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Subject: B&V: gas + hydro modeling run

Preliminary Draft Confidential

Please find attached the Black and Veatch supplemental modeling run results assuming gas pipeline and hydro. Like some of the other supplemental analysis outside the four corners of the main study, we do not intend to go back and forth with B&V on edits (the analysis is very straightforward and based on previously agreed upon assumptions) or to post/release. If Managers prefer to post/release, please let me know. Pending hearing that decision, please do not forward outside your offices.

Thanks -

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NATURAL GAS INFRASTRUCTURE AND ELECTRIC GENERATION: PROPOSED SOLUTIONS FOR NEW ENGLAND – MULTIPLE LONG- TERM SOLUTIONS SCENARIO

B&V PROJECT NO. 178511

PREPARED FOR

The New England States Committee on
Electricity

23 NOVEMBER 2013

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1.0 Multiple Long-term Solutions Scenario

At NESCOE's request, Black & Veatch analyzed a scenario assuming both a Cross-Region natural gas pipeline and a Firm Contract Based Canadian Energy Imports solution are developed in New England. This scenario is compared against the High Demand Scenario as referenced in the Gas – Electric Report. Results of these analyses are presented in this addendum.

Scenario Assumptions

This Multiple Long-Term Solutions Scenario describes a future where the demand for natural gas from the residential, commercial, industrial and electric sectors is growing and multiple long-term solutions are constructed to reduce constraints in the natural gas market. The scenario assumes that both the Cross-Region Pipeline and Firm Contract Based Canadian Energy Import solutions as referenced in the Gas-Electric Report will be developed to serve the growing New England market. Specific assumptions include:

- Cross-Region Natural Gas Pipeline - A 1.2 Bcf/d natural gas pipeline is constructed to provide New England with additional natural gas supplies and reinforce existing natural gas infrastructure.
- Firm-Based Energy Imports – An electric transmission line importing 1,200 megawatts (MW) of energy from Canada that delivers *firm* energy supplies, a constant amount of energy equal to the maximum capacity of the transmission line enabled through the construction of additional generation infrastructure.
- All New England states implement incentives to encourage increased residential and commercial usage of natural gas similar to Connecticut's Comprehensive Energy Strategy. However, Black & Veatch lowered assumptions for growth in customer penetration in states that already have high rates of penetration.
- New England states are expected to meet 75% of their RPS targets, rather than the 100% assumed in the Base Case. This assumption increases electric-sector demand for natural gas.
- Lower energy efficiency achievement increases net load growth. The growth rate in energy efficiency was lowered to achieve a 0.20% per year growth rate in electric energy demand over the study period, versus the 0.18% in the more energy-efficient Base Case.
- Expedited nuclear power plant deactivations increase natural gas demand, due to assumed energy replacement from gas-fired power generators. In the Base Case, three nuclear units (Pilgrim, VT Yankee, and Millstone II) are assumed to be deactivated concurrent with licenses expiring in the 2032-2035 time period. In the High Demand Scenario, the licenses are assumed to expire five years sooner.
- An additional 4 Bcf/d of LNG (relative to the Base Case) is assumed to be exported from the Gulf Coast and West Coast between 2017 and 2020, reducing the availability of gas supplies from the Gulf Coast and Appalachian shales to meet New England demand.

- The M&NP can reverse flow to Canada when arbitrage opportunities between prices in New England and Eastern Canada present themselves.

Natural Gas Demand under the Multiple Long-Term Solutions Scenario

New England natural gas demand under the Multiple Long-Term Solutions Scenario is projected to be higher than the Base Case, but lower than the High Demand Scenario due to Canadian energy imports starting in 2018. As shown in Figure 1, by 2029, the demand for natural gas from the power sector is expected to increase to 1,300 MMcf/d, which is 120 MMcf/d lower than in the High Demand Scenario.

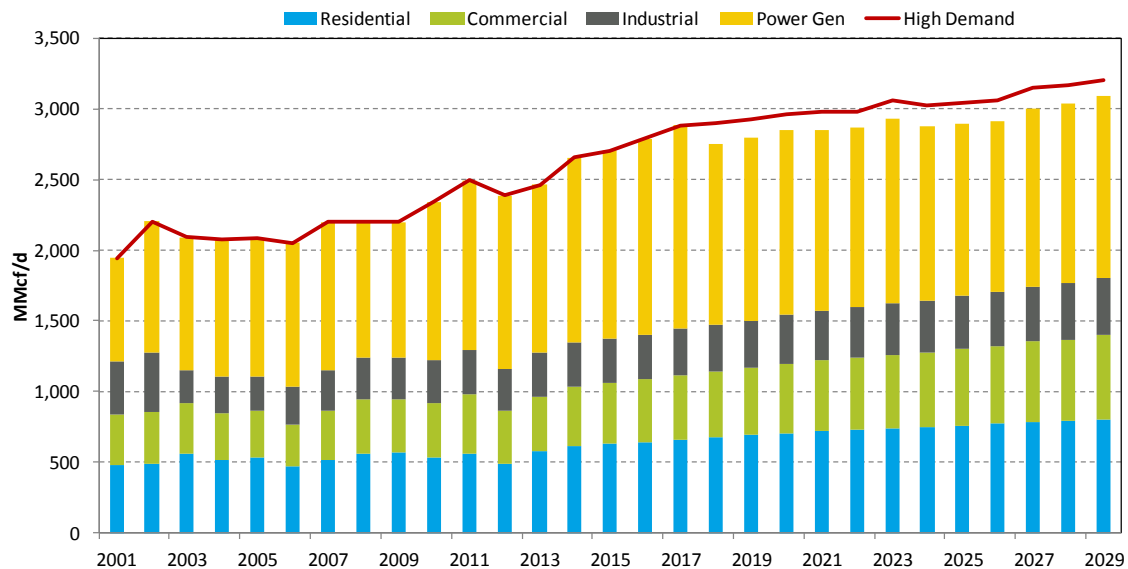


Figure 1 New England Natural Gas Demand: Multiple Long-Term Solutions Scenario

The natural gas demand growth across all sectors will impact the seasonal natural gas demand profile, and increase pipeline infrastructure constraints during peak winter months.

Natural Gas and Electricity Prices under the Multiple Long-Term Solutions Scenario

Similar to the High Demand scenario, New England natural gas basis in the Multiple Long-Term Solutions Scenario, is projected to decline from \$5.00/MMBtu in 2014 to \$1.00/MMBtu in 2016 during peak winter months. The introduction of the Cross-Regional pipeline further reduced peak winter basis. By 2018, the peak winter basis under the Multiple Long-Term Solutions Scenario is \$0.40/MMBtu lower than the High Demand Scenario. As shown in Figure 2, the Cross-Region pipeline starting in spring 2017 will stabilize regional prices and reduce daily price volatility. Winter month basis spikes never re-emerge under the Multiple Long-Term Solutions Scenario. The Multiple Long-Term Solutions Scenario reduces the New England natural gas basis to a lower level than the Scenario with Cross-Regional Pipeline and the Scenario with Firm Canadian Energy Import Scenario.

In the Multiple Long-Term Solutions Scenario, the peak winter basis averages \$0.72/MMBtu, which is \$3.41/MMBtu lower than the High Demand Scenario.

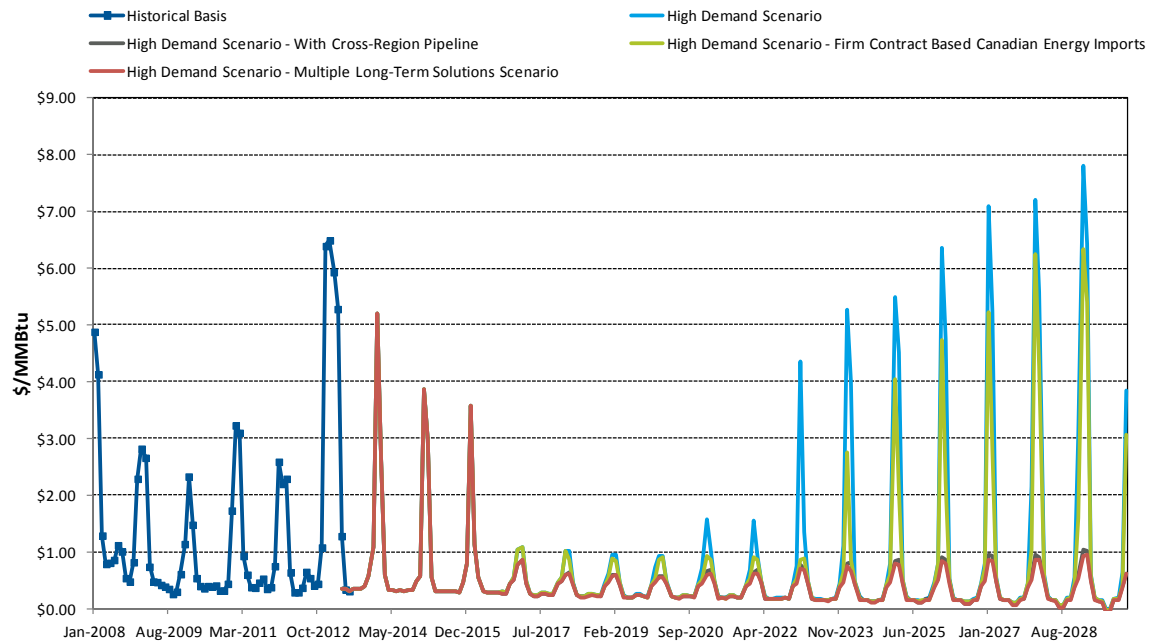


Figure 2 Monthly Algonquin, City-Gates Basis to Henry Hub: Multiple Long-Term Solutions Scenario

As a result of the reduction in regional natural gas basis, and additional energy imports from Canada, the monthly average electricity prices in New England transmission zones are projected to be \$5/MWh lower than in the High Demand Scenario. In the latter half of the analysis period, the Multiple Long-Term Solutions Scenario reduces the average monthly electricity prices in peak winter months by \$16/MWh relative to the High Demand Scenario. It also reduces the peak summer month electricity prices by \$3/MWh relative to the High Demand Scenario.

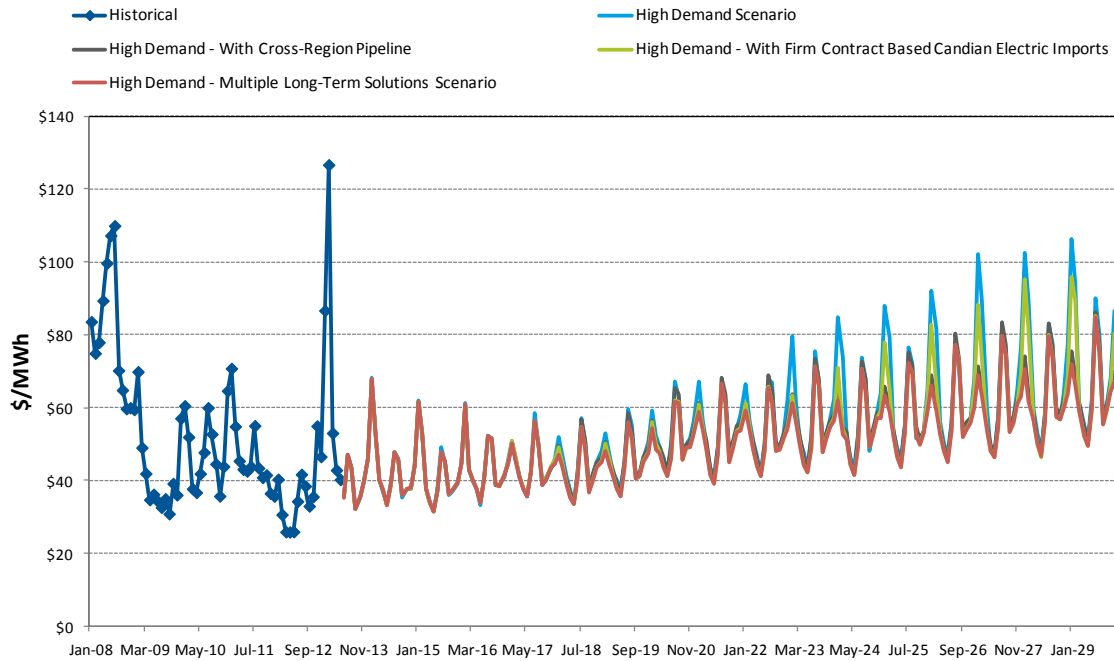


Figure 3 Historical and Projected - Boston Electric Prices for Multiple Long-Term Solution Scenario

Benefits to New England Natural Gas and Electricity Customers

Black & Veatch calculated the gas and electricity market savings that New England customers may experience under the Multiple Long-Term Solutions Scenario relative to the High Demand scenarios. Similar to analyses of other solutions in the Gas-Electric study, Black & Veatch calculated gas and electricity market price reduction benefits separately for the electric customers and the natural gas customers.

As shown in Table 1, the Multiple Long-Term Solutions Scenario generates, on average, \$780 million a year of benefits to New England natural gas and electric consumers. The development of both long-term solutions, the Cross-Region Pipeline and Firm Contract based Canadian Energy Imports, creates additional benefits to the region. Table 1 shows that the New England consumers benefit the most from the reductions in monthly electric price and in natural gas price volatility that the long-term infrastructure solutions provide.

Table 1 Multiple Long-Term Solutions Scenario Customer Benefits

Customer Benefits for Multiple Long-Term Solutions Scenario (in Millions of Dollars)																		
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total	Average
Electric Customer Benefits	\$-	\$-	\$-	\$ 86	\$ 337	\$ 344	\$ 403	\$ 364	\$ 447	\$ 680	\$ 933	\$ 952	\$ 960	\$ 1,340	\$ 1,365	\$ 1,559	\$ 9,769	\$ 751
Monthly Electric Price Reduction	\$-	\$-	\$-	\$ 75	\$ 318	\$ 324	\$ 383	\$ 332	\$ 417	\$ 581	\$ 775	\$ 784	\$ 771	\$ 1,102	\$ 1,101	\$ 1,257	\$ 8,220	\$ 632
Gas Daily Price Volatility Reduction	\$-	\$-	\$-	\$ 11	\$ 19	\$ 19	\$ 20	\$ 32	\$ 31	\$ 99	\$ 158	\$ 168	\$ 189	\$ 238	\$ 264	\$ 302	\$ 1,548	\$ 119
Natural Gas Customer Benefits	\$-	\$-	\$-	\$ 3	\$ 4	\$ 4	\$ 4	\$ 7	\$ 7	\$ 22	\$ 36	\$ 40	\$ 45	\$ 58	\$ 65	\$ 74	\$ 369	\$ 28
Total Benefits	\$-	\$-	\$-	\$ 88	\$ 341	\$ 348	\$ 407	\$ 371	\$ 454	\$ 701	\$ 969	\$ 992	\$ 1,005	\$ 1,398	\$ 1,430	\$ 1,633	\$ 10,138	\$ 780

However, the combined costs of developing the pipeline and transmission infrastructure solutions significantly reduce the net benefits to the region's energy consumers. As shown in Table 2, the Multiple Long-Term Solutions Scenario, on average, provides a \$215 million a year of net benefits, \$100 million higher than the Canadian Energy Imports Solution and \$100 million lower than the Cross-Regional Pipeline solution.

Table 2 High Demand Scenario Cost-Benefit Summary

Total Benefits for Infrastructure Solutions (in Millions of Dollars)																		
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total	Average
Cross-Region Pipeline	\$ -	\$ -	\$ -	\$ 94	\$ 113	\$ 127	\$ 122	\$ 79	\$ 177	\$ 407	\$ 687	\$ 719	\$ 740	\$1,050	\$1,096	\$1,300	\$ 6,712	\$ 516
Firm Contract Based Canadian Energy Imports	\$ -	\$ -	\$ -	\$ -	\$ 264	\$ 270	\$ 333	\$ 296	\$ 385	\$ 621	\$ 763	\$ 623	\$ 557	\$ 781	\$ 613	\$ 634	\$ 6,139	\$ 512
Multiple Long-Term Solutions Scenario	\$ -	\$ -	\$ -	\$ 88	\$ 341	\$ 348	\$ 407	\$ 371	\$ 454	\$ 701	\$ 969	\$ 992	\$1,005	\$1,398	\$1,430	\$1,633	\$10,138	\$ 780

Total Costs for Infrastructure Solutions (in Millions of Dollars)																		
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total	Average
Cross-Region Pipeline	\$ -	\$ -	\$ -	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 176	\$ 2,288	\$ 176
Firm Contract Based Canadian Energy Imports	\$ -	\$ -	\$ -	\$ -	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 389	\$ 4,668	\$ 389
Multiple Long-Term Solutions Scenario	\$ -	\$ -	\$ -	\$ 176	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 565	\$ 6,956	\$ 565

Net Benefits for Infrastructure Solutions (in Millions of Dollars)																		
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total	Average
Cross-Region Pipeline	\$ -	\$ -	\$ -	\$ (82)	\$ (63)	\$ (49)	\$ (54)	\$ (97)	\$ 1	\$ 231	\$ 511	\$ 543	\$ 564	\$ 874	\$ 920	\$1,124	\$ 4,424	\$ 340
Firm Contract Based Canadian Energy Imports	\$ -	\$ -	\$ -	\$ -	\$ (125)	\$ (119)	\$ (56)	\$ (93)	\$ (4)	\$ 232	\$ 374	\$ 234	\$ 168	\$ 392	\$ 224	\$ 245	\$ 1,471	\$ 123
Multiple Long-Term Solutions Scenario	\$ -	\$ -	\$ -	\$ (88)	\$ (224)	\$ (217)	\$ (158)	\$ (194)	\$ (111)	\$ 136	\$ 404	\$ 427	\$ 440	\$ 833	\$ 865	\$1,068	\$ 3,182	\$ 215

Other Benefits - Reduction in Market Value of Hydro Energy Imports

As shown above, the Multiple Long-Term Solutions Scenario provides additional benefits compared to the solution with Canadian Energy Imports infrastructure alone. One such benefit can also be reflected as reduction in the market value of the imported hydro energy.

The market value is calculated as the average hourly energy price in all New England zones, multiplied by the 1200 MW firm Hydro energy imported through the transmission line every hour. Table below shows that the Multiple Long-Term Solutions Scenario reduces the annual market value of the hydro energy imports by \$17 million dollars.

Market Value of Hydrom Energy Imports (in Million Dollars)														
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	Total	Average
Multiple Long-Term Solutions Scenario	\$ 443	\$ 466	\$ 529	\$ 539	\$ 546	\$ 566	\$ 570	\$ 585	\$ 605	\$ 629	\$ 642	\$ 667	\$ 6,787	\$ 566
Firm Contract Based Canadian Electric Imports Scenario	\$ 448	\$ 470	\$ 533	\$ 544	\$ 549	\$ 570	\$ 580	\$ 606	\$ 629	\$ 659	\$ 684	\$ 718	\$ 6,992	\$ 583
Market Value Reduction	\$ (5)	\$ (5)	\$ (4)	\$ (4)	\$ (4)	\$ (4)	\$ (10)	\$ (21)	\$ (24)	\$ (30)	\$ (42)	\$ (51)	\$ (206)	\$ (17)

Table 3 Reduction in Market Value of Hydro Energy Imports

Other Benefits - Reduction in Greenhouse Gas Emissions

Another benefit of the Multiple Long-Term Solutions Scenario is the reduction of electric sector green house gas emissions from introducing a firm contract based Canadian energy imports into the New England electric grid. The benefits associated with electric sector

greenhouse gas emission reductions, were not monetized since additional analysis would be required to place an economic value on emission reductions. Black & Veatch presented below the amount of Greenhouse Gas Emissions.

Black & Veatch compared the greenhouse gas emissions from the power generators in New England under the Multiple Long-Term Solutions Scenario, the Base Case and the High Demand Scenario. As shown in Figure 4, the emission levels are very similar between the Base Case and the High Demand Scenario, while the Multiple Long-Term Solutions Scenario reduces emission levels starting in 2018 by 9% as compared to the High Demand Scenario.

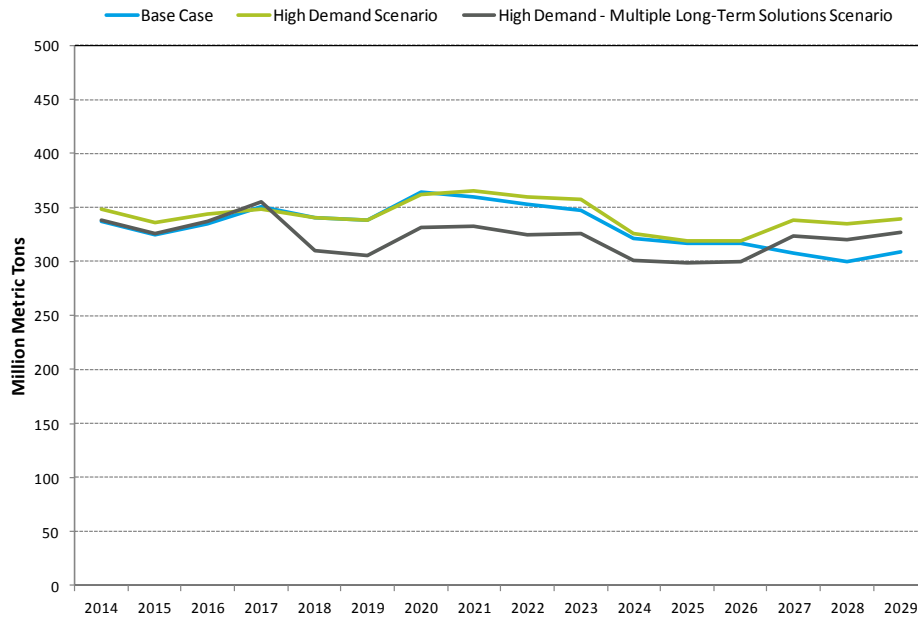


Figure 4 Green House Gas Emissions from the Power Sector in New England