STATE OF NEW HAMPSHIRE
BEFORE THE
PUBLIC UTILITIES COMMISSION

Docket No. DG 17-152

Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities
Least Cost Integrated Resource Plan

DIRECT TESTIMONY

OF

PAUL J. HIBBARD

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I. INTRODUCTION

Q. Please state your full name, business address, and occupation.

A. My name is Paul J. Hibbard. I am a Principal at Analysis Group, Inc., an economic, finance and strategy consulting firm headquartered in Boston, Massachusetts, where I work on energy and environmental economic and policy consulting. My business address is 111 Huntington Avenue, 14th Floor, Boston, Massachusetts, 02199.

Q. On whose behalf are you submitting this testimony?

A. I am submitting this testimony before the New Hampshire Public Utilities Commission (the "Commission" or "NHPUC") on behalf of Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities ("Liberty" or the "Company").

Q. Please describe your background and qualifications.

A. I have been with AGI for approximately twelve years, first, from 2003 to April 2007, and most recently, from August 2010 to the present. From April 2007 to June 2010 I served as Chairman of the Massachusetts Department of Public Utilities ("MA DPU") and also served as a member of the Massachusetts Energy Facilities Siting Board ("EFSB"), the New England Governors' Conference Power Planning Committee, and the NARUC Electricity Committee and Procurement Work Group. I also served as State Manager for the New England States Committee on Electricity and as Treasurer on the Executive Committee of the 41-state Eastern Interconnect States' Planning Council. My experience as Chairman of the MA DPU and as a Board Member of the EFSB includes considering and deciding on issues relating to need, costs, environmental impacts, and benefits in the

zoning, permitting and siting of major energy infrastructure in the Commonwealth of Massachusetts, including power plants, transmission lines, and fuel transport pipelines.

I worked in energy and environmental consulting with Lexecon, Inc. from 2000 to 2003. Prior to working with Lexecon, I worked in state energy and environmental agencies for almost ten years. From 1998 to 2000, I worked for the Massachusetts Department of Environmental Protection on the development and administration of air quality regulations, Clean Air Act State Implementation Plans, and emission control programs for the electric industry, with a focus on criteria pollutants and carbon dioxide, as well as various additional policy issues related to controlling pollutants from electric power generators within the Commonwealth. From 1991 to 1998, I worked in the Electric Power Division of the MA DPU on cases related to the setting of company rates, the restructuring of the electric industry in Massachusetts, the quantification of environmental externalities, integrated resource planning, energy efficiency, utility compliance with state and federal laws and emission control requirements, regional electricity market structure development, and coordination with other states on electricity and gas policy issues through the staff subcommittee of the New England Conference of Public Utility Commissioners.

I hold an M.S. in Energy and Resources from the University of California, Berkeley, and a B.S. in Physics from the University of Massachusetts at Amherst. A more detailed description of my relevant background and experience and my curriculum vitae are attached as Exhibit 1.

Q. Have you previously testified before any regulatory bodies?

A. Yes. I have filed testimony before the Connecticut Siting Council on the siting of the Killingly Energy Center, Docket No. 470; before the State of Vermont Public Service Board on behalf of Vermont Gas Systems Inc., Docket No.'s 8698 and 8710; before the Massachusetts Department of Public Utilities on behalf of the Massachusetts Department of Energy Resources, DPU 13-07; before the Minnesota Public Utilities Commission on behalf of Calpine Construction Finance Company, Docket No. E-002/CN-12-1240; and before the Florida Public Service Commission on behalf of Calpine Construction Finance Company, Docket No. 140110-E1. I have also filed testimony as an expert witness in litigation and arbitration cases.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to provide additional environmental impact analysis in response to Order No. 26,225 (Mar. 13, 2019) (the "Order"), which directed the Company "to submit a supplemental filing, including supporting testimony, to address each of the specific elements required under RSA 378:38 and RSA 378:39 that are not already addressed in its LCIRP, with adequate sufficiency to permit the Commission's assessment of potential environmental, economic, and health-related impacts of each option proposed in the LCIRP, as required by RSA 378:39." Order at 7. On April 30, 2019, The Company filed testimony by William Killeen in response to the Order. The purpose of my testimony is to expand on and supplement the testimony of Mr. Killeen.

Q. How have you organized your testimony?

A. In Section II I provide an overview of the scope of my analysis of the potential environmental, economic, and health-related impacts of each option proposed in the Company's LCIRP, based upon my review of the Commission Orders related to the relevant statutes, and present the results of that analysis. In Section III I summarize the conclusions I draw from my analysis. The analysis I summarize is presented in detail in Exhibit 2 to my testimony.

Q. Would you please summarize your analysis and conclusions?

A. Yes. I have reviewed the two options presented and reviewed by Liberty to meet the resource needs identified in its LCIRP. Specifically, I have reviewed the impact of these options on compliance with the Clean Air Act ("CAA"), and on public health and the environment in the state of New Hampshire.

Meeting heating and other service needs of the state's residents and businesses is not optional - these are essential services that must be met to avoid adverse public health and safety consequences that would result from a lack of heat, hot water, and cooking fuel. In New Hampshire, the use of natural gas to meet these needs reduces the emissions that otherwise would occur if they were instead met with alternative fuels (in New Hampshire, alternative fuels are primarily oil, propane, and wood). To the extent meeting service needs with natural gas avoids using alternative and higher-emitting fuels, it reduces public health and environmental impacts.

This choice of fuels by residents and businesses in New Hampshire to meet their heat, hot water, and process needs (collectively, "service needs") is the primary driver of emission and health impacts under different scenarios related to the Company's LCIRP. I evaluate these impacts with a focus on heating technologies. I also analyze any potential differences in impacts of the two projects at issue in the LCIRP associated with fuel transport. Based on my quantitative analysis summarized in this testimony and presented in detail in Exhibit 2, I come to the following observations and conclusions:

- Nearly every household and business in New Hampshire requires the use of some type of fuel and/or electricity to meet these service needs.[1] The CAA compliance, public health, environmental, and climate change impacts of meeting customers' service needs differ depending on the type of fuel used.[2]
- Residential, commercial, and industrial consumption of oil, propane, natural gas, biomass, or electricity for meeting service needs results in emissions of air pollutants - such as sulfur dioxide ("SO_2"), nitrogen oxides ("NO_x"), particulate matter ("PM"), mercury ("Hg"), and greenhouse gases ("GHG") including carbon dioxide ("CO_2") - that affect (1) public health and the environment within New Hampshire (with associated costs to the state and its residents), (2) the ability of

[1] For a small number of residents in New Hampshire, data are not provided on how heating, cooking, and/or hot water needs are met. See US Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, NH House Heating Fuel, available at https://factfinder.census.gov.

[2] For fuels such as natural gas, oil, propane, and wood, the impacts result from direct combustion at the business or residence. For electricity, impacts result from the generation of electricity at power plants in New Hampshire and elsewhere in New England (using natural gas and other fuels), to meet customer electricity demand.

and cost to the state to meet Environmental Protection Agency ("EPA") CAA requirements, and (3) the risks associated with climate change.

- Both options proposed in Liberty's LCIRP - expansion of service through the Concord Lateral, and development and operation of the Granite Bridge Pipeline ("Granite Bridge," or "Project") - provide for the use of natural gas to meet service needs for (1) existing demand from current customers in the Company's service territory, and (2) new demand from new customers in the Company's service territory, including both newly-constructed buildings and residences and existing buildings converting to natural gas from other fuels ("service conversions"). On top of this, the Granite Bridge Pipeline provides for the use of natural gas to meet resident and business service needs (new customers and service conversions) in communities that do not currently have access to natural gas, and that otherwise would have to meet service needs through alternative fuels (primarily oil, propane, wood, electricity).[3]
- In order to assess the impact of the Company's options on CAA compliance and public health and the environment, one needs to compare project impacts to a hypothetical "status quo" scenario - that is, one where neither project is adopted to meet the Company's identified resource need. In the status quo case, the Company would not be able to offer natural gas for meeting service needs to new customers or service conversions in either their current service territory or the new

[3] The Communities that currently do not have access to natural gas, but would have access with the Granite Bridge Pipeline in operation, include Epping, Raymond, and Candia (towns all located in Rockingham County).

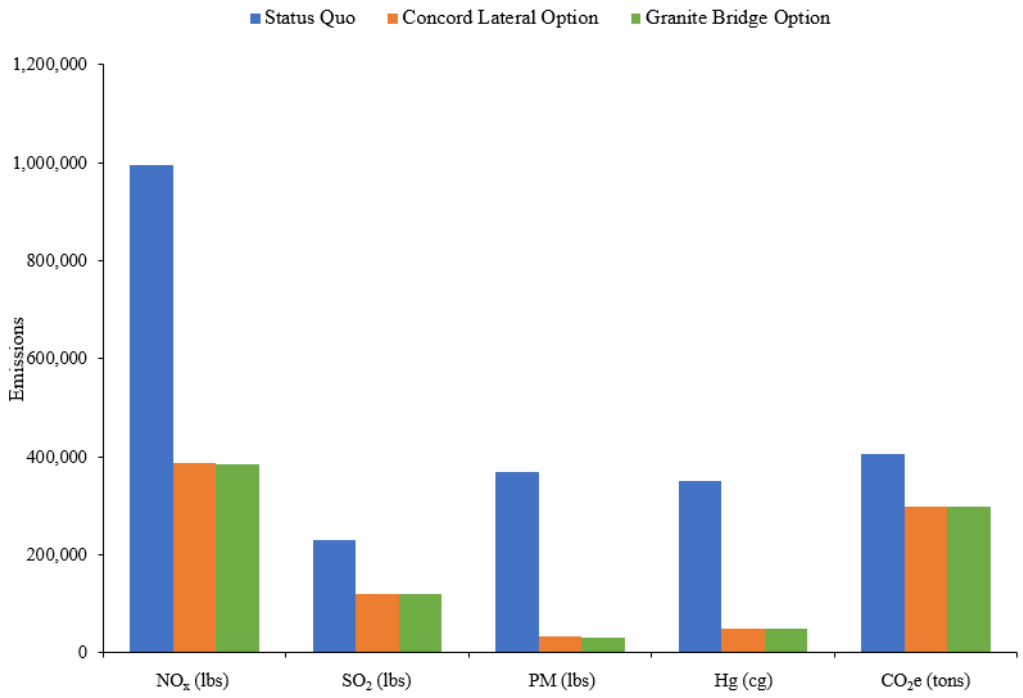
communities along the Granite Bridge Pipeline route. These customers would have to meet (or continue to meet) service needs through alternative fuels.

- The most significant effect the Company's LCIRP has on CAA compliance, public health and environmental impacts, and climate change risks is its overall influence on the use of fuels for heating, hot water, and process needs in residences and businesses in Liberty's current and expected future service territories. As a proxy for these impacts I focus on differences in emissions of harmful pollutants associated with service conversions for heating technologies.[4]
- Based on my quantitative analysis summarized in this testimony and presented in detail in Exhibit 2, I make several observations related to emissions and public health and environmental impacts. First, the Project will benefit New Hampshire's efforts to comply with the CAA. Most importantly, I find that the proposed options represent meaningful reductions in emissions of SO_2 for heating and other service needs relative to the status quo, with the Granite Bridge Pipeline providing the greatest level of reductions over time. As shown in Figure 1 below, I find that the Granite Bridge Pipeline reduces total emissions of SO_2 relative to the status quo by 111,784 pounds (the Concord Lateral expansion also reduces total emissions of

[4] There are additional benefits of service conversions associated with switching to natural gas not only for heating, but also for other services, such as hot water, cooking, and potentially other commercial/industrial processes. However, since it is difficult to obtain data on or forecast what portion of service conversion customers would use natural gas for these other service needs, I focus only on the heating portion of service needs. As a result, my estimates may meaningfully understate the actual potential benefits of natural gas service conversions in New Hampshire.

SO_2 relative to the status quo by 111,292 pounds).[5] Since under the proposed LCIRP natural gas will displace the use of higher-polluting fuels, particularly oil, the Project will make positive contributions towards New Hampshire's attainment of NAAQS. In particular, the Project aligns with the focus in New Hampshire's state implementation plan ("SIP") to make progress in reaching attainment of SO_2 standards (where in nonattainment) in part through a reduction in the combustion of oil for home heating.

Figure 1: Total emissions from customers remaining on existing heating technologies compared to switching to natural gas heating technologies under the Granite Bridge or Concord Lateral Expansion options - IRP Scenario.



[5] See also Exhibit 2, Table 1.

- Second, the options presented in the Company's LCIRP would generate important public health and environmental benefits relative to the status quo. These benefits include reduced emissions of criteria pollutants and reductions in costs associated with the harmful effects of these pollutant emissions on public health. In addition to the reductions in emissions of SO_2 noted above, the Granite Bridge Pipeline will reduce emissions of NO_x by 612,412 pounds (2,588 pounds more than under the Concord Lateral expansion), emissions of PM by 336,690 pounds (1,016 pounds more than under the Concord Lateral expansion), and emissions of Hg by 107 ounces, relative to the status quo (0.5 ounces more than under the Concord Lateral expansion).[6, 7] As shown in Table 1, the reductions in SO_2, NO_x, and PM together contribute to health benefits of the Granite Bridge Pipeline of between $1.06 million and $2.39 million, relative to the status quo.[8] I also find that the options will lead to lower emissions of GHG relative to the status quo scenario, thereby contributing to a lowering of the risks associated with climate change. Specifically, I find that the Granite Bridge Pipeline would reduce CO_2 and CO_2-equivalent ("CO_2-e") emissions (including methane, or "CH_4") by 108,903 tons, relative to the status quo.[9]

[6] See Figure 1; see also Exhibit 2, Table 1.

[7] The Concord Lateral expansion would reduce emissions of NO_x by 609,824 pounds, emissions of particular matter by 335,674 pounds, and emissions of mercury by 107 ounces, relative to the status quo. See Figure 1; see also Exhibit 2, Table 1.

[8] See also Exhibit 2, Table 9.

[9] The Concord Lateral expansion would also reduce emissions of CO_2-equivalent emissions by 108,435 tons relative to the status quo. See Figure 1; see also Exhibit 2, Table 1.

Table 1: Summary of Total residential, commercial, and industrial annual average health impacts associated due to the two project options relative to the status quo - IRP Scenario.

		Total Average Annual Impact
Granite Bridge Relative to Status Quo	$ Total Health Benefits (low estimate)	1,057,086
	$ Total Health Benefits (high estimate)	2,387,346
Concord Lateral Relative to Status Quo	$ Total Health Benefits (low estimate)	955,083
	$ Total Health Benefits (high estimate)	2,156,979
Differential	$ Total Health Benefits (low estimate)	102,004
	$ Total Health Benefits (high estimate)	230,366

- Third, the Granite Bridge Pipeline will reduce large truck traffic for deliveries of propane and/or liquefied natural gas ("LNG"), and will further reduce local deliveries of oil and propane to residences and businesses that switch from those fuels to natural gas. I estimate the potential emission reductions from the expected reductions in large truck deliveries for replenishing the Company's satellite storage tanks. Specifically, this could reduce emissions of CO_2 by roughly 50 to 63 thousand pounds, emissions of NO_x by 290 to 360 pounds, and emissions of PM by seven to nine pounds.[10] The reductions in NO_x, and PM together contribute to health benefits of between $700 and $2,000 per year.[11]
- Finally, as can be seen in the results presented above, the Granite Bridge Pipeline would lead to lower overall emissions of harmful pollutants and GHG than an expansion of the Concord Lateral, primarily due to increases in the number of

[10] See Exhibit 2, Table 10.

[11] See Exhibit 2, Table 11.

customers who would have access to natural gas, and convert to gas from alternative fuels for heating and other service needs.

II. THE SCOPE OF ENVIRONMENTAL IMPACTS

Q. Have you reviewed RSA 378:38 and RSA 378:39 with respect to LCIRP filing requirements for and Commission review of resource plan environmental impacts?

A. Yes. I have.

Q. Please describe which sections are the focus of your analysis and testimony.

A. Section RSA 378:38 provides content requirements for utility LCIRP filings including, in relevant part, the following:[12]

> V. An assessment of plan integration and impact on state compliance with the Clean Air Act of 1990, as amended, and other environmental laws that may impact a utility's assets or customers.
> VI. An assessment of the plan's long- and short-term environmental, economic, and energy price and supply impact on the state.
> VII. An assessment of plan integration and consistency with the state energy strategy under RSA 4-E:1.

Section RSA 378:39 states that, "[i]n deciding whether or not to approve the utility's plan, the commission shall consider potential environmental, economic, and health-related impacts of each proposed option."[13]

[12] 2015 New Hampshire Revised Statutes, Title XXXIV Public Utilities, Chapter 378 Rates and Charges, Least Cost Energy Planning, Section 378:38 Submission of Plans to the Commission.

[13] 2015 New Hampshire Revised Statutes, Title XXXIV Public Utilities, Chapter 378 Rates and Charges, Least Cost Energy Planning, Section 378:39 Commission Evaluation of Plans.

Q. How do you structure your review in light of this language?

A. Sections 378:38 and 378:39 provide guidance for the filing and Commission review of, among other things, Clean Air Act-related, public health, and environmental impacts of a company's LCIRPs. The sections apply to both electric and natural gas utilities, and need to be interpreted and applied by the Commission on a case-by-case basis based on precedent, state energy policy, and the individual circumstances of and current context for each company's LCIRP.

In this case, Liberty is filing its LCIRP at a time when it needs to plan for additional resources and infrastructure to reliably meet the heating, hot water, and process needs of its existing natural gas customers, as well as new customers to be added over the period of the LCIRP 2017-2022.[14] In its LCIRP, Liberty presents and reviews two options for meeting these needs: expansion of the capacity of the Concord Lateral, and the Granite Bridge Pipeline. In this context, RSA 378:38 and 378:39 guide the Company's filing of CAA, public health, and environmental information and data on these two options, and provide for Commission review of this information.

[14] This time period is measured in gas years. Specifically, the LCIRP covers the November 2017 - October 2018 gas year to the November 2021 - October 2022 gas year.

Q. Please describe how you have approached your analysis considering these filing and review provisions of RSA 378:38 and 378:39 in light of the Company's LCIRP context.

A. The Company has presented two options in its LCIRP. Each option has positive or negative implications (relative to the status quo) for New Hampshire compliance with the requirements of the CAA, and for the public health and environmental impacts of reliable utility service. Consequently, I focus on how the projects would affect the state's compliance with the CAA, and would alter emissions that affect public health and the environment, including emissions of SO_2, NO_x, PM, and Hg. Since RSA 378:38 V's language also includes "…other environmental laws that may impact a utility's assets or customers," I also review the emissions of GHGs (including CO_2) for each option, relative to the status quo. Finally, the focus of my analysis is primarily the period of the LCIRP 2017-2022;[15] however, given RSA 378:38's reference to "long-term impacts," I also present information on the potential longer-term public health and environmental implications of the Company's options.

Q. Could you please summarize the scope of impacts you have reviewed in your analysis?

A. Yes. Based on my review of RSA 378:38 and 378:39, I present information, data, and analysis on the impact of the options identified in the Company's LCIRP, relative to the status quo, with respect to (a) state compliance with EPA requirements under the CAA, (b)

[15] This time period is measured in gas years. Specifically, the LCIRP covers the November 2017 - October 2018 gas year to the November 2021 - October 2022 gas year.

public health and environmental impacts, and (c) emissions of GHG, including CO_2, that contribute to the risks associated with climate change.

A. State Compliance with the Clean Air Act

Q. Could you please summarize key elements of the CAA?

A. Yes. The CAA is a federal law establishing air pollution programs and limits on certain types of harmful emissions. The CAA's key provisions, set forth in 1970, require the EPA to determine national ambient air quality standards ("NAAQS") for six common criteria pollutants: particulate matter, ozone ("O_3"), SO_2, nitrogen dioxide (NO_2), carbon monoxide (CO), and lead (Pb). For each of these pollutants, the EPA designates areas nationwide as in "attainment" or "nonattainment" of the standard as determined by air quality monitoring over some period of time, typically three years. For areas designated as in attainment or unclassifiable, SIPs must "prevent significant deterioration of air quality," and for areas designated as in nonattainment, SIPs must "go further, and strive for attainment of the air quality standard 'as expeditiously as practicable."[16]

Each state is required to devise a state implementation plan ("SIP") to ensure that NAAQS are met (i.e., the state is in attainment). SIPs must demonstrate two main components to receive EPA approval - that the state has the infrastructure in place to implement and monitor emissions standards, and that the state has established regulations that will maintain new or existing NAAQS. In addition to NAAQS for the six criteria pollutants,

[16] U.S. Court of Appeals for the District of Columbia Circuit, Samuel Masias et al v. EPA et al., No. 16-1314, dated October 19, 2018.

the CAA contains provisions for regulating other hazardous air pollutants ("HAP"), motor vehicle emissions, and stationary source emissions. Finally, New Source Performance Standards ("NSPS") set forth acceptable levels of emissions from new or modified stationary sources deemed to "contribute significantly to air pollution that may reasonably be anticipated to endanger public health or welfare."[17]

Since 1970, the CAA has been amended twice, in 1977 and 1990. These amendments established provisions related to modified NAAQS, acid rain regulation, expanded HAP standards, and air quality deterioration, among other things. The EPA continues to promulgate regulations applicable to new, modified, and reconstructed sources, as well as review and update NAAQS and other pollutant limitations.[18]

Q. Please briefly summarize New Hampshire's compliance with the CAA.

A. New Hampshire's SIP is the state's "blueprint for carrying out requirements of the Clean Air Act."[19] SIP requirements under the CAA vary depending on current and former NAAQS attainment status. As of 2019, New Hampshire has achieved attainment for each criteria pollutant except for SO_2. Table 2 below summarizes New Hampshire's current and former air quality designations by pollutant.[20]

[17] Lattanzio, Richard, "Methane and Other Air Pollution Issues in Natural Gas Systems," https://fas.org/sgp/crs/misc/R42986.pdf.

[18] EPA, NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table.

[19] NH DES, State Implementation Plan (SIP), https://www.des.nh.gov/organization/divisions/air/do/sip/index.htm.

[20] NH DES, "State of New Hampshire Air Quality - 2017." The 2019 statuses are identical to those from 2017, https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-01.pdf.

Table 2: Summary of New Hampshire current and former air quality designations by pollutant.

Pollutant	Area Designations	
	Former Status	Current Status
Carbon Monoxide (CO)	Nonattainment for Manchester and Nashua; attainment for all other areas[a]	Attainment for all areas
Lead (Pb)	Attainment for all areas	Unclassifiable/Attainment for all areas
Nitrogen Dioxide (NO_2)	Attainment for all areas	Unclassifiable/Attainment for all areas
Ozone (O_3)	1-hour NAAQS: Nonattainment for Cheshire, Hillsborough, Merrimack, Rockingham, and Strafford Counties; attainment for all other areas[b] 8-hour NAAQS: Nonattainment for portions of Hillsborough, Merrimack, and Rockingham Counties; attainment for all other areas[c]	Attainment for all areas
Particulate Matter (PM)	Attainment for all areas	Attainment for all areas
Sulfur Dioxide (SO_2)	Attainment for all areas	Nonattainment for portions of Hillsborough, Merrimack, and Rockingham Counties; unclassifiable for all other areas[d]

Due to nonattainment of SO_2 in Hillsborough, Merrimack, and Rockingham Counties, New Hampshire is required under the CAA to detail in its SIP specific programs or regulations efforts to lower SO_2 emissions to the EPA defined standards. According to the New Hampshire Department of Environmental Services (DES), Merrimack Generating Station contributes significantly to the nonattainment status, contributing as much as 83% of all *point-source* SO_2 emissions in the nonattainment area. DES also states that "residential and commercial and industrial oil combustion are the largest area and non-

EGU [electric generating unit] point sources of SO_2, contributing over 90 percent in each category."[21]

New Hampshire's SIP cites the following major regulations in its plan to achieve SO_2 attainment going forward:[22]

- **Multiple Pollutant Reduction Program** (RSA 125-O): Requires mercury reductions of 80 percent or more from New Hampshire coal-fired power plants. This facilitated Merrimack Station's installation of a wet, limestone based flue gas desulfurization (FGD) system, for which SO_2 removal is a "co-benefit."
- **Sulfur Limits of Certain Liquid Fuels** (RSA 125-C:10-d): Imposed new limitations on sulfur content in Nos. 2, 4, 5, and 6 fuel oil beginning in July 2018.
- **Statewide permit system** (Env-A 600 and Env-A 2900): An annual budget trading and banking system for SO_2 (among other pollutants).

Apart from SO_2, all other criteria pollutants in New Hampshire have achieved air quality designations of attainment or unclassifiable/attainment. As a result, New Hampshire's SIP requirements for other criteria pollutants are less stringent. New Hampshire's SIP proposes maintenance of PM, O_3, NO_2, CO, and Pb through existing regulations, which DES expects will yield continued compliance with CAA limits. By and large, New Hampshire's CAA

[21] NH DES, "1-Hour Sulfur Dioxide (2010 Standard) Redesignation Request and Maintenance Plan for the Central New Hampshire Nonattainment Area," https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-06.pdf. Emphasis added.

[22] Ibid.

compliance-related legislation is contained within the New Hampshire Air Program Rules (Env-A).[23] Below is a high-level summary of major provisions included in Env-A that aim to achieve CAA compliance:

- **Ambient Air Quality Standards** (Env-A 300): Sets standards for criteria pollutants at least as stringent as those set by the EPA.[24]
- **Standards Applicable to Certain New or Modified Facilities and Sources of Hazardous Air Pollutants**; **State Plans for Designated Facilities and Pollutants** (Env-A 500): Defining NSPS for stationary sources.[25]
- **Air Toxics Program** (Env-A 1400): Expands on EPA's list of HAPs and sets ambient air limits (AALs) for pollutants.[26]
- **Clean Power Act** (Env-A 2900): Establishes cap-and-trade programs for SO_2, and NO_x.[27]

[23] NH DES, New Hampshire Infrastructure SIPs, https://www.des.nh.gov/organization/divisions/air/do/sip/sip-revisions.htm#so2.

[24] NH DES, Code of Administrative Rules, Chapter Env-A 300: Ambient Air Quality Standards, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/enva300.pdf.

[25] NH DES, Code of Administrative Rules, Chapter Env-A 500: Standards Applicable to Certain New or Modified Facilities and Sources of Hazardous Air Pollutants; State Plans for Designated Facilities and Pollutants, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-a500.pdf.

[26] NH DES, Code of Administrative Rules, Chapter Env-A 1400: Regulated Toxic Air Pollutants, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-a1400.pdf.

[27] NH DES, Code of Administrative Rules, Chapter Env-A 2900: Sulfur Dioxide and Nitrogen Oxides Annual Budget Trading and Banking Program, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-a2900.pdf.

- **Open market programs** (Env-A 3000-3100): Voluntary discrete emissions reduction trading and rate-based emission reduction credits trading programs.[28, 29]

Q. Could you please summarize how the options contained in the Company's LCIRP could affect state compliance with the CAA?

A. Yes. Based on a review of CAA provisions and New Hampshire's SIP, there are a few areas where the Company's LCIRP intersects in a positive or negative way with the state's compliance with the CAA.

First and foremost, the Company's LCIRP has implications for the state's management of nonattainment with the NAAQS SO_2 standard. As described below, both LCIRP options establish opportunities for residents and businesses to select natural gas for their service needs, either initially if new construction, or through conversion from other fuels. Specifically, there are thousands of customers who could make this selection that otherwise would not have the option under the status quo scenario, reducing dependence on other fuels, primarily oil and propane. As noted above, the New Hampshire SIP notes that "…residential and commercial and industrial oil combustion are the largest area and non-EGU [electric generating unit] point sources of SO_2, contributing over 90 percent in each

[28] NH DES, Code of Administrative Rules, Chapter Env-A 3000: Emissions Reduction Credits Trading Program, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-a3000.pdf.

[29] NH DES, Code of Administrative Rules, Chapter Env-A 3100: Discrete Emissions Reductions Trading Program, https://www.des.nh.gov/organization/commissioner/legal/rules/documents/env-a3100.pdf

category."[30] The U.S. Energy Information Administration (EIA) explains that per capita petroleum consumption in New Hampshire is among the highest nationwide, "in part because of heavy dependence on heating oil and propane during the state's frigid winters."[31] Displacement of heating oil with natural gas, which emits only "trace amounts" of SO_2, would therefore assist in New Hampshire's compliance with NAAQS.[32]

According to New Hampshire's ten-year energy plan, "the dearth of new natural gas capacity… limits [its] attractiveness for heating customers who could potentially transition away from heating oil," and the "most critical current infrastructure need is for natural gas capacity."[33] The Project will provide just this, bringing additional natural gas to towns in and bordering the nonattainment area, ultimately making positive contributions to SO_2 and other criteria pollutant NAAQs.

With the Concord Lateral expansion, Liberty estimates an additional 10,716 customers would be able to select natural gas over the LCIRP term rather than other sources. With the Granite Bridge Pipeline even more customers could make this selection - 10,778 in total. As noted in our review of long-term impacts, this value for the Granite Bridge

[30] NH DES, "1-Hour Sulfur Dioxide (2010 Standard) Redesignation Request and Maintenance Plan for the Central New Hampshire Nonattainment Area," https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-06.pdf. Emphasis added.

[31] U.S. EIA, New Hampshire State Profile and Energy Estimates, https://www.eia.gov/state/analysis.php?sid=NH.

[32] EPA, Natural Gas Combustion, https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf.

[33] New Hampshire Office of Strategic Initiatives, New Hampshire 10-Year Sate Energy Strategy, April 2018, https://www.nh.gov/osi/energy/programs/documents/2018-10-year-state-energy-strategy.pdf.

Pipeline grows to a total of 37,294 customers over 21 years that would be able to use natural gas over alternative fuels in the state of New Hampshire.

This leads to meaningful reductions in emissions of SO_2 for service needs relative to the status quo, with the Granite Bridge Pipeline providing the greatest level of reductions over time (an average of 11 tons per year). Given that under the proposed LCIRP natural gas will displace the use of higher-polluting fuels, particularly oil, the Project is expected to make positive contributions towards New Hampshire's attainment of NAAQS. In particular, the Project aligns with New Hampshire's SIP to make progress in reaching attainment of SO_2 standards in the current nonattainment area in part through reduction in combustion of oil for home heating. However, in addition to helping reach attainment with the NAAQS for SO_2, the Project will help New Hampshire *maintain* attainment with other NAAQS under the CAA, by reducing emissions of criteria pollutants (or their precursors), or reducing the level of expected growth in such emissions.

Finally, NSPS and NESHAPS regulated by the CAA and New Hampshire SIP are applicable to pipeline transportation of natural gas. Any new transportation infrastructure must meet certain emissions levels and technological requirements related to methane, VOCs, and HAPs that were put in place to control the potential leakage of fugitive emissions from various stages of the natural gas production and distribution process. Thus either of the pipeline options in the Company's LCIRP would need to meet the NH DES technological standards for these categories of infrastructure, and in doing so would conform to state-specific requirements under the CAA.

B. Public Health and the Environment, and GHG Emissions

Q. Have you reviewed the impact the resource options identified and reviewed in the Company's LCIRP would have on the public health and the environment of New Hampshire?

A. Yes.

Q. How might the identified resource options affect public health and the environment?

A. The Company has identified and reviewed two options to reliably meet the demand of its customers (existing and new), as identified in its Least Cost Integrated Resource Plan. These options include potential expansion of the capacity of the Concord Lateral and development of the Granite Bridge Pipeline. The identified resource options cannot be evaluated in isolation; in order to account for public health and environmental impacts, one must consider the proper context for such an evaluation. In this case, the context is the need of New Hampshire's residents and businesses for fuels to meet their heating, hot water, cooking and process needs (collectively "service needs").

The service needs of New Hampshire's residential, commercial, and industrial customers require consumption of oil, propane, natural gas, biomass, or electricity. The use of such fuels, in turn, leads to emissions that affect public health and the environment within New Hampshire (with associated costs to the state and its residents), and contribute to the risks associated with climate change due to emissions of greenhouse gases. The impacts associated with meeting customers' service needs differ depending on the type of fuel

used.[34] Importantly, nearly every household and business in New Hampshire requires the use of some type of fuel, and/or electricity, to meet these service needs.[35]

Meeting customer service needs can result in local and regional health impacts. This is because the combustion of fuel to meet home and business heating (and other service needs) is a source of harmful pollutants - including NO_x, SO_2, PM, Hg, and CO_2. CO_2 (and other GHGs involved in energy production and use, such as methane) contribute to the risks associated with climate change. The rest of the pollutants can have local and regional impacts, and can lead to or exacerbate premature deaths, asthma, and other major health problems for the state's residents:

- Nitrogen oxides are implicated in a wide variety of health and environmental impacts. Health impacts include respiratory infection and disease, such as asthma. Environmental effects include acid rain, haze, and nutrient pollution in coastal waters.[36]

[34] For fuels such as natural gas, oil, propane, and wood, the impacts result from direct combustion at the business or residence. For electricity, impacts result from the generation of electricity at power plants in New Hampshire and elsewhere in New England (using natural gas and other fuels), to meet customer electricity demand.

[35] For a small number of residents in New Hampshire, data are not provided on how heating, cooking, and/or hot water needs are met. See US Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, NH House Heating Fuel, available at https://factfinder.census.gov.

[36] "Nitrogen Dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NOx) […] NO_2 is used as the indicator for the larger group of nitrogen oxides." EPA, Basic Information about NO_2, accessed September 5, 2018, available at https://www.epa.gov/no2-pollution/basic-information-about-no2#Effects.

- Sulfur dioxide is implicated in a wide variety of health and environmental impacts. Like NO_x, health impacts include respiratory infection and disease, such as asthma. Environmental effects include acid rain and haze.[37]
- Particulate matter is implicated in a wide variety of health and environmental impacts. Health impacts include negative effects on the heart and lungs, such as respiratory disease and non-fatal heart attacks. Environmental effects include acid rain, depletion of nutrients in soil and water, and negative effects on the diversity of ecosystems.[38]
- Mercury is implicated in a wide variety of health and environmental impacts. Some of the health impacts include headaches, changes in nerve response, and poor performance on tests of mental function. Prolonged high exposure can cause kidney effects, respiratory failure, and death. Environmental effects are concentrated in animals that eat fish. Due to mercury exposure, these animals are subject to reduced reproduction, slower growth and development, abnormal behavior, and even death.[39]

[37] EPA, Sulfur Dioxide Basics, accessed September 5, 2018, available at https://www.epa.gov/so2-pollution/sulfur-dioxide-basics.

[38] EPA, Health and Environmental Effects of Particulate Matter (PM), accessed September 5, 2018, available at https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm.

[39] EPA, Basic Information about Mercury, accessed September 5, 2018, available at https://www.epa.gov/mercury/basic-information-about-mercury; Health impacts listed are from inhaling elemental mercury, EPA, Health Effect of Exposures to Mercury, accessed September 5, 2018, available at https://www.epa.gov/mercury/health-effects-exposures-mercury.

- Emissions of greenhouse gases contribute to the social, economic, and environmental risks associated with climate change.

Many such impacts can only be identified qualitatively. However, it is possible to quantify and monetize the direct public health impacts of some pollutants. For example, the New Hampshire DES estimates that one premature death due to air pollution results in $9.35 million in costs, one asthma-related emergency room visit costs $440, and one lost work day averages $150.[40] Moreover, DES estimates that fine particulate matter and ozone accounted for approximately $3.8 billion in health impacts in New Hampshire from 2013 through 2015.[41]

Q. Does Liberty's use of natural gas to meet the heating and other service needs of New Hampshire residents and businesses necessarily imply negative public health and environmental impacts?

A. No. Meeting heating and other service needs of the state's residents and businesses is not optional - these are essential services that must be met to avoid adverse consequences that would result from a lack of heat, hot water, and cooking fuel. The use of natural gas to meet these needs can reduce the emissions that otherwise would occur if they were met

[40] "Considerable variability in valuation exists. Valuations presented here are interpolated median 2011 valuations." New Hampshire Department of Environmental Services, State of New Hampshire Air Quality – 2017: Air Pollution Trends, Effects and Regulation, March 2018, available at https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-01.pdf, Table 4.2, p. 64-65.

[41] Figure reported in 2010 dollars. Economic impacts of air pollution consider ozone and particulate matter pollution together. New Hampshire Department of Environmental Services, State of New Hampshire Air Quality – 2017: Air Pollution Trends, Effects and Regulation, March 2018, available at https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-01.pdf, Table 4.3, p. 66.

with alternative fuels. To the extent meeting service needs with natural gas avoids using alternative and higher-emitting fuels, it can *reduce* public health and environmental impacts.

Q. Considering this context, how have you analyzed the public health and environmental impacts that can reasonably be assigned to the resource/supply options included in the Company's LCIRP?

A. The primary public health and environmental impact of the options identified in the Company's IRP relate to the possibility of switching to natural gas from more polluting fuels for heat and other service needs. To the extent this occurs, the LCIRP resource options open the door to achieving reductions in emissions of pollutants, relative to the status quo scenario.

Both the Concord Lateral and Granite Bridge options would open access to customers in Liberty's service territory that are currently using other fuels to use natural gas to meet heating and other service needs. In addition, Granite Bridge would open this access for additional residents and businesses along the pipeline route. In terms of magnitude, Liberty estimates that in the first year after Granite Bridge comes into service, it would add approximately 1,800 residential customers and over 500 commercial and industrial ("C&I") customers. In each subsequent year, Liberty expects to add fewer customers, but by 2037/2038, still anticipates adding over 1,000 residential customers and over 200 C&I customers per year. These customers will be choosing natural gas for heating over oil,

propane, or some other heating source and would not have access to natural gas without the Granite Bridge Pipeline.[42]

In order to assess the impacts of the resource options in the LCIRP, I take two steps. First, I estimate differences in total emissions to meet heating needs under the Concord Lateral expansion, Granite Bridge Pipeline, and "status quo" scenarios.[43] These differences in emissions at least directionally indicate the potential for public health and environmental benefits. However, some public health impacts may be quantified. Thus, in the second step I translate the differences in emissions into quantifiable public health benefits, where possible. To carry out these calculations, I use estimates of average customer heating load in New Hampshire, heating technology efficiencies for different fuel types, and different time frames (i.e., short-term results across the term of the LCIRP, and longer-term results more indicative of total lifetime impacts).

[42] Expected customer growth stems from new service and conversions within the company's existing service territory and - in the case of the Granite Bridge option - new access to natural gas along the route of the Project in towns that currently do not have access to natural gas. Liberty Utilities has noted that without Granite Bridge, it may be unable to meet growth in new natural gas services. See New Hampshire Public Utilities Commission, Docket No. DG 17-198, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Pre-Filed Testimony of Susan L. Fleck and Francisco C. Dafonte, December 21, 2017, p. 23, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-198/INITIAL%20FILING%20-%20PETITION/17-198_2017-12-22_ENGI_PDTESTIMONY_FLECK_DAFONTE.PDF.

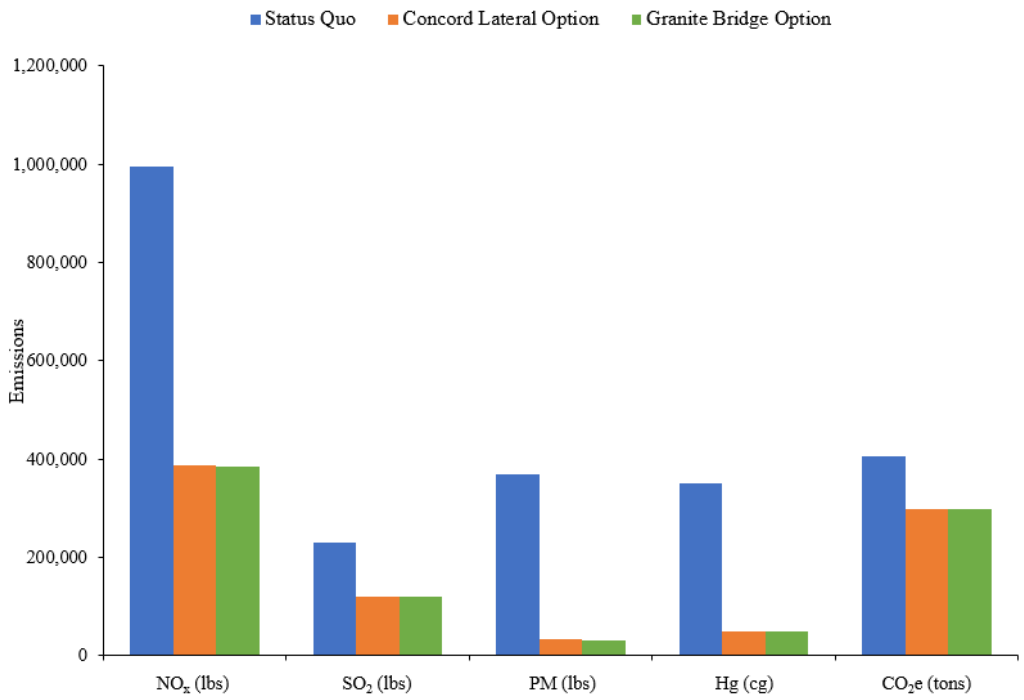
[43] There are additional benefits of service conversions associated with switching to natural gas not only for heating, but also for other services, such as hot water, cooking, and potentially other commercial/industrial processes. However, since it is difficult to obtain data on or forecast what portion of service conversion customers would use natural gas for these other service needs, I focus only on the heating portion of service needs. As a result, my estimates may meaningfully understate the actual potential benefits of natural gas service conversions in New Hampshire.

Q. Could you please summarize your results?

A. Yes. The method, inputs and results of my analysis are presented in Exhibit 2 to this testimony. In Exhibit 2, results are presented for the status quo, Concord Lateral, and Granite Bridge scenarios. Results are also presented across different timeframes, and for all classes of customers. Metrics include average per-customer impacts and overall impacts for Liberty's service territory in terms of avoided emissions and cost savings associated with public health benefits. Figures 1 through 2 and Tables 1 through 11 in Exhibit 2 show the results. The options in the Company's LCIRP are likely to lower emissions of all pollutants, in any scenario, with Granite Bridge achieving the greatest emission reductions.

To summarize my results in further detail, I find that over the 5-year IRP planning period, the Granite Bridge Pipeline option produces fewer emissions of NO_x, SO_2, PM, and CO_2-e than the Concord Lateral expansion, and that both the Granite Bridge Pipeline option and the Concord Lateral expansion would reduce NO_x, SO_2, PM, Hg, and CO_2-e relative to the status quo in which the New Hampshire residents and businesses that would meet service needs using natural gas would instead (absent the LCIRP options) need to meet service needs using alternative - and generally higher-emitting - technologies. Figure 2 below illustrates these emission differences across options under the 5-year IRP planning period.

Figure 2: Short-run emissions impacts associated with additional residential customers under IRP planning period.



As Figure 3 and Table 3 show, these conclusions hold true over the long-term as well. In particular, my estimates of emissions over the 21-year planning period associated with the Granite Bridge Pipeline show that the project produces the fewest emissions across all categories of pollutants. In particular, the Granite Bridge Pipeline option produces 5,250,732 pounds of NO_x, or 270,277 fewer pounds of NO_x than the Concord Lateral expansion option, and 8,738,321 fewer pounds of NO_x than the status quo option. Similarly, the Granite Bridge Pipeline option produces 51,335 fewer pounds of SO_2 than the Concord Lateral expansion and 1,526,653 fewer pounds of SO_2 than the status quo, 106,099 fewer pounds of PM than the Concord Lateral expansion and 4,640,199 fewer pounds of PM than the status quo, 51 fewer pounds of Hg than the Concord Lateral

expansion and 1,451 fewer pounds of Hg than the status quo, and 48,854 fewer tons of CO_2-e than the Concord Lateral expansion and 1,481,325 fewer tons of CO_2-e than the status quo.

Figure 3: Long-run emissions impacts associated with additional residential customers under long-term Granite Bridge Pipeline planning period.

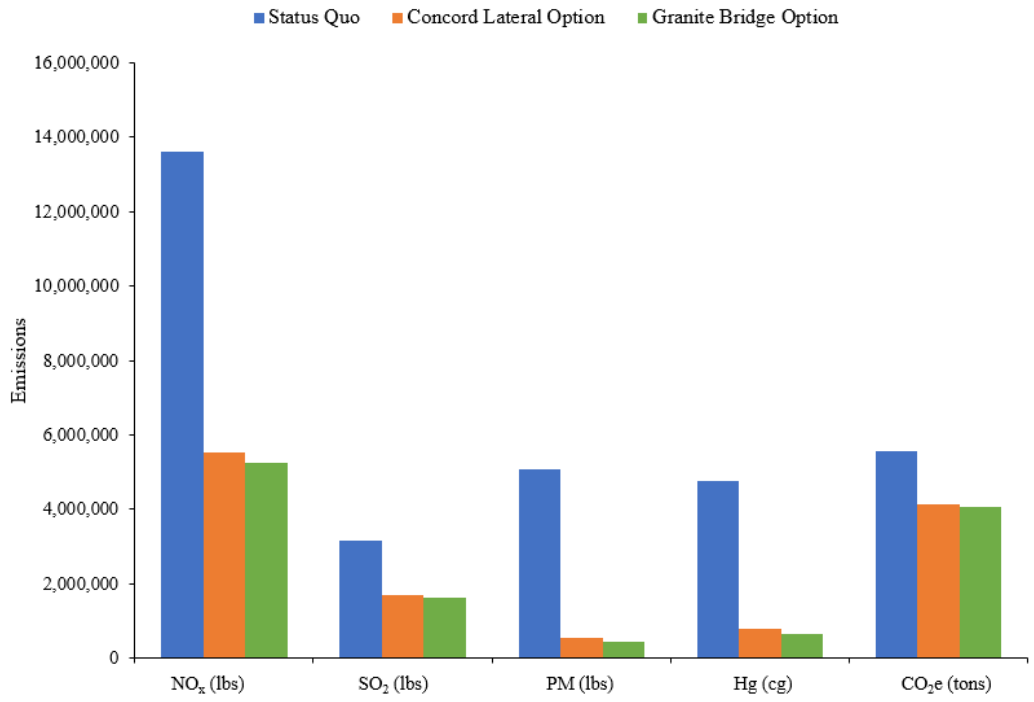


Table 2: Total long-run emissions from customers remaining on existing heating technologies compared to switching to natural gas heating technologies under the Granite Bridge or Concord Lateral Expansion options.

GB-LR	Status Quo	Granite Bridge Option	Concord Lateral Option
NO_x (lbs)	13,629,053	5,250,732	5,521,009
SO_2 (lbs)	3,157,123	1,630,470	1,681,805
PM (lbs)	5,062,057	421,858	527,957
Hg (oz)	1,682	231	282
CO_2e (tons)	5,558,784	4,077,459	4,126,312

I am also able to quantify a subset of the health benefits of the LCIRP options - those associated with emissions of NO_x, SO_2, and PM - across planning periods. Table 4 summarizes my results (discussed in more detail in Exhibit 2). In particular, across planning periods, I find that the Granite Bridge Pipeline yields increased health benefits (relative to the status quo option) over the Concord Lateral expansion by between $57,000 and $230,000, on average each year.

Table 3: Health impacts associated with residential, commercial, and industrial emissions for the short- and long-term planning periods of the Granite Bridge Pipeline option and the Concord Lateral expansion relative to the status quo.

		IRP	GB - LR
		Average Annual Impact	Average Annual Impact
Granite Bridge Relative to Status Quo	$ Total Health Benefits (low estimate)	1,057,086	800,789
	$ Total Health Benefits (high estimate)	2,387,346	1,808,520
Concord Lateral Relative to Status Quo	$ Total Health Benefits (low estimate)	955,083	743,554
	$ Total Health Benefits (high estimate)	2,156,979	1,679,259
Differential	$ Total Health Benefits (low estimate)	102,004	57,236
	$ Total Health Benefits (high estimate)	230,366	129,262

Finally, the Granite Bridge Pipeline will reduce large truck traffic for deliveries of propane and/or LNG, and will further reduce local deliveries of oil and propane to residences and businesses that switch from those fuels to natural gas. I estimate the potential emission reductions from the expected reductions in large truck deliveries for replenishing the Company's satellite storage tanks. Specifically, this could reduce emissions of CO_2 by roughly 50 to 63 thousand pounds, emissions of NO_x by 290 to 360 pounds, and emissions

of PM by seven to nine pounds.[44] See Table 5. The reductions in NO_x, and PM together contribute to health benefits of between $700 and $2,000 per year.[45]

Table 4: Annual reductions in emissions associated with reduced delivery truck traffic (estimates in pounds).

	235 trucks	300 trucks
CO_2e (CO_2 + CH_4)	49,594.5	63,312.1
NO_x	285.7	364.7
$PM_{2.5}$	6.7	8.5

III. CONCLUSIONS

Q. What do you conclude based on your review of public health and environmental impacts?

A. Based on my quantitative analysis summarized in part in this testimony and presented in detail in Exhibit 2, I come to the following observations and conclusions:

- The options presented in the Company's LCIRP are likely to generate meaningful public health and environmental benefits relative to the status quo. These benefits include reductions emissions of criteria pollutants, and reductions in costs associated with the harmful effects of these pollutant emissions on public health. I also find that the options will lead to lower emissions of GHG relative to the status

[44] See Exhibit 2, Table 10.

[45] See Exhibit 2, Table 11.

quo scenario, and thereby contribute to a lowering of risks associated with climate change.

- The Granite Bridge Pipeline would lead to lower overall emissions of harmful pollutants and GHG than an expansion of the Concord Lateral, primarily due to increases in the number of customers who would have access to natural gas and convert to gas from alternative fuels for heating and other service needs.

Q. Does this complete your testimony?

A. Yes.

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Exhibit 1
Curriculum Vitae & Testimony

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EDUCATION

Ph.D. program (coursework), Nuclear Engineering, University of California, Berkeley

M.S. in Energy and Resources, University of California, Berkeley
Thesis: Safety and Environmental Hazards of Nuclear Reactor Designs

B.S. in Physics, University of Massachusetts, Amherst

PROFESSIONAL EXPERIENCE

2010 - Present Analysis Group, Inc., Boston, MA
Principal
Vice President

2007 - 2010 MA Department of Public Utilities, Boston, MA
Chairman
Member, Energy Facilities Siting Board
Manager, New England States Committee on Electricity
Treasurer, Executive Committee, Eastern Interconnect States' Planning Council
Representative, New England Governors' Conference Power Planning Committee
Member, NARUC Electricity Committee, Procurement Work Group

2003 - 2007 Analysis Group, Inc., Boston, MA
Vice President
Manager ('03 – '05)

2000 - 2003 Lexecon Inc., Cambridge, MA
Senior Consultant
Consultant ('00 – '02)

1998 - 2000 Massachusetts Department of Environmental Protection, Boston, MA
Environmental Analyst

1991 - 1998 Massachusetts Department of Public Utilities, Boston, MA
Senior Analyst, Electric Power Division

1988 - 1991 University of California, Berkeley, CA
Research Assistant, Safety/Environmental Factors in Nuclear Designs

TESTIMONY IN THE LAST EIGHT YEARS

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ANALYSIS GROUP
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Exhibit 2
Public Health and Environmental Impacts of Options to Meet Resource Needs
Analysis of Resource Options in Liberty Utilities' LCIRP
June 2019

Liberty Utilities (EnergyNorth Natural Gas) Corp. (Liberty, or the Company) has identified options to meet resource needs identified in its Least Cost Integrated Resource Plan (LCIRP), including potential expansion of the capacity of the Concord Lateral, and development of the Granite Bridge Pipeline (Granite Bridge Project).

In addition to helping continue to meet the needs of existing customers in its service territory, both options would allow some New Hampshire residents and businesses to switch to natural gas (service conversions) for heating, cooking, hot water, and/or process needs (service needs), from other fuels. In providing an alternative service need option, the projects reviewed open the door to achieving reductions in emissions of pollutants, to the extent that they would displace the use of higher-emitting sources for meeting heating and other service needs. Reducing local sources of pollution provides public health and environmental benefits in New Hampshire, potentially reducing premature deaths, respiratory and other health impacts, and the risks associated with climate change. This could also support New Hampshire's compliance with emission and air quality requirements under the Clean Air Act (CAA).

This document assesses the potential public health and environmental impacts of the options reviewed in the Company's LCIRP with respect to these potential shifts in customer fuel use. The focus is on pollutants and impacts for which there is sufficient knowledge and data to estimate changes in emissions, and associated impacts on public health and the environment.

How might projects lead to public health and environmental impacts?

In response to increasing demand for natural gas inside and outside Liberty's service territory, the development of the resource/supply options identified in the Company's LCIRP would increase access to natural gas for thousands of residents and businesses across southern New Hampshire, including residents that currently meet their heating and other service needs through older equipment and higher-emitting resources.

In addition to service conversion impacts, the options could reduce public health environmental impacts compared to the status quo by reducing Liberty's heavy-duty truck traffic that currently delivers liquid fuel to satellite fuel centers across the state, reducing the pollutants associated with delivery operations. Specifically, Liberty currently contracts for hundreds of truck deliveries of propane and liquefied natural gas (LNG) to satellite storage tanks, which are used to support wintertime operations. Liberty expects that these can be greatly reduced once the Granite Bridge Project is online.[1] In addition service conversions to natural gas could eliminate truck deliveries of oil and propane to individual homes and businesses previously needed to serve new Liberty customers prior to their conversion.

[1] The Granite Bridge Project would reduce propane and LNG truck traffic to facilities in Nashua, Manchester, Concord, and Tilton. See New Hampshire Public Utilities Commission, Docket No. DG 17-198, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Pre-Filed Testimony of Susan L. Fleck and Francisco C. Dafonte, December 21, 2017, p. 18, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-198/INITIAL%20FILING%20-%20PETITION/17-198_2017-12-22_ENGI_PDTESTIMONY_FLECK_DAFONTE.PDF.

What are the potential benefits?

- The combustion of fuel to meet home and business heating is a source of local pollutants - including nitrogen oxides (NO_x), sulfur dioxide (SO_2), particulate matter (PM), mercury (Hg), carbon dioxide (CO_2) and methane (CH_4), the latter two of which are associated with climate change.

- These pollutants lead to or exacerbate premature deaths, asthma, and other major health problems for the state's residents, and increase the economic and environmental risks of climate change. For example, the New Hampshire Department of Environmental Services (NH DES) estimates that one premature death due to air pollution results in $9.35 million in costs, one asthma-related emergency room visit costs $440, and one lost work day averages $150.[2] NH DES estimates that fine particulate matter and ozone alone accounted for approximately $3.8 billion in health impacts in New Hampshire from 2013 through 2015.[3]

- Residents and businesses in New Hampshire require fuel for heating and other winter service needs - fuel such as oil, propane, natural gas, biomass/wood, and electricity. Opening access to natural gas will necessarily displace the use of other energy sources for heating needs that are less clean and less efficient. Specifically, other than natural gas, the dominant sources of fuel for heating and other service needs in New Hampshire are oil and propane. The corresponding reduction in emissions from service conversions is driven both by the lower emission rates of natural gas relative to other sources, and by the installation at the point of service conversions of more efficient equipment for meeting service needs.

- Both the Concord Lateral and Granite Bridge options would open access to natural gas to meet service needs. For example, Liberty estimates that during the first year after Granite Bridge comes into service, it would add approximately 1,800 residential customers and over 500 commercial and industrial (C&I) customers. In each subsequent year, Liberty expects to add additional customers; for example, by 2037/2038, they estimate additions of over 1,000 residential customers and over 200 C&I customers. These customers will be choosing natural gas for heating over oil, propane, or some other heating source and would not have access to natural gas without the Granite Bridge Project.[4] Thus, over time, as these customers select natural gas for heating, the state will avoid additional emissions of NO_x, SO_2, PM, Hg, CO_2, and CH_4, and realize corresponding health benefits compared to emissions produced from more polluting sources such as oil or propane.

- Health benefits derive from fewer emission of pollutants associated with negative health impacts:

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[2] "Considerable variability in valuation exists. Valuations presented here are interpolated median 2011 valuations." New Hampshire Department of Environmental Services, State of New Hampshire Air Quality – 2017: Air Pollution Trends, Effects and Regulation, March 2018, available at https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-01.pdf, Table 4.2, p. 64-65.

[3] Figure reported in 2010 dollars. Economic impacts of air pollution consider ozone and particulate matter pollution together. New Hampshire Department of Environmental Services, State of New Hampshire Air Quality – 2017: Air Pollution Trends, Effects and Regulation, March 2018, available at https://www.des.nh.gov/organization/commissioner/pip/publications/documents/r-ard-17-01.pdf, Table 4.3, p. 66.

[4] Expected customer growth stems from new service and service conversions within the Company's existing service territory and - in the case of the Granite Bridge option - new access to natural gas along the route of the Project in towns that currently do not have access to natural gas. Liberty Utilities has noted that without Granite Bridge, it may need to stop providing natural gas services to new customers. See New Hampshire Public Utilities Commission, Docket No. DG 17-198, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Pre-Filed Testimony of Susan L. Fleck and Francisco C. Dafonte, December 21, 2017, p. 23, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-198/INITIAL%20FILING%20-%20PETITION/17-198_2017-12-22_ENGI_PDTESTIMONY_FLECK_DAFONTE.PDF.

- Nitrogen oxides are implicated in a wide variety of health and environmental impacts. Health impacts include respiratory infection and disease, such as asthma. Environmental effects include acid rain, haze, and nutrient pollution in coastal waters.[5]

- Sulfur dioxide is implicated in a wide variety of health and environmental impacts. Like NO_x, health impacts include respiratory infection and disease, such as asthma. Environmental effects include acid rain and haze.[6]

- Particulate matter is implicated in a wide variety of health and environmental impacts. Health impacts include negative effects on the heart and lungs, such as respiratory disease and non-fatal heart attacks. Environmental effects include acid rain, depletion of nutrients in soil and water, and negative effects on the diversity of ecosystems.[7]

- Mercury is implicated in a wide variety of health and environmental impacts. Some of the health impacts include headaches, changes in nerve response, and poor performance on test of mental function. Prolonged high exposure can cause kidney effects, respiratory failure, and death. Environmental effects are concentrated in animals that eat fish. Due to mercury exposure, these animals are subject to reduced reproduction, slower growth and development, and abnormal behavior, and even death.[8]

- Emissions of greenhouse gases contribute to the social, economic and environmental risks associated with climate change.

What options for meeting expected demand were considered in assessing the health and environmental impacts?

The Concord Lateral and the Granite Bridge Project were reviewed by Liberty as resource options to reliably meet future customer demand identified in its LCIRP. In order to understand how these options may affect public health and the environment in New Hampshire, we review the potential of each option relative to circumstances absent either project (the status quo). Thus, we analyze the following three scenarios related to natural gas supply and demand in and around Liberty's service territory going forward:

1. **Status Quo:** If Liberty does not move forward with any resource options reviewed in its LCIRP, any potential new customers - whether new to the service territory or those that otherwise would be willing to switch to natural gas for service needs - will be unable to meet their space heating needs through natural gas and must use heating technologies reliant upon other fuel sources such as oil, propane, biomass, and electricity. Under the Status Quo option, we assume that additional customers to Liberty's service territory use oil, propane, biomass, and electric heating technologies in the same proportion as current customers in the counties encompassing Liberty's existing service territory, and that no existing customers will switch to natural gas. Likewise for customers along the proposed Granite Bridge pipeline route, we assume they will use (or continue to use) oil, propane, biomass, and electric heating technologies in the same proportion as current

[5] "Nitrogen Dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NO_x) […] NO_2 is used as the indicator for the larger group of nitrogen oxides." EPA, Basic Information about NO_2, accessed September 5, 2018, available at https://www.epa.gov/no2-pollution/basic-information-about-no2#Effects.
[6] EPA, Sulfur Dioxide Basics, accessed September 5, 2018, available at https://www.epa.gov/so2-pollution/sulfur-dioxide-basics.
[7] EPA, Health and Environmental Effects of Particulate Matter (PM), accessed September 5, 2018, available at https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm.
[8] EPA, Basic Information about Mercury, accessed September 5, 2018, available at https://www.epa.gov/mercury/basic-information-about-mercury; Health impacts listed are from inhaling elemental mercury, EPA, Health Effect of Exposures to Mercury, accessed September 5, 2018, available at https://www.epa.gov/mercury/health-effects-exposures-mercury.

residents in the county encompassing the proposed pipeline route. The Status Quo option formed the basis of comparison for the two other options we considered.

2. **Granite Bridge:** The Granite Bridge Project will enable additional customers to meet their service needs through natural gas technology. For estimating customer additions and service conversions, we relied on Liberty's growth projections included in their LCIRP. This includes growth in natural gas use for customers in Liberty's existing service territory, including both new build as well as service conversions for customers in the service territory but currently meeting service needs through alternative fuels. We also use Liberty's projections of new customers in the communities of Raymond, Epping, and Candia (i.e. those along the Granite Bridge Project's proposed route).

3. **Concord Lateral Expansion:** Like the Granite Bridge project option, expanded capacity on the Concord Lateral will enable additional customers to meet their service needs through natural gas technology. For this we relied on the same growth projections as in the analysis of the Granite Bridge project. However, in this option, the potential new customers in Raymond, Epping, and Candia will not have access to natural gas and will therefore remain on their current heating technologies.

We made these comparisons under two forecasts of additional customers covering different time periods:[9]

1. **IRP:** The IRP scenario is based on forecasts of additional customers identified by Liberty for its LCIRP. The LCIRP forecast begins in the 2017/2018 gas year and ends five years later in the 2021/2022 gas year.

2. **GB-LR:** The GB-LR scenario reflects long-run impacts due to the Granite Bridge project. A forecast of additional customers generated by Liberty that assumes Granite Bridge comes online in 2022/2023 forms the basis for the GB-LR scenario, which is one year later than in the LCIRP forecast (a timing difference that does not materially affect the analysis). The time period for the GB-LR scenario extends to the 2037/2038 gas year.

Finally, for the purposes of this analysis we focus initially only on the heating portion of service needs. That is, we recognize that there are additional benefits of service conversions associated with switching to natural gas not only for heating, but also for other services, such as hot water, cooking, and potentially other commercial/industrial processes. However, since it is difficult to obtain data on or forecast what portion of service conversion customers would use natural gas for these other service needs, we assume in effect that natural gas is only used for heating in our calculations. In this sense, we may significantly understate the potential benefits of natural gas service conversions in New Hampshire.

What heating technologies were considered?

We considered the following heating technologies that reflect options used by residents in the counties encompassing Liberty's existing service territory, as well as (where relevant) those counties encompassing the proposed route of the Granite Bridge pipeline.[10] The forecasted additional customers reflect existing residents and businesses that switch to natural gas, as well as new development. We assume that without access to natural gas, (1) service conversion customers would remain on their existing lower efficiency heating technologies, and (2) new development customers would select a higher efficiency non-gas option, such as a high efficiency oil boiler or a high efficiency electric heat pump.

[9] Our analysis also relies on a forecast of gas consumed per customer. This forecast does not change across the two forecasts of additional customers.
[10] Belknap, Hillsborough, Merrimack, and Rockingham counties. These counties cover the path of the Granite Bridge project and Liberty's current natural gas service territory.

Thus we present results for both standard and high-efficiency options, and assume similar efficiencies for all classes of customers.[11]

1. *Natural gas-fired space heating*: high-efficiency option only
2. *Oil-fired space heating*: standard-efficiency and high-efficiency options
3. *Propane-fired space heating*: standard-efficiency and high-efficiency options
4. *Biomass-fired space heating*: standard-efficiency (as modeled by the median efficiency of a range of wood stoves and boilers used for home heating) and high-efficiency (as modeled by the 90th percentile efficiency of a range of wood stoves and boilers used for home heating) options.[12]
5. *Electric heating*: standard-efficiency (as modeled by electric baseboard heating) and high-efficiency (as modeled by a high-efficiency heat pump) options. We assume, however, that customers using a heat pump will require a back-up source of heating, which we consider to be electric baseboard heating. While the precise share of heating load served by a back-up heating source varies, it is well documented that heat pumps do not typically supply the entirety of the required heating load.[13] In our calculations, we assume that in New Hampshire a supplemental heating source is used for twenty five percent of total winter heating load.
6. *Other*: this category includes customers who have either no heating system, or some other technology such as solar, which generates no emissions.

By how much will emissions decrease under the IRP scenario?

Table 1 – Aggregate, cumulative emission estimates for the IRP scenario
Total emissions from using heating technologies under the Status Quo, Granite Bridge, and Concord Lateral Expansion options.

IRP	Status Quo	Granite Bridge Option	Concord Lateral Option
NO_x (lbs)	995,514	383,102	385,690
SO_2 (lbs)	230,746	118,962	119,453
PM (lbs)	367,469	30,779	31,795
Hg (oz)	123.9	16.8	17.3
CO_2e (tons)	406,401	297,498	297,966

Table 1 presents estimates of aggregate emissions of residential and C&I customers for the IRP scenario under the Status Quo, Granite Bridge, and Concord Lateral Expansion options. As Table 1 illustrates, the Granite Bridge option results in the lowest quantity of emissions for all pollutants.

[11] We compared our selected residential heating technology efficiencies with estimates of C&I heating technology efficiencies derived from the SEEAT model (discussed in more detail below) and found the efficiencies to be similar.
[12] Our median efficiency wood stove is a hydronic, non-catalytic stove fueled by cord wood. Our high efficiency wood stove is a hydronic, non-catalytic stove fueled by wood pellets.
[13] See, for example, a 2016 CADMUS study evaluating heat pumps in Massachusetts and Rhode Island, in which the study concludes, among other things, that "In most cases, [dual mini-split heat pumps] served as secondary systems, either to provide heat for a single space or to provide supplemental heat in addition to a primary system" (CADMUS, "Ductless Mini-Split Heat Pump Impact Evaluation," December 30, 2016 at 21).

Table 2a – Per-residential customer average annual emissions
Average annual emissions from using heating technologies driven by natural gas, oil, propane, biomass, and electricity.

	Natural Gas	Oil		Propane		Biomass		Electric	
Efficiency	*High*	*Standard*	*High*	*Standard*	*High*	*Standard*	*High*	*Baseboard*	*Heat Pump*
NO_x (pounds)	6.71	20.55	17.93	18.03	15.73	31.75	27.27	9.38	4.84
SO_2 (pounds)	2.08	4.61	4.02	4.87	4.25	2.05	1.76	5.68	2.94
PM (pounds)	0.54	1.23	1.07	0.54	0.66	76.31	65.54	--	--
Hg (ounces)	0.0003	0.0041	0.0036	--	--	--	--	--	--
CO_2e (tons)	5.21	8.49	7.41	7.09	6.19	9.18	7.88	6.65	3.43

Table 2a presents annual average emissions per residential customer for different fuel types and efficiencies (under the IRP scenario).[14]

Table 2b – Per-commercial customer average annual emissions
Average annual emissions from using heating technologies driven by natural gas, oil, propane, biomass, and electricity.

	Natural Gas	Oil		Propane		Biomass		Electric	
Efficiency	*High*	*Standard*	*High*	*Standard*	*High*	*Standard*	*High*	*Baseboard*	*Heat Pump*
NO_x (pounds)	32.60	99.88	87.10	87.63	76.42	154.29	132.51	45.56	23.54
SO_2 (pounds)	10.12	22.40	19.54	23.66	20.63	9.95	8.55	27.61	14.26
PM (pounds)	2.62	5.99	5.22	2.62	3.21	370.80	318.45	--	--
Hg (ounces)	0.0014	0.0201	0.0175	--	--	--	--	--	--
CO_2e (tons)	25.32	41.27	35.99	34.47	30.06	44.60	38.30	32.30	16.69

Table 2a presents annual average emissions per commercial customer for different fuel types and efficiencies (under the IRP scenario).

Figures 1a and Figure 1b illustrate the cumulative lifetime emissions associated with forecasted additional residential and C&I customers (including additional customers within Liberty's existing service territory as well as the additional customers Liberty anticipates serving under the Granite Bridge Project option) for the IRP scenario.

[14] The annual average is a simple average over the 5-year period associated with the IRP scenario. Because average consumption per customer changes each year, actual annual values differ slightly over time compared to what is shown in the table.

Figure 1a – Cumulative lifetime emissions for the IRP scenario
Additional residential customers[15]

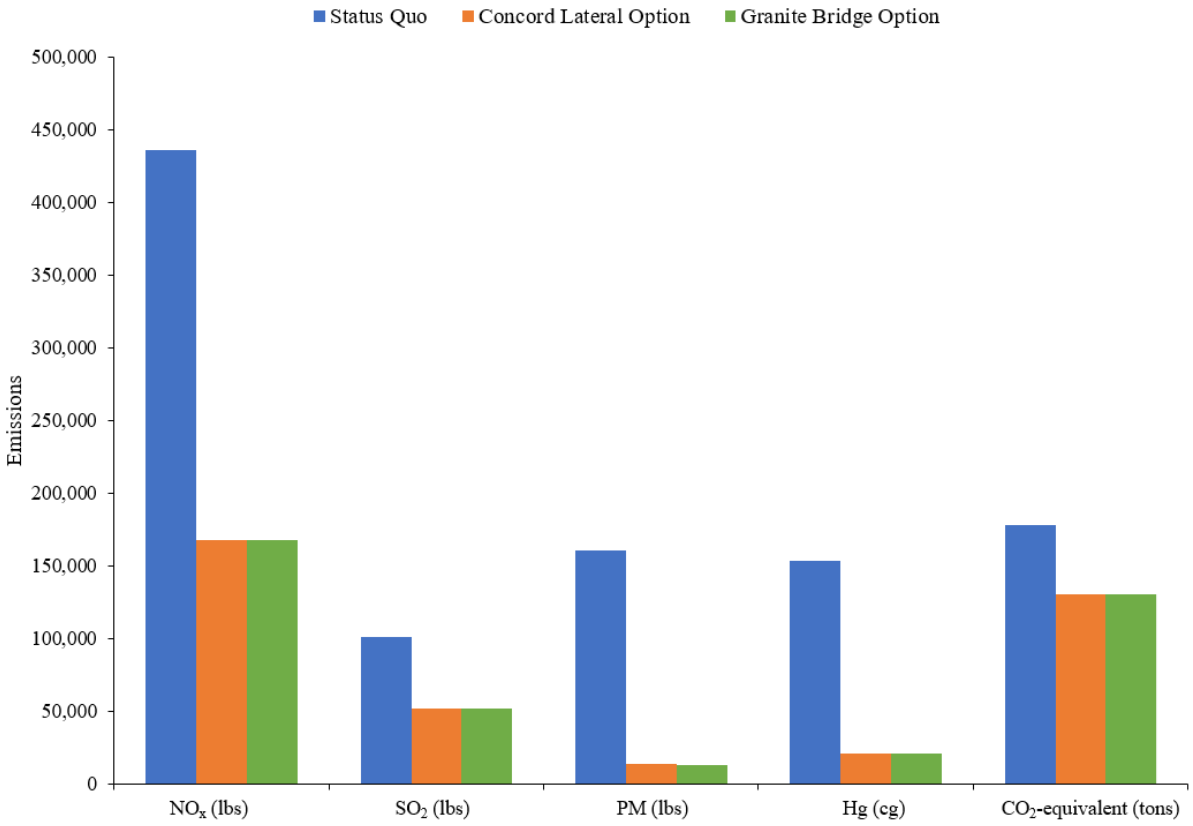

Table 3 – Data underlying Figure 1a

		NO_x (lbs)	SO_2 (lbs)	PM (lbs)	Hg (cg)	CO_2-equivalent (tons)
Status Quo	New Customers In Existing Territory	435,360	100,901	160,883	153,598	177,722
	New Customers in Epping, Raymond, Candia	218	52	59	82	90
	Total	**435,578**	**100,953**	**160,942**	**153,680**	**177,812**
Concord Lateral Option	New Customers In Existing Territory	167,534	52,023	13,460	20,887	130,099
	New Customers in Epping, Raymond, Candia	218	52	59	82	90
	Total	**167,753**	**52,075**	**13,519**	**20,969**	**130,189**
Granite Bridge Option	New Customers In Existing Territory	167,534	52,023	13,460	20,887	130,099
	New Customers in Epping, Raymond, Candia	84	26	7	11	66
	Total	**167,619**	**52,049**	**13,467**	**20,898**	**130,165**

[15] Please note that for display purposes, different units are used for each pollutant shown. Specifically, NO_x, SO_2, and PM are in pounds, Mercury is in centigrams, and CO_2 is in tons.

Figure 1b – Cumulative lifetime emissions for the IRP scenario
Additional C&I customers

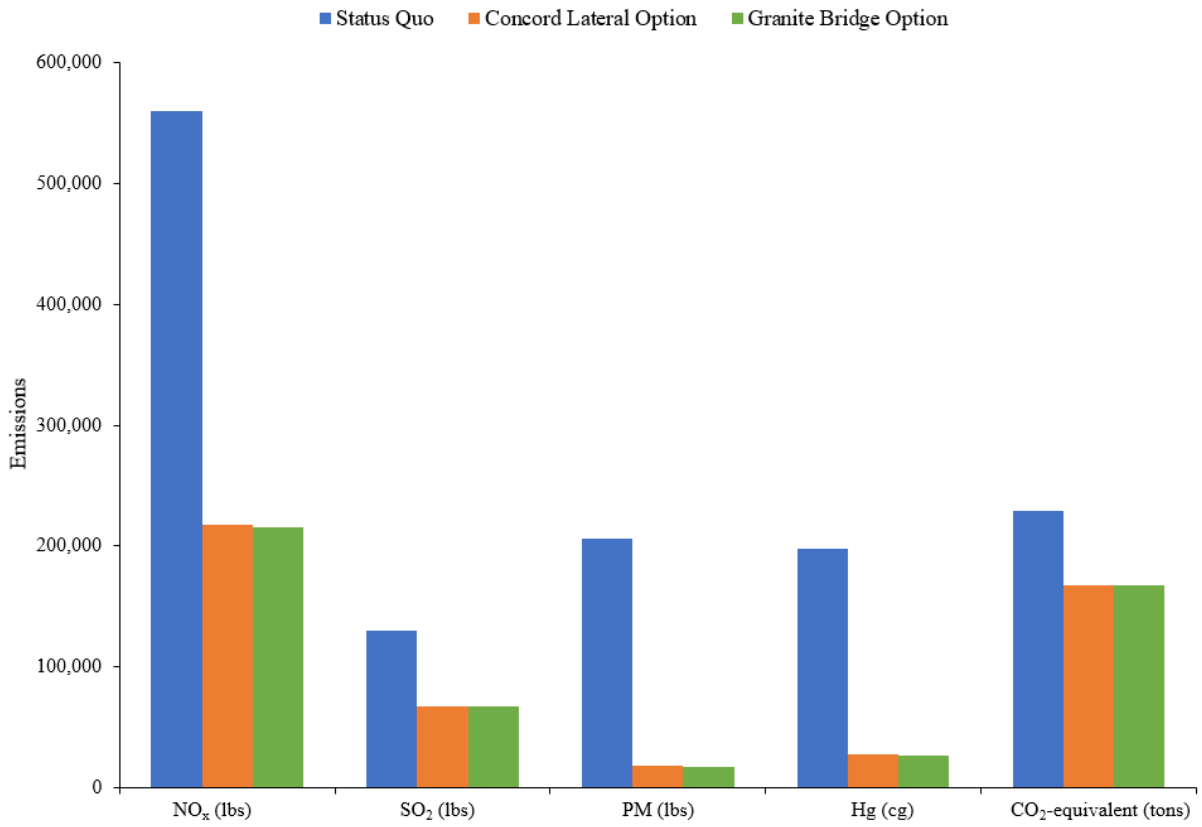

Table 4 – Data underlying Figure 1b

		NO_x (lbs)	SO_2 (lbs)	PM (lbs)	Hg (cg)	CO_2-equivalent (tons)
Status Quo	New Customers In Existing Territory	555,931	128,845	205,439	196,136	226,941
	New Customers in Epping, Raymond, Candia	4,005	948	1,088	1,500	1,648
	Total	**559,936**	**129,793**	**206,527**	**197,636**	**228,589**
Concord Lateral Option	New Customers In Existing Territory	213,933	66,431	17,188	26,672	166,129
	New Customers in Epping, Raymond, Candia	4,005	948	1,088	1,500	1,648
	Total	**217,938**	**67,379**	**18,276**	**28,171**	**167,777**
Granite Bridge Option	New Customers In Existing Territory	213,933	66,431	17,188	26,672	166,129
	New Customers in Epping, Raymond, Candia	1,551	482	125	193	1,204
	Total	**215,483**	**66,912**	**17,312**	**26,865**	**167,334**

As the figures and underlying tables illustrate, the Granite Bridge project option produces the least amount of cumulative emissions over time compared to either the Status Quo option or the Concord Lateral Expansion option.

By how much will emissions decrease under the GB-LR scenario?

Table 5 – Aggregate, cumulative emission estimates for the GB-LR scenario
Total emissions from using heating technologies under the Status Quo, Granite Bridge, and Concord Lateral Expansion options.

GB-LR	Status Quo	Granite Bridge Option	Concord Lateral Option
NO_x (lbs)	13,629,053	5,250,732	5,521,009
SO_2 (lbs)	3,157,123	1,630,470	1,681,805
PM (lbs)	5,062,057	421,858	527,957
Hg (oz)	1,682	231	282
CO_2e (tons)	5,558,784	4,077,459	4,126,312

Table 5 presents estimates of aggregate emissions of residential and C&I customers for the GB-LR scenario under the Status Quo, Granite Bridge, and Concord Lateral Expansion options. As in the IRP scenario, the Granite Bridge option produces the fewest cumulative emissions across all three options considered for each pollutant assessed.

Table 6a – Per-residential customer average annual emissions
Average annual emissions from using heating technologies driven by natural gas, oil, propane, biomass, and electricity.

	Natural Gas	Oil		Propane		Biomass		Electric	
Efficiency	*High*	*Standard*	*High*	*Standard*	*High*	*Standard*	*High*	*Baseboard*	*Heat Pump*
NO_x (pounds)	6.56	20.10	17.53	17.64	15.38	31.06	26.67	9.17	4.74
SO_2 (pounds)	2.04	4.51	3.93	4.76	4.15	2.00	1.72	5.56	2.87
PM (pounds)	0.53	1.21	1.05	0.53	0.65	74.64	64.10	--	--
Hg (ounces)	0.0003	0.0040	0.0035	--	--	--	--	--	--
CO_2e (tons)	5.10	8.31	7.24	6.94	6.05	8.98	7.71	6.50	3.36

Table 6a presents annual average emissions per residential customer for different fuel types and efficiencies (under the GB-LR scenario).[16]

Table 6b – Per-commercial customer average annual emissions
Average annual emissions from using heating technologies driven by natural gas, oil, propane, biomass, and electricity.

	Natural Gas	Oil		Propane		Biomass		Electric	
Efficiency	*High*	*Standard*	*High*	*Standard*	*High*	*Standard*	*High*	*Baseboard*	*Heat Pump*
NO_x (pounds)	31.25	95.72	83.48	83.98	73.24	147.87	126.99	43.67	22.56
SO_2 (pounds)	9.70	21.47	18.73	22.68	19.77	9.54	8.19	26.46	13.67
PM (pounds)	2.51	5.74	5.00	2.51	3.07	355.37	305.20	--	--
Hg (ounces)	0.0014	0.0193	0.0168	--	--	--	--	--	--
CO_2e (tons)	24.26	39.55	34.49	33.03	28.81	42.74	36.71	30.96	15.99

Table 6b presents annual average emissions per commercial customer for different fuel types and efficiencies (under the GB-LR scenario).

Figures 2a and Figure 2b illustrate the cumulative lifetime emissions associated with forecasted additional residential and C&I customers (including additional customers within Liberty's existing service territory

[16] The annual average is a simple average over the 20-year period associated with the GB-LR scenario. As average consumption per customer changes each year, actual annual values differ slightly over time.

as well as the additional customers Liberty anticipates serving under the Granite Bridge Project option) for the GB-LR scenario.

Figure 2a – Cumulative lifetime emissions for the GB-LR scenario
Additional residential customers

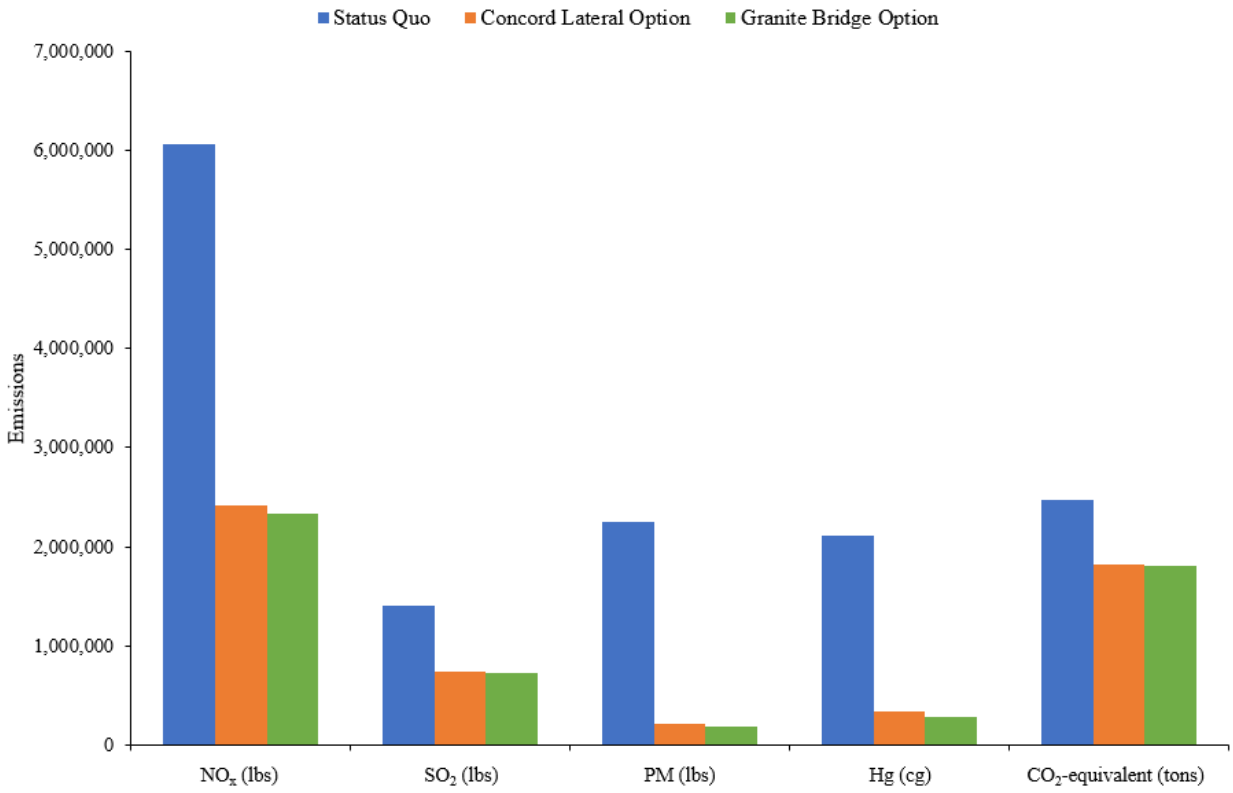

Table 7 – Data underlying Figure 2a

		NO_x (lbs)	SO_2 (lbs)	PM (lbs)	Hg (cg)	CO_2-equivalent (tons)
Status Quo	New Customers In Existing Territory	5,927,124	1,372,010	2,221,205	2,069,077	2,416,742
	New Customers in Epping, Raymond, Candia	128,168	30,328	34,819	47,988	52,735
	Total	**6,055,291**	**1,402,338**	**2,256,024**	**2,117,065**	**2,469,477**
Concord Lateral Option	New Customers In Existing Territory	2,283,100	708,954	183,430	284,640	1,772,942
	New Customers in Epping, Raymond, Candia	128,168	30,328	34,819	47,988	52,735
	Total	**2,411,267**	**739,282**	**218,249**	**332,628**	**1,825,677**
Granite Bridge Option	New Customers In Existing Territory	2,283,100	708,954	183,430	284,640	1,772,942
	New Customers in Epping, Raymond, Candia	49,627	15,410	3,987	6,187	38,538
	Total	**2,332,727**	**724,364**	**187,417**	**290,827**	**1,811,480**

Figure 2b – Cumulative lifetime emissions for the GB-LR scenario
Additional C&I customers

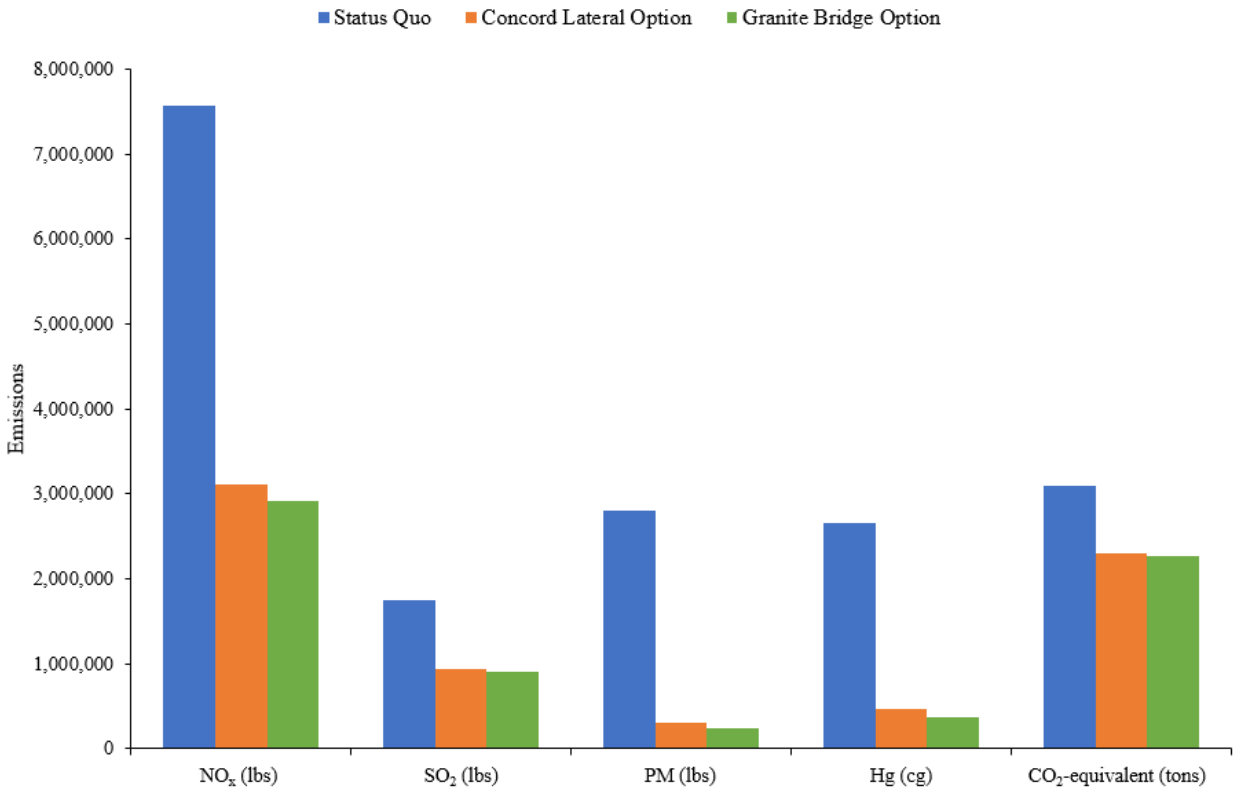

Table 8 – Data underlying Figure 2b

		NO_x (lbs)	SO_2 (lbs)	PM (lbs)	Hg (cg)	CO_2-equivalent (tons)
Status Quo	New Customers In Existing Territory	7,260,873	1,680,747	2,721,031	2,534,671	2,960,569
	New Customers in Epping, Raymond, Candia	312,889	74,038	85,001	117,150	128,738
	Total	**7,573,762**	**1,754,785**	**2,806,033**	**2,651,821**	**3,089,307**
Concord Lateral Option	New Customers In Existing Territory	2,796,853	868,486	224,706	348,691	2,171,898
	New Customers in Epping, Raymond, Candia	312,889	74,038	85,001	117,150	128,738
	Total	**3,109,742**	**942,524**	**309,708**	**465,842**	**2,300,636**
Granite Bridge Option	New Customers In Existing Territory	2,796,853	868,486	224,706	348,691	2,171,898
	New Customers in Epping, Raymond, Candia	121,152	37,620	9,734	15,104	94,081
	Total	**2,918,006**	**906,106**	**234,440**	**363,796**	**2,265,979**

As the above figures and tables illustrate, under the GB-LR scenario, the Granite Bridge project option produces the fewest emissions across all those pollutants considered compared to either the Status Quo or the Concord Lateral Expansion options.

What are the potential health benefits?

AG modeled the potential health benefits associated with the Granite Bridge option and Concord Lateral Expansion option relative to the Status Quo option under each demand forecast scenario using the EPA

Co-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool.[17,18] COBRA estimates annual health impacts based on user-specified emissions changes from a projected baseline emission levels of either 2017 or 2025. We select 2025 as our baseline emissions level and discount monetary benefits at a 3 percent discount rate back to 2017 dollars.

Table 9 – Total Residential and Commercial & Industrial Health Impacts

		IRP	GB - LR
		Average Annual Impact	Average Annual Impact
Granite Bridge Relative to Status Quo	$ Total Health Benefits (low estimate)	1,057,086	800,789
	$ Total Health Benefits (high estimate)	2,387,346	1,808,520
Concord Lateral Relative to Status Quo	$ Total Health Benefits (low estimate)	955,083	743,554
	$ Total Health Benefits (high estimate)	2,156,979	1,679,259
Differential	$ Total Health Benefits (low estimate)	102,004	57,236
	$ Total Health Benefits (high estimate)	230,366	129,262

Referring to Table 9 depicting total customer health impacts,[19] the Granite Bridge option has a $102,000 to $230,000 annual average health benefit over the Concord Lateral Expansion option in the IRP scenario. Additionally in the GB-LR scenario, the Granite Bridge option has a $57,000 to $129,000 annual average health benefit over the Concord Lateral Expansion option.[20]

[17] The COBRA model is available for download here: https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool. COBRA is a tool used to approximate air quality impacts and associated costs. See EPA, User's Manual for the Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) Version: 3.2, available at https://www.epa.gov/statelocalenergy/users-manual-co-benefits-risk-assessment-cobra-screening-model, p. 15.

[18] In order to capture the impacts of customers using natural gas for heating relative to a more polluting source, we adjust emissions in the oil, wood, other (propane), electric power sector, and natural gas combustion emission tiers of COBRA. For example, in the residential Granite Bridge Relative to Status Quo Scenario, status quo heating system emissions for the annual average number of projected new customers are subtracted from the appropriate emissions source tiers in COBRA. The profile of different heating systems used in the status quo is based on the US Census Bureau 2013-2017 American Community Survey, see tables A5a and A5b in the Technical Appendix for additional detail. Conversely, efficient natural gas heating system emissions for the same annual average number of projected new customers are added to the residential natural gas combustion emission tier in COBRA. The COBRA model measures fuel combustion emissions for the commercial and industrial sectors separately. These results allocate 80% of Commercial & Industrial emission changes to the Commercial/Institutional emission tiers in COBRA, and 20% to the Industrial emission tiers in COBRA based on the division of electricity sales by sector in the 2017 EIA 861 data for New Hampshire. The same methodology for the adjustment of emissions tiers described above for residential health benefits is also used for the commercial and industrial health benefits. The calculations assume all PM emissions are $PM_{2.5}$.

[19] The annual average number of projected new customers assumed in each case are as follows:
IRP: In the Granite Bridge relative to Status Quo scenario, we assume an annual average of 1,710 new residential and 484 new commercial & industrial (C&I) customers in Liberty's existing service territory and new Epping, Raymond, and Candia territory combined will switch from status quo heating systems to efficient natural gas heating systems over the 5 year period 2017-2022. In the Concord Lateral relative to Status Quo scenario, new customers in Epping, Raymond, and Candia remain on status quo heating systems.
GB-LR: In the Granite Bridge Relative to Status Quo scenario, we assume an annual average of 1,418 new residential and 357 new C&I customers in Liberty's existing service territory and new Epping, Raymond, and Candia territory combined will switch from status quo heating systems to efficient natural gas heating systems over the 21 year period 2017-2038. In the Concord Lateral relative to Status Quo scenario, new customers in Epping, Raymond, and Candia remain on status quo heating systems.

[20] If a 7% discount rate is used, the health benefits vary as follows: The Granite Bridge option has $91,000 to $205,000 average annual benefit over the Concord Lateral option in the IRP scenario, and $51,000 to $115,000 in the GB-LR scenario.

Emissions benefits from reduced truck traffic

Delivery trucks currently supply the network of on-system propane and LNG tanks used by Liberty as supplemental resources to meet winter demand. Liberty notes that the Granite Bridge project option will enable Liberty to eliminate the need for operation of the satellite propane facilities, and substantially reduce the need for the LNG facilities, and thus nearly eliminate this truck traffic.[21] The consequent reduced truck traffic will lead to further reductions in emissions not already captured. It should be further noted that there would be local reductions in delivery truck traffic for residential and business customers using natural gas heating technology that otherwise would have used oil or propane.

We estimate the potential emission reductions and associated public health benefits from reduced deliveries of propane and/or LNG to Liberty's satellite storage tanks. Liberty estimates that it currently requires approximately 235 deliveries each winter to supply its network of propane storage tanks, a number that could increase if tanks were used to support growth in demand.[22] We therefore assess the reduction of emissions associated with eliminating 235 deliveries; we also estimate what the impacts would be for 300 deliveries to approximate what the benefits would be if avoiding increased deliveries to meet future growth. Table 10 shows our estimates of annual emission reductions from reduced delivery truck traffic. Table 11 shows the annual health impacts of these emission reductions.

Table 10 – Annual reductions in emissions associated with reduced delivery truck traffic (estimates in pounds)

	235 trucks	300 trucks
CO_2e (CO_2 + CH_4)	49,594.5	63,312.1
NO_x	285.7	364.7
$PM_{2.5}$	6.7	8.5

Note: We assume each delivery amounts to one diesel truck achieving 6.4 mpg covering a distance of 60 miles. Sources of emission derived from EPA.

[21] The Granite Bridge Project would reduce propane and LNG truck traffic to facilities in Nashua, Manchester, Concord, and Tilton. See New Hampshire Public Utilities Commission, Docket No. DG 17-198, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Pre-Filed Testimony of Susan L. Fleck and Francisco C. Dafonte, December 21, 2017, p. 18, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-198/INITIAL%20FILING%20-%20PETITION/17-198_2017-12-22_ENGI_PDTESTIMONY_FLECK_DAFONTE.PDF.

[22] Liberty received 704 deliveries of propane and LNG over the past three calendar years, and this number is projected to increase over the next few years. Assuming the same number of deliveries each year, we approximate Liberty requiring 235 deliveries each winter. See New Hampshire Public Utilities Commission, Docket No. DG 17-152, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Direct Testimony of William Killeen, April 30, 2019, pp. 4-5, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-152/TESTIMONY/17-152_2019-04-30_ENGI_DTESTIMONY_KILLEEN_SUPPLEMENTAL_FILING_RESPONSE_ORDER_26225.PDF.

Table 11 – Annual health impacts of reductions in emissions associated with reduced delivery truck traffic[23]

		Average Annual Impact
235 Trucks Off the Road	$ Total Health Benefits (low estimate)	717
	$ Total Health Benefits (high estimate)	1,619
300 Trucks Off the Road	$ Total Health Benefits (low estimate)	915
	$ Total Health Benefits (high estimate)	2,067

[23] Health impact estimates use the COBRA model, as described above. COBRA estimates annual health impacts based on user-specified emissions changes from a projected baseline emission levels of either 2017 or 2025. We select 2025 as our baseline emissions level, and subtract the emissions projected from 235 or 300 trucks off the road from the highway heavy duty diesel truck emissions tier in COBRA. Monetary benefits are discounted at a 3 percent discount rate back to 2017 dollars.

Technical Appendix

Analytic Method

We estimate annual emissions from using natural gas, oil, propane, biomass, or electricity for space heating over both a 5-year and 21-year period based on estimates of additional residential and commercial and industrial (C&I) customers in Liberty's New Hampshire service territory as well as potential new customers in Epping, Raymond, and Candia that fall outside Liberty's current service area and that would be able to be served by the Granite Bridge project. Potential emission and health impacts stem from the lower level of emissions from using natural gas compared to the alternative sources of home heating considered in our analysis.

Our method for estimating annual emissions for each fuel involves two primary estimates. First, we estimate annual energy demand required for heating based on customer average consumption estimates from Liberty. Second, we estimate annual emissions of various pollutants associated with our estimated demand using emissions factors. After estimating annual emissions, we calculate total emissions as the sum across all years. We describe each step outlined above more fully below.

Annual Energy Demand: For each year and each technology option (described in the next section), we estimate energy demand in MMBtu using Eq. (1) below:[24]

$$\text{(Energy Demand)} = \text{(Annual Load)} / \text{(Heating Technology Efficiency)} \quad (1)$$

where 'Annual Load' refers to the projected annual energy required (in MMBtu) to heat either a residential or commercial and industrial space in Liberty's New Hampshire service territory. AG received per customer demand projections for 2017/2018 through 2037/2038 from Liberty Utilities. To translate these demand projections at point of end-use to Annual Load estimates, we assume the annual demand projections reflect the demand of customers using a mix of high-efficiency natural gas heating (see Table A1 below) and lower efficiency natural gas heating, which we take to be 0.793.[25] In particular, we assume a 50-50 split between high- and low-efficiency gas technology. This assumption reflects the fact that the per-customer demand projections received from Liberty incorporate both existing customers who will likely be using lower-efficiency natural gas heating technologies and entirely new natural gas customers that will likely use high-efficiency natural gas heating technologies. Based on our assumed technology efficiencies for the natural gas heating option, we then back out an estimate for 'Annual Load.'[26]

Air Pollutant Emissions: To estimate emissions, we apply emission factors for each considered pollutant to each technology. Discussed more fully below, we source emissions factors from the Gas Technology Institute's Source Energy and Emissions Analysis Tool (SEEAT),[27] EPA, and ISO-NE. With the exception of particulate matter (PM) and mercury (Hg), our emission factors consider both emissions due

[24] The formula for a heat pump varies slightly from the formula presented in Eq. (1), since the "efficiency" of heat pumps typically is presented in units of Btu produced per watt-hr consumed. For heat pumps, we use the following formula:

$$\text{(Energy Demand)} = \text{(Annual Load)} / \text{(HSPF)} \times 1000 \times (0.00341 \text{ MMBtu/kW-hr})$$

where Annual Load has units of MMBtu, HSPF has units of Btu per watt-hour, the factor of 1000 converts watt-hours per Btu to kW-hrs per MMBtu, and the final conversion factor translates Energy Demand from kW-hrs to MMBtu.

[25] Mass Save, "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures; 2016-2018 Program Years – Plan Revision," October 2015, 436 pages).

[26] For example, consider a hypothetical demand projection in 2018 of 100 MMBtu. If the heating technology option equals 75 percent, then the annual heating load must be 100 × 0.75 = 75 MMBtu (See Eq. (1)).

[27] http://seeatcalc.gastechnology.org/.

to fuel combustion as well as emissions from upstream processing (such as extracting, processing, and transportation).

To estimate emissions for wood, we source emission factors from EPA. All emissions calculations are derived from downstream combustion and we assume no emissions from the upstream processing of wood.[28]

We estimate emissions in pounds using Eq. (2) below:

$$(\text{Emissions}) = (\text{Energy Demanded}) \times (\text{Emission Factor}) \quad (2)$$

where 'Energy Demanded' is described above in Eq. (1) and 'Emission Factor' describes the pounds of emissions per MMBtu of energy demanded at the point of end-use.

We assume that emission factors remain fixed in each year of our analysis.[29]

In the sections below, we describe in more detail the heating technology options and the emission factors we use to estimate emissions.

Technology Options

We consider the following five heating technologies. The forecasted customer additions represent customers from new development (that is, residential customers or businesses that move into Liberty's service territory, undertake new construction, and install a gas-fired heating technology) or customers who switch from a non-gas fired heating technology to natural gas. We assume that any customer who installs natural gas heating technology in a new development or switches to natural gas would install a high efficiency system. For this reason, we only consider one natural gas technology efficiency. However, without natural gas expansion, the additional customers would either remain on their existing, what we assume to be lower efficiency, heating option (this would be relevant for the existing residents and businesses who would elect to switch to natural gas), or convert to a higher efficiency non-gas technology such as a high-efficiency oil boiler or a high efficiency electric heat pump (this would be relevant for the portion of additional customers from new build.). For this reason, for every non-gas technology considered, we assume a standard-efficiency (that is, low-efficiency) option along with a corresponding high-efficiency option. We further assume that among the additional customers projected by Liberty, half the additions will be due to existing customers switching to natural gas, while the other half will derive from new build.

1. **Natural Gas:** heating provided by a higher efficiency natural gas-burning boiler.
2. **Standard- and High-Efficiency Oil:** heating provided by one of two types of oil-burning boilers.
3. **Standard- and High-Efficiency Propane:** heating provided by one of two types of propane-burning boilers.

[28] Downstream emissions factors for wood were sourced from the EPA. Carbon dioxide and methane emissions are pulled directly from "EPA, Emission Factors for GHG Inventories, March 9, 2018." Emissions for particulate matter, sulfur dioxide, and nitrogen oxide are pulled from "EPA, AP 42, Fifth Edition, Volume 1, Chapter 1: External Combustion Sources." Table 1.10-1 includes emission factors for the pollutants and different types of residential wood heaters (wood stoves, pellet stoves, masonry heaters). Households using wood heating vary in their use of forced air heating versus hydronic heating and in the type of wood they use, so a simple average of the emission factors for each pollutant for each type of heating was used to estimate emissions factors for wood heating for PM, SO_2, and NO_x. We ignore upstream emission factors for wood, which are difficult to consistently aggregate across source.

[29] This implies little degradation in boiler efficiency and a relatively unchanged pollutant content of distillate oil and natural gas.

4. **Standard- and High-Efficiency Biomass:** heating provided by one of two types of wood-burning stoves/boilers.
5. **Standard- and High-Efficiency Electric:** heating provided by electric baseboards (the standard-efficiency option) or a high efficiency electric heat pump (the high-efficiency options); we make the assumption that a heat pump requires 25 percent of the building's heating load to be served by an electric baseboard back-up heating system.

Table A1 presents our assumptions regarding the technological efficiency associated with each heating option. We derive these efficiencies from the Massachusetts Technical Reference Manual.[30] We derive efficiencies for biomass heating technology from EPA, which reports efficiencies across a range of wood stoves used for heating.[31] We assume the same heating technology efficiencies for residential as well as commercial and industrial customers.

Table A1
Summary of Heating Technology Combinations and Efficiency Assumptions

Heating Option	Efficiency
Natural Gas	0.894
Standard Efficiency Oil	0.75
High Efficiency Oil	0.86
Standard Efficiency Propane	0.75
High Efficiency Propane	0.86
Standard Efficiency Biomass	0.73
High Efficiency Biomass	0.85
Baseboard Electric Heat	1
High Efficiency Heat Pump	9.6 HSPF

Emission Factors

The combustion of oil, propane, biomass, and natural gas for heating emits various air pollutants. Methane leaks from natural gas lines and the extraction, processing, and transportation of natural gas, propane, and oil also emit air pollutants. We consider both sources of emissions in our analysis. There is also an upstream and downstream combustion emissions component for the generation of electricity that we apply to the use of electric heating technologies.

For upstream emissions, we utilize the SEEAT tool's New Hampshire emission factors for NO_x, SO_2, CH_4, and CO_2. For downstream emissions for oil, propane, biomass, and natural gas, we use EPA emissions factors for NO_x, SO_2, PM,[32] Hg, CH_4, and CO_2 (we do not consider any upstream emissions of

[30] Mass Save, "Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures; 2016-2018 Program Years – Plan Revision," October 2015, 436 pages).
[31] The EPA-Certified Wood Stove Database (https://cfpub.epa.gov/oarweb/woodstove/index.cfm?fuseaction=app.about) provides a list of all residential wood heaters approved by the EPA for sales in the United States, including room heaters (e.g., wood stoves/pellet stoves) and central heaters (e.g., outdoor wood boilers). The database includes a range of wood heaters with different levels of efficiency. A standard efficiency wood heater was estimated using the median efficiency across all approved room heaters and central heaters (Maine Energy System's PE32 Hydronic Heating Non-Catalytic Stove using Wood Pellets). A high efficiency wood heater was estimated using the 90th percentile across all approved room heaters and central heaters (Polar Furnace Manufacturing, Inc.'s Classic Edge 550 Hydronic Heating Non-Catalytic Stove using Cord Wood).
[32] PM emission factors are calculated as the sum of condensable PM and filterable PM emission factors. Condensable PM is the particulate matter collected using EPA Method 202. Filterable PM is the particulate matter collected on, or prior to, the filer of an EPA Method 5 (or equivalent) sampling train. See note (c) in Table 1.4-2, available at https://www3.epa.gov/ttn/chief/ap42/ch01/final/c01s04.pdf. PM emission factors are reported as PM_{10} or $PM_{2.5}$ based on the fuel

particulate matter or mercury). For downstream emissions for electricity, we use the ISO-NE December 2017 marginal emission rate for all locational marginal units for NO_x, SO_2, and CO_2.[33] For downstream electricity CH_4 emissions, we use SEEAT and the December 2017 ISO-NE marginal fuel mix.[34] We do not consider particulate matter or mercury emissions from electric generation.[35] Table A2 below illustrates the upstream and combustion emission factors that we consider.

Table A2[36]
Emission Factors for Nitrogen Oxide, Sulfur Dioxide, Particulate Matter, Mercury, Methane, and Carbon Dioxide (lb/MMBtu)

upstream	NO_x	SO_2	PM	Hg	CH_4	CO_2	Source
Natural Gas	0.594	0.302	--	--	6.451	127.8	SEEAT
Oil	0.500	0.272	--	--	0.403	166.6	SEEAT
Propane	0.454	0.375	--	--	0.522	161.3	SEEAT
Electric	Dependent on Electric Generation Fuel Mix						SEEAT
combustion							
Natural Gas	0.037	0.0006	0.0075	2.5E-07	0.0022	117.0	EPA
Oil	0.143	0.0015	0.0143	3.0E-06	0.0066	163.1	EPA
Propane	0.142	0.0011	0.0077	--	0.0066	138.6	EPA
Biomass	0.358	0.0231	0.8613	--	0.0159	206.8	EPA
Electric	0.070	0.0498	--	--	0.0062	173.5	ISO-NE/SEEAT

type and diameter of the particles released. PM_{10} is particulate matter 10 micrometers or less in diameter. $PM_{2.5}$ is particulate matter 2.5 micrometers or less in diameter. We assume PM_{10} and $PM_{2.5}$ to be equivalent in terms of emission factors for biomass, because a large share (~93%) of PM_{10} from wood/bark waste external combustion is $PM_{2.5}$. See South Coast Air Quality Management District, Final - Methodology to Calculate Particulate Matter (PM) $_{2.5}$ and PM $_{2.5}$ Significance Thresholds, Table A, available at http://www.aqmd.gov/home/rules-compliance/ceqa/air-quality-analysis-handbook/pm-2-5-significance-thresholds-and-calculation-methodology.

[33] ISONE, "2017 ISONE Electric Generator Air Emissions Report," April 2019, Appendix Table 9.

[34] ISONE, "2017 ISONE Electric Generator Air Emissions Report," April 2019, Figure 4-6: 2017 percentage of time various fuel types were marginal—all LMUs.

[35] Downstream emission factors for particulate matter (PM) and mercury (Hg) from electric-generated heating were calculated by taking a weighted average of emissions factors for the various fuels making up the New England marginal fuel mix. We derive weights from the 2017 ISO-NE marginal fuel mix (see ISO-NE, "2017 ISONE Electric Generation Air Emissions Report", April 2019). Approximately 60% of the New England's marginal fuel mix (natural gas, oil, and coal) emits small amounts of particulate matter and mercury in the fuel combustion process, while the remainder of the marginal fuel mix emits zero emissions. To estimate combustion emission factors, we use the EPA AP 42, Fifth Edition (Volume I, Chapter 1: External Combustion Sources), available at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors. Assuming common firing configurations for natural gas, oil, and coal, we find a de minimis increase in total emissions for PM and Hg for electric-fired generation. The presence of emission control devices in certain New England natural gas-, oil- and coal-fired power plants would further reduce PM and Hg estimates for electric-generated heating in New Hampshire.

[36] We consider distillate fuel oil No. 2. For NO_x, SO_2, PM and Hg, we use the EPA AP 42, Fifth Edition (Volume I, Chapter 1: External Combustion Sources), available at https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors. For distillate fuel oil, Table 1.3-1 reports a NO_x emission factor of 20 lb/10^3 gallons. Table 1.3-1 also reports an SO_2 distillate fuel oil emission factor of 142S lb/10^3 gallons, where S refers to the percent of sulfur content by weight (see Table 1.3-1 note b). We assume S = 0.0015, noting that the EIA states that "[s]ince 2006, most distillate fuel has had less than 15 parts per million (ppm) of sulfur" (see EIA, "Large reduction in distillate fuel sulfur content has only minor effect on energy content," February 24, 2015, available at: https://www.eia.gov/todayinenergy/detail.php?id=20092; see also Vermont Dept. of Environmental Conservation, "Sulfur Content in Heating Oil – Fact Sheet," which indicates that 15ppm equals 0.0015 percent by weight). Table 1.3-1 finally reports a filterable PM emission factor for distillate fuel oil of 2 lb/10^3 gallons. To convert to lb/MMBtu, we divide by 140 MMBtu/10^3 gallons (see AP 42, at p. 1.3-8). Finally, Table 1.3-10 reports an Hg emission factor for distillate oil of 3 lb/10^{12} Btu. To convert to lb/MMBtu, we divide by 10^6. For natural gas, Table 1.4-1 reports a NO_x emission

Because of losses in the production and distribution process, every one MMBtu of natural gas combusted in a home boiler requires more than one MMBtu to have been extracted (the same idea applies to other fuels). A complete assessment of air pollutant emissions requires assessing the emissions due to these "upstream" losses. We assume losses in each upstream process (extraction, processing, transportation, and distribution) based on SEEAT's assessment of losses for New Hampshire. Table A3 illustrates these losses. To fix ideas, Table A3 implies that 5.1 percent (1 - 0.949) of energy is lost in the extraction of fuel oil, and that 1 percent of natural gas is lost in the distribution phase.

Table A3a
Upstream Losses Assumed by SEEAT and Adopted by AG

	Extraction	Processing	Transportation	Distribution	Total
Natural Gas	0.962	0.97	0.99	0.99	0.915
Oil	0.949	0.891	0.997	0.996	0.840
Propane	0.946	0.936	0.992	0.992	0.871

Note: 'Total' is derived by taking the product across the extraction, processing, transportation, and distribution loss estimates. Note that the SEEAT tool considers residual fuel oil, while our analysis considers distillate fuel oil.

Table 3b
Upstream Losses Assumed by SEEAT and Adopted by AG: Electricity

	Extraction	Processing	Transportation	Conversion	Distribution	Total
Coal	0.993	0.996	0.98	0.318	0.955	0.294
Oil	0.963	0.938	0.988	0.271	0.955	0.231
Natural Gas	0.962	0.97	0.993	0.472	0.955	0.418
Renewable Natural Gas	1	0.8	0.993	0.413	0.955	0.313
Nuclear	0.99	0.962	0.999	0.326	0.955	0.296
Hydro	1	1	1	1	0.955	0.955
Biomass	0.994	0.95	0.975	0.244	0.955	0.215
Wind	1	1	1	1	0.955	0.955
Solar	1	1	1	1	0.955	0.955
Geothermal	1	1	1	1	0.955	0.955
Other	1	1	1	0.203	0.955	0.194

Note: 'Total' is derived by taking the product across the extraction, processing, transportation, and distribution loss estimates.

factor of 38 lb/10^6 scf after applying a reduction for boilers with selective non-catalytic reduction (SNCR) control. Table 1.4-2 reports a SO_2 emission factor for natural gas of 0.6 lb/10^6 scf. Table 1.4-2 also reports a total PM emission factor for natural gas of 7.6 lb/10^6 scf. Table 1.4-4 reports a Hg emission factor of 2.6E-04. To convert to all to lb/MMBtu, we divide by 1,020 Btu/scf (see AP 42, at section 1.4.1). For propane, Table 1.5-1 reports a NO_x emission factor of 13 lb/10^3 gallons. Table 1.5-1 also reports a total PM emission factor for natural gas of 0.7 lb / 10^3 gallons. For SO_2 for propane, we use the Emissions Inventory Improvement Program, A National Methodology and Emission Inventory for Residential Fuel Combustion. Table 2 reports an SO_2 emission factor for propane of 0.1 lb / 10^3 gallons. To convert to lb/MMbtu, we divide by 91.5 MMBtu / 1,000 gallons. For biomass, table 1.10-1 reports an average NO_x emissions factor of 6.2 lb/ton. Table 1.10-1 reports an average SO_x emission factor for biomass of 0.4 lb/ton. Table 1.10-1 reports an average PM emission factor for biomass of 14.9 lb/ton. To convert to lb/MMBtu, we divide by 17.30 MMBtu/ton (see AP 42, at section 1.10.3). For methane and carbon dioxide, we use EPA's Emission Factors for Greenhouse Gas Inventories, March 9, 2018 update (available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf). EPA reports No. 2 oil's CH_4's emission factor as 3.0 g / MMBtu and CO_2's emission factor as 73.96 kg / MMBtu. EPA reports natural gas's CH_4's emission factor as 1.0 g / MMBtu and CO_2's emission factor as 53.06 kg / MMBtu. EPA reports propane's CH_4's emission factor as 3.0 g / MMBtu and CO_2's emission factor as 62.87 kg / MMBtu. EPA reports biomass CH_4's emission factor as 7.2 g / MMBtu and CO_2's emission factor as 93.8 kg / MMBtu. To convert to lb / MMBtu, we multiply by 0.002205 (for CH_4) and 2.205 (for CO_2), since 2.205 pounds equals 1 kilogram.

To combine the upstream and combustion emissions factors, we follow the same method as SEEAT, adding a weighted average upstream emission factor with the combustion emission factor for each pollutant.[37] We summarize this method below in Eq. (3):

(Composite Emission Factor) = (Weighted Upstream Emission Factor) + (Combustion Emission Factor) (3a)

(Weighted Upstream Emission Factor) = (Upstream Emission Factor) x (1 - 'Total') / ('Total') (3b)

where 'Total' refers to the product of the loss estimates for extraction, processing, transportation, and distribution shown in Table A3a and Table A3b.

The electric generation upstream emissions factor has an additional step. The result from Eq. (3b) for each fuel type is multiplied by the share of a specified electric generation fuel mix, and then summed across all fuel types in the electric generation mix to come up with a single upstream emissions factor representative of the share of emissions of each electric generation fuel type. We used the marginal ISO-NE electric generation fuel mix from December 2017.[38]

Table A4 below presents our resulting composite emission factors for NO_x, SO_2, PM, Hg, CH_4, and CO_2.

Table A4
Composite Emission Factors (lb/MMBtu)

	NO_x	SO_2	PM	Hg	CH_4	CO_2
Natural Gas	0.093	0.029	0.0075	2.5E-07	0.605	128.91
Oil	0.238	0.053	0.0143	3.0E-06	0.084	194.87
Propane	0.209	0.055	0.0022	--	0.084	162.42
Biomass	0.358	0.023	0.8613	--	0.016	206.79
Electric	0.145	0.088	--	--	0.630	189.82

Note: The emissions factors for Biomass reflect combustion only. The emission factor for PM and Hg reflects combustion only. Furthermore, for oil, the combustion factor for PM reflects filterable PM only.

Aggregating annual technology specific emissions to overall option specific emissions

In order to estimate emissions for the three options considered in our analysis (Status Quo, Granite Bridge, and Concord Lateral Expansion), we undertake the following steps:

1. Applying the method discussed above, we estimate emissions for a representative residential or C&I customer in each year for each heating technology.
2. In each year, we multiply the cumulative new customers forecasted for that year[39] by a year-specific weighted average of per residential or per C&I customer emissions. The annual weighted average per customer emissions depends on the heating technology profile assumed for a given scenario, explained in more detail below.

[37] See Gas Technology Institute, Full-Fuel-Cycle Energy and Emission Factors for Building Energy Consumption – 2018 Update, at p. A-6 - A-7.
[38] ISONE, "2017 ISONE Electric Generator Air Emissions Report," April 2019, Figure 4-6: 2017 percentage of time various fuel types were marginal—all LMUs.
[39] That is, the emissions from new customers added in year one continue to be counted cumulatively over the full period analyzed.

3. In the *Status Quo* option, we assume additional customers use heating technologies in proportion to the current share of New Hampshire home heating technologies as reported by the American Community Survey,[40] net of natural gas.[41] Specifically, for additional customers within Liberty's existing service territory, we use the non-natural gas heating technologies from counties encompassing this area (i.e. Rockingham, Hillsborough, Merrimack, and Belknap counties) as shown in Table A5a below. For additional customers along the proposed pipeline route (i.e. in Epping, Raymond, and Candia), we use the non-natural gas heating technologies specific to the county encompassing the proposed pipeline route (Rockingham County), as shown in Table A5b below. We use the same shares to distribute the additional C&I customers.[42]
4. In the *Granite Bridge Project* option, we assume all cumulative customer additions will be heating their homes with natural gas.
5. In the *Concord Lateral Expansion* option, we assume new customers in the existing Liberty service territory will be heating their homes with natural gas, but that forecasted new customers outside Liberty Utilities' existing service territory (i.e. those in Epping, Raymond, and Candia) will heat their homes with the share of technologies as shown in Table A5b.

Table A5a[43]
Heating technologies (net of natural gas) used by New Hampshire residents in the counties encompassing Liberty's existing service territory

	Household Count	Share
Oil	147,039	55.4%
Propane	54,336	20.5%
Electricity	34,270	12.9%
Wood	21,584	8.1%
Other Non-Emitting	8,399	3.2%

Table A5b[44]
Heating technologies (net of natural gas) used by New Hampshire residents in Rockingham County, which encompasses the proposed route of the Granite Bridge project pipeline

	Household Count	Share
Oil	60,148	59.1%
Propane	21,280	20.9%
Electricity	11,678	11.5%
Wood	5,596	5.5%
Other Non-Emitting	3,134	3.1%

[40] US Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, House Heating Fuel, available at https://factfinder.census.gov
[41] We net out natural gas since we assume that under the Status Quo option, no expansion of natural gas heating technology will be possible.
[42] The American Community Survey only reports a heating technology profile for residential customers.
[43] Counties encompassing Liberty's existing service territory include Rockingham, Hillsborough, Merrimack, and Belknap. Home-heating types were collected and aggregated for in 2017. We used the US Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, House Heating Fuel, available at https://factfinder.census.gov.
[44] Rockingham County encompasses the proposed route of the Granite Bridge project pipeline. Home-heating types were collected for Rockingham County in 2017. We used the US Census Bureau, 2013-2017 American Community Survey 5-Year Estimates, House Heating Fuel, available at https://factfinder.census.gov.

Details regarding emission reductions from reduced delivery truck traffic

In order to estimate emissions impacts from reduced delivery truck traffic, we make the following assumptions:

- Between 235 deliveries (in the short term)[45] and 300 deliveries (in the long term) would no longer be needed.
- Each delivery requires a truck to travel a distance of 60 miles.
- We model each delivery truck as a class VIIIa vehicle (gross weight of 33,001 to 60,000 lbs) that burns diesel and achieves an average fuel economy of 6.4 miles per gallon.[46]

To estimate emissions, we use data published by EPA. In particular, EPA reports a diesel fuel mobile consumption CO_2 emission factor of 10.21 kg CO_2 per gallon and a diesel fuel mobile consumption CH_4 emission factor in medium- and heavy-duty vehicles of 0.0051 grams CH_4 per mile.[47] For heavy duty diesel trucks, EPA reports a NO_x emission factor of 9.191 grams per mile and a $PM_{2.5}$ emission factor of 0.215 grams per mile.[48] Using these emission rates and our assumptions about number of vehicles, miles traveled, and fuel economy, we calculate the annual emissions benefit for CO_2-e, NO_x, and $PM_{2.5}$ as follows (note that we convert methane into equivalent CO_2 impacts by taking methane's global warming potential to be 25 times that of carbon dioxide's):

- Total miles driven = (number of deliveries) × (average number of miles driven)
- CO_2-e: (Total miles driven) × (CH_4/mile) × 25 + (Total miles driven) / 6.4 mpg × (CO_2 per gallon)
- NO_x: (Total miles driven) × (NO_x/mile)
- $PM_{2.5}$: (Total miles driven) × ($PM_{2.5}$/mile)

[45] Liberty received 704 deliveries of propane and LNG over the past three calendar years, and this number is projected to increase over the next few years. Assuming the same number of deliveries each year, we approximate Liberty requiring 235 deliveries each winter. See New Hampshire Public Utilities Commission, Docket No. DG 17-152, Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities, Approval of Natural Gas Supply Strategy, Direct Testimony of William Killeen, April 30, 2019, pp. 4-5, available at http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-152/TESTIMONY/17-152_2019-04-30_ENGI_DTESTIMONY_KILLEEN_SUPPLEMENTAL_FILING_RESPONSE_ORDER_26225.PDF.

[46] See EIA Table 2.8 Motor Vehicle Mileage, Fuel Consumption, and Fuel Economy, 1949-2010, available at: https://www.eia.gov/totalenergy/data/annual/showtext.php?t=pTB0208.

[47] See "Emission Factors for Greenhouse Gas Inventories," March 9, 2018 update (available at: https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf)

[48] See "Average In-Use Emissions from Heavy Trucks," October 2008 update (available at: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100EVY6.TXT). We assume class VIIIa vehicles which reflect a standard oil and propane delivery truck.

STATE OF NEW HAMPSHIRE
BEFORE THE
PUBLIC UTILITIES COMMISSION

Docket No. DG 17-152

Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities
Least Cost Integrated Resource Plan

DIRECT TESTIMONY

OF

SHERRIE TREFRY

June 28, 2019

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I. PERSONAL BACKGROUND

Q. Please state your name, title, and business address.

A. Sherrie L. Trefry, CSS, Director of Energy and Environmental Services, VHB, 2 Bedford Farms Drive, Suite 200, Bedford, New Hampshire.

Q. Briefly summarize your educational background and work experience.

A. I was educated at the University of New Hampshire in Durham, New Hampshire, where I obtained a BS in Environmental Conservation with a concentration in Soil Science in 1999 and a MS in Natural Resources, Soil Science, in 2001.

I have 15 years of New Hampshire environmental consulting experience. I began my career as an Environmental Consultant in 2004 with New Hampshire Soil Consultants, Inc. (NHSC) following a 30-month assignment as an Agroforestry Peace Corps Volunteer in Cameroon, Africa. I worked for NHSC conducting wetland delineations, wetland function and value assessments, wetland restoration implementation and monitoring, soils mapping, and local, state and federal environmental permitting until 2009. In 2009, NHSC was acquired by GZA GeoEnvironmental, Inc. (GZA). From 2009 to 2014, I worked at GZA primarily conducting natural resource assessments and preparing environmental permit applications for electric utility projects in New Hampshire. In 2014, I joined VHB as the Director of Energy Services to continue to provide environmental services to energy clients. In 2016, I was promoted to Director of Energy and Environmental Services overseeing a team of professionals providing natural resource assessment and permitting services to clients in various markets.

I am a Certified Soil Scientist in the State of New Hampshire (CSS #93) and in the State of Maine (SS #527). I am currently an active member of the Society of Soil Scientists of Northern New England and the New Hampshire Association of Natural Resource Scientists and have formerly served on the Board of Directors for each organization.

Q. Have you previously testified before the New Hampshire Public Utilities Commission?

A. No. I have not previously testified before the New Hampshire Public Utilities Commission.

Q. What is your involvement in the Granite Bridge Project?

A. I am a consultant hired by Liberty Utilities to lead the permitting process for the Granite Bridge Project. I am responsible for identifying and preparing the environmental permit applications. To support the development of the permit applications, I have coordinated the completion of appropriate natural resource assessments and regulatory consultations. I expect to provide testimony before the New Hampshire Site Evaluation Committee in support of the Granite Bridge Project.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to describe the permits that will be required to support Liberty Utilities' planned filing before the New Hampshire Site Evaluation Committee for the Granite Bridge Pipeline, and also to describe the permits that would likely be required for a similar filing to support the expansion of the Tennessee Gas Pipeline (TGP) Concord Lateral, which is an alternative to the Granite Bridge Pipeline.

Q. Can you describe the Granite Bridge Pipeline project?

A. The Granite Bridge Pipeline project is a proposed natural gas pipeline that is to run from Exeter to Manchester within the state-owned Route 101 Energy Infrastructure Corridor. As stated above, Liberty Utilities hired VHB to lead the Granite Bridge permitting process. Therefore, I am familiar with the various permits that will be required for the Granite Bridge Pipeline.

Q. Can you describe the TGP Concord Lateral expansion project?

A. I understand from my work on the Granite Bridge Project that an alternative to the Granite Bridge Pipeline is an expansion of the Concord Lateral, which expansion would be constructed by its owner, TGP. I also understand that although TGP provided Liberty with confidential estimates of the cost to complete an expansion of the Concord Lateral, TGP did not provide specific plans. Thus, I do not know TGP's specific plans for expanding the Concord Lateral to provide additional capacity similar to what the Granite Bridge Pipeline would provide. For purposes of this testimony, however, I will assume that expansion of the TGP would involve construction of new sections of transmission pipeline and perhaps a compressor station, which new construction would likely require approval by the SEC[1] or a similar siting process through the Federal Energy Regulatory Commission ("FERC"). The Concord Lateral is part of an interstate pipeline and its expansion would likely be subject to FERC's siting process.

[1] The SEC has jurisdiction over "energy facilities" which include "energy transmission pipelines." RSA 162-H:2,VII(a)

II. ENVIRONMENTAL ASSESSMENTS

Q. Please describe the permit application efforts that would be required for the Granite Bridge Pipeline.

A. The Granite Bridge Pipeline will require a Certificate of Site and Facility to be issued from the Site Evaluation Commission (SEC). The Company will have to prepare an SEC application that addresses the applicable siting criteria under the SEC rules. This includes a number of studies and assessments pertaining to environmental, visual, health and safety, historic, and orderly development effects of the project on the State. As part of the SEC process, review of the project by the New Hampshire Department of Safety, Division of Fire Safety, State Fire Marshal is required to ensure compliance with the State Fire Code and the State Building Code.

Particular to my area of expertise, the project will require significant ground disturbance for the installation of additional pipe and infrastructure that would require various permits through the New Hampshire Department of Environmental Services (NHDES) (which permitting process falls under the umbrella of the SEC). The Granite Bridge Pipeline will require a Wetlands Permit for wetland impacts, a Shoreland Permit for impacts to protected shoreland, a 401 Water Quality Certificate if the project requires an Individual Army Corps 404 Permit, and an Alteration of Terrain Permit for ground disturbance that exceeds 100,000 square feet. Since the Granite Bridge Pipeline does not involve a compressor station, an Air Resources Division Permit is not required from NHDES. As part of the NHDES permit applications, the Company is also consulting with the New Hampshire Natural Heritage Bureau (NHNHB) to determine if any rare, threatened, or endangered

species are present in the project vicinity, and with the NHNHB for any listed plants and with the New Hampshire Fish and Game Department for any listed animals. Liberty Utilities will also have to consult with the New Hampshire Division of Historical Resources (NHDHR) regarding any known or potential historic resources are present within the project vicinity.

The Granite Bridge Pipeline will require a number of approvals from the New Hampshire Department of Transportation for installation of the pipeline. Required permits will include NHDOT Excavation Permits, Crossing and Temporary Use permits, and Driveway permits to access the work area from State roads. Approvals are also required from the Bureau of Trails since trail crossings are required.

In addition to state permits, the project will require federal permits. A Notice of Intent will have to be filed with the United States Environmental Protection Agency (USEPA) for coverage under the Construction General Permit for ground disturbance in excess of one acre. The project will also require a Section 404 permit under the Clean Water Act to impact waters of the United States. In support of the 404 Permit, Liberty Utilities will have to consult with the United States Fish and Wildlife Services to determine if any nationally listed endangered species occurred within the project vicinity.

Q. Please describe the permit application efforts that would be required for the TGP Concord Lateral Expansion project.

A. As stated above, I assume that an upgrade of the Concord Lateral would include construction of new transmission pipeline and possibly a compressor station. If such a

project were presented to the SEC, it would require the same permits that are required for the Granite Bridge Pipeline that are described above, with one important difference. Should the Concord Lateral upgrade include a new compressor station, it would also have to obtain an Air Resources Division Permit from NHDES.

If the Concord Lateral upgrade required FERC approval rather than SEC approval, it is my understanding that TGP would still have to demonstrate to FERC that the project would comply with all applicable state and local environmental laws.

Q. RSA 378:38, VI, requires "An assessment of plan integration and impact on state compliance with the Clean Air Act of 1990, as amended, and other environmental laws that may impact a utility's assets or customers." What is your assessment of the relative impacts of the Granite Bridge Pipeline and an upgrade of the Concord Lateral on "other environmental laws"?

A. As described above, both projects would require permits to demonstrate compliance with the identified environmental laws. Assuming both projects perform the necessary work to obtain those permits and comply with those laws, there would be no meaningful difference between them as to their impact on these environmental laws.

Q. Does this conclude your testimony?

A. Yes it does.

STATE OF NEW HAMPSHIRE
BEFORE THE
PUBLIC UTILITIES COMMISSION

Docket No. DG 17-152

Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities
Least Cost Integrated Resource Plan

DIRECT TESTIMONY

OF

ERIC M. STANLEY

June 28, 2019

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I. INTRODUCTION

Q. Please state your name and business address.

A. My name is Eric M. Stanley. My business address is 15 Buttrick Road, Londonderry, New Hampshire.

Q. By whom are you employed and in what capacity?

A. I am employed by Liberty Utilities Service Corp., which provides services to Liberty Utilities (Granite State Electric) Corp. and Liberty Utilities (EnergyNorth Natural Gas) Corp. ("EnergyNorth" or the "Company").

I am the Manager of Energy Efficiency and Customer Programs at Liberty Utilities for New Hampshire. My primary responsibilities are the planning, marketing, implementation, and reporting of the Company's electric and natural gas energy efficiency programs in the state.

Q. Please state your educational backgrounds and professional experiences.

A. I received an MBA from Southern New Hampshire University in 2015 and a Bachelor's of Science degree in Business Administration from the University of New Hampshire in 2000. Since 2012, I have worked as Liberty Utilities' Manager of Energy Efficiency and Customer Programs in New Hampshire. Prior to this role, I worked at National Grid from 2001 to 2012 in a variety of capacities including, most recently, as the Manager, Marketing Strategy – Energy Efficiency from 2009 to 2012 where I was responsible for developing energy efficiency marketing strategies across their businesses in Massachusetts, New Hampshire, New York, and Rhode Island. From 2007 to 2009, I was the Manager of

Natural Gas Residential Advertising, responsible for all customer growth direct marketing activities. From 2004 to 2007, I was a Senior Marketing Analyst responsible for new product and gas growth marketing activities. From 2001 to 2003, I was an Energy Efficiency Analyst, responsible for planning and evaluation activities related to National Grid's Massachusetts natural gas energy efficiency programs. From 1999 to 2001, I was an Analyst for Ellacoya Networks responsible for competitive and market intelligence research and data analytics.

Q. Have you previously testified before this Commission?

A. Yes. I have testified in numerous proceedings before the Commission.

Q. On whose behalf are you testifying?

A. I am testifying on behalf of EnergyNorth.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to briefly describe the Company's natural gas energy efficiency programs in New Hampshire, the relative strategy and achievements of the programs over time and in comparison to other natural gas utilities in New England, in order to demonstrate that the Company's assumption of demand reduction from these energy efficiency efforts was reasonable.

Q. Please provide a description of the Company's programs.

A. EnergyNorth offers a comprehensive suite of natural gas energy efficiency programs available to its entire base of residential, income-eligible, multifamily, commercial, industrial, and municipal customers. Specific measure offerings include services such as

energy audits, air sealing and weatherization, engineering and technical analysis, building plan energy efficiency certification and verification service, and prescriptive and custom incentives for natural gas devices such as: building control systems and thermostats, furnaces, boilers, water heaters, chillers, energy recovery ventilation systems, combined heat and power systems, spray valves, faucet aerators and showerheads, ovens, fryers, griddles, and steam cookers. The Company offers various types of incentive formats for customers to participate in its energy efficiency offerings such as discounted purchase prices at retailers and equipment distributors, mail-in and online rebate applications, third-party and on-bill financing, in addition to free and no-cost services depending on the customer type and specific efficiency measure. The Company also offers energy efficiency education, training, and curriculum programs for K-12 students, contractors, residential and non-residential customers. Lastly, the company provides personalized home energy reports to a portion of its residential customers that depicts a comparative analysis of customer's energy usage.

Complete details of the Company's energy efficiency offerings are found in the 2018–2020 New Hampshire Statewide Energy Efficiency Plan, revised on January 12, 2018, as part of NHPUC Docket No. DE 17-136, and attached as Exhibit A.

Q. How do the specific energy efficiency program offerings provided by the Company compare with other natural gas utilities in the New England?

A. Beginning with the inception of the Company's energy efficiency programs in New Hampshire in 2003,[1] where the programs were modeled after what the Company's sister business was delivering for natural gas energy efficiency programs in Massachusetts, the Company's energy efficiency portfolio strategy has essentially followed this same approach, where there are very few, if any, exceptions in terms of the types of services available to customers and what types of natural gas energy efficiency measures can be incentivized in New Hampshire as compared to those in Massachusetts. The Company has also been consistently engaged in regional natural gas program offerings in partnership with the other New England states, such as the GasNetworks®[2] program, where identical program measures, delivery mechanisms, and relative incentive levels are brought to the market and leveraged. In some cases, the Company has even been one of the first to introduce energy efficiency incentives for certain groundbreaking technologies. Recent examples include the piloting of an innovating polymer bead commercial washing technology in 2014, which was one of the first-of-its-kind to be tested, evaluated, and incentivized by a natural gas utility in the United States,[3] and in 2017 a unique pre-rinse spray valve device that is used specifically in beauty salons.[4]

[1] NH Public Utilities Commission (December 31, 2002). DG 02-106, EnergyNorth Natural Gas, Inc. d/b/a KeySpan Energy Delivery New England and Northern Utilities, Inc. "Energy Efficiency Programs for Gas Utilities. Order Approving the Settlement Agreement." Order No. 24,109. p.5.
[2] Gas Networks (2019). "Gas Networks Member Companies and Service Areas." Retrieved from https://GasNetworks.com
[3] RISE Engineering (2014, February 11). "Xeros Laundry Technical Assessment Study: Final Report"
[4] ECOHeads (2019). Showerheads. https://ecoheads.com/

Q. How do the Company's energy efficiency programs compare quantitatively to other natural gas utilities in New England?

A. Table 1 below depicts a sampling of natural gas utilities across New England and their respective natural gas energy efficiency sales reduction targets in 2018 relative to their actual annual sales volumes. As shown, EnergyNorth's natural gas energy efficiency annual savings target in 2018 compares favorably to the other New England natural gas utilities depicted, only being exceeded by National Grid and Eversource in Massachusetts, who have more than eight and four times the respective natural gas sales volume as Liberty Utilities in New Hampshire.

Table 1. Natural Gas Utility Energy Efficiency Sales Reduction Targets, 2018			
Utility	**2018 Natural Gas Annual Savings Target (MMBtus)**	**2018 Natural Gas Sales (MMBtus)**	**Ratio of Savings Target to Sales**
National Grid (MA)	**1,725,114**[5]	**155,603,750**[6]	**1.11%**
Eversource (MA)	**663,225**[7]	**72,623,600**[8]	**0.91%**
Liberty Utilities (NH)	**130,072**[9]	**17,868,268**[10]	**0.73%**
Columbia Gas (MA)	**420,827**[11]	**59,822,202**[12]	**0.70%**
Connecticut Natural Gas (CT)	**230,641**[13]	**37,995,000**	**0.61%**
Berkshire Gas Company (MA)	**53,815**[14]	**10,545,000**[15]	**0.51%**
Southern Connecticut Gas (CT)	**175,428**[16]	**36,251,000**[15]	**0.48%**
Unitil (NH)	**33,544**[9]	**8,621,418**[17]	**0.39%**

1

[5] National Grid (2015). 2016-2018 Plan Data Tables National Grid Gas. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-4-2016-2018-Plan-Data-Tables-National-Grid-Gas.xlsx

[6] National Grid (2019). Statement of Operating Revenues for Boston Gas Company and Colonial Gas Company for Year 2018. Boston Gas Company retrieved from https://www.mass.gov/files/documents/2019/05/01/Boston%20Gas%202018.pdf; Colonial Gas Company retrieved from https://www.mass.gov/files/documents/2019/05/01/Colonial%20Gas%202018.pdf

[7] Eversource (2015). 2016-2018 Plan Data Tables NSTAR Gas dba Eversource. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-4-2016-2018-Plan-Data-Tables-NSTAR-Gas-dba-Eversource.xlsx

[8] Eversource Energy (2019). Annual Report – 2018. Retrieved from https://www.eversource.com/content/docs/default-source/Investors/annual-report.pdf

[9] NHSAVES (2017, September 1). New Hampshire Statewide Energy Efficiency Plan, 2018-2020. Retrieved from http://www.puc.state.nh.us/Regulatory/Docketbk/2017/17-136/INITIAL%20FILING%20-%20PETITION/17-136_2017-09-01_NHUTILITIES_EE_PLAN.PDF

[10] Liberty Utilities (EnergyNorth Natural Gas) Corp (2019, April 4). Annual Report – Form F-16. Retrieved from https://www.puc.nh.gov/Gas-Steam/Annual%20Reports/2018/2018-Gas-Annual-Report-Liberty-Utilities-20190520.pdf

[11] Columbia Gas (2015). 2016-2018 Plan Data Tables CMA. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-4-2016-2018-Plan-Data-Tables-CMA.xlsx

[12] Columbia Gas (2019). Return of the Bay State Gas Company d/b/a Columbia Gas of Massachusetts, 2018. Retrieved from https://www.mass.gov/files/documents/2019/05/01/CY%202018%20CMA%27s%20Annual%20Return%20to%20DPU.pdf

[13] Eversource Energy, The United Illuminating Company, Connecticut Natural Gas, Southern Connecticut Gas (2017, November 1). 2018 Plan Update of the 2016-2018 Conservation & Load Management Plan. Retrieved from https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/2018_plan_update_11-1-17.pdf

[14] Berkshire Gas Company (2015). 2016-2018 Plan Data Tables Berkshire. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/Exhibit-4-2016-2018-Plan-Data-Tables-Berkshire.xlsx

[15] Avangrid, Inc. (2018). Form 10-K, for the fiscal year ended December 31, 2018. Retrieved from https://avangridinc.gcs-web.com/static-files/fecfc11b-aa88-477f-aa85-322d2a6b50dd

[16] Eversource Energy, The United Illuminating Company, Connecticut Natural Gas, Southern Connecticut Gas (2017, November 1). 2018 Plan Update of the 2016-2018 Conservation & Load Management Plan. Retrieved from https://www.ct.gov/deep/lib/deep/energy/conserloadmgmt/2018_plan_update_11-1-17.pdf

[17] Northern Utilities (2019, April 3). Annual Report – Form F-16 G. Retrieved from https://www.puc.nh.gov/Gas-Steam/Annual%20Reports/2018/2018-Gas-Annual-Report-Northern-Utilities-20190404.pdf

Q. Does this conclude your testimony?

A. Yes, it does.

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Steven E. Mullen
Director, Rates & Regulatory Affairs
O: 603-216-3516
E: Steven.Mullen@libertyutilities.com

May 30, 2019

Via Electronic and US Mail

Debra A. Howland, Executive Director
New Hampshire Public Utilities Commission
21 South Fruit Street, Suite 10
Concord, NH 03301-2429

RE: DE 17-136; Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities NHSaves Energy Efficiency Programs – YE 2018

Dear Ms. Howland:

On behalf of Liberty Utilities, I enclose for filing in the above-captioned docket an original and three copies of the calculation of the shareholder incentive report relating to the Company's energy efficiency programs for program year 2018. The Commission approved the 2018 programs in its Order No. 26,095 issued on January 2, 2018.

Thank you for your attention to this matter. Please do not hesitate to call if you have any questions.

Sincerely,

Steven E. Mullen

Enclosures
cc: Service List

NEW HAMPSHIRE PUBLIC UTILITIES COMMISSION

LIBERTY UTILITIES (ENERGYNORTH NATURAL GAS) CORP. d/b/a LIBERTY UTILITIES

NHSAVES EE PROGRAMS - 2018 YEAR-END REPORT

N.H.P.U.C. Docket No. DE 17-136

May 30, 2019

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SUMMARY OF 2018 PROGRAM ACTIVITY

The following report presents the results of Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities ("Liberty Utilities" or "Company") residential and commercial & industrial energy efficiency programs for calendar year 2018.

Table 1 shows a summary of overall program savings results. In total, the Company served 44,828 participants and saved 2,088,370 Lifetime MMBTUs. Annual MMBTU savings were 139,250 with an average savings per participant per year of 3.11. Of the 44,828 participants, 4,837 also had electric savings which totaled 3,871,811 Lifetime kWh's. Annual kWh savings were 324,571 with an average savings per participant per year of 67.10.

Table 2 documents the quantified benefits and costs achieved by program for the residential market. In total, the residential programs generated $8,012,591 in customer benefits and incurred costs of $5,837,235, for an overall program benefit cost ratio of 1.37.

Table 3 documents the quantified benefits and costs achieved by program for the commercial & industrial market. In total, the commercial & industrial programs generated $9,765,013 in customer benefits and incurred costs of $4,680,028 for an overall program benefit cost ratio of 2.09.

Table 4 documents the MMBTU savings achieved by program for the individual residential and commercial and industrial programs. In summary, the residential program activities resulted in 887,976 in total lifetime MMBTU savings and 2,146,811 lifetime kWh savings. The commercial and industrial program activities resulted in 1,200,395 in total lifetime MMBTU savings and 1,725,000 lifetime kWh savings.

Table 5 documents footnotes for the residential and commercial & industrial program benefit cost ratios and the rate of savings per MMBTU based on the Avoided Energy Supply Components in New England: 2018 Report.

Table 6 documents the Company's earned 2018 year-end performance incentive of $387,978. As specified by the Commission, the performance incentive for 2018 has been documented using assumptions that are consistent with assumptions used to develop program-year goals. Table 6 summarizes the performance incentive calculation by component (commercial & industrial and residential). As specified by the Commission, results for all programs have been included in the performance incentive calculation.

Table 7 documents the planned versus actual benefit cost ratio by sector (residential and commercial & industrial), and for the entire portfolio of energy efficiency programs implemented in 2018.

Table 8 documents the Company's expenses by Program and budget category. Overall, the Company incurred a total of $5,902,020 of expenses in 2018.

Table 9 documents the forecast of annualized therm savings by month and the total lost base revenue calculation.

Table 10 documents the actual annualized therm savings by month and the associated lost base revenue calculation. There was a total program actual annualized savings by month of 817,220 therms and a total lost base revenue of $351,097 for 2018.

Table 11 documents the calculation of average distribution rates for lost revenue based on actual billing determinants and actual distribution rates for 2018. The Average Distribution Revenue was calculated for each sector by dividing the total therm distribution revenue by the therms for the applicable time period (January – April 2018, May – June 2018, and July – October 2018). The distribution revenue is calculated by multiplying the volumetric distribution rates that were billed for the period (month) by the billing determinants for the same period.

Liberty Utilities (EnergyNorth Natural Gas) Corp. d/b/a Liberty Utilities
NHSaves Energy Efficiency Programs 2018 Year End Report
NHPUC Docket No. DE 17-136

Table 1. Program Savings Summary

Gas Savings in MMBTU's resulting from Energy Efficiency Measures Installed in the Program Year	
Number of Participants served in the annual program year time period	44,828
MMBTU Savings per Participant Per Year	3.11
Total MMBTU Savings Per Year	139,250
Measure Life of Measures Installed in the annual program year time period	15.00
Grand Total MMBTU Savings Benchmark for Performance Incentive	2,088,370
Electric Savings in kWh's resulting from Energy Efficiency Measures Installed in the Program Year	
Number of Participants served in the annual program year time period	4,837
kWh Savings per Participant Per Year	67.10
Total kWh Savings Per Year	324,571
Measure Life of Measures Installed in the annual program year time period	12
Grand Total kWh Savings Benchmark for Performance Incentive	3,871,811

Table 2. Benefit Cost (B/C) Benchmark for Computing Performance Incentive - Residential Programs

Residential Programs	Home Energy Assistance	ENERGY STAR Products	Home Performance w/ENERGY STAR	ENERGY STAR Homes	Home Energy Reports	Total
Benefits:						
Avoided Generation, Transmission & Distribution Costs for:						
Program Participants	$ 978,954	$ 4,902,879	$ 1,268,665	$ 594,352	$ 267,742	$ 8,012,591
Market effects (e.g., spillover, post-program adoptions)	$ -	$ -	$ -	$ -	$ -	$ -
Customer Benefits (including O&M)	$ -	$ -	$ -	$ -	$ -	$ -
Quantifiable avoided resource costs (e.g., water, electricity)	$ -	$ -	$ -	$ -	$ -	$ -
Adder for other non-quantifiable benefits (e.g., environmental and other)	$ -	$ -	$ -	$ -	$ -	$ -
Total Benefits	**$ 978,954**	**$ 4,902,879**	**$ 1,268,665**	**$ 594,352**	**$ 267,742**	**$ 8,012,591**
Costs:						
Program costs (e.g. incentives, admin, monitoring, evaluation for:						
Utility Costs (e.g., for admin, monitoring, evaluation, markeing)	$ 984,077	$ 1,230,077	$ 688,212	$ 234,317	$ 264,914	$ 3,401,597
Program participants (e.g., incremental costs not reimbursed)	$ -	$ 1,438,469	$ 309,517	$ 453,793	$ -	$ 2,201,778
Market effects (e.g., spillover, post-program adoptions)	$ -	$ -	$ -	$ -	$ -	
Customer Costs (including O&M)	$ -	$ -	$ -	$ -	$ -	
Quantifiable additional resource costs (e.g. water, electricity)	$ -	$ -	$ -	$ -	$ -	
Total Costs	**$ 984,077**	**$ 2,668,546**	**$ 997,729**	**$ 688,110**	**$ 264,914**	**$ 5,603,375**
Utility Performance Incentive at the Sector Level	n/a	n/a	n/a	n/a	n/a	**$ 233,860**
Total Costs Including Utility Performance Incentives at Sector Level						**$ 5,837,235**
Benefit Cost Ratio by Sector (i.e., B/C Benchmark for PI Calc.)	**0.99**	**1.84**	**1.27**	**0.86**	**1.01**	**1.37**

Table 3. Benefit Cost (B/C) Benchmark for Computing Performance Incentive - Commercial & Industrial Programs

Commercial & Industrial Programs	Small Business	Large Business	C&I Education	Total
Benefits:				
Avoided Generation, Transmission & Distribution Costs for:				
Program Participants	$ 4,206,997	$ 5,558,016	$ -	$ 9,765,013
Market effects (e.g., spillover, post-program adoptions)	$ -	$ -	$ -	$ -
Customer Benefits (including O&M)	$ -	$ -	$ -	$ -
Quantifiable avoided resource costs (e.g., water, electricity)	$ -	$ -	$ -	$ -
Adder for other non-quantifiable benefits (e.g., environmental and other)	$ -	$ -	$ -	$ -
Total Benefits	**$ 4,206,997**	**$ 5,558,016**	**$ -**	**$ 9,765,013**
Costs:				
Program costs (e.g. incentives, admin, monitoring, evaluation for:				
Utility Costs (e.g., for admin, monitoring, evaluation, markeing)	$ 1,226,552	$ 1,253,657	$ 20,213	$ 2,500,423
Program participants (e.g., incremental costs not reimbursed)	$ 1,074,918	$ 950,570	$ -	$ 2,025,488
Market effects (e.g., spillover, post-program adoptions)	$ -	$ -	$ -	
Customer Costs (including O&M)	$ -	$ -	$ -	
Quantifiable additional resource costs (e.g. water, electricity)	$ -	$ -	$ -	
Total Costs	**$ 2,301,470**	**$ 2,204,227**	**$ 20,213**	**$ 4,525,911**
Utility Performance Incentive at the Sector Level	n/a	n/a	n/a	**$ 154,118**
Total Costs Including Utility Performance Incentives at Sector Level				**$ 4,680,028**
Benefit Cost Ratio by Sector (i.e., B/C Benchmark for PI Calc.)	**1.83**	**2.52**	**-**	**2.09**

Table 4. MMBTU Savings Benchmark for Computing Performance Incentive

Residential Programs	**Home Energy Assistance**	**ENERGY STAR Products**	**Home Performance w/ENERGY STAR**	**ENERGY STAR Homes**	**Home Energy Reports**	**Total**
Gas Savings in MMBTU's from Measures Installed in the Program Year						
Number of Participants	216	5,024	436	78	38,000	43,754
MMBTU Savings per Participant Per Year	26	7	20	31	0.2	1
Total MMBTU Savings Per Year	5,636	35,151	8,527	2,385	8,116	59,815
Measure Life of Measures Installed During the Program Year	19	16	16	25	4	15
Grand Total MMBTU Savings Benchmark for Performance Incentive	109,394	548,424	140,554	59,576	30,027	887,976
Electric Savings in kWh's from Measures Installed in the Program Year						
Number of Participants	38	4,635	123	23	-	4,819
kWh Savings per Participant	344	7	945	1,532	-	41
Total kWh Savings Per Participant Per Year	13,069	31,248	116,260	35,233	-	195,810
Measure Life of Measures Installed in the annual program year time period	20.40	17.00	6.58	16.57	-	10.96
Grand Total kWh Savings Benchmark for Performance Incentive	266,644	531,216	765,217	583,735	-	2,146,811

Commercial & Industrial Programs	**Small Business**	**Large Business**	**C&I Education**	**Total**
Number of Participants	1,013	61	-	1,074
MMBTU Savings per Participant Per Year	29	825	-	74
Total MMBTU Savings Per Year	28,935	50,500	-	79,435
Measure Life of Measures Installed During the Program Year	17	14	-	15
Grand Total MMBTU Savings Benchmark for Performance Incentive	501,103	699,292	-	1,200,395
Electric Savings in kWh's from Measures Installed in the Program Year				
Number of Participants	17	1	-	18
kWh Savings per Participant	3,904	62,399	-	7,153
Total kWh Savings Per Participant Per Year	66,362	62,399.00	-	128,761.00
Measure Life of Measures Installed in the annual program year time period	16.59	10.00	-	13.40
Grand Total kWh Savings Benchmark for Performance Incentive	1,101,010	623,990	-	1,725,000

Table 5. Footnotes for Benefit Cost Ratio

Residential Programs	Home Energy Assistance	ENERGY STAR Products	Home Performance w/ENERGY STAR	ENERGY STAR Homes	Home Energy Reports	Total
Number of Participants*	216	5,024	436	78	38,000	43,754
MMBTU Savings per Participant Per Year**	26	7	20	31	0.2	1
Total MMBTU Savings Per Year	5,636	35,151	8,527	2,385	8,116	59,815
Number of Years in the Measure Life**	19	16	16	25	4	15
Grand Total MMBTU Savings Benchmark for Performance Incentive	109,394	548,424	140,554	59,576	30,027	887,976
Lifetime Therm Savings	1,093,939	5,484,243	1,405,538	595,763	300,274	8,879,757
Rate of Savings per MMBTU ***	$ 8.28	$ 8.28	$ 8.28	$ 8.28	$ 8.28	$ 8.28
Grand Total Dollar Savings	$ 905,781	$ 4,540,953	$ 1,163,786	$ 493,292	$ 248,627	$ 7,352,439

Commercial & Industrial Programs	Small Business	Large Business	C&I Education	Total
Number of Participants*	1,013	61	-	1,074
MMBTU Savings per Participant Per Year**	29	825	-	74
Total MMBTU Savings Per Year	28,935	50,500	-	79,435
Number of Years in the Measure Life**	17	14	-	15
Grand Total MMBTU Savings Benchmark for Performance Incentive	501,103	699,292	-	1,200,395
Lifetime Therm Savings	5,011,031	6,992,916	-	12,003,946
Rate of Savings per MMBTU ***	$ 7.34	$ 7.34	$ -	$ 7.34
Grand Total Dollar Savings	$ 3,678,096	$ 5,132,800	$ -	$ 8,810,896

* eTrack (Liberty Utilities Energy Efficiency Program Tracking System)
** The values are variable for program year measurement purposes and based upon the B/C model assumptions.
*** Source: Avoided Energy Supply Components in New England: 2018 Report, Synapse Energy Economics, Inc., (Amended June 1, 2018). Pg.47, Table 14

Residential Programs	Home Energy Assistance	ENERGY STAR Appliances	Home Performance w/ENERGY STAR	ENERGY STAR Homes	Residential Building Practices & Demo	Total
Number of Participants*	216	5,024	436	78	38,000	43,754
Participant Incremental Cost	$ -	$ 1,438,469	$ 309,517	$ 453,793	$ -	$ 2,201,778
Program Participant Cost	$ -	$ 286	$ 710	$ 5,818	$ -	$ 50

Commercial & Industrial Programs	Small Business	Large Business	C&I Education	Total
Number of Participants*	1,013	61	-	1,074
Participant Incremental Cost	$ 1,074,918	$ 950,570	$ -	$ 2,025,488
Program Participant Cost	$ 1,061	$ 15,538	$ -	$ 1,886

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Table 6. Performance Incentive Calculation - 2018

Commercial & Industrial Incentive	**Planned**	**Actual**
1. Benefit/Cost Ratio	1.44	2.09
2. Threshold Benefit / Cost Ratio[1]	1.00	
3. Lifetime MMBTU Savings	1,210,888	1,200,395
4. Threshold Lifetime MMBTU Savings (65%)[2]	787,077	
5. Budget / Actual Spend	$3,580,741	$2,500,423
6. Benefit / Cost Percentage of Budget	2.75%	
7. Lifetime MMBTU Percentage of Budget	2.75%	
8. Commercial & Industrial Incentive	**$196,941**	**$154,118**
9. Cap	**$246,176**	**$246,176**
Residential Incentive		
10. Benefit / Cost Ratio	1.07	1.37
11. Threshold Benefit / Cost Ratio[1]	1.00	
12. Lifetime MMBTU Savings	615,741	887,976
13. Threshold Lifetime MMBTU Savings (65%)[2]	400,232	
14. Budget / Actual Spend	$3,579,834	$3,401,597
15. Benefit / Cost Percentage of Budget	2.75%	
16. Lifetime MMBTU Percentage of Budget	2.75%	
17. Residential Incentive	**$196,891**	**$233,860**
18. Cap	**$246,114**	**$246,114**
19. TOTAL INCENTIVE	**$393,832**	**$387,978**

Notes
1. Actual Benefit / Cost Ratio for each sector must be greater than or equal to 1.0.
2. Actual Lifetime MMBTU Savings for each sector must be greater than or equal to 65% of projected savings.

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Table 7. Planned Versus Actual Benefit / Cost Ratio by Sector - 2018

Commercial & Industrial:	**Planned**	**Actual**
1. Benefits (Value) From Eligible Programs	$9,492,221	$9,765,013
2. Implementation Expenses	$3,580,741	$2,500,423
3. Customer Contribution	$2,791,851	$2,025,488
4. Performance Incentive	$196,941	$154,118
5. Total Costs Including Performance Incentive	**$6,569,532**	**$4,680,028**
6. Benefit/Cost Ratio - C&I Sector	**1.49**	**2.16**
7. Benefit/Cost Ratio including PI in cost	**1.44**	**2.09**
Residential:		
8. Benefits (Value) From Eligible Programs	$5,641,977	$8,012,591
9. Implementation Expenses	$3,579,834	$3,401,597
10. Customer Contribution	$1,475,247	$2,201,778
11. Performance Incentive	$196,891	$233,860
12. Total Costs Including Performance Incentive	**$5,251,972**	**$5,837,235**
13. Benefit/Cost Ratio - Residential Sector	**1.12**	**1.43**
14. Benefit/Cost Ratio including PI in cost	**1.07**	**1.37**

Table 8. Program Expenditures by Category - 2018 Actual

Program	Evaluation	External Administration	Internal Administration	Internal Implementation	Marketing	Rebates-Services	Total
Residential Programs							
ENERGY STAR Products	$ 48,542	$ 496	$ 25,104	$ 36,591	$ 21,750	$ 1,097,595	**$ 1,230,077**
ENERGY STAR Homes	$ 6,772	$ 94	$ 7,799	$ 13,669	$ 3,832	$ 202,150	**$ 234,317**
Home Energy Assistance	$ 39,804	$ 553	$ 27,357	$ 52,834	$ 24,892	$ 838,637	**$ 984,077**
Home Performance with ENERGY STAR	$ 25,085	$ 348	$ 17,150	$ 50,509	$ 37,895	$ 557,225	**$ 688,212**
Home Energy Reports	$ 10,495	$ 135	$ 4,304	$ 14,604	$ 5,376	$ 230,000	**$ 264,914**
Subtotal - Residential	**$ 130,699**	**$ 1,626**	**$ 81,713**	**$ 168,207**	**$ 93,744**	**$ 2,925,608**	**$ 3,401,597**
Commercial & Industrial Programs							
C&I Education	$ 550	$ 35	$ 86	$ 16	$ 799	$ 18,728	**$ 20,213**
Large Business Energy Solutions	$ 65,173	$ 900	$ 19,877	$ 134,801	$ 51,975	$ 980,932	**$ 1,253,657**
Small Business Energy Solutions	$ 50,039	$ 691	$ 22,172	$ 105,441	$ 52,982	$ 995,227	**$ 1,226,552**
Subtotal - C&I	**$ 115,761**	**$ 1,627**	**$ 42,135**	**$ 240,258**	**$ 105,755**	**$ 1,994,886**	**$ 2,500,423**
Total - All	**$ 246,460**	**$ 3,253**	**$ 123,848**	**$ 408,466**	**$ 199,500**	**$ 4,920,494**	**$ 5,902,020**

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Table 9. Lost Base Revenue and Savings - 2018 Forecast
Estimated Monthly and Cumulative Savings (therm) and Lost Base Revenue
January 1, 2018 to December 31, 2018

Line	Description	12/31/2017	Forecast Jan 2018	Forecast Feb 2018	Forecast Mar 2018	Forecast Apr 2018	Forecast May 2018	Forecast June 2018	Forecast Jul 2018	Forecast Aug 2018	Forecast Sep 2018	Forecast Oct 2018	Forecast Nov 2018	Forecast Dec 2018	2018 Annual Savings
	Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H	Col. I	Col. J	Col. K	Col. L	Col. M	Col. N	Col. O
1	Residential Annualized Savings	358,104	19,321	19,321	19,321	32,202	32,202	32,202	32,202	32,202	32,202	45,082	-	-	296,255
2	C&I Annualized Savings	876,732	45,715	45,715	45,715	76,192	76,192	76,192	76,192	76,192	76,192	106,668	-	-	700,964
3	Total	1,234,836	65,036	65,036	65,036	108,393	108,393	108,393	108,393	108,393	108,393	151,751	-	-	997,219

			Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	June 2017	Jul 2017	Aug 2017	Sep 2017	Oct 2017	Nov 2017	Dec 2017	Cumulative LBR Savings
4	Monthly Residential Savings	29,842	1,610	1,610	1,610	2,683	2,683	2,683	2,683	2,683	2,683	3,757	-	-	
5	Cumulative Residential Savings	29,842	31,452	33,062	34,672	37,356	40,039	42,723	45,406	48,090	50,773	54,530	-	-	418,103
6	Average Residential Distribution Rate		0.35019	0.35019	0.35019	0.35019	0.35019	0.35019	0.35019	0.35019	0.35019	0.35019	-	-	
7	Lost Residential Revenue		$ 11,014	$ 11,578	$ 12,142	$ 13,082	$ 14,021	$ 14,961	$ 15,901	$ 16,840	$ 17,780	$ 19,096	$ -	$ -	$ 146,414
8	Monthly C&I Savings	73,061	3,810	3,810	3,810	6,349	6,349	6,349	6,349	6,349	6,349	8,889	-	-	
9	Cumulative C&I Savings	73,061	76,871	80,680	84,490	90,839	97,188	103,538	109,887	116,236	122,586	131,475	-	-	1,013,789
10	Average C&I Distribution Rate		0.22845	0.22845	0.22845	0.22845	0.22845	0.22845	0.22845	0.22845	0.22845	0.22845	-	-	
11	Lost C&I Revenue		$ 17,561	$ 18,432	$ 19,302	$ 20,752	$ 22,203	$ 23,653	$ 25,104	$ 26,554	$ 28,005	$ 30,036	$ -	$ -	$ 231,602
12	**Total Lost Revenue**		**$ 28,575**	**$ 30,010**	**$ 31,444**	**$ 33,834**	**$ 36,224**	**$ 38,614**	**$ 41,005**	**$ 43,395**	**$ 45,785**	**$ 49,131**	**$ -**	**$ -**	**378,017**

Line 1: Estimated Annualized Residential Savings
Line 2: Estimated Annualized Commercial Savings
Line 3: Line 1 + Line 2
Line 4: Line 1 / 12
Line 5: Prior Month Line 5 + Current Month Line 4
Line 6: ENNG Estimated Avg Distribution Rates
Line 7: Line 5 x Line 6
Line 8: Line 2 / 12
Line 9: Prior Month Line 9 + Current Month Line 8
Line 10: ENNG Estimated Avg Distribution Rates
Line 11: Line 9 x Line 10
Line 12: Line 7 + Line 11

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Table 10. Lost Base Revenue and Savings - 2018 Actual
Actual Monthly and Cumulative Savings (therm) and Lost Base Revenue
January 1, 2018 to December 31, 2018

Line	Description	12/31/2017	Actual Jan 2018	Actual Feb 2018	Actual Mar 2018	Actual Apr 2018	Actual May 2018	Actual June 2018	Actual Jul 2018	Actual Aug 2018	Actual Sep 2018	Actual Oct 2018	Actual Nov 2018	Actual Dec 2018	Cumulative LBR Savings
	Col. A	Col. B	Col. C	Col. D	Col. E	Col. F	Col. G	Col. H	Col. I	Col. J	Col. K	Col. L	Col. M	Col. N	Col. O
1	Residential Annualized Savings	317,225	61,091	26,652	26,188	23,989	23,168	20,726	14,374	22,377	27,216	35,863	-	-	281,644
2	C&I Annualized Savings	700,195	76,897	11,531	46,542	158,159	57,342	32,107	38,304	29,209	61,214	24,271	-	-	535,576
3	Total	1,017,420	137,989	38,183	72,730	182,148	80,511	52,833	52,678	51,585	88,430	60,134	-	-	817,220
4	Monthly Residential Savings	26,435	5,091	2,221	2,182	1,999	1,931	1,727	1,198	1,865	2,268	2,989	-	-	
5	Cumulative Residential Savings	26,435	31,526	33,747	35,930	37,929	39,860	41,587	42,785	44,649	46,917	49,906	-	-	404,836
6	Average Residential Distribution Rate		0.34860	0.34860	0.34860	0.34860	0.52963	0.52963	0.53690	0.53690	0.53690	0.53690	-	-	
7	Lost Residential Revenue		$ 10,990	$ 11,764	$ 12,525	$ 13,222	$ 21,111	$ 22,026	$ 22,971	$ 23,972	$ 25,190	$ 26,795	$ -	$ -	$ 190,566
8	Monthly C&I Savings	58,350	6,408	961	3,878	13,180	4,779	2,676	3,192	2,434	5,101	2,023	-	-	
9	Cumulative C&I Savings	58,350	64,758	65,719	69,597	82,777	87,556	90,231	93,423	95,857	100,958	102,981	-	-	853,856
10	Average C&I Distribution Rate		0.25546	0.25546	0.25546	0.25546	0.15364	0.15364	0.15503	0.15503	0.15503	0.15503	-	-	
11	Lost C&I Revenue		$ 16,543	$ 16,788	$ 17,779	$ 21,146	$ 13,452	$ 13,863	$ 14,483	$ 14,861	$ 15,651	$ 15,965	$ -	$ -	$ 160,531
12	**Total Lost Revenue**		**$ 27,533**	**$ 28,553**	**$ 30,304**	**$ 34,368**	**$ 34,563**	**$ 35,889**	**$ 37,454**	**$ 38,833**	**$ 40,841**	**$ 42,760**	**$ -**	**$ -**	**$ 351,097**

Line 1: Actual Annualized Residential Savings
Line 2: Actual Annualized Commercial Savings
Line 3: Line 1 + Line 2
Line 4: Line 1 / 12
Line 5: Prior Month Line 5 + Current Month Line 4
Line 6: Page addition to NHPUC Docket No. DE 14-216 Attachment OG-1 Proposed Distribution Rate
Line 7: Line 5 x Line 6
Line 8: Line 2 / 12
Line 9: Prior Month Line 9 + Current Month Line 8
Line 10: Page addition to NHPUC Docket No. DE 14-216 Attachment OG-1 Proposed Distribution Rate
Line 11: Line 9 x Line 10
Line 12: Line 7 + Line 11

	10 mo
original filing	$ 378,017
110% of total	$ 415,818
actual to be received	$ 351,097

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Table 11. Calculation of Average Distribution Rates for Lost Revenue
Based on Actual Billing Determinants and Actual Distribution Rates for 2018

Line	Rate	Description	Avg # of Customers	Customer Charge	Billing Determinants - Winter First Therms	Billing Determinants - Winter Excess Therms	Winter Distribution Rates First Therms $/thm	Winter Distribution Rates Excess Therms $/thm	Distribution Volumetric Revenue	Billing Determinants - Summer First Therms	Billing Determinants - Summer Excess Therms	Summer Distribution Rates First Therms $/thm	Summer Distribution Rates Excess Therms $/thm	Summer Distribution Volumetric Revenue	Total Distribution Revenue	Total Volumetric Distribution Revenue	Total Period Therms	Avg Distribution Rate $/therm
	January - April billing determinants & rates		(a)	(b)	(c)		(d)		(e) = (c) X (d)	(f)		(g)		(h) = (f) X (g)	(i) = ((a) x (b)) + (e) + (h)	(j) = (e) + (h)	(k) = (c) + (f)	(l) = (j) / (k)
1	R-1	Residential, Non-Heating	3,094	$16.88	326,395		$ 0.2231		$72,819	0		$ -		$0	$125,045	$72,819		
2	R-3	Residential, Heating	71,075	$24.43	21,860,317	9,358,649	$ 0.3863	$ 0.3197	$11,436,601	0	0	$ -	$ -	$0	$13,172,963	$11,436,601		
3	R-4	Residential Heating, Low Income	6,042	$9.77	1,871,839	677,204	$ 0.1545	$ 0.1278	$375,746	0	0	$ -	$ -	$0	$434,776	$375,746		
4	Total Residential Service				24,058,551	10,035,853			$11,885,165	0	0			$0	$13,732,784	$11,885,165	34,094,404	$ 0.3486
5																		
6	G-41	Low Annual, High Winter Use	9,057	$53.45	3,023,688	10,925,654	$ 0.4383	$ 0.2944	$4,541,795	0	0	$ -	$ -	$0	$5,025,892	$4,541,795		
7	G-42	Medium Annual, High Winter Use	1,405	$160.36	5,265,769	12,779,981	$ 0.3986	$ 0.2655	$5,492,020	0	0	$ -	$ -	$0	$5,717,326	$5,492,020		
8	G-43	High Annual, High Winter Use	54	$688.20	5,721,941		$ 0.2449		$1,401,303	0		$ -		$0	$1,438,466	$1,401,303		
9	G-51	Low Annual, Low Winter Use	1,157	$53.45	337,273	1,286,996	$ 0.2642	$ 0.1717	$310,085	0	0	$ -	$ -	$0	$371,926	$310,085		
10	G-52	Medium Annual, Low Winter Use	375	$160.36	1,423,363	2,350,544	$ 0.2268	$ 0.1511	$677,986	0	0	$ -	$ -	$0	$738,121	$677,986		
11	G-53	High Annual, Load Factor Less Than 90%	37	$708.24	4,274,759		$ 0.1585		$677,549	0		$ -		$0	$703,754	$677,549		
12	G-54	High Annual, Load Factor Greater Than 90%	28	$708.24	5,101,475		$ 0.0605		$308,639	0		$ -		$0	$328,470	$308,639		
13	Total Commercial/Industrial Service				25,148,268	27,343,175			$13,409,378	0	0			$0	$14,323,956	$13,409,378	52,491,443	$ 0.2555
14																		
15	Total Company January - April				49,206,819	37,379,028			$25,294,543	0	0			$0	$28,056,740	$25,294,543	86,585,847	
16																		
17																		
18		May - June billing determinants & rates	(m)	(n)	(o)		(p)		(q) = (o) X (p)	(r)		(s)		(t) = (r) X (s)	(u) = ((m) x (n)) + (q) + (t)	(v) = (q) + (t)	(w) = (o) + (r)	(x) = (v) / (w)
19																		
20					Billing Determinants - Winter		Winter Distribution Rates			Billing Determinants - Summer		Summer Distribution Rates						
21														Summer Distribution		Total Volumetric		Avg Distribution
22			Avg # of	Customer	First	Excess	First	Excess	Distribution Volumetric	First	Excess	First	Excess	Volumetric	Total Distribution	Distribution	Total Period	Rate
23	Rate	Description	Customers	Charge	Therms	Therms	Therms $/thm	Therms $/thm	Revenue	Therms	Therms	Therms $/thm	Therms $/thm	Revenue	Revenue	Revenue	Therms	$/therm
24																		
25	R-1	Residential, Non-Heating	3,095	$14.88	0		$ -		$0	72,911		$ 0.3902		$28,450	$74,504	$28,450		
26	R-3	Residential, Heating	71,944	$14.88	0	0	$ -	$ -	$0	2,990,226		$ 0.5580		$1,668,546	$2,739,073	$1,668,546		
27	R-4	Residential Heating, Low Income	11,665	$5.95	0	0	$ -	$ -	$0	243,635		$ 0.2232		$54,379	$123,786	$54,379		
28	Total Residential Service				0	0			$0	3,306,772	0			$1,751,375	$2,937,362	$1,751,375	3,306,772	$ 0.5296
29																		
30	G-41	Low Annual, High Winter Use	8,908	$56.07	0	0	$ -	$ -	$0	224,684	658,524	$ 0.4597	$ 0.3088	$306,640	$806,111	$306,640		
31	G-42	Medium Annual, High Winter Use	1,410	$168.21	0	0	$ -	$ -	$0	767,601	866,828	$ 0.4181	$ 0.2785	$562,345	$799,522	$562,345		
32	G-43	High Annual, High Winter Use	55	$721.86	0		$ -		$0	706,683		$ 0.1174		$82,965	$122,667	$82,965		
33	G-51	Low Annual, Low Winter Use	1,166	$56.07	0	0	$ -	$ -	$0	141,691	324,214	$ 0.2271	$ 0.1801	$90,569	$155,946	$90,569		
34	G-52	Medium Annual, Low Winter Use	381	$168.21	0	0	$ -	$ -	$0	613,316	509,179	$ 0.1724	$ 0.0980	$155,635	$219,723	$155,635		
35	G-53	High Annual, Load Factor Less Than 90%	37	$742.88	0		$ -		$0	1,371,047		$ 0.0798		$109,410	$136,896	$109,410		
36	G-54	High Annual, Load Factor Greater Than 90%	28	$742.88	0		$ -		$0	2,998,212		$ 0.0344		$103,138	$123,939	$103,138		
37	Total Commercial/Industrial Service				0	0			$0	6,823,233	2,358,745			$1,410,702	$2,364,804	$1,410,702	9,181,977	$ 0.1536
38																		
39	Total Company May - June				0	0			$0	10,130,005	2,358,745			$3,162,077	$5,302,167	$3,162,077	12,488,749	
40																		
41																		
42		July - October billing determinants & rates	(y)	(z)	(aa)		(bb)		(cc) = (aa) X (bb)	(dd)		(ee)		(ff) = (dd) X (ee)	(gg) = ((y) x (z)) + (cc) + (ff)	(hh) = (cc) + (ff)	(ii) = (aa) + (dd)	(jj) = (hh) / (ii)