

Highgate Converter

Vermont System Planning Committee

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Existing Highgate Converter

Highgate Converter

- Criticality
 - The Highgate Converter is an essential interface between the Eastern and Québec asynchronous interconnections, providing controlled, bi-directional power transfer that strengthens grid stability and enhances regional energy resilience
 - The Converter is modeled in state and regional planning studies showing its importance to the reliability of the New England system
- History
 - The Converter was put in service in 1985 to facilitate contractual flows for the first Hydro Québec import contract
 - At that time, converter built/operated by VELCO and owned by Highgate Joint Owners (VDUs/VPPSA)
 - In 2018 ownership transferred to VELCO and the converter was classified as “HTF” (Highgate Transmission Facility) asset receiving PTF-like funding treatment from the region
- Current state
 - Since 2023, system operations have shifted from import-only to increasingly bi-directional transfers, resulting in more frequent starts, stops, and cold starts
 - The original manufacturer (ABB), now Hitachi, no longer supports the legacy technology, creating growing reliability and maintainability risks
 - Recent assessments have identified asset condition deficiencies
 - Launched project, with the initial goal of exploring alternatives and identifying the preferred solution

Key Asset Maintenance Work During Replacement Timeframe

- Investments will be needed to sustain reliable operation during replacement timeframe to address critical items, including the following near-term items:
 - *Refurbish 50 AC breakers*
 - *Replace 200 post insulators*
 - *Replace 23 Current transformers*
 - *Re-gasket transformers and replace bushings*
 - *Replace 5 servers and workstations*
 - *Battery bank and charger improvements*
 - *Fencing and security system upgrades*
 - *Address failed transformer*

Highgate Converter Project

Project Objective:

Identify the preferred option for Vermont and the regional grid for addressing asset deficiencies and reliability concerns associated with the aged and obsolete Highgate Converter facility, including non-transmission alternatives.

Decision Realities:

- Generational decision
- Key reliability asset to Vermont and New England
- Value for New England and Québec regions in sharing renewable energy resources and leveraging long-duration Hydro Quebec storage capacity
- Improving existing bi-directional line operations
- Right-sizing opportunity that is responsive to system constraints identified in:
 - ISO-NE 2033 Vermont Needs Assessment
 - ISO-NE 2050 Transmission Study
 - 2024 Vermont Long-Range Transmission Plan
 - Inter-RTO and U.S. Department of Energy interregional transfer capacity increase goals
- Supports evolving New England and Hydro Québec grid operations

Highgate Converter Alternative Selection Project overview

Project What is the project?	Purpose Why are we changing?	Particulars What are we changing?	People Who will be changing?
<p>Select a preferred solution to advance that will replace the Highgate Converter Facility.</p> <p>We must select a preferred solution to replace this essential interface between the Eastern and Québec asynchronous interconnections, providing controlled, bi-directional power transfer that strengthens grid reliability and enhances regional energy resilience.</p>	<p>The Highgate Transmission Facility is nearing end of life.</p> <p>There is a very long-lead time to manufacture a new converter.</p> <p>Selecting the preferred solution in a timely way will allow VELCO's Board/owners to choose a path for financing the project.</p>	<p>Screening tool criteria (technical, economic, environmental, siting, constructability, risk)</p> <p>Comparative analysis of alternatives, including no-build and phased options</p> <p>Performing multiple Benefit Cost Ratios for several solutions.</p> <p>Justifying the upgrades we need to support the evolving grid over the next 40 years vs. same for same</p> <p>Assembling Highgate Advisory Team for DU Owner engagement</p> <p>VELCO Board and regulatory review of the selected alternative</p>	<p>Higher demand for coordination, communications, and issue identification and resolution</p> <p>Exploring multiple alternatives can make it more challenging to fully align team behind one solution</p> <p>Largest construction project we have undertaken in decades</p>

Evaluating alternatives

- PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) multi-criteria decision-making model
- Comparison of several alternatives based on multiple criteria to enable
 - Transparent and structured decisions
 - Quantitative and qualitative measures
 - Regulatory and cost allocation discussions
 - Sensitivity analysis and scenario testing
- Supports the development of a Benefits Cost Ratio (BCR) assessment

Benefits

Production cost and congestion savings

Avoided capital cost of local resources needed to serve demand

Avoided transmission investment

Reduction in losses

Reduction in expected unserved energy

Costs

Highgate Advisory Team

- Brian Connaughton, Co-Chair, VELCO, VP Transmission Services
- Betsy Bloomer, Co-Chair, VELCO, VP Corporate Affairs & Strategy
- Emily Stebbins-Wheelock, BED, CFO and Manager of Strategy and Innovation
- James Gibbons, BED, Director of Policy and Planning
- Josh Castonguay, GMP, VP, Chief Innovation Officer
- Kamran Hassan, GMP, Leader of Engineering
- Sarah Juzek, Stowe Electric Department, Director of Finance
- Jackie Pratt, Stowe Electric Department, General Manager
- Dan Potter, VEC, Power Planning Analyst
- Caroline Mashia, VEC, Chief Financial Officer
- Grace Sawyer, VPPSA, Assistant General Manager & Chief Financial Officer
- Heather D'Arcy, VPPSA, Manager of Power Resources
- Louis Porter, WEC, General Manager
- Brian Callnan, WEC, Director of Power Supply & Regulatory Affairs

Alternative solutions



		Alternative		Circuit Mile Impact	
Study	Site	MW	Converter	Solution 1	Solution 2
Ph 1	Highgate - Brownfield	250	B2B	-	-
	Highgate - Greenfield			-	-
	Highgate	350		37	61
		450		83	80
		550		207	151
		650		303	262
Williston	650	238	198		
Ph 2	Williston PT-PT	650	P2P	238	198
	Williston - Lake/Submarine			238	198
	Georgia	B2B	TBD	TBD	
	New Haven		TBD	TBD	

HVDC VSC grid support features

Select Key Features	Description
Grid forming technology (GFM)	Grid following is default mode of control, but on AC system conditions, GFM could be needed to support various system strength parameters
Black start capability	Provides system restoration support for the AC grid energization during outages/blackout conditions
Dynamic reactive power control	Dynamically control reactive power output to regulate voltage on AC grid, control power factor on AC grid, and provide voltage support for large disturbances in the AC network
Voltage control modes	Control steady state voltage and instantaneously support AC during disturbances
Inertial support	Provides inertia by leveraging grid forming feature and energy delivered from asynchronous systems
Run-back/run-up schemes	Automatically change real power set points based on external events in AC grid to prevent overloading of AC lines, e.g., if fast power reversal is needed as part of operation scenario
Frequency response	Adjustment of real power flow in response to a sudden frequency drop, supports system operators by stabilizing frequency during fast changes in loads
Steady state reactive power control (RPC)	Constant and AC voltage-dependent RPC control modes, providing more flexibility within reactive power control (STATCOM mode, strong and weak AC networks)

OEM Evaluation

- 5 Major manufacturers of HVDC equipment

HICO
HYOSUNG HEAVY INDUSTRIES

Changwon, Korea

 **MITSUBISHI
ELECTRIC**
MITSUBISHI ELECTRIC
POWER PRODUCTS, INC.

Osaka, Japan

 **GE VERNOVA**

Stafford, England

 **Hitachi Energy**

Ludvika, Sweden

SIEMENS
energy

Nuremburg, Germany

- Evaluation Scorecard

- Commercial – Cost, manufacturing capacity, delivery schedule, efficiency
- Technical – Experience, design, reliability, protection philosophy, compliance with technical requirements

HVDC Manufacturers Evaluation Scorecard

VELCO TOPICS		MAX SCORE	MITSUBISHI (MEPPI)	GE VERNOVA	HYOSUNG (HICO)	HITACHI ENERGY	SIEMENS ENERGY
A. Compliance with Technical Requirements Category %		64%					
1	Geographical Location(s)						
	Criterion Total Points	11					
2	Manufacturing Capacity						
	Criterion Total	5					
3	Experience & References						
	Criterion Total	25					
4	Converter Topology & Design Strength						
	Criterion Total	11					
5	Reliability & Losses Performance [CIGRE Metrics]						
	Criterion Total	11					
6	HVDC Controls and Protection (C&P)						
	Criterion Total	20					
7	HVDC & AC Protection Philosophy						
	Criterion Total	4					
8	Redundancy Concepts & Design						
	Criterion Total	11					
9	Cyber Security Architecture						
	Criterion Total	5					
10	Engineering & Technical Review						
	Criterion Total	4					
	Cumulative Criterion Total	107					
B. Project Delivery Workplan & Schedule Category %		9%					
	Criterion Total	15					
C. Qualifications of Key Personnel Category %		2%					
	Criterion Total	4					
D. Manufacturing Factory Visit Evaluation Category %		9%					
	Criterion Total	15					
E. Field (Customer) Site Visit Evaluation Category %		6%					
	Criterion Total	10					
F. Commercial Terms & Conditions Category %		5%					
	Criterion Total	9					
G. Commercial Total Cost of Ownership (O&M 20YR) Category %		5%					
	Criterion Total	8					
Total (Cumulative) Points Alloted		168					
Sum of ALL Categories by %		100%					



Highgate Converter decision milestones

