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July 31, 2019

The Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL A1A 5B2

Attention: Ms. Cheryl Blundon
Director of Corporate Services and Board Secretary

Dear Ms. Blundon:

Re: Reliability and Resource Adequacy Study – TP-TN-068 Application of Emergency Transmission Planning Criteria for a Labrador-Island Link Bipole Outage

On May 24, 2019, Newfoundland and Labrador Hydro ("Hydro") filed a report with the Board of Commissioners of Public Utilities ("Board") entitled "Avalon Capacity Study – Solutions to Serve Island Demand during a LIL Bipole Outage" ("TGS Study"). This report was further to the "Reliability and Resource Adequacy Study", filed with the Board on November 16, 2018. In Hydro's response to PUB-NLH-064 regarding the TGS Study, Hydro committed to "use the findings of the Study to develop criteria for emergency system operations in the event of a prolonged outage of the LIL bipole."

Attached is Hydro's Transmission Planning Technical Note "TP-TN-068 Application of Emergency Transmission Planning Criteria for a Labrador Island Link Bipole Outage." As described in this Technical Note, Hydro recommends that Emergency Transmission Planning Criteria be adopted and that transmission system upgrades are not required to deliver capacity from existing sources of supply. The Technical Note indicates that the appropriateness of the Emergency Transmission Planning Criteria as a long-term solution is dependent on whether incremental generation is installed, and on where the generation is located. The criteria and the resulting impacts shall therefore be re-evaluated as Hydro's Reliability and Resource Adequacy Study continues.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

SWalsh

Shirley A. Walsh
Senior Legal Counsel, Regulatory
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Encl.

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Danny Dumaresque
Larry Bartlett, Teck Resources Limited

TP-TN-068

Application of Emergency Transmission Planning Criteria for a Labrador Island Link Bipole Outage

Executive Summary

As part of Hydro's Reliability and Resource Adequacy study, TransGrid Solutions ("TGS") were engaged to perform a review of power delivery to the Avalon Peninsula in the event of an outage to the Labrador Island Link ("LIL") bipole. The Avalon Capacity Study ("TGS Study")[1] involved the examination of transmission system constraints in consideration of aspects such as voltage profiles, transmission line thermal limits, and transient stability. A series of operating conditions were assessed and violations to Newfoundland and Labrador Hydro's ("Hydro") Transmission Planning Criteria were identified. The analysis also included a review of the transmission system upgrades that would be required to meet peak load without violations to criteria.

The violation scenarios presented in the TGS study were extensive, as were the array of system upgrades that would be required to mitigate them. This is due to the fact that the assessment included the addition of significant generation off of the Avalon Peninsula to meet peak load. The delivery of this capacity to load centres in eastern regions of the transmission system resulted in the excessive loading of transmission corridors.

As a next step, Hydro must make a determination as to whether Emergency Transmission Planning Criteria should be adopted or if transmission system upgrades are required. As part of this decision process, the analysis summarized in this report is an extension of the review performed by TGS and includes an assessment of the performance of the existing system without incremental generation.

Hydro notes that the Island Interconnected System ("IIS") faces a significant generation shortfall during a LIL bipole outage if no incremental capacity is installed. With such limited generation, the transmission system is much less heavily loaded and violations to criteria are less severe. The objectives of this analysis are therefore to define appropriate action for the existing transmission system without incremental generation.

The methodology for this analysis is defined as follows:

1. Develop base case scenarios to reflect the maximum Island Demand that can be supported by existing generating resources.

[1] Newfoundland and Labrador Hydro Avalon Capacity Study - Solutions to Serve Island Demand during a LIL Bipole Outage, TGS, Technical Note: TN1529.01.02, May 23, 2019

2. Assess system performance for the existing system and review of the application of Transmission Planning Criteria during a LIL bipole outage scenario.
3. Identify violations to Transmission Planning Criteria and assess if remedial actions are required.
4. Recommend appropriate Transmission Planning Criteria for a LIL bipole outage scenario.

Conclusions of this report are as follows:

1. Base Cases were developed to determine maximum customer loads that can be supported during a LIL bipole outage. The cases are summarized as follows:
    - Base Case 1 - Maximum Island Generation with 300 MW Maritime Link ("ML") Import
        - Total Island System Capacity ≃ 1700 MW
        - A total customer load of 1530 MW can be supported
    - Base Case 2 – Maximum Island Generation with No ML Import
        - Total Island System Capacity ≃ 1400 MW
        - A total customer load of 1260 MW can be supported

2. The following violations to Transmission Planning Criteria were identified in the base cases:
    - Base Case 1
        - Thermal overload of TL201 in the event of an outage to TL217
        - Thermal overload of TL217 in the event of an outage to TL201
        - Transient undervoltage violations for three-phase fault at Sunnyside
        - While not a violation, instability occurs for a three-phase fault at Bay d'Espoir, followed by the tripping of TL202, TL206, or TL267.
    - Base Case 2
        - Thermal overload of TL201 in the event of an outage to TL217

3. If no transmission system upgrades are to be performed, the following criteria would be required:
    1. In the event that the LIL bipole is out of service, load shedding is permitted in response to a transmission line outage to avoid thermal overloading.
    2. In the event of a three-phase fault while the LIL bipole is out of service, the suppression of transient recovery voltages is acceptable as long as stable operation is maintained.[2]
    3. As per normal operation, three-phase faults at Bay d'Espoir terminal station are excluded from consideration. Such faults may result in instability in cases with high power flows eastward from Bay d'Espoir.[3]

[2] This criterion would not be required if capacity is limited to existing generation within the Island System.

[3] This criterion would not be required if capacity is limited to existing generation within the Island System.

4. If the criteria listed above were to be adopted, the following operational considerations would need to be assessed to ensure that customer impacts are minimized during a LIL bipole outage:
    1. Develop/Modify Restoration Procedures
    2. Develop a Rapid Load Shedding Procedure
    3. Review Protection Settings

5. If the criteria listed above are not adopted, the following upgrades would need to be considered:
    1. Transmission System Upgrades in the 230 kV Corridor between Western Avalon Terminal Station and Soldiers Pond Terminal Station
    2. Reactive Support in the Area of Sunnyside Terminal Station
    3. Addition of Incremental Generation on the Avalon Peninsula

6. Hydro recommends that the Emergency Transmission Planning Criteria defined above be adopted as Hydro continues its Reliability and Resource Adequacy Study. This recommendation has the following outcomes:
    a. If no incremental capacity or imports are available within the IIS, the possible customer impacts due to transmission system restrictions would only occur as a result of thermal overloads following the loss of TL217, which would require load shedding.
    b. If incremental capacity is imported over the ML, there is an increased risk of customer impact due to transmission system limitations. Outages to TL201 or TL217 would require load shedding to avoid overload conditions. There would also be an exposure to system instability in the event of a three-phase fault at Bay d'Espoir terminal station; however, such events are not considered as part of Transmission Planning Criteria.

7. The appropriateness of the Emergency Planning Criteria as a long term solution is dependent on whether incremental generation is installed and where the generation is located. The criteria and the resulting impacts shall therefore be re-evaluated as Hydro's Reliability and Resource Adequacy Study continues. In the interim, they will provide a basis for Transmission Planning and will serve to further inform the discussion as Hydro looks to ensure long term reliability for its customers.

1 Background

As part of Hydro's Reliability and Resource Adequacy Study, TGS were engaged to perform a review of power delivery to the Avalon Peninsula in the event of an outage to the LIL bipole. The TGS Study involved the examination of transmission system constraints in consideration of aspects such as voltage profiles, transmission line thermal limits, and transient stability. A series of operating conditions were

assessed and violations to Transmission Planning Criteria[4] were identified. The analysis also included a review of the transmission system upgrades that would be required to meet peak load without violations to criteria.

The violations presented in the TGS Study were extensive, as were the array of system upgrades that would be required to mitigate them. This is due to the fact that the assessment included the addition of significant generation off of the Avalon Peninsula to meet peak load. The delivery of this capacity to load centres in eastern regions of the transmission system resulted in the excessive loading of transmission corridors.

2 Purpose

As a next step, Hydro must make a determination as to whether Emergency Transmission Planning Criteria should be adopted or if transmission system upgrades are required. As part of this decision process, the analysis summarized in this report is an extension of the review performed by TGS and includes an assessment of the performance of the existing system without incremental generation.

Hydro notes that the IIS faces a significant generation shortfall during a LIL bipole outage if no incremental capacity is installed. With such limited generation, the transmission system is much less heavily loaded and violations to criteria are less severe. The objectives of this analysis are therefore to define appropriate actions for the existing transmission system without incremental generation.

The methodology for this analysis is defined as follows:

1. Develop base case scenarios to reflect the maximum Island Demand that can be supported by existing generating resources.
2. Assess system performance for the existing system and review of the application of Transmission Planning Criteria during a LIL bipole outage scenario.
3. Identify violations to Transmission Planning Criteria and assess if remedial actions are required.
4. Recommend appropriate Transmission Planning Criteria for a LIL bipole outage scenario.

3 Base Case Development

Base cases were developed in accordance with Generation Planning capacity assumptions. All Island generation summarized in Table 1 is assumed to be available.

[4] NLSO Standard TP-S-007 - Transmission Planning Criteria, March, 2019

Table 1 - Island Generation Capacity

Island Generation Capacity	Firm Capacity
Unit	**MW**
Bay D'Espoir - Unit 1	76.5
Bay D'Espoir - Unit 2	76.5
Bay D'Espoir - Unit 3	76.5
Bay D'Espoir - Unit 4	76.5
Bay D'Espoir - Unit 5	76.5
Bay D'Espoir - Unit 6	76.5
Bay D'Espoir - Unit 7	154.4
Cat Arm - Unit 1	67
Cat Arm - Unit 2	67
Granite Canal	40
Hinds Lake	75
Paradise River	8
Upper Salmon	84
Holyrood Thermal - Unit 1	-
Holyrood Thermal - Unit 2	-
Holyrood Thermal - Unit 3	-
Newfoundland Power - Avalon Hydro	43.9
Newfoundland Power - Off-Avalon Hydro	27.6
Newfoundland Power - Thermal	39
Hardwoods GT	-
Hawkes Bay Diesels	5
Holyrood GT	123.5
Holyrood Diesels	8.5
St. Anthony Diesels	9.7
Stephenville GT	-
Deer Lake - Units	102
Watsons Brook	2.0
Bishop's Falls - Unit 1-6	9.6
Bishop's Falls - Unit 7	1.7
Grand Falls - Beeton	20.7
Grand Falls - Unit 4	19.7
Grand Falls - Unit 5/6	5.8
Grand Falls - Unit 7	2.6
Grand Falls - Unit 8	2.9
Corner Brook CoGen	-
Fermeuse Wind	6

Island Generation Capacity	Firm Capacity
Unit	**MW**
Rattle Brook	-
St. Lawrence Wind	6
Star Lake	18
Vale Diesels	-
Total Island Generation Capacity	**1408.6**

As discussed above, it is assumed that no transmission system upgrades or incremental generating resources are installed on the IIS.

For the purposes of this investigation, the following assumptions were made to maximize power flows and assess worst-case contingencies within the transmission system:

1. **Load Interruption of approximately 100 MW at Corner Brook Pulp and Paper**
   A load interruption of approximately 100 MW at Corner Brook Pulp and Paper is assumed to be available. The interruption does not serve as incremental capacity, but would allow for a reduction of industrial load and for the "Deer Lake – Units" capacity indicated in the table above to be made available for other Island customers, including those on the Avalon Peninsula and in eastern regions of the transmission system.

2. **Import over the Maritime Link**
   Hydro does not currently have an arrangement for firm import over the ML. For the purposes of this investigation, cases were developed with and without an import of 300 MW at Bottom Brook. This additional capacity allows for more load to be served. However, the delivery of this additional 300 MW to load centres results in increased corridor loading, thereby increasing the probability of violations to Transmission Planning Criteria.

3. **Load Curtailment**
   During a LIL bipole outage the system is constrained from a generation standpoint and there is insufficient capacity to meet peak load. Load curtailment was therefore performed for all base cases and all Newfoundland Power and Hydro Rural customers were curtailed on a proportional basis.[5]

As per the considerations listed above, the following base case scenarios were developed:

1. Base Case 1 – Maximum Island Generation with 300 MW ML Import
2. Base Case 2 – Maximum Island Generation with No ML Import

[5] The system was not found to be "transmission constrained" during the load curtailment process. For example, there was no transmission system limitation that required the curtailment of a disproportionate amount of customers on the Avalon Peninsula as opposed to the remainder of the IIS. All Newfoundland Power and Hydro Rural customers were therefore evenly curtailed across the system.

Base Case 1 is illustrated in Appendix A and is characterized as follows:

- Total Island System Capacity ≃ 1700 MW, representing total Island generation and ML imports.
- A regulating reserve of 70 MW is maintained within the Island system.[6]
- An Island Demand of approximately 1630 MW can be supported in this case.[7]
- The sum of station service and transmission losses in this case is approximately 100 MW.
- A customer load of 1530 MW can therefore be supported in this case.[8]

Base Case 2 is also illustrated in Appendix A. It is noted that available capacity is reduced when imports over the ML are not available. Calculations for this case are as follows:

- Total Island System Capacity ≃ 1400 MW, representing total Island generation.
- A regulating reserve of 70 MW is maintained within the Island system
- An Island Demand of approximately 1330 MW can be supported in this case.
- The sum of station service and transmission losses in this case is approximately 70 MW.
- A customer load of 1260 MW can therefore be supported in this case.

4 Base Case Analysis

Transmission Planning Criteria were assessed for the base cases described in the previous section using the same methodology that TGS employed for the TGS Study. The results of the analysis are such that criteria were met for all contingencies, with the exception of those listed in the following sections.

4.1 Base Case 1 – Maximum Island Generation with 300 MW ML Import

The following violations to Transmission Planning Criteria were noted for the case that included 300 MW of import over the ML:

Thermal Overloading of Transmission Lines

- Thermal overload of TL217 to 109% for the loss of TL201
- Thermal overload of TL201 to 154% for the loss of TL217

Violations to Transient Stability Limits

- Three-phase faults at Sunnyside Terminal Station, followed by a trip of TL267 resulted in a post-fault recovery voltage of less than 0.8 pu for a duration in excess of 20 cycles. This is illustrated in Figure 1.

[6] Hydro employs a minimum reserve of 70 MW within the island system under contingency operations to provide for acceptable frequency regulation.

[7] The maximum Island Demand that can be supported is equal to the Total Island System Capacity minus regulating reserve requirements.

[8] The maximum customer load that can be supported is equal to of the Island Demand minus station service and transmission losses.

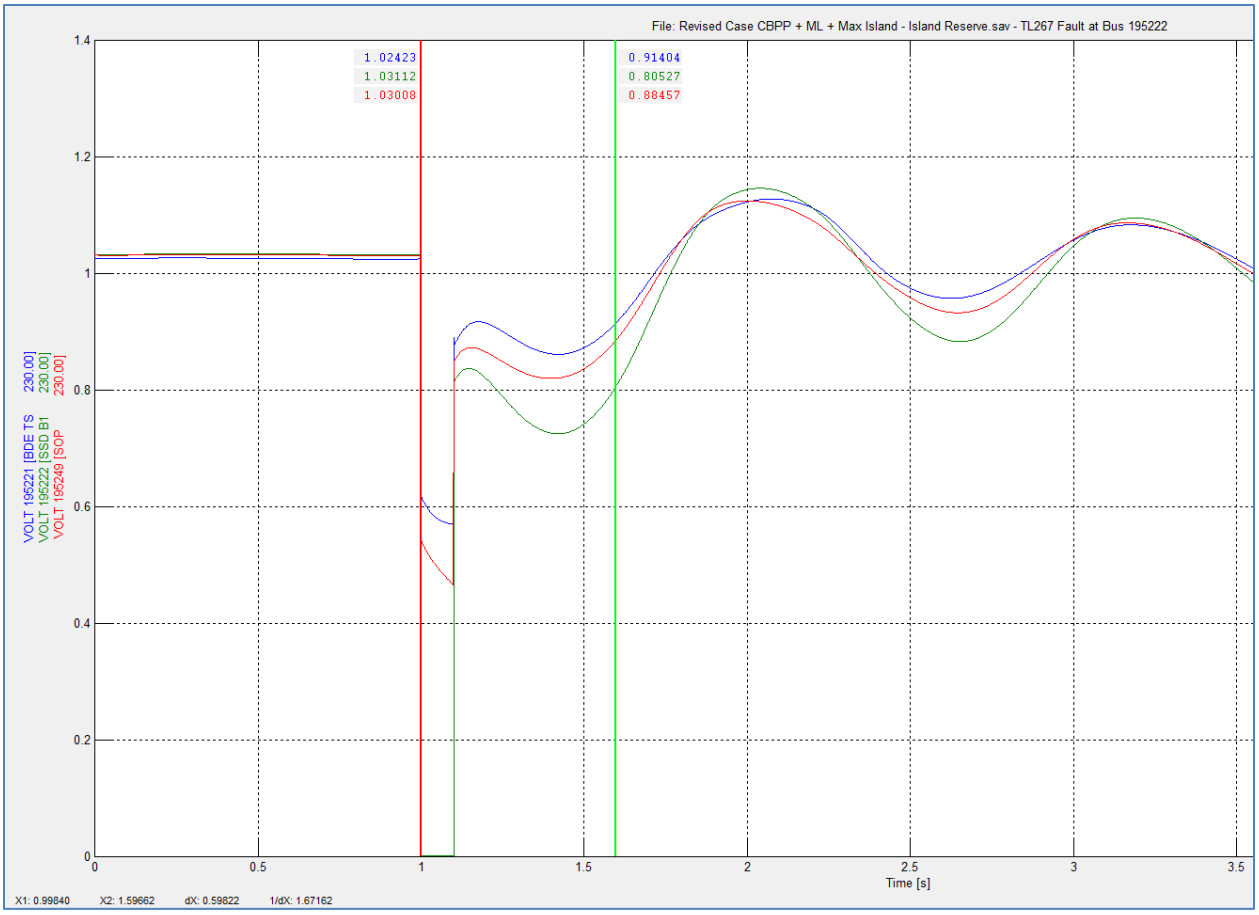

Figure 1 – Post-Fault Recovery Voltage Plot
Three-Phase Fault at Sunnyside Terminal Station, resulting in a trip of TL267

Assessment of Three-Phase Faults at Bay d'Espoir Terminal Station

Hydro notes that Transmission Planning Criteria are defined such that a three-phase fault at Bay d'Espoir Terminal Station is not considered. As part of this investigation, three-phase faults were applied at Bay d'Espoir Terminal Station and unstable responses were found for the following cases:

- Three-Phase Fault at Bay d'Espoir Terminal Station, followed by a trip of TL202
- Three-Phase Fault at Bay d'Espoir Terminal Station, followed by a trip of TL206
- Three-Phase Fault at Bay d'Espoir Terminal Station, followed by a trip of TL267

4.2 Base Case 2 – Maximum Island Generation with No ML Import

The following violations to Transmission Planning Criteria were noted for the case without import over the ML:

Thermal Overloading of Transmission Lines

- Thermal overload of TL201 to 118 % (for loss of TL217)

No instability or other violations to transient stability criteria were found for this case.

5 Consequences of Criteria Violations

Analysis was performed to assess the impact of the violations listed above. The results are summarized below.

5.1 Base Case 1 – Maximum Island Generation with 300 MW ML Import

For the base case that included 300 MW of import over the ML, the following remedial actions were required:

Thermal Overloading of Transmission Lines

In the event of the loss of TL201 or TL217, load shedding is required to mitigate thermal overloads. Analysis indicates the following load shed requirements:

- 40 MW of load shed is required east of Soldiers Pond Terminal Station in the event of the loss of TL201.
- 200 MW of load shed is required east of Soldiers Pond Terminal Station in the event of the loss of TL217.

Violations to Transient Stability Limits

As noted above, a three-phase fault at Sunnyside Terminal Station with a trip of TL267 will result in a post-fault recovery voltage of less than 0.8 pu for a duration in excess of 20 cycles. This event does not result in a customer impact, but is a violation to Transmission Planning Criteria.

This is deemed a violation as voltages are unacceptably close to a point of instability for this contingency. If such a violation were found under normal operation, transmission system upgrades would be required to ensure acceptable margins to protect against unstable operation.

Assessment of Three-Phase Faults at Bay d'Espoir Terminal Station

Risks associated with three-phase faults at Bay d'Espoir Terminal Station were assessed as part of the Stage 4A Operational Study[9] that was completed by Hydro and TGS. The results of this analysis indicate that the instability resulting from such faults arises as power flows eastward from Bay d'Espoir reach

[9] Stage 4A LIL Bipole: Preliminary Assessment of High Power Operation, TGS, November 21, 2018

approximately 615 MW.[10] In Base Case 1, these flows were found to exceed 650 MW. There is no risk of instability in Base Case 2, where power flows eastward from Bay d'Espoir are approximately 520 MW.

Under the assumption that stability would be maintained if power flow eastward from Bay d'Espoir is limited to approximately 615 MW, an interpolation can be made as an approximate stability limit on the basis of the results stated above. In Base Cases 1 and 2, the power flow east of Bay d'Espoir equates to approximately 40% of Island Demand. Using this ratio, a total Island Demand in the order of 1540 MW could be supported without risk of instability.

5.2 Base Case 2 – Maximum Island Generation with No ML Import

For the base case that included no import over the ML, the following remedial action was required:

Thermal Overloading of Transmission Lines

- In the event of the loss of TL217, load shedding is required to mitigate the thermal overload of TL201. Analysis indicates that a load shed of approximately 65 MW on the Avalon Peninsula is required in this case.

6 Application of Emergency Transmission Planning Criteria

The results presented in previous sections indicate violations to Transmission Planning Criteria when the LIL bipole is out of service. Hydro must therefore make a determination as to whether system upgrades should be installed or if Emergency Transmission Planning Criteria should be defined for this mode of operation.

6.1 Specification of Emergency Transmission Planning Criteria

If no transmission system upgrades are to be performed, the following criteria would be required:

1. In the event that the LIL bipole is out of service, load shedding is permitted in response to a transmission line outage to avoid thermal overloading.

2. In the event of a three-phase fault while the LIL bipole is out of service, the suppression of transient recovery voltages is acceptable as long as stable operation is maintained.[11]

[10] This limit is based on preliminary results of the Stage 4A study and will be further investigated in ongoing operational studies to be completed in 2019.

[11] As stated above, a post-fault recovery voltage of less than 0.8 pu for a duration in excess of 20 cycles is a violation under normal operating conditions. This is an indication that the margin between the response and the point of instability is less than what is deemed acceptable. With the LIL out of service, criteria are specified such that this margin is eliminated and system performance is deemed acceptable as long as stability is maintained.

3. As per normal operation, three-phase faults at Bay d'Espoir terminal station are excluded from consideration. Such faults may result in instability in cases with high power flows eastward from Bay d'Espoir.

6.2 Operational Considerations of Emergency Transmission Planning Criteria

If the criteria listed above were adopted, the following operational considerations would need to be assessed to ensure that customer impacts during a LIL bipole outage are minimized:

1. **Develop/Modify Restoration Procedures**
   Hydro is in the process of developing restoring procedures to black start the IIS. Such procedures will need to be in place to ensure rapid restoration in the event of a system-wide outage resulting from instability.

2. **Develop a Rapid Load Shedding Procedure**
   As discussed above, up to 200 MW of load shedding would be required on the Avalon Peninsula to avoid the thermal overloading of transmission lines. To ensure that transmission lines are not damaged due to significant overloads, it is recommended that load shedding be complete in an acceptable timeframe.[12] A review would therefore need to be performed in consultation with Newfoundland Power to develop a procedure.

3. **Review Protection Settings**
   In the event of a trip of TL201 or TL217, overloads of up to 154% may be experienced on the remaining line. It is recommended that a protection review be performed to ensure overloads of this magnitude do not result in activation of overcurrent relays or other protection systems.

6.3 Alternatives to Emergency Transmission Planning Criteria

If the criteria listed above are not adopted, ether incremental generating resources or transmission upgrades would be required. In accordance with the results of the TGS Study, the following upgrades would need to be considered:

1. **Transmission System Upgrades in the 230 kV Corridor between Western Avalon Terminal Station and Soldiers Pond Terminal Station**
   As summarized above, thermal overloads are experienced in the event of an outage to TL201 or TL217. Reinforcements in the form of thermal uprates to transmission lines or the construction

[12] A targeted timeframe of thirty minutes would be comparable to the duration required to off-load transmission lines using gas turbines. In the base case scenarios described in this analysis, no incremental gas turbine capacity is available and load must be shed.

of a new 230 kV transmission line would be required in this corridor. It is noted that this upgrade would not provide a capacity benefit when all 230 kV transmission lines are in service.

2. **Reactive Support in the Area of Sunnyside Terminal Station**
   To avoid transient undervoltage violations, incremental reactive support in the form of capacitor banks, synchronous condensers, or power electronic devices such as STACOMs would be required in the area of Sunnyside Terminal Station. Such system reinforcements would also reduce the risk of instability due to three-phase faults at Bay d'Espoir Terminal Station. This upgrade would not provide a capacity benefit when all 230 kV transmission lines are in service.

3. **Addition of Incremental Generation on the Avalon Peninsula**
   The addition of generation on the Avalon Peninsula would offload eastward power flows from Bay d'Espoir Terminal Station and would provide incremental capacity to meet customer load. As per the results of the TGS Study, peak loads could be met without risk of instability and all criteria violations could be eliminated by the addition of gas turbines. The other upgrades listed above may not be required depending on the capacity of the incremental generation.

6.4 Recommended Course of Action

As stated above, Hydro's Reliability and Resource Adequacy study is ongoing. This study involves an extensive review of the capacity of the IIS and will determine any requirement for incremental generation.

The Reliability and Resource Adequacy Study results summarized in this technical note are based on existing generating resources and indicate that system performance is heavily dependent on where incremental sources of supply are located. For example, the import of capacity over the ML results in an increase in the number of criteria violations and exposure to instability. Conversely, the addition of generation on the Avalon Peninsula would offload eastward power flows from Bay d'Espoir and reduce or eliminate requirements for transmission system upgrades.

On this basis, it is recommended that the Emergency Transmission Planning Criteria defined above be adopted as Hydro continues its Reliability and Resource Adequacy study. This recommendation has the following outcomes:

- If no incremental capacity or imports are available, the IIS is constrained during peak periods from a generation standpoint. This has the effect of limiting power flows within the transmission system to the point that there is only one violation to Transmission Planning Criteria. This violation would be the load shedding required as a result of thermal overloads following the loss of TL217.
- If incremental capacity is imported over the ML, there is an increased risk of customer impact due to transmission system limitations. Outages to TL201 or TL217 would require load shedding to avoid overload conditions. There would also be an exposure to system instability in the event of a three-

phase fault at Bay d'Espoir Terminal Station; however, such events are not considered as part of Transmission Planning Criteria.[13]

6.5 Consideration of Further Incremental Off-Avalon Generation to Meet Peak Load

The TGS Study included a review of system performance if incremental off-Avalon generation were added to meet peak load. The increased power flows across the transmission system in this case result in the following more extensive listing of violations to Transmission Planning Criteria:[14]

- Thermal Overloading of Transmission lines
- Undervoltages for system intact conditions
- Undervoltages for contingency (n-1) conditions
- Transient undervoltages following three-phase faults
- Instability following three-phase faults at Sunnyside Terminal Station

The TGS Study includes detail on these violations as well as an assessment of power flow limits if criteria were enforced. The TGS study also includes descriptions of mitigating transmission system upgrades.

These results will be considered as incremental off-Avalon generation alternatives are evaluated as part of Hydro's ongoing Reliability and Resource Adequacy Study. Such alternatives would require either an expansion of the definition of Emergency Transmission Planning Criteria or the addition of incremental transmission system upgrades.

The appropriateness of the Emergency Planning Criteria as a long term solution is dependent on whether incremental generation is installed and on where the generation is located. The criteria and the resulting impacts shall therefore be re-evaluated as Hydro's Reliability and Resource Adequacy study continues. In the interim, they will provide a basis for Transmission Planning and will serve to further inform the discussion as Hydro looks to ensure long term reliability for its customers.

7 Conclusions and Recommendations

The analysis summarized in this document is in support of Hydro's ongoing Reliability and Resource Adequacy Study and includes an assessment of system performance of the existing system without incremental generation.

The methodology for this analysis is defined as follows:

[13] This fault would not result in instability in the case with no ML import. This is due to the fact that power flows within the transmission system in the case are limited below the point at which instability concerns would arise.

[14] While not a violation to Transmission Planning Criteria, three-phase faults at Bay d'Espoir Terminal Station would also result in instability in this case.

1. Develop base case scenarios to reflect the maximum Island Demand that can be supported by existing generating resources.
2. Assess system performance for the existing system and review of the application of Transmission Planning Criteria during a LIL bipole outage scenario.
3. Identify violations to Transmission Planning Criteria and assess if remedial actions are required.
4. Recommend appropriate Transmission Planning Criteria for a LIL bipole outage scenario.

Conclusions of the report are as follows:

1. Base Cases were developed to determine maximum customer loads that can be supported during a LIL bipole outage. The cases are summarized as follows:
    - Base Case 1 - Maximum Island Generation with 300 MW ML Import
        - Total Island System Capacity ≃ 1700 MW
        - A total customer load of 1530 MW can be supported
    - Base Case 2 – Maximum Island Generation with No ML Import
        - Total Island System Capacity ≃ 1400 MW
        - A total customer load of 1260 MW can be supported

2. The following violations to Transmission Planning Criteria were identified in the base cases:
    - Base Case 1
        - Thermal overload of TL201 in the event of an outage to TL217
        - Thermal overload of TL217 in the event of an outage to TL201
        - Transient undervoltage violations for three-phase fault at Sunnyside
        - While not a violation, instability occurs for a three-phase fault at Bay d'Espoir, followed by the tripping of TL202, TL206, or TL267.
    - Base Case 2
        - Thermal overload of TL201 in the event of an outage to TL217

3. If no transmission system upgrades are to be performed, the following criteria would be required:
    a. In the event that the LIL bipole is out of service, load shedding is permitted in response to a transmission line outage to avoid thermal overloading.
    b. In the event of a three-phase fault while the LIL bipole is out of service, the suppression of transient recovery voltages is acceptable as long as stable operation is maintained.[15]
    c. As per normal operation, three-phase faults at Bay d'Espoir terminal station are excluded from consideration. Such faults may result in instability in cases with high power flows eastward from Bay d'Espoir.[16]

[15] This criterion would not be required if capacity is limited to existing generation within the Island System.

[16] This criterion would not be required if capacity is limited to existing generation within the Island System.

4. If the criteria listed above were to be adopted, the following operational considerations would need to be assessed to ensure that customer impacts are minimized during a LIL bipole outage:
    - Develop/Modify Restoration Procedures
    - Develop a Rapid Load Shedding Procedure
    - Review Protection Settings

5. If the criteria listed above are not adopted, the following upgrades would need to be considered:
    - Transmission System Upgrades in the 230 kV Corridor between Western Avalon Terminal Station and Soldiers Pond Terminal Station
    - Reactive Support in the Area of Sunnyside Terminal Station
    - Addition of Incremental Generation on the Avalon Peninsula

6. It is recommended that the Emergency Transmission Planning Criteria defined above be adopted as Hydro continues its Reliability and Resource Adequacy study. This recommendation has the following outcomes:
    a. If no incremental capacity or imports are available within the IIS, the only possible customer impacts due to transmission system restrictions would only occur as a result of thermal overloads following the loss of TL217, which would require load shedding.
    b. If incremental capacity is imported over the ML, there is an increased risk of customer impact due to transmission system limitations. Outages to TL201 or TL217 would require load shedding to avoid overload conditions. There would also be an exposure to system instability in the event of a three-phase fault at Bay d'Espoir terminal station; however, such events are not considered as part of Transmission Planning Criteria.

7. The appropriateness of the Emergency Transmission Planning Criteria as a long term solution is dependent on whether incremental generation is installed and on where the generation is located. The criteria and the resulting impacts shall therefore be re-evaluated as Hydro's Reliability and Resource Adequacy study continues. In the interim, they will provide a basis for Transmission Planning and will serve to further inform the discussion as Hydro looks to ensure long term reliability for its customers.

Appendix A – Load Flow Plots

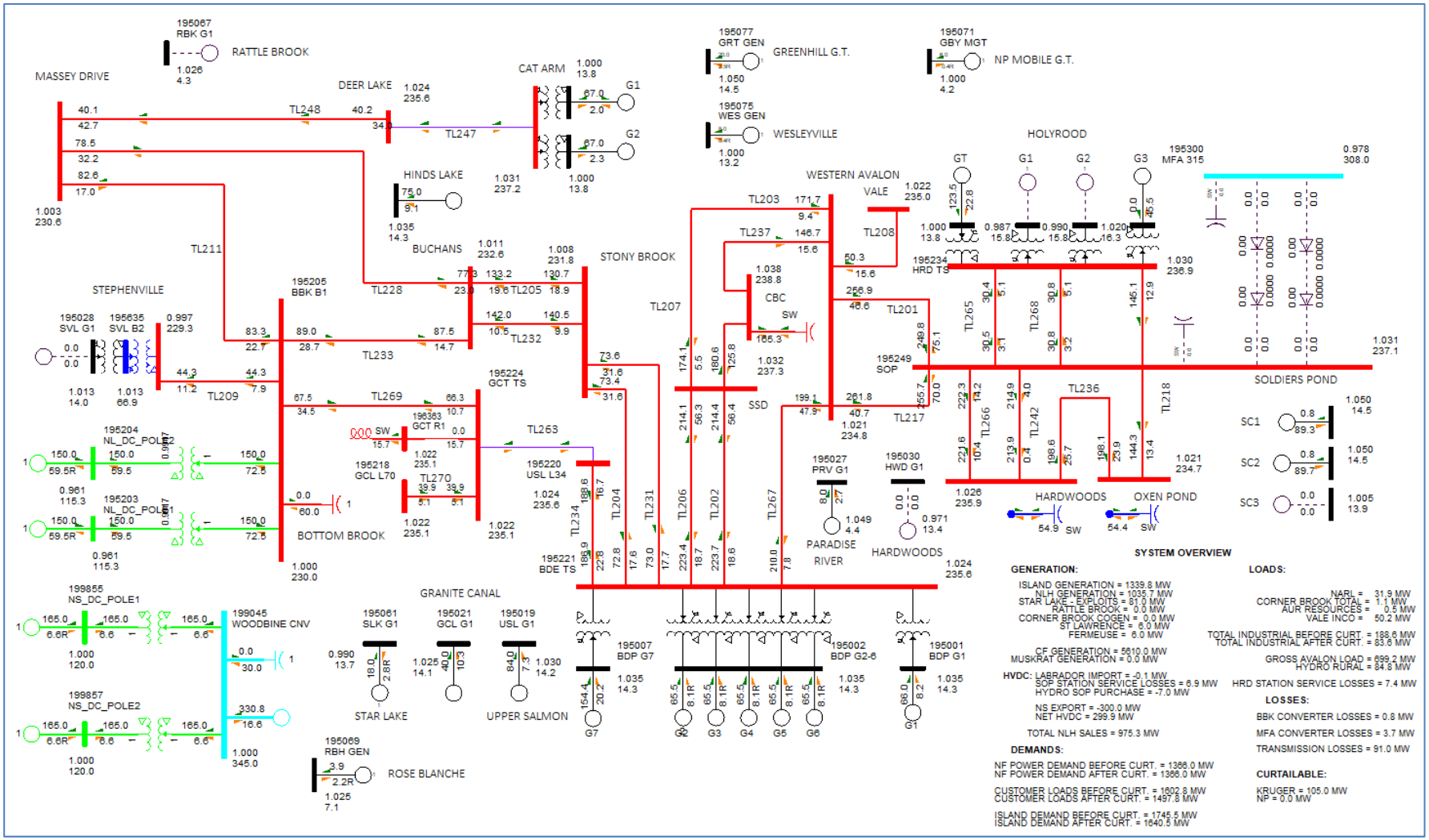

Figure 2 - Base Case 1 – Maximum Island Generation with 300 MW ML Import

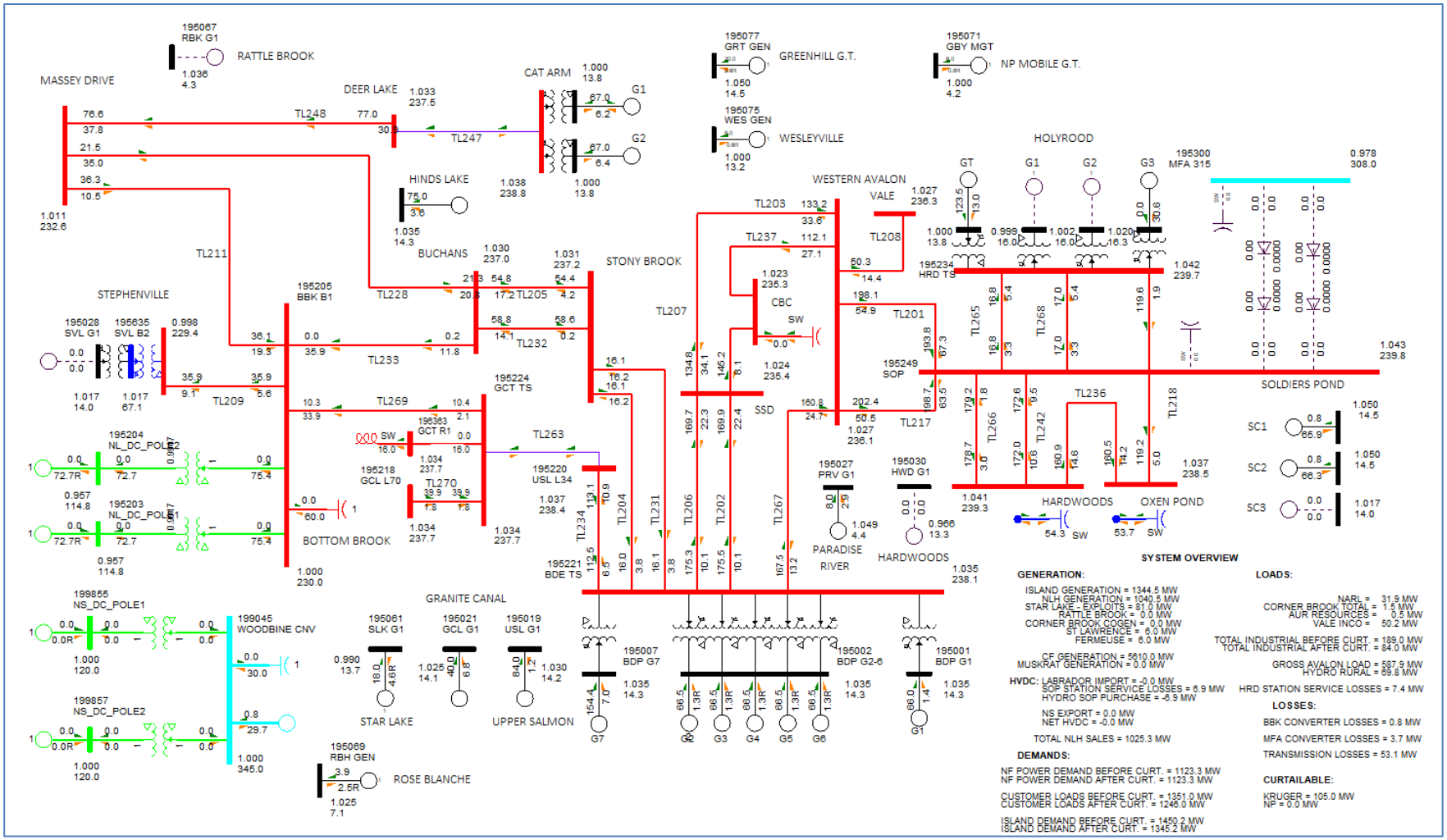

Figure 3 - Base Case 2 – Maximum Island Generation with No ML Import

Document Summary

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Revision History

Revision	Prepared by	Reason for change	Effective Date
1	R. Collett	Original Issue	2019/07/30

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