STATE OF MAINE
PUBLIC UTILITIES COMMISSION

	)	
BANGOR NATURAL GAS COMPANY	)	
	)	Docket No. 2019-00105
Request for Approval of Precedent Agreements with	)	
Westbrook Xpress Phase III Project	)	
	)	

DIRECT TESTIMONY OF

PAUL CHERNICK

ON BEHALF OF

CONSERVATION LAW FOUNDATION

Resource Insight, Inc.

AUGUST 20, 2019

PUBLIC

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EXHIBITS

I. Identification & Qualifications

Q: Mr. Chernick, please state your name, occupation, and business address.

A: My name is Paul L. Chernick. I am the president of Resource Insight, Incorporated, 5 Water Street, Arlington, Massachusetts.

Q: Summarize your professional education and experience.

A: I received a Bachelor of Science degree from the Massachusetts Institute of Technology in June 1974 from the Civil Engineering Department, and a Master of Science degree from the Massachusetts Institute of Technology in February 1978 in technology and policy.

I was a utility analyst for the Massachusetts Attorney General for more than three years, and was involved in numerous aspects of utility rate design, costing, load forecasting, and the evaluation of power supply options. Since 1981, I have been a consultant in utility regulation and planning, first as a research associate at Analysis and Inference, after 1986 as president of PLC, Inc., and in my current position at Resource Insight since 1990. In these capacities, I have advised a variety of clients on utility matters.

My work has considered, among other things, the cost-effectiveness of prospective new electric generation plants and transmission lines, retrospective review of generation-planning decisions, ratemaking for plants under construction, ratemaking for excess and/or uneconomical plants entering service, conservation program design, cost recovery for utility efficiency programs, the valuation of environmental externalities from energy production and use, allocation of costs of service between rate classes and jurisdictions, design of retail and wholesale rates, and performance-based ratemaking and cost recovery in restructured gas and electric industries. My professional qualifications are further summarized in Exhibit PLC-1.

Q: Have you testified previously in utility proceedings?

A: Yes. I have testified over three hundred times on utility issues before various regulatory, legislative, and judicial bodies, including utility regulators in thirty-seven states and six Canadian provinces, and three U.S. federal agencies. This previous testimony has included many reviews of the economics of power plants, utility planning, marginal costs, and related issues.

Q: On whose behalf have you worked?

A: A large percentage of my testimony has been filed on behalf of consumer advocates (e.g., the Massachusetts, New Mexico, Washington, and Illinois Attorney Generals; other official public consumer advocates in Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Pennsylvania, Illinois, Minnesota, Maryland, Ohio, Vermont, Indiana, South Carolina, Arizona, West Virginia, Utah, District of Columbia, and Nova Scotia; and such non-profit consumer advocates as AARP, East Texas Legal Services, Public Interest Research Groups, Alliance for Affordable Energy, citizens' groups, Ontario School Energy Group, Citizens Action Coalition, and Small Business Utility Advocates). I have also worked for regulatory bodies in Massachusetts, Connecticut, District of Columbia, and Puerto Rico, as well as the Vermont House of Representatives.

The remainder of my clients include investor-owned and municipal utilities, municipalities (New York City, Chicago, Cincinnati, several Massachusetts, New Hampshire and New York towns in various proceedings), large customers, power-plant developers and owners, labor unions, energy advocates and environmental groups.

Q: Have you testified previously before the Maine PUC?

A: Yes. I have filed testimony before the Maine PUC in about seven proceedings, starting with multiple dockets related to Seabrook in 1984, on behalf of the Public Advocate and Staff. Those proceedings are listed in my qualifications. Most recently, I filed testimony on behalf of Conservation Law Foundation in docket no. 2019-00101.

II. Introduction

Q: On whose behalf are you testifying?

A: I am testifying on behalf of Conservation Law Foundation.

Q: What is the scope of your testimony?

A: In this docket, Bangor Natural Gas Company (the "Company") has submitted a petition (the "Petition") requesting that the Maine Public Utilities Commission approve precedent agreements and related agreements (the "Agreements") for the Company to obtain firm upstream natural gas transportation capacity including capacity to be made available under the third phase of the Westbrook Xpress Project (WXP), for 15-year initial terms including the winters of 2022/23 through 2037/38. I consider the following issues related to the request:

- whether the Company's assumptions about load are consistent with Maine's statutory carbon emissions reduction targets and commitment to high-performance air-source electric heat pumps;
- the role of electrification in the state's energy future;
- the use of gas in the state's energy future;
- the cost-effectiveness of the Agreements; and
- alternatives to increased pipeline capacity.

Q: What are your conclusions?

A: I do not believe that the Agreements would be economically advantageous for the Company's customers. While the commodity cost of the Dawn supply would be lower than the commodity plus adder for the Algonquin supply, the cost of the WXP capacity would outweigh that commodity advantage over the course of the year.

In addition, it is unreasonable for the Company to commit to 15-year contracts on the basis of current system demand without conducting any analysis of what its customer base or demand will be over the terms of the Agreements. The assumption that current system demand will be maintained is inconsistent with Maine's statutory carbon emissions reduction targets and commitment to high-performance air-source electric heat pumps.

Further, electricity is preferable to natural gas as an energy source to displace oil, especially for space and water heating. Compliance with state policies and statutes will require both large increases in energy efficiency and a broad movement toward electricity and away from natural gas during the course of the Agreements' 15-year terms. Both conservation and electrification will reduce the Company's sales, the need for the Agreements, and the cost-effectiveness of the Agreements.

There is a significant risk that the increased capacity the Company seeks will not remain useful through 2037. A commitment to long-term gas capacity contracts nearly two decades into the future exposes customers to unnecessary risks.

Q: What is the Company's stated basis for contracting for long-term gas supply on the Westbrook Xpress?

A: The Company's basis for adding the Westbrook Xpress to its existing supplies is that the additional capacity will:

> …help ensure the continued reliability of the Company's natural gas service for the future…. [and] result in better price stability and certainty in cost of gas for ratepayers. Holding upstream pipeline capacity will also allow the Company to diversify and enhance its gas supply portfolio because of the ability to source gas at the Dawn Index, in addition to the Algonquin Index. Further, having access to gas priced at the Dawn Index will enable the Company to secure gas supply at prices that have historically been less volatile than the Algonquin Index.

Petition at 1.[1]

In other words, the claimed benefits of the Westbrook Xpress are "continued reliability" and "better price stability and certainty in cost of gas," due to the ability to purchase spot gas on the Dawn Index, rather than the Algonquin Index. The Petition does not claim that Westbrook Xpress will reduce customer gas rates, but that position is suggested in Confidential Appendix 2.

Q: What firm gas supplies is Bangor Gas losing, so that reliability of service would be endangered without Westbrook Xpress?

A: The Company does not identify any such supplies.

Q: If the Company is not losing any supply, is it anticipating growth in loads that would raise reliability concerns in the absence of Westbrook Xpress?

A: Not that the Company has asserted. BEGIN CONFIDENTIAL [redacted]

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[1] Note that prices can be very stable and very certain, but also very high. The total cost of the WXP supplies are likely to be more stable than spot purchases in New England, although not necessarily more stable than hedged purchases, but the WXP price is likely to be higher than the New England price.

[redacted]

END CONFIDENTIAL Confidential Response to CLF-001-015. The Company has not conducted any load forecasting for the period covered by the 15-year Agreements.[2]

The Company assumes that current system demand will persist over the term of the contracts at the average consumer throughput for the last three years.[3]

Q: Is the Company's assumption that current system demand will persist over the term of the contracts reasonable?

A: Without efforts to acquire new customers, the Company's sales would probably fall over time. The usage of existing customers would tend to decline as older gas equipment and converted oil boilers are replaced with more efficient modern equipment and as customers improve their building shells. Some of these actions are facilitated by Efficiency Maine Trust, while others will occur simply because new equipment uses less energy and people prefer less drafty houses and lower utility bills. The Company's assumption that it will maintain current system demand, despite its current efforts to encourage increases in its sales,[4] demonstrates the natural trend in gas sales to the

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[2] "MS. GREEN: Could you describe the extent to which the company has engaged in any sort of load forecasting for any period of time covered by the contracts?

MR. LIVENGOOD: We do forecast one year out as part of our supply RFP and hedging program. That's the most we've done."

Technical Conference Transcript (July 23, 2019) at 30:18-20.

[3] Technical Conference Transcript (July 23, 2019) at 30:5-7; *see also* Confidential Response to CLF-001-015.

[4] *See, e.g.,* http://www.bangorgas.com/sign-up-for-service; http://www.bangorgas.com/upcoming-service/; www.bangorgas.com/natural-gas-conversion/;

Company's existing customers is downward and stability can be maintained only through vigorous promotion of new sales.

Over the course of the Agreements, the Company's efforts to increase sales would be inconsistent with increased efficiency and electrification required by existing statutes, described in greater detail below.

Q: Has the Company demonstrated a likelihood that the cost of the Westbrook Xpress contracts and gas purchased at Dawn would be lower than its existing supplies?

A: No. While the Company presents some analyses in Confidential Appendix 2 that purport to reach that conclusion, several of the underlying assumptions are inconsistent and incorrect.

First, BEGIN CONFIDENTIAL [redacted]

[redacted]

[redacted]

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www.bangorgas.com/conversion-financing/; www.bangorgas.com/service-area/; http://www.bangorgas.com/safety-information/natural-gas-and-the-environment/.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted] END CONFIDENTIAL

Q: Have you corrected these apparent errors in the Company's analysis?

A: Yes. I started with the monthly forward prices for the Algonquin and Dawn Hubs, using data from ICE for September 2019 through December 2022.[5] I then computed the load that would be served by WXP, using the load data from the Company's analysis for 2017/18, to reflect the uneven loads and WXP usage within each month. I priced out the Algonquin portion at the forward price plus the historical monthly Algonquin adders, from Table 1. I compared that cost to the monthly price of supply from Dawn, using corrected values for the fuel rate, effective capacity, and commodity rate.

The result of this analysis was that the commodity cost of the Dawn supply, even including the corrected usage and commodity rates, would be lower than the commodity plus adder for the Algonquin supply. But that

[5] https://www.theice.com/marketdata/reports/142

advantage is swamped by the costs of the WXP capacity in April to November of every year for which I have forward prices. WXP does save a lot of money in December to February, and a little in March, but that is not enough to outweigh the losses in the other eight months.

In short, WXP supply does not appear to be economic.

III. Targets for Reducing Greenhouse Gas Emissions

Q: What is the environmental and policy background to decisions about natural gas use?

A: Natural gas use, in Maine and nationally, must decline if we are to avoid the most severe consequences of global warming. In 2018—a year of record-breaking weather extremes[6]—the Intergovernmental Panel on Climate Change released a report linking human-caused climate change to wide-ranging impacts on natural and human systems.[7] The report emphasized that "[f]uture climate-related risks depend on the rate, peak and duration of warming."[8]

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[6] *See, e.g.,* NOAA National Centers for Environmental Information, State of the Climate: Global Climate Report for Annual 2018, published online January 2019. Available at https://www.ncdc.noaa.gov/sotc/global/201813.

[7] International Panel on Climate Change, Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y.Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]

[8] IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-

Climate-related risks are projected to be higher in scenarios assuming global warming of 2º Celsius than in scenarios with global warming of 1.5º Celsius.[9] Climate mitigation to reduce the global temperature would reduce climate-related risks.[10]

Maine has joined a number of other states in setting targets for emissions of greenhouse gases. The recently enacted *Act to Promote Clean Energy Jobs and to Establish the Maine Climate Council*, P.L. 2019, ch. 476, requires:

> By January 1, 2030, the State shall reduce gross annual greenhouse gas emissions to at least 45% below the 1990 gross annual greenhouse gas emissions level.
>
> By January 1, 2040, the gross annual greenhouse gas emissions level must, at a minimum, be on an annual trajectory sufficient to achieve the 2050 annual emissions level.
>
> By January 1, 2050, the State shall reduce gross annual greenhouse gas emissions to at least 80% below the 1990 gross annual greenhouse gas emissions level.

38 M.R.S. § 576-A (1)-(3).

Q: What does the 2030 greenhouse gas reduction target mean for Maine gas consumption?

A: Table 3 shows energy-related carbon dioxide emissions in Maine in 1990 and 2016, the latest available data.[11]

Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)], at 5. In Press.

[9] *Id.*

[10] *Id.*

[11] https://www.eia.gov/environment/emissions/state/. I do not have comparable data for all other greenhouse gases.

Table 3: Maine Carbon Dioxide Emissions (million tonnes)

		1990	2016
Buildings			
	Coal	0.10	0.00
	Oil	5.00	3.94
	Natural Gas	0.12	0.61
Industry			
	Coal	0.52	0.04
	Oil	2.87	0.43
	Natural Gas	0.11	1.04
Transportation			
	Coal	0.00	0.00
	Oil	8.24	8.89
	Natural Gas	0.00	0.04
Electric Generation			
	Coal	0.36	0.17
	Oil	1.77	0.11
	Natural Gas	0.01	1.21
Total			
	Coal	0.98	0.21
	Oil	17.89	13.36
	Natural Gas	0.24	2.89
	Total	19.12	16.46

Reducing CO_2 emissions 45% from 1990 levels would bring emissions to 10.5 million metric tonnes, 36% below 2016 levels.

Q: Could Maine reach that level by switching all fuel use to natural gas?

A: No. Table 4 shows that switching 100% of coal and oil fuel use to gas would reduce emission to 12.8 million tonnes, only 62% of the reduction required from 2016 to 2030.[12]

[12] This computation excludes the additional emissions related to energy used for compressing gas for vehicle use, methane leakage from new gas mains and services, and upstream methane emissions from production, gathering and interstate transportation.

Table 4: Carbon Emissions with other Fuels Switched to Gas[13]

		2016	Gas:fuel Ratio	2030
Buildings				
	Coal	0.00	56%	0.00
	Oil	3.94	73%	2.85
	Natural Gas	0.61	100%	0.61
Industry				
	Coal	0.04	56%	0.02
	Oil	0.43	67%	0.29
	Natural Gas	1.04	100%	1.04
Transportation				
	Coal	0.00		0.00
	Oil	8.89	74%	6.58
	Natural Gas	0.04	100%	0.04
Electric Generation				
	Coal	0.17	56%	0.09
	Oil	0.11	67%	0.08
	Natural Gas	1.21	100%	1.21
Total				
	Coal	0.21		0.12
	Oil	13.36		9.79
	Natural Gas	2.89		2.89
	Total	16.46		12.80

This hypothetical, inadequate as it is, is clearly impractical. The gas distribution system will not be extended to every oil-heated building, and natural gas is unlikely to ever serve a large share of the transportation fuel market.

Reaching Maine's emission goals will require reducing the amount of fuel burned, by some combination of end-use efficiency, replacing fossil-fueled electric generation with renewables, and shifting end-use combustion of fossil fuels to higher-efficiency electric equipment, served by increasing amounts of renewable resources and declining reliance on fossil fuel generators.

[13] Assumes that oil is #2 distillate for buildings, mostly gasoline for transportation, and #6 residual for other sectors.

IV. Shifting Energy Load

Q: Is natural gas the preferred energy choice for space and water heating?

A: No. Compared to natural gas combustion at the end use, electricity can provide energy services while emitting less greenhouse gases, so long as it is either (1) sourced largely from renewable resources, including wind, solar and Canadian hydro or (2) produced and used in a manner that is more efficient than direct gas use at the end use.

Q: Is electric space heating as efficient as gas heating?

A: Yes. Modern high-efficiency heat pumps have a seasonal performance factors in the range of 9.5 to 12 Btu/kWh, which means that they provide 2.8 to 3.5 units of usable heat for each unit of input electric energy. In other words, they are 280% to 350% efficient. A very efficient gas furnace or boiler might be in the 90%–95% range. The heat pump is thus three to four times as efficient as the gas space heating appliance. So unless the electricity for the heat pump comes from a mix of power plants that emit three or four times more CO_2 than direct gas combustion per unit of energy delivered to the home, emissions will be less with the heat pump than with a gas furnace or boiler. As I show below, the emissions of the New England electric system are far below those levels, so using electricity rather than natural gas will almost always reduce carbon emissions.

Q: What sources would serve loads shifted to electricity?

A: The emissions associated with electricity depend on the type of generator that provides the energy. Additional wind, solar and hydro added to serve the loads have nearly zero emissions. Maine's Renewable Portfolio Standard requires that 40% of electric energy load be met with Class I, Class IA and Class II renewables, rising to 80% in 2030 and 100% in 2050.[14] The definition of "renewable" resources in Maine is rather broad, including fuel cells and plants that burn wood and municipal solid waste. Nonetheless, a large portion of incremental electric load in Maine is likely to be met by wind and solar generation.

My conclusion is confirmed by a study of the sources of renewable energy likely to meet the expanded Maine RPS, which estimates that about 65% of the additional energy will be from wind, 20% from solar, 5% from hydro, and 10% from other renewables, which the authors expect to be mostly expanded biogas facilities.[15]

Q: What about the portion of the electric supply for new loads that is not served by new renewable resources?

A: The portion of new load that is not offset with new renewable resources will be served by the marginal energy supply on the ISO-NE system. According to the 2018 Annual Markets Report from the ISO Internal Market Monitor (May 23, 2019), the real-time marginal energy supply was from natural gas over 70% of the time, with nearly another 20% from pumped storage (which generally would be refilled by energy from natural gas or surplus renewables) and 2% from other hydro (which was probably mostly storage hydro that would otherwise have saved the water to generate at a later hour, competing displacing gas). The remaining 7% or so of marginal supply was provided by about equal parts oil, coal, wind, and unspecified.

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[14] An Act To Reform Maine's Renewable Portfolio Standard, P.L. 2019, ch. 477, § 1.

[15] Maine Renewable Portfolio Standard: Examination of the Benefits and Costs of a Proposed RPS Policy Reform, Technical Appendix, Sustainable Energy Advantage, LLC & Synapse Energy Economics, Inc., May 2019, pp. 9–10.

Hence, the energy for a marginal electric load, like a new heat pump, would come almost entirely from clean renewables or from natural gas. Over time, the gas portion of power supply will shrink as renewables dominate Maine's energy supply.

Q: Will coal continue to be a significant contributor to New England electricity supply?

A: No. New England coal is rapidly being retired. Since 2011, about 66% of New England coal capacity has retired. The largest remaining coal unit, Bridgeport Harbor 3 (42% of the remaining capacity), is committed to retire in 2021, while New Hampshire's Schiller 4 has not cleared in the capacity market for 2021/22 or 2022/23 and Schiller 6 has dropped from clearing its full 47.8 MW for 2020/21, to 30 MW in 2021/22 and 14.5 MW in 2022/23. Schiller 4 and 6 have been running at very low capacity factors (8% and 7% in 2017, 11% and 15% in 2018, 6% and 8% in January–May 2019), which are unlikely to cover the costs of keeping them in service. Once those three units are gone, New England will be left with only Merrimack 1 and 2, which have run very little in recent years: 9% and 5% in 2017, 17% and 13% in 2018, and 14% and 8% so far in 2019. Since the first part of the year includes most of the winter conditions in which coal and oil plants are most likely to operate, the decline in operation from the coal plants is even more striking. Output for the first five months is down 54% from 2018 to 2019 for Merrimack 1, 63% for Merrimack 2, and 67% for Schiller 4 and 6.[16]

[16] The poor performance of Merrimack is not surprising, since its operating costs (just fuel and O&M from the FERC Form 1, p. 402, excluding capital additions and overheads, such as insurance, taxes, and employee benefits) were 9.0¢/kWh in 2016, 11.5¢/kWh in 2017, and 14.9¢/kWh in 2018. Schiller 4 and 6 were reported with wood-fired Schiller 5 in PSNH's FERC Report, so I do not have similar data for those units.

In addition, 1,500 MW of gas-fired capacity are expected to enter operation in 2019–2023, which will further push coal (and oil, and inefficient older gas plants) out of the dispatch stack.

Q: How do the carbon emissions from natural gas combustion for electricity compare to the emission from natural gas combustion for space heating?

A: From the EIA 923 database for 2018, I calculate that the average natural-gas heat rate (MMBtu of fuel per MWh of output) for New England was 7.4 MMBtu/MWh, or 46% efficient. Some of the energy generated is dissipated as heat, but the delivered efficiency is still over 40%. So long as the electricity is converted to heat at an efficiency of more than about 2.5, electric space heating uses less gas than direct gas combustion at the end use. Since the majority of the incremental electric energy delivered to new loads during the life of the Westbrook Xpress contracts would be from low-carbon renewables, the gas used for electric heating would be much less than that for gas heating.

Q: How does that comparison work out for water heating?

A: Heat-pump water heaters (HPWH) are less efficient than heat-pump space heaters. A 2016 report of HPWH performance in the Northeast, presumably using a mix of older heat pumps, reported both rated Efficiency Factor (measured using a particular set of temperature and usage parameters) and measured coefficient of performance (COP) in Massachusetts and Rhode Island.[17] Table 5 shows the results of those studies, along with an extrapolation to current EF ratings.

[17] Field Performance of Heat Pump Water Heaters in the Northeast, Carl Shapiro and Srikanth Puttagunta, Consortium for Advanced Residential Buildings, National Renewable Energy Laboratory, February 2016,

Table 5: HPWH Efficiency

		pre-2016		2019	
Model	**Capacity (gal)**	**Rated Energy Factor**	**Average New England COP**	**Rated Energy Factor**	**Extrapolated New England COP**
		A	*b*	*c*	*d*
GE	50	2.35	1.82	3.25	2.52
A,O. Smith	60/80	2.33	2.12	3.24	2.95
Stiebel Eltron	80	2.51	2.32	3.05	2.82

a Shapiro and Puttagunta, Table 3
b Shapiro and Puttagunta, Table 1
c https://mozaw.com/heat-pump-water-heater-reviews/
d $c \times b \div a$

Gas-fired water heaters have rated efficiencies of 0.65 to 0.93.[18] So electric heat-pump water heating is at least 2.7 times as efficient as gas water heating (comparing the best gas storage water heater to the worst HPWH in Table 5), so less gas is used for HPWH than for the best gas water heaters. And as more of the electric supply is provided by renewables over time, the advantage of the electric equipment increases.

Q: What are the implications of the higher efficiency of electricity, as opposed to direct gas combustion, for space and water heating?

A: Since using electricity reduces gas use, it reduces greenhouse gas emissions, reduces pollutants (assuming the same emissions per therm burned), and could help relieve regional concerns about winter availability of gas capacity and supplies by freeing up space in existing pipelines to deliver gas to gas-fired generators in New England. In addition, since the gas-fired generation has emission controls and closer operational control than gas-fired end-use appliances, the emissions per therm from the power plants will tend to be lower than emissions from the gas appliances, and whatever pollutants are released are not in buildings or as near them as for gas appliances.

[18] https://www.energystar.gov/productfinder/product/certified-water-heaters/

Q: Does electricity have advantages over natural gas in terms of pollutants, other than greenhouse gases?

A: Yes. Natural gas combustion emits NOx, CO, and (depending on combustion conditions) particulates. Burning gas for space heating, water heating and clothes drying emits the pollutants close to occupied building space (or in it, if the equipment is not working properly), while gas cooking emits pollutants inside those buildings. Non-combustion renewables produce none of those pollutants. Burning gas to produce electricity is not benign, but it produces little CO or particulates, and most gas-fired power plants have controls to reduce NOx emissions. And whatever NOx is emitted by electric generation is not in (or usually adjacent to) occupied buildings.

Q: Has electricity always been preferable to direct fossil-fuel heat sources environmentally or in terms of efficiency, for New England energy users?

A: No. In the late 1980s and early 1990s, I pointed out the economic and environmental benefits of switching New England electric end-uses to burn gas.[19] At that point, the New England electric system was largely fueled with high-sulfur heavy fuel oil, which produced much more CO_2, sulfur, NOx, particulate and other pollutants than modern gas-fired combined-cycle units. Solar and wind were not significant parts of the incremental power supply, and renewable portfolio standards were still in the future. In addition, cold-climate heat pumps had not been developed, so electric heating used much more energy than today's new efficient heating systems.

Q: What is Maine's statutory position with respect to replacing fossil fuels with heat pumps?

[19] Any gas appliances installed as a result of my analyses will be nearing the end of their useful lives.

A: The legislature has enthusiastically embraced the transition to high-efficiency electric heat. An Act To Transform Maine's Heat Pump Market To Advance Economic Security and Climate Objectives requires the Efficiency Maine Trust to administer the Heating Fuels Efficiency and Weatherization Fund to reduce heating fuel consumption and to achieve the following goal:

> From fiscal year 2019-20 to fiscal year 2024-25, to install 100,000 new high-performance air source heat pumps in the State to provide heating in residential and nonresidential spaces. "High-performance air source heat pump" means an air source heat pump that satisfies minimum heating performance standards as determined by the [Efficiency Maine Trust].[20]

Q: How will the installation of 100,000 new high-performance air-source heat pumps in Maine affect the market for gas service?

A: The US Census's American FactFinder web site reports that about 439,000 Maine households heat their homes with fossil fuel.[21] Switching nearly 100,000 households to high-performance air-source heat pumps (some homes may use more than one heat pump, some heat pumps will replace resistance electric, and some heat pumps may be installed in commercial properties) would reduce the market for fossil-fuel heating by about 23%. In addition, after installation of so many heat pumps, the distribution and delivery services for heat pumps (wholesalers, retailers, contractors) will be well-developed and many energy consumers will have friends and neighbors with heat pumps, increasing familiarity with the technology and comfort with using that technology. The result would be additional installations of heat pumps, even if Efficiency Maine stops promoting conversion after the first 100,000 units.

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[20] An Act to Transform Maine's Heat Pump Market to Advance Economic Security and Climate Objectives, P.L. 2019, ch. 306, § 6.

[21] https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk.

As customers become comfortable with heat pumps for space heating, they are also likely to look for similar benefits for water heating and install HPWHs.

Within the period of the Westbrook Xpress contracts, some of the Company's existing gas customers will install heat pumps, reducing their space- and water-heating gas loads. And many customers who might have otherwise switched to gas will adopt heat pumps instead. Thus, Maine's existing statutory policies are likely to not only reduce the Company's future load growth, but also to cut into the Company's existing system demand.

Q: Are cold-climate heat pumps economically competitive with oil heat, from the consumer's perspective?

A: Yes. Several analyses have found that the lifecycle costs of heat pumps are lower than those of oil and propane heat.[22]

Q: Have other jurisdictions determined that fossil end uses should be shifted to high-efficiency electric equipment?

A: Yes. For example, the Draft 2019 New Jersey Energy Master Plan found that:[23]

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[22] *See, e.g.,* Energy Savings, Consumer Economics, and Greenhouse Gas Emissions Reductions from Replacing Oil and Propane Furnaces, Boilers, and Water Heaters with Air-Source Heat Pumps, Steven Nadel, July 2018, American Council for an Energy-Efficient Economy, Report A1803; Ductless Heat Pump Meta Study, Faesy, R., et al, Northeast Energy Efficiency Partnerships, November 13, 2014.

[23] Draft 2019 New Jersey Energy Master Plan, Policy Vision to 2050, June 10, 2019. "statewide, multi-agency effort is led by New Jersey Board of Public Utilities (NJBPU)." https://nj.gov/bpu/pdf/publicnotice/EMP Press Release 610_Revised.pdf .

Over the next ten years, the state should prioritize buildings with the lowest cost, and the most pollution, for electrification by incentivizing electrification for existing oil or propane-fueled buildings. NJBPU should also provide incentives for natural gas-fueled properties to transition, as well as terminate existing programs that incentivize the transition from oil heating systems to natural gas heating systems.

Goal 4.2.1: Incentivize transition to electrified heat pumps, hot water heaters, and other appliances. New Jersey should prioritize buildings with oil and propane heating systems for electrification given the cost benefits and pollution reduction potential. … In addition, since the heat pump can also provide high-efficiency air conditioning, there is also an electricity savings. NJBPU should develop a program to ease the financial burden of making this one-time upgrade.

Prioritizing the transition away from oil and propane for residential and commercial buildings is an aggressive but achievable goal with a low-cost impact and a noticeable gain in carbon reductions. It will also set the stage for the more complicated transition away from natural gas in the out years.

Additionally, NJBPU should offer financial incentives for natural gas-heated properties to upgrade to electric heating and cooling now, and ramp down approval of new subsidies that incentivize building owners to retrofit from oil heating systems to natural gas heating systems. ,,,

Goal 4.2.2: Develop a transition plan to a fully electrified building sector…. It is expected that heat pumps will become more economically attractive in colder regions as technology continues to improve and becomes more efficient. …NJBPU expects that beyond 2030, state policy will have to aggressively target existing natural gas-heated buildings.

An interagency task force should be established to work in close coordination with relevant stakeholders to establish a roadmap through 2050 that transitions existing building stock away from fossil fuels.[24]

[24] Draft EMP at 71–72.

Analysis for the California Energy Commission found that "Building electrification was shown to be one of the lower cost GHG mitigation strategies." and that "[r]eplacing gas equipment with electric equipment upon burnout lowers the societal cost of achieving California's climate policy goals."[25]

The Massachusetts Comprehensive Energy Plan recommends, based on analysis of four scenarios including both average and extended cold weather conditions, increased electrification of the thermal sector.[26] Specifically, the plan recommends providing incentives for switching to air source heat pumps for heating.[27]

The Québec 2030 Energy plan shows electricity backing out oil and coal, without expansion of natural gas use.[28]

The New York PSC approved a Con Edison proposal to avoid a pipeline expansion by, among other things, accelerating gas energy-efficiency efforts and shifting gas and oil heating load to electric heat pumps:[29]

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[25] Aas, et al, 2019 (op cit) at 3, 6.

[26] Massachusetts Comprehensive Energy Plan, Commonwealth and Regional Demand Analysis, Massachusetts Department of Energy Resources, December 12, 2018, § 9.2.1.

[27] *Id.*

[28] mern.gouv.qc.ca/english/energy/strategy/pdf/Highlights-The-2030-Energy-Policy.pdf.

[29] Many of the oil-heated building would be required to switch fuels by 2030. NY PSC Case 17-G-0606, Petition of Consolidated Edison Company of New York, Inc. for Approval of the Smart Solutions for Natural Gas Customers Program, Order Approving with Modification the Non-Pipeline Solutions Portfolio, February 7, 2019.

> The planned programs …include the installation of: (1) ground-source heat pumps at 8,800 single-family residences in Westchester County; (2) air-source heat pumps at over 1,000 small and mid-sized multi-family buildings that currently use fuel oil for heating in the Bronx and other areas of the Company's natural gas service territory; and, (3) heat pumps to pre-heat boiler return water at more than 1,000 small commercial and large residential facilities throughout the Company's natural gas service territory.[30]

Even in Con Edison's territory, with very high costs for electric energy, generation capacity and transmission and distribution capacity, the heat pump program was expected to have a benefit-cost ratio of 1.7.[31]

V. Risk of Pipeline Commitments

Q: To what risks are ratepayers exposed as a result of the Company committing to long-term gas delivery contracts?

A: The Company has not demonstrated that the Westbrook Xpress contracts will be beneficial to customers, even in the near term. But even if there were some value to the contracts in 2022, there is a significant risk that they will not remain useful through 2037. As Maine follows through on its commitment to reducing greenhouse gas emissions, the Company will face a declining need for the WXP delivery capacity. The fixed costs of the contracts are likely to be spread over diminishing load by the late 2030s, leaving the Company with the choice of maintaining excess capacity or giving up lower-cost resources that would otherwise renew before the end of the WXP contracts. The Company's remaining gas loads may face higher costs if the Company locks in additional

[30] *Id.*

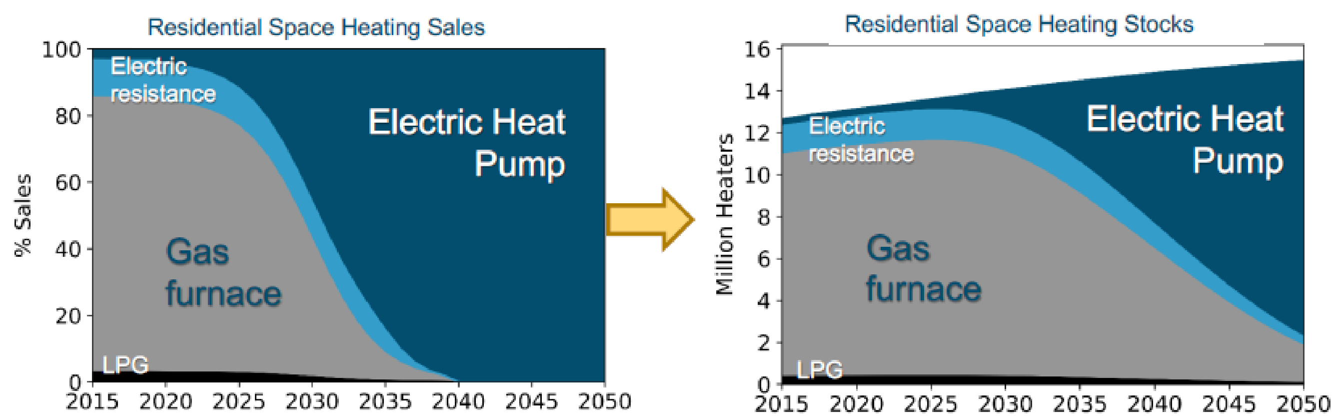
[31] *Id.* at 8.

supply before Maine clarifies the trajectory of the winddown of gas consumption.[32]

Q: Have other jurisdictions recognized the likelihood that natural gas use must decline?

A: Yes. In California, analysis of options for meeting greenhouse gas goals found that the least-cost approach would include a relatively rapid transition of new and replacement heating equipment installations to electricity. Since these appliances tend to be used for many years and replaced rather slowly, the mix of operating equipment (the stock) changes at a slower rate than the mix of sales, as shown in Figure 1. If Maine wants to be carbon-free (or even nearly so) by 2050, it needs to quickly start switching out space- and water-heating equipment.

Figure 1: Projected California Residential Heating Transition[33]

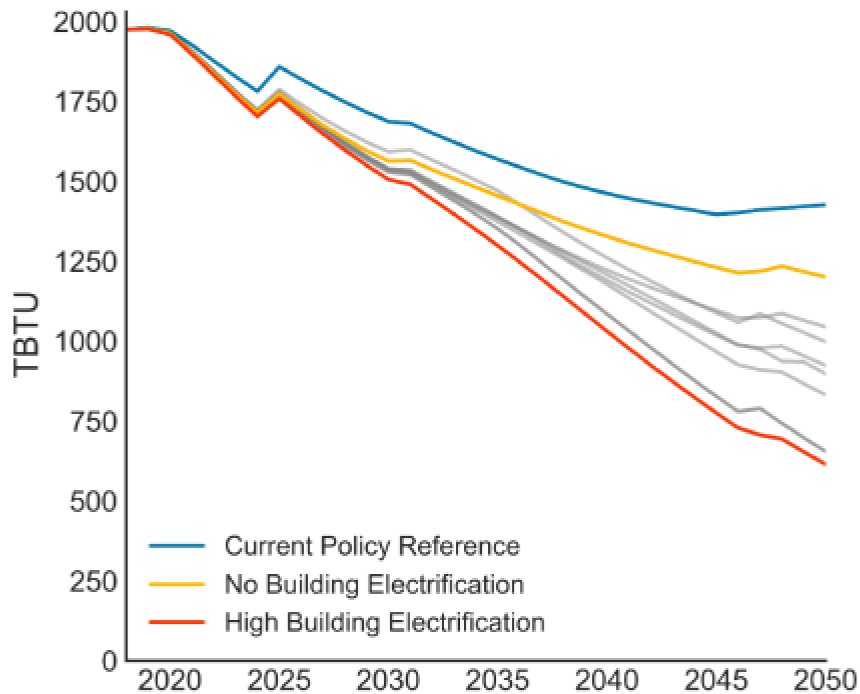


[32] Even after 2050, some gas may continue to flow through the Company's mains, carrying biogas and perhaps other energy-bearing gases produced from excess renewable electricity. Those volumes are likely to be much smaller than the Company's current loads, let alone its projection for 2019/20.

[33] Aas, et al., 2019 (op cit) at 48.

Figure 2 shows the projected deliveries of natural gas (along with biogas and other renewable gas) under the range of approaches considered in the study. The High Building Electrification case is the lowest-cost option.

Figure 2: California Gas Distribution Futures[34]



Q: How are these California results relevant to Maine?

A: Maine's climate and energy use mix differ from California's, so the optimal decarbonization trajectory will not be identical for the two states. But the general relationships are likely to be similar. A low-carbon future requires replacement of fossil-fueled space- and water-heating with electric appliances, as well as increased efficiency.

[34] Aas, et al., 2019 (op cit) at 52.

VI. Alternatives

Q: If Bangor Gas were to anticipate a gap between its resources and its customers' current demand, what options does the Company have to close that hypothetical supply gap?

A: The Company should be working with Efficiency Maine Trust to increase energy-efficiency savings, even if there is no near-term supply gap. In addition, if Bangor Gas were to identify a supply shortfall, and if no firm pipeline gas supplies were available to bridge the gap, large amounts of LNG storage and imports are available.

A. Energy Efficiency

Q: Does the Efficiency Maine Trust operate an aggressive energy-efficiency effort?

A: No. The most recent ACEEE scoreboard (for 2017 savings) shows gas savings of more than 1% of sales in four northern states (including two in New England), compared to about 0.5% for Maine.[35]

[35] https://aceee.org/research-report/u1808

Table 6: Commercial and Residential Gas Conservation, 2017

State	Savings as % of sales
Minnesota	1.35%
Massachusetts	1.08%
Rhode Island	1.02%
Michigan	1.01%
Utah	0.78%
California	0.78%
Oregon	0.73%
District of Columbia	0.73%
Vermont	0.68%
Iowa	0.64%
Arkansas	0.56%
Maine	0.53%

The Massachusetts Joint Statewide Electric and Gas Three-Year Energy Efficiency Plan 2019–2021 (October 31, 2018) includes gas savings of 1.25% of statewide sales.[36]

Acceleration of the Efficiency Maine Trust's energy-efficiency programs would be a lower-cost low-risk approach to meeting the Company's customers' energy needs and would be more consistent with the State's greenhouse gas plans than the Agreements.[37]

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[36] http://ma-eeac.org/plans-updates/

[37] The Legislature has recently amended the state's Efficiency Maine Trust Act such that the state's energy efficiency efforts will be more in line with regional approaches. *See, e.g.*, 35-A M.R.S. § 10111(2):

> When determining the maximum achievable cost-effective natural gas energy efficiency resources . . . [t]he trust shall use, and the commission shall give deference to, values for each element of avoided energy cost from a regional avoided energy cost study as long as the analysis has been developed through a transparent process, with input from state agencies, public advocates, utilities or energy efficiency administrators from at least 3 other states in New England and the analysis has been published not more than 24 months prior to the trust's filing of the triennial plan.

Q: If the Company worked with Efficiency Maine Trust to implement the equivalent of Massachusetts's current efficiency plan, how much would that reduce its current loads?

A: If Bangor Gas does not significantly expand its customer base, so its loads remain constant before energy-efficiency savings, and the energy-efficiency programs were raised to Massachusetts's 1.25% annual savings, over 2020/21 through 2029/30 (the middle of the WXP contract term), the Company's usage would be about 11% and 200 BBtu lower than current levels.[38] The natural turnover of gas-burning equipment and building renovations would further reduce loads.

Q: What is Maine's official policy with respect to installation of heat pumps?

A: Efficiency Maine Trust is required, "by 2030, to provide cost-effective energy efficiency and weatherization measures to substantially all homes and businesses whose owners wish to participate in programs established by the trust." 35-A M.R.S. § 10119(2)(A)(1). Furthermore, Efficiency Maine Trust is obligated to implement heat pumps:

> Cost-effective energy heating fuel efficiency measures must include measures that improve the energy efficiency of energy-using systems, such as heating and cooling systems, through system upgrades or conversions, including conversions to energy-efficient systems that rely on renewable energy sources, high-performance air source heat pumps or other systems that rely on effective energy efficiency technologies.

Id. § 10119(2)(B)(3).

As I note above, the Legislature has codified a goal of the addition of at least 100,000 high-performance air source heat pumps over the next six years.

[38] Continued energy-efficiency efforts would further reduce load in later years.

B. Supplemental LNG Supplies

Q: What are the Company's stated concerns with gas supply?

A: The Company expresses four concerns. First, it worries that the price of gas purchased on a small number of winter days can be very high:

> Due to market changes, including increased customer and weather-driven demand in the region as well as declines in available supply in the region, there have been significant spikes in the Algonquin index. In the winter of 2017-2018 the average price of the top 10 days was $31.87 per Dth. The average price in 2016-2017, 2015-2016, and 2014-2015 respectively were $9.94, $6.35, and $24.99. The basis between Algonquin and Henry Hub continues to be a significant factor in commodity costs and drives higher spot and fixed priced gas costs.

Petition at 5.

It is important to recognize that this concern applies to only a small number of days, and only in some years. In addition, the prices that the Company cites are the prices for gas purchased in the spot market a day or so in advance. Most gas requirements can be purchased much further in advance, in the less-volatile futures markets. Indeed, the stipulation in Docket No. 2016-00040 sets a standard for Bangor Gas to hedge 60% to 75% of its sales in October to April. As of April 2016, the average basis for Algonquin in December 2016 to February 2017 was about $3.90, and the Henry Hub forwards were about $2.90, for a total of $6.77/MMBtu, 32% lower than the selected peaks that the Company spotlights.

Second, Bangor Gas expresses concern about New England's dependence on LNG imports and/or regional LNG storage (the Petition is somewhat vague).

> The New England region is dependent on LNG imports to meet peak day demand, when cold weather increases overall demand for natural gas. …Historically, LNG has been needed to meet 25% of New England's natural gas needs.

Petition at 6.

The Company's "historically" refers to a narrow window from November 2010 to January 2012.[39] Figure 5 below shows that New England imports of liquefied natural gas dropped dramatically in March 2012. Since the LDCs meet essentially all of their load with contract capacity, most of the spot LNG purchases would be occasioned by natural gas demand for generation. As the owner of the Northeast Gateway explained earlier this year:

> Excelerate Energy L.P.'s (Excelerate's) Northeast Gateway Deepwater Terminal (Northeast Gateway), located offshore Boston, reached a peak send-out flow rate of over 800,000 MMBTU per day of natural gas on February 1, 2019, a first for the terminal. The operation was completed by two of Excelerate's floating storage regasification units (FSRUs), *Exemplar* and *Express* discharging in parallel through Excelerate's proprietary offshore buoys.
>
> During the coldest days of the year, demand for natural gas from residential customers rises in New England. Historically, during these times, as natural gas deliverability becomes constrained, power generators have been forced to burn dirtier fuels such as oil. This year, liquefied natural gas (LNG) imports from Excelerate's Northeast Gateway facility have complimented the system by providing a stable, reliable supply of clean energy during this peak demand, allowing generators to continue burning natural gas.

[39] Petition at 6 n 9.

> The terminal is designed to respond to local market conditions in real-time and can ramp up service to ensure energy providers meet customer demand. At a flow rate of 800,000 MMBTU per day, this represents approximately the average gas demand of power generators during recent January – February periods.[40]

Even that power-generation demand has been low in recent years.

Third, the Company then jumps from 2011 imports to 2018/19 sendout from LNG storage facilities in New England (rather than imports), noting that in "cold weather…, LNG becomes a key marginal source of natural gas supply because New England lacks underground storage infrastructure and is not a natural gas-producing region." Petition at 6. That is correct. New England gas utilities and shippers use LNG facilities (storing gas imported by sea over the summer or in the winter, trucked in, or liquefied in the region) to meet winter peak. However, that is a feature of the New England gas system, not a defect. LDCs would be wasting ratepayer money if they were to pay for pipelines that can import gas 365 days a year, in order to meet normal peaks for a handful of winter days, let alone a design peak that occurs only once in a decade or more.

The Company's fourth concern, discussed in greater detail below, is premised on a report from ISO New England regarding the potential for shortfalls in natural gas power generation due to inadequate fuel availability, and has since been addressed by the Inventoried Energy Program and a number of other approaches.

Q: Does New England have adequate LNG import capacity to supplement the Company's gas supply in the near term?

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[40] LNG Imports Helping New England Meet Energy Demand During Extreme Cold Weather, https://excelerateenergy.com/excelerates-northeast-gateway-terminal-ramps-up-send-out-in-arctic-blast/.

A: Yes. New England and the Maritimes have not been using most of their LNG capacity. Figure 3 shows the history of imports through Canaport, from Petition Figure 1.

Figure 3: Utilization of the Canaport LNG Import Facility

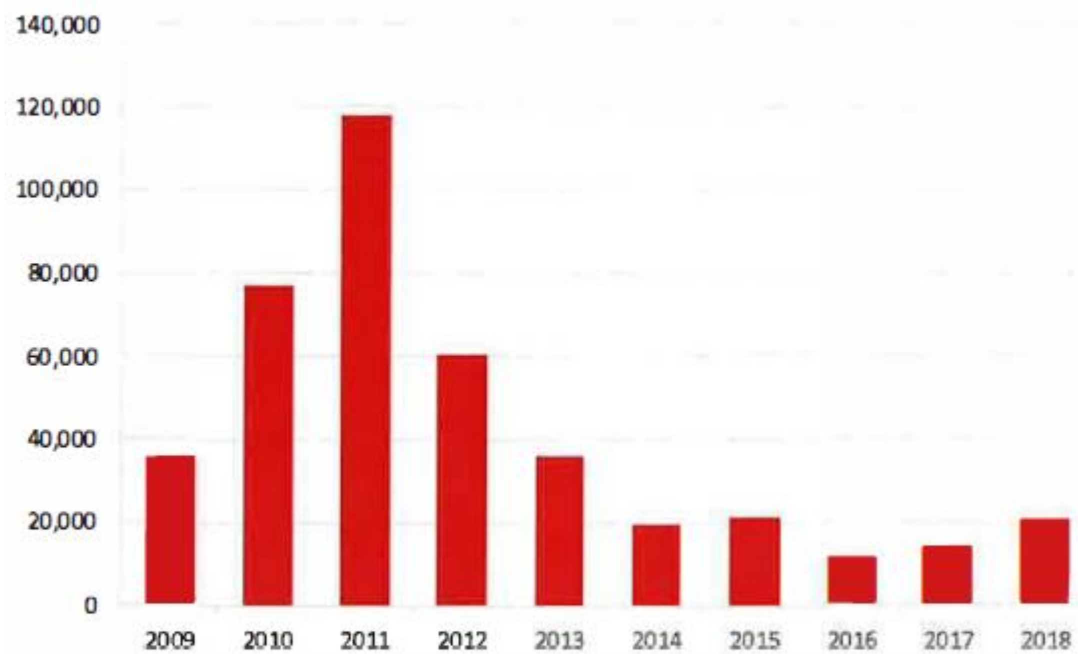
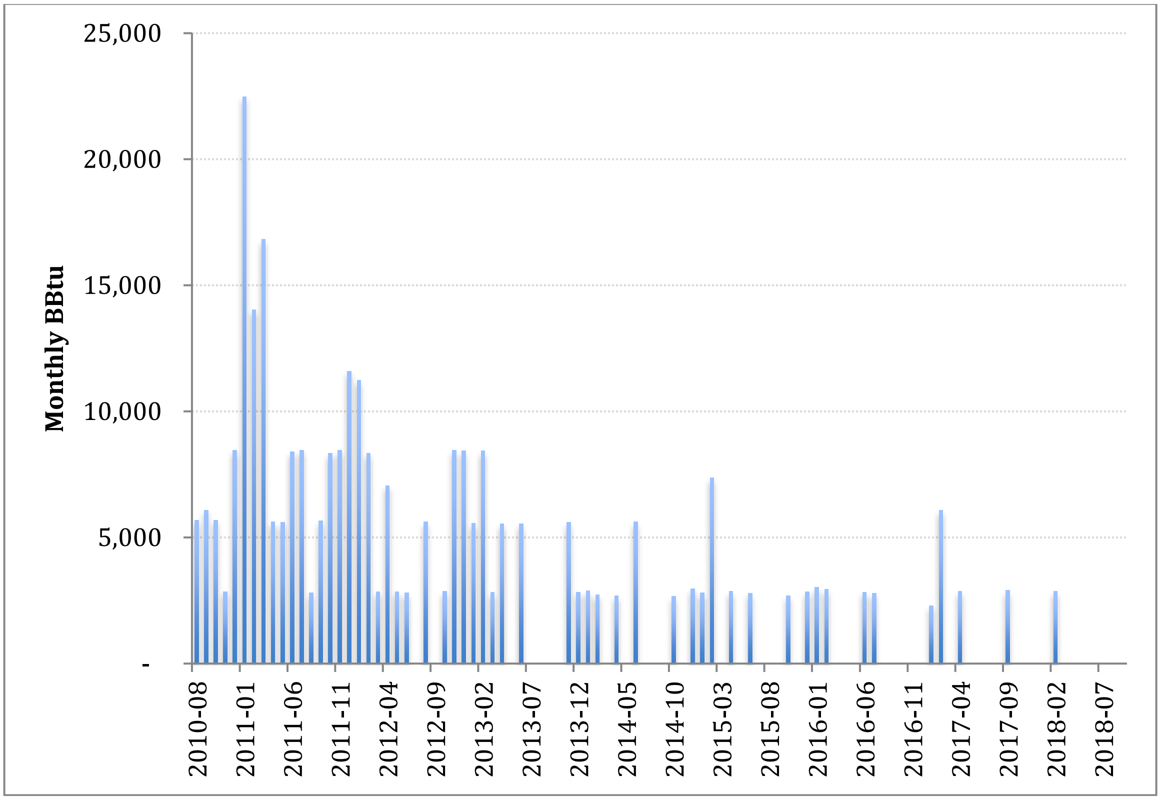


Figure 4 breaks down the deliveries by month, from the Canadian National Energy Board's "Imports of Liquefied Natural Gas."[41]

[41] https://apps.neb-one.gc.ca/CommodityStatistics/Statistics.aspx?

Figure 4: Canaport Monthly Deliveries

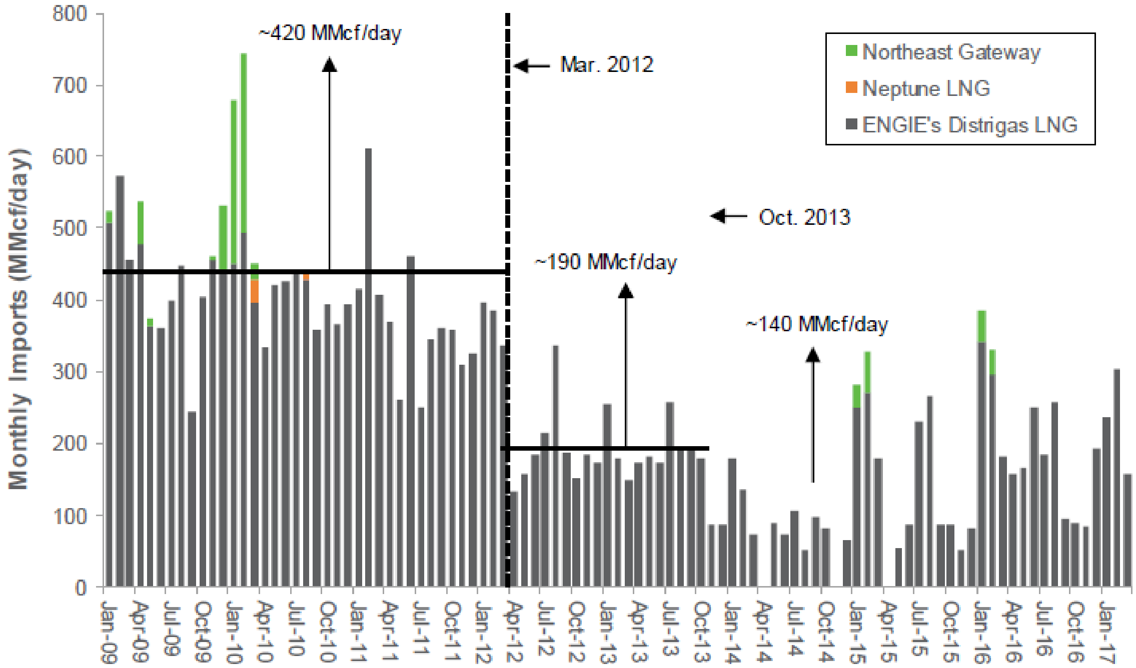


The Petition suggests that the lack of demand for Canaport LNG is some sort of problem, and that Canaport is not providing more gas because "the Canaport LNG storage terminal has reshuffled the services that once provided baseload services to meet demand." Petition at 6. However, Canaport and the other North American LNG facilities are not providing baseload import services because there has been no market demand for those services. The under-utilization of the import facilities is in fact an advantage for gas buyers, since import (and associated storage) capacity is readily available to supplement the Company's supplies during times of high winter demand, without burdening customers with the cost of a long-term capacity contract.

The same pattern is evident in deliveries to the three Massachusetts LNG import facilities: ENGIE's Distrigas LNG facility in Everett, Massachusetts; and two off-shore LNG facilities near Cape Ann, Massachusetts (Excelerate

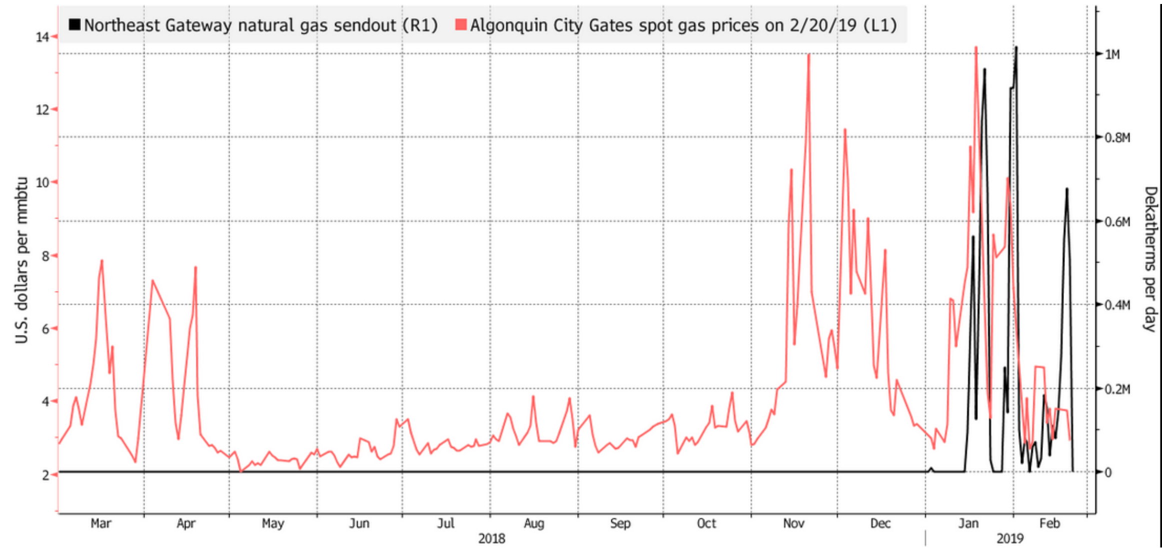
Energy's Northeast Gateway Deepwater Port and ENGIE's Neptune LNG facility).[42] Those trends are shown in Figure 5, copied from Liberty Utilities' 2017 NH IRP. Northeast Gateway was active again last winter, providing 800 BBtu on February 1, 2019, as described in the quote from Excelerate, above, and in Figure 6.

Figure 5: LNG Deliveries to New England Ports



[42] Neptune may be decommissioned, due to lack of demand.

Figure 6: Northeast Gateway 2019 Operation[43]



Q: Is LNG supply expected to increase?

A: Yes. By the end of 2018, domestic gas liquefaction and shipping capacity along the Gulf and the Southeast was expected to more than double in 2019, from 4.9 Bcf/day to about 10 Bcf/day.[44] As of July 31, 2019, 13 Bcf/day of supply was in operation, in commissioning or under construction.[45] Additional LNG supply is under construction in Canada, Australia, Indonesia, Russia, Mozambique, Malaysia, Senegal and Argentina, with more projects proposed.[46]

Between New England's LNG import capacity and global development of additional LNG, to the extent that New England or the Company periodically needs supplemental winter gas during the transition to a low-

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[43] https://www.bloomberg.com/news/articles/2019-02-22/two-month-window-for-priciest-u-s-gas-keeps-this-tanker-adrift

[44] https://www.eia.gov/todayinenergy/detail.php?id=37732.

[45] https://www.eia.gov/naturalgas/U.S.liquefactioncapacity.xlsx.

[46] https://www.igu.org/sites/default/files/node-news_item-field_file/IGU%20Annual%20Report%202019_23%20loresfinal.pdf

carbon economy, the LNG system appears to be adequate to provide that supply.

Q: What is the Company's fourth ill-founded concern about gas supply for electric generation?

A: The Company claims that "a recent report from ISO New England contemplates the potential for shortfalls in natural gas power generation due to inadequate fuel availability….ISO New England has recognized that the foremost challenge to a reliable power grid in New England stems from the possibility that power plants will not have or be able to get the fuel they need to run, particularly in the winter," citing a January 2018 report. Petition at 8–9. That report was part of the support for the ISO's effort to provide incentives for generators to have fuel available over the winter, which has now been implemented through the Inventoried Energy Program, which rewards generators for having stored fuel including committed LNG supplies and stored energy.[47] ISO-NE has used a number of approaches to ensure adequate winter energy supply, and will likely refine its mechanisms in the future (such as by recognizing the winter energy value of wind generation and to a less extent, solar), but there is little likelihood that the ISO will neglect energy reliability in the future. Again, the Company misinterprets good news as harbinger of doom.

Q: What lessons can be extrapolated from the experience of the Northeast LNG import facilities?

A: Just as the Company believes that the Agreements will provide desirable price stability, the developers of Canaport, Neptune and Northeast Gateway thought

[47] FERC Docket ER19-1428-000. The ISO filing is at https://www.iso-ne.com/static-assets/documents/2019/03/inventoried_energy_program.pdf.

they were making reasonable investments for decades of profitable operation. For example, Neptune was licensed in March 2007, entered operation in mid-2010, imported its last gas in October 2010, suspended operations in July 2013, and was slated for decommissioning in a March 2017 filing. The facility went from an innovative addition to New England's gas supply to a white elephant in just a few years.

Five or ten years from now, Bangor Gas, its customers, and the Commission may be in the same position with respect to Westbrook Xpress.

Q: Does this conclude your testimony?

A: Yes.