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October 13, 2021

New York State Department of Environmental Conservation
Division of Environmental Permits
625 Broadway
Albany, NY 12233-1750
Attention: Karen M. Gaidasz, Offshore Wind and Hydroelectric Section Chief

Re: Iroquois Gas Transmission System, LP
Enhancement By Compression (ExC) Project
Air State Facility Permit ID Nos. 3-1326-00211 and 4-1922-00049

Dear Ms. Gaidasz:

Enclosed please find Iroquois Gas Transmission System, L.P.'s responses to Questions 1 through 3 of the New York State Department of Environmental Conservation's March 5, 2021 Request for Additional Information related to the above-referenced Air State Facility permit modification applications for the Enhancement by Compression ("ExC") Project.

Feel free to contact me if you have any questions or require additional information.

IROQUOIS GAS TRANSMISSION SYSTEM, L.P.
By its Agent
Iroquois Pipeline Operating Company

By: ______________________
Name: Michael Kinik
Title: Director, Engineering Services

<u>**Response to NYSDEC March 5, 2021 Request for Additional Information**</u>

Iroquois Gas Transmission System, LP

Enhancement By Compression (ExC) Project

Air State Facility Permit ID Nos. 3-1326-00211 and 4-1922-00049

Below are Iroquois Gas Transmission System, L.P.'s ("Iroquois") responses to Question Nos. 1 through 3 of New York State Department of Environmental Conservation's ("DEC") March 5, 2021 Requests for Additional Information ("RFAI")[1] associated with Iroquois' applications for minor modifications to the Air State Facility Permits (the "Applications")[2] for Iroquois' Athens Compressor Station (DEC ID No. 4-1922-00049) and Dover Compressor Station (DEC ID No. 3-1326-00211) related to the proposed Enhancement by Compression Project (the "ExC Project" or the "Project").

For convenience, set forth below are Question Nos. 1 through 3 of the RFAI followed by Iroquois' response.

Question No. 1:

Regardless of any de minimis arguments (e.g., the project is less than x% of total NYS emissions), projects that contribute to the continued use of fossil fuels must be reviewed for alignment with the CLCPA emission limits because fossil fuels are the main source of all GHG emissions in New York State. Additionally, the CLCPA Assessment assumes that the continued conversion of buildings from fuel oil to natural gas is in alignment with the CLCPA, but there is no comparison to total emissions associated with these two types of fuels, including upstream and downstream GHG emissions as well as those related to combustion. The CLCPA requires NYSDEC to consider this full picture when reviewing air applications. Iroquois therefore must provide such information.

Response:

As further discussed below, a comparison of estimated life cycle greenhouse gas ("GHG") emissions that would result from the Project to alternative energy sources demonstrates that the Project is consistent with the statewide GHG emissions limits established by the Climate Leadership and Community Protection Act ("CLCPA").[3]

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[1] DEC sent one RFAI to Iroquois for each of the Air State Facility Permit Applications. Since the RFAI questions were identical for both Applications, this document includes Iroquois' response to both RFAI. Iroquois' responses to Question Nos. 4-6 of the RFAI were included in its submission to DEC dated May 14, 2021.

[2] The Applications, as supplemented, and this response have been filed with DEC without prejudice to any rights that Iroquois now has, may have, or which it seeks to assert in the future under the Natural Gas Act (15 U.S.C. § 717 et seq.) or any other federal or state law or regulation, all of which are hereby expressly reserved.

[3] DEC's DAR Technical Guidance Memo, titled Climate Leadership and Community Protection Act (CLCPA) and Permit Applications, dated September 1, 2020, provides that CLCPA consistency review is required for applications for new permits and significant permit modifications. Accordingly, since the Applications seek neither new permits nor significant modifications to Iroquois' permits, pursuant to DEC's guidance, a CLCPA consistency review is not

CLCPA Consistency

Iroquois' December 23, 2020 Supplement to Air Permit Applications ("December 2020 Supplement") included M.J. Bradley and Associates' ("MJB&A") "End-Use Greenhouse Gas Analysis of the Enhancement by Compression (ExC) Project" (the "MJB&A Downstream Study"). However, DEC's RFAI indicates that Iroquois must estimate upstream GHG emissions so that DEC can assess the Project's consistency with the CLCPA. To fully respond to DEC's RFAI, Iroquois retained MJB&A to expand upon the evaluation that was included in the MJB&A Downstream Study. This new study, titled "Life Cycle Greenhouse Gas Analysis of the Enhancement by Compression (ExC) Project," is attached hereto as Attachment A (the "MJB&A Supplemental Study"). The MJB&A Supplemental Study estimates lifecycle GHG emissions from the ExC-transported natural gas and compares those emissions, for the 20-year term of the of the ExC shippers' transportation service agreements ("ExC Contracts Term"), to the lifecycle GHG emissions that would be associated with alternative energy sources needed to meet the same anticipated energy needs of the ExC shippers' customers.

The results of the MJB&A Supplemental Study demonstrate that life cycle GHG emissions resulting from the Project would be less than the GHG emissions that would result from viable alternative energy sources (identified as the "Heat Pumps and Oil Scenario" in the MJB&A Supplemental Study) that would be required to meet the energy demand satisfied by the Project. The MJB&A Supplemental Study shows that ExC would produce, on an annual average basis throughout the ExC Contracts Term, between 0.02 and 0.05 million metric tons ("MMT") less carbon dioxide equivalent (CO_2e) emissions than the Heat Pumps and Oil Scenario. Throughout the ExC Contracts Term, on a cumulative basis, the ExC Project would result between 0.46 and 1.2 MMT less CO_2e emissions than the Heat Pumps and Oil Scenario, a net reduction of GHG emissions of between 3-7%. As such, when compared to the Heat Pumps and Oil Scenario, the ExC Project results in a net reduction in GHG emissions and, thus, is consistent with the CLCPA GHG emissions limits.

Life Cycle Emissions Analysis

The MJB&A Supplemental Study provides DEC with the requested estimate of life cycle emissions that would result from the Project and the alternatives that would otherwise be required to meet the energy demand (for space heating, water heating and other purposes) met by the Project. The MJB&A Supplemental Study also incorporates the ExC shippers' updated natural gas demand forecasts and anticipated energy demand assumed to be met by heat pumps.[4] Additionally, MJB&A utilizes a 20-year Global Warming Potential ("GWP") for carbon dioxide,

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required. However, to be fully responsive to DEC's RFAI, Iroquois hereby provides additional information regarding the ExC Project's consistency with the CLCPA.

[4] MJB&A Supplemental Study at 3.

methane and nitrous oxide,[5] represents methane and nitrous oxide in carbon dioxide equivalent emissions, and integrates the methodology that DEC is considering for its annual statewide greenhouse gas emissions inventory. Accordingly, MJB&A's lifecycle analysis provides estimates of both in-state and out-of-state upstream (production, processing and transport) emissions.

As noted in the MJB&A Supplemental Study, the heat pump penetration scenarios that are analyzed in the study are not actual projections based on current economics or market demand for heat pumps.[6] Instead, the analyzed scenarios rely heavily on the heat pump assumptions that are reflected in the June 2021 National Grid Natural Gas Long-Term Capacity – Second Supplemental Report ("National Grid LTCSR"). The heat pump assumptions reflected in the National Grid LTCSR are based on energy demand of the region – not what is actually forecast to occur based on the current heat pump market. In other words, the scenarios presented in the National Grid LTCSR are not grounded in actual heat pump installation projections but, rather, are heat pump installation rates that would be required to fill the anticipated gap between the forecasted demand and supply in the region. As a result, the heat pump installation assumptions in the MJB&A Supplemental Study far exceed both historical rates and New Efficiency New York ("NENY")[7] targets. The MJB&A Supplemental Study applies these aggressive assumptions to both Project shippers' service territories. Currently, incentives and/or regulatory mandates do not exist that would support the heat pump penetration assumptions that are reflected in the National Grid LTCSR and MJB&A Supplemental Study. If actual heat pump installations during the study period were to occur at rates that are closer to historical levels or the NENY targets, GHG emissions associated with the scenarios presented in the MJB&A Supplemental Study would be greater than those that are reflected in the analysis.

The most aggressive heat pump installation assumptions in the MJB&A Supplemental Study (other than the 100% Heat Pumps hypothetical scenario) are those included in the No Infrastructure Scenario. The No Infrastructure Scenario assumes that heat pump installations are aligned with the No Infrastructure Solution scenario described in the National Grid LTCSR,[8] which are far greater than the heat pump installation rates assumed in the Heat Pumps and Oil Scenario during the early years of the study period. In fact, the heat pump installation rates in the No Infrastructure Scenario are assumed to be approximately five times greater than NENY targets in 2023 and approximately eight times higher than the NENY installation rates by 2024. Accordingly, the heat pump penetration assumptions of the No Infrastructure Scenario are not well aligned with the current economics and the heat pump market, as it is unclear what funding sources would support those assumed installation rates. Moreover, the No Infrastructure Scenario is inconsistent with the

[5] The GHG's included in the study are carbon dioxide, methane, and nitrous oxide.
[6] MJB&A Supplemental Study at 5.
[7] See PSC Case 18-M-0084, Order Authorizing Utility Energy Efficiency and Building Electrification Portfolios through 2025 (Jan. 16, 2020).
[8] The MJB&A Supplemental Study assumes that oil is used to fill energy demand needs rather than demand response, which is assumed in the National Grid LTCR.

CLCPA regulatory framework in that it assumes that heat pump installations will dramatically increase before the CLCPA regulations are adopted and implemented. As such, Iroquois does not believe that heat pump assumptions of the No Infrastructure Scenario reflect a reasonable case for comparison to the ExC Scenario.[9] Furthermore, the very aggressive and unrealistic assumptions of the No Infrastructure Scenario must also be contextualized within the framework of the National Grid LTCSR, which explains that there is significant risk that, if the ExC Project is not constructed, customer energy demand in the region may not be met.[10] Thus, while the No Infrastructure Scenario is included in the MJB&A Supplemental Study, it should be viewed merely as a further bounding scenario of what emissions could be if the economics, market demand for heat pumps, and the CLCPA regulatory framework were assumed to differ significantly from actual existing conditions.

A more reasonable heat pump penetration assumption is reflected in the scenario of the MJB&A Supplemental Report referred to as the "Heat Pumps and Oil Scenario." Although it also assumes aggressive heat pump penetration rates – several times the rates of current installations – the rate of heat pump adoption in the first few years of the study period is better aligned with the current economics and market for heat pumps in the region, given the NENY 2023-2024 installation targets. Also, this scenario's heat pump installation assumptions for the later years of the study period are aligned with the anticipated completion of the CLCPA scoping plan and adoption and implementation of regulations that could result in increased heat pump installation rates. As a result, Iroquois believes that the Heat Pumps and Oil Scenario provides a more realistic scenario for comparison to the ExC Scenario. As discussed above, the results of the MJB&A Supplemental Study demonstrate that life cycle GHG emissions resulting from the Project would be less than the GHG emissions that would result from the Heat Pumps and Oil Scenario alternative that would be required to meet the energy demand satisfied by the Project.

Notably, the MJB&A Supplemental Study takes a conservative approach with respect to its GHG comparative quantification. For example, potential leakage of R410A, a refrigerant in heat pumps with a high GWP value, was not included in the analysis. Similarly, producer-certified natural gas purchases were not explicitly included in the analysis. If these factors were fully accounted for in

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[9] Iroquois' belief is supported by the statements set forth in independent assessment of the National Grid LTCSR prepared by PA Consulting. *See e.g.,* PA Consulting's Assessment of National Grid's Natural Gas Long-Term Capacity Second Supplemental Report (Sept. 10, 2021) ("PA Assessment") at Section 3.1 ("Two of the three components (electrification and demand response) of National Grid's DSM strategy are in early development with high uncertainty of adoption and rate of growth."); *see also* PA Assessment at Section 6.2 ("Currently, there is limited information to determine the capacity of Incremental Electrification to help address a supply gap or whether it is a reasonable expectation"). The PA Assessment can be found at the following website: https://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=19-G-0678&CaseSearch=Search

[10] *See* National Grid LTCSR at Section 1. This additional consideration provides further justification as to the necessity for the Project beyond, and independent from, the GHG benefits summarized herein. *See also* PA Assessment at Section 3.1(4) (If new infrastructure, including ExC, is not developed, "policy makers and customers would need to accept the risk of emergency curtailments which can have significant health and safety consequences, in the event that the Incremental DSM programs are unable to deliver the necessary peak demand reduction.")

the analysis, the GHG quantitative comparison would likely further evidence the benefits of the ExC Project.

Moreover, as National Grid has explained in its LTCSR, the ExC Project, as one component of National Grid's Distributed Infrastructure Solution, is consistent with New York State's Net Zero goals.[11] The ExC Project will aid in reducing National Grid's reliance upon compressed natural gas sites, which are a more expensive and more GHG-intensive gas supply than pipeline delivery.[12] The ExC Project will also allow National Grid to transition to low carbon fuels.[13] Additionally, the ExC Project would benefit National Grid's efforts to right size its gas portfolio over time,[14] providing it with the flexibility to meet current and projected customer demand while also allowing for reduced utilization in the future if the goal of decreased gas demand is realized. These same benefits are also likely to be realized in the Con Edison service territory. Significantly, the Public Service Commission ("PSC") recently referenced many of the same virtues in determining that the Joint Proposal in the Brooklyn Union Gas Company (KEDNY) and KeySpan Gas East Corporation (KEDLI) rate proceeding was consistent with the CLCPA, stating: "additional infrastructure helps to ensure that National Grid can reliably meet its customers' peak demand in the near future while enabling the ramp-up of the energy efficiency, heat electrification, and demand response."[15] These benefits should similarly be weighed by DEC in determining that the ExC Project is consistent with the CLCPA.

Additionally, as part of the Project, Iroquois proposes to install vent recovery systems ("VRS") for planned blowdown events and recovery of compressor dry seal gas at the Project compressor stations. The VRS will reduce the aggregate methane emissions from all of the ExC Project compressor stations by an estimated 70% from historic levels (approximately 73% reduction in New York and 68% reduction in Connecticut methane emissions). Furthermore, the ExC Project facilities do not include any new pipeline, but rather, consist solely of compression and cooling, which have a far shorter defined useful life than pipe main. When all of these factors are considered in light of the results of the MJB&A Supplemental Study, the Project is consistent with the goals and mandates of the CLCPA.

Question No. 2:

The CLCPA Assessment of upstream emissions asserts that the ExC Project has no impact because it would not increase upstream emissions. This is not sufficient. The CLCPA does not require NYSDEC to evaluate all emissions in the U.S. natural gas system, but emissions associated with

[11] National Grid LTCSR at Section 5.1.3.
[12] Id.
[13] Id.
[14] Id.
[15] PSC Case No. 19-G-0309, Order Approving Joint Proposal, as Modified, and Imposing Additional Requirements (Aug. 12, 2021) at 78.

the fuels that are brought into New York State are considered part of Statewide GHG emissions under the law, and therefore must be addressed by Iroquois for the ExC Project. See ECL § 75-0101(13); 6 NYCRR § 496.3(g). As such, the ExC Project should estimate all GHG emissions from the extraction, production, and transmission of the gas volumes that would be supplied to or through the ExC Project. The CLCPA Assessment does not discuss these emission sources or how they would be mitigated. Iroquois therefore must provide such information.

Response:

To be fully responsive to DEC's RFAI (and solely for that purpose), Iroquois assumed that the Project would result in upstream GHG emissions. The MJB&A Supplemental Study estimates lifecycle GHG emissions (including in state and out of state upstream emissions resulting from extraction, production and transmission) that could result from the Project. The results of the MJB&A Supplemental Study demonstrate that, when compared to alternative energy sources supplying the same amount of energy contracted by the LDCs (and even while assuming the aggressive heat pump installation rates reflected in the Heat Pumps and Oil Scenario), the ExC Project produces lower annual average and cumulative GHG emissions over the ExC Contract Term. As such, the ExC Project results in a net reduction of GHG emissions when compared to alternatives required to meet the same energy demand and, thus, is consistent with the goals and objectives of the CLCPA.

Additionally, National Grid has stated that the ExC Project is consistent with New York's Net Zero goals because it would allow it to transition to "to low-carbon fuels (i.e., RNG and green hydrogen) and place less reliance on [higher GHG emitting] CNG sites."[16] This potential further decarbonization of the gas mix and the displacement of more intensive GHG-emitting natural gas supplies must also be considered when assessing the current and future GHG emissions benefits of the ExC Project.

Question No. 3:

Regarding downstream emissions, the requirements of the CLCPA include the consideration of all sources of GHG emissions. These are to be estimated in terms of carbon dioxide equivalents using a 20-year Global Warming Potential ("GWP"). See 6 NYCRR § 496.5 (list of GHGs and their carbon dioxide equivalent value using a 20-year GWP). This includes fugitive emissions of methane in the gas transmission and distribution system. The CLCPA Assessment does not discuss these emission sources or how they would be mitigated. Iroquois therefore must provide such information.

[16] National Grid LTCSR at Section 5.1.3.

Response:

The MJB Supplemental Study estimates lifecycle GHG emissions (including fugitive emissions from the transmission and distribution systems) using the 20-year GWP converted to carbon dioxide equivalent emissions. However, the MJB&A Supplemental Study does not fully account for the assumed 80% reduction in methane emission reductions that National Grid anticipates will occur along its distribution system by 2030 and it does not account for ExC to displace gas that would otherwise be supplied through higher-intensity supply such as CNG sites. Also, as noted above, the MJB&A Supplemental Study does not attempt to account for potential R410A leakage from heat pumps or fully account for producer-certified natural gas purchases. If these factors were fully accounted for in the analysis, it would show that the Project would result in a greater net reduction of GHG emissions compared to the alternative energy sources. Moreover, as noted above, Iroquois has proposed to install VRS at the Project compressor stations, which will reduce GHG emission by an average of 70% below Iroquois' historic levels.

Accordingly, when all of these factors are considered with the results of the MJB&A Supplemental Study, the ExC Project will result in a net reduction of GHG emissions when compared to alternative energy sources and is therefore consistent with the CLCPA's GHG emission limits.

Dated: October 13, 2021

ATTACHMENT A

M.J. Bradley & Associates

Life Cycle Greenhouse Gas Analysis of the Enhancement by Compression (ExC) Project

Life Cycle Greenhouse Gas Analysis of the Enhancement by Compression (ExC) Project

MJB & A
an ERM Group company

October 2021

Contents

Acknowledgements

Lead Author: Brian M. Jones

Contributors: Luke Hellgren and Sophia Hill

The following study was prepared by M.J. Bradley & Associates (MJB&A), an ERM Group Company, to assess the life cycle greenhouse gas (GHG) impacts associated with the Enhancement by Compression (ExC) Project proposed by Iroquois Gas Transmission System, L.P. This report is intended to quantify the life cycle GHG emissions associated with the incremental natural gas supply from the project that would be supplied to two natural gas utilities in downstate New York — Consolidated Edison Company of New York (CECONY) and National Grid — compared to the life cycle GHG emissions of the fuels that would otherwise be required to meet energy demand for space heating, water heating, and other end uses if the ExC Project was not developed and sufficient natural gas was unavailable to meet projected demand.

The findings of the GHG analysis presented in this report were prepared by MJB&A based on market demand and technology adoption assumptions in the geographic study area informed by publicly available sources and information. The report and results reflect the analysis and judgment of the authors alone based on information available at the time.

About M.J. Bradley & Associates

MJB&A, an ERM Group Company, provides strategic consulting services to address energy and environmental issues for the private, public, and non-profit sectors. MJB&A creates value and addresses risks with a comprehensive approach to strategy and implementation, ensuring clients have timely access to information and the tools to use it to their advantage. Our approach fuses private sector strategy with public policy in air quality, energy, climate change, environmental markets, energy efficiency, renewable energy, transportation, and advanced technologies. Our international client base includes electric and natural gas utilities, major transportation fleet operators, investors, clean technology firms, environmental groups and government agencies. Our seasoned team brings a multi-sector perspective, informed expertise, and creative solutions to each client, capitalizing on extensive experience in energy markets, environmental policy, law, engineering, economics and business. For more information we encourage you to visit our website, www.mjbradley.com.

Introduction

This study was prepared by M.J. Bradley & Associates (MJB&A) at the request of Iroquois Gas Transmission System, L.P. ("Iroquois") to provide an independent evaluation of the life cycle greenhouse gas (GHG) emissions associated with the Enhancement by Compression (ExC) Project. As proposed, ExC would increase the amount of natural gas that Consolidated Edison Company of New York, Inc. (CECONY)[1] and National Grid's downstate New York gas utilities — The Brooklyn Union Gas Company (KEDNY) and KeySpan Gas East Corporation (KEDLI)[2] — can deliver to customers, by increasing the effective peak capacity of the existing Iroquois natural gas transmission pipeline.

This analysis covers the service areas of CECONY, KEDNY, and KEDLI. Long-term gas plans from both National Grid and CECONY forecast growing natural gas demand due to new construction in the commercial and single- and multi-family residential sectors, as well as requests from owners of existing buildings to convert their energy source from heating oil to natural gas. National Grid projects that Design Day (or peak) gas demand will increase by approximately 1.5 percent per year, from 2,766 thousand dekatherms per day (MDth/day) in winter 2020-2021 to 3,430 MDth/day in winter 2034-2035, after taking into account energy efficiency and demand response programs, as well as programs to incentivize electric heat pump installations.[3] This forecast reflects projected growing demand in both the KEDNY and KEDLI service areas. Similarly, CECONY projects that the compound annual growth rate (CAGR) for delivered firm natural gas volume will be approximately 1.3 percent from 2018 through 2023.[4]

National Grid has indicated that in the absence of the ExC Project, there is substantial risk that National Grid will be unable to meet projected customer demand for natural gas.[5] National Grid has further indicated that the ExC Project is consistent with New York's climate goals in that it "creates flexibility to transition our

Enhancement by Compression (ExC) Project

The proposed ExC Project is a compression-only enhancement of Iroquois' existing system to receive an additional 125 MDth/day of natural gas at Iroquois' interconnect with the TC Energy Canadian mainline in Waddington, New York for redelivery to the New York utilities. The ExC Project involves the addition of compression and associated gas cooling at existing Iroquois compressor station sites only; no new pipeline is proposed as part of this project. All new facilities would be constructed entirely within Iroquois' existing compressor station properties. The target in-service date for the ExC Project is November 1, 2023.

National Grid's downstate New York gas distribution utility KEDLI has contracted for fifty percent of the gas supply that would be made available by the ExC Project. CECONY has contracted for the other fifty percent. Based on input from each utility, the anticipated additional annual volume of gas sales that would be enabled by the ExC Project is approximately 11,395 MDth.

1 CECONY provides electric service to approximately 3.5 million customers in all of New York City (excluding a portion of Queens) and most of Westchester County, and natural gas service to approximately 1.1 million customers in Manhattan, the Bronx, parts of Queens, and most of Westchester County.

2 KEDNY provides natural gas service to approximately 1.9 million customers in Brooklyn, Queens, and Staten Island. KEDLI provides natural gas service to approximately 600,000 customers on Long Island and the Rockaway Peninsula. While only KEDLI would directly contract for ExC supply, it is expected that ExC supply would also benefit KEDNY customers due to service interconnects and capacity sharing programs.

3 National Grid, Natural Gas Long-Term Capacity Second Supplemental Report for Brooklyn, Queens, Staten Island and Long Island ("Downstate NY"), June 2021.

4 Con Edison Energy Management.

5 Id. at 100.

infrastructure in the future to low-carbon fuels (i.e., [renewable natural gas, or RNG] and green hydrogen) and place less reliance on [compressed natural gas (CNG)] sites [that are comparatively more emissions-intensive]."[6]

This analysis assumes that the portion of ExC capacity that would be utilized by each utility[7] never exceeds the gap between projected Design Day demand and existing supply.

Overview of Approach

This analysis focuses on the life cycle GHG emissions associated with ExC-supplied natural gas over the years 2023 to 2043 (e.g., the primary term of the contracts entered into by CECONY and National Grid), compared to the life cycle GHG emissions of the fuels that would otherwise be required to meet increased demand for space heating, water heating, and other purposes (cooking, clothes drying, etc.) if the ExC Project was not developed and sufficient gas was unavailable to meet projected demand.

Given significant uncertainties related to customer technology and fuel choice in the event of insufficient gas supply, this study evaluates different "No ExC" scenarios to bound the range of potential GHG emissions if ExC were not built, for comparison to the *ExC Scenario*. These No ExC scenarios vary in terms of the percentage of incremental space heating, water heating, and cooking energy demand that is assumed to be allocated to new construction versus to conversions of existing buildings, as well as in how many buildings of each type would use electric heat pumps versus heating oil.

Within each scenario, this analysis assumes improvement in upstream methane emission rates (consistent with historical trends) throughout the study period and increasing amounts of low- and zero-carbon gas supplies (e.g., renewable natural gas, or RNG, and hydrogen) blended into the pipeline supply during the study period.

This study quantifies emissions using a life cycle approach that accounts for GHG emissions – carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) – emitted throughout the entire value chain (from production through end use) of natural gas and other fuels required to meet customer energy demand equivalent to the amount that would be supplied by the proposed ExC Project. Emissions of CH_4 and N_2O are converted to CO_2-equivalent emissions (CO_2e) using their global warming potentials over a 20-year period (GWP_{20}).[8]

Analysis Framework

Consistent with National Grid and CECONY demand forecasts, this analysis assumes that natural gas delivered by ExC will be used to meet incremental space and water heating demand from new construction as well as conversions of existing buildings previously using heating oil. Both new and converted buildings are assumed to include both residential (including single- and multi-family) and commercial buildings.[9]

6 Id. at 60.

7 Approximately 6,395 and 5,000 MDth/year for CECONY and National Grid, respectively. See Appendix A for discussion of how these volumes were determined.

8 Intergovernmental Panel on Climate Change (IPCC) AR5 20-year GWP values were used in this analysis.

9 Natural gas deliveries to residential and commercial buildings for each utility service territory were estimated using reported 2019 sales and projected through 2043 using projected Mid-Atlantic residential and commercial natural gas growth rates from the U.S. Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2021. No incremental gas demand is assumed for electricity generation. Based on existing local and state policy, total gas demand for electricity generation in the New York City region is projected to fall during the analysis period.

The No ExC scenarios assume that without ExC, new buildings will either install electric heat pumps or oil heating systems instead of using natural gas due to insufficient natural gas supply. Similarly, they assume that existing buildings that would convert to natural gas heating under the *ExC Scenario* will either continue to use heating oil or convert to electric heat pumps.

Under the *ExC Scenario*, all fuel accounted for in this analysis is natural gas (comprised of conventional natural gas, RNG, and hydrogen), while under the No ExC scenarios this natural gas is replaced by a combination of electricity and heating oil.[10] The relative amount of electricity and heating oil used in each No ExC scenario is informed primarily by two assumptions: 1) the amount of ExC gas that is directed to new construction versus conversions, and 2) the market uptake of electric heat pumps. Heat pumps are currently more expensive to purchase than oil heating systems, and heat pump market penetration for both new construction and retrofits is relatively low. While current air and ground source heat pump adoption is increasing, the technologies account for just 1 to 3 percent of residential heating, ventilation, and air conditioning (HVAC) installations annually across New York State.[11] However, both New York State and New York City have adopted goals to increase the use of heat pumps, which are backed by existing electric utility incentive programs and market transformation initiatives.[12]

This analysis incorporates two different demand scenarios and four different heat pump penetration scenarios to develop eight separate No ExC scenarios. These scenarios, described in further detail below, bound the possible range of GHG emissions that could result from electricity and oil use for building heating in the absence of the ExC Project.

The two demand scenarios are characterized as “Low New Construction” and “High New Construction.” The Low New Construction scenario assumes that 35 percent of incremental energy supply will be used to satisfy demand from newly constructed buildings and the remaining 65 percent will satisfy demand from heating retrofits or conversions in existing buildings (if applicable). Alternatively, the High New Construction scenario assumes that 65 percent of incremental energy supply will meet demand from new buildings and 35 percent will satisfy demand from retrofits or conversions (if applicable). These scenarios are informed by historical demand from new construction and conversions and are intended to bound the range of demand from each customer type.

For each demand scenario, four different heat pump penetration scenarios were analyzed: 1) *100% Oil Scenario* (no heat pumps), 2) *100% Heat Pumps Scenario* (no oil), 3) *Heat Pumps and Oil Scenario*, and 4) *No Infrastructure Scenario*. The first two cases, the *100% Oil Scenario* and *100% Heat Pumps Scenario,* provide a bounding low-to-high range of theoretical emissions that could occur without the development of the ExC Project. These bounding scenarios are illustrative in nature and do not represent scenarios that are likely to occur.

The third No ExC case, *Heat Pumps and Oil Scenario*, described in greater detail below, is informed by the “Distributed Infrastructure Solution” and “No Infrastructure Solution” scenarios described in National Grid’s Second Supplemental Long-Term Capacity Report (Second Supplemental LTCR). According to the Second Supplemental LTCR, these scenarios reflect the heat pump installations that would be required to fulfill total energy demand in the region consistent with Climate Leadership and Community Protection Act (CLCPA) requirements. The *No Infrastructure Scenario* assumes heat pump installation rates that are equal to the “No Infrastructure Solution” described in the Second Supplemental LTCR. For this analysis, the *No Infrastructure Scenario* assumes oil meets the energy need in the absence of ExC. These different heat pump

10 Life cycle GHG emissions attributed to electricity in this analysis are derived using non-baseload (marginal) electricity generation associated with the grid region of each utility. Within the National Grid and CECONY service territories, this electricity is mostly generated by natural gas-fired steam turbines and combined cycle units (minimal oil-fired and coal-fired electricity generation).

11 NYSERDA 2019 HVAC Market Characterization: Residential Building Stock Assessment.

12 For information on existing heat pump policies and incentives, please see the “Natural Gas Utility Background” section of this report.

scenarios are considered in context of the National Grid LTCR "Distributed Infrastructure Solution," which provides heat pump assumptions associated with the *ExC Scenario*. In other words, the *ExC Scenario* provides baseline heat pump installation assumptions against which the other scenarios are compared.

Summary of No ExC Scenarios

No ExC – 100% Oil Scenario

Under the *100% Oil Scenario* (no heat pumps), building energy needs that would be met with natural gas in the *ExC Scenario* are assumed to be met using No. 2 heating oil. This scenario serves as a theoretical upper limit on GHG emissions. All new buildings are assumed to install new oil-fired heating systems and all existing buildings that would have converted to natural gas under the *ExC Scenario* are assumed to continue to burn heating oil. No electric heat pumps are installed in new construction and no oil-to-electric conversions occur over the analysis timeline.

No ExC – 100% Heat Pumps Scenario

Under the *100% Heat Pumps Scenario* (no oil), all building energy needs that would be met with natural gas in the *ExC Scenario* are assumed to be met using electric heat pumps. This scenario serves as a theoretical lower limit on GHG emissions. All new buildings are assumed to install heat pumps and all existing buildings that would have converted to natural gas under the *ExC Scenario* are assumed to convert to heat pumps. It is assumed that heat pumps are used for both space heating and water heating.[13] Ninety percent of installed heat pumps are assumed to be air-source heat pumps (ASHP) and 10 percent are assumed to be ground-source heat pumps (GSHP).[14]

No ExC – Heat Pumps and Oil Scenario

Under the *Heat Pumps and Oil Scenario*, building energy needs that would be met with natural gas in the *ExC Scenario* are assumed to be met using a combination of electric heat pumps and No. 2 heating oil. Annual heat pump installation assumptions through 2035 were applied for each utility service territory using National Grid's Second Supplemental LTCR. The *Heat Pumps and Oil Scenario* is informed by two scenarios presented in the Second Supplemental LTCR: the most aggressive electrification scenario ("No Infrastructure Solution") and the primary scenario in which ExC is approved ("Distributed Infrastructure Solution"). The *Heat Pumps and Oil Scenario* assumes that across both National Grid's and CECONY's service territories, annual heat pump installations will be aligned with the trajectory of the "Distributed Infrastructure Solution" scenario from 2021 to 2028. During this period, heat pump installations would effectively follow those of the New Efficiency New York (NENY) targets through 2025 before increasing significantly between 2026 and 2028. While annual heat pump installations in the "Distributed Infrastructure Solution" plateau after 2028, the *Heat Pumps and Oil Scenario* assumes that annual heat pump adoption continues to increase linearly to achieve cumulative heat pump installations in 2035 that are consistent with the Second Supplemental LTCR "No Infrastructure Solution" scenario; the annual heat pump installation rate assumed in the *Heat Pumps and Oil Scenario* remains at its 2035 level through 2043 such that by 2043, this scenario results in higher cumulative heat pump installations than the *No Infrastructure Scenario*, described below. The remainder of the energy needs that would have been met using ExC gas is assumed to be supplied with heating oil.

No ExC – No Infrastructure Scenario

The *No Infrastructure Scenario* assumes heat pump installation rates equal to the "No Infrastructure Solution described" in the National Grid Second Supplemental LTCR. This scenario assumes aggressive electrification is applied to meet energy supply constraints projected to occur if ExC is rejected and other

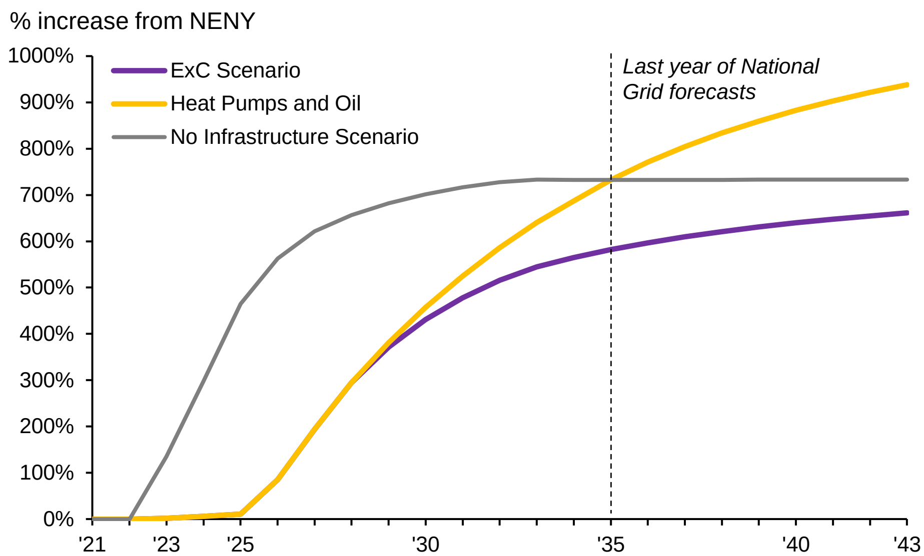
[13] Cooking and clothes drying is assumed to use electric resistance heat.
[14] Electric resistance back-up heat assumed to comprise 5% of ASHP winter heating load (unnecessary for GSHPs).

contingency options are not realized. The heat pump installation rates in the *No Infrastructure Scenario* are assumed to be nearly five times greater than NENY targets in 2023 and approximately 8 times higher than the NENY installation rates by 2024. This scenario corresponds with high cumulative heat pump installation projections relative to those forecasted in National Grid's "Distributed Infrastructure Solution" scenario. The *No Infrastructure Scenario* and *Heat Pumps and Oil Scenario* provide additional bounding scenarios to create a narrower range of potential emissions associated with No ExC cases.

Heat Pump Installation Assumptions

Heat pump installations associated with this analysis are informed by the National Grid LTCR heat pump assumptions that were developed to fulfill total energy demand; as such, these installations are not actual projections based on current economics and market demand for heat pumps. As shown in **Figure 1**, the *ExC Scenario*, *Heat Pumps and Oil Scenario*, and *No Infrastructure Scenario* assume that cumulative heat pump installations are approximately six to eight times higher than the projected NENY levels by 2035.[15] Accordingly, this analysis assumes heat pump installation rates during the study period are greater than existing policy requirements and historic adoption rates.

Figure 1 Assumed Cumulative Heat Pump Installations (percentage of NENY targets)



ExC Scenario

This scenario incorporates time-variable inputs, including upstream emission rates and the transmission and delivery of low- and zero-carbon gases. Upstream emission rates refer to the GHG emissions resulting from the production, processing, and transmission of fuels prior to its distribution to the customer; low- and zero-carbon gas refer to the percent composition of pipeline gas that is RNG and/or hydrogen, rather than natural gas.[16] This analysis assumes moderate changes over time to upstream emission rates (consistent with historical trends) and pipeline gas supply composition, consistent with New York utilities' goals and the goals and policies of New York State and New York City.[17] Historical trends in reductions of upstream

[15] Appendix A provides additional details on heat pump installation forecasts by service territory.

[16] See Appendix A for methodology on projected upstream emission rates and low-and zero-carbon gas composition.

[17] Results of this analysis are sensitive to a variety of assumptions, including (but not limited to) upstream gas emission rates, applicable electric-generating resources, and low- or zero-carbon gas added to pipeline gas. For

emission rates were continued through the study period to account for methane leak detection and repair, equipment modernization and upgrades, the adoption of best management practices, increased emissions disclosure and reporting, and other factors, including regulation, that are projected to reduce upstream GHG emission rates. This analysis assumes an annual decline in natural gas and oil upstream methane emission rates of approximately 5 percent and 8 percent, respectively, through 2043.[18] This analysis also assumes the potential of an increasing supply of low- and zero-carbon gases such that hydrogen[19] and RNG make up 10 percent and 15 percent, respectively, of delivered gas (by energy content) by 2043.[20]

In New York State's gas planning proceeding,[21] all New York gas distribution utilities, including CECONY and National Grid, note RNG as a growing supply-side solution. Actions proposed by the utilities to scale RNG use include studying feasibility, actively exploring projects, establishing standards to support market growth, and interconnecting low-carbon gas projects to the gas network. Gas distribution utilities are currently also studying the potential for blending hydrogen into the gas system. In New York's gas planning proceeding, gas utilities indicated that RNG and hydrogen are the most viable supply-side options to reduce emissions from natural gas use given the state's CLCPA. Similarly, a report released in April 2021, *Pathways to Carbon-Neutral NYC*, concluded that low-carbon gases are an important emissions reduction strategy for end uses that do not electrify across all pathways.[22]

Summary of Scenario Assumptions

ExC Scenario	**No ExC Scenarios**
• Incremental natural gas demand of 11,395 MDth/year beginning in 2023 through 2043 • Natural gas supplied for uses in residential and commercial sectors • Gas supplied to new construction and oil-to-gas conversions in the residential and commercial sectors • Heat pump installation projections consistent with National Grid LTCR *Distributed Infrastructure Solution*	*100% Oil (no heat pumps)* • All new building energy needs are met with heating oil (no oil-to-gas or electric conversions) *100% Heat Pumps (no oil)* • 100% electrification of new construction & conversions *Heat Pumps and Oil* • Heat pump installation projections informed by National Grid LTCR scenarios *No Infrastructure Scenario* • Heat pump installation projections in National Grid LTCR in which ExC is not approved

Assumptions Applied to both ExC and No ExC Scenarios

- Annual reduction in upstream methane emission rates; ~5% and 8% (CAGR) for gas and oil, respectively
- 15% RNG by 2043 (linear increase from 0% in 2022 to 15% in 2043)
- 10% hydrogen by 2043 (linear increase from 0% in 2029 to 10% in 2043)

instance, if upstream emission rates decline at rates higher than currently assumed, GHG emissions of the ExC scenario would also decline.

18 U.S. EPA GHG Inventory used to historical change in upstream methane emission factors for gas and petroleum systems; more information in Methodology & Assumptions section and Appendix B

19 Assumed to contribute to delivered gas beginning in 2030.

20 Hydrogen composition assumed to annually and linearly increase from zero percent of gas composition in 2029 until achieving target in 2043; RNG composition assumed to annually and linearly increase from zero percent of gas composition in 2022 until achieving target in 2043.

21 New York State PSC, Case 20-G-013.

22 NYC Mayor's Office of Sustainability (MOS), Con Edison, and National Grid, Pathways to Carbon-Neutral NYC, April 2021, https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/Carbon-Neutral-NYC.pdf.

Key Findings

The following findings provide the range of estimated emission results for each scenario depending on whether incremental demand includes low or high new construction.

- Annual average GHG emissions for the *ExC Scenario* are 0.78 million metric tons (MMT) CO_2e during the study period of 2023 through 2043. Cumulative estimated life cycle GHG emissions associated with the *ExC Scenario* through 2043 are 16.29 million metric tons (MMT) CO_2e.

- The *Heat Pumps and Oil* scenario has higher annual average emissions than the *ExC Scenario*, ranging from 0.80 to 0.83 MMT CO_2e. Through 2043, cumulative GHG emissions under the *Heat Pumps and Oil Scenario* are approximately 0.46 to 1.2 MMT higher (3-7 percent increase) than the *ExC Scenario*.

- The *No Infrastructure Scenario* has higher annual emissions than the *ExC Scenario* through 2026 and lower annual emissions from 2027 through 2043. Through 2043, cumulative GHG emissions under the *No Infrastructure Scenario* are approximately 3.4 to 3.8 MMT lower (a 21 to 23 percent reduction) than the *ExC Scenario*.

- The *100% Heat Pump Scenario* has the lowest life cycle emissions of all scenarios analyzed, with annual emissions lower than the *ExC Scenario* in all years after 2024. Through 2043, cumulative GHG emissions under this scenario are approximately 9.5 MMT lower than the *ExC Scenario* (a 59 percent reduction).

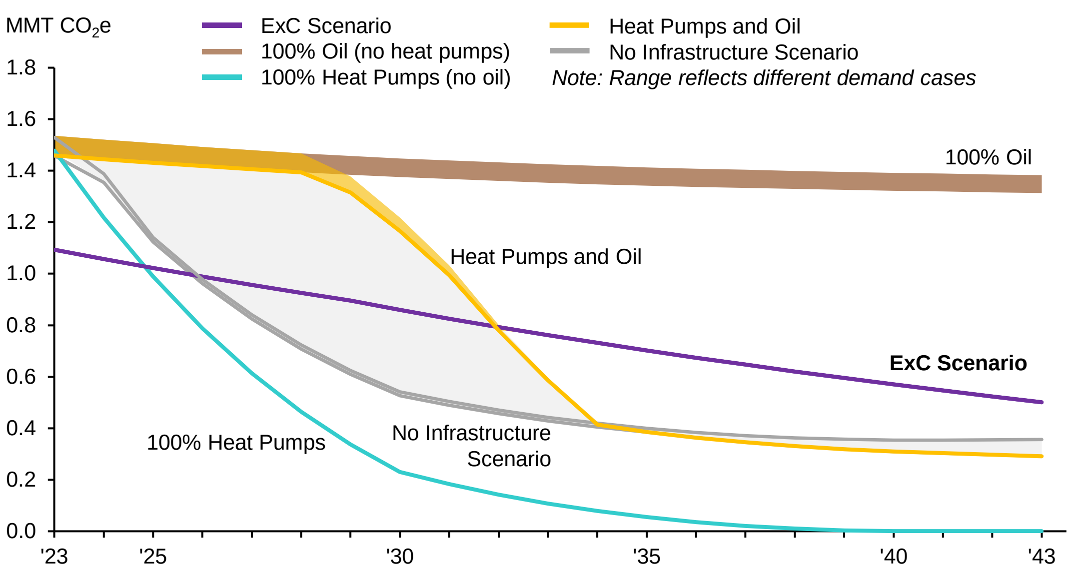
- The *100% Oil Scenario* (100 percent heating oil for incremental demand, with no electric heat pumps) has the highest life cycle emissions of all scenarios analyzed, with annual emissions higher than the *ExC Scenario* in all years. Through 2043, cumulative GHG emissions under this scenario are approximately 12.4 to 13.9 MMT higher (a 43 to 46 percent increase) than the *ExC Scenario*.

- Life cycle GHG emissions associated with the *Heat Pumps and Oil Scenario* and the *No Infrastructure Scenario* are sensitive to assumptions regarding heat pump installations and how they compare to heat pump installations that would still occur in the *ExC Scenario*. The uncertainty associated with future heat pump policies, incentives, and other implementation drivers – as well as the impact of the approval or rejection of the ExC Project – results in a wide range of potential heat pump requirements to meet energy demand; consequently, life cycle GHG emissions may vary significantly when applying different assumptions.

Summary of Greenhouse Gas Results

Estimated annual life cycle GHG emissions from 2023 (ExC start date) through 2043 under the *ExC Scenario* and the No ExC Scenarios are shown in **Figure 2**. The *Heat Pumps and Oil Scenario* yields annual emission estimates that are higher than the *ExC Scenario* initially but gradually decline and, beginning in 2032, fall below those of the *ExC Scenario* as heat pump penetration increases and the carbon intensity of the electric grid decreases.[23] The scenario with the lowest cumulative life cycle GHG emissions is the *100% Heat Pumps Scenario*; the highest emissions estimates correspond with the *100% Oil Scenario*.

Figure 2 Projected Annual Life Cycle GHG Emissions Across Scenarios

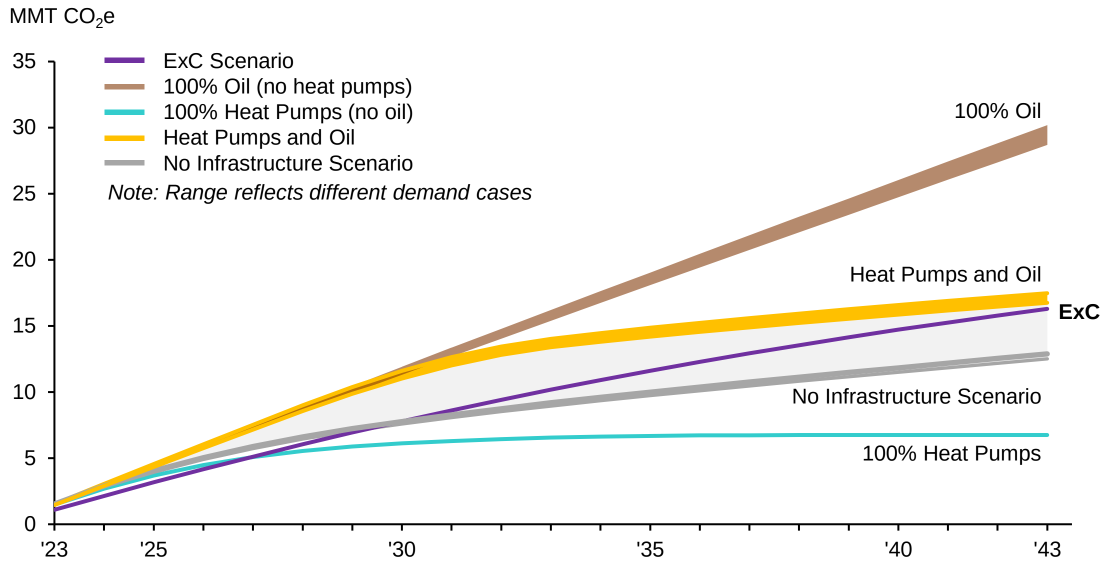


Cumulative life cycle GHG emissions under the ExC and No ExC scenarios are shown in Figure 3. The *Heat Pumps and Oil Scenario* should be considered as one of several scenarios that may occur if the ExC project is rejected. Collectively, this scenario and the *No Infrastructure Scenario* provide a potential range of emissions corresponding with different heat pump trajectories. However, as noted above, the *ExC Scenario*, *Heat Pump and Oil Scenario*, and the *No Infrastructure Scenario* assume high rates of heat pump installations to meet energy demand based on National Grid's Second Supplemental LTCR.

The *100% Heat Pumps Scenario* is associated with lower cumulative emissions than those of the *ExC Scenario* throughout the analysis timeline; the *Heat Pumps and Oil Scenario* corresponds with higher cumulative emissions than those of the *ExC Scenario* throughout the analysis timeframe.

[23] Emissions associated with incremental electric load were estimated using projected marginal electric grid rates. However, these rates are sensitive to economic dispatch, load reduction programs, and renewable electricity penetration.

Figure 3 Projected Cumulative Life Cycle GHG Emissions Across Scenarios



Summary emission results for each scenario are shown in **Table 1** and reflect data shown in Figures 2 and 3.

Table 1 Summary of Projected Life Cycle GHG Emissions

Demand Breakdown	Scenario	Life Cycle GHG Emissions (MMT CO_2e) Average Annual	Cumulative	ExC relative to No ExC (neg. % = reduction)
	ExC	**0.78**	**16.29**	-
Low New Construction	100% Oil (no heat pumps)	1.44	30.20	-46%
	100% Heat Pumps (no oil)	0.32	6.75	141%
	Heat Pumps and Oil	0.83	17.49	-7%
	No Infrastructure	0.61	12.89	26%
High New Construction	100% Oil (no heat pumps)	1.37	28.68	-43%
	100% Heat Pumps (no oil)	0.32	6.75	141%
	Heat Pumps and Oil	0.80	16.75	-3%
	No Infrastructure	0.60	12.52	30%

Natural Gas Utility Background

National Grid

National Grid provides natural gas to 1.9 million customers –1.3 million throughout Brooklyn, parts of Queens, and Staten Island, and 0.6 million across Long Island. KeySpan Energy Delivery New York (KEDNY) is the operating company for Brooklyn, Queens, and Staten Island service area and KeySpan Energy Delivery Long Island (KEDLI) is the operating company in Long Island.

In February 2020, National Grid issued its Long-Term Natural Gas Capacity Report for its Downstate New York service territories.[24] In May 2020, National Grid issued its first supplemental Long-Term Natural Gas Capacity report and in June 2021, National Grid issued its second supplemental Long-Term Natural Gas Capacity Report.[25] The reports provide analysis of potential long-term options to address downstate New York's projected natural gas constraints.

The June 2021 second supplemental report provides a forecast for Downstate New York natural gas demand through 2035, a summary of National Grid's current supply capacity and operating characteristics, and various supply and demand side options to meet customer energy needs. According to National Grid data, residential customers represent 93 percent of their customer base and account for 60 percent of Design Day demand. Commercial and multi-family customers account for 40 percent of Design Day consumption.[26] The ExC Project is included in the evaluation along with other supply options. For this analysis, MJB&A leverages several assumptions and outputs from these reports.

National Grid and KeySpan Energy Delivery New York (KEDNY) and KeySpan Energy Delivery Long Island (KEDLI)

The Second Supplemental Long-Term Capacity Report projects that Design Day gas demand will increase at a CAGR of approximately 1.5 percent from 2020 through 2035. This forecast reflects growing demand in KEDNY and KEDLI service areas. Demand growth is associated with new construction in the commercial and multi-family sectors and conversion requests from heating oil to natural gas. National Grid estimates that approximately 50 percent of residential customer additions are non-heating to heating conversions, 40 percent are new conversions, and 10 percent are new construction.

New York State and utility programs and targets associated with New Efficiency New York (NENY),[27] including energy efficiency and demand response programs and electric heat pump installations, serve as the baseline scenario in the Second Supplemental LTCR. In this scenario, National Grid assumes that the NENY

[24] National Grid, Natural Gas Long-Term Capacity Report for Brooklyn, Queens, Staten Island and Long Island ("Downstate NY"), February 2020.

[25] See: https://www.nationalgridus.com/media/pdfs/other/ltng-supplementalreport.pdf and https://millawesome.s3.amazonaws.com/NationalGrid-LTC-Longform-Report-second-supplement-063021.pdf.

[26] National Grid, Natural Gas Long-Term Capacity Second Supplemental Report for Brooklyn, Queens, Staten Island and Long Island ("Downstate NY"), June 2021.

[27] NENY targets 185 trillion British thermal units (Btus) of end-use energy savings below the 2025 energy-use forecast.

targets are fully achieved through 2025 and then continue through 2035. Achieving these targets will provide approximately 25 MDth/day of demand reduction by 2025.

Two key drivers for heat pump growth are Local Law 97, which applies to the boroughs of NYC, and the NENY heat pump targets that CECONY and PSEG Long Island are pursuing in the KEDNY/KEDLI territories.[28] Under NENY, heat pump incentives are offered to customers, contractors and distributors for both ASHP and GSHP for both space heating and cooling, as well as for Heat Pump Water Heaters (HPWH) for water heating.[29]

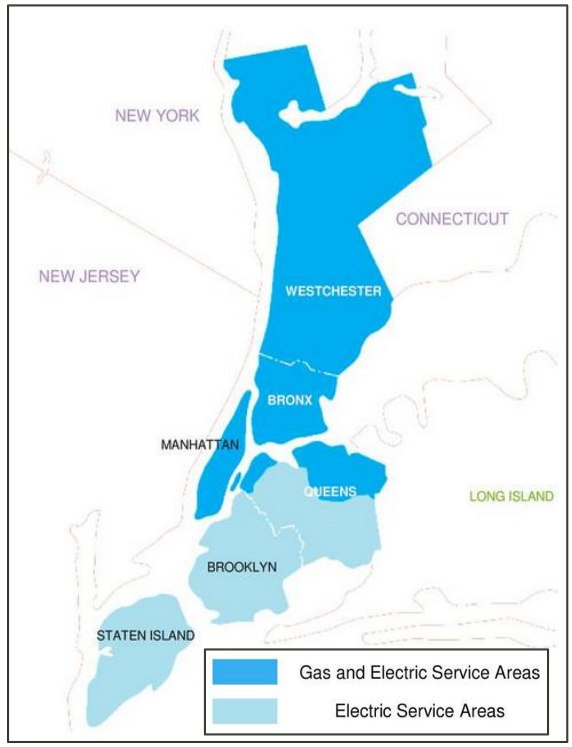
According to the National Grid analysis, electrification must play a significant role in meeting energy demand in the late-2020s in the "Distributed Infrastructure Solution" scenario. During 2026-2030, to achieve the "Distributed Infrastructure Solution" scenario, National Grid estimates that electrification efforts must increase more than ten-fold from roughly 2,300 customers per year in 2025 to around 24,000 customers per year by 2029. This annual rate of heat electrification by 2029 is also approximately ten times higher than that associated with NENY targets. According to the Second Supplemental LTCR, National Grid indicates that there are "major challenges to reach this number of customers per year at this pace. The scale of electrification required is driven by the high costs of customer and building conversions, but it is not yet clear if all funding sources and partners to achieve these levels of electrification will be available".[30]

[28] Local Law 97 mandates that buildings greater 25,000 square feet must achieve a specified emissions performance target (kilograms CO_2e per square foot per year). Buildings can achieve such targets by reducing electricity consumption or on-site fuel consumption, among other things.

[29] NYS Clean Heat: Statewide Heat Pump Program Implementation Plan, NYSERDA and New York Utilities, March 16, 2020.

[30] Second Supplemental LTCR, at 76.

Consolidated Edison Company of New York, Inc.



Consolidated Edison Company of New York, Inc. (CECONY) provides natural gas service to approximately 1.1 million customers in Manhattan, the Bronx, parts of Queens, and most of Westchester County.[31]

As of May 2021, CECONY forecasts an average annual growth of the gas peak day demand for firm sales customers over the next five years at design conditions to be approximately 1.3 percent in its service area, including the effect of certain gas energy efficiency programs and the temporary moratorium on new gas hook-ups in Westchester County.[32] The five-year forecast in peak demand is used by the company for gas supply planning purposes. CECONY's long-range gas plan projects that the near-term CAGR for delivered firm natural gas annual volume will be approximately 0.7 percent from 2021 through 2026.[33]

In January 2020, the New York State Public Service Commission (NYSPSC) issued an order directing electric and gas energy efficiency targets and budgets for New York utilities for 2021 through 2025.[34] The order authorized CECONY budgets of $593 million for electric energy efficiency programs, $235 million for gas energy efficiency programs; and $227 million for heat pump programs. The targets for 2025 are a 3 percent annual demand reduction for electricity and a 1.3 percent annual demand reduction for gas.[35]

The order additionally required CECONY to dedicate a minimum of $56.8 million towards the installation of heat pumps in the KEDNY service area. CECONY has programs underway to install more than 17,000 heat pumps across their service territory from 2020 through 2025. PSEG Long Island will also target to achieve a similar level of heat pump installations over the same period.

[31] Con Edison also provides electric service to approximately 3.5 million customers throughout New York City and Westchester County, and operates the largest steam distribution system in the United States by producing and delivering approximately 18 billion pounds of steam annually to approximately 1,570 customers in parts of Manhattan. Consolidated Edison Energy Management.

[32] Consolidated Edison Energy Management.

[33] Consolidated Edison Energy Management

[34] State of New York Public Service Commission, Case 18-M-0084 - In the Matter of a Comprehensive Energy Efficiency Initiative, Order Authorizing Utility Energy Efficiency and Building Electrification Portfolios Through 2025, January 16, 2020.

[35] Achieving these targets may affect near-term demand in delivered firm natural gas forecasted in CECONY's Long-Range Plan.

Appendix A – Analysis Methodology & Assumptions

This analysis estimates the life cycle GHG emissions of natural gas projected to flow through the ExC Project over the years 2023 to 2043 (*ExC Scenario*). It also calculates life cycle GHG emissions associated with the energy sources that would be used in lieu of natural gas if the ExC Project is not built, and therefore insufficient gas is available to meet projected demand (No ExC Scenarios). These energy sources include oil, electricity, hydrogen, and RNG.[36] The methods used to estimate GHG emissions from the modeled scenarios, and the sources of major assumptions, are discussed below.

Energy Demand

Under the *ExC Scenario*, the natural gas delivered by the ExC Project each year is assumed to meet incremental demand for new gas from new building construction, as well as from conversions to natural gas of existing buildings that currently use other fuels. The building types (both new construction and existing building conversions) are assumed to be a mix of residential (single- and multi-family buildings) and commercial buildings, as shown in Table A-1. This mix is based on National Grid and CECONY demand estimates, informed by historical trends in demand by customer type. The significant difference across the three service territories in the percentage of ExC demand assumed to go to residential single family homes versus residential multi-family and commercial buildings is a function of the existing settlement patterns and housing stock; the CECONY service territory is highly urbanized, the KEDLI service territory is primarily suburban, and the KEDNY service territory is a mix of urban and suburban.

For each building type, 85 percent of the ExC gas is assumed to be used for space heating, 10 percent for water heating, and 5 percent for other purposes (primarily cooking).

Table A-1 Percentage of ExC Gas Demand by Building Type*

	CECONY	KEDNY	KEDLI
Residential (single-family)	10%	59%	51%
Residential (multi-family)	37%	25%	3%
Commercial	53%	16%	47%

*percentages may not total 100% due to rounding

Under the No ExC scenarios new buildings that cannot get natural gas and existing buildings that cannot convert to natural gas, due to insufficient gas supply, are assumed to use or continue to use either:

1) No. 2 heating oil for space heating, either No. 2 oil (boiler) or electricity (electric resistance hot water heater) for water heating, and electricity for cooking, or

2) An air source heat pump (ASHP) or ground source heat pump (GSHP) for both space heating and water heating, and electricity for cooking. Both types of heat pumps operate using electricity.[37]

To calculate the amount of No. 2 oil and electricity that replaces natural gas in the No ExC Scenarios, the *ExC Scenario* natural gas is apportioned to the different uses (85 percent space heating, 10 percent water heating, 5 percent other) in each building type, and the "useful" energy derived is calculated by multiplying each apportioned volume by the assumed efficiency of relevant natural gas appliances (i.e. furnace, water heater). The amount of input energy required under the No ExC Scenarios to generate the same amount of useful energy is then calculated by dividing required useful energy by the efficiency of relevant oil and electric appliances. This calculation accounts for the fact that older appliances (in buildings that convert to

[36] Hydrogen combustion GHG emissions are assumed to be zero and RNG combustion GHG emissions are assumed to be equivalent to natural gas; upstream emissions estimates for these sources are described in Appendix B.

[37] For each building type, 90 percent of installed heat pumps are assumed to be ASHP and 10 percent are assumed to be GSHP. Energy for cooking is assumed to come from electric resistance devices.

gas under the *ExC Scenario*) are less efficient than new appliances that would be installed in new buildings, and that new appliances operating on different fuels have significantly different efficiencies (see discussion of appliance efficiencies below).

Currently, heat pumps are more expensive to install than oil or natural gas heating systems, particularly as retrofits in existing buildings. However, in support of their climate change and clean energy goals, the State of New York and New York City are prioritizing the phase out of both oil and natural gas for space heating and water heating and are implementing programs, together with utility specific programs, to incentivize heat pump installations in both new and existing buildings.

In July 2019, Governor Cuomo signed the Climate Leadership and Community Protection Act (CLCPA, or the Act) that, among other things, sets an economy wide GHG emissions reduction goal of 40 percent below 1990 levels by 2030, 85 percent below 1990 levels by 2050, and net-zero emissions economy-wide by 2050. The Act requires the NYSPSC to establish a renewable energy program by July 2021 that requires, by 2030, that at least 70 percent of electric generation supplying New York's end-use customers be generated by renewables (an increase from the existing Clean Energy Standard of 50 percent). By 2040, the Act requires that the statewide electrical system be zero emissions. The Act sets an energy efficiency goal of achieving 185 trillion BTU of end-use energy savings below the 2025 end-use forecast. In January 2020, the NYSPSC issued an order directing energy efficiency targets and budgets for New York utilities. The order approved $2 billion statewide for electric and gas energy efficiency programs; and heat pump budgets, and associated targets, for the years 2021 through 2025 to meet the NYSPSC's goal of reducing electric use by 3 percent and gas use by 1.3 percent annually by 2025. Energy efficiency and building electrification is projected to provide one-third of the emissions reductions necessary to achieve the 40 percent by 2030 goal under the CLCPA. CECONY heat pump incentive programs are approved for funding of $227 million.

Given this policy background, this analysis uses two demand scenarios and four different heat pump penetration assumptions to create eight scenarios to be compared to the ExC scenario. The demand scenarios are characterized as "Low New Construction" and "High New Construction." The Low New Construction scenario assumes 35 percent of ExC gas will be used to satisfy demand from newly constructed buildings and the remaining 65 percent will satisfy demand from oil-to-gas conversions in existing buildings. Alternatively, the High New Construction scenario assumes that 65 percent of ExC gas will meet demand from new buildings and only 35 percent will satisfy demand from conversions. These scenarios are informed by historical demand from new construction and conversions and are intended to bound the range of demand from each customer type.

The four heat pump penetration assumptions include: 1) *100% Oil Scenario* (no heat pumps), 2) *100% Heat Pumps Scenario* (no oil), 3) *Heat Pumps and Oil Scenario*, and 4) *No Infrastructure Scenario*. The *100% Oil Scenario* and the *100% Heat Pumps Scenario* provide a bounding low-to-high range of potential emissions that could occur without the development of the ExC Project, while the *Heat Pumps and Oil Scenario* and *No Infrastructure Scenarios* are intended to represent the range of potential heat pump installation forecasts that could occur given the significant uncertainty of current economic and policy landscapes in the National Grid and CECONY service territories.

Under the *100% Oil Scenario*, all ExC energy demand is met with No. 2 oil for all building types (new and conversions) as of 2023,[38] with no ExC energy demand met by electricity. The *100% Heat Pumps Scenario* represents the maximum use of electricity for space and water heating within the National Grid and CECONY service territories, in which all ExC energy demand is met with heat pumps[39] for all building types (new and conversions) as of 2023, with no ExC energy demand met by No. 2 oil. Achieving the levels of

[38] ExC projected start year and the first year of the analysis period.
[39] Other than energy demand for cooking, which is met by electric resistance.

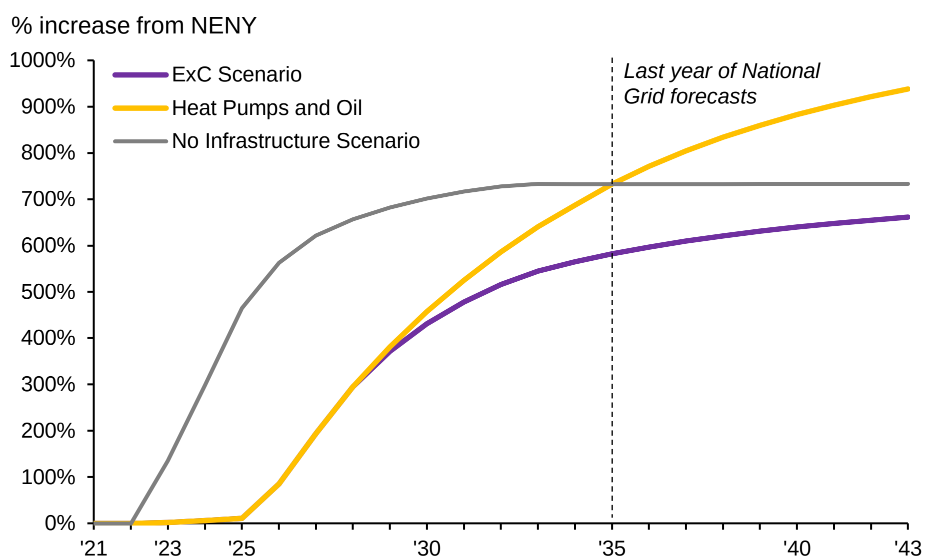
heat pump penetration assumed in this scenario would require a significant change in the current economics of heat pumps and/or significant new policy developments by the city and state.

The *Heat Pumps and Oil Scenario* is informed by the "Distributed Infrastructure Solution" and "No Infrastructure Solution" scenarios described in National Grid's Second Supplemental LTCR. According to the Second Supplemental LTCR, these scenarios reflect the heat pump installations that would be required to fulfill total energy demand in the region consistent with CLCPA requirements. The *No Infrastructure Scenario* assumes heat pump installation rates that are equal to the "No Infrastructure Solution" described in National Grid's Second Supplemental LTCR. This represents a scenario in which ExC is rejected and no other gas supply project or contingency option is realized (e.g., LNG Vaporization, LNG Barge, Clove Lakes Transmission Loop). For this analysis, the *Heat Pumps and Oil Scenario* and *No Infrastructure Scenario* each assume that heating oil supplies the energy demand that is not met by heat pumps. These different heat pump scenarios are considered in context of the National Grid LTCR "Distributed Infrastructure Solution," which provides heat pump assumptions that are incorporated into the *ExC Scenario*. In other words, the *ExC Scenario* provides baseline heat pump installation assumptions against which the other scenarios are compared.

This report provides annual heat pump installation forecasts for multiple scenarios in both KEDNY and KEDLI, broken down by residential and commercial buildings through 2035.[40] This report also informed by potential heat pump forecasts in CECONY by assuming the energy output of heat pumps to be similarly proportional to projected energy demand in the KEDNY and CECONY.

Figure A-1 shows how projected cumulative heat pump installations for the *Heat Pumps and Oil Scenario* and *No Infrastructure Scenario* compare to those associated with the *ExC Scenario*.

Figure A-1 Assumed Cumulative Heat Pump Installations (as percentage of NENY targets)



[40] Heat pumps installed in KEDNY impact the territory's gas demand and are effectively allocated to National Grid.

No ExC Scenario Energy Output

Under the No ExC Scenarios, electricity and/or No. 2 heating oil must satisfy the energy demand that would be supplied by the ExC Project. Because the scope of this study included different service territories, MJB&A approximated territory- and sector-specific energy demand. This section outlines and provides references for the energy demand distribution and appliance efficiency assumptions used in this analysis.

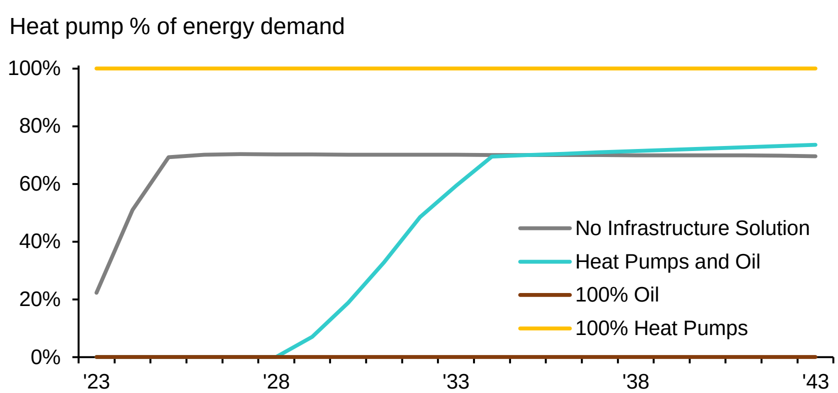
Energy Demand Breakdown

CECONY and KEDLI have each contracted for fifty percent of the gas supply that will be created by the ExC Project. Based on input from each utility, CECONY anticipates utilizing approximately 6,395 million dekatherms per year (MMDth/year) and KEDLI expects to utilize 5,000 MMDth/year (including uses by its affiliate, KEDNY).[41] U.S. Energy Information Administration (EIA) Form 176 (EIA-176) provided the current residential and commercial breakdown of natural gas deliveries within each territory; the Reference Gas Case of the EIA Annual Energy Outlook 2021 (EIA AEO 2021) for the Middle Atlantic Region (New York EIA region) was used to project sectoral gas distribution through 2043.[42] After further breaking down energy demand using the two demand scenarios (Low New Construction versus High New Construction), efficiencies of natural gas appliances used for space/water heating and other purposes were applied to estimate the final energy output required to be met by other fuel sources in the No ExC Scenarios. These efficiency assumptions are discussed in the following section.

Heat Pump Energy Output

Although National Grid and CECONY heat pump projections provided estimates of annual installations, this analysis required further processing to determine the applicable contribution of electricity toward meeting ExC energy demand. National Grid projections do not specify the allocation of single-family residential heat pumps between new construction and existing building conversions, so heat pumps were allocated to each building type based on the percentage of ExC gas assumed to go to new construction and conversions in the Low and High New Construction demand scenarios, to maintain consistency with the ExC scenario. As CECONY has not estimated how target heat pumps installations will be distributed across building types, this analysis assumes the same distribution in the CECONY service territory as in the National Grid service

Figure A-2 Heat Pump Energy Output Share of No ExC Scenarios (all service territories)



41 Approximately 2,930 and 2,070 MMDth/year for KEDNY and KEDLI, respectively, based on the 2019 of natural gas delivery data (EIA-176). While only KEDLI will contract for ExC supply, projected overall system demand (in both KEDNY and KEDLI territories) informed the National Grid decision to contract for ExC gas. In addition, existing capacity sharing regulations and system interconnects will likely result in some ExC gas being delivered to KEDNY customers.

42 U.S. Energy Information Administration, Annual Energy Outlook 2021, February 3, 2021.

territories. Figure A-2 shows the percentage of energy demand met by heat pumps in the different scenarios. Note that this percentage is only specific to the energy that would be delivered by the ExC project.

These heat pump projections were then multiplied by the average energy demand by customer type in each territory to calculate the electrical energy contribution. The remaining energy demand not met by electric heat pumps (delta between total energy demand and energy output of heat pumps) is assumed to be met by No. 2 heating oil.

The assumed ExC energy demand by customer type is shown in Table A-3.[43]

Table A-3 Natural Gas Demand by Customer/Building Type

Customer/Building Type	Gas Demand by Type (dth/year)		
	CECONY	**KEDNY**	**KEDLI**
Residential (single-family)	75 (new); 120 (existing)	75 (new); 120 (existing)	135 (new & existing)
Residential (multi-family)	75 (new); 120 (existing)	75 (new); 120 (existing)	135 (new & existing)
Commercial	625	625	1,035

Appliance Efficiencies

MJB&A investigated appliance efficiencies to determine the emissions and energy use impacts of converting between appliances or installing appliances powered by different fuels. This section outlines and provides references for the appliance efficiency assumptions used in this analysis.

Natural Gas-Fired Appliances

MJB&A evaluated the efficiency of natural gas appliances, including furnaces for space heating, commercial boilers and condensing and non-condensing water heaters, residential storage water heaters, and other appliances like cooking equipment. For the purposes of the calculations, all efficiencies reported for natural gas conversion appliances are efficiencies of the newly installed devices, not of the devices being replaced.

For natural gas furnaces installed in both conversions and new construction, the model includes efficiencies reported in supporting materials for the EIA AEO 2019. The AEO conducts a comprehensive assessment of the devices available on the market to develop baseline and projected performance and cost characteristics for residential and commercial end-use equipment. It reviews literature, state and federal standards, and contractor and manufacturer information to determine the required and typical performance expected from appliances on the market. Based on the information presented in the AEO, the model assumes an appliance efficiency of 95 percent for natural gas-fired furnaces in commercial and residential buildings, in both new construction and conversions.

For natural gas boilers and storage water heaters installed in both conversions and new construction, the model also includes efficiencies reported in the EIA AEO 2019. For storage water heaters, higher efficiency models operate at 81 percent efficiency, and the less common but more efficient tankless water heater has a typical efficiency of 87 percent. Therefore, the model uses an efficiency of 84 percent for both new construction and conversions. For larger residential buildings and commercial buildings using boilers, condensing and non-condensing water heaters, typical efficiencies range from 80 to 85 percent. The model includes an estimate of the efficiency of larger-scale water heating devices of approximately 82 percent. For “other” natural gas-fired appliances, like those used for cooking, an efficiency of 95 percent was assumed.

[43] CECONY: CECONY, Non-Pipeline Solutions to Provide Peak Period Natural Gas System Relief, April 21, 2020; National Grid: National Grid-provided data for Northeast Supply Enhancement Project analysis conducted by MJB&A, May 2019

Oil-Fired Appliances

For new oil-fired furnaces, water heaters, and "other" appliances installed in new construction, the model includes efficiencies reported in the EIA AEO 2019. For oil furnaces installed in residential homes, the 2017 ENERGY STAR-qualifying efficiency was 85 percent, and the higher end of device efficiency on the market is 95 percent. The model uses 90 percent as the average efficiency of new oil-fired devices. Commercial furnaces are not ENERGY STAR-rated but have a minimum required efficiency of 80 percent and typically have an efficiency range between 81 and 85 percent. Given the cost-effectiveness of switching to a natural gas appliance, this analysis assumed a higher baseline efficiency for new oil appliances of 90 percent.

All efficiencies reported for oil-fired "conversion" appliances in the model are efficiencies of the devices being replaced. As there is not a collective database of older appliance efficiencies, investigation of these efficiencies ranged across multiple sources. The assumption around residential oil-fired furnaces is derived from the NYSERDA residential heat pump analysis conducted as part of the New Efficiency: New York initiative. NYSERDA determined an existing residential fuel oil appliance coefficient of performance (COP) of 66 percent based on a literature review of Department of Energy (DOE) Technical Reference documents, and this analysis adopted NYSERDA's efficiency assumption. The COP unit represents energy output divided by energy input.

Estimates of 80 percent efficiency for existing residential oil-fired storage water heaters were derived from the AEO 2019 finding that the average annual fuel utilization efficiency (AFUE) of these heaters in 2009 was 80 percent. Existing commercial and larger-scale residential estimates derive from efficiency levels in the 2007 version of ASHRAE 90.1, the commercial building energy code. Depending on the make and model of commercial water heaters, base required efficiency ranges from 77 to 84 percent. Estimates for efficiencies of #4 oil-fired space and water heating equipment are further corroborated by a recent NYC Department of Environmental Protection (DEP) mandate that increased minimum combustion efficiency of existing commercial oil-fired boilers from 80 to 83 percent.

As reported in the AEO 2019, new oil-fired residential water heater AFUE ranged from 83 percent, the 2017 standard efficiency, to 97 percent in highly efficient models. Given the cost-effectiveness of switching to a natural gas appliance and increasing stringency of oil phase-outs, the model assumes relatively high baseline efficiency for new oil appliances of 90 percent. Table A-4 shows a summary of the appliance efficiencies for natural gas and oil heating appliances used in this study.

Table A-4 Natural Gas and Oil Appliance Efficiency

	Natural Gas (all)			**#2 Oil (Conversions/New Construction)**		
Sector	Space Heat	Water Heat	Other	Space Heat	Water Heat	Other
Residential (Single-Family)	95%	84%	95%	75%/90%	90%/95%	80%/90%
Residential (Multi-Family)	95%	82%	95%	75%/90%	90%/95%	80%/90%
Commercial	95%	85%	95%	78%/90%	78%/98%	80%/85%

Electric Appliances

Electric appliance efficiencies are either reported in terms of percentages, or in kilowatt-hours of electricity input per million British thermal units of heat output (kWh/MMBtu). Lower kWh/MMBtu values represent higher efficiencies (i.e. less input energy required per unit of heat output). For electric air-source heat pump (ASHP) and ground-source heat pump (GSHP) equipment, existing and new construction efficiencies are assumed to be identical. This analysis leverages NYSERDA's assumption of COP-3 for ASHP residential space heating (~97.7 kWh/MMBtu) as reported in its residential heat pump analysis. It assumes a slightly lower COP of 2.9 (~101.1 kWh/MMBtu) for commercial ASHPs based on the 2017 U.S. Energy Conservation Code.

GSHP residential space heating efficiency is assumed as COP-4.5 (~65.1 kWh/MMBtu) and commercial efficiency is assumed as COP-4 (~73.3 kWh/MMBtu), based on AEO 2019 findings. Residential and commercial ASHP water heaters assume a COP-2 (~146.5 kWh/MMBtu) based on current ENERGY STAR standards.

In the analysis, all efficiencies reported for electric resistance "conversion" appliances are efficiencies of the devices being replaced. For residential models, 90 percent efficiency derives from AEO 2019. While there are no federal minimum efficiencies for commercial electric storage water heaters, federal Energy Conservation Standards require minimum electric instantaneous water heater efficiencies of 77-80 percent for commercial use. The AEO 2019 reports new commercial storage and tankless electric water heater efficiencies to be quite high, at around 98 percent.

Table A-5 shows a summary of the assumptions used in the analysis for energy use by electric appliances (kWh input electricity per MMBtu heat output).

Table A-5 Electric Heat Pump Energy Use

Building Type	Sector	Electric Heat (kWh/MMBtu)		
		Space Heat	Water Heat	Other
New Construction	Residential (all)	94.4	146.5	299.1
	Commercial	98.3		
Conversion	Residential (all)	94.4	146.5	318.6
	Commercial	98.3		

Air- and Ground-Source Heat Pump Adoption Split

GSHPs, or geothermal systems, are generally more expensive and difficult to install than ASHPs but can still be a compelling option in the right conditions. Compared to ASHPs these systems are more efficient and operate more reliably in very cold temperatures without the need for back-up heat. A 2014 NYSERDA heat pump study found that in New York ASHPs were more cost-effective than GSHPs because the additional cost of installing a GSHP did not fully counteract increased savings when compared to a high-efficiency ASHP alternative.[44] However, the 2019 NYSERDA residential heat pump study notes that the cost of GSHPs has decreased significantly in New York State over time as the market has scaled and the state has provided a more supportive policy environment. Despite decreasing costs, GSHPs are not suitable for all sites in New York. In some locations, like Manhattan and Brooklyn, GSHP technical potential is limited by population density, small lot sizes, and extensive underground infrastructure. NYSERDA estimated "applicability factors," or the true technical potential of GSHPs, that considers all physical barriers (see Table A-6).

[44] New York State Energy Research and Development Authority. "Heat Pumps Potential for Energy Savings in New York State." Report Number 14-39. July 2014.

Table A-6 NYSERDA Heat Pump "Applicability Factors"

Zone	Residential	Commercial
New York City (NYC)	30%	30%
Long Island (LI)	70%	70%
Hudson Valley (HV)	70%	70%
Upstate (UP)	80%	80%

GSHP technical potential for NYC is low compared to areas like Long Island with less underground infrastructure and lower population density. Even so, technical potential does not account for cost, permitting, installation and other barriers that will further reduce the practical applicability of GSHPs. To account for these challenges, all No ExC scenarios assume that only 10 percent of all heat pumps installed in the National Grid and CECONY service territory will be GSHPs and 90 percent will be ASHPs.

Back-up Heating Load Assumptions

Back-up heat for heat pumps refers to a secondary source of heat powered by electricity, oil, gas, or other fuels that can supplement heat pumps when winter temperatures are very low. The efficiency of an ASHP decreases with temperature, so the device requires more energy to maintain the same indoor temperature as outdoor temperatures drop. This is one reason why heat pumps have been more quickly adopted in states with warmer and milder climates than New York.

An ACEEE study reviewed the need for back-up heat in Minnesota, where winter temperatures can drop as low as -25°F.[45] The author found that heat pumps provide more than 85 percent of heat in homes with electric resistance back-up systems over the course of the winter, indicating that the cold-climate air-source heat pumps can provide comfortable heat in severe winter temperatures. Extrapolating results to other regions, the study found that "using some electric resistance heat when the temperatures drop below about 5°F may be acceptable in places where this happens only occasionally."

In 2018, New York City temperatures dropped close to 5°F on three occasions during the official heating season of October 1 to May 31, or on about 1.2 percent of 2018 heating days. Given that the assumed back-up heat source in the downstate New York area is electric resistance heat and considering the inefficiency of electric resistance as compared to ASHPs as well as potential user error that can further decrease efficiency, the No ExC scenarios assume that electric resistance back-up heat for ASHPs will comprise 5 percent of total winter heating load.

Review of the literature suggests that GSHPs are more efficient than ASHPs and are assumed to operate without back-up heat at all downstate New York winter temperatures. As such, the No ExC scenarios assumes that electric resistance back-up heat supporting GSHPs will comprise zero percent of the total annual heating load.

Fossil Fuel Combustion

When combusted, all fossil fuels produce CO_2. Most combustion processes also produce N_2O and emit varying amounts of unburned CH_4 in combustion exhaust.

To estimate the CO_2 emissions associated with natural gas combustion, MJB&A developed CO_2 emission factors (g CO_2/MMBtu) based on the average composition of natural gas delivered in downstate New York.

45 Nadel, Steven. "Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps," American Council for an Energy-Efficient Economy. July 2018.

Carbon dioxide emission factors for combustion of #2 oil were developed using higher heating values (Btu/gallon) taken from the Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET) Model,[46] and fuel density (lb/gallon) and carbon content (% by weight) from EPA's AP-42 Compilation of Air Emissions Factors.[47]

Emissions factors for CH_4 and N_2O from combustion of natural gas and #2 oil were also taken from EPA's AP-42. To be consistent with proposed DEC methodology, MJB&A converted estimated CH_4 and N_2O emissions to CO_2-equivalent emissions using 20-year global warming potential (GWP_{20})[48] values from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report.[49] Table A-7 provides a summary of end-use emission factors used in the analysis.

Table A-7 End-Use Emission Factors for Natural Gas and #2 Oil (g/MMBtu)

	CO_2	CH_4	N_2O
Natural Gas	52,526	1.023	0.680
#2 Oil	74,416	5.877	0.165

End-Use Emissions from Electricity Generation

For the purposes of estimating GHG emissions from fuel switching from natural gas to electricity, the marginal generation mix can be more relevant than the average generation mix of existing demand. Marginal generation and associated emissions correspond with electric generating facilities that are brought online as necessary to meet demand, thus providing a more accurate estimation of the net emissions effect of increasing electricity demand. However, identifying the electric load met by marginal generation is difficult and highly sensitive to a variety of factors, such as economic dispatch, load reduction programs (e.g., energy efficiency and demand response), and renewable electricity penetration. Marginal generation generally corresponds with the highest-emitting electric generating units and therefore has a higher emissions rate than the average grid.

New York State Energy Research & Development Authority (NYSERDA) has adopted the NYS Public Service Commission's recommendation in its January 2016 Order Establishing the Benefit Cost Analysis Framework that New York's GHG emissions factor methodology shift from an average grid emission profile to a marginal grid emission profile.[50] For comparison, although the average electricity grid emissions rate in New York in 2019 was approximately 380 pounds CO_2e/MWh,[51] NYSERDA applies a marginal grid emission factor of around 1,100 pounds CO_2e/MWh.[52]

EPA's Emissions & Generation Resource Integrated Database (eGRID) also provides estimates for non-baseload emission rates by North American Electric Reliability Corporation (NERC) sub-regions, including areas relevant to this analysis: Long Island and New York City/Westchester.[53] These rates correspond with generating facilities that are effectively "on the margin," or facilities that that are dispatched to address

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46 Argonne National Laboratory. Model is available at https://greet.es.anl.gov/

47 U.S. Environmental Protection Agency, AP-42, Fifth Edition Compilation of Air Pollutant Emissions Factors, Volume 1: Stationary Point and Area Sources. Tables 1.3. and 1.4.

48 GWP values enable comparisons of global warming impacts of different gases relative to CO_2.

49 IPCC, Fifth Assessment Report (AR5), April 2014. GWP_{20} values of 84 and 264 for CH_4 and N_2O, respectively.

50 NYS PSC, CASE 14-M-0101 - Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision, Order Establishing the Benefit Cost Analysis Framework, January 21, 2016.

51 EPA Emissions & Generation Resource Integrated Database (eGRID), 2019, https://www.epa.gov/egrid.

52 Per the Clean Energy Advisory Council (CEAC) Metrics, Tracking, and Performance Assessment (MTPA), applicable for all Regional Greenhouse Gas Initiative (RGGI)-funded projects (energy efficiency, renewable electricity installations, etc.) completed after 2015; projects completed prior to 2016 assume a marginal rate of 1,160 pounds CO_2e/MWh based on analysis of grid emissions at the time.

53 EPA, Emissions & Generation Resource Integrated Database (eGRID), 2019, https://www.epa.gov/egrid

demand exceeding that met by baseload facilities. Table A-8 displays non-baseload generation and associated emission rates within relevant New York regions of NPCC.

Table A-8 NPCC Non-Baseload Emission Rates (end-use emissions only)*

	Non-Baseload GWh			CO2e Rate
Region	Gas	Oil	Total	lb/MWh
NYC/Westchester	12,557	10	12,617	**1,019**
Long Island	5,194	97	5,351	**1,306**

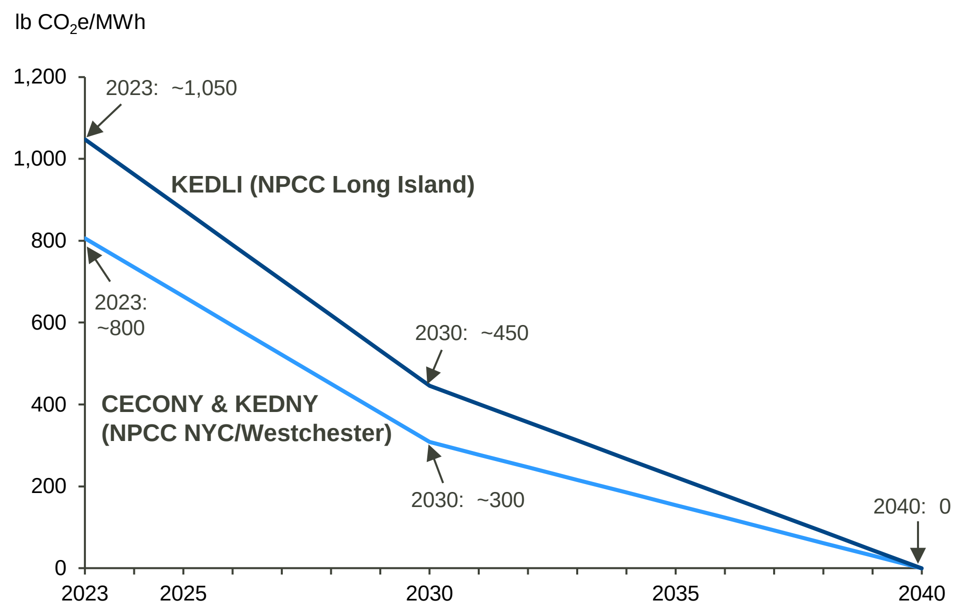
*Source: MJB&A analysis of U.S. EPA eGRID. IPCC AR5 20-year GWP values assumed.

To estimate generation emissions associated with fuel switching from natural gas to electricity, MJB&A projected marginal grid mix and emission rates over the analysis time frame. These projected marginal emission rates account for CLCPA electric sector goals (specifically, that 70 percent of generation statewide will come from renewable sources by 2030, and 100 percent will come from zero-emitting resources by 2040).

Because electrification leads to increased electric sales, additional new demand effectively brings zero-emitting generation onto the grid that would otherwise not have entered the system. Thus, it is reasonable to assume that this zero-emitting component of marginal generation is connected to CLCPA requirements and corresponds with declining marginal rates. If the state meets CLCPA electric sector goals, total marginal GHG emissions from electricity generation in New York would fall from the current rate of approximately 1,000-1,300 pounds CO_2e/MWh to zero pounds CO_2e/MWh after 2040.[54]

Figure A-3 displays the projected marginal emissions rate in Long Island and NYC/Westchester electric service territories, assuming that zero-emitting resources come online early to meet CLCPA goals.

Figure A-3 Projected Marginal Electricity Emissions Rate with CLCPA Electric Sector Goals*



Note: CLCPA 2040 goal corresponds with zero-emitting resources (including nuclear) while 2030 goal is specific to renewable electricity; defined approach and further analysis necessary to determine marginal emission rates.

* Source: MJB&A analysis. IPCC AR5 20-year GWP values assumed.

54 These rates should include all upstream and combustion emissions associated with natural gas, oil, and other fuels used for meeting marginal energy demand.

Appendix B – Upstream Emissions Methodology & Assumptions

Annual upstream GHG emissions are estimated using fuel life cycle segment-specific emission factors and delivered fuel and energy (natural gas, oil, electricity, and hydrogen/RNG). These emissions factors account for emissions associated with production, processing, transport to NYC area, and local distribution to end-use customers. For electricity, upstream emissions represent those associated with the fuel sources projected to generate the electricity required to meet incremental energy demand under No ExC scenarios (specifically in the CECONY and National Grid service territories).

Upstream emission factor assumptions utilize historical EPA Greenhouse Gas Inventory (GHGI) data[55] to project how methane emissions for each upstream segment may change because of upgraded operations, technology and equipment updates, regulation and/or improved reporting.

MJB&A applied an upstream emissions calculation methodology utilizing publicly available data and studies. This analysis also integrated the proposed methodology developed by ERG for the New York State Department of Environmental Conservation (NYSDEC).[56] Summary emission factors are provided in Table B-2 (following fuel-specific methodology descriptions).

Natural Gas

Upstream GHG emissions associated with natural gas flowing through Iroquois pipeline (ExC scenarios) were developed using life cycle assessment studies of natural gas published by the Department of Energy National Energy Technology Laboratory (NETL),[57] GHGenius (for natural gas deriving from Canada),[58] Environmental Defense Fund (EDF),[59] and other federal data sources. The following methodology corresponds with ExC scenarios only.[60]

Production & Processing

Based on internal feedback, 85% of natural gas was assumed to derive from the Appalachian basin, while the remaining 15% was assumed to be produced in western Canada (Alberta). NETL emission factors for Appalachia gas were adjusted with EDF methane study findings, and the GHGenius model was consulted for Alberta gas.

Transmission

NETL emission factors (with EDF adjustments) were applied to delivered gas. This analysis assumed a pipeline distance of approximately 350 miles from the relevant production region of the Appalachian basin to the beginning of the Iroquois pipeline in Waddington, New York. For Canadian gas (produced in Alberta), a pipeline distance of approximately 1,400 miles along the TransCanada pipeline was assumed.

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55 Natural gas systems: https://www.epa.gov/sites/production/files/2021-02/2021_ghgi_natural_gas_systems_annex36_tables.xlsx
Petroleum systems: https://www.epa.gov/sites/production/files/2021-02/2021_ghgi_petroleum_systems_annex35_tables.xlsx

56 See NY DEC website: https://www.dec.ny.gov/energy/99223.html

57 NETL. Accessible through https://www.netl.doe.gov/energy-analysis/details?id=3198

58 GHGenius. Accessible through https://www.ghgenius.ca/

59 Alvarez et al., 2018; accessible through https://pubmed.ncbi.nlm.nih.gov/29930092/

60 The proposed DEC methodology developed by ERG was used to calculated upstream emissions associated with natural gas demand for electricity generation (No ExC scenarios). This proposed methodology better represents the average composition of delivered natural gas in New York and is thus more reflective of natural gas being consumed at electric generating units.

Distribution

Data reported by CECONY and National Grid utilities (via EIA Form-176) were applied to estimate company-specific, distribution-related emissions.

Oil

The proposed DEC methodology developed by ERG was used to calculate upstream emissions associated with oil demand in both ExC and No ExC scenarios. However, because these proposed emission factors encompass only oil production, processing, and transmission emissions, MJB&A performed an additional analysis to estimate emissions from the delivery of oil to end use customers in CECONY and National Grid utility service territories. Using U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA) data on the average annual vehicle miles traveled of single-unit trucks (12,435 miles per year),[61] a common tanker volume of 5,500 gallons, truck emission factors (via Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET) Model developed and maintained by Argonne National Laboratory)[62], and modeled oil demand across different scenarios, oil distribution emissions were ultimately calculated.

Hydrogen & RNG

All scenarios that include natural gas consumption correspond with a changing composition of delivered pipeline gas. Hydrogen was assumed to be produced through electrolysis enabled by renewable electricity; consequently, upstream emissions associated with hydrogen were assumed to be zero. Upstream RNG emissions are largely sensitive to the feedstock/origin of RNG and assumed to derive relatively evenly from dairy digestors, landfills, and wastewater treatment facilities. MJB&A then used the production and processing emission factors provided by GREET for each RNG type.[63] Because RNG and conventional gas are effectively fungible molecules once mixed in the pipeline, RNG transmission and distribution emission factors are assumed to be equal to those of conventional gas. See Table B-1 for production and processing emission factors associated with each included RNG feedstock.

Table B-1 RNG Feedstock Production & Processing Emission Factors (g/MMBtu)

RNG Feedstock	CO_2	CH_4	N_2O	Total GHG*
Dairy	43.3	-4.39	-0.01	-328.1
Landfill	-60.4	0.38	0	-28.4
Wastewater Treatment	-75.9	-0.74	-0.02	-143.3

*IPCC AR5 20-year GWP values applied.

[61] Used as proxy for short-haul tanker trucks; FHWA 2019 Highway Statistics. Accessible through https://www.fhwa.dot.gov/policyinformation/statistics/2019/

[62] The GREET Model is available at https://greet.es.anl.gov/

[63] All emission impacts resulting from RNG are allocated to the production and processing segments

See Table B-2 for a summary of the upstream emission factors used for all included fuels (hydrogen assumed to have zero life cycle emissions).

Table B-2 Upstream GHG Emission Factors (kg CO_2e/MMBtu)[a]

Upstream Segment	Gas (ExC)	Gas (No ExC)	Oil	RNG
Production and Processing	20.13	44.21[b]	25.38[b]	-163.14[c]
Transmission	Basin-Iroquois: 10.91 Iroquois: 3.03			Same as Gas
Distribution	CECONY: 2.31 KEDNY: 23.26 KEDLI: 16.16	NA	14.60-17.29[d]	Same as Gas
Upstream Methane Rate Reduction[e]	*CAGR: -5.5%* *'23-'43 Change: -67.5%*	*CAGR: -4.8%* *'23-'43 Change: -62.7%*	*CAGR: -7.9%* *'23-'43 Change: -80.7%*	*Same as Gas (exc. prod. & processing)*
TOTAL *(low range corresponds w/ upstream CH_4 rate reduction assumption)*	**CECONY: 28.0-36.4** **KEDNY: 38.7-57.3** **KEDLI: 35.1-50.2**	**16.5-44.2**	**31.1-42.7**	**CECONY: -150 to -147** **KEDNY: -139 to -126** **KEDLI: -143 to -133**

[a] IPCC AR5 20-year GWP values applied
[b] Proposed DEC methodology emission factors developed by ERG (combined production, processing, and transmission)
[c] Production-weighted average of all included RNG feedstocks
[d] Oil distribution emissions decline through project lifespan due to tanker truck fuel efficiency improvements
[e] U.S. EPA GHG Inventory used to calculate 10-year CAGR of upstream methane emission factors for gas and oil systems; applied through 2043

The upstream emission factors associated with the production and delivery of natural gas, oil, hydrogen, and RNG were also used to develop upstream emission factors for electricity generation, as discussed below.[64]

Upstream Emissions from Electricity Generation

For this analysis, MJB&A developed estimates of the marginal GHG emission rates for generation of electricity in downstate New York over the time frame of the analysis (2023 – 2043). These estimated marginal emission rates account for expected changes in the electric system grid mix over time, in response to state and local policy and market forces. MJB&A utilized the ERG-developed proposed DEC methodology/emission factors for the oil and natural gas used for marginal electricity generation in the Long Island and NYC/Westchester NPCC regions.

[64] Estimated upstream emission rates of CO_2, CH_4, and N_2O for each fuel type were converted into a single CO_2e value using their respective global warming potential (GWP) numbers. The upstream CO_2e values were then added to the CO_2 content of each fuel (i.e., their end use combustion related emissions) to arrive at an overall life cycle CO_2e emission rate value for each fuel.