

The integrated system modeling performed during the study determined an optimal set of common, near-term investments in the 2025-2035 timeframe that involves deploying electric-driven assets. This determination, in conjunction with regulatory requirements and the associated financial impacts, will inform how and where the Company will invest in electric-driven assets and retire existing, non-electric assets.

For the post 2035 period, the Company then narrowed in on three long-term, asset-deployment pathways that reflect different supply-side constraints that may emerge in the future. The following pathways differ based on potential tradeoffs and considerations, such as the need for new infrastructure, the extent of the deviation from the current system's operational footprint, and exposure to technological uncertainty:

- **Pathway 1** – This is the least constrained pathway. It reflects a cost-optimal approach that balances both electric and gas-based steam generation.

- **Pathway 2** – This pathway assumes a delay in necessary electric infrastructure which results in an electricity-constrained approach that leverages greater use of thermal energy storage (TES) to minimize the impact on the peak electrical demand.
- **Pathway 3** – This pathway assumes a delay in pipeline decarbonization which results in a pipeline-gas-constrained approach that leverages greater use of hydrogen in place of renewable natural gas (RNG) and synthetic natural gas (SNG).

As the Company gradually converts to the use of electric-driven assets to provide base steam generation, three such assets are projected to drive the majority of steam decarbonization across the three pathways. These are:

1. Electric boilers (EB)
2. Industrial heat pumps (IHP), and
3. Thermal energy storage (TES)

These assets represent the most technologically- and- commercially-mature decarbonization technologies available, the use of which would result in the electrification of up to one third of the total steam capacity by 2035.

Longer-term, the cost-optimal pathway (i.e., Pathway 1) would need to leverage both electrification and clean, molecule-based technologies, which utilize low-carbon fuels (LCF) in boilers and turbines. Figure i.1 on the following page illustrates the projected capacity mix by fuel type between 2024 and 2050.

Beyond 2035, as diverging pathways are likely to appear, the importance of signpost monitoring (i.e., monitoring important events and decision points) and remaining attuned to the changing landscape is further emphasized when committing to future asset deployments and/or retirements.

Figure i.1

Steam Installed Capacity Mix[1] (Mlb/hr)

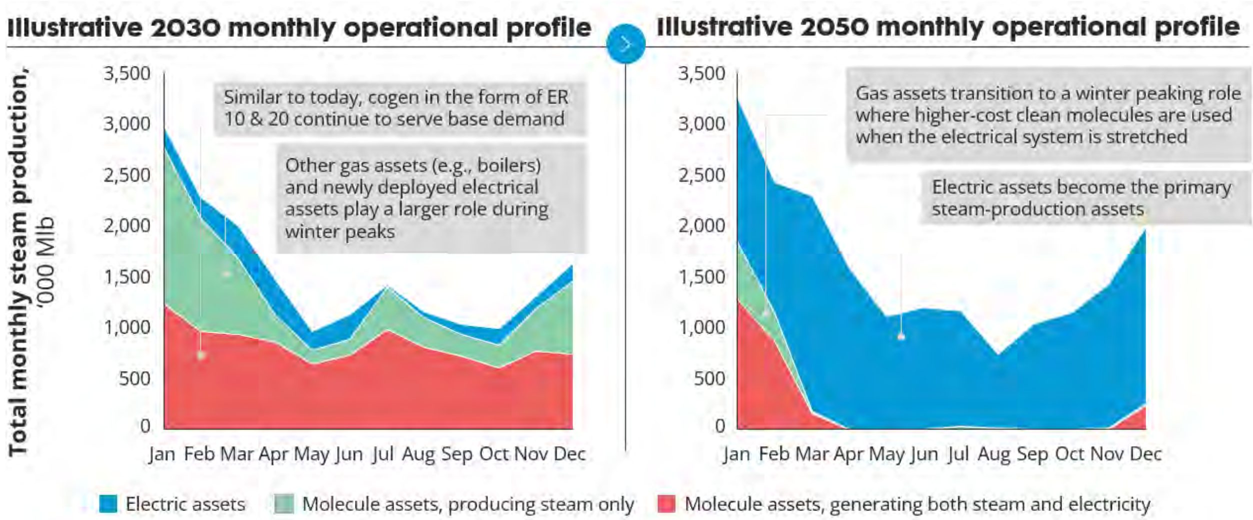
		Current	2035	2050
Electric	Electric Boiler		1,800	2,850
	TE Storage		1,120	1,200
	Industrial Heat Pump		600	1,000
Combustion (SteamOnly)	Gas Boiler	4,750	3,120	4,200
	ER 60/70[2]	2,040	1,200	
Combustion (Co-Gen)	ER 10/20	3,200	3,200	3,200
	Gas Turbine + HRSG[3]			1,200
	electric capacity	0%	32%	37%
	steam-only combustion capacity	68%	39%	31%
	co-gen combustion capacity	32%	29%	32%

[1] Excludes Brooklyn Navy Yard Co-Generation Partners (BNYCP) contract for steam production through 2035.
[2] Capacity decrease reflects reduction in steam production only. East River Units 60 and 70 (ER 60/70) are expected to remain in place for generation of electricity.
[3] A Heat Recovery Steam Generator (HRSG) produces steam using what would otherwise be wasted heat generated by the gas turbine.

Through 2050, new gas assets fueled by carbon-free molecules will continue to play a valuable role in producing steam when the electricity grid is most constrained, as shown in Figure i.2 on the following page.

Combined with TES, these assets will provide significant support to the electric grid, which is expected to become increasingly utilized as beneficial electrification progresses.

Figure i.2



Source: System optimization modeling results

These carbon-free gas assets – which would replace existing, less efficient gas boilers – can feasibly be deployed within Con Edison's existing steam-plant footprint by leveraging unutilized space at the former Hudson Avenue and Ravenswood Stations, and via strategic sequencing of retirements and deployments at other active operating stations.

Figure i.3 on the following page displays a table that identifies the locations where future steam generating assets may be housed.

Figure i.3

	Co-Gen	G Boiler	E Boiler	TES	Heat Pump
74th Street	2050	2024 & 2050	2050	2050	
Ravenswood	2050	2050	2050	2050	
60th Street	2050	2024 & 2050			
59th Street	2050	2024 & 2050	2050	2050	2050
East River	2024 & 2050	2024	2050		2050
Hudson Ave		2050	2050	2050	2050

● 2024 ● 2050 ● 2024 & 2050

The various generating assets will be spread across plants to allow for consistent network coverage. For TES, locating this technology at various facilities would provide capacity in both Manhattan's northern and southern demand pockets.

The majority of the electric-asset capacity will be located at the Hudson Avenue Station, where the upcoming Brooklyn Clean Energy Hub will provide clean renewable energy.

3. The Study: The Value of Decarbonized Steam

The steam system is a valuable energy solution, not only for hard to electrify customers, but also for New York City's energy makeup as a whole. Investing in decarbonizing it makes sense, both from a climate perspective and financially – as the retrofit costs required to fully electrify all existing steam customers could be as much as three- to- five-times more.

These higher costs would have a substantial societal impact, including increased financial burdens on existing steam customers and potential disruptions in the lives of building occupants as the retrofits are performed. Decarbonizing the steam system, while requiring significant capital investment, offers a cost-effective alternative.

Early conceptual cost estimates indicate that decarbonizing the steam system could require between $13 billion and $21 billion in capital investment for the most optimal pathway, whereas alternative options may be costlier.

Pathway 1 is the most cost-effective long-term, as it optimizes the economic deployment of a mix of electric and low-carbon molecule assets (assuming both power and clean pipeline gas supply is readily available).

Pathway 2 represents a costlier long-term pathway overall, primarily driven by greater use of the most expensive technologies (e.g., TES) to support and accommodate an increasingly utilized electric grid.

Pathway 3 represents a middle-ground in terms of cost, but incurs the largest spike in overall investment in 2040 as the steam system transitions from existing pipeline-gas assets to new hydrogen assets (e.g., hydrogen boilers and hydrogen gas turbines).

Regardless of the pathway, however, investing in decarbonization is necessary for compliance with future environmental regulations and positions the steam system as a sustainable and resilient energy solution for the long term.

Alternatively, electrifying all of the square footage in New York City that is currently served by steam could result in customer-retrofit costs between $50 billion and $70 billion. For many building owners that currently utilize fuel oil and/or natural gas, the high capital investment cost, as well as logistical and technical challenges of electrification, could render conversion to electric heating impractical. Decarbonizing the steam system centrally would remove the cost burden from those buildings that would need to be retrofitted for electrification, thus streamlining the transition to cleaner energy.

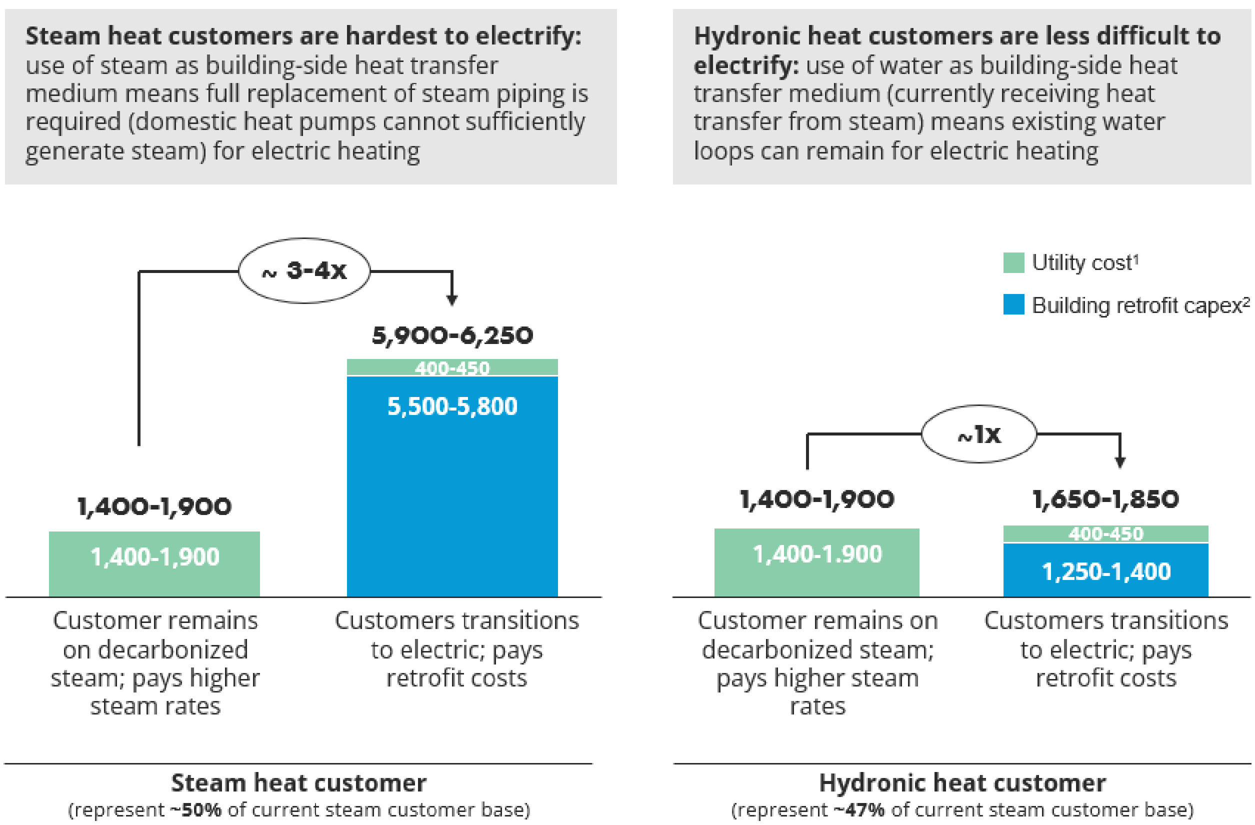
For the city, a decarbonized steam system can also minimize the impact on NYC's (NYISO Zone J) electric system, which is already facing the prospect of substantial demand growth. By strategically leveraging TES and zero-carbon molecules, the steam system can minimize the overall peak impact on the electric system, even as it transitions to electrification. While electric and steam peaks are expected to occur on the same day in winter, they are not expected to happen at the same time, which, combined with optimized dispatch of assets, minimizes impact on the electric system. TES would be discharged during the electric peak, reducing the need for power at this time. Decarbonization of steam would also reduce required electrical transmission and distribution (T&D) upgrade investment associated with widespread electrification by mitigating electric peak demand. This approach ensures more efficient and resilient energy infrastructure for the city.

For hard to electrify steam customers, steam decarbonization offers a practical and cost-effective pathway to achieving sustainability. Many existing steam customers would face high-cost barriers and potentially significant tenant disruption if required to switch to electric heating through a full-building gut retrofit.

Additionally, decarbonizing the steam system also allows for other benefits, such as historical building preservation and centralization of decarbonization activities as opposed to relying on shifting individual customer behavior. By 2040, steam rates are expected to rise significantly due to investments in decarbonization. However, despite these higher rates, customers utilizing steam distribution will still find it economically advantageous to stay on the steam system. For customers with hydronic distribution, the two options are economically equivalent due to lower retrofit costs and would likely be influenced by other factors such as potential tenant disruption or loss of space to electric equipment. Ultimately, steam decarbonization is the most viable path forward, balancing sustainability goals with economic and operational efficiency.

Figure i.4 provides – for illustrative purposes only – the annualized cost ($000's) for current steam customers as of 2040.

Figure i.4



1. Includes customer O&M costs (small relative to utility cost)
2. Includes heat pump capex; estimated at $98K for commercial & multifamily buildings with 21-year lifespan per EIA report

Source: Previous Con Ed studies, EPRI, EIA

While hydronic customers are less difficult to electrify and will incur similar costs to convert to steam or go all-electric, there are additional qualitative benefits to steam conversion. These include avoiding disruptive and costly individual building retrofits, preventing tenant displacement and the associated economic losses, and preserving and protecting historic buildings from invasive retrofitting.

4. Implementation Plan: Path Forward to Decarbonize by 2050

Based on the results of the Steam Decarbonization Study, a decarbonized district energy system would be a valuable solution for hard to electrify customers that are still utilizing fossil fuels and would aid in achieving the climate goals set forth by the City and State of New York. Achieving this decarbonized end-state requires a 25-year transformation, with some near-term initiatives and several longer-term developments to monitor.

The Steam Decarbonization Study concluded that from now to 2035, electric driven assets were the optimal asset deployment for all three pathways. The Company is proposing three early deployment projects from now to 2030 that will reinforce our commitment to decarbonize by 2050. We will learn from the early deployment investments, adjust as necessary, all the while continuing to monitor the dynamic regulatory, energy supply, technological, and customer landscapes.

From 2030 to 2035, the study will be used to inform how and where we invest in future electric driven assets and retire existing gas assets while balancing regulatory requirements and financial impacts. Beyond 2035, the study shows that diverging pathways appear, further emphasizing the importance of signpost monitoring and remaining attuned to the changing landscape in NYC when committing to future asset deployments and retirements.

To progressively transform the system, new decarbonized assets would need to be deployed and existing assets would need to be retired over time. Additionally, these deployments and retirements would need to be balanced across the system to ensure resiliency and reliability. Unused space at existing Company facilities along with strategically sequenced retirements would also need to be leveraged in order to free up additional space and prevent the need to acquire new sites. Electric-driven asset deployment would be prioritized at sites with the fewest constraints.

This decarbonization plan enables the Company to reduce steam-system emissions in line with City and State goals. This will be accomplished in three distinct phases:

1. Through 2030, the Company will continue to implement operational-efficiency improvements and will begin the early deployment of electric-

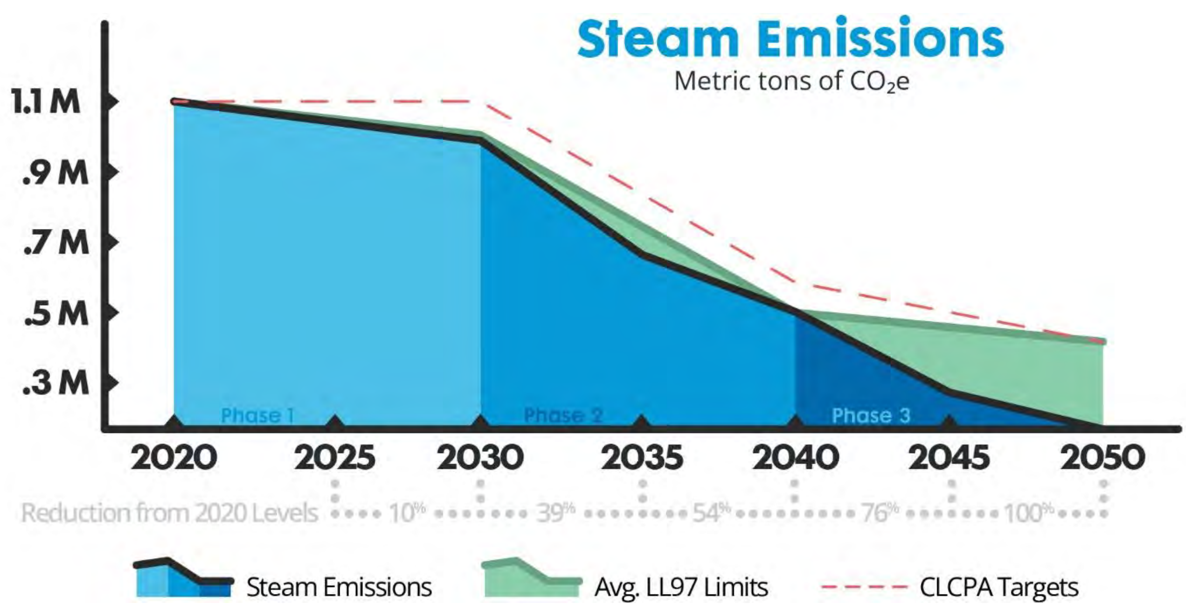
driven assets at a measured pace in order to test its three core decarbonization technologies (i.e., EB, IHP and TES) prior to extensive investment.

2. Beyond 2030, the Company will use the insights gained from these early deployments to ramp up decarbonization investments, thus boosting emissions reductions in line with the accelerating LL97 target trajectory.

3. By 2050, Company investment in decarbonization technologies, combined with an offset of 15 percent of its emissions through the purchase of carbon credits (as set forth in CLCPA), will result in net-zero emissions on the steam system. Full decarbonization of electric and gas supplies – as outlined in CLCPA objectives and the Con Edison GSLTP – would result in emissions-free steam by 2050 without the purchase of carbon credits.

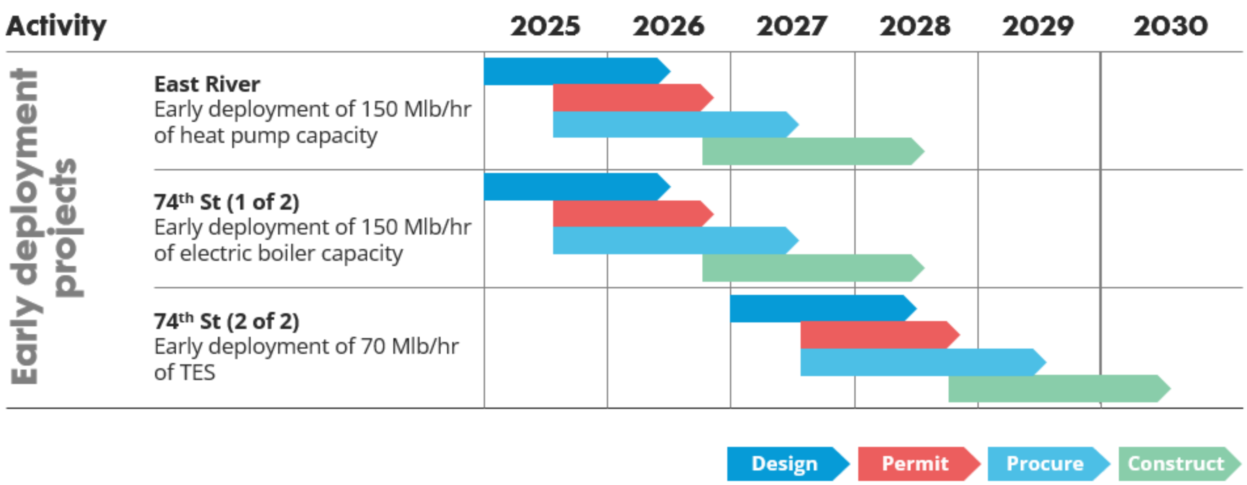
A graphic representation of these three phases is provided in Figure i.5.

Figure i.5



As shown in Figure i.6, the transformation would begin with projects over the next five years which include the deployment of the three core electrification technologies identified in Section B of this summary (i.e., EB, IHP, and TES).

Figure i.6



Through these initial projects, the company would gather learnings and engage in regulatory discussions.

The steam system has already met the statewide regulatory target set forth in CLCPA of a 40 percent reduction in emissions from 1990 levels by 2030. From 2030 to 2035, the Company will continue to decarbonize in line with regulatory targets and prioritize 100-percent electric investments. The Company's plan will utilize the Steam Decarbonization Study results for the near-term investments to guide further deployment of electric-driven assets.

In the post-2035 timeframe, Con Edison will need to continuously monitor the following key indicators that have the potential to significantly impact the decarbonization plan and shift the Company's trajectory from one pathway to another:

- Delayed Electric Buildout
    - Steam Operations would need to deploy additional TES and cogeneration in place of other electric assets (e.g., electric boilers and heat pumps) that would require more supply from the electric grid.

- SNG/RNG Not Considered Carbon Neutral
    - Steam Operations would need to replace and/or retrofit planned pipeline-gas assets with those that run on hydrogen (e.g., hydrogen boilers and hydrogen cogeneration).
- Hydrogen Fuel Availability
    - Steam Operations must monitor for indicators that reflect changes in the attractiveness of H_2 compared to SNG/RNG (e.g., the emergence of an H_2 economy and development of H_2 infrastructure in NYS).
- Relaxed Emission Standards
    - The Company would need to scale back on decarbonized asset deployment to reduce capital spend in line with new targets.
- Technical Challenges with Selected Technologies
    - The Company would need to replace the planned capacity with alternative technologies (e.g., replace heat pumps with additional electric boilers).
- Accelerated Electrification of District Steam Customers
    - The Company would need to evaluate the risk of significant steam demand decline and the economic viability of the decarbonization plan.

As Con Edison progresses in decarbonizing its district steam system, it is crucial to clearly define the upcoming steps to ensure alignment across all sectors of the Company. Indeed, the integration of gas, steam, and electric systems is becoming increasingly important. The future plans of all three commodities will be dependent on each other, as the steam system's reliance on electricity and LCFs grows.

Specifically, the Company will need to strengthen its joint planning process between the steam and electric sides of the business as the steam system prepares to electrify.

From a regulatory perspective, the Company will need to have early discussions with various regulatory bodies regarding its decarbonization plan, the permitting requirements for the chosen technologies, and ways to promote district steam as an alternate decarbonization solution.

Monitoring the evolution of LL97 and its implementation will be critical. The Company will offer its perspectives on key topics such as coefficients and adequacy of penalties. As per the Joint Proposal, the Company will develop a plan based on the results of the Decarbonization Study to request an adjustment to the district steam coefficient in LL97.

Operationally, the Company will need to continue to explore potential plant efficiency and flexibility levers to maximize the potential of existing assets. As the system evolves to leverage multiple fuels and storage capabilities, current operational policies and procedures will need to change. Expected market volatility will necessitate an approach that leverages sector coupling to optimize dispatch efficiency while adhering to technical and regulatory constraints.

As part of its Business Development Plan, the Company plans to engage steam customers to sharpen the value proposition of decarbonizing steam and start securing interest and/or commitments. Con Edison will continue to assess the technical, economic, and market feasibility and attractiveness for decarbonizing its district steam network to support the decarbonization goals of the City, the State, and its customers.

The Company will regularly assess and refine its plans going forward based on feedback and observed outcomes. While there is a large amount of uncertainty around the future of the energy landscape, the Company has developed a sound plan to achieve the goals set forth by CLCPA and has confirmed the steam system will have a significant role to play in New York City’s future energy landscape.

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ii. Introduction

2024 Steam Decarbonization Study
& Implementation Plan

To support future steam and electric generation decarbonization investment strategy development, Consolidated Edison Company of New York, Inc. ("Con Edison" or the "Company") was approved to conduct a Steam Operations Decarbonization Study and create an Implementation Plan as part of the Joint Proposal from the Steam Rate Case (Case 22-S-0659).

This initiative is to examine the Company's steam system's potential role in meeting the requirements of climate related policies and legislation, including the Climate Leadership and Community Protection Act (CLCPA), which sets greenhouse gas (GHG) emissions limits for New York State (NYS) by 2050,[1] and the City of New York's Local Law 97 (LL97). This report is for the Steam Operations business unit within Con Edison only and does not include any of the other subsidiaries of Consolidated Edison, Inc.

1. Steam System Background

Con Edison's steam system is the largest district steam system of its kind in the United States and has been serving customers in the borough of Manhattan for over 140 years.

Figure ii.1 highlights the district steam system service territory and major steam generating stations, outlining neighborhoods that could be served by additional steam connections.

[1] Case 22-M-0149, Proceeding on Motion of the Commission Assessing Implementation of and Compliance with the Requirements and Targets of the Climate Leadership and Community Protection Act, Order on Implementation of the Climate Leadership and Community Protection Act (issued May 12, 2022) (Order).

Figure ii.1 Con Edison Steam System Overview[2]

Steam is produced at six generating stations[3] primarily using natural gas for production. In addition to steam production capacity, these facilities generate more than 700 megawatts (MW) of electric power, more than half of which is the result of steam-electric cogeneration technologies. The total gross steam system production

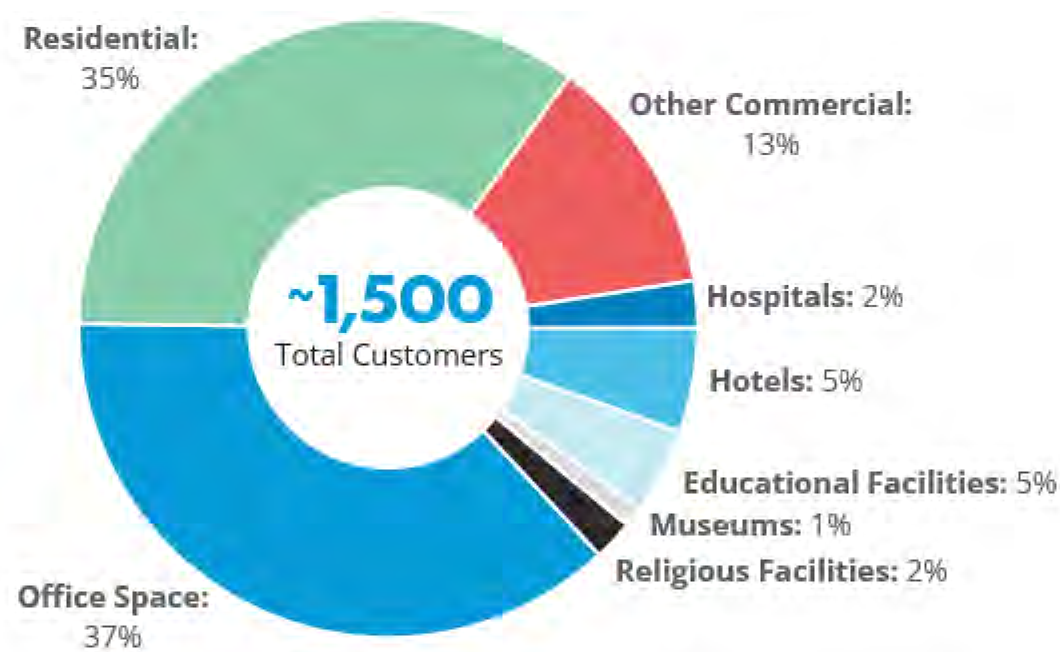
[2] Con Edison, "The Evolution and Future of the Con Edison Steam System," https://www.nyiso.com/documents/%2020142/33938587/20221021%20%20Steam%20Future%20Overview_NYISO%20(002).pdf/,October 21, 2022.
[3] This includes the Company's steam purchase contract with Brooklyn Navy Yard Cogeneration Partners (BNYCP)

capacity is approximately 10,800,000 pounds per hour (lb/hr) with a forecasted peak demand of 7,643 Mlb/hr for Winter 2024/2025.

The system is considered an "N-1" system, meaning that enough quick-response reserve ("QRR" or "reserve") capacity, is maintained to cover the loss of the largest steam production unit in operation. The QRR is available for use in the event of an unexpected equipment failure, or to prevent system pressures from falling below the required operating range when demand is higher than forecasted. Additionally, the QRR is used at various times of year when steam assets are taken out of service for routine maintenance.

The steam system provides service to approximately 1,500 customer accounts and uses 105 miles of steam mains to serve nearly 3 million people who work, live, and visit Manhattan from Battery Park to 96th Street on the west side, and 89th Street on the east side. The steam system currently serves a diverse set of building types across NYC shown in Figure ii.2. Steam is used by hospitals and medical centers, hotels, museums, financial institutions, commercial buildings, and residences for heating in the winter, air conditioning in the summer, domestic hot water, sterilization, humidification, and food processing. Steam sustains healthcare, hospitality, transportation, entertainment, housing, and commerce.

Figure ii.2



2. Study Background

Con Edison agrees with the state's leaders and our customers: addressing climate change and advancing the clean energy transition is critical for New York's future. The Company's Clean Energy Commitment (CEC)[4] demonstrates the actions that the Company wants to take to achieve the ambitious climate goals established by the City and State. The commitment consists of five pillars to help the Company achieve its vision, one of which is to aim for zero direct greenhouse gas emissions (Scope 1) for the company-owned electric-generating units on our steam system by 2040, and overall net-zero Scope 1 emissions from our operations by 2050, in support of NYS's climate goals to be in line with CLCPA.

The Con Edison steam system has gone through several evolutions over its lifetime to reduce environmental impact, while making it more resilient, reliable, and safe. During the late 1960s and early 1970s, all generating stations were converted from coal to lower sulfur oil. During the 1980s and into the 2010s, the systems were modified to include gas-firing capability, including the 59th Street and 74th Street generating stations that were made fully gas-capable in 2013. A fully decarbonized steam system will be the next evolution.

This district steam system is, and will continue to be, a clean alternative for buildings that would have significant challenges converting to electric heating, including some of the largest and most iconic buildings in Manhattan. For many building owners that currently utilize fuel oil and/or natural gas, the high capital investment cost, as well as logistical and technical challenges of electrification, could render conversion to electric heating impractical. Many steam customers will have difficulty modifying their individual buildings and their specific business models. These building owners are not in the business of energy, with their focus on the success of their individual businesses, not building retrofits and energy operations. Also, buildings with unique process loads, such as hospitals and museums, will have their own unique challenges for electrification. For example, hospital and healthcare facilities often rely on process steam for sterilization; these loads would require a solution other than heat pumps to generate their process steam. Therefore, any incremental investment made into our system could immediately benefit the customer base in their pursuit of preparing their locations for the clean energy future. Con Edison set out to identify the true challenges that

[4] Con Edison, "Our Clean Energy Commitment", https://www.coned.com/en/our-energy-future/our-energy-vision/our-energy-future-commitment

existing and potential steam customers would endure and the energy options available to them through the Company's "Electrification Challenges in a Dense Urban Environment" Study.[5] The study was finalized in mid-2024, which provided a detailed analysis of the cost effectiveness and feasibility comparison of district steam and electrification building decarbonization alternates for large NYC customers. The results of this study were filed as part of the Steam Business Development Plan and utilized to help guide portions of the Decarbonization Study, which are discussed later in this report.

The steam system currently has excess production and distribution capacity and can accommodate new business without adding additional steam generating assets. Leveraging the existing assets to their fullest potential benefits all existing customers and potential new customers. Being a centralized and fully interconnected district steam system allows the Company to make significant changes at strategic locations, bringing clear benefits to the New York City (NYC) energy system and its customers, including:

- A viable decarbonization path for difficult-to-electrify customers
- Flexible and dispatchable electrical capacity within Zone J

The Company's goal of achieving net-zero steam emissions by 2050 would enable potential customers to take advantage of a district energy source that will become cleaner over time as well as aid in decarbonizing NYC.

[5] Case 22-S-0659, Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Consolidated Edison Company of New York, Inc. for Steam Service, "Electrification Challenges in Dense Urban Environments Study" (issued April 4, 2024).

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iii. Decarbonization Study

2024 Steam Decarbonization Study
& Implementation Plan

As part of Con Edison's current Rate Plan in Case 22-S-0659, the Company committed to conducting a steam decarbonization study that would include a strategy to address the future production needs of the district steam system so that the Company meets the expectations of our customers while becoming carbon neutral by 2050. The scope of the study is set forth in the Rate Plan in Subsection "a" of Section 6 of the Joint Proposal. Primarily, the study needed to assess the strategic value of each of existing asset with respect to the overall system and identify replacement and/or redevelopment strategies that effectively align the Company's steam system with the future needs of its business, customers, and the energy goals of the State and City. Moreover, the study considered how best to maximize use and productivity of these facilities and properties, and achieve improvements in the system's operating efficiency, system flexibility, and overall environmental performance. To accomplish these goals, the study was organized into three major phases with the overall objectives to:

- **Phase I** - Evaluate and identify feasible technologies to decarbonize the steam generation asset portfolio while developing detailed near – and long-term deployment sequencing of these assets to reduce emissions in line with regulatory targets (e.g., CLCPA, LL97).
- **Phase II** - Determine engineering and conceptual designs of decarbonized steam system in the near term, including identifying optimal siting and configuration of new assets across the steam system.
- **Phase III** - Evaluate the financial impact of steam decarbonization.

1. Decarbonization Study Assumptions

To decarbonize the steam system in a cost-effective way that meets the needs of the state, city, and customers, Con Edison's decarbonization plan must draw on a full range of potential steam generation technologies, while maintaining flexibility to adapt to long-range uncertainty in customer demand and technological maturity. Therefore, multiple scenarios were assessed that optimize different combinations and sequences of technology deployment with three defined boundaries in place:

- Decarbonization trajectory that brings Con Edison's steam system in line with LL97 criteria by 2040 and in line with CLCPA requirements by 2050,
- Steam demand scenarios to explore different strategies to reposition the steam system,

- Decarbonization technology solutions that aid in less dependence on fossil fuels and the ability to manage system peaks more effectively.

2. Regulatory Landscape

New York has seen an evolving landscape of initiatives and legislation at all levels of government that are shaping the energy future. The Study first analyzed the current regulatory landscape by reviewing city, state, and federal regulations impacting the steam and electrical systems.

Figure iii.1 on the following page provides a high-level description of policies and legislation that, directly or indirectly, will drive steam decarbonization in NYC.

Figure iii.1 Climate-Related Policy/Legislation

Year	Policy/Legislation	Gov't Level	Description	Implications
2014	Reforming the Energy Vision (REV)	State	Set of initiatives with goal of increasing renewable-energy use and modernizing the grid via regulatory changes and incentives	Evolved utility role and revenue models to include transaction facilitation as distribution system platforms (DSPs) and encouraged distributed energy resources (DER) development
2016	Roadmap to 80 x 50	City	Strategic plan with a goal of reducing NYC's greenhouse-gas emissions by 80% of 2005 levels by 2050	Laid out a comprehensive road map of strategies that included improving building energy efficiency, transitioning to electric vehicles and reducing waste
2016	OneNYC 2050	City	Long-term sustainability plan for New York City to be carbon neutral by 2050	Complimentary to Roadmap 80 x 50, outlines a detailed plan of strategies aimed at enhancing building energy efficiency, transitioning to electric vehicles, and minimizing waste
2018	New Efficiency: New York	State	Comprehensive white paper published by NYSERDA outlining energy-efficiency targets and supporting initiatives	Recommended a target cumulative annual energy savings of 185 TBtu by 2025 from efficiency improvements
2019	Climate Leadership and Community Protection Act (CLCPA)	State	Environmental legislation that aims to address climate change via emissions reductions across multiple sectors	Mandated a number of targets, including 6 GW of distributed solar by 2025 and 10 GW by 2030, 3 GW of energy storage by 2030 and 9 GW of offshore wind by 2035
2019	Climate Mobilization Act (CMA)	City	Legislation and set of local laws passed by the City Council to reduce greenhouse-gas emissions from large buildings	Introduced several local laws (e.g., LL92 and LL95) aimed at reducing building emissions, including LL97 which established emissions limits for large buildings
2022	Inflation Reduction Act	Federal	Legislation aimed at addressing climate change, reducing healthcare costs, and increasing tax revenues	Financing and tax credits for clean-energy production (e.g., renewables, nuclear CCS, green H_2), as well as consumer tax credits for EVs and home-energy retrofits
2023	2023-24 Enacted State Budget	State	Budget provided New York Power Authority (NYPA) with new authority and mandates regarding energy production	NYPA given authority to develop and operate renewable-energy generation projects, but their gas peaker plants are to be retired by 2030
2023	New York Cap and Invest (NYCI)	State	Proposed cap and trade system that would limit annual emissions and create a market for additional allowances	Program is currently in the early pre-proposal stages. If approved: Would serve as a "back stop" to limit emissions after more direct emissions-restricting legislation (e.g., CMA)
2024	EPA Clean Air Act (final emissions limits rule)	Federal	Final new CO2 emissions limits and guidelines for certain new and existing fossil fuel-fired power plants	Certain new natural gas plants will need to achieve a 90% CO2 capture rate by 2032; emissions limits based on routine operation and maintenance for existing oil- and gas-fired boilers used to generate electricity start in 2030; regulation of existing gas-fired combustion turbines is deferred

2.1 Government Policy Level: Federal

Federal regulations relevant to the study include rules under the Inflation Reduction Act (IRA) and Clean Air Act (CAA). The IRA, officially signed into law August 2022, aims to reduce emissions in the United States (U.S.) to 40% of 2005 levels by 2030 along with improving U.S. economic competitiveness by investment in domestic energy technology, infrastructure, and manufacturing through federal funding directed toward clean energy through a mix of tax incentives, grants, and loans. The EPA introduced new policy changes in May 2023 through a new proposal, "Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants," where existing and new natural gas combustion turbines used to generate electricity (including combined cycle units) would need to meet new emissions-reducing requirements depending on utilization and scheduled retirement. For example, certain new and existing natural gas combustion turbines would have needed to achieve a 90% CO_2 capture rate by 2035, or co-fire with 30% hydrogen (H_2) by 2032 and 96% H_2 by 2038. The proposed rule would have also imposed emissions-reducing requirements on existing coal plants and existing oil- and natural gas-fired boilers used to generate electricity. Through CAA, the EPA published the final carbon pollution standards at the end of April 2024, which regulated all of the categories in the proposed rule except for existing gas-fired turbines. Under the final standards, new natural gas plants with a capacity factor greater than 40% would need to achieve a 90% CO_2 capture rate by 2032 (earlier than the 2035 deadline in the original proposal). The final rule is no longer based on H_2 co-firing for new gas turbines. EPA intends to issue a separate, new proposal for existing gas-fired turbines by the end of 2024. It is unknown whether H_2 co-firing will be included as a compliance pathway as in the original proposal. Beginning in 2030, the final rule also requires states to apply emissions limits based on routine operation and maintenance to existing oil- and gas-fired boilers used to generate electricity, which includes East River Units 6 and 7. The final rule is currently the subject of litigation and it is anticipated that the new administration will take steps to revise the final rule after it takes office in January 2025.

2.2 Government Policy Level: State

The Climate Leadership and Community Protection Act (CLCPA), as stated previously, sets greenhouse gas emissions limits goals specific to New York State. The Act was passed in 2019 to achieve a 40% reduction in emissions below 1990 levels by 2030, and 85% below 1990 levels by 2050, and allowing for the remaining 15% to be achieved through carbon offsets. The CLCPA also requires that 70% of electricity delivered to NYS to come from renewable sources by 2030 and that all statewide electric demand be met by resources having zero greenhouse gas emissions by 2040. Additional goals of CLCPA include:

- 185 TBtu of end-use reduction achieved through efficiency improvements by 2025,
- 6 GW of distributed solar operating by 2025, 10 GW by 2030,
- 6 GW of energy storage operating by 2030,
- 9 GW of offshore wind operating by 2035.

2.3 Government Policy Level: City

The Climate Mobilization Act (CMA) of 2019 is a demand-sided regulation with emissions targets imposed by the City pertinent to this for the study. The goals for CMA include reducing emissions from large buildings in the city 40% below their 2005 levels by 2030 and reaching net-zero by 2050 through overall improvement of building energy efficiency and transitioning away from carbon-emitting building heating technologies. CMA includes a set of local laws with specific mechanisms to achieve City emissions goals, including LL97, which sets progressively stricter annual carbon emission limits for large buildings, with financial penalties for buildings fail to meet the emissions limits within the law’s set emissions reduction timeframes. The Department of Buildings is promulgating a series of rules, which translate the LL97’s mandates into specific emission limits for various property types and establish reporting procedures. LL97 is in its first phase of implementation, requiring most buildings over 25,000 square feet to reduce operational emissions starting in 2024, with the goal of reaching net-zero by 2050, or face progressively more stringent carbon penalties.

2.4 Decarbonization Regulations: Emissions Trajectory and Drivers

Both CLCPA and LL97 were identified as the regulations driving decarbonization and the primary drivers that influenced the decarbonization trajectory used for the steam system modeling. While CLCPA is the primary decarbonization regulation, it only sets statewide emissions limits and does not provide specific broad emission reduction targets without any specific targets for steam. LL97, however, indirectly imposes steam specific requirements due to its building heating end-use targets. As mentioned previously, part of the Company's CEC aims to reduce the carbon footprint of the steam system to help the state achieve the CLCPA goals and minimize building owners' exposure to LL97 penalties. Steam emissions have already decreased by more than 40% from 1990 levels, ahead of the CLCPA requirement for statewide greenhouse gas emissions reductions by 2030. This is primarily due to an increase in cogeneration, conversion to lower carbon fuels, and operational efficiencies.

Decarbonization efforts for assets that produce both electricity and steam (i.e., cogeneration) must be completed by 2040, due to meet the CLCPA's requirement to have sufficient zero emissions resource to meet statewide electric demands for the emissions intensity of electricity. The remaining decarbonization for steam-only assets could be achieved through carbon offsets by 2050. An emissions trajectory for the system was selected as a boundary condition for the modeling to ensure minimum compliance based on these regulatory requirements. The reductions are based on the trajectory corresponding to average LL97 limits targeted at buildings as per emission factors in Rule 103-14. By continuing to decrease the emissions profile below regulatory requirements, the Company would ensure further CLCPA emissions reductions compliance and demonstrate its early and sustained commitment to the clean energy future to public stakeholders.

3. Steam Decarbonization Scenarios

To support the transition to a clean energy future, the Company explored various strategies to transform and modernize the steam system. The study looked at various scenarios that support a range of steam demand scenarios. They vary from a deep electrification scenario where the peak demand declines 26% by 2050 to a growth scenario where the peak demand grows 35% by 2050 to. Below is a description of the scenarios that were initially considered:

- "Deep Electrification Pathway" Scenario incorporates the assumptions of the Climate Action Council (CAC)/ NYSERDA integration analysis and meets the State's economy-wide greenhouse gas emissions goals. This scenario assumes that gas delivery service is significantly reduced by 2050 to serve select large customers. Energy needs are assumed to be met almost fully through electrification and decarbonized steam.

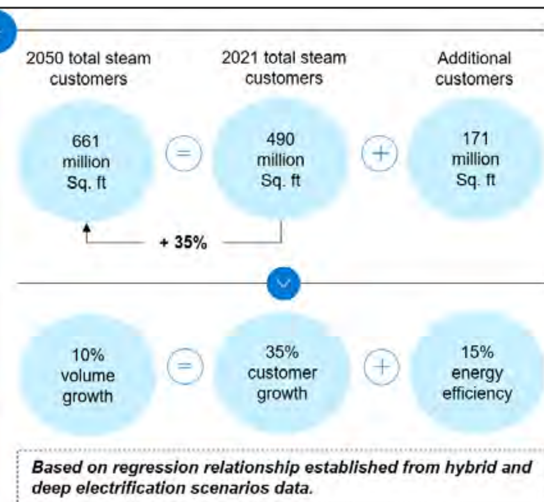
- “Hybrid Pathway” Scenario incorporates both clean electricity and low-carbon fuels (“LCFs”) and meets the State’s economy-wide greenhouse gas emissions goals. Decarbonized steam supports building heating for hard to electrify buildings in our service territory not covered by electric and/or not covered by on-site combustion of low-to-zero carbon fuels.
- “Steam Growth” Scenario utilizes the “Hybrid Pathway” Scenario and layers on the insights gained from the “Electrification Challenges in a Dense Urban Environment” Study. This study utilized a dataset of Manhattan buildings (see Figure iii.2) to understand the magnitude of priority building conversions to district steam, specific challenges associated with those conversions, and the added capacity that may be required in the steam network to serve these new customers. Priority buildings were selected based on the following criteria:
    - Distance from steam main (shorter distance, higher score)
    - Building Square Footage [SF] (larger SF, higher score)
    - Building age (older building, higher score)
    - Projected Revenue (larger revenue, higher score)
    - $0 cost connection (no cost, higher score)

The Electrification Study identified over 600 existing fossil fuel customers that met the criteria for a priority steam building. This scenario then assumed a steam growth potential of 35% by 2050, which equates to a 10% increase in steam volume. Customer growth in this scenario becomes more aggressive post-2030, as more customers face potential LL97 penalties.

Figure iii.2 “Steam Growth” Scenario Development

Summary	Near term additions (2030)	Long term additions (2050)	Total growth
Number of customers	119	488	607
Gross floor area ('000 sq ft)	12,836	158,887	171,722
Annual equivalent steam consumption (Mlbs/yr)	606,434	4,848,754	5,455,188
Estimated steam winter peak (lbs/hr)	505,108	6,406,117	6,911,225

Study methodology captures the likelihood of buildings to switch to steam based on proximity to steam mains, building size, building age, payback rate and steam system connection costs



Source: Electrification Challenges in Dense Urban Environments Study report; Strategy Planning Group data

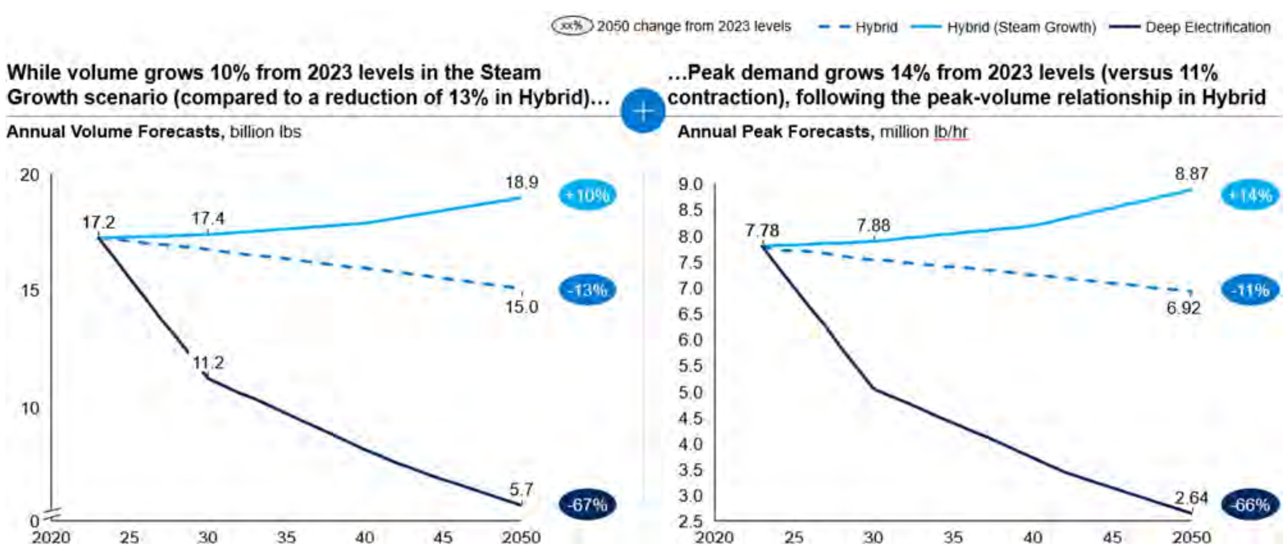
The “Hybrid Pathway” and “Deep Electrification Pathway” Scenarios were shared publicly as part of the Gas System Long Term Plan (GSLTP). The “Steam Growth” Scenario was developed for the purposes of this study. Figure iii.3 highlights the assumptions for each of the potential scenarios considered, while Figure iii.4 displays the corresponding volume and demand anticipated through 2050.

Figure iii.3 Scenario Assumptions Comparison

Descriptors		Steam Growth (adapted from hybrid)	Hybrid	Deep Electrification (Declining steam demand)
CLCPA compliance		Yes	Yes	Yes
Steam volume		+10%	- 13%	- 67%
	Steam customers	+35%	+12%	- 26%
	Energy efficiency[1]	- 15%	- 20%	- 51%
Floorspace allocation by fuel	Gas/Oil (2030/2050)	81%/50%	81%/50%	71%/5%
	Electric (2030/2050)	10%/41%	10%/42%	22%/90%
	Steam (2030/2050)	8%/9%	8%/8%	7%/5%

1. Percent reduction in energy use in steam buildings from current levels

Figure iii.4 Scenario Volume and Demand Comparison



After comparing the three potential scenarios, the “Steam Growth” Scenario was selected as the basis for the study moving into the remaining phases. From a conservative perspective, anticipating an increase in customer usage would require a larger system capacity and additional production assets. Designing around a larger system capacity will confirm the limit of feasibility. The Steam Growth Scenario also reflects our commitment to business development and growing the customer base of the system. Going forward, potential investments in new steam asset deployments will be evaluated at regular intervals and adjusted to reflect the most current projections for steam demand at that time.

4. Electric & Gas Supply Assumptions

The study assumes that the electric and gas systems meet their own respective CLCPA goals when evaluating the decarbonization technology set. The Company's long term clean energy strategy includes transforming its energy supply mix between now and 2050 by building an electric grid that integrates, delivers and balances 100% renewable electric generation and supporting the development of LCFs. Over the modeling timeframe, certain technologies and fuels were introduced, considering specific infrastructure cost assumptions aligned with Con Edison's GSLTP.

In line with the GSLTP, Con Edison sees a role for LCFs, gaseous fuels with a lower GHG impact than natural gas that could supplement our energy delivery system. Renewable natural gas ("RNG"), H_2 and synthetic natural gas were identified to potentially aid in decarbonizing gas consumption for difficult-to-electrify customers and to achieve NYS and NYC clean energy goals by 2050 regardless of the demand scenario. The study is consistent with the GSLTP, which includes H_2 blending over time. Specific details used in this study, such as dates and percentages, are aligned with the publicly communicated information in the GSLTP report. The Company is a founding sponsor of the Low Carbon Resource Initiative[6] which seeks to develop and commercialize technologies that will allow greater use of innovative LCFs. As part of the consideration for use within the steam system, the fuels are also under review to determine if they will be acknowledged as clean and beneficial in reducing the Company's carbon footprint. Although these LCFs are not currently part of the City's plan for decarbonization as they are not currently recognized as clean fuels due to their burner tip emissions, that may change if their classifications are revisited, and the overall lifecycle of the fuels is considered.

[6] https://lcri-vision.epri.com/

5. Valuation of Decarbonization Technologies

The study reviewed the landscape of technology options that have the potential to decarbonize Con Edison's steam system and manage forecasted system demand peaks. The scope of technology solutions considered certain electric and gas supply assumptions and developed a scorecard assessment with evaluation criteria to sharpen the decarbonization technology option set to include only feasible, high-potential solutions to help the Company meet its goals.

5.1 Methodology

Decarbonization technologies were assessed using a scorecard methodology against technical, regulatory, and system focused criteria to inform technology considerations for integrated modeling, that were then further prioritized to rank technologies. Below were the various criteria used to evaluate the original 24 decarbonization technologies.

5.1.1 High Priority Assessment Criteria:

- **Operating Parameter Suitability, Technical**
  Operating parameter suitability examines whether the technology can meet specific performance requirements of the steam system, such as temperature, pressure, and flow rates.

- **Regulatory Compliance, Regulatory**
  This criterion checks whether the technology complies with all current regulations, laws and industry standards. Regulatory compliance is essential in ensuring the technology is approved for use and can meet environmental and safety standards without hindrance.

- **Permitting Difficulty, Regulatory**
  This criterion assesses the difficulty in obtaining the necessary permits and approvals to deploy the technology. It considers environmental regulations, the complexity of the approval process, and potential delays.

- **Local Community / Neighborhood Impact, Regulatory**
  Public and environmental impact evaluates how the technology will affect surrounding communities, ecosystems, and the overall public perception, which can influence regulatory approvals and community acceptance.

- **Fuel Supply Availability, System**
  Fuel supply availability looks at whether the required energy inputs, such as specific fuel types or renewable sources, are readily accessible.

- **Existing Equipment Compatibility, System**
  Existing equipment compatibility examines how well the new technology fits with the infrastructure already in place. Seamless integration reduces the cost of modifications and ensures smoother implementation without major disruptions to existing systems.

- **Land Use & Physical Footprint, System**
  This criterion assesses the amount of physical space required to implement the technology and how it affects the existing land. Technologies that require a large footprint might be harder to implement in urban areas that have limited space.

5.1.2 Medium Priority Assessment Criteria:

- **Technology Maturity, Technical**
  Technology maturity assesses how developed the technology is and its readiness for deployment in real-world settings. A mature technology reduces the risks associated with early-stage development or untested performance.

- **Firmness, Technical**
  Firmness refers to the reliability of the technology when operating independently, especially in relation to intermittency (whether the technology can run consistently without failure).

- **Operational Flexibility, Technical**
  Operational flexibility assesses how quickly and efficiently the technology can adjust to changes in demand, such as peak periods or emergency situations.

Together, these criteria determine whether the technology can be counted on for both stability and adaptability in varying operational conditions.

- **Implementation Modularity, System**
  Modularity refers to the ability to adopt technology in phases, allowing for gradual integration rather than full integration all at once. This reduces risks, limits operational disruption, and allows for scalability as the technology is proven effective.

5.1.3 Low Priority Assessment Criteria:

- **Level of Decarbonization, Regulatory**
  This criterion measures the technology's ability to reduce carbon emissions. Technologies that significantly reduce greenhouse gas emissions contribute to sustainability goals and compliance with environmental policies.

- **Contribution to System Resiliency, System**
  System resiliency refers to the technology's ability to strengthen the overall reliability of the system, particularly in cases of extreme events. This includes enhancing the system's capability to recover from disruptions and maintaining consistent performance during critical moments.

5.1.4 Technology Assessment

Figure iii.5 displays the set of 24 technologies assessed for the study.

Figure iii.5 Decarbonization Technologies Included in Assessment

Electric boilers	H2 turbines	Industrial heat pumps only
Thermal energy storage (all forms)	Other synfuel (e.g., synthetic diesel) boilers	Green ammonia boilers
LDES batteries (all forms)	Pre-combustion carbon capture	Enhanced geothermal
Li-ion batteries	Post-combustion carbon capture	Waste heat recovery / condensate recovery
Industrial heat pumps + MVRs/boilers	Biomass boilers	Concentrated solar
SNG/RNG boilers	Nuclear fission (e.g., SMRs)	On-site/dedicated solar PV
SNG/RNG turbines	Conventional hydrothermal	Nuclear fusion
H2 (green/blue) boilers	Geothermal looping (e.g., deep geothermal)	Ocean thermal

The scoring methodology and targets for each category, which the set of 24 technologies were assessed against along with the scorecard results, are displayed in Appendix v.1. The methodology and targets include the technology readiness level (TRL), determining whether the technology could support saturated steam generation, run hours and ramp-up rate, overall carbon intensity, implementation difficulties, and any impacts to the local communities and supply infrastructure. The scorecard results combined the individual scores for the decarbonization technologies, criteria prioritization, and heuristics to rank the technologies.

Based on the scorecard rankings, eight of the 24 technologies were deemed infeasible for the Company to pursue due to significant weaknesses in different areas as highlighted in Figure iii.6. Inherent immaturity of decarbonized technology means continued evaluation will be necessary to determine if these technologies would be viable based on the future needs of the system.

Figure iii.6 Technologies with Fatal Flaws

Primary fatal flaw	Technology	Rationale
Technology maturity	Nuclear fusion Ocean thermal Green ammonia boilers	Relatively **immature technologies** (e.g., TRL <5) with **uncertain development future**
Land use and physical footprint	On-site/ dedicated solar PV Concentrated solar	**Significant footprint requirements** which would present a significant barrier considering NYC density
Regulatory compliance	Enhanced geothermal	Involves rock fracturing to create necessary reservoirs underground, which has been **banned in NYS**[1]
Operating parameter suitability	Industrial heat pumps only	**Unable to provide required temperatures and pressures** independently[2]
Existing equip. and infrastruct. compatibility	Move to closed loop steam system	Would necessitate **significant system expansion to introduce closed-loop return lines**

1. While geothermal is not explicitly considered there is uncertainty around whether enhanced geothermal would be exempt
2. Heat pumps will be considered when paired with complimentary technology (e.g., mechanical vapor recompression) but not standalone
A deeper dive for a heat pump with an associated technology is analyzed later in the report

Several other technologies were assessed but not considered further for the study as the most suitable to decarbonize Con Edison's steam supply in NYC due to their high-risk and low potential based on the current state of the technologies:

- Potential permitting challenges and departure in steam generation technology from current operations which limits ability to utilize existing equipment.
    - Nuclear fission (e.g., SMR)

- Potential stakeholder pushback around carbon-neutrality leading to permitting challenges and difficulty in reliably sourcing feedstock.
    - Biomass boilers

- Potential permitting hurdles due to land rights and geological limitation and uncertainty around suitability of NYC bedrock.
    - Conventional hydrothermal, geothermal looping (e.g., deep geothermal)

- Potential space constraint as footprint would require additional space along with the steam generation assets themselves.
    - Pre/Post combustion carbon capture

- Technology does not directly generate steam as effectively as other storage technologies assessed.
    - Li-ion batteries, LDES batteries (all forms)

5.1.5 Initial Core Technology Set

The scorecard assessment applied the criteria to sharpen the technology option set to include only feasible, high-potential solutions at both centralized and decentralized levels. The initial technologies identified as most suitable for decarbonizing Con Edison's steam supply in NYC are illustrated in Figure iii.7. These technologies are categorized into two groups: electron-driven (electrification) and clean molecule-driven (gas-based). Following this categorization, each technology is examined in greater detail based on the current available information. The preliminary core set of technologies is anticipated to be integrated into the Con Edison system in various ways, providing steam and/or electricity.

iii.7 Preliminary Core Set of Technologies for Decarbonization

Technology	Electrification	Clean Molecules
Electric boilers	●	
Thermal Energy Storage (all forms)	●	
Industrial Heat Pumps + MVRs/Boilers	●	
SNG/RNG Turbines		●
SNG/RNG Boilers		●
H_2 Turbines/Boilers		●
H_2 Boilers		●
Other Synfuel Boilers (e.g., synthetic diesel)		●

Electric Boilers

Electric boilers have been in existence for almost 100 years and are able to produce steam through the use of electrodes and counter-electrodes that come in contact with water. High voltage electricity is applied to the electrodes, and current flows to the counter-electrodes using water as the conductor. As water has naturally resistive properties, the current flow generates heat directly in the water itself and as the current and heat levels increase, steam can be produced. Electric boilers have an expected efficiency of 97% and can ramp from standby to full output in 180 seconds. Despite this technology adding to electrical load with no inherent incremental resiliency (e.g., energy storage, dual-fuel capabilities), it met and scored highly for the majority of the criteria. Con Edison has heavily explored the possibility of introducing electric boilers in the steam system and has engaged in discussions and field visits with a number of vendors including ACME Engineering, Precision Boilers and Zander & Ingestrom. Con Edison has visited customer installations for all these manufacturers in paper mills, distilleries, airports, and district heating at college campuses in both the U.S. and Europe. Through those meetings and visits, the Company has explored opportunities to further improve the technology through higher input voltages that reduce installation costs and will continue to develop those options going forward. The Company has also held field visits and benchmarking meetings with Vicinity Energy in Boston to discuss the benefits of implementing electric boilers for high pressure district steam systems. They are currently installing their first 42 MW electric boiler at their Cambridge, MA facility.

Thermal Energy Storage (TES)

TES converts electricity (including that generated from renewables) to heat a storage medium and when needed, that heat energy can be transferred to produce steam through thermal transfer as shown in Figure iii.8. Three main ways TES heat energy is stored are:

- Sensible heat storage – directly increases the temperature of a storage medium with high heat capacity (e.g., refractory or concrete) while maintaining its state,
- Latent heat storage – similar to sensible heat storage, but utilizes Phase Change Materials (PCMs) that transition between states; these transitions absorb and release heat energy as they occur,
- Thermochemical storage – uses electrical energy to facilitate reversible chemical reactions, which store and release heat energy as they happen.

TES has the benefit of allowing steam production to come from off peak clean energy that may be more prevalent or cost effective at certain times of the day. This, along with the potential that TES could replace existing assets operating at minimum load to satisfy Con Edison's margin requirement, will enable more efficient operation with both decarbonization and economic benefits. All three TES technologies are either in pilot or research and development stages (Technical Readiness Levels (TRL)[7] below 6, with sensible heat being comparatively more mature. In TES, both electric-to-heat conversion and heat discharge achieve efficiencies over 95%, yielding an overall system efficiency exceeding 90%. Any solutions must be tailored to meet the demands of constructing in urban settings

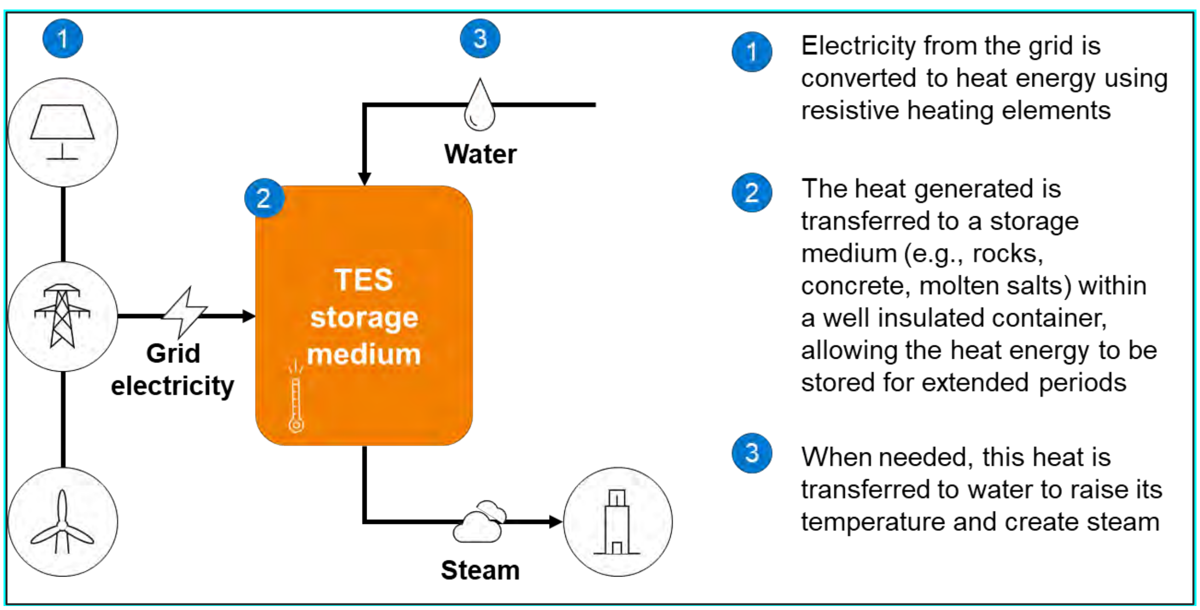
[7] TRL system, originally created by NASA, has been adapted by EPRI to evaluate and monitor the progress of energy storage technologies, showing how mature a technology is and allows for comparison of development time and costs between similar technologies. TRL-9 is the stage of first commercial use.

such as NYC, requiring high energy density, vertical integration, and high charging input voltage. Con Edison has evaluated over 30 TES vendors to identify those that best suit the steam system's specific needs. Starting in 2023, field visits were conducted to 8 selected TES vendors to assess their technology, production capability, and pilot installations. The Company is working closely with EPRI through Program 221: Bulk Energy Storage to monitor this space, looking for new companies with solutions that are more energy dense, have higher steam outputs, and will meet our future requirements. Below are some of the vendors and their storage material that are believed to currently offer feasible TES solutions meeting Con Edison's needs:

- Sensible Heat Technology:
    - Antora Energy – carbon blocks
    - Rondo Energy – refractory bricks (firebricks)
    - Electrified Thermal Solutions – electrically-conductive firebrick

- Thermo-chemical Technology:
    - RedoxBlox – magnesium manganese oxide blocks

iii.8 TES Schematic

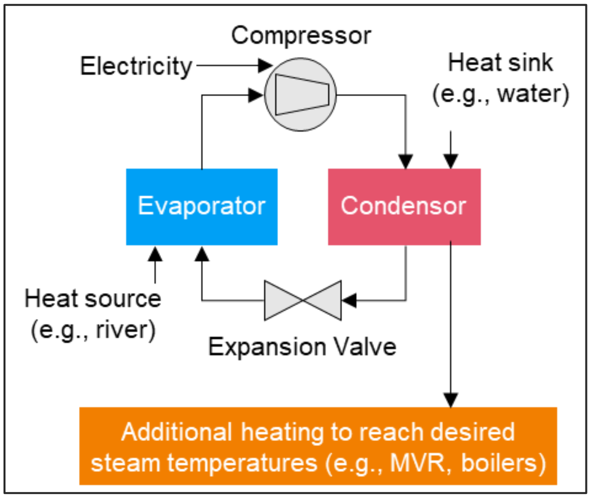


Industrial Heat Pumps

Industrial Heat Pumps (IHP) transfer heat via the use of a refrigerant cycle and vapor compression as shown in Figure iii.9. The refrigerant transfers heat from a low temperature heat source, such as air or water, to a high temperature heat sink, such as hot water or steam. Heat pumps are considered viable only if they produce steam directly to the distribution system. From our investigation, IHP are not considered as a standalone technology since they cannot independently provide the temperature lift required to generate steam at the required temperatures and pressures of the steam system. They will be paired with mechanical vapor recompression (MVRs) or electric boilers to reach the desired steam temperature ranges. When paired with MVR, the efficiency of an individual heat pump unit is around 150% with a ramp rate of 10% per minute. However, IHP deployment is constrained for direct steam generation based on the availability of river water for heat extraction or a high temperature heat source to obtain the energy for steam generation. Permitting will be required for river water use as a heat pump unit will cool down the water before it is returned to the river. Existing facilities with river withdrawal permits will need modifications to account for this as existing permits mainly cover a rise in river temperature from industrial uses. Additional considerations have been given to using an air-source heat pump leveraging high temperature air at East River Station, but technical capabilities fall short of operational needs. There are different types of refrigerants that can be used in a heat pump, though only certain types can provide the temperatures needed for steam production. These refrigerants will operate at high pressure and temperature within the steam stations and will require new permits and training for operators. Regulatory review with FDNY and other agencies will be required before final refrigerant selection can be made.

Con Edison has evaluated several IHP vendors for the feasibility of direct steam generation and feedwater pre-heating. The Company has benchmarked heat pump installations in Europe used for district hot water loops as steam generating IHP are still being developed. Major vendors the Company has been in discussions with are Turboden, Siemens Energy, MAN Energy Solutions, and AtmosZero. Following those discussions, Turboden and Man Energy were deemed to be developing technology that could meet the Company’s requirements. Field visits to manufacturing facilities and deployment sites were conducted in Europe. The Company has also engaged with EPRI and Southwest Research Institute (SwRI) on the future development of steam generating IHP and their installation in urban environments.

Figure iii.9 Heat Pump Schematic



SNG/RNG/Synfuel Boilers and Turbines

A conventional boiler generates heat via combustion of a fuel source, typically natural gas or fuel oil, which is then transferred to water to generate steam. Meanwhile a conventional gas turbine can be used to generate both electricity and steam by passing the hot exhaust gases through a heat recovery steam generator, transferring the heat to water. The emission intensities of the boiler and the turbine can be reduced, and have the potential to be net-zero, if the traditional fossil fuels used are replaced with lower carbon options such as:

- Synthetic natural gas (SNG) – a gas substitute created via H_2 and methanation (considered zero-carbon only if carbon dioxide stock used is already carbon neutral).
- Renewable natural gas (RNG) – a purified biogas obtained from decomposing organic matter.
- Other Synthetic fuels (Synfuels) –a liquid substitute created via processes such as Fischer-Tropsch.

For the study, it was assumed that SNG/RNG refer to carbon-free natural gas while synfuels refer to carbon-free liquid fuels (e.g., diesel or jet fuel produced by Fischer-

Tropsch synthesis) and that all three fuels can be used interchangeably in the boilers and turbines.

The efficiency of SNG/RNG boilers is around 93% with a ramp rate of 3% while Synfuel based boilers are around 95% and 3% per minute. The SNG/RNG turbine has an expected efficiency of 58% assuming electricity generation but could have a steam generation efficiency around 87% and a ramp rate of 8% per minute. Outside of the availability via injection/blending into existing natural gas distribution system, these fuels are estimated to be available around 2035. While the New York City Department of Environmental Protection has been producing and using RNG since the 1930s, and National Grid operates an RNG production plant at the Newtown Creek Wastewater Resource Recovery Facility ("WRRF"), there is currently minimal to no infrastructure beyond this in NYC for producing and generating SNG, RNG, and synthetic fuels. This is a major constraint for boilers and turbines utilizing SNG/RNG/Synfuel. While SNG and RNG may eventually be blended into natural gas distribution system, direct supply of liquid synthetic fuels would likely be limited to trucking and/or barging, assuming supply is available. Another potential challenge for this technology will be obtaining air permits from the Department of Environmental Conservation (DEC).

H_2 Boilers/Turbines

H_2 boilers and turbines operate the same way as conventional gas boilers and turbines but use H_2 gas as the fuel source during combustion. In addition to being installed as brand-new equipment, it is possible to convert or retrofit conventional boilers and turbines to run off H_2. However, as H_2 has different properties than natural gas (e.g., faster burn, higher temperatures, smaller molecules), retrofitting will typically involve modifying subcomponents such as the burner/combustion chamber and cooling system. The efficiency of either new or retrofit boilers is around 93% with a ramp rate of about 3% per minute. New or retrofit H_2 turbines have an efficiency of approximately 58% regarding electricity generation with ramp rates of 8% per minute. H_2 fuel availability is expected to occur around 2040. Major constraints with utilizing H_2 boilers include potential permitting challenges and lengthy project approval time, and the possibility of political/public pushback regarding the concerns around safety risk of H_2 use in urban environments. Additionally, there is no pipeline infrastructure to supply H_2 to NYC, so short-term supply would need to be via truck/barge or produced on-site (e.g., electrolysis).

6. Feasibility of Decarbonization Through 2050

6.1 Integrated System Modeling

After confirmation of the boundary conditions (decarbonization trajectory, steam demand outlook and technology solution space), integrated system modeling was performed in Phase I to characterize technology investment trade-offs and inform the development of the decarbonization pathways. Decarbonization solutions were modeled from a full system level to confirm initial feasibility and to determine required capacities from 2030 through 2050. The model used optimizes future supply and demand dynamics for steam, electricity, and clean molecules over the planning horizon to develop an integrated view of economics and emissions within New York City.

Based on the numerous inputs below, the model solved for the cost-optimal approach to decarbonizing the steam system for each of the steam decarbonization pathways:

- Steam emissions trajectory
- Hourly steam demand and annual growth
- Steam transmission capacity
- Current steam asset mix
- Resource constraints
- Technology cost outlook
- Electric load and annual growth
- Emissions constraint for electricity
- Ability to build interconnection lines between Zone J and other regions or sections of Zone J
- Fuel price outlook
- Future CO_2 sink and RNG availability
- Flexibility tools (demand response, energy storage)

For power generation, the model enforced the targets specified in CLCPA as minimum constraints and set an end-use reduction of 185 TBtu through efficiency improvements by 2025 as part of demand forecast across all NYISO zones.

For the steam system, several additional considerations were incorporated into the model regarding financial, dispatch, and future planning:

- Brooklyn Navy Yard Cogeneration Partners contract volumes assumed to be fixed based on season until end of contract in 2036 with no renewal.
- Existing steam assets did not have a set retirement date, but rather an ongoing 'fully-loaded' OPEX (recurring O&M and capital) assumption that keeps them running indefinitely until retired due to economics.
- Consideration was given to maintaining ER1/10 and 2/20 due to favorable economics.
- Steam system reserve capacity was maintained according to "N-1" principles.

Using these inputs, the model provided the capacity and generation mix, sources of flexibility, average system cost and investment required, shadow power, steam and fuel price, electricity and steam transmission lines expansion, and carbon budget.

The modeling inputs and outputs were also reviewed to ensure they align with future clean energy interconnection & storage hubs. Below are the considerations made regarding future hubs:

- Brooklyn Clean Energy Hub (BCEH)
    - Planned to be in service by 2028; will accommodate up to 1.5 GW and can be expanded to accommodate up to 6 GW of offshore wind energy if developers express interest in connecting to it.
    - Three GW of offshore wind capacity are expected to be brought in.
    - Expectations that at least 1 GW will be available for steam.

- Additional Clean Energy Hub(s)
    - At least 1 additional clean energy hub is planned to be in service by 2033 and bring an additional 1.7 GW of offshore wind capacity (for a total of 4.7 GW).

The integrated system modeling identified solutions that drive steam decarbonization in the most cost-effective way over the planning horizon and revealed eight key system dynamics that will shape the steam decarbonization pathways:

1. There is a role for both electric and fuels-based steam production. In a decarbonizing NYC, both molecules (e.g., SNG, RNG) and electrons (e.g., from renewables & storage) are more expensive and constrained than they are today & the least cost solution to produce steam will need a balance of both.
2. Higher capital expenditures (capex), more fuel-efficient options (e.g., new gas boilers) are favored. As molecules and electrons become more expensive due to decarbonization, fuel cost savings outweigh increase in capital.
3. The most efficient electric steam production will play a role during off-peak hours. Due to increasing cost of electricity, the least cost solution leverages heat pumps due to higher COP when available; if heat pumps are limited, additional electric boilers and thermal energy storage will be used outside peak hours to minimize high-cost clean molecules.
4. Fuels based equipment will likely transition to a peaking role: Higher cost of molecules transitions operation of ER 1/10 and ER 2/20 from current baseload operation to a more seasonal operational profile to use costlier clean molecules when the system is more stretched.
5. Electrification and decarbonization of electricity increase value of new cogeneration: additional cogeneration capacity (similar to ER1/10 and 2/20) is valuable as electric and steam peaks get closer.
6. Electric assets will likely need to be concentrated where capacity is available. Electric assets likely to be deployed at Brooklyn and Queens due to lower cost of transmission and distribution reinforcements to enable high peak consumption.
7. Thermal energy storage will be critical to shifting production away from peak hours. Thermal energy storage starts to play role in 2030 and this role increases over time as electric peak and steam peak get closer.

8. Decarbonization pathways are not a function of steam demand outlook. The system configuration remains consistent across scenarios while adjusting scale of investments over time.

6.2 Steam Decarbonization Pathways

Based on the “Steam Growth” scenario and its anticipated customer demand, three pathways for steam decarbonization were identified to reflect different supply-side constraints that may emerge in the future. For these pathways, two types of steam generation were considered based on the results of the technology evaluation. Molecule-based steam generation relies heavily on low-carbon molecules such as SNG/RNG, H_2, and other synfuels. Electric-driven steam generation relies heavily on electric powered equipment like electric boilers and heat pumps. There were a number of design trade-offs to consider between molecule-based and electric-drive steam generation. There would be a need for new infrastructure if there was insufficient LCF supply in the existing gas distribution, requiring additional dedicated pipeline infrastructure, or if there was increased electric load raising the peak beyond what is expected from customer electrification. There is also different exposure to technology uncertainty. The availability of clean molecules has a relatively high degree of supply uncertainty while electric based technologies such as electric boilers are readily proven and available. From a space perspective, molecule driven steam generating equipment has a relatively similar footprint and water consumption to current steam generating equipment at the company’s facilities. Electrification technologies necessitate additional footprint and water usage beyond what is currently used. In terms of cost, electricity could be cheaper than LCFs but additional transmission and distribution costs would drive up Capex.

The three pathways chosen represent the different tradeoffs and considerations regarding the need for new infrastructure, deviation from current system operational footprint, and exposure to technology uncertainty:

1. The least constrained (steam growth) pathway reflects a cost-optimal pathway that balances both electric and molecule-based steam generation.
2. Delayed electric infrastructure reflects an electricity-constrained pathway that leverages greater use of TES to minimize impact on electric peak.

3. Delayed pipeline decarbonization is a pipeline-gas-constrained pathway that leverages greater use of H_2 in place of SNG/RNG due to the assumption that SNG/RNG is not considered a zero-carbon molecule; based on CCS being unviable due to significant land-use required and unsuitability for NYC.

Figure iii.10 provides an overview of the supply-side constraints for each pathway. Several assumptions were made to show the different investment decisions required over time to achieve the desired emissions trajectory mentioned.

For Pathway 1 – Least constrained:

- Pipeline gas decarbonizes as per Con Edison's long-range plan; SNG/RNG are considered zero-carbon molecules (assumed to also include increasing blending of H_2 to lower GHG impact aligned with GSLTP).
- The electric grid meets its CLCPA targets.
- Some increase in electricity consumption for steam production viable; the BCEH materializes as planned and sufficient power is available for steam.

For Pathway 2 - Delayed electric infrastructure:

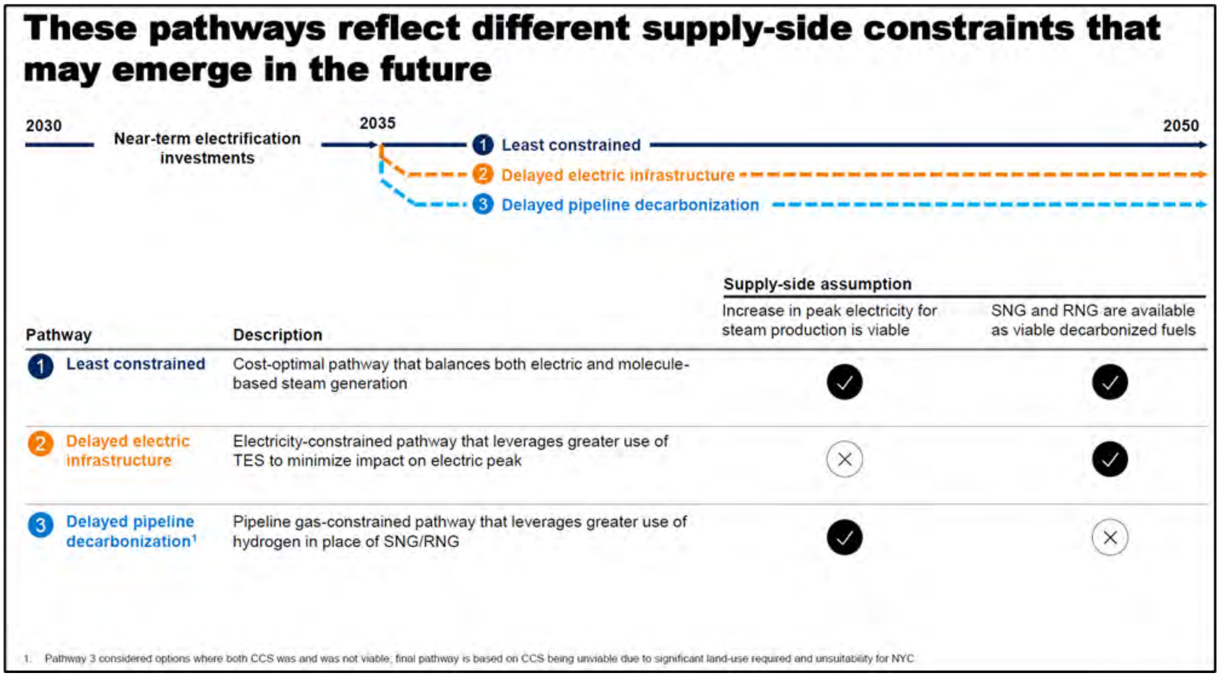
- Pipeline gas decarbonizes as per Con Edison's long-range plan; SNG/RNG are considered zero-carbon molecules (assumed to also include increasing blending of H_2 to lower GHG impact aligned with GSLTP).
- The electric grid meets its CLCPA targets.
- Sufficient increase in electricity consumption for steam production is not viable; the electric transmission system faces challenges with insufficient generation, capacity, and interconnects.

For Pathway 3 - Delayed pipeline decarbonization:

- Pipeline gas does not decarbonize as planned and/or SNG/RNG are not considered viable zero-carbon molecules.
- H_2 infrastructure can be developed safely and reliably in NYS to supply 100% H_2 as a carbon-free molecule.

- Some increase in electricity consumption for steam production viable; BCEH materializes as planned and sufficient power is available for steam.
- CCS deployment is not a viable option in NYC.

Figure iii.10 Supply-Side Constraints for the Three Pathways



Pathway	Description	Supply-side assumption: Increase in peak electricity for steam production is viable	Supply-side assumption: SNG and RNG are available as viable decarbonized fuels
1 Least constrained	Cost-optimal pathway that balances both electric and molecule-based steam generation	✓	✓
2 Delayed electric infrastructure	Electricity-constrained pathway that leverages greater use of TES to minimize impact on electric peak	✗	✓
3 Delayed pipeline decarbonization[1]	Pipeline gas-constrained pathway that leverages greater use of hydrogen in place of SNG/RNG	✓	✗

1. Pathway 3 considered options where both CCS was and was not viable; final pathway is based on CCS being unviable due to significant land-use required and unsuitability for NYC

In addition to the integrated system modeling in Phase I, increasingly detailed modeling at the steam system level was conducted in Phase II to enhance the steam decarbonization plan. The Phase II model focused exclusively on the steam system, operating within assumed constraints. The optimal configuration and location of assets, such as determining which plants should house specific assets, was identified to ensure service to core load pockets. This was done while adhering to both plant-specific constraints, like space availability, and system-specific constraints, such as pipeline flow limits.

Modeling was further performed in Phase III to identify the hourly dispatch patterns of the steam system, integrating new decarbonized asset deployments and building on the results from Phases I and II. During this phase, a Digital Twin of the steam system was utilized that modeled variables including, but not limited to, steam and steam-electric production assets, system constraints, economic constraints, electric markets, gas market prices, and electric transmission constraints. Additionally, it applied more granular dispatch considerations, such as QRR, and economic considerations, like BNYCP contract mechanisms, to finalize technical and economic projections, including power demand, operating costs, and fuel costs. Modeling of these pathways showed commonality in the near-term investments from now until 2035 and divergence after the 2035 timeframe. The near-term investments aligned with a full electrification future and involved significant retirement of gas assets. In each modeling phase, the specifics and feasibility of the steam decarbonization pathways were progressively refined and tested in greater detail.

7. Capacity Retirements/Deployments Through 2035

The modeled site-by-site asset configurations support the three pathways based on the evolution of the energy landscape in Con Edison's service territory. These asset configurations optimize the addition of new decarbonization assets and the retirement of existing fossil fuel assets while balancing customer demand, system- and plant-specific constraints, and operational preferences. It also took into consideration current interconnections between the generating stations and four major load pockets across Manhattan (Upper West Side, Upper East Side, Midtown, and Downtown), utilizing guiding principles to inform and maximize asset siting through 2035.

The constraints included:

- Balance deployments and retirements across the system to ensure uncompromised demand fulfilment.
  - Assets will be deployed with a system-wide view to ensure steam production continues to reach all core demand areas (e.g., avoiding over-deployment or retirement at a single location).
- Maximize utilization of existing facilities vs. acquisition of new sites.
  - Any new deployment will be limited to current steam plants and space that can be made available in the near-term.

- Leverage existing unused space and strategically sequence retirements to free up additional space.
    - Given the space premium in Manhattan, prioritize early deployment within unused space at existing plants and prioritize retirements where additional space is needed.
- Prioritize electrical asset deployment at sites with the fewest constraints.
    - Factor in the investment and space required to interconnect to nearby substations and build associated electrical infrastructure within steam plants.
- Prioritize heat pump deployment at sites with existing water access and allowances.
    - Focus the majority of near-term deployment at East River due to existing water allowances, intake and discharge infrastructure.
- Use logical unit sizing to reflect approximate minimum viable installation scale and allow for phased and modular installations.
    - Plan asset deployments in “building block” units of 150 Mlb/hr.

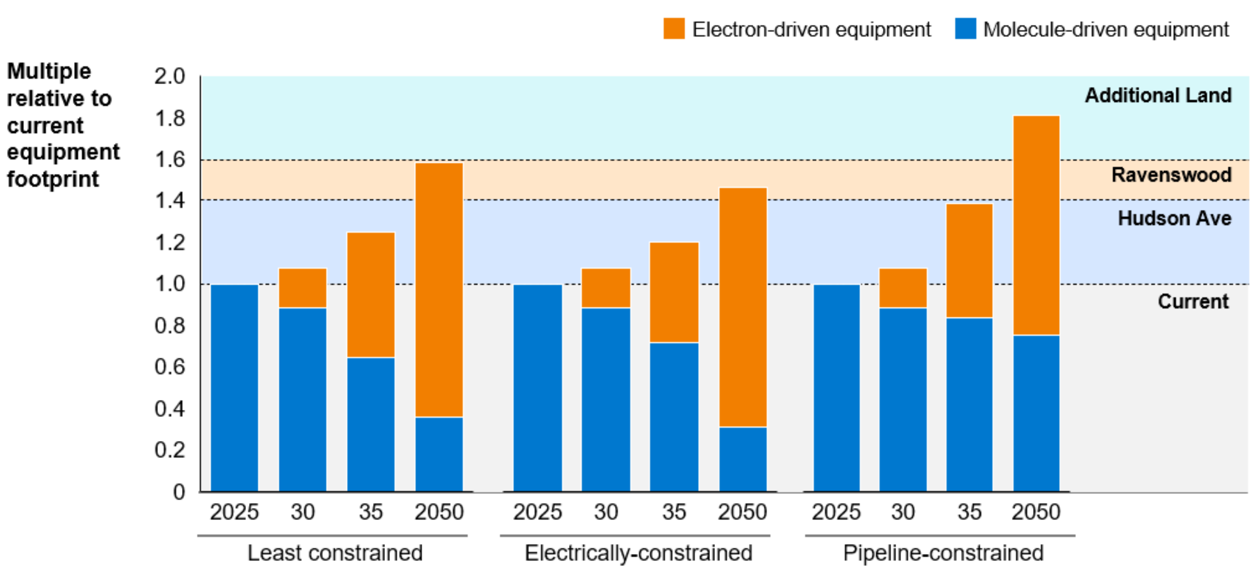
Across the three decarbonization pathways established for the steam system, the near-term asset configuration will involve a common deployment of electric assets. The future district steam system will operate differently from today and the Company believes that the evolution of the system to the 2035 state will involve early deployments of electric boilers, heat pumps (along with MVR) and TES to drive the majority of steam decarbonization. Beyond 2035, the study assumes that the ultimate steam system asset mix will be dependent on the buildout of the electric infrastructure to support the additional electron-based decarbonization technologies.

Despite the unpredictability of future supply and demand, these technologies offer economic advantages by replacing outdated, inefficient gas boilers, especially as the variable costs of electricity and fuels rise over time. By investing in these technologies early, Con Edison can demonstrate its commitment to decarbonization while keeping options open to address long-term uncertainties. The current asset mix has the potential to retire between 2,000 and 4,100 Mlb/hr of gas boilers, while electric generating units ER 1, 2, 6, and 7 will continue to operate beyond 2035. These retired fossil fuel assets will be replaced by new decarbonization technologies, including approximately 500 Mlb/hr of heat pumps and MVR, 400 to 1,000 Mlb/hr of TES, and 700 to 1,600 Mlb/hr of electric boilers.

Based on the modeling results, the necessary assets can be deployed within existing Con Edison facilities. However, all three pathways and their associated demand will likely require expansion beyond the current footprint of the steam system unless there is a significant reduction in steam demand. This underscores the importance of retaining land within the Company where available.

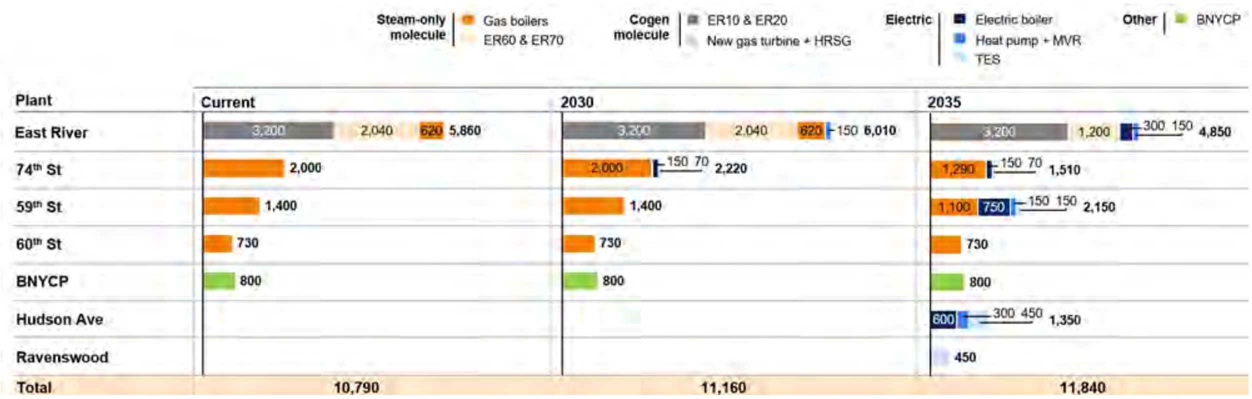
In the short term, there is potential to site new equipment at Hudson Avenue. The former Hudson Ave Station was connected to an existing steam main crossing the East River into Manhattan with a capacity of 2,900 Mlb/hr. This location, along with the Ravenswood site, offers attractive options outside Manhattan for new assets due to the availability of space and the less constrained electrical grid. Figure iii.11 illustrates the estimated footprint required for all electron- and molecule-driven equipment for the decarbonization pathways.

Figure iii.11 Estimated Footprint Required for all Equipment



The expected capacity changes from the current state to 2030 and 2035, displayed in Figure iii.12, were further refined so that the asset configuration would balance system and plant-specific constraints with operational and strategic preferences, regardless of the long-term pathway. From 2030 to 2035, deployment is primarily emissions-driven as new decarbonized assets will be installed to stay below the targeted emissions trajectory, with one-third of the entire steam system expected to be electric driven by 2035. It should be noted that the exact timing of deployment may shift as near-term projects are further scoped and timelines are confirmed such as the development of the BCEH due to the required site work.

Figure iii.12 Expected Capacity Change by Location/Technology (Mlb/hr)

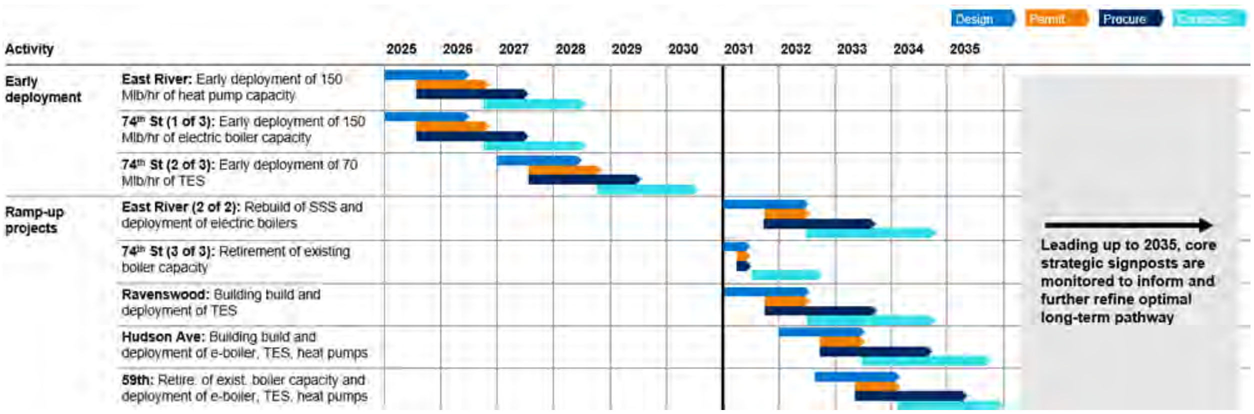


To optimize potential production (and thus deployment) outside of Manhattan, the Hudson Avenue feed could be maximized by deploying electric boilers and TES while reducing production at East River to mitigate a distribution system bottleneck between Downtown and Midtown. This reduction would come from limiting steam sendout from ER 60 and ER 70 as they remain in operation through 2035 for local cogeneration. ER 10/20 and heat pump deployment would be prioritized at East River while retiring the gas boilers at South Steam Station by 2035. Ravenswood would be used a secondary electrical asset location outside-Manhattan with significant deployment of TES using a new tie-in to a nearby transmission main, which would allow for additional capacity to serve the northern side of Manhattan.

At the other existing steam generating facilities, approximately 35% of existing gas boiler capacity (approximately 710 Mlb/hr) is expected to be retired at 74th Street Station while adding 70 Mlb/hr of TES. At the 59th Street Station, about 20% of existing gas boiler capacity (around 300 Mlb/hr) is projected to be retired, and the station will become the primary location of in-Manhattan electrical assets due to available space. The current state at 60th Street Station will remain unchanged due to space restrictions and accessibility issues, and BNYCP will remain the same as well due to the expectation that the current contract will be valid until 2036.

The study recommends that the near-term focus for the Company should be on effective execution and operation of early deployments and ramp-up projects over next 10 years. Figure iii.13 displays a potential outline of how the near-term investments would be deployed through 2035 for the demonstration and ramp-up projects. Depending on whether the Company plans to utilize new electric assets at the locations outside Manhattan, only deploy at the existing buildings or only decommission existing boilers, each project will likely take around 2-4 years to bring online to allow time for design, permitting, procurement of the necessary equipment, and construction and commissioning.

Figure iii.13 Potential Project Timeline of Near-Term Investments

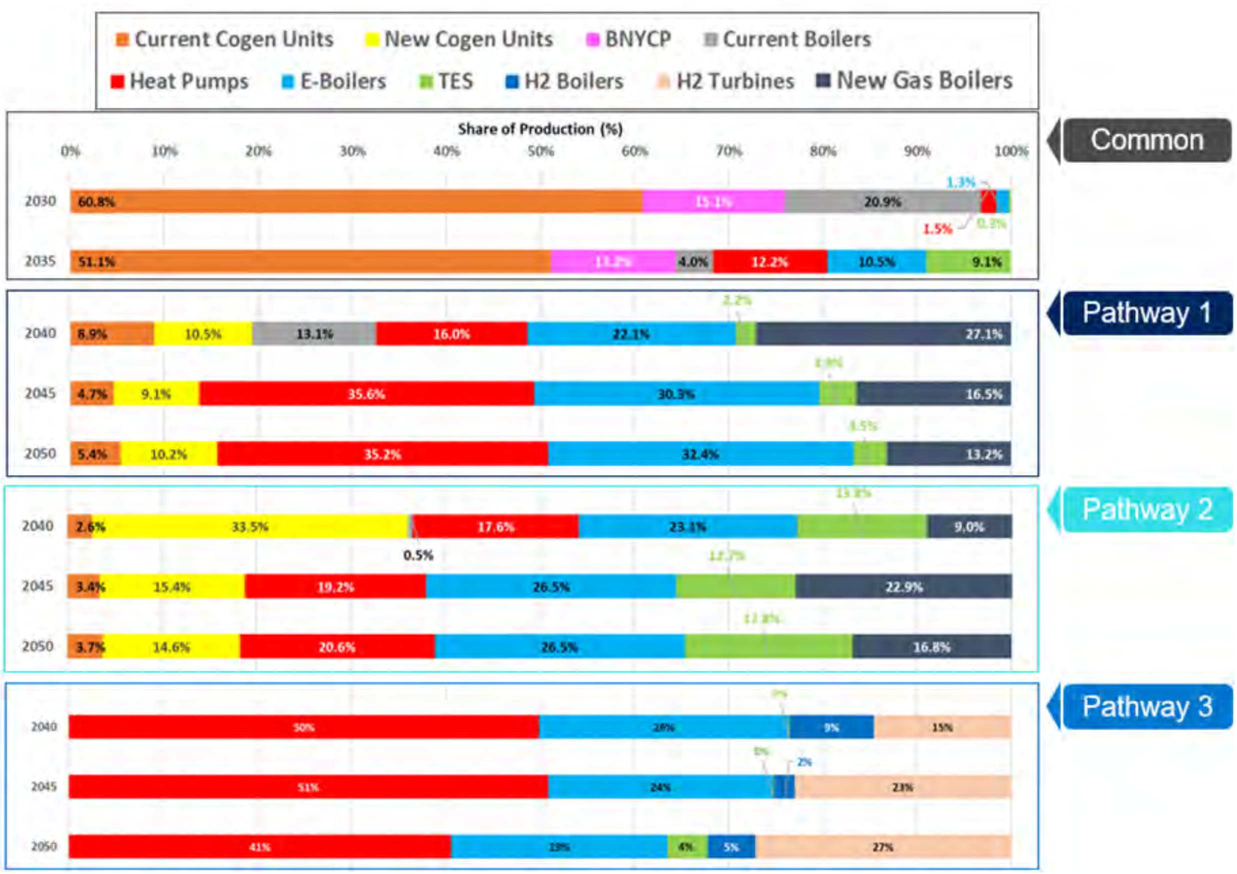


8. Capacity Retirements/Deployments 2036-2050

Beyond 2035, the three pathways begin to diverge depending on how the energy system evolves in terms of system constraints on footprint requirements, electric infrastructure, and clean molecules. However, all the pathways, regardless of the final asset mix, spread the different decarbonization technologies across various plants to ensure all network areas can benefit from technology optionality and the flexibility to use electric versus clean molecules when optimizing dispatch and utilizing energy storage to minimize grid impact. Gas assets are expected to transition to a winter peaking role, where higher-cost clean molecules are used when the electrical system is stretched, and electric assets become the primary steam-production assets. Figure iii.14 displays an expected share of asset production across the pathways through 2050. The dispatch trends should be treated as highly illustrative and based on a set of assumptions that will be highly variable as it depends on the specific profile of each day (i.e., load, weather, asset condition and scheduled maintenance). Additionally, dispatch outputs are highly sensitive to electric and fuel price assumptions and a variety of factors that could influence what an operator decides to dispatch in any given hour.

Production from existing natural-gas boilers is projected to drop after 2040 due to high marginal costs. Steam supply from electric-based units is estimated to be significant, and molecule-driven boilers will continue to be required to react to limitations on the electric system or during favorable market conditions. Heat pumps will be utilized for their high efficiency, electric boilers for their flexibility and TES for its intra-day flexibility and ability to respond to a fluctuating electric grid. The key difference between the pathways is the installed capacity of electron-driven units, thus their impact on the overall generation mix through 2050.

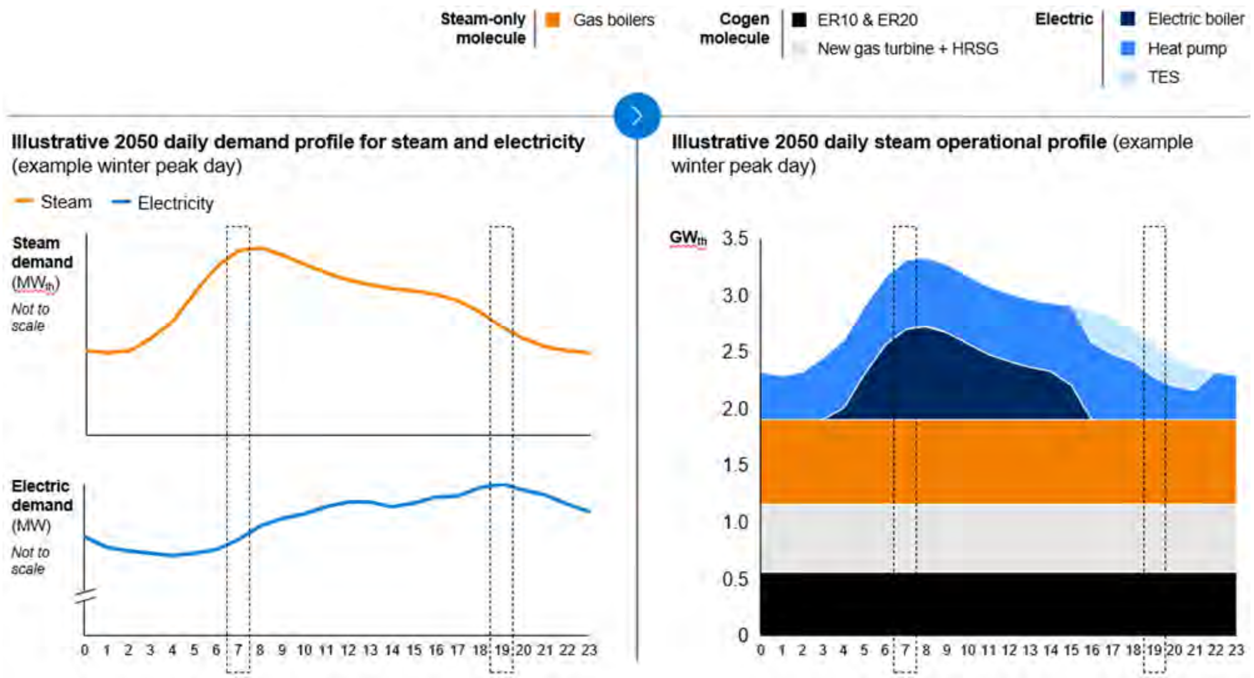
Figure iii.14 Pathways Dispatch Modeling Trends



The steam system's ability to leverage TES and zero-carbon molecules strategically would be used to minimize overall electric system peak impact, even as the steam system electrifies. It would especially be helpful for NYC's Electric System (Zone J), which is already facing the prospect of substantial demand growth. By 2050, the decarbonized steam system could require up to 1.5GW of electricity during peak steam demand. However, an optimized dispatch that leverages assets such as TES, high-efficiency heat pumps, and molecule-driven steam generation can reduce electric load when the electric grid is most constrained. This has the potential to reduce steam's electric demand by up to 75% during hours when overall demand on the electric system is at its peak.

While electric and steam peaks are expected to occur on the same day during the winter, they are not projected to happen at the same time of day. This, combined with optimizing the dispatch of assets, would minimize the impact on the electrical system. Figure iii.15 provides an illustrative 2050 view of the daily demand profile for steam and electricity compared to the daily steam operational profile on a winter peak day. The steam and electric peaks would occur at different hours of the peak day, even after accounting for building electrification. Therefore, the steam system could discharge TES during the electric peak, reducing the need for power at this time. The decarbonization of steam would also reduce the required electrical T&D upgrade investment associated with widespread electrification by mitigating the electric peak demand.

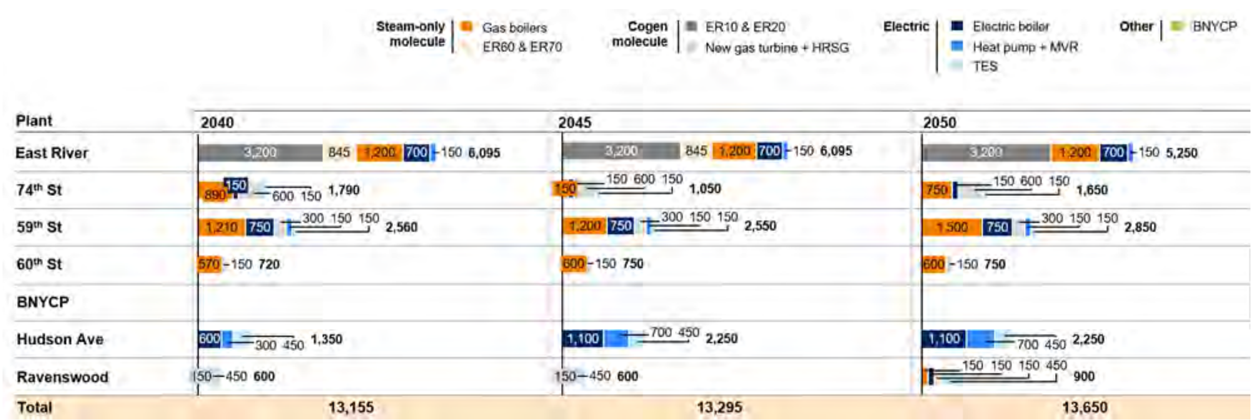
Figure iii.15 Illustrative Winter Peak Operational Profile for 2050



8.1 Pathway 1: Least Constrained

If both electric infrastructure and a variety of clean fuels are available to Con Edison, the steam system will balance these commodities to optimize cost. High efficiency electrical assets, such as heat pumps and electric boilers, are expected to become the primary steam-producing assets with clean fuel-powered equipment used more seasonally when the electrical system is constrained during peak demand periods. The expected capacity changes from 2040 to 2050 are displayed in Figure iii.16.

Figure iii.16 Least Constrained Pathway Proposed Long-Term Capacity Change by Location/Technology (Mlb/hr)



The first wave of existing fossil fuel boilers retirements and replacements with new boilers utilizing clean fuels at the 59th Street, 60th Street, and 74th Street generating stations is projected to take place by 2040. ER 60/70 steam production is thought to be further reduced with the potential to fully retire ER 60 by 2040. Additional heat pumps and new gas boilers would also be deployed at East River. By 2045, all existing fossil fuel boilers are expected to be replaced, and additional electric boilers and heat pumps would be deployed at Hudson Avenue. The potential full retirement of ER 60/70, or drastic reduction in production, could happen by 2050 with more gas boilers being deployed at 74th Street, 59th Street and Ravenswood. Supplemental electrical boilers could also be installed at Ravenswood by this time. ER 10/20 will remain in service through 2050 and 60th Street will remain a gas-only facility. ER 6 and 7 are expected to continue to be online for electric production. The majority of TES will be deployed outside Manhattan at Hudson Avenue and Ravenswood.

8.2 Pathway 2: Delayed Electric Infrastructure

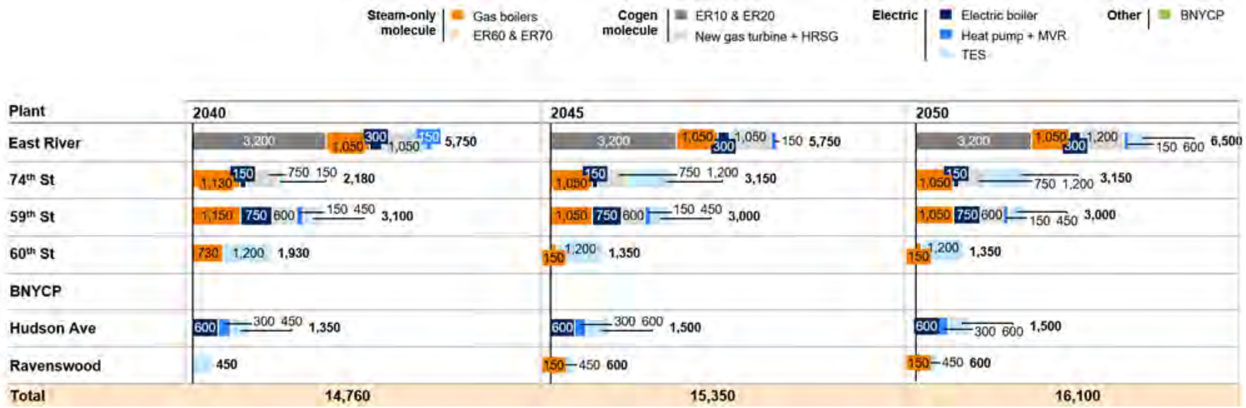
If electric production and T&D capacity buildout is less than anticipated through 2050, electric steam generation will still continue to play a role rather than fully shifting to low carbon fuels. Factors that could hinder the continued development of the electric infrastructure include:

- T&D build out faces challenges given dense NYC environment
    - Inherent construction challenges in an urban/dense environment are faced (e.g., limited space for new substations or transmission lines, extended construction times) resulting in slower build out of electrical system than planned.
- NYC electric demand increases even faster than anticipated
    - Electrification of transport and heating accelerates faster than planned grid enhancements anticipate, further straining the grid even with planned reinforcement.
- Offshore wind projects face development challenges and capacity does not come online as planned
    - Regulatory and supply chain hurdles currently being faced by some offshore wind developers (e.g., cancellation of recent projects due to GE Vernova turbine supply challenges) continue, compromising the

deployment of clean power generation (even if interconnection is available).

While electrification of the steam system would continue to be a core pillar of this decarbonization pathway, the planned capacity mix would change to emphasize technologies that further increase electrical use flexibility and support the grid via cogeneration. A scale back on the future deployment of additional electricity-consuming assets (e.g., electric boilers) would most likely need to happen while TES could play a larger role in the capacity mix. This would assist in minimizing the impact on the electric peak along with utilizing more cogeneration to meet demand. Figure iii.17 shows the projected capacity mix through 2050 for the delayed electric infrastructure pathway. The general configuration of the capacity mix is like the least constrained pathway but with increased deployment of TES, which necessitates additional gas assets overall to accommodate peak steam demand if TES is used to minimize impact on electric peak.

Figure iii.17 Delayed Electric Infrastructure Pathway Proposed Long-Term Capacity Change by Location/Technology (Mlb/hr)



Steam production from ER 60/70 is expected to reduce completely, with the potential for full retirement of both units by 2040, while installing new gas boilers at East River. Like the least constrained pathway, the first wave of retirement of existing boilers and replacement with new boilers at 59th Street, 60th Street, and 74th Street would also take place by 2040. Additionally, new cogeneration gas turbines would be deployed at East River, 59th Street and 74th Street while installing more TES at 59th Street and 60th Street. All existing fossil fuel boilers are projected to be replaced by 2045 with more TES deployed at 74th Street and Hudson Avenue and new gas boilers at Ravenswood. East River would see the addition of more TES by 2050. ER 10/20 will remain in service through 2050 but is supplemented with additional cogeneration capacity. This additional cogeneration capacity would support the grid as an additional generation source while TES is deployed in greater quantities within Manhattan. Gas boilers are required for peaking in addition to TES to accommodate steam peak demand if TES is operated to prioritize economics (i.e., used on electric peak which is thought to coincide with off peak steam demand).

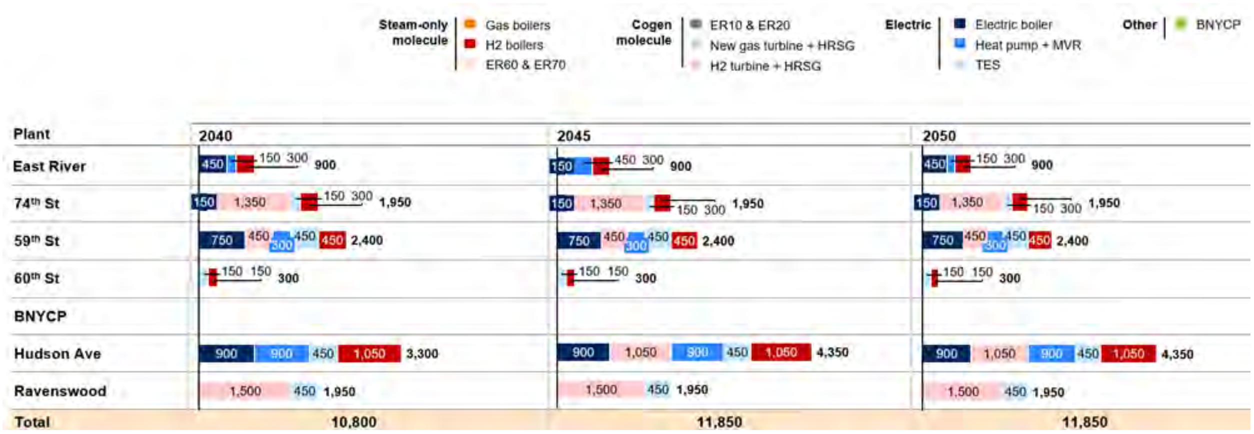
8.3 Pathway 3: Delayed Pipeline Decarbonization

For the delayed pipeline decarbonization pathway, if SNG/RNG are not available nor viewed as a decarbonization solution, a shift in the long-term pathway would be required. Developments that could result in the assumptions from the least constrained pathway to change include:

- A clear ruling is made that RNG / SNG cannot be considered zero-carbon
  - Regulators may consider CO_2 emitted during the burning of SNG/RNG as rationale to consider the fuel not "truly carbon free."
- Insufficient feedstock availability
  - Feedstock used to produce SNG/RNG (e.g., organic waste biogas) is not available in sufficient quantities within NYS.
- Lack of conversion tech and infrastructure development
  - The technology used to produce and transport SNG/RNG (e.g. Fischer-Tropsch plants) does not mature/scale up.
- Emergence of an H_2 economy
  - Demand for H_2 grows across industrial uses driving infrastructure development and overall feasibility of supply, thus lowering cost.
- H_2 infrastructure is developed in NYS
  - A local H_2 hub or development facilities (e.g., electrolyzer plants) are developed with supporting infrastructure (e.g., H_2 pipelines) making the fuel accessible to Con Edison.

Neither the steam system nor the power sector in Zone J are expected to reliably function without molecules-based capacity assets to support peak demand. If SNG/RNG is not available in the quantities required, shifting to the use of H_2, as an alternative low-carbon molecule-based fuel, would still be an economically preferred option due to the resulting benefit of being able to leverage the fuel source when the electric system is most constrained. As shown in Figure iii.18, the capacity configuration changes significantly when compared to the least constrained pathway as the steam system shifts to H_2 use.

Figure iii.18 Delayed Pipeline Decarbonization Pathway Proposed Long-Term Capacity Change by Location/Technology (Mlb/hr)



The majority of the capacity retirements and installation of new decarbonization technologies in this pathway are estimated to occur by 2040. H_2 boilers (either via retrofits or new installations) would be deployed at significant levels to make up approximately 20% of the overall steam capacity mix by 2050. ER 10/20 would be retired and replaced with new H_2 cogeneration capacity that is distributed across other sites at 74th Street, 59th Street and Ravenswood. The retirement of ER10/20 would create an opportunity to shift capacity outside of Manhattan due to reduced production, which would remove steam distribution system bottlenecks mainly at Hudson Avenue. Also, Ravenswood would include greater overall capacity due to the deployment of energy-dense H_2 turbines. All remaining existing fossil fuel boilers would be retired and replaced with H_2 boilers at the existing facilities as well as Hudson Avenue. Additional heat pumps would be installed at East River, 59th Street and Hudson Avenue while deploying more TES at 59th Street and 60th Street.

9. Financial Impact of a Decarbonized Steam System

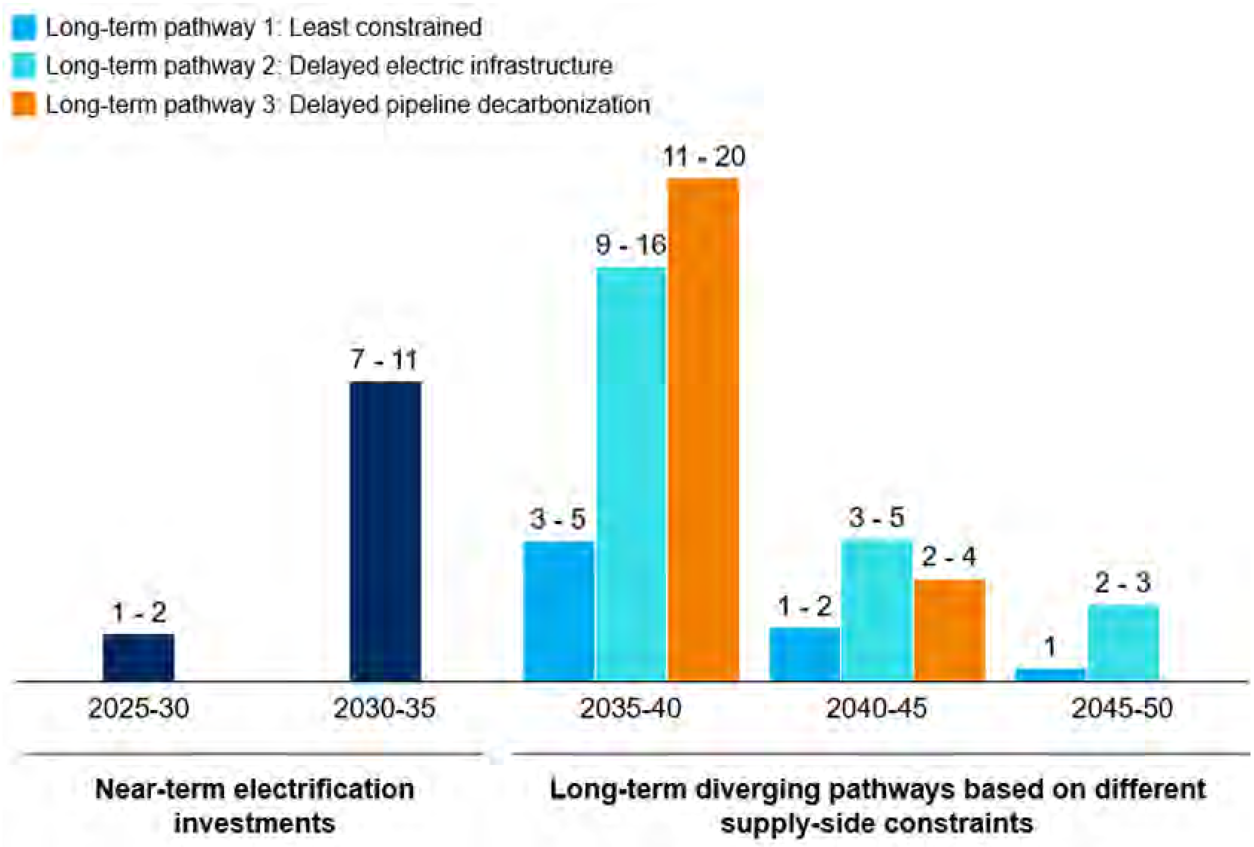
The transition to a decarbonized steam system represents a significant shift towards sustainable industrial practices. This transformation not only aligns with City and State environmental goals but also has profound financial implications. The sections below explore the multifaceted financial impacts of implementing a decarbonized steam system, highlighting both the immediate and long-term economic benefits.

9.1 Decarbonization Pathway Capital Investments

Based on the completed evaluation, the decarbonized district steam system presents a valuable solution for decarbonizing hard to electrify customers. While decarbonizing steam will require significant capital investment, it is projected to be more cost-effective than the expenses associated with retrofitting customers for electrification along with the capital investment in the electric grid to accommodate additional heating load from electrification.

Preliminary cost estimates suggest that decarbonizing the district energy system will necessitate $13-21 billion in capital investment over the next 25 years for the most optimal pathway. Alternative options, as shown in Figure iii.19, could be more expensive. The least constrained pathway (Pathway 1) offers the most cost-effective long-term solution. This approach optimizes the economic deployment of a combination of electric and low-carbon molecule assets, ensuring the availability of both carbon-free electricity and clean pipeline gas supply. The delayed electric infrastructure pathway (Pathway 2) is the most expensive long-term option overall, costing around $22-$37 billion. This high cost is mainly due to the need for extensive installation of costly technologies like TES to support and relieve the burden on an overtaxed electric grid. Delayed pipeline decarbonization (Pathway 3) entails investment costs comparable to those of the delayed electric infrastructure pathway, approximately $21-$37 billion. The most significant surge in overall investment is anticipated in 2040, as the system shifts from existing pipeline gas assets to new H_2 assets, such as H_2 boilers and H_2 gas turbines. It should be noted that SNG/RNG is considered the "preferred" carbon-free molecule (assuming it is considered carbon-free) in this study due to the potential challenges that could exist with the viability of H_2. This is demonstrated by the fact that the cost-optimal least constrained Pathway 1 uses SNG/RNG, and H_2 is only used as an alternative in the delayed pipeline decarbonization Pathway 3, where a constraint to SNG/RNG usage is assumed.

Figure iii.19 Estimated Steam System Decarbonization Investments through 2050, $B



Direct capital costs cover the engineering, procurement, and construction of the new steam decarbonization assets. This also includes utility services and existing asset retirement costs. Permanent equipment costs include items like pumps, boilers, and electrical equipment, and materials costs cover concrete and steel. The total capital costs also encompass owner's costs (overhead) for managing and overseeing the project, as well as estimated contingency costs for system development and delivery, including any related utility services.

9.2 Societal Costs

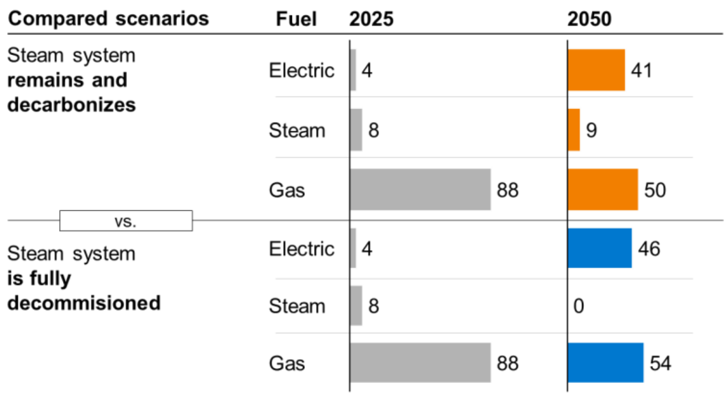
To determine the economic cost-benefit of a decarbonized district energy system, there is a need to evaluate which path is most cost-effective without needing to factor in specific customer pricing mechanisms or policy. The economic analysis requires an incorporation of costs incurred by both the energy system and its customers to decarbonize while meeting energy demands.

The societal cost to decarbonize heating through decarbonizing the district steam system compared to decommissioning the system and a full electrification option looked at the system-level and customer-level costs. The system-level costs include capital costs incurred by the steam and electric systems, such as the costs to install decarbonization assets and expanded the transmission and distribution system to handle the higher capacity expected. Operating costs incurred by the district steam system would also need to be considered. Customer-level costs would include retrofit costs for customers needing to switch to an alternative home-heating source and expected fuel costs (e.g., for decarbonized fuels).

The comparison of the expected 2050 space heating floorspace allocation for the decarbonized steam system and a fully decommissioned system is shown in Figure iii.20. The customer assumptions that were made when comparing a steam system that remains and decarbonizes reflects the least constrained decarbonization pathway and while the fully decommissioned steam system proposition is adapted from the "Hybrid Pathway" scenario but modified to include steam customer transitions to other commodities:

- Steam system remains and decarbonizes
    - All existing steam customers remain
    - Vast majority of transitioning gas customers (95%) move to electric
    - Minority of transitioning gas customers (5%) move to steam
- Steam system is fully decommissioned
    - All transitioning gas customers move to electric
        - Transitioning steam customers move to electric, with the exception of the most costly to electrify which instead move to gas

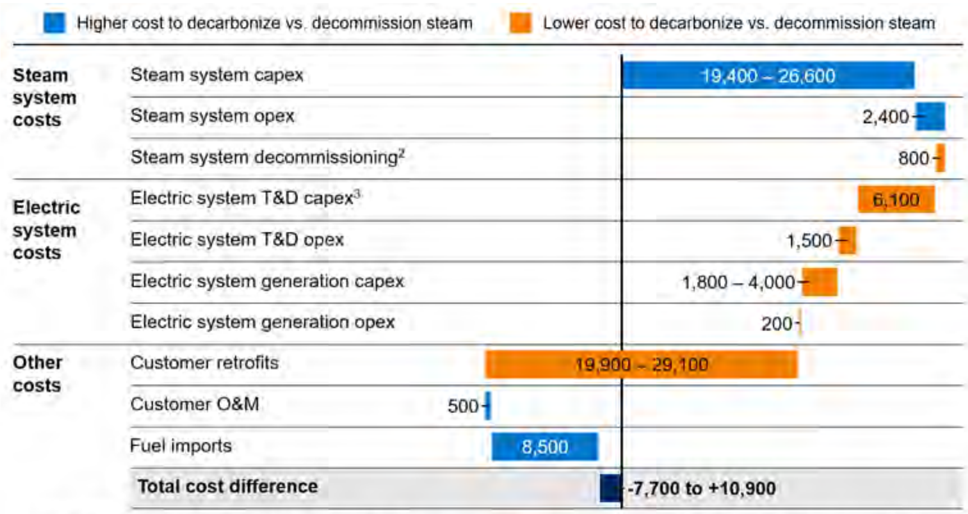
Figure iii.20 Space Heating Floorspace Allocation, %



Decarbonizing the steam system is expected to be just as cost effective as decommissioning the system. While decarbonization efforts will require significant capital investment and there will be a continued need to use imported fuels, it is expected to minimize the required buildout of the decarbonized electric grid by utilizing TES and gas pipeline using clean molecules. It will also prevent costly retrofits of hard-to-electrify customers, which would potentially result in a societal cost saving of up to $11 billion as shown in Figure iii.21. In addition, some qualitative benefits from decarbonizing steam encompass the following:

- Avoids disruptive and costly need for individual building retrofits, preventing tenant displacement and economic losses.
- Efficient net-zero achievement through system-wide approach, ensuring all buildings are decarbonizing uniformly, avoiding dependence on individual choices.
- Preservation of heritage by protecting historic buildings from invasive retrofitting, maintaining NYC’s architectural integrity.

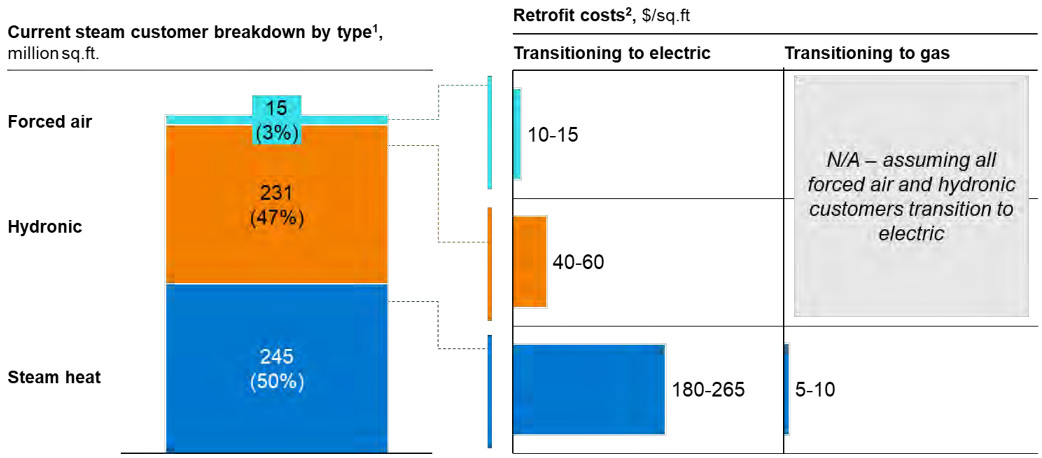
Figure iii.21 Levelized Societal Costs (Benefits) of Decarbonizing vs. Decommissioning Steam System[1] 2025 – 2050, $M



1. Capex levelized using with a FCR of 5.6% for Con Ed and 7.8% for customers, average asset lifetimes are estimated at 40 years for Con Ed and 25 years for customers; steam capex ranged +/- 20%; generation cost ranged to reflect range of potential generation technologies (e.g., cost of gas turbines vs. off-shore wind); customer retrofit costs based on prior studies from Guidehouse and McKinsey
2. The steam system is decommissioned based on the timeline established by the 2011 CECONY Steam Group study
3. $5M/MW for T&D CAPEX provided by Con Ed electric system planning team based on 2016 study. This analysis adjusts that number for inflation from 2016 to 2024

Existing steam customers who choose to electrify to meet their decarbonization goals are expected to incur significant costs to retrofit their properties, even with the assumption that the customers with the costliest conversions will move to gas instead. Figure iii.22 displays an illustrative view of the expected retrofit costs for the different types of current steam customers, with retrofit costs adapted from internal studies such as the “Electrification Challenges in Dense Urban Environments” study.

Figure iii.22 Potential Retrofit Costs for Current Steam Customers

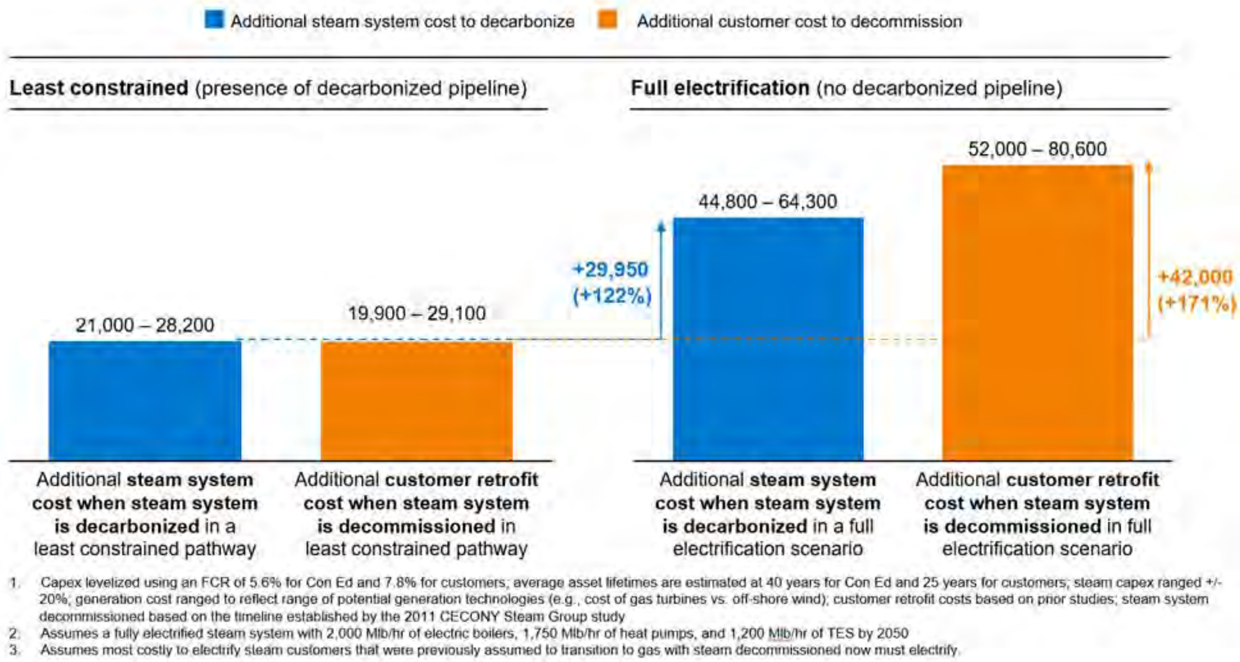


1. Break down of steam customers by existing system technology type as per One City Built to Last report, applied to total steam square footage in Company forecast
2. Dstrict steam to gas retrofit expenses are considered equivalent to the costs associated with replacing a gas boiler. Does not include service connection costs ; electrification retrofit costs include electrical upgrade expenses (e.g., panel upgrades)
3. Figures reflect levelized capex using an FCR of 5.6% for Con Ed and 7.8% for customers; average asset lifetimes are estimated at 40 years for Con Ed and 25 years for customers

In the full electrification scenario, the study assumes that all steam customers will move to the electric system as gas is no longer available to serve customer heating needs nor for steam production. In this scenario, there is a significant benefit to decarbonize steam due to high retrofit costs for the hardest-to-electrify steam customers, as shown in Figure iii.23. Full electrification of the steam system would increase the cost of system decarbonization by $29.9 billion (+122%) when compared to the "least constrained" pathway (Pathway 1). If the steam system were decommissioned in this scenario, and all steam customers were required to electrify, customer retrofit costs would increase by $42 billion (+171%) compared to the reference scenario given the absence of alternatives for hard-to-electrify customers. In addition, an energy system that leverages both steam and electricity provides three cost benefits over greater electrification:

- Greater efficiency - Using zero-carbon molecules to generate heat energy directly (vs. conversion to electricity and then heat) is more cost efficient.
- Lower T&D costs - Leverages existing steam network infrastructure to transport energy vs. additional electrical T&D infrastructure buildout.
- Emissions allowance - CLCPA requires all electricity to be 100% emissions free by 2050 from 1990 levels vs. broader target of 85% reduction (remainder offset) for other emissions from 1990 levels.

Figure iii.23 Potential Retrofit Costs for Current Steam Customers



9.3 Customer Costs

The study evaluated the heating costs from a steam customer perspective under two scenarios:

1. Steam customer remains on steam heating as the steam system decarbonizes, and
2. Steam customer shifts to electric heating as an alternative decarbonization route.

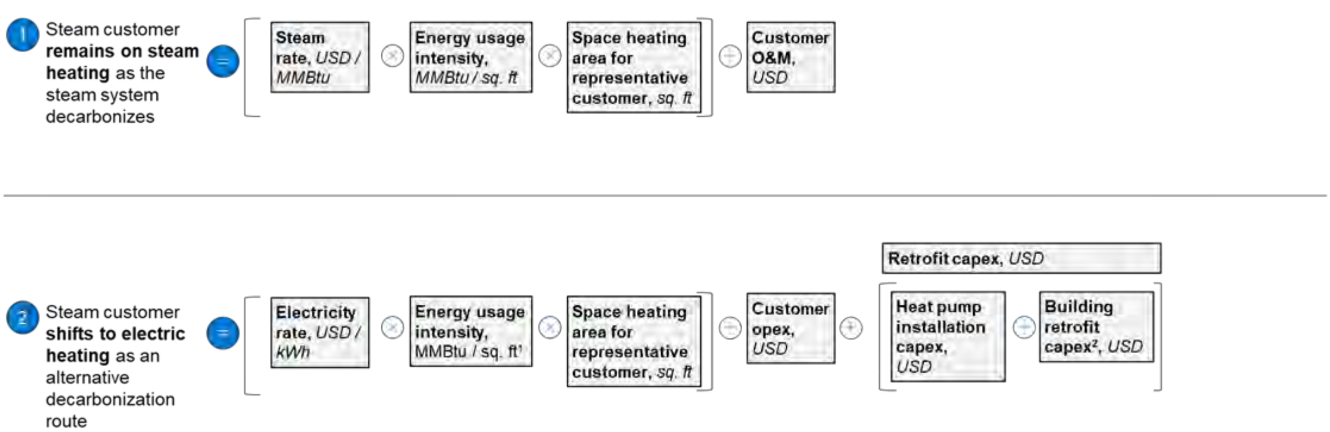
The costs considered in the analysis included:

- 2025-2050 steam rate (USD / Mlb) – future steam costs for customers, projected until 2050
- 2025-2050 electricity rate (USD / kWh) - future electric costs for customers, projected until 2050
- Customer opex (USD) – annual costs associated with operating and maintaining steam or electric heating

- Customer retrofit capex (USD) – capital expenditure required to replace steam heating with electric; this includes the heat pump installation Capex and the retrofit Capex for modifying or replacing the distribution system to accommodate electrification

The calculation components for the annualized total cost of ownership for customers in the two scenarios are shown in Figure iii.24. The projected steam rate was provided by the Company using the forecasted capex and opex associated with the least constrained decarbonization pathway. It also includes assumptions for the depreciation impact of the decarbonization pathway and potential allocation cost of cogeneration between steam and electric. Steam rates are expected to increase four to six times over current rates due to decarbonization investments and could potentially increase if any additional investments are required outside what is currently forecast in the least constrained pathway by 2050. Meanwhile electric rates are projected to increase two to three times by 2050 over the current electric rates according to the Company’s “Hybrid Pathway” scenario assumption. The rate increase is forecast to be most substantial during the 2030-2040 period as the level of required investments ramps up to keep pace with accelerating regulatory targets. The projections also factor in the electrical cost sharing mechanism for the expected cogeneration (currently in place for ER 10/20) and an accelerated depreciation that will occur as existing assets are retired.

Figure iii.24 Annualized Total Cost of Ownership for Customers, USD/year



1. Converted into kWh per square foot using rate of 293 kWh = 1 MMBtu as per US EIA
2. Reflects modifying or replacing the distribution system to accommodate electrification, i.e., replacing steam distribution system with ducting
3. Retrofit capex is discounted using the expected lifetime of the equipment and the blended cost of capital to customers

Figure iii.25 displays the expected annualized cost for current steam customers for 2040, comparing the two decarbonization scenarios and a non-decarbonized steam scenario where the customer would pay a LL97 penalty. The annualized costs are over a 21-year lifespan. The utility costs include customer operations and maintenance costs, and the customer retrofit costs are based on assumptions adapted from the "Electrification Challenges in Dense Urban Environments" study. LL97 penalties are calculated by comparing a building's fuel-specific GHG emissions to their use-specific GHG limit. Each property type has a specific emission factor, outlined in section 28-320.3.1 of Title 28: New York City Construction Codes, that will decline over time and reduce the GHG limit of the property. LL97 then quantifies the emissions each building emits by assigning a specific fuel coefficient to the fuel use (e.g., electricity, natural gas, fuel oil, district steam).

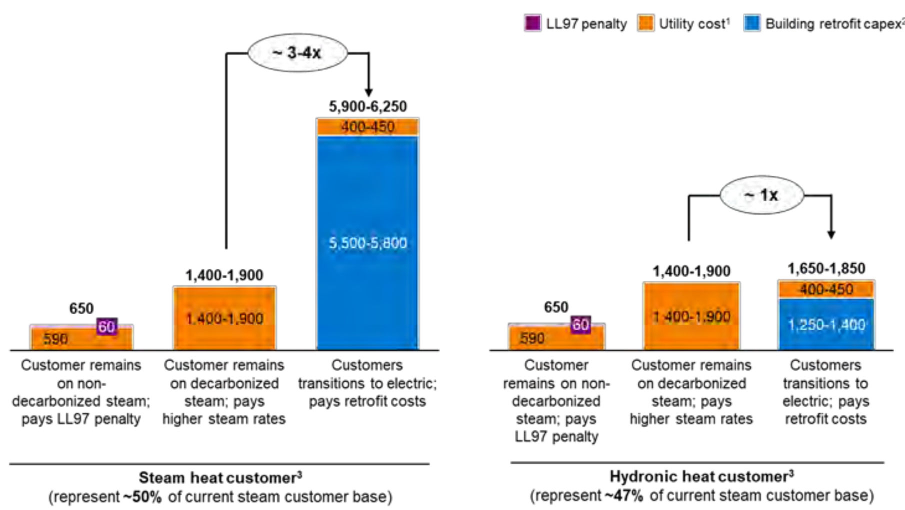
The study found that it would potentially cost buildings that currently use steam for heating purposes 3-4 times more if it chooses to electrify as their decarbonization option than if they remained on decarbonized steam. This customer base, which is assumed to represent approximately 50% of the current steam customer base on a square footage basis, use steam as a building-side heat transfer medium, which would mean a full replacement of steam piping is required as domestic heat pumps cannot sufficiently generate steam for electric heating. These customers show an economic benefit to remaining on the steam system even if steam rates increase due to significant retrofit costs (~$220/sq. ft). Hydronic customers, who are assumed to represent about 47% of the current steam customer base on a square footage basis, use water as a building-side heat transfer medium, which would mean that existing water loops can likely remain for electric heating. The decision to electrify for this customer base is more economically equivalent and could be influenced by other factors, such as:

- Tenant disruption impact
- Historical preservation requirements
- Building suitability for retrofits (e.g., utility room space)
- Policy intervention (e.g., retrofit rebates)

A small portion of existing steam customers (approximately 3% on a square footage basis) use forced air and will be relatively easy to electrify given the presence of existing ductwork that can be leveraged for conversion.

With the expected continuation of decreasing emissions from the decarbonization projects, it should help reduce the risk of customer defection due to LL97 requirements. However, in either scenario, the LL97 penalty is unlikely to drive customer behavior due to it being significantly cheaper than both higher rates for decarbonized steam and/or required capex investments relating to customer electrification.

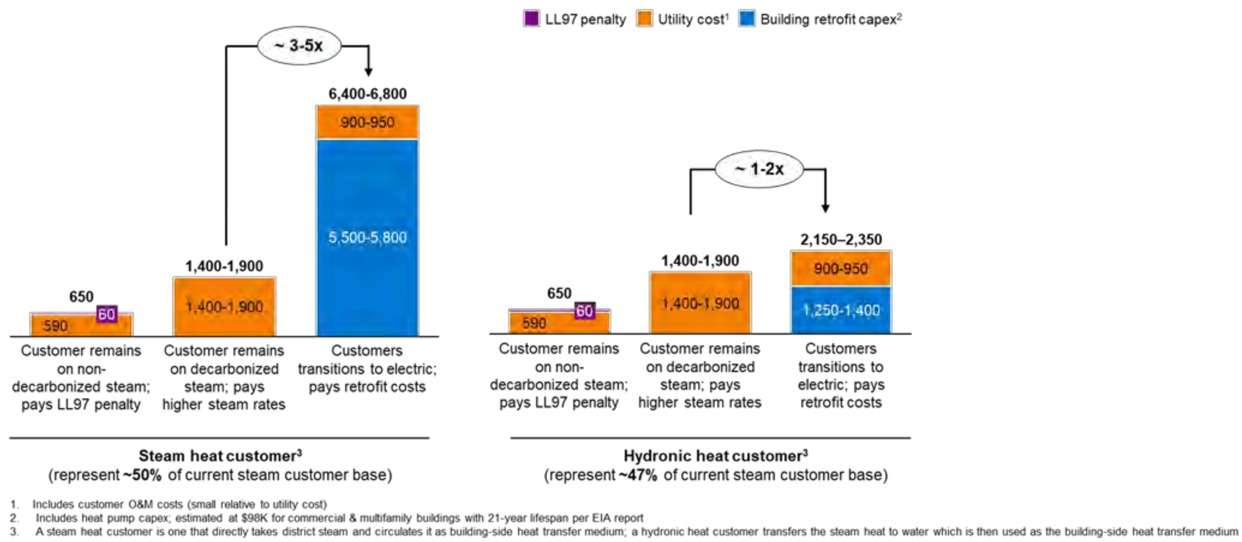
Figure iii.25 Annualized Cost for Current Steam Customer, 2040, $k



1. Includes customer O&M costs (small relative to utility cost)
2. Includes heat pump capex; estimated at $98K for commercial & multifamily buildings with 21-year lifespan per EIA report
3. A steam heat customer is one that directly takes district steam and circulates it as building-side heat transfer medium; a hydronic heat customer transfers the steam heat to water which is then used as the building-side heat transfer medium

While the "Hybrid Pathway" scenario currently assumes an approximate 3% CAGR over 25 years, Con Edison's electricity rates for commercial buildings grew around 7.2% CAGR between 2021 and 2023. Therefore, the study performed an electric rate growth sensitivity to identify any shifts in customer behavior and assumed a more moderate growth rate between the two points, around 5.5% CAGR. Please note that the electric rates used in the sensitivity analysis are consistent with Con Edison's Long-Range Plans. With the future uncertainty of customer electrification adoption and electric capital investment requirements there is the potential that the electric rates used for the purpose of this study are conservative side and may potentially be higher in future. The analysis found that the overall economics for hydronic heat customers would shift from the least constrained pathway, and it would become more cost effective if they remained on the decarbonized steam system as shown in Figure iii.26. However, similar to the least constrained pathway, the LL97 penalty is not a driving factor to change customer behavior.

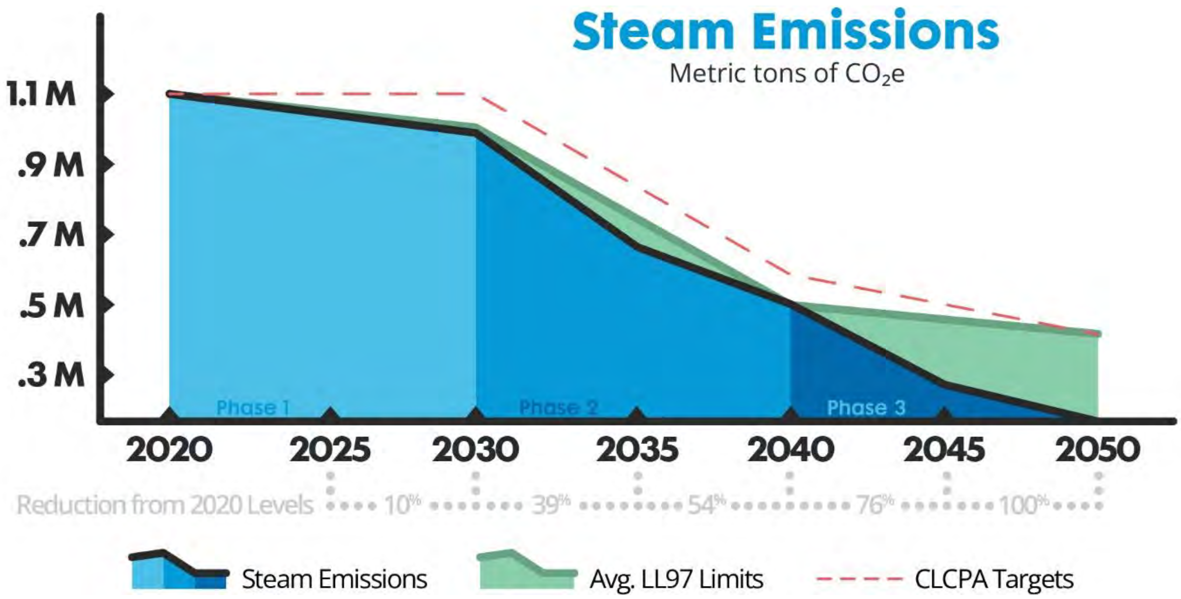
Figure iii.26 Annualized Cost for Current Steam Customer, 2040, $k



9.4 Local Law 97 Coefficient

Con Edison's decarbonization pathway allows for the reduction of GHG emissions in line with State and City goals as highlighted in Figure iii.27. It should be noted that actual emissions are heavily dependent on the dispatch strategy of the district steam system and further reductions in emissions could be achieved by optimizing and balancing the dispatch decisions between economics and emissions. The steam emissions represent the emissions associated with combustion only and are based on the EPA 20-yr global warming potential (GWP) as per CLCPA.

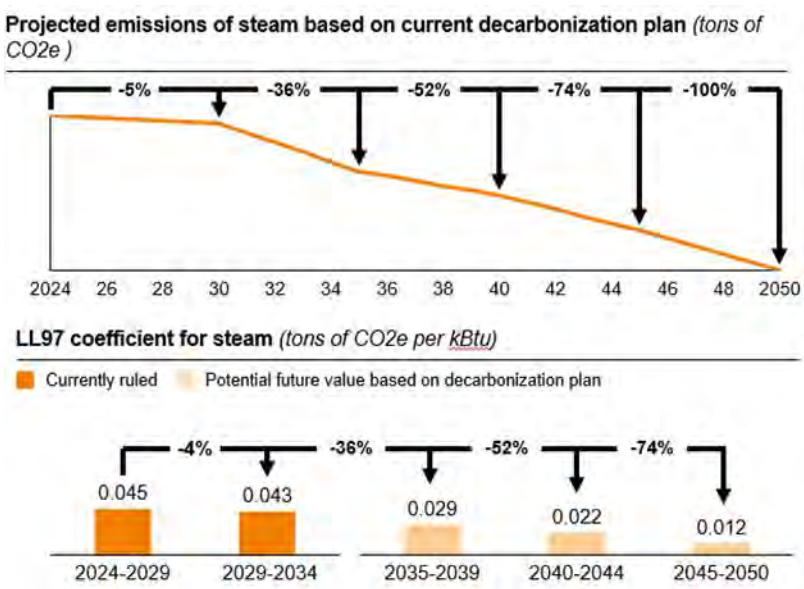
Figure iii.27 Projected Steam GHG Emissions Trajectory, '000 metric ton CO_2e



The actual emissions reflect the average value over the previous 5-years and until 2030, Con Edison will continue its operational improvements through steam generation energy efficiencies as well as promotion of customer-based energy efficiency efforts. The Company will begin with an early deployment of electrification projects at a measured pace as detailed in the Company's Implementation Plan to test the core electrification-based decarbonization technologies (heat pumps, electric boilers and TES) prior to extensive investment. The emissions reductions in the mid-term would be based on learnings from the early deployment projects as Con Edison ramps up investments (particularly with the continued electrification technologies) to be in line with the accelerating LL97 target trajectory. There is an inherent uncertainty in the emissions trajectory post-2040 as the broader energy landscape and regulatory requirement evolve. However, as both steam fuel sources (electricity and pipeline gas) are expected to be fully decarbonized by 2050, this inherently results in emissions-free steam by 2050 despite CLCPA allowing for up to 15% of 1990 emissions to be offset by carbon credits to be compliant with net-zero objectives.

As previously stated, LL97 measures individual building emissions by applying a specific fuel coefficient to the fuel consumption. As customers decarbonize by converting from fossil fuels to district steam, there will be an overall reduction in emissions for the customer, the city, and the state. With a lower LL97 coefficient for district steam, customers will also see a decrease in penalties. Even though the LL97 coefficients have already been set through 2034, the Company plans to have discussions with the NYC DOB regarding future adjustments to the steam system coefficient based on planned decarbonization projects and corresponding emissions reduction trajectory, similar to the recent decreases established for the electricity coefficient. While the steam co-efficient currently has a lower carbon equivalent, emissions per unit of electricity are expected to be approximately 50% lower in the 2030-2034 timeframe as more wind, solar and hydro are expected to be connected to supply NYC. Con Edison's decarbonization plans could potentially justify an estimated 36% decrease in the LL97 steam coefficient for 2035-2039 when compared to the current 2024-2029 level, as shown in Figure iii.28.

Figure iii.28 Projected LL97 Steam Coefficients



9.5 Sources of Funding

Con Edison is aware that the route to decarbonization will require a large amount of financing to help the City and State achieve their desired climate goals. There are two types of funding sources that the Company could utilize for project financing and, if combined, can be an effective way to maximize value as well as strengthen a funding application request through increased credibility:

- Public funding sources

    - Numerous avenues are available (e.g., grants, loans, tax exempt bonds, tax credits) that are driven by governmental policy and efforts to decarbonize, but come with necessary application processes and effort.
- Partnerships with vendors
    - Partnerships can help mitigate financial risk, provide access to expertise, accelerate project timelines, and improve cost efficiency

Public Funding Sources

There are three broad categories of public funding sources currently available to utilities, each with their respective pros and cons to pursue as highlighted in Figure iii.29:

Figure iii.29 Types of Public Funding Sources

Category of funding	Description	Pros and cons	Examples
Federal, state or private grants	Funds provided by the federal or state government to support specific initiatives awarded based on project merit and alignment with priorities (i.e., GHG reduction, energy efficiency)	(+) Non-repayable – reduces financial burden (−) Competitive application process with compliance and reporting requirements	U.S. Department of Energy grants (DOE), Environmental Protection Agency grants,
Federal or state loans	Funds provided by the federal or state government that must be repaid with interest (rates more favorable than private loans)	(−) Repayable – increases debt load (+) Favorable loan terms	USDOE Loan Programs Office Rural Utilities Service (RUS) loans for rural energy projects
State or federal tax credits or tax-exempt bonds	**Tax exempt bonds:** Debt securities issued by govts. where the interest earned by investors is tax-exempt **Tax credits:** Incentives provided by the federal government that reduce the amount of tax owed by the utility	(+) Tax-exempt interest earned by investors (+) Reduces overall tax liability but only if there is a liability to offset (−) Strict eligibility requirements	NYSERDA bonds, green bonds Investment tax credit, production tax credits

While federal loans have the most funding available, grants are generally a more attractive funding source for decarbonization projects. Figure iii.30 on the following page shows various funding sources that could be pursued by the Company and the total funding available. Many of the public sources, such as the Grid Resilience and Innovation Partnerships (GRIP) Program, focus on electricity grid improvement projects. Therefore, the Company would need to educate the funding parties by demonstrating the district steam system's ability to support the electric load via technologies like TES. Grants and tax credits should be prioritized given there is no need to take on debt. However, loans can still be a good secondary source of funding since there is a large amount of funding available, and they are often provided at attractive rates.

Figure iii.30 Public Funding Sources and Funding Available

Federal or state grant | Federal or state loan | Other financial tools

Name of funding source	Description	Total funding available
Advanced Research Projects Agency-Energy (ARPA-E)	Energy research funding agency that provides targeted and open funding opportunities across the full spectrum of energy applications	$3.8
Funding opportunity announcements (FOAs) across DOE[1]	Multiple topic specific funding opportunities regularly announced by the DOE	Undefined
Project Opportunity Notices (PONs) from NYSERDA[1]	Multiple topic specific funding opportunities regularly announced by NYSERDA	Undefined
IRA Investment tax credits (ITC)	Tax credits based on project investments which can include energy storage and combined heat and power projects	Undefined
NYSERDA conduit bonds	Tax-exempt bonds for utility companies to finance clean energy projects[2] and $1.6B has already been issued	Undefined
Grid Resilience and Innovation Partnerships (GRIP) Program	Broad set of programs primarily focused on grid resiliency projects	$10.5B
Clean Energy Fund	State level investment portfolio that provides loans, investments and other financial support to clean energy projects	$5B
Title 17 Clean Energy Financing (DOE Loan Programs Office)	Loan programs that support development of wide range of clean energy projects in US	$400B

Partnerships with Vendors

Utilities can leverage partnerships with vendors to provide joint offerings that would allow for more comprehensive decarbonization solutions. Below are summaries of two case studies on a utility-vendor partnerships.

1. Xcel Energy, an electric and natural gas utility based in Minnesota and Form Energy, an energy storage company that is producing commercial 100-hour iron-air batteries, are partnering on a public utility commission (PUC) approved pilot that is supported by DOE funding. A 10 MW / 10 MWh multi-day LDES system pilot will be deployed at the Sherburn County Generating Station in Becker, Minnesota as early as 2025. This project received regulatory approval by Minnesota PUC , with costs recoverable through a

renewable energy rate rider included in customer bills. Form Energy will supply the iron-air battery modules, capable of storing electricity for 100hrs, that will be used in the LDES facility which will be owned and operated by Xcel Energy. The utility will also build an approximately 460MW solar project ('Sherco Solar Project') nearby to be used to power the LDES facility. Xcel Energy applied for, and successfully received, a DOE grant for up to $70 million on behalf of both parties to partially fund the project.
For Con Edison, a PUC application can potentially be made with a partner already identified but this would require advanced commitment. Also, a successful first application can open the door to follow-up projects such as a proposed second project in Colorado between Xcel and Form Energy that would be further supported by the DOE.

2. In 2022, Enel, an Italian utility focused on renewables and smart grids, and Brenmiller, a TES developer leveraging rock-based storage medium, launched a pilot 24 MWh TES system in Italy that stores excess energy as heat and releases it to generate electricity via a steam turbine. Steam produced by Enel's power plant is used to charge the TES system, which can then be discharged up to 5 hours later. According to the companies, when charging, TES is charged using high-pressure steam (9 tons/hour at 550°C, 80 bar), with condensate returning to steam cycle; when discharging, 150°C water feeds TES (6 tons/hour), generating intermediate pressure steam (360°C) that returns to the HRSG for the steam turbine. Brenmiller supplied their proprietary bGen thermal energy storage batteries while Enel owns and operates the TES system, which is used to provide storage and resiliency to steam turbines at their existing 390 MW Santa Barbara power station. The project was partly financed by 1 million Euros provided to Brenmiller by the Israeli Innovation Authority. As a true first-of-its-kind TES system, both parties have stated that knowledge sharing was crucial for project success.

   For Con Edison, the Company would build expertise similar to Enel as they implemented a pilot project that enabled real-world testing/validation of new technology before large-scale deployment. In addition, the Company could potentially receive international financial support for a project in a similar fashion as to Enel, an Italian company, who was able to receive international project support via funding that a partner received from their home country.

conEdison

iv. Implementation Plan

2024 Steam Decarbonization Study
& Implementation Plan

Con Edison remains committed to meeting the challenges of the City and State's nation-leading clean energy policy goals as a next-generation clean energy leader. The Company realizes that the future district steam system will leverage and accommodate dynamic, innovative, resilient, and scalable solutions that provide abundant clean energy choices for a carbon-free future. The Company will continue to monitor and adapt to changes in customer expectations, the climate, clean energy legislation and technological advancement. To achieve overall decarbonization goals, several key strategies must be implemented. First, enhancing customer energy efficiency is crucial to reducing the overall load on energy systems. This involves encouraging customers to adopt more energy efficient equipment and practices. Second, utilizing decarbonization technologies with high efficiencies (i.e., electric boilers, TES, heat pumps), and other innovative decarbonization methods such as waste heat recovery systems, is essential. These technologies can significantly reduce emissions by making better use of energy that would otherwise be wasted. The Company is currently involved in a District Hot Water Loop project to evaluate the potential viability of hot water loop systems within the steam service territory. That study will identify potential users/participants, along with providing conceptual designs for closed hot water loop projects within Manhattan that would be connected to the existing Con Edison steam system. The Company applied for $6 million in cost share through DE-FOA-0003136: Connected Communities 2.0. Obtaining this funding would alleviate the financial burden on steam ratepayers, preventing an increase in rates associated with the construction of this project. Lastly, the integration of low-carbon fuels (LCFs) into the energy mix is vital. This includes the use of H_2, and other sustainable energy sources to replace traditional fossil fuels, thereby reducing the carbon footprint of energy production and consumption. Together, these strategies form a comprehensive approach to achieving significant reductions in greenhouse gas emissions.

As mentioned earlier, the Steam Decarbonization Study evaluated three decarbonization pathways and concluded that from now until 2035, electric driven assets were the optimal assets for deployment in all pathways. Between 2025-2030, the Company is proposing three early deployment projects to begin the decarbonization process, all the while continuing to monitor the dynamic regulatory, energy supply, technological, and customer landscapes. These early projects will provide valuable learnings that will be incorporated into future projects. Looking further out to 2035, the consistency of optimal asset mix per the

Study, will be used to inform how and where future electric driven assets are invested and how and where existing gas assets are retired while balancing regulatory requirements and financial impacts. Beyond 2035, the study shows that diverging pathways appear, further emphasizing the importance of signpost monitoring and remaining attuned to the changing landscape in NYC when committing to future asset deployments and retirements.

1. Near-Term Prioritization — 2030 Clean Energy Strategy

Con Edison's near-term clean energy strategy emphasizes electrification and enhancing the efficiency of our steam system. By focusing on innovative decarbonization technologies that offer greater heat rates and efficiency, significant reductions in our carbon footprint will begin. Key technologies in this strategy include electric boilers, TES and heat pumps at existing Company locations. These solutions not only improve energy efficiency but also support our commitment to sustainable and environmentally friendly operations.

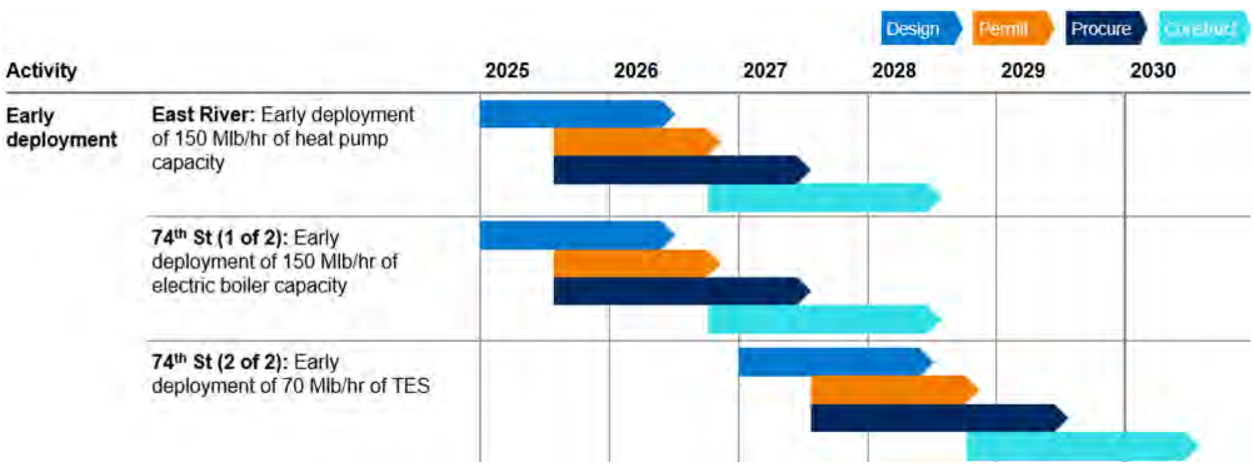
Our primary focus will center around the meticulous execution and seamless operation of early deployment projects. These initial endeavors will serve as crucial steppingstones, laying the groundwork for future growth and expansion. To achieve this, we must ensure that every aspect of these projects — from planning to implementation — is carried out with precision to allow us to identify and address potential challenges early on. By demonstrating our ability to manage and operate these early initiatives effectively, we not only build credibility but also pave the way for sustained success in the long term.

2. Proposed Decarbonization Projects

Each decarbonization project is expected to take approximately 2-4 years to progress from design through to construction and commissioning, depending on the scope of the project, with some potential efficiency gains in permitting over time. Procurement is expected to take up to two years due to the long lead times for equipment design and manufacturing. The construction time for asset retirement is estimated at 12-18 months, including additional contingency for potential significant site remediation, such as asbestos abatement. Early permitting discussions are anticipated to begin approximately five months into the design phase.

Figure iv.1 illustrates the timeline for three early deployment projects that the Company plans to develop over the next five years. The initial phase of decarbonization technology investments will prioritize existing locations with space not currently being used. Therefore, initial deployments were strategically carried out in open areas at existing Company facilities to maintain the existing system. By choosing locations with available space, the costs associated with demolitions can be avoided. Technology deployments at Hudson Avenue and Ravenswood will be considered for later stages, as their operation and maintenance (O&M) plans require additional staffing at these sites.

Figure iv.1 Early Deployment Schedule of Proposed Projects



Once completed, the decarbonized assets will contribute to substantial reductions in carbon emissions. The Company has completed optimization modeling to determine what the reduction in carbon emissions would be under two scenarios:

1. Economics Driven – where the units are introduced and allowed to operate under economical dispatch criteria.
2. Emission Driven – where the units are forced to operate as must run units to maximize the contribution to steam demand and carbon reduction.

The results of that modeling determined that nearly 50,000 tons of CO_2 can be eliminated under the Economic Model and over 125,000 tons of CO_2 eliminated if an Emissions Model is implemented.

Below are descriptions of the three potential electric-based technology projects that the Company proposes to demonstrate district steam system viability and will use as the basis of learnings for full-scale deployment across the system.

1. **Electric Boiler**
   Con Edison is proposing a 50MW electric boiler project as part of the first phase of decarbonized asset deployment. This electric boiler will be installed at the East 74th Street Generating Facility and provide 150,000 lb/hr of 400 psi steam for the distribution system. The electrical supply will come from an existing 13.8kV substation located nearby. This electrical feed will be shared with a TES project that is detailed in the next section below. Preliminary order of magnitude estimate for this project is $50 million.

   As electric boilers are a mature technology and have been installed for district heating applications, this project has low risks and limited technological issues to address. The main consideration for this electric boiler installation is the availability of electricity. This project will utilize an existing connection in the substation formerly used by gas turbines for peaking electric production. After discussions with Con Edison Transmission & Distribution Planning, this substation will have 50 MW of availability with limited curtailments for the next 20 years. These curtailments would be limited to mid-day hours during the summer peaks and some hours in the winter after 2041. Limited details were available for this use case as no winter peak day curves were available for 2042-2043. For these reasons, Con Edison believes this project has high viability.

2. **Thermal Energy Storage**
   Con Edison is proposing a 50MWe TES project as part of the first phase of decarbonized asset deployment. This TES unit will be installed at the East 74th St Generating Facility and provide up to 67,000 lb/hr of 400 psi steam for the distribution system for 12-15 hours. The electrical supply will come from an existing 13.8kV substation located nearby. This electrical feed will be shared with the electric boiler project that was discussed previously through a manual transfer switch, that will charge the TES unit or run the electric

boiler. Optionally, a 2 MW non-condensing steam turbine is proposed for this project to utilize the TES unit for electrical generation when needed by the grid. This is proposed in order to apply for grant proposals that require electric generation to receive funding. Preliminary order of magnitude estimate for this project is $100 million. Con Edison is seeking additional funding for this project through DOE and NYSERDA. The Company applied for $20M in cost share through DOE FOA-0003399, and $5M in cost share through NYSERDA PON 5779.

Thermal energy storage is a leading technology for decarbonization. However, TES has not been commercially proven at the scale proposed for this project, and not for district steam heating uses. Most of the vendors Con Edison has been in discussions with have TRL levels of 6 or lower with plans to reach commercial deployment by 2030. Currently, TES systems have been deployed at the pilot scale in powerplants or for industrial heating at a larger scale. This project would represent the first time a TES system is used in a district steam system and in a dense urban environment. Con Edison is mitigating these risks by working closely with EPRI to monitor emerging TES technologies and companies, working directly with manufacturers on specific Con Edison steam needs, and prioritizing vendors that meet Con Edison's main priorities for TES. These priorities are vertical integration, high voltage charging, and high energy density. For these reasons, Con Edison believes this project has moderate viability.

3. **Industrial Heat Pump**

Con Edison is proposing a 35 MWe Industrial Heat Pump project as part of the first phase of decarbonized asset deployment. This unit will consist of a heat pump and MVR system to provide 150,000 lb/hr of 400 psi steam for the distribution system. This unit will be installed at the East River Generating Facility and tie into existing water treatment and steam distribution systems. The electrical supply for the IHP unit will come from the generator bus of the existing gas turbine (Unit 2). River water will be the heat source for the IHP, and this project will connect to the existing river water circulation system used by two of the units at the station. Preliminary order of magnitude estimate for this project is $150 million. The Company is developing a specific Request for Proposal (RFP) to select one of the IHP vendors to complete a detailed engineering design for the IHP project described in this section. That effort will be funded under the Company's existing rate plan, where funding was allocated for such purpose. At the conclusion of this study, Con Edison will complete a full appropriation estimate for the IHP project to confirm the project costs before seeking funding by the Commission.

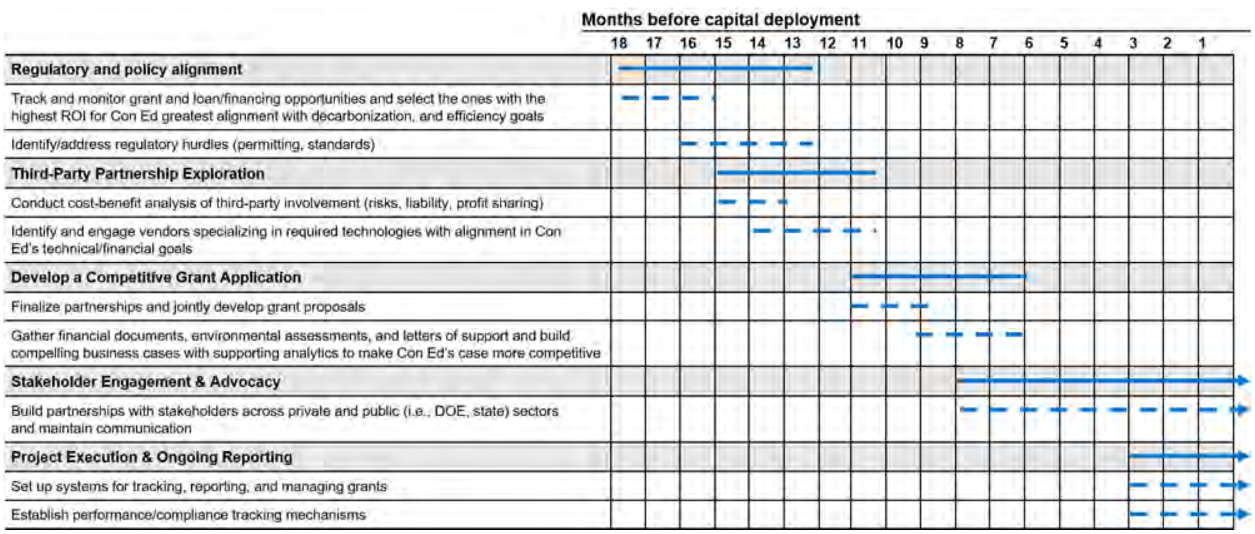
Industrial heat pumps and MVRs are commercially available technologies that have been used in industries around the world. The combining of these two technologies for district heating is a new development that has not been commercially proven yet. For this reason, the Company estimates this technology to have a TRL level of 8. Con Edison has visited and discussed IHP systems with various vendors to confirm its feasibility at the East River Generating Facility and determine what the efficiency gains are compared to an electric boiler. Potential issues for this IHP project will be with refrigerants and river water withdrawal permits. New York State has banned refrigerants with a high GWP, and there is uncertainty about what further regulations will govern the refrigerants Con Edison can consider. The Company will work closely with EH&S personnel to monitor city and state regulations as the engineering study progresses to determine which refrigerants will be acceptable for use in the station and what safety measures will need to be in place. The IHP unit will use river water as a heat source, which will cool river water that is returning to the East River. Regulatory review and studies will need to be conducted to confirm if this use case meets the current East River SPDES permits, and what modifications would need to be made to the permits or the existing fish protection systems to allow a heat pump unit to operate. Con Edison will work with EH&S and the NYSDEC to evaluate the project and how it will impact current station operations as the study progresses. Con Edison believes this project has moderate viability as other district steam systems in the northeast are installing IHP technology at a similar scale and are looking at the same issues outlined above.

3. Potential Funding Opportunities

There are various resources available to Con Edison that can minimize the impact on customers as the district steam system undergoes decarbonization. To secure funding and ease the financial obligations for these projects, the Company has begun identifying opportunities and potential partners and plans to continue to do so well in advance of new capital asset deployment. Figure iv.2 illustrates a roadmap for identifying funding opportunities prior to capital deployment. By initiating these efforts in the near term, it may be possible to secure funding for projects as early as 2026.

Con Edison has already participated in and is evaluating applications for grants under DOE FOAs 3036, 3020, and 3206, along with NYSERDA: PON 5472. As mentioned earlier, the Company has submitted applications for DOE and NYSERDA funding for a TES project, has received $450M in NYSERDA conduit bonds, and will continue to actively explore further funding opportunities.

Figure iv.2 Illustrative Capital Funding Deployment Roadmap



4. Potential Long-Term Barriers to District Steam Decarbonization

The Company recognizes that reaching a decarbonized future necessitates a 25-year transformation. This journey involves taking immediate actions in the short term while keeping an eye on various long-term factors. To gradually transform the district energy system, new decarbonized assets will be introduced while existing assets are phased out over time. This process will start with the early deployment of heat pumps, electric boilers, and thermal energy storage (TES) within the next five years. However, Con Edison will need to keep a close watch on key regulatory changes, technological advancements, and shifts in supply and demand in the long-term. This will help to manage uncertainties and adjust plans for adding or retiring assets to stay aligned with the changing energy landscape.

Beyond 2030, the Company will persist in its decarbonization efforts, aligning with regulatory targets and focusing on 100% electric investments. The steam system has already achieved the CLCPA's 2030 target of a 40% reduction from 1990 levels. To avoid acquiring new sites, the Company must utilize unused space at its existing facilities, strategically sequence retirements to free up additional space, and prioritize electrical asset deployment at locations with minimal constraints.

The Company will need to continuously monitor key regulatory, technological, and supply/demand indicators to manage uncertainty and adapt asset additions and retirements to the evolving energy landscape. Con Edison's strategy and plan post-2030 is to maintain optionality and flexibility based on indicators to ramp up or down specific programs or actions based on technological and policy shifts to achieve the future value the communities and customers expect. Figure iv.3 highlights key indicators that could significantly impact the decarbonization plan and shift our trajectory and how Steam Operations could potentially respond:

Figure iv.3 Summary of Expected Long-Term Investment Barriers

● High importance signpost with potential for significant impact

Category	Signpost	How Con Ed Steam could respond
Regulation / policy	● 1 **Relaxed emissions standards** (e.g., lower LL97 limits, CLCPA target date extended)	Scale back decarbonized asset deployment (e.g., reduce ramp-up in 2030-2040) to reduce capital spend in line with new targets
	● 2 **SNG/RNG not considered carbon neutral**[1,2] by regulators or policymakers	Replace and/or retrofit planned pipeline gas assets with those that run on hydrogen (e.g., H2 boilers, H2 cogen)
	3 **Limitations on use of river water** as heat source for heat pumps (e.g., restricted by regulators)	Evaluate alternative heat sources (e.g., cogen wastewater) or replace capacity with electrified alternative (e.g., electric boilers)
Energy supply	● 4 **Delayed electric buildout**[2]: Electric grid capacity/supply does not expand at the rate anticipated (e.g., 1 GW of offshore wind expected at BCEH for steam)	Deploy additional TES (up to 3x) & cogen (up to 2x) in place of other electric assets (e.g., electric boilers, heat pumps)
	5 **Lower SNG/RNG prices** than projected (i.e., < $19-23/MMBtu)	Assess if current plan to replace existing gas assets for efficiency gains (due to high fuel costs) remains economical
	● 6 **H2 fuel availability increases**[2] and becomes a cost competitive molecule-based fuel vs. SNG/RNG (e.g. increasing industrial demand results in local hydrogen infrastructure development, such as a pipeline)	Replace and/or retrofit planned pipeline gas assets with those that run on hydrogen (e.g., H2 boilers, H2 cogen)
Decarb technology	● 7 **Technical challenges with selected technologies** in early deployments (e.g. heat pumps can't reach required temps/pressures)	Replace planned capacity of technology with alternative high-scored technology (e.g., replace heat pumps with additional electric boilers)
	8 **Improvement in viability** of technologies previously excluded (e.g., CCUS infrastructure developed)	Revisit considerations that previously eliminated technology and evaluate whether scoring has changed / technology is now viable
Customer	● 9 **Accelerated electrification of district steam customers** (e.g., policy incentives improve electrification economics for existing steam customers)	Evaluate risk of significant steam demand decline (e.g., up to -67% in Deep Electrification scenario) and economic viability of decarb plan
	10 **Slower steam growth** vs. pace assumed in pathway development (e.g., +10% by 2050)	Scale back planned deployments with same relative asset mix changes (e.g., continue partial system electrification)

1. This action could also be informed by a lack of SNG/RNG supply that increases cost (even if considered viable from a regulatory perspective)
2. Signposts 2, 4, and 6 have had corresponding alternative 2035+ decarbonization pathways developed given the relatively high impact these signposts would have on optimal asset mix

5. Next Steps

The three early deployment projects proposed from now to 2030 will reinforce the Company's commitment to decarbonize by 2050. The Company will file a petition for these projects according to the mechanism outlined in the Joint Proposal to request the Commission's approval for proposed Future Decarbonization Projects. This mechanism allows the Company to petition for projects of various types, scopes, and maturity levels. The petition will include information on design, location, feasibility, costs, and anticipated emissions reductions, while also incorporating results from the Decarbonization Study and Implementation Plan as well as the Steam Business Development Plan. This approach ensures that approved decarbonization projects are feasible, cost-effective, and can reasonably contribute to achieving CLCPA targets.

As Con Edison advances its efforts to decarbonize, the integration of gas, steam, and electric systems is becoming increasingly vital. The Company has recognized that future plans for all three commodities will be interdependent, particularly as the steam system's demand for electricity and LCFs increases and plans to release an Integrated Long-Term Plan in early 2025.

Con Edison is also uniquely positioned to drive beneficial outcomes across commodities by decarbonizing the steam system. Decarbonizing the steam system can help increase flexible and dispatchable electrical capacity within Zone J, an outcome aligned with the overall goal of the Grid of the Future Proceeding (Case 24-E-0165). Although the Grid of the Future Proceeding is more focused on behind-the-meter resources, like aggregating customer heating into flexible grid resources and virtual power plants, the additional flexible capacity achieved in Zone J from decarbonizing the steam system can complement those goals.

From a regulatory standpoint, the Company will need to initiate early discussions with various regulatory bodies regarding the steam system's roadmap to 2050 and the permitting requirements for new technologies. Monitoring the evolution and implementation of LL97 will be crucial. The Company will provide its perspectives on key issues such as coefficients and the adequacy of penalties. The Company will also develop a plan based on the Decarbonization Study results to aid in discussions regarding future changes to the district steam coefficient in LL97. A stakeholder meeting to discuss the Company's plan will be scheduled within the first quarter of 2025.

Operationally, the Company will need to continue exploring ways to enhance plant efficiency and flexibility to maximize the potential of existing assets. The Company is evaluating using the business intelligence application utilized in the Phase III modelling to continue to assist the Company with future decarbonization efforts. This application will allow for integration of new decarbonized production assets such as electric boilers, heat pumps, and thermal energy storage into the existing system configuration. It will help to identify the hourly dispatch patterns of the steam system with integration of new decarbonized asset deployments. As the system evolves to incorporate multiple fuels and storage capabilities, current operational policies and procedures will need to be updated. Anticipated market volatility will require an approach that leverages sector coupling to optimize dispatch efficiency while adhering to technical and regulatory constraints.

As part of its Business Development Plan, which will be filed at the end of 2024, the Company intends to engage steam customers to enhance the value proposition of decarbonizing steam and begin securing interest and commitments. Con Edison will continue to evaluate the technical, economic, and market feasibility and attractiveness of decarbonizing its district steam network to support city, state, and customer building GHG emissions reduction goals.

The Company will continuously evaluate and improve its strategies based on feedback and observed results. Despite the considerable uncertainty surrounding the future of the energy landscape, the Company has crafted a robust plan to meet the objectives outlined by the CLCPA. Additionally, it has affirmed that the steam system will play a crucial role in New York City's future energy framework.

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v. Appendix

2024 Steam Decarbonization Study
& Implementation Plan

1. Technology Evaluation Methodology

Scorecard criteria assessment and threshold levels

Multi-valued scoring: High / Medium / Low / Fatal flaw — Binary scoring: Meets requirements / Fatal flaw

Category	Criteria	Description	Scoring methodology and targets			
Technical	1 **Technology maturity**	What is the technology's maturity level based on its development and deployment progress?	Technology is **fully developed, tested, and demonstrated in real-world conditions** (e.g., TRL 9)	Technology is a **near-desired prototype** has been developed and tested in either a simulated or real-world environment (e.g., TRL 7-8)	Technology includes **basic integration of sub-components** but has **not been yet been formally tested** (e.g., TRL 5-6)	Technology has a substantially **low technology readiness level** (e.g., TRL <5) and **development remains uncertain**
	2 **Operating parameter suitability**	Can the technology operate at the parameters required by the steam system?	Technology **can** meaningfully support saturated steam generation at the required parameters (e.g.,>~ 400°F, >~200-400psi)		Technology **cannot** meaningfully support saturated steam generation at the required parameters (e.g.,>~ 400°F, >~200-400psi)	
	3 **Reliability** (as a standalone technology)	What is the expected level of technology intermittency?	Technology can typically run **>100 hours** continuously without interruption (excluding exogenous factors)	Technology can typically only run **10-100 hours** continuously without interruption (excluding exogenous factors)	Technology can typically only run **<10 hours** continuously without interruption (excluding exogenous factors)	
	4 **Operational flexibility**	How flexible is the technology to quickly meet changing demand?	Technology has a ramp rate that is **>80% of total capacity/hr**	Technology has a ramp rate between **40-80% of total capacity/hr**	Technology has a ramp rate that is **<40% of total capacity/hr**	
Regulatory	5 **Regulatory compliance**	Does the technology comply with relevant regulations?	Technology **fully meets or exceeds** emissions-related regulatory requirements and there are **no other major regulatory restrictions**		Technology **does not meet** emissions-related regulatory requirements or there are **other potential major regulatory restrictions**	
Regulatory	6 **Level of decarbonization** (as a standalone technology)	What level of obtainable decarbonization does the technology possess?	Technology can obtain a carbon intensity of **0** g CO2e / kWh without releasing any carbon (e.g., does not include offsets)	Technology can obtain a carbon intensity between **0-100** g CO2e / kWh	Technology can obtain a carbon intensity > **100 g** CO2e / kWh	
	7 **Permitting difficulty** (inc. public perception and non-CO_2 environmental impact)	What is the expected permitting effort driven by environmental impact and public perception?	Permitting process expected to be have **minimal** hurdles (e.g., obtainable in **< 3 years**) due to: • Positive and/or neutral public perception expected • Minimal to no non-CO_2 environmental impact expected (e.g., significant water usage, potential habitat impact)	Permitting process expected to be have **moderate** hurdles (e.g., obtainable in **3-4 years**) due to: • Possibility of moderate adverse public perception (such as need to educate on new technologies) • Possibility of moderate non-CO_2 environmental impact (e.g., significant water usage, potential habitat impact)	Permitting process expected to be have **considerable** hurdles (e.g., obtainable in **>5 years**) due to: • Possibility of negative public perception (e.g., safety concerns) • Possibility of significant non-CO_2 environmental impact (e.g., significant water usage, potential habitat impact)	
	8 **Local community/ neighborhood impact**	To what extent does the technology have impact on local communities and neighborhoods?	The technology could potentially have **<2** of the following adverse impacts at a significant level:	The technology could potentially have to have **2-3** of the following impacts at a significant level:	The technology is expected to have **> 3** of the following impacts at a significant level:	
			• Disruption during construction • Adverse air quality impact	• Visual aesthetics • Significant land use impact	• Non-air waste generation	
System	9 **Fuel supply availability**[1]	Are necessary supply inputs (e.g., specific fuel/energy source) available?	There is **existing supply infrastructure in place** with **readily available supply**	There is **some existing supply infrastructure in place**, but **potential supply constraints exist**	There is **little to-no existing supply infrastructure** in place	

1. For carbon-capture related technologies, this score also considers infrastructure/supply availability to adequately transport and store captured carbon

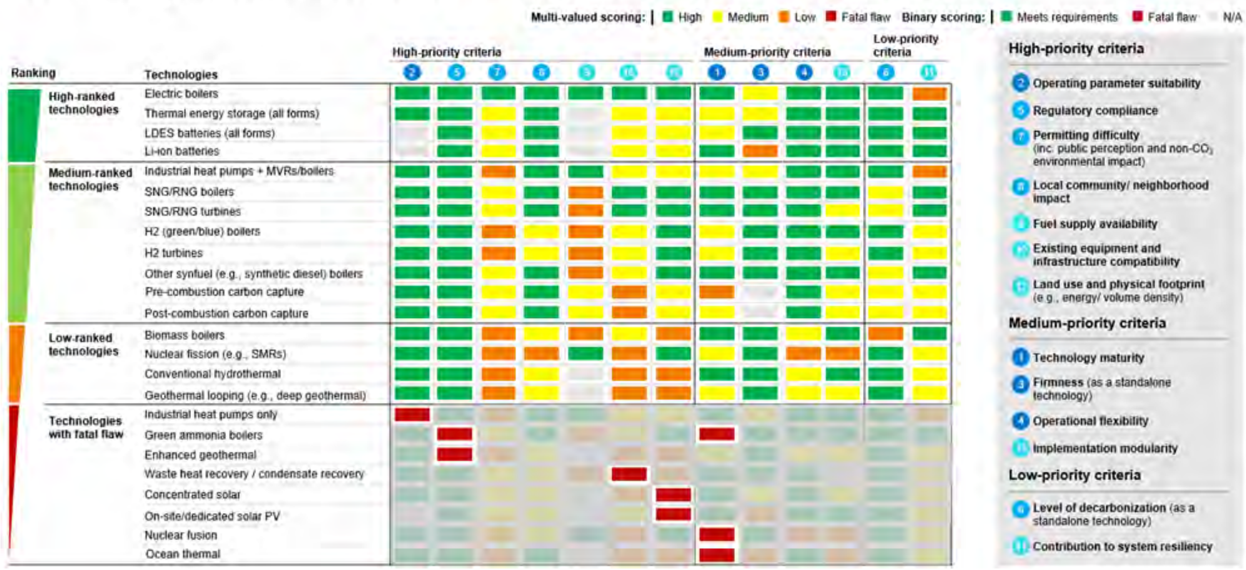
Scorecard criteria assessment and threshold levels (cont'd)

Multi-valued scoring: High | Medium | Low | Fatal flaw

Binary scoring: Meets requirements | Fatal flaw

Category	Criteria	Description	Scoring methodology and targets			
System	10 **Existing equipment and infrastructure compatibility**	How compatible is the technology with existing equipment and infrastructure?	Technology can integrate **relatively seamlessly with existing equipment and infrastructure** (e.g., installed in existing facilities with minimal system modifications)	Technology would necessitate **some adjustments to existing equipment and infrastructure** (e.g. can be installed in existing facilities, but would require some system modifications)	Technology would necessitate **significant expansions to existing equipment and infrastructure** (e.g., significant additional area or new sites required)	Technology would necessitate a **substantial overhaul or upgrade** to a significant portion of the steam system
	11 **Contribution to system resiliency**	To what extent does the technology incrementally improve system resiliency?	Technology **incorporates storage and/or possess dual-fuel capabilities**	Technology **does not** incorporate storage and/or dual fuel capabilities, but **does not** add to electric grid load	Technology **does not** incorporate storage and/or dual fuel capabilities, and **does** add to electric grid load	
	Land use and physical footprint (e.g., energy density)	What is the technology's expected footprint considering current operations?	Technology can potentially be implemented in **1-2x the footprint** as current operations	Technology can potentially be implemented in **2-3x the footprint** as current operations	Technology can potentially be implemented in **3-5x the footprint** as current operations	Technology would potentially need to be implemented in **>5x the footprint** as current operations
	Installation impact	Can the technology be implemented in phases to minimize disruption?	Minimum realistic/viable scale of technology installation is **< 100 MW**	Minimum realistic/viable scale of technology installation is between **100-400 MW**	Minimum realistic/viable scale of technology installation is between **400-1000MW**	Minimum realistic/viable scale of technology installation is **> 1000 MW**

Tech evaluation combined individual scores and criteria prioritization to rank potential technologies

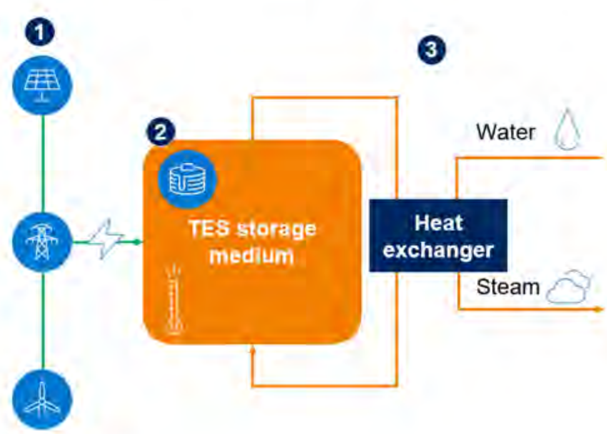


2. Technology Feasibility Analysis — Thermal Energy Storage

The information presented in these slides is from the TES stakeholder meeting held on June 21, 2024 and is considered preliminary. Please note that the content is subject to change as further developments and updates occur.

Thermal Energy Storage (TES) Technology Overview

TES converts electricity to heat, and allows it to be stored for use at a later time



How it works

1. Electricity (including that generated from renewables) is used as the source of energy input
2. This electricity is converted and stored as heat energy in one of three main ways:
   - **Sensible heat storage:** Directly increases the temperature of a storage medium with high heat capacity (e.g., molten salts, concrete) while maintaining its state
   - **Latent heat storage:** Similar to sensible heat storage, but utilize Phase Change Materials (PCMs) that transition between states; these transitions absorb and release heat energy as they occur
   - **Thermochemical storage:** Use electrical energy to facilitate reversible chemical reactions, which store and release heat energy as they happen
3. When needed, the heat energy can be transferred to water (either via direct heat transfer or via working fluid) to raise its temperature and generate steam

There are three main TES types, all of which are in early development stages

	Description	Temperature range	Duration use case
Sensible heat	Stores thermal energy by increasing the temperature of a solid or liquid medium	**<0–2,000ºC** Most technologies able to span a large range of temperatures	**Minutes to months** Most technologies able to serve intraday (hours) to multi-day durations, with some up to months
Latent heat	Relies on the phase changes of the medium (e.g., from solid to liquid) that use latent heat to store energy	**<0–1,600ºC** Specific temperature ranges served by specific technologies	**Hours to days** Most technologies serve intraday (hours) to multi-day durations
Thermo-chemical heat	Leverages the capacity of chemical reactions to absorb and release heat	**0–1500ºC** Spans smaller range on average due to less variety in available technologies	**Hours to months** Potential to serve intra-day (hours) durations up to months

All three technologies are either in pilot or R&D stages, with sensible heat being comparatively more mature

Solutions must be tailored to meet the demands of constructing in dense urban settings such as NYC, requiring high energy density, vertical integration, and high input voltage

Source: LDES Council 2022 report "Net-zero heat – LDES to accelerate energy system decarbonization"

TES decouples timing of electric steam production from electric supply, offering three major benefits

Increases use of clean electricity

TES enables a greater proportion of steam generation to be fueled by electricity, which is projected to become increasingly greener over time (CLCPA aims to achieve zero emissions from the electricity sector by 2040)

Optimizes energy costs

TES can lower steam costs by leveraging lower-cost electricity off-peak and using it during high-demand peak when electricity cost is at its highest

Provides steam system resilience

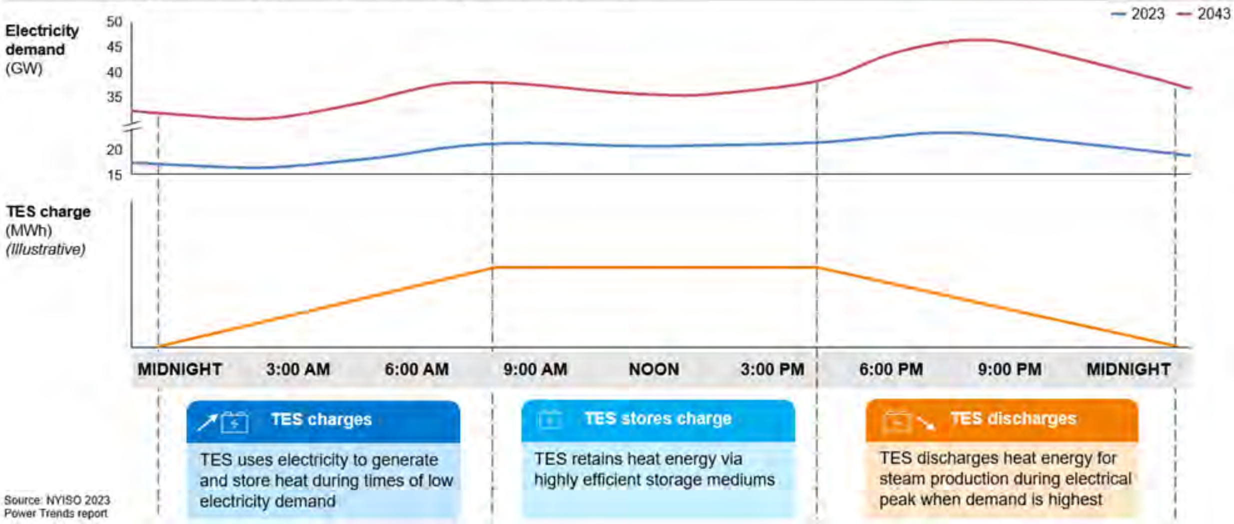
TES could replace existing assets operating at minimum load to satisfy Con Ed's margin requirements (QRR), enabling more efficient operating with both decarbonization and economic benefits

Source: LDES Council 2022 report "Net-zero heat – LDES to accelerate energy system decarbonization"

TES in Decarb Steam Network

TES allows for shifting of energy from times of low to high peak, helping to smooth overall electric demand

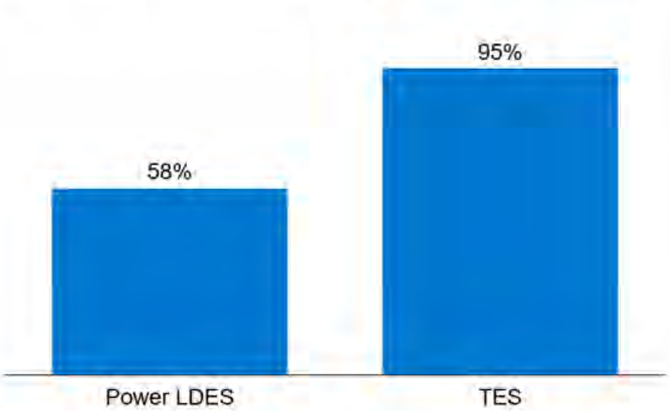
Winter hourly demand profile for electricity and use of TES



Source: NYISO 2023 Power Trends report

TES is the most energy efficient if the end use is heat

Power Long Duration Energy Storage (LDES) and TES efficiency benchmark for heat generation[1], %



1 Benchmark for top-quartile technologies in terms of efficiency. For TES, efficiency can vary depending on output gauge pressure

Source: LDES Council 2022 report "Net-zero heat – LDES to accelerate energy system decarbonization"

Key takeaways

TES charges and discharges energy at a higher round-trip efficiency (~95%) than power LDES (~58%) when the end use is heat

- In TES, both electric-to-heat conversion and heat discharge achieve efficiencies over 95%, yielding an overall system efficiency exceeding 90%
- Power LDES generates heat by charging and discharging electricity with 57-61% efficiency. It then converts this electricity to heat with over 95% efficiency, resulting in an overall efficiency of about 54-58%

Energy Storage Industry Outlook

EPRI 221: Bulk Energy Storage

The TES market is evolving rapidly, with over 30 vendors leveraging various storage technologies

Source: EPRI Energy Storage Developer List

Con Ed has evaluated 30+ vendors to identify those that best suit the steam system's specific needs

Market scan	Technical viability	Urban environment suitability
30+ vendors	**~15 vendors**	**~5 vendors**
Initial feasibility search began with a broad range of companies at different levels of maturity offering different technical solutions	~15 vendors were evaluated and identified as capable of meeting Con Ed's specific steam generation requirements of 200-400 PSIG steam and 15-20F of superheat	Of the vendors capable of generating steam at Con Ed's technical specifications, a handful have emerged as the most feasible options The identified vendors were those aligned best with specific criteria important in a dense urban setting such as NYC, which included: • High energy density (i.e., spatial requirements), • Vertical integration potential (to maximize ability to build 'up' in addition to 'out') • High input voltage (to minimize need for additional electrical infrastructure)

Several vendors have been identified as candidates that can offer feasible TES solutions meeting Con Ed needs

	Technical features					Company information	
Company	**Technology**	**Storage material**	**M. temperature**	**Charging voltage**	**TRL (1-9)**	**Funding**	**Sample projects**
ANTORA	Sensible heat	Carbon blocks	2,000°C+	13.8kV	5	$230M (Series B, Feb 2024)	5MWh thermal system with Wellhead Electric Company in California, currently operating
ELECTRIFIED THERMAL SOLUTIONS	Sensible heat	Electrically-conductive firebrick	1,800°C	13.8kV	4	$5M (seed in June 2022)	No commercial project currently in operation; co-patented with MIT thermal solutions with demonstrated 95% efficiency – potential for GWh's at-scale applications
NREL	Sensible heat	Silica sand	1,100°C	-	5	$3M (Grant)	No commercial project currently in operation; pilot project completed – IP agreement signed with a U.S. manufacturer
redoxblox	Thermo-chemical	Magnesium manganese oxide pellets	1,500°C	4kV	5	$107M (Series B, 2023)	No commercial project currently in operation; 100 kWh_{th} demonstrated for 1000+ hours and development for 10 MWh_{th}-scale industrial heat application
RONDO	Sensible heat	Clay bricks	1,500°C	7.2kV	7	$25M (Series A)	2MWh thermal with California ethanol production company Calgren, currently operating

Source: Company websites, pitchbook, press search, EPRI Energy Storage Developer List

74th TES Feasibility Scope

PRELIMINARY

- TES system to produce 400 psi superheated steam
- Install in Parking Lot
- Existing 13kV feeder from Gas Turbines provides 20 MW of charging
- Target Specs
  - Charge in 4-6 hours
  - Discharge over 24 hours
  - Simultaneous charge & discharge

74th TES Feasibility Scope

PRELIMINARY

- Multiple quotes
  - ~100 MWh of storage
  - 7-10 MW steam discharge
- Limitations
  - Weight would require floor reinforcements (1000+ tons)
  - Max steam output of ~30 mlbs/hr (1/4th a package boiler)
  - Budgetary proposals around $10M for TES equipment

Several TES-specific federal and state-level funding opportunities exist and are actively being pursued

Number	Name	Description	Primary partner	Con Ed role	Status
DOE: FOA[1] 3036	Energy Storage Demonstration and Validation	Up to **$15M** in funding for field demonstrations of different types of energy storage technologies: lithium batteries, flow batteries, and other innovative technologies	RedoxBlox	**Active partner:** committed to hosting and partial project funding	Not Selected
DOE: FOA[1] 3020	Storage Innovations 2030: Technology Liftoff	Up to **$15M** in funding for direct projects from partnerships between companies within storage technology industries to tackle pre-competitive R&D challenges	General Electric Research	**Interested party**: drafted a letter of support as part of application	Concept paper encouraged for full proposal which is currently in development
DOE: FOA[1] 3206	Industrial Efficiency and Decarbonization Office; Cross-Sector Technologies	Up to **$38M** in funding for general projects focused on cross-sector technologies designed to reduce industrial emissions	Rondo	**Active partner:** considering application of proposed project at 74th Street	Discouraged from Applying
NYSERDA: PON[2] 5472	Long Duration Energy Storage and Product Development	Up to **$8.15M** in funding for development and project demonstration of for long duration energy storage solutions	Potential application for this funding pending; evaluating internal resource availability and potential partnerships		

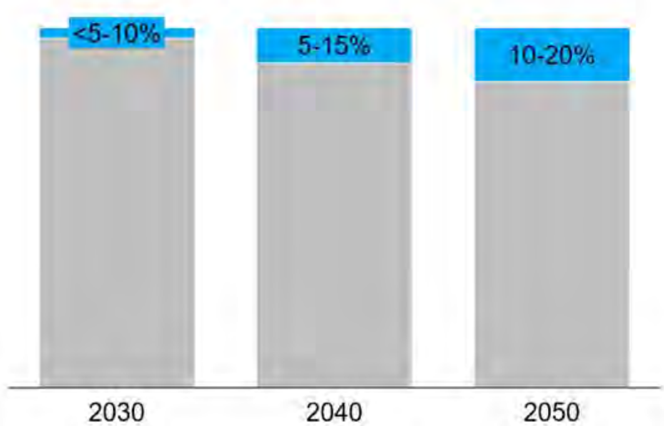
1. Funding Opportunity Announcement
2. Program Opportunity Notice

Pathways to 2050

TES is playing an important role in Con Ed's steam decarbonization effort

PRELIMINARY

TES share in decarbonized steam installed capacity (2030-2050), %



1. Other assets include electric boilers, heat pumps, and zero-carbon molecule driven gas assets (e.g., boilers, co-generation)

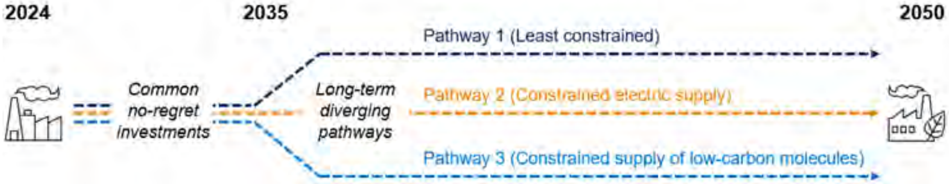
In alignment with CLCPA and NYC LL97, Con Ed plans to **progressively decarbonize steam generation to carbon neutrality** by 2050

Con Ed is currently developing a steam carbon neutrality strategy, outlining adjustments to its steam asset mix that can enable steam decarbonization

TES plays a crucial and growing role in the decarbonization of the steam system, and is projected to account for 10-20% of total steam capacity by 2050

Con Ed steam is developing several decarbonization pathways for its steam production

PRELIMINARY



Pathway	Details	Electricity supply minimally constrained	Gas distribution system decarbonizes
1 Least constrained	A cost-optimal solution balances both electric and molecule-based steam generation	✓	✓
2 Constrained electric supply	If electricity supply is constrained, TES plays a greater role to minimize impact on electric peak	✗	✓
3 Constrained supply of low-carbon molecules	If decarbonized gas supply is constrained, alternative sources of zero-carbon molecules are leveraged	✓	✗

In alignment with CLCPA and NYC LL97, Con Ed plans to **progressively decarbonize steam generation to carbon neutrality** by 2050

To accommodate various potential evolutions of electric and gas supply through 2050, **Con Ed is developing three potential pathways for decarbonizing steam generation. Between now and 2035, all three pathways share a common set of investments, and then diverge** based on various supply constraints

In all decarbonization pathways, **TES plays an essential role** and could account for up to 35% of all installed steam capacity by 2050