EXECUTIVE SUMMARY

The 2009 Transmission System Analysis is an update of the 2006 Vermont transmission system 10-year long-range plan analysis. The update incorporates several changes in approach required by the Docket 7081 Memorandum of Understanding (MOU), which was approved by the Vermont Public Service Board subsequent to the 2006 analysis, on June 20, 2007. The changes include: increasing the planning horizon from 10 to 20 years; testing the sub-transmission system; screening non-transmission alternatives to each proposed conceptual solution; and incorporating the comments of the Vermont System Planning Committee (VSPC).

As the Regional Transmission Organization for New England, ISO-NE manages the New England region's bulk electric power system, administers and operates the wholesale electricity market, administers the region's Open Access Transmission Tariff ("OATT"), and conducts regional transmission planning. The development of this plan was coordinated with the 10-year analysis required by the New England Independent System Operator (ISO-NE). For this purpose, VELCO prepared a separate report covering the performance of the transmission system up to year 2018. That report will be utilized to prepare the 2009 ISO-NE regional system plan (RSP), which identifies regional system deficiencies, and the transmission reinforcements that address these deficiencies. The scope of the 10-year transmission analysis was prepared under the guidance of ISO-NE and in collaboration with the neighboring transmission owners, such as National Grid (NGRID) New York, NGRID New England and Public Service of New Hampshire (PSNH), and was reviewed by the Planning Advisory Committee (PAC). Through participation in the PAC, the public stakeholders and other interested parties can influence the ISO-NE regional system plan (RSP), have advance knowledge of deficiencies, and are able to propose alternative solutions that may include demand reduction and supply measures.

METHOD AND CRITERIA

The transmission analysis was performed in accordance with the planning standards of the North American Electric Reliability Corporation (NERC), the Northeast Power Coordinating Council (NPCC), and ISO-NE. The sub-transmission system was tested under the "N-1"[1] standard to apply a consistent set of planning criteria when measuring the performance of the sub-transmission system across the state. VELCO recognizes that the Vermont distribution utilities may have used varying sets of planning standards. However, utilizing a single set of planning standards commonly used in the industry for evaluating the sub-transmission system allows the statewide analysis to be performed more efficiently with consistent reporting of subtransmission deficiencies.

The longer the horizon of a transmission planning analysis, the more uncertain are its conclusions due to uncertainties regarding predictions of load level, generation, system topology, changes to planning standards and how the transmission system will be utilized. Therefore, although VELCO conducted a 20-year analysis as required by the 7081 MOU, the bulk of the analysis focused on the 10-year horizon, i.e. through the year 2018. Once the limiting conditions[2] were identified for the 10-year analysis, these conditions were tested up to the 2028 load level. The results from the 2028 load level were used to examine system performance trends, evolving system needs, solution robustness with increased demand, and longer-term

[1] Under the N-1 standard, the system is required to not exceed applicable emergency limits for a single outage event at the peak load level.

[2] Conditions that cause criteria violations

solution options. The projected year of need was determined by testing the limiting conditions between years 2009 and 2028.

The New England 2018 estimated extreme weather (90/10) load level examined was approximately 33,200 MW, based on the ISO-NE 2008 load forecast. The corresponding Vermont 2018 90/10 load level was modeled at approximately 1275 MW, based on the 2008 load forecast prepared by ITRON for VELCO. To represent 2028 conditions, the Vermont load level was increased to 1425 MW, with the load outside of Vermont held constant.

The Energy Efficiency Utility of Vermont is presently forecasting Demand Side Management (DSM) peak demand reductions for the 20-year horizon. These DSM amounts can be superimposed on the ITRON load forecast to determine the load level at which transmission reinforcements may be needed. The Vermont load power factor at the distribution level was assumed to be approximately 0.96 at all load levels, with the load power factor as seen from the step-down transformers calculated at approximately 0.97. This approach assumes that distribution and sub-transmission capacitor banks will be added over time to compensate for any additional reactive loading.

All relevant projects that have received a Proposed Plan Application approval by ISO-NE were modeled in-service in the load flow cases. The relevant projects outside of Vermont were those located near the New Hampshire and Massachusetts borders with Vermont. Inside Vermont, the Coolidge Connector project, the Stratton synchronous condenser project, the Lamoille County project, the East Avenue Loop project, the Gorge project, and the Tafts Corner Phase 2 project were modeled in service. Only the Coolidge Connector project is critical with respect to overall transmission system performance. Generators that have been proposed, but are not yet in service, were dispatched at Swanton, Newport, Coventry and Moretown. The Maine Power Reliability Program (MPRP) and the New England East West Solution (NEEWS) were not modeled because they are expected to have almost no effect on the Vermont system.

Under the guidance of ISO-NE, the Vermont analysis was conducted in a manner consistent with the methods utilized in the other regional 10-year analyses. Generation was dispatched to stress the Vermont system and the relevant interfaces, and to determine the effects of various dispatch scenarios. For the Vermont system, the relevant interfaces are New York-New England and East-West, which are a summation of flows along a vertical boundary running from Northern New Engand to Southern New England. The McNeil 50-MW wood burning generator in Burlington, Vermont, was assumed out of service in all base cases, to satisfy the ISO-NE requirement for all regional studies that the two most critical generators within the study area be dispatched off. With all lines in, 68 MW out of 183 MW (installed summer claimed capability of the Vermont thermal units not counting McNeil) were dispatched in service. After a first contingency resulting in a long-term outage, an additional 31 MW were dispatched in service. After a first contingency resulting in a short-term outage, an additional 62 MW were dispatched in service. Therefore, for the limiting conditions tested, as much as 130 MW out of 183 MW were dispatched in service in addition to 15 MW of hydro generation and 5 MW of wind generation. Phase angle adjustments, capacitor dispatch, and transformer tap changing were allowed between the first and the second contingency. Finally, the system was tested with either Vermont Yankee retired or the Highgate Converter decommissioned as a sensitivity analysis to understand the potential reliability impacts of these resources not being present on the system, and no upgrades were proposed as a result of these analyses.

SPECIFIC AREAS OF CONCERN

The following discussions of results focus on the West-East transfer condition for year 2018 except where noted otherwise.

There were no thermal or voltage criteria violations on the transmission system with all lines in.

There were no transmission overloads for single-element contingencies. However, there were many voltage violations, including local voltage collapse.

Concerns were more severe for multi-element contingencies or NERC category C and D events. There was one overload for a breaker failure contingency. All other transmission overloads occurred for contingencies with a facility already out of service. Voltage violations were also very severe under element-out conditions.

Effects of serving the Newport Block load on VT

The Newport block load is normally supplied from Canada on the Stanstead-Newport 120 kV line. This load is transferred to Vermont frequently, requiring the Vermont transmission system to serve that load at any time. Moving the Newport load into Vermont had a negative impact on the system, particularly in the northern portion of Vermont. The need for voltage support and other transmission deficiencies were advanced due to the Newport load being supplied from the Vermont system. The timing of transmission deficiencies listed in the table at the end of this summary assumed that the Newport load is supplied from Vermont.

System performance with Vermont Yankee retired

Recognizing that Vermont Yankee's license may not be renewed, a sensitivity analysis was performed for information purposes. No upgrades were proposed in Vermont based on this scenario. However, system studies in New Hampshire and Massachusetts may result in transmission upgrades that will interconnect to substations located in Vermont. Detailed regional studies of transmission alternatives are expected to be completed sometime in 2009.

The analysis did not show any additional violations in Vermont at the 2018 load level. However, severe overloads and voltage collapse occurred for certain Category C contingencies in New Hampshire and Massachusetts. Those thermal and voltage concerns affect the Vermont system.

System performance with Highgate decommissioned

The capacity terms of the Hydro Québec energy contracts delivered over the Highgate HVdc converter will be gradually reduced from 200 MW in 2015 to 31 MW in 2016, 6 MW in 2017, and 0 MW in 2018. Therefore, starting in 2016, the converter may be disconnected with the contract to deliver 31 MW flowing on the Stanstead radial line to supply part of the Newport block load. Recognizing that the Highgate contracts may not be renewed, a sensitivity analysis was performed for information purposes. No upgrades were proposed based on this scenario.

For the purpose of this sensitivity analysis, it was assumed that Highgate would no longer be available for dispatch even under emergency conditions. As such, switching Highgate out of service was not a contingency in this instance, but a base condition before the first outage.

With the Highgate Converter decommissioned, there were no pre-contingency thermal or voltage violations. However, there were thermal violations for single-element outages and failed breaker outages without a second element out of service.

Based on the overall performance of the system, the analysis showed that a more significant transmission system upgrade would be needed to mitigate the adverse effects of Highgate being inoperable. The multiple thermal and voltage violations were resolved with a new phase angle regulator-controlled 230 kV line between Plattsburgh, NY and Essex, VT in parallel with the existing PV-20 115 kV line.

2023 Results

The proposed 2018 upgrades were not sufficient to serve 2023 loads reliably. Additional voltage support will be needed locally between Highgate and Littleton, NH and on the overall system, particularly near the Northwest Vermont load pocket. Many 115 kV lines became overloaded starting in 2021, and additional lines will become overloaded as load continues to increase.

Based on the results, it is recommended to investigate the need for a new 230 kV line from Plattsburgh to Essex in parallel with the existing PV-20 line.

2028 Results

There were no overloads or voltage concerns with all lines in-service on the transmission system. Numerous 46 kV buses (30+) had sub 0.95 pu voltages even with all facilities in-service. These buses were located predominantly in central Vermont beneath the 115 kV network between Chelsea, Hartford, Ascutney, Bellows Falls and Cold River, with a small number of stations in the 46 kV network beneath the Highgate and Newport substations.

The 2028 performance demonstrates the network's weakness with added system load and the upgrades carried forward from the year 2018 analysis. Possible solutions to these problems would be:

- A three-breaker 115 kV ring bus at Chelsea
- Potentially dynamic reactive reinforcement in the Highgate / St. Albans area or additional transmission to support the local area for the limiting outage.
- Potentially additional switched reactive reinforcement on the local 115 kV or underlying 34.5 kV system to support voltage.

System performance for the 2028 system was further degraded when examined with one facility out of service. These facility-out conditions resulted in numerous voltage, thermal, and voltage collapse violations on the system.

If one chose to rebuild the lines that would overload between 2018 and 2023 and add capacitor banks, these modest upgrades would do little to resolve the voltage collapse and low voltage concerns described above. To address those, a new transmission tie into northwestern Vermont and/or significant dynamic reactive support would be needed. The benefit of a new transmission tie is that multiple line rebuilds beyond 2018 would be replaced by the new tie.

One new transmission tie was examined. This tie was a new 230 kV transmission line from the New York Power Authority (NYPA) Plattsburgh substation across Lake Champlain and into the VELCO Essex substation. The transmission tie was connected to the grid via a 230/115 kV transformer at Essex. While the termination point may not ultimately be Essex, for the purposes of planning analysis, this model was sufficient for evaluation. Additional study work is needed to determine how to best interconnect such a tie.

The results of this analysis demonstrated that the voltage collapse scenarios and the low voltage cases were completely resolved by this new tie. The reinforcement does not remove a local unacceptably low voltage. Options that may resolve the voltage issues include a significant reactive power source (50+ MVAR) at Highgate plus the rebuilding of portions of the underlying 34.5 kV sub-transmission system between East Fairfax and Milton, the addition of a 34.5 kV injection at the Georgia substation with the rebuilding of smaller portions of the underlying sub-transmission system or a new 115 kV line between Georgia and the St. Albans substation. Additional analysis is needed to determine the best reinforcement needed for the northern system connected to Highgate.

Sub-Transmission System Results

As required by the 7081 MOU, the sub-transmission system was tested. For purposes of this analysis, the sub-transmission system in Vermont was considered to be the system whose operating voltage is above 34 kV and below 70 kV. A consistent set of criteria were applied to the sub-transmission system regardless of the owner of the system. The analysis was performed at the projected summer peak load level for years 2009 to 2018. For violations that occurred at load levels below the projected 2009 summer peak load, the results of prior analyses were used to state the load level at which the violation would occur, and the timing of the violation was noted as 2009 to represent the immediacy of the violation. The results are discussed for year 2018 unless noted otherwise.

With all lines in, there was a line overload in the Montpelier area. Overloads occurred for loss of a sub-transmission line or with a sub-transmission breaker open near St Albans, Rutland, and Montpelier. Overloads occurred for loss of a step-down transformer near St Albans, Hartford, Ascutney, Rutland, Blissville, and Montpelier, as adjacent transformers attempt to compensate for loss of a transformer. If sub-transmission lines between substations cannot carry the post-contingency flows, adjacent transformers cannot back each other up effectively. Typically, installing a spare transformer takes from one to five days depending on the weather, site accessibility, spare transformer location and availability, transportation, and installation difficulties. If a portable transformer can be used under ideal circumstances, the initial duration of the outage can be less than one day, and another outage may be required to install a spare transformer and release the portable transformer to mitigate another potential failure. Before a spare transformer can be installed, the system is exposed to the potential outage of another transformer. Overloads due to sub-transmission contingencies were unaffected by the proposed transmission upgrades. Overloads occurred for loss of a transmission line, with no other transmission element out of service, near St Albans, Ascutney, Cold River, Montpelier and Barre.

With all lines in, voltages were below 0.95 pu near Ascutney, Blissville, and St Johnsbury. Voltages were below 0.9 pu for loss of a sub-transmission line or with a sub-transmission breaker open near St Albans, Chelsea, Hartford, Ascutney, Rutland, Cold River, and Blissville. Voltages were below 0.9 pu for loss of a step-down transformer near St Albans, Chelsea, Hartford, Ascutney, Rutland, Cold River, Blissville, and Barre. Voltage collapse occurred for loss of a transformer at two locations. Voltages were below 0.9 pu for loss of a transmission line, with no other transmission element out of service, near St Albans, Chelsea, Hartford, Ascutney, Rutland, Cold River, Blissville, Barre, and St Johnsbury. Voltage collapse could occur near Chelsea for loss of a transmission line. The solutions proposed for the transmission system postponed the need to address some of these voltage concerns. However, additional reactive compensation is recommended at the sub-transmission and distribution systems near the substations noted above. Existing and new capacitor banks need to be equipped with switching equipment to dispatch capacitor banks off when the load level is lower than peak. Recent ISO-NE power factor surveys showed that the Vermont power factor is higher than desired during shoulder load levels, particularly during the fall and winter seasons. Too many distribution and sub-transmission capacitor banks remain on line during shoulder load levels, while additional capacitor banks are needed for peak load levels.

Listing of deficiencies and conceptual solutions

The transmission reinforcements identified in the 2009 plan would address only the identified reliability concerns. The plan does not include transmission projects that could be needed to accommodate the purchase and delivery of renewable generation, to replace resources that may retire, to facilitate the operation of the energy market, or as the result of large, localized increases in load due to potential development. It is possible that one or more transmission projects will be proposed for these reasons within the plan's horizon. For instance, two major energy sources that supply a large percentage of Vermont energy needs – Vermont Yankee and Hydro Quebec – may retire within the next ten years. Replacing these resources may require transmission system reinforcement. If New England decides to access renewable resources from Canada or New York, transmission reinforcements may also be needed. Finally, reliability concerns in other parts of the system, such as New York, New Hampshire and Massachusetts may involve upgrades in Vermont, particularly with Vermont Yankee out of service.

Based on the analysis performed, the deficiencies and proposed conceptual solutions are provided in the table on page VIII. A number of the deficiencies have a year of need of 2009. Most of these deficiencies occur at load levels below the 2009 peak load level. For transformer related concerns, VELCO and the affected DUs will perform additional analyses to confirm that the criteria violations are indeed violations based on the DUs' reliability criteria. If the violation is confirmed, additional planning studies will be conducted to determine the best transmission solution and evaluate the viability of non-transmission alternatives. For transmission related concerns, VELCO will perform additional analyses in conjunction with ISO-NE to determine the effects of a lower load forecast and future demand resources. If the violations are confirmed, the transmission solutions will need to be implemented as quickly as possible. Following is an explanation of the table headings:

Location: refers to the location of the criteria violation or the location of the conceptual solution

Upgrade: brief description of the proposed conceptual solution except in two cases. The Lyndonville upgrade proposed to address the reliability concern associated with loss of the single St Johnsbury transformer is the result of a detailed study, and the upgrade will be filed for 248 approval in the next few months. The Weybridge to New Haven 46 kV line proposed to address the reliability concern associated with loss of a radial 46 kV line from Middlebury is the result of a detailed study, and CVPS stated it will file for 248 approval in the next few months. This 46 kV line upgrade will postpone the need for a second transformer at Middlebury.

Need:	description of the reliability concern or criteria violation
Category:	refers to the label placed on the solution proposed as defined in the 7081 MOU. Because the proposed solutions are conceptual at this stage of the analysis, it is possible that the final solutions may be given a different label depending on whether the solution is a bulk or subsystem solution.
Affected system:	refers to the portion of the system that may be affected by the criteria violation. Additional studies are needed to make a final determination.
Year needed:	refers to the year associated with the load level at which the criteria violation would occur. The timing of deficiencies is dependent on the growth rate assumed for electrical load, ongoing changes to the system, the planning standards and the manner in which the system is operated. For violations that occurred at load levels below the projected 2009 summer peak load, the results of prior analyses were used to state the load level at which the violation would occur, and the timing of the violation was noted as 2009 to represent the immediacy of the violation.
Load MW needed:	refers to the load level at which the criteria violation would occur. For violations that occurred at load levels below the projected 2009 summer peak load, the results of prior analyses were used to state the load level at which the violation would occur.
Affected DUs:	refers to the distribution utilities that are affected by or whose load is a contributor to the criteria violation as defined in the 7081 MOU.
Lead DU:	refers to the distribution utility that is responsible for managing a study process for a particular deficiency as defined in the 7081 MOU.
Priority:	the solutions are prioritized based on the planning stage of the project, the load exposure, and the expected need date. A priority of 1 signifies that the proposed solution is likely to be the first project to be filed with the Public Service Board. A high priority, e.g. 1, does not mean that the solution is the most important solution. The priority order is not synonymous with implementation order. Some of the proposed reinforcements may not go forward following additional studies. Proposed reinforcements may be implemented at the same time because every effort will be made to resolve as many of the criteria violations as quickly as possible to comply with regional reliability standards.
Severity:	provides a sense of the potential impacts of a reliability deficiency. This description considers the potential amount of load affected, the potential location of and the exposure to the criteria violation.
NTA Screened In?:	lists the results of the NTA screening analysis based on the current NTA screening tool.

Transmission deficiencies and proposed conceptual solutions

Location	*Upgrade*	*Need*	*Category*	*Affected Systems*	*Year Needed*	*Load MW Needed*	*Estimated Cost (Millions)*	*Affected DUs*	*Lead DU*	*Priority*	*Severity*	*NTA Screened IN?*
St. Johnsbury	Construct new station with 115/34.5 kV transformer. Install capacitor banks.	Loss of transformer causes loss of load	Predominantly Bulk	Subsystem for transformer Bulk for capacitor banks	2009	400	$22	CVPS and Lyndonville (LED) for station. CVPS, Lyndonville and VEC for capacitor banks	LED	1	High	See Screening for Lyndonville project on the VSPC web site http://www.vermontspc.com
Middlebury	Install 2nd 115/46 kV transformer & rebuild to ring station – Can be postponed by CVPS proposed 46 kV line	Loss of transformer and breaker failures cause voltage collapse. Timing depends on CVPS 46 kV line project.	Predominantly Bulk	Subsystem	2009	700	$10 to $20	CVPS	CVPS	2	High	NO
St. Albans	Construct new ring station with two 115/34.5 kV transformers	Loss of line causes voltage collapse. Transformers overload for loss of transformer	Predominantly Bulk	Subsystem	2009	900	$25 to $50	CVPS, VEC	CVPS	3	High	NO
Georgia	Rebuild to ring station	Breaker failures cause voltage collapse	Predominantly Bulk	Primarily Bulk	2009	1100	$20 to $40	All Vermont DUs	CVPS	3	High	NO
Georgia-St. Albans	Construct new Georgia-St. Albans 115 kV line	Voltage instability	Bulk	Primarily Bulk	Before 2018	Lower than 1275	$15 to $30	All Vermont DUs	VEC	3	High	YES
South Rutland	Construct new station with a 115/46 kV transformer	Loss of transformer causes sub-transmission and transformer overloads, which will result in loss of load	Predominantly Bulk	Subsystem	2009	1000	$15 to $30	CVPS	CVPS	4	High	NO
Blissville	Install 2nd 115/46 kV transformer & Rebuild to ring station. Install capacitor bank	Loss of transformer causes low voltages and overloads, which will result in loss of load. Loss of line causes low 115 kV voltage	Predominantly Bulk	Subsystem	2009	800	$15 to $30	CVPS	CVPS	5	High	NO

Location	*Upgrade*	*Need*	*Category*	*Affected system*	*Year Needed*	*Load MW Needed*	*Estimated Cost (Millions)*	*Affected DUs*	*Lead DU*	*Priority*	*Severity*	*NTA Screened IN?*
Hartford	Install 2nd 115/46 kV transformer & Rebuild to ring station	Loss of transformer causes low voltages and overloads, which will result in loss of load. Breaker failures cause voltage collapse.	Predominantly Bulk	Subsystem	2009	1000	$15 to $30	CVPS, GMP	CVPS	6	Medium	NO
Ascutney	Rebuild to breaker-and-a-half station	Breaker failures cause voltage collapse.	Predominantly Bulk	Bulk	2009	Lower than 1170	$14 to $28	All Vermont DUs, NU and NGRID	CVPS	7	High	NO
Newport	Install capacitor bank	Loss of line causes voltage collapse	Bulk	Bulk	2009	1000	$1 to $2	All Vermont DUs	VEC	8	High	NO
Queen City	Install capacitor bank	Loss of line causes low voltage	Bulk	Bulk	2009	Lower than 1170	$2 to $4	All Vermont DUs and NGRID	GMP	8	Very high	NO
West Rutland	Install capacitor banks and shunt reactor	Loss of line causes low voltage. High voltages during low load levels.	Bulk	Bulk	2009	Lower than 1170	$6 to $12	All Vermont DUs and NGRID	CVPS	8	Very high	NO
Ascutney	Install capacitor banks	Loss of line causes low voltage	Predominantly Bulk	Bulk	2009	Lower than 1170	$2 to $4	All Vermont DUs, NU and NGRID	CVPS	8	Very high	NO
Coolidge	Install shunt reactor.	High voltages during low load levels.	Bulk	Bulk	2011	1200	$4 to $8	All Vermont DUs, NU, NGRID, NY	CVPS	8	High	NO
Coolidge-Ascutney 115 kV K-31 line	Rebuild to higher rating	Line overloaded with a line out of service and for loss of a line	Bulk	Bulk	2009	Vermont load generally not relevant	$25 to $50	All Vermont DUs, NGRID and NU	GMP	9	High	NO
VY to Vernon Road 115 kV K-186 line	Rebuild to higher rating	Line overloaded for loss of a transformer	Bulk	Bulk	2009	Lower than 1170 NH and Brattleboro load mostly	$5 to $10	All Vermont DUs, NU, NGRID	CVPS	10	High	NO
Vernon	Install 2nd 345/115 kV transformer	Loss of a transformer overloads a line with a transformer out of service	Bulk	Bulk	2010	1185	$15 to $30	All Vermont DUs, NU, NGRID	CVPS	11	High	NO

Location	Upgrade	Need	Category	Affected system	Year Needed	Load MW Needed	Estimated Cost (Millions)	Affected DUs	Lead DU	Priority	Severity	NTA Screened IN?
Ascutney-Ascutney Tap 115kV K-149 line	Rebuild to higher rating	Line overloaded with a line out of service and for loss of a line	Bulk	Bulk	2013	1210	$5 to $10	All Vermont DUs, NU, NGRID	CVPS	12	High	YES
Coolidge-Cold River 115 kV K-32 line	Rebuild to higher rating	Line overloaded with a line out of service and for loss of a line	Bulk	Bulk	2013	1210	$35 to $70	All Vermont DUs and NY	CVPS	13	High	YES
Bennington	Rebuild to Ring station Install cap banks	Breaker failures cause voltage collapse Low voltage.	Bulk	Primarily Bulk	2009	Lower than 1170	$10 to $20	All Vermont DUs and NGRID	CVPS	14	High	NO
Ascutney	Install 2nd 115/46 kV transformer	Loss of transformer causes low voltages and overloads, which will result in loss of load.	Predominantly Bulk	Subsystem	2013	1210	$6 to $12	CVPS, Ludlow, GMP	CVPS	15	High	YES
Coolidge	Install 2nd 345/115 kV transformer.	Loss of transformer causes low voltages and overloads.	Bulk	Bulk	2016	1245	$20 to $40	All Vermont DUs, NU, NGRID, NY	CVPS	16	High	YES
Barre	Install 2nd 115/34.5 kV transformer & rebuild to ring station	Loss of transformer causes low voltages and overloads, which will result in loss of load.	Predominantly Bulk	Subsystem	2018 assuming 34.5 kV upgrades	1275	$10 to $20	GMP, WEC	GMP	17	Low	YES
Chelsea	Install 2nd 115/46 kV transformer & Rebuild to ring station	Loss of transformer causes low voltages. Loss of line causes voltage collapse.	Predominantly Bulk	Subsystem	2018	1275	$15 to $30	CVPS, WEC	CVPS	18	Low	YES
Plattsburgh to Essex	Construct 230 kV line from Plattsburgh to Essex in parallel with 115 kV line	Severe voltage concerns and multiple overloads beyond 10-yr horizon. Severe voltage concerns and multiple overloads with Highgate removed within 10-yr horizon.	Bulk	Bulk	Depends on multiple factors as noted below	See note below	$200 to $300 Vermont portion	All Vermont DUs	GMP	See note below	Extremely high	YES

Note: The timing of the PV-20 230 kV upgrade depends on multiple factors, including the remaining life of existing facilities, recent operating events, ISO-NE interests, as well as regional coordinated planning between New England and New York. For example, if Highgate remains available for dispatch even if the contracts are not renewed, the year of need would be approximately 2021. If Highgate is unavailable, the timing is 2016. However, if the condition of the underwater cables is such that they need to be replaced, the upgrade may be needed sooner.