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**Sheffield-Highgate Export Interface Alternatives Study—Update 1**

The SHEI study as originally scoped is 70% complete, with testing completed on 17 of the initial 18 cases for all-lines-in conditions and most of facility-out conditions. The battery storage option will be tested at the end of the study to ensure that the battery analysis takes advantage of information inferred from earlier parts of the study. VELCO has reviewed the preliminary results, which indicate the following:

- In the existing system, the SHEI export limit is based on voltage and thermal concerns coincidently.
- The B20 upgrade addresses both of these concerns, but another contiguous 34.5 kV line will become limiting if not upgraded as well.
- The upgrades that provide additional reactive support do not improve the thermal performance of the system, but they reduce reactive power flow, which is a beneficial outcome.
- The best of the reactive support upgrades is the Highgate synchronous condenser, which improves performance during all-lines-in conditions, but most significantly during facility-out conditions.
- Only the line upgrades were able to improve thermal performance. Options 10 and 11 modeled, in cases 14 and 15, performed very well, to the point of accommodating not only existing generation, but also a significant amount of additional generation even during facility-out conditions. These two upgrades are not necessarily the preferred options because of the anticipated cost, which would likely exceed $100M.

The study will be expanded to evaluate cases without the B20 upgrade, and additional upgrades that we determined to be useful to test based on the review of preliminary results. Below is a description of the additional study scope. These additional cases nearly double the scope, and we anticipate that the timeline for completing the study will be extended by at least one month.

**Description of the additional analysis**

The expanded scope consists of options 12 to 15 and cases 19 to 36, which will be tested under all-lines-in conditions and two of the previously tested facility-out conditions. Voltage limits will be determined under all-lines-in and facility-out conditions, and thermal limits will be determined under all-lines-in conditions only.

**Previous options**

**Subtransmission upgrade**

Option 1: Reconductor the B20 line and replace the Lowell 46/34.5 kV transformer

**Reactive support**

Option 2: Enable the AVR of one plant
Option 3: Demonstrate that the Jay synchronous condenser can be operated at a higher capacity for 1 hour
Option 4: Enable the AVR of another plant
Option 5: Install a 15 MVAr synchronous condenser at Highgate

**Transmission upgrades**

Option 6: Reconductor the K42 line
Option 7: Install a second line alongside the K39 line
Option 8: Install a 15 MVA battery storage at Highgate (size to be confirmed by study)
Option 9: Reconductor the K41 line
Option 10: Install a new line from Irasburg to Stowe 115 kV
Option 11: Install a new line from Irasburg to East Fairfax 115 kV

**Additional options**

**Subtransmission upgrades**

Option 12: close the normally open Lowell C53 switch
Option 13: close the normally open Richford 14W switch and reconductor the Richford to Highgate 46 kV line

**Transmission upgrades**

Option 14: Install a 15 MVA battery storage at Sheffield (size to be confirmed by study)
Option 15: Install a second line alongside the K42 line

The following table provides the additional cases that VELCO proposes for testing. An X indicates which options are included in each of the cases.

| Options | Description | Cases | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** | **34** | **35** | **36** |
| 1 | Reconductor B20 Lowell-Johnson 34.5 kV line and upgrade the Lowell 46/34.5 kV transformer | | | | X | X | X | | | X | X | | | X | | | | X | |
| 2 | Enable the Sheffield AVR | X | | X | | X | X | | | X | | X | | | | | | X | |
| 3 | Recognize Jay synch condenser 1.15 service factor | | | | | | | | | X | | | | | | | | X | |
| 4 | Enable the Sheldon Springs AVR | | X | X | | X | X | | | X | | | | | | | | X | |
| 5 | Install a 15MVAr synchronous condenser at Highgate 115 kV | | | | | | | | | | | | X | X | | | | | X |
| 6 | Reconductor K42 Highgate-St Albans 115 kV line | | | | | | | | | | X | X | X | X | X | X | X | | |
| 7 | Install a 2nd 115 kV line alongside the K39 line | | | | | | | | | | | | | | | | | | |
| 8 | 15 MVA battery storage at Highgate 115 kV | | | | | | | X | | | | | | | X | | | | |
| 9 | Reconductor K41 Highgate-Jay 115 kV line | | | | | | | | | | | | | | | | | | |
| 10 | Install a new Irasburg to Stowe 115 kV line | | | | | | | | | | | | | | | | X | | |
| 11 | Install a new Irasburg to East Fairfax 115 kV line | | | | | | | | | | | | | | | | | | |
| 12 | Close the normally open Lowell C53 switch | | | | X | X | X | | | | | | | | | | | | |
| 13 | Close the normally open Richford 14W switch and reconductor from Richford to Highgate 46 kV | | | | | | X | | | | | | | | | | | | |
| 14 | Install a 15 MVA battery storage at Sheffield 115 kV | | | | | | | | X | X | | | | | | X | | | |
| 15 | Install a 2nd 115 kV line alongside the K42 line | | | | | | | | | | | | | | | | | X | X |

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**Sheffield-Highgate Export Interface Alternatives Study**

**Introduction**

The summary describes consulting services currently being conducted for Vermont Transco to assess subtransmission, reactive support, and transmission options, including battery storage, and rank these options or sets of options in terms of their performance in comparison to the existing system under all-lines-in and facility-out conditions. Essentially, the analysis will allow us to determine the incremental MW export benefit of the options compared to the existing system. When the voltage limit exceeds the thermal limit for an option, both limits should be provided. Below is a description of the options to be evaluated.

***These options are not planned upgrades***, and the majority, particularly the transmission line additions, will likely be rejected because of their high cost compared to the export benefit they provide and/or the infeasibility of implementation. Economic and impact evaluation of alternatives will be completed as needed in a later phase.

**Subtransmission upgrade**

Option 1: reconductor the B20 line and replace the Lowell 46/34.5 kV transformer

**Reactive support**

Option 2: Enable the AVR of one plant
Option 3: Demonstrate that the Jay synchronous condenser can be operated at a higher capacity for 1 hour
Option 4: Enable the AVR of another plant
Option 5: Install a 15 MVAr synchronous condenser at Highgate

**Transmission upgrades**

Option 6: Reconductor the K42 line
Option 7: Install a second line across the interface from station 220 to station 210
Option 8: Install a 15 MVA battery storage at Highgate (size to be confirmed by study)
Option 9: Reconductor the K41 line
Option 10: Install a new line across the interface from station 230 to station 666
Option 11: Install a new line across the interface from station 230 to station 390

The following table provides the cases that VELCO proposes for testing. Case 0 represents the existing system. Cases 1 to 18 represent the upgraded system with an X indicating which options are included in each of the cases.

| | Cases | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Options | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 1 | | X | X | X | X | X | X | X | X | X | X | X | X | X | | | | | |
| 2 | | | X | | | X | X | | X | X | X | X | X | X | X | X | X | X | X |
| 3 | | | | X | | X | | X | X | X | X | X | X | X | X | X | X | X | X |
| 4 | | | | | X | | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 5 | | | | | | | | | | X | | | | | | | | X | |
| 6 | | | | | | | | | | | X | | | | | | | | X |
| 7 | | | | | | | | | | | | X | | | | | | | |
| 8 | | | | | | | | | | | | | X | | | | | | |
| 9 | | | | | | | | | | | | | | X | | | | | |
| 10 | | | | | | | | | | | | | | | X | | | | |
| 11 | | | | | | | | | | | | | | | | X | | | |