newfoundland labrador hydro
a nalcor energy company

Hydro Place. 500 Columbus Drive.
P.O. Box 12400. St. John's. NL
Canada A1B 4K7
t. 709.737.1400 f. 709.737.1800
www.nlh.nl.ca

March 31, 2021

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 & Board Secretary

Dear Ms. Blundon:

Re: Reliability and Resource Adequacy Study Review — Operational Studies

On October 2, 2020, Newfoundland and Labrador Hydro ("Hydro") provided correspondence[1] within which it advised the Board of Commissioners of Public Utilities ("Board") and Parties to the Reliability and Resource Adequacy Study ("RRA Study") review that it was in the process of undertaking several operational studies which would be filed with the Board as part of the RRA Study Review proceeding. The studies are enclosed with this correspondence and are further described below.

- The study titled "LIL Operation at Low Short Circuit Level"[2] used PSCAD to assess the performance of the Labrador Island-Link under Island Interconnection System conditions with low short circuit levels. It was undertaken in support of the development of operating instructions.

- The Under-Frequency Load Shedding ("UFLS") Study was undertaken in consultation with Newfoundland Power to refine the load shedding scheme specified in the Stage 4E Operational Study. The UFLS study involved the optimization of load shedding blocks and includes a review of the system restoration process subsequent to an UFLS event. Within the UFLS Study, there is reference to a study entitled "Operational Considerations of LIL[3] restarts and ML[4] Runbacks." To ensure the Board and Parties have the full context required, this report is also provided.

- The Critical-Clearing Time Study was undertaken in consultation with Newfoundland Power to determine the critical clearing times for all the 66 kV and 138 kV buses within the Island Interconnected System following the full integration of the Lower Churchill Project.

Should you have any questions, please contact the undersigned.

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[1] "Reliability and Resource Adequacy Study Review – Further Information and Filing Schedule," Newfoundland and Labrador Hydro, October 2, 2020.
[2] This study was originally intended to be filed with the Board in the fourth quarter of 2020; however, as communicated to the Board on December 18, 2020, an issue with GE's PSCAD model of the Labrador-Island Link caused delay with the analysis.
[3] Labrador-Island Link ("LIL").
[4] Maritime Link ("ML").

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel, Regulatory
SAW/kd

Encl.

ecc: **Board of Commissioners of Public Utilities**
Jacqui Glynn
Maureen P. Greene, Q.C.
PUB Official Email

Newfoundland Power
Gerard M. Hayes
Kelly C. Hopkins
Regulatory Email

Consumer Advocate
Dennis M. Browne, Q.C., Browne Fitzgerald Morgan & Avis
Stephen F. Fitzgerald, Browne Fitzgerald Morgan & Avis
Sarah G. Fitzgerald, Browne Fitzgerald Morgan & Avis
Bernice Bailey, Browne Fitzgerald Morgan & Avis

Industrial Customer Group
Paul L. Coxworthy, Stewart McKelvey
Denis J. Fleming, Cox & Palmer
Dean A. Porter, Poole Althouse

Labrador Interconnected Group
Senwung Luk, Olthuis Kleer Townshend LLP
Julia Brown, Olthuis Kleer Townshend LLP

NLSO Operational Studies

LIL Operation at Low Short Circuit Levels

Humud Said

March 30, 2021

Revisions

Project Name:	NLSO Operational Studies
Document Title:	LIL Operation at Low Short Circuit Levels
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Rev. No.	Status	Prepared By	Checked By	Date	Comments
01	Draft for comments	Humud Said	Pete Kuffel	2020/11/19	Initial submission
02	Updated with the new PSCAD model from GE	Humud Said	Pete Kuffel	2021/03/16	For review
03	Final version based on NLSO input	Humud Said	Pete Kuffel	2021/03/26	Final version
04	Submitted version	Humud Said	Peter Kuffel	2021/03/30	Submitted version

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Executive Summary

This report was prepared as part of the validation of NLSO system operations studies. The objective of the report was to validate the results obtained in PSSE by using the PSCAD EMTDC tool. The results of the PSSE analysis indicated the presence of Labrador Island Link ("LIL") commutation failures under conditions with low short circuit levels. Since it is difficult to capture commutation failure accurately in a phasor simulator like PSSE, it was deemed prudent that these results be checked in a time-domain simulator such as PSCAD.

A custom HVDC PSCAD model provided by GE was used to perform the studies. Thevenin equivalent circuits with correct short circuit levels ("SCL") were used to represent the network. A matrix of SCL levels at Soldiers Pond ("SOP") is shown in the table below [1]. The SCL depends on the number of synchronous condensers available as well as the number of Holyrood ("HRD") units available.

Minimum SOP Short Circuit Levels (MVA)				
No. of SOP units online	No of HRD units online			
	3	2	1	0
3	4409	3905	3402	2930
2	3822	3318	2816	2344
1	3218	2714	2212	1740
0	2633	2129	1627	1157

Table 1 Short circuit levels at SOP for different combinations of synchronous condensers and HRD units.[1]

The basis for the analysis is summarized as follows:

- To ensure compliance with the specification, the LIL will only be operated in system conditions when a total of least two of the seven units at SOP or HRD are in service. The Holyrood Gas Turbine can be considered one of the two units, as it would increase the SCLs by 450 MVA.
- With only two units in service, stable operation must be confirmed for contingency scenarios involving the loss of one of the units.
- As per Table 1, the worst-case short circuit level with a single unit in service is 1627 MVA.

Important AC faults capturing the bookends in terms of stressing the HVDC, as agreed with the NLSO were simulated. The faults considered were as follows:

1. Bolted 3ϕ fault at SOP bus with SOP operating as an inverter.
2. Remote fault 3ϕ fault at SOP with SOP operating as an inverter.
3. Temporary DC line fault with 4 restarts.

The results of the analysis are as follows:

[1] The Holyrood Gas Turbine was not considered in this table, but can be dispatched to increased the SCL at SOP by approximately 450 MVA.

- At a short circuit level of 1627 MVA, steady-state instability was detected at high power flow levels.
- From the simulation results, it was determined that the HVDC could transfer up to 700MW without repeated commutation failures after fault recovery.

On the basis of the above, the following conclusion and recommendations are specified for the operation of the LIL:

- To ensure that short circuit levels are in accordance with the specification, the LIL should only be operated in system conditions when a total of least two of the seven units at SOP or HRD are in service.
- If only two of the seven units are in service, there is a risk of unstable LIL operation at steady-state if one of the units were to trip. To avoid the risk of instability, the LIL is to be operated below 700 MW in this mode of operation. If another unit is not available to be dispatched the LIL must be shutdown as the loss of the remaining unit could result in system instability.

1 Introduction

1.1 Terms of Reference

Terms of reference for the study included:

- Review of the custom PSCAD model provided to ensure that it initializes and runs correctly.
- Use the model with SCL levels matching the ones highlighted in [2] that resulted in commutation failure to validate the PSSE results.
- Run the cases identified as being the critical ones.
- Document the results in a report.

2 Assumptions

The report is based on the following assumptions:

- The custom PSCAD HVDC model from GE captures an accurate representation of the LIL. [2]

2.1 Network representation

Thevenin equivalents were used to represent the AC systems at each end of the LIL. Each Thevenin equivalent consisted of a resistance in parallel with an inductance in series with a resistance circuit. The Thevenin equivalent of the island network was selected to provide a short circuit level of 1627MVA at an X/R ratio of 14.2, as per LIL specifications The Thevenin source voltage behind the impedance is fixed during model initialization to provide the desired commutating bus voltage once steady state is reached.

Although the use of Thevenin equivalents provides sufficient representation of the ac system to evaluate commutation performance during fault recovery it does introduce several simplifications to the response of the AC system as described below:

- The Thevenin equivalent is a simplification of the AC grid based solely on short circuit level and damping angle.
- The dynamic response of the grid is not captured accurately. The response of generator exciters and governors to the transient introduced to the grid by the fault is not represented by the Thevenin equivalent. The magnitude of the source voltage behind the equivalent system impedance remains constant.
- The frequency response of the grid is not represented. The Thevenin equivalent maintains a constant fundamental frequency.
- Characteristics of loads including motors characteristics are not accounted for.
- It was found that the system performance was very sensitive to the damping angle of the equivalent source. The X/R ratio of 14.2 was used as this was specified in the technical specifications. The sensitivity to the damping angle should be kept in mind and should be periodically checked in the operational cases to ensure that system damping is not much lower to this assumed value (or appropriate operational margins are applied).

3 Methodology

The following cases were considered for this analysis as a reference for this analysis [2]:

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[2] The PSCAD model has been validated against RTDS results for a set of preliminary factory test results. Further validation is pending and will be completed once the final version of the control system is tested.

- Light-LIL-ML500-GE-0SOP
- Peak-LIL-ML500-GE-0SOP

The short circuit levels for these two cases correspond to the cases with one HRD unit for the light case and three HRD units for the peak case. Since the light case results in the lowest SCL level, the value of 1627MVA was used for the simulations.

The following disturbances were considered:

1. Bolted 3ϕ fault at SOP bus with SOP behaving as an inverter. From a commutation failure performance perspective, this represents the worst-case scenario in terms of the AC voltage drop.
2. Remote 3ϕ fault at SOP with SOP behaving as an inverter. This fault captures the behavior of a fault at Western Avalon or Sunnyside. From a commutation performance perspective, it is prudent to check the performance of this fault as the inductive impedance of the fault may cause severe distortion of the AC voltage even though the voltage drop is not as severe as compared to the bolted fault.
3. Temporary DC line fault with 4 restarts. 4 restart attempts is the maximum number of attempts for LIL with increasing deionization time for each attempt. The 4^{th} attempt restarts to 80% of the DC voltage. This is the worst case in terms of the duration of power disruption to the network and the impact that has on the converter AC bus voltages.

The fault scenarios listed above were simulated with the LIL transfer at 700MW as this is the maximum power transfer that can be obtained without the steady-state oscillations (described in subsection 3.1). If any of the faults caused instabilities (including repeated commutation failure), the LIL dispatch was reduced by 50MW increments until a stable LIL transfer was found. The fault duration used was 6 cycles (100ms) to be consistent with the PSSE studies [3]

3.1 PSCAD model steady-state limitations

As mentioned previously, for the SCL value of 1627MVA, the PSCAD model was unstable for DC power transfers of above 700MW. Figure 1 shows a comparison at steady state for the two power transfers. It can be seen that 700MW is at the threshold of steady-state instability with a slight oscillation for inverter alpha but with the control mode stable in voltage control mode (control mode 2). For the 730MW power transfer case, the firing angle oscillations are higher and display steady state instability.

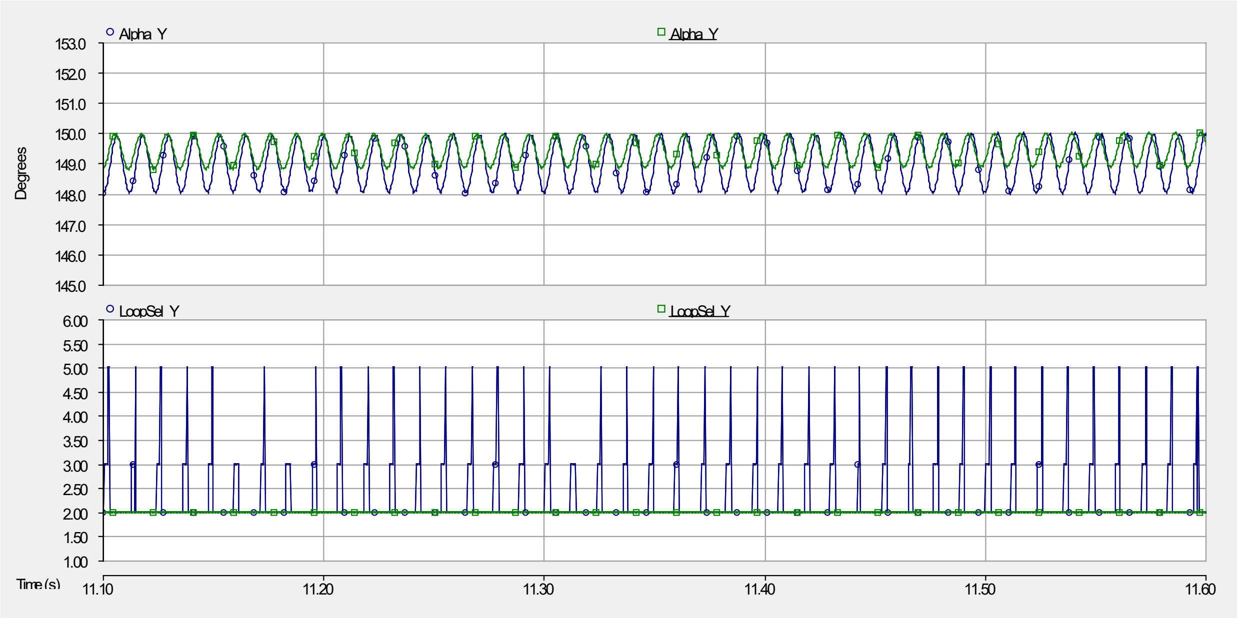

Figure 1 A comparison for inverter alpha (Alpha_Y) and inverter control mode (LoopSel_Y) between 700MW (green trace) and 730MW (blue trace) power transfer levels.

4 Simulation Results

This section summarizes the results obtained from the simulations. As described in Section 3, three disturbances were considered, and the results are summarized in the following subsections.

Figures 2 and 3 show the results for a 6-cycle bolted fault applied at SOP. Figure 2 shows the DC response for Pole 1, and Figure 3 shows the response for Pole 2. As can be seen, the HVDC recovers in a stable manner with no repeated commutation failure.

Figures 4 and 5 show the results for a 6-cycle remote fault representing disturbances a few buses away from SOP. Figure 4 shows the DC response for Pole 1, and Figure 5 shows the response for Pole 2. As can be seen, the HVDC recovers in a stable manner with no repeated commutation failure.

Finally, Figures 6 and 7 show the results for a 1 second DC line fault with 4 restart attempts. The fault is on Pole 1, and during the fault, Pole 2 picks up as much power transfer as possible to minimize the disruption to the network. As can be seen, the HVDC recovers in a stable manner with no repeated commutation failure.

4.1 Bolted 3ϕ fault at SOP bus with SOP behaving as an inverter.

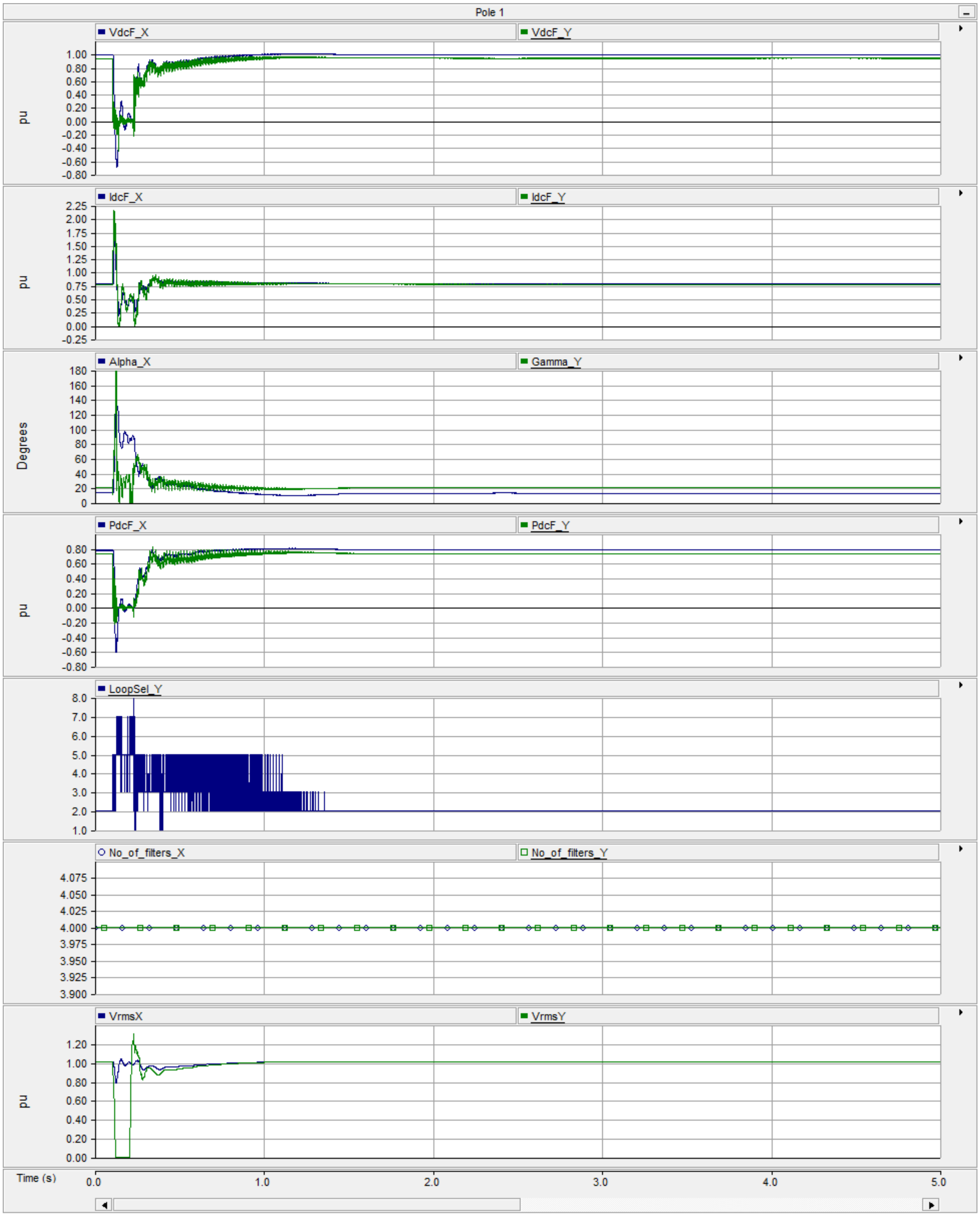

Figure 2 DC response when a 100ms bolted inverter fault is applied – Pole 1

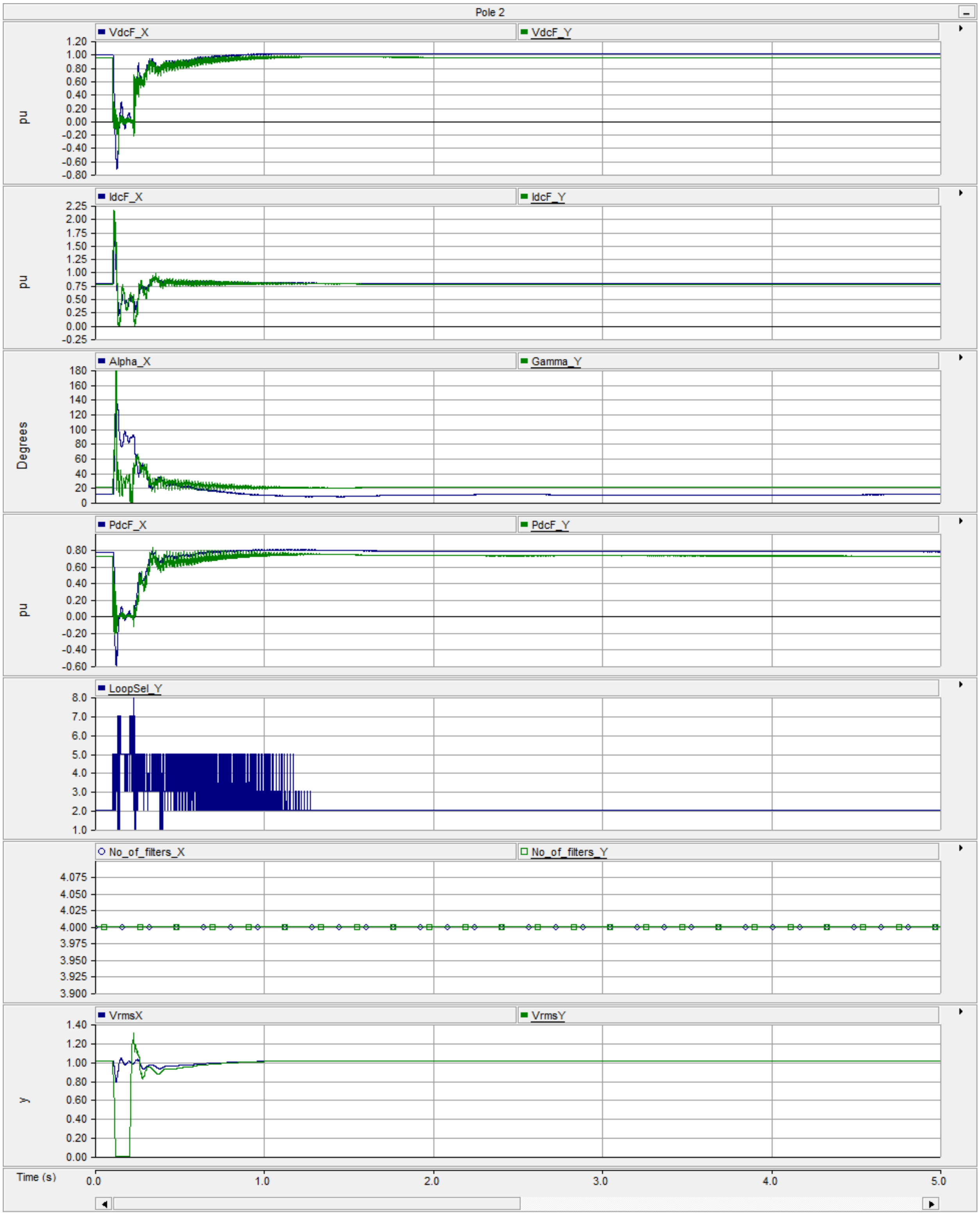

Figure 3 DC response when a 100ms bolted inverter fault is applied – Pole 2

4.2 Remote fault 3ϕ fault at SOP with SOP behaving as an inverter

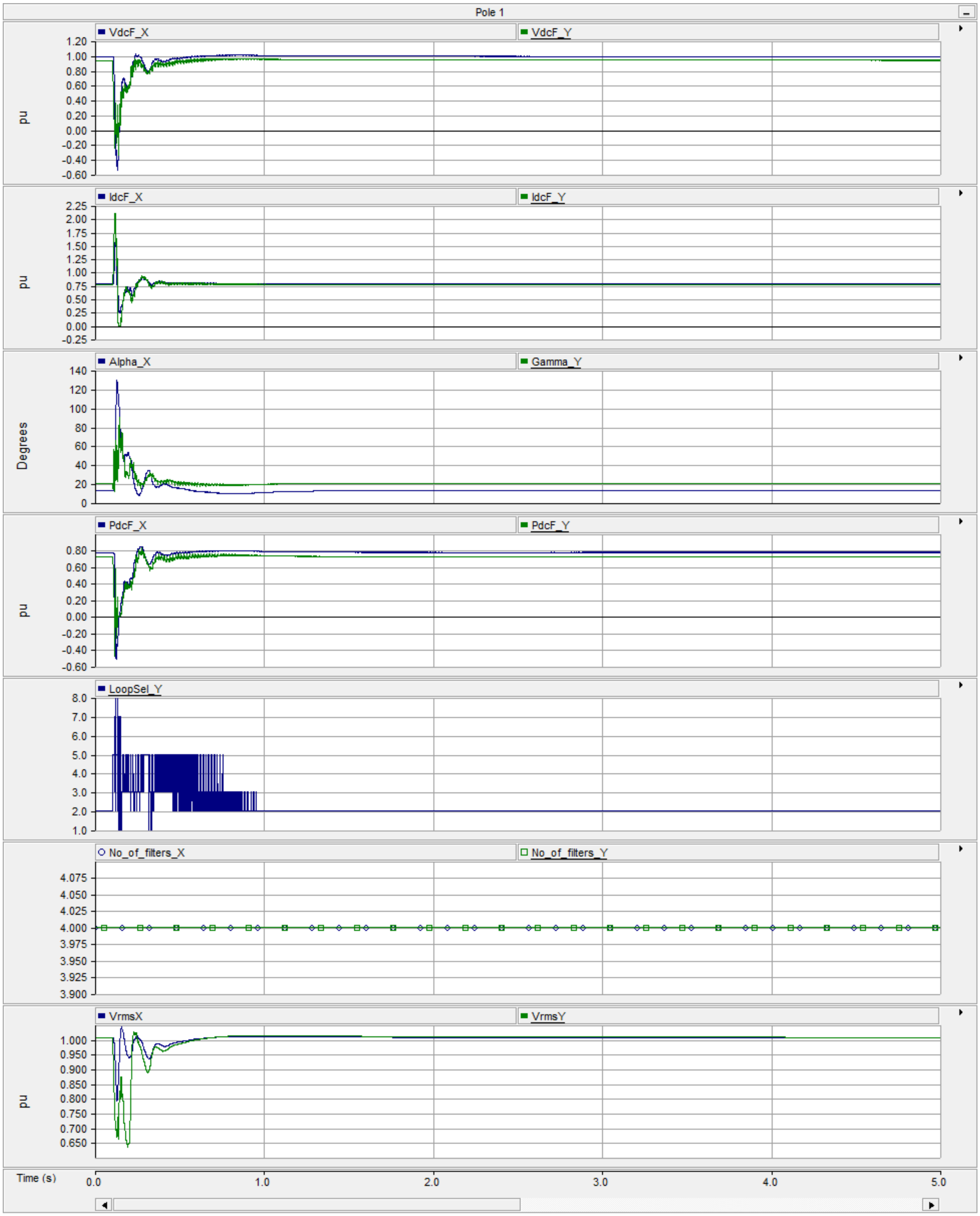

Figure 4 DC response when a 100ms remote inverter fault is applied – Pole 1

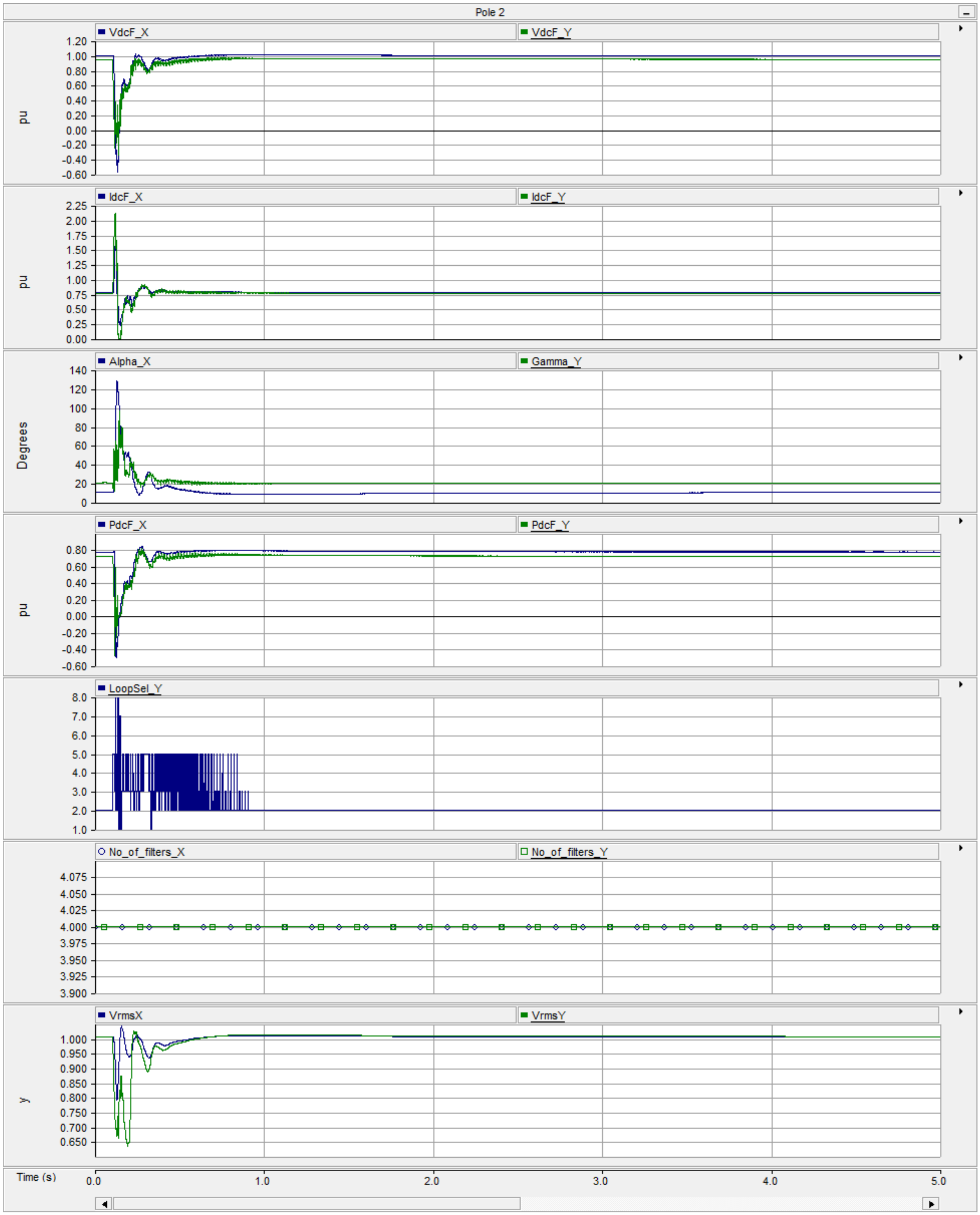

Figure 5 DC response when a 100ms remote inverter fault is applied – Pole 2

4.3 Temporary DC line fault with 4 restarts.

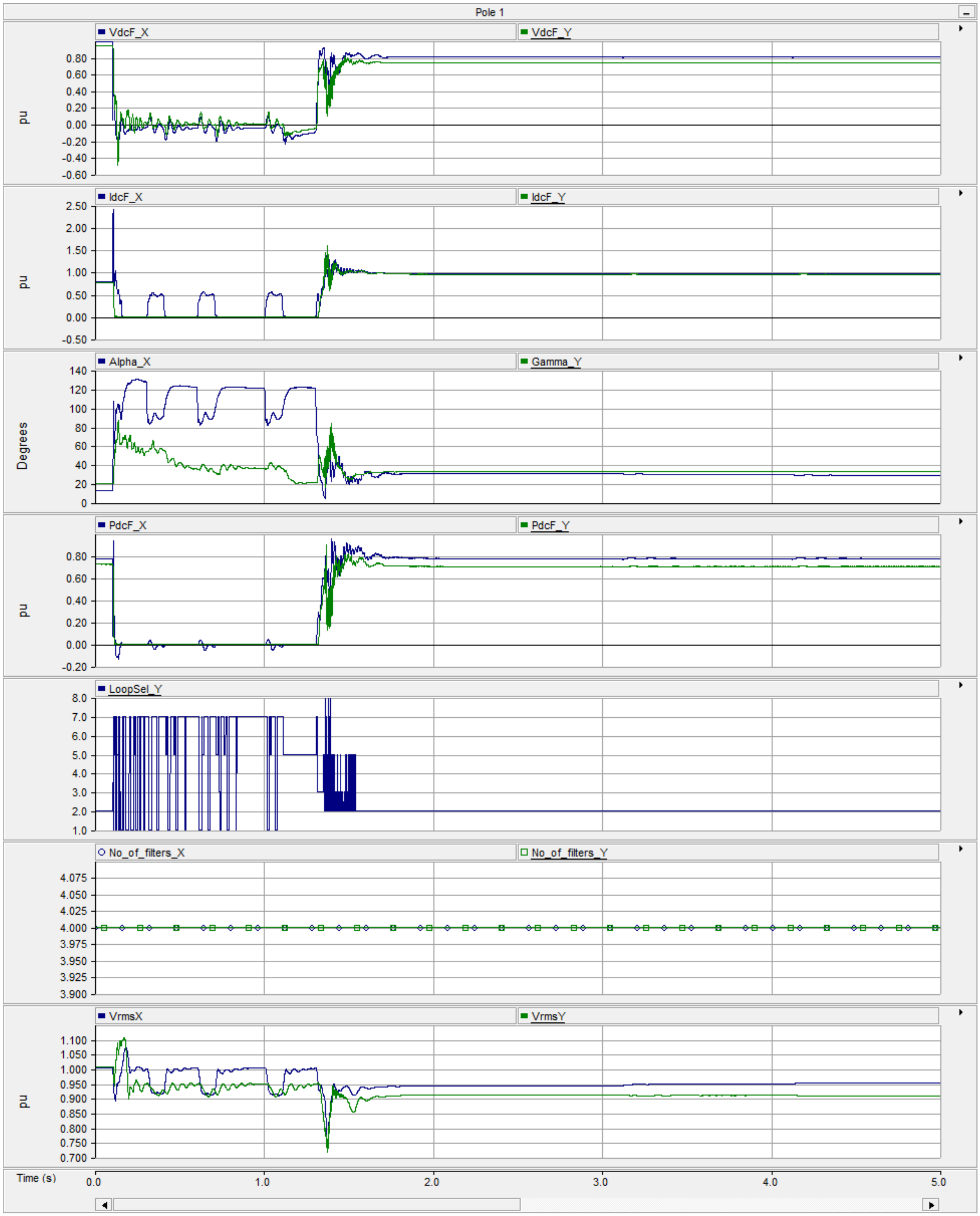

Figure 6 DC response when a DC line fault with 4 restarts is applied – Pole 1

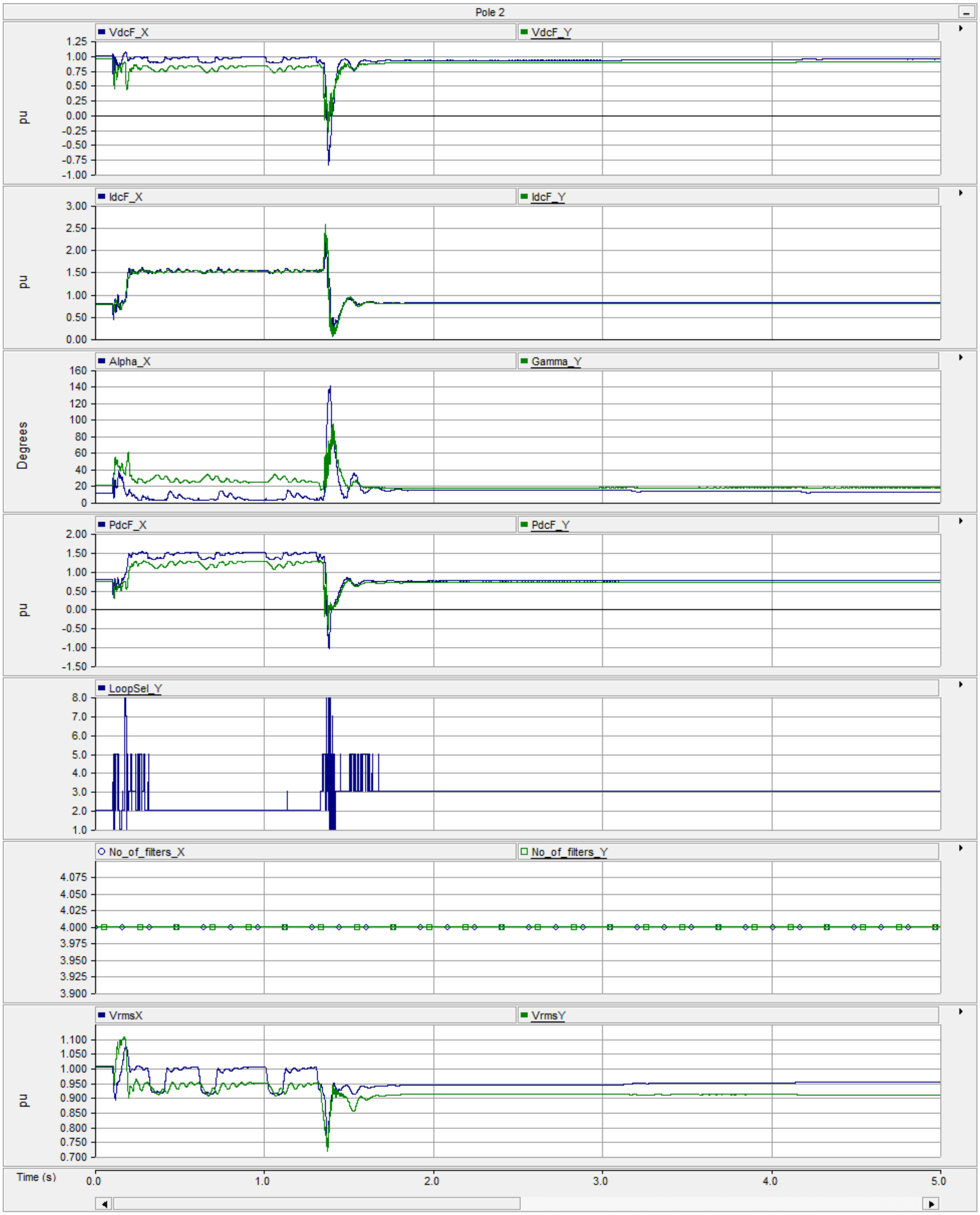

Figure 7 DC response when a DC line fault with 4 restarts is applied – Pole 2

5 Conclusions and Recommendations

Based on the above, the following conclusion and recommendations are specified for the operation of the LIL:

1. To ensure that short circuit levels are in accordance with the specification, the LIL should only be operated in system conditions when a total of least two of the six units at SOP or HRD are in service.
2. If only two of the six units are in service, there is a risk of unstable LIL operation at steady-state if one of the units were to trip. To avoid the risk of instability, the LIL is to be operated below 700 MW in this mode of operation.

By adhering to the operating guidelines defined above, stable LIL operation will be ensured for steady-state and contingency conditions when short circuit levels are below specified values.

6 References

[1.] Email from Rob Collet. September 14, 2020.
[2.] Operational Considerations With 0 and 1 SOP Synchronous Condensers.
[3.] Stage 4E LIL Bipole: High Power Operation

Engineering Support Services for:

RFI Studies

Newfoundland and Labrador Hydro

Attention: Mr. Rob Collett

Redesign of UFLS Scheme for High Power Operation

Technical Note: TN1205.84.09
Date of issue: March 17, 2021

Prepared By:
TransGrid Solutions Inc.
100-78 Innovation Dr.
Winnipeg, MB R3T 6C2
CANADA

Disclaimer

This technical note was prepared by TransGrid Solutions Inc. ("TGS"), whose responsibility is limited to the scope of work as shown herein. TGS disclaims responsibility for the work of others incorporated or referenced herein. This technical note has been prepared exclusively for Newfoundland and Labrador Hydro and the project identified herein and must not be reused or modified without the prior written authorization of TGS.

Revisions

Project Name:	RFI Studies
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Document Type:	Technical Note
Document No.:	TN1205.84.09
Last Action Date:	March 17, 2021

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00	DFC	R. Ostash		December 23, 2020	Draft Issued for review by Hydro
01	IFC	R. Ostash		January 15, 2021	Updated after comments received on Jan 15, 2021
02	IFA	R. Ostash		January 18, 2021	Updated after comments received on Jan 18, 2021
03	IFA	R. Ostash		February 22, 2021	Updated after meeting on Feb 10, 2021 and after receiving comments from NP
04	IFA	R. Ostash		February 23, 2021	Updated after comments received Feb 22, 2021.
05	IFA	R. Ostash		March 5, 2021	Updated after comments received March 2, 2021.
06	IFA	R. Ostash		March 9, 2021	Cleaned up version for final review.
07	IFA	R. Ostash		March 15, 2021	Updates to Section 4.
08	IFA	R. Ostash		March 15, 2021	Updates to Section 4 and UFLS table.
09	ABC	R. Ostash		March 17 2021	Updated based on Executive review.

Legend of Document Status:

Approved by Client	ABC	Issued for Approval	IFA
Draft for Comments	DFC	Issued for Information	IFI
Issued for Comments	IFC	Returned for Correction	RFC

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Appendices

1. Summary

The previous operational study[1] that evaluated high power operation of the Labrador Island Link ("LIL") included a redesign of the underfrequency load shedding ("UFLS") scheme to allow higher LIL power transfer under more Interconnected Island System ("IIS") conditions. In the redesigned UFLS scheme, more load was added to the existing frequency blocks, such that the entire UFLS scheme was nearly doubled in size. The redesign was required to allow higher LIL power transfer, while maintaining IIS stability in case the LIL bipole were to trip.

This study further evaluates the redesigned UFLS scheme by investigating the following:

- Impact of the location of the load shed in the UFLS, specifically the impact of on or off-Avalon load shed
- Impact of the split of the load blocks throughout the UFLS scheme, specifically whether more load could be shifted to lower frequency blocks without negatively impacting IIS recovery
- Final analysis of the loss of LIL bipole scenarios to determine the minimum IIS frequencies, amount of load that is shed and the maximum LIL power transfer limits to achieve a stable recovery of the IIS following the loss of the LIL bipole under various IIS conditions and Maritime Link ("ML") transfer levels
- Investigation of the impact of the UFLS on the 66 kV system voltages, by tabulating the pre- and post-event voltage at each 66 kV bus when the UFLS has operated due to loss of the LIL bipole
- Restoration of IIS load after it has been shed subsequent to an UFLS event

The primary objective of this study is to develop an optimized UFLS scheme that ensures Hydro's transmission system will remain stable following a LIL bipole trip. The conclusions should assist Newfoundland Power ("NP") in the development of a restoration plan, establishing the location of the load shed blocks and help guide further analysis to determine if any minor system modifications are required (e.g. protection settings).

The analysis included a review of system impacts associated with UFLS and system restoration. The analysis was performed using Hydro's system models, which include representations of Newfoundland Power's regional systems. While these models allow for an assessment system frequency impacts, results associated with specific local voltage impacts on Newfoundland Power's systems are preliminary. It is therefore recommended that further analysis be performed by Newfoundland Power using their detailed system models as part of the final design of the UFLS scheme. Such a study would include reviews of the local impacts of scheme implementation, particularly voltage regulation.

1.1 Study Conclusions

The study conclusions are summarized below:

[1] TGS report TN1205.72.04 "Stage 4E LIL Bipole: High Power Operation", dated April 7, 2020.

- The redesigned UFLS scheme includes a total of 841 MW of load compared to 474 MW in the existing UFLS scheme, based on peak demand levels.[2]
- The location of the load being shed, be it on or off-Avalon, does not have a significant impact on the IIS frequency recovery. The main importance is the total amount of load being shed on the IIS. Therefore, NP has full flexibility in selecting the feeders to be shed.
- It is better to evenly split the load being shed in each frequency block, rather than to shift more load to lower frequency blocks. Shifting load to lower frequency blocks resulted in faster frequency decay, which ultimately led to more load being shed and lower IIS frequency compared to when the loadshed was more evenly spread over the frequency blocks.
- The largest changes in 66 kV bus voltages due to the most severe UFLS events (loss of LIL bipole) were as high as 0.082 pu, with most of the highest impacts observed in PSSE zone 14 (Central) and zone 11 (St Johns), and a small pocket in zone 15 (West). A full table of impacts showing pre- and post-UFLS event 66 kV voltages over a full range of IIS conditions is provided in Appendix 2.
- In the event of a LIL bipole outage, it is recommended to ensure the ML frequency controller is in-service when restoring load that has been shed. The ML frequency controller significantly increases the maximum allowable size of load blocks that can be switched back into service at one time, while maintaining IIS frequency above 59 Hz, and avoiding further UFLS. Restoration activities would require close communications and coordination with Nova Scotia Power Inc. to fully utilize the ML frequency controller during the restoration process.
- Imports from NS cannot be assumed during restoration. The real power provided by the ML frequency controller (150 MW) is temporary (or transient) and it should be assumed unavailable after 10 minutes. Therefore, the operator must ensure generation is available within 10 minutes after switching in a block.

[2] This includes load shed at CBP&P (Kruger) - Refiner line 5P and 5S tripped at 58.8 Hz.

2. Redesign of UFLS Scheme

2.1 New UFLS Scheme

With the existing UFLS scheme, LIL power transfer must be limited so the IIS remains stable in case the LIL bipole trips. The UFLS scheme was redesigned in the Stage 4E operational study by adding more load to the frequency blocks to increase LIL transfer limits. This study revisited the redesigned UFLS scheme to see if it could be optimized and to check the sensitivity to the location of the load (on versus off Avalon) and to see if it would be possible to shift some of the load to lower frequency blocks.

The final redesigned UFLS scheme is compared to the existing UFLS scheme in Table 2-1. The new UFLS scheme sheds approximately 90-95 MW of load every 0.1 Hz starting at 58.8 Hz down through to 58.0 Hz. Appendix 1 contains a table showing the PSSE load buses that have been included in the redesigned UFLS scheme.

Table 2-1. Existing and Redesigned UFLS Schemes

Frequency Block (Hz)	Existing UFLS – Load blocks (MW)	Redesigned UFLS – Load blocks (MW)
58.8	45	93
58.7	-	94
58.6	46	93
58.5	-	91
58.4	58	94
58.3	-	94
58.2	73	94
58.1	92	92
58.0	160	95
Total Load (MW)	**474**	**841**

Appendix 1 also contains a table listing the amount of load that is shed and the minimum resulting frequency that occurs when the LIL bipole trips when operating at the maximum LIL transfer limits for a wide range of IIS conditions. The tables in Appendix 1 were obtained in another study[3] that determined guidelines for the number of LIL restart attempts that are permissible in order to ensure the IIS frequency remains within the limits defined in the Transmission Planning Criteria for loss of a LIL pole or loss of the LIL bipole. The guidelines depend on the ML power flow level, direction and whether runbacks are required if the LIL bipole or pole trips. In certain scenarios ML runback must be delayed by the time it takes to allow for the LIL restart attempts.

[3] TGS report TN1205.77.04, "Operational Considerations of LIL restarts and ML Runbacks", refer to Table 1-1 Section 1-1.

2.2 Impact of On versus Off-Avalon Load Shed

The newly redesigned UFLS includes approximately 338 MW of off-Avalon load and 503 MW of on-Avalon load.

The sensitivity to location of the load blocks was tested by shifting all the 338 MW of off-Avalon load included in the UFLS scheme to the higher frequency blocks and all the 503 MW of on-Avalon load to the lower frequency blocks (as opposed to a mix of on and off-Avalon load locations through the UFLS blocks). In most cases, minimal impact was observed in the IIS frequency response. An example is given in Figure 2–1 below. It is observed in Figure 2–1 that the frequency reaches a similar minimum value but recovers slightly faster in the on-Avalon case (blue waveform) compared to the off-Avalon case (green waveform). However, this difference in recovery is not due to the difference in location of the load, but rather to the fact that slightly more load was shed in the on-Avalon case (a total of 515 MW load was shed) compared to the off-Avalon case (a total of 476 MW load was shed). This is because it was not possible to exactly match the size of load blocks at each frequency in the UFLS models for the on-Avalon versus off-Avalon UFLS scheme variations. So even though in both cases the same frequency blocks were shed, the total amount of load shed was not exactly the same, hence the slight difference observed in IIS frequency response.

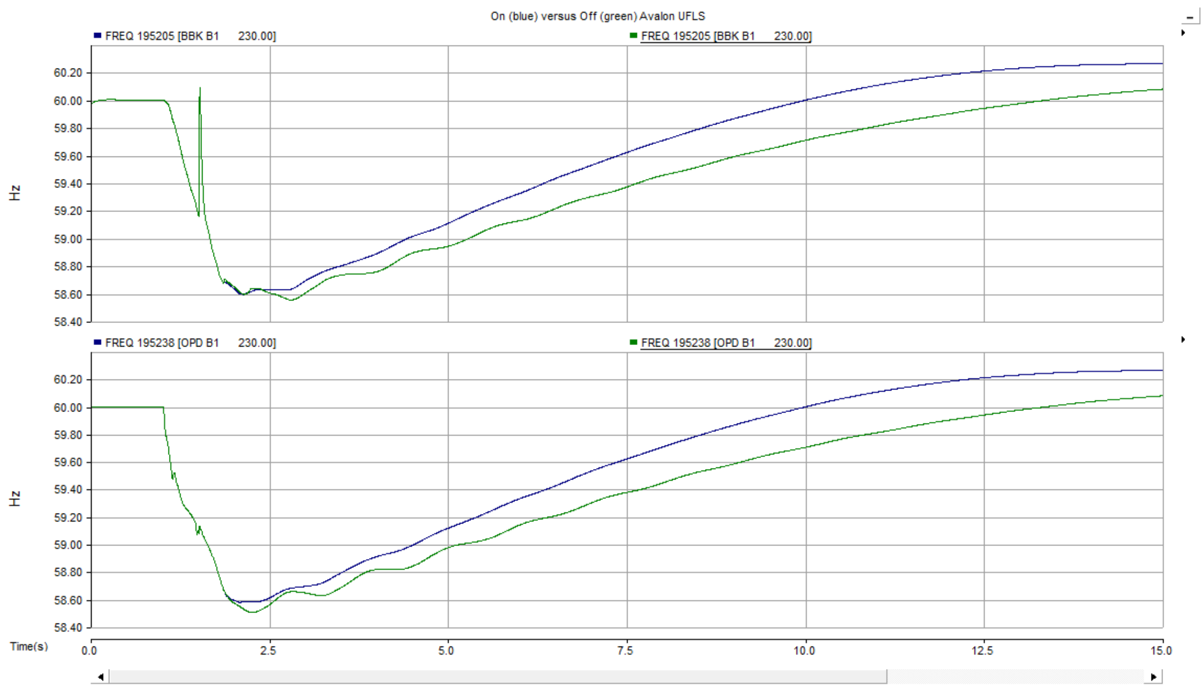

Figure 2–1. Example of IIS frequency when LIL bipole is lost - On (blue) versus Off (green) Avalon UFLS

The only time a larger difference was observed was if the frequency response was on the verge of hitting the next frequency block, and in that case there was a difference in on versus off-Avalon load shedding, however, it did not impact the final result of maintaining stability in the IIS. Therefore, it is the quantity of load shed that is of primary importance, not the location of the load shed.

2.3 Impact of Shifting Load to Lower Frequency Blocks

The impact of shifting load to lower frequency blocks was tested, as shown in Table 2-2. The proportions of load in this case were set to be more similar to the existing UFLS scheme, which has smaller blocks of loadshed at the higher frequencies and larger blocks of loadshed at the lower frequencies.

Table 2-2. Redesigned UFLS Scheme – Sensitivity to amount of load per block

Frequency Block (Hz)	Evenly spaced load blocks (MW)	More load at lower frequency blocks (MW)
58.8	93	99
58.7	94	-
58.6	93	70
58.5	91	-
58.4	94	111
58.3	94	-
58.2	94	141
58.1	92	174
58.0	95	245
Total Load (MW)	**841**	**841**

The study showed that shifting more load to lower frequency blocks resulted in more significant frequency decay when the LIL bipole was lost. For scenarios when loss of the LIL bipole did not require the entire UFLS to operate, shifting the load to lower frequency blocks resulted in more load being shed and lower minimum frequency, when compared to a UFLS scheme that had the load more evenly spread out over the frequency blocks. An example is shown in Figure 2–2.

Therefore, it is concluded that it is better to space the load shed amounts more evenly throughout the frequency blocks. Approximately 90-95 MW is shed every 0.01 Hz starting from 58.8 Hz in the redesigned UFLS scheme to minimize the system impact for a wide range of load shedding events.

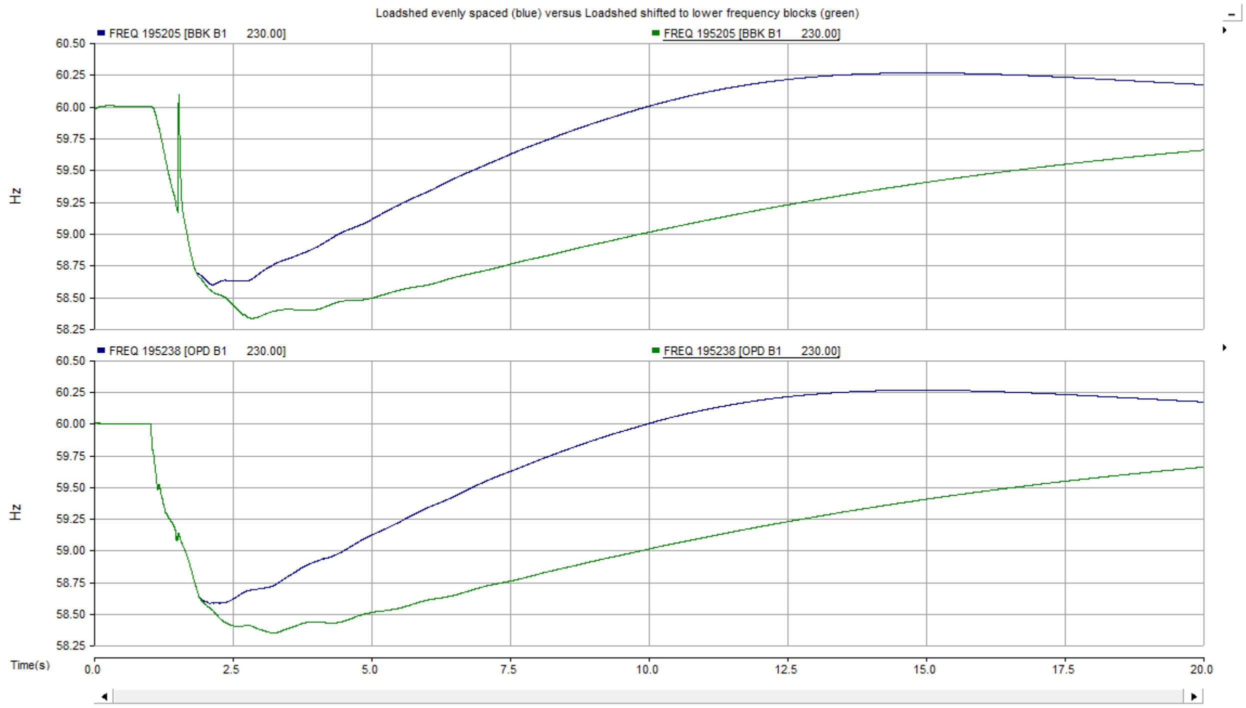

Figure 2–2. Example of IIS frequency when LIL bipole is lost – loadshed shifted to lower frequency blocks (green) versus loadshed more evenly spaced throughout frequency blocks (blue)

2.4 Loss of ML Bipole

If the ML bipole trips when importing, LIL frequency controller action and/or LIL run-up are designed to operate to automatically offset the loss of infeed from the ML, and no load shed would occur.

However, to test the newly redesigned UFLS scheme to see how much load would be shed if the rare scenario occurred in which the LIL frequency controller and LIL run-ups were not in-service, loss of the ML bipole when importing 320 MW was tested with the LIL frequency controller out-of-service and without applying a LIL run-up. The results are summarized in Table 2-3, which shows the minimum frequency that occurs in the IIS and the total amount of load that would be shed for various IIS conditions ranging from peak demand to light demand.

Table 2-3. UFLS for loss of ML Bipole, if there is no LIL frequency controller/runup

Demand Scenario	IIS Demand (MW)	IIS Generation (MW)	LIL Transfer (MW)	ML Import (MW)	Minimum Frequency (Hz)	Amount of Load Shed that occurred (MW)
Peak	1825	998	900	320	58.48	357
Intermediate Peak	1400	422	680	320	58.38	346
Intermediate	987	421	250	320	58.23	270
Light	750	400	90	260*	58.18	218

*Case already at minimum generation, therefore 260 MW is the maximum ML import under light load conditions.

3. 66 kV Voltage – Pre/Post UFLS

The impact of UFLS on the 66 kV voltage was observed by noting the pre-event and post-event 66 kV voltages after the LIL bipole was lost and UFLS had taken place. Please note that the voltages were taken from the post-event dynamic simulation cases, meaning that tap-changers and automatic switched capacitors/reactors in the system have not yet operated.

The largest changes in 66 kV bus voltages due to the most severe UFLS events (loss of LIL bipole) were as high as 0.082 pu. A table showing pre- and post-UFLS event 66 kV voltages over a full range of IIS conditions is provided in Appendix 2. In the table, impacts greater than 0.02 pu are highlighted in red, and impacts greater than 0.05 pu are highlighted in yellow.

3.1 1.07 pu Feeder Trip Settings

There are various 66 kV feeders located in the areas of Stephenville and Burin that have 1.07 pu voltage trip settings (with a 6 second delay). The table in Appendix 2 shows that under certain IIS conditions in the post-UFLS event system (prior to operation of tap changers and switched capacitors/reactors), these 66 kV areas experience voltages greater than the 1.07 pu trip setting.

3.1.1 Stephenville

The 66 kV area near Stephenville experienced post-UFLS event voltages > 1.07 pu in the peak demand case when ML was importing 320 MW. The PSSE UFLS scheme had included a 52 MW peak load at bus 195635 (SVL), however, it was determined after the fact that there is only 20.8 MW (GAL) of load available to be shed in the Stephenville area. When this 52 MW load was removed from the UFLS scheme (and replaced with load from other areas to keep total amount of load in the UFLS scheme the same) the voltages in this area remained below 1.07 pu post-UFLS.

Therefore, a solution would be to exclude load in the Stephenville area from the UFLS scheme.

3.1.2 Burin

In the Burin area, voltages greater than 1.07 pu were also observed. Redistributing load in the UFLS scheme to different areas did not have a significant improvement on the high voltages. The worst-case voltages greater than 1.07 pu were observed in extreme light demand case when ML was exporting 500 MW. In this pre-event power flow case, there is a large transfer of power in the 230 kV bulk system from the LIL infeed to export 500 MW on the ML. When the LIL bipole trips, the ML export runs back to 0 MW and UFLS occurs, and the voltages in the 230 kV bulk system rise to more than 1.06 pu in the Come-By-Chance and Sunnyside area. The high voltage in the bulk system transfers through to the 66 kV area in Burin resulting in 66 kV voltages higher than 1.07 pu. Once the transformer tap-changers operate, the high voltages on the 66 kV system are mitigated, however, this action is expected to take longer than the 6-second trip setting.

In theory, this same issue could arise in the system for events unrelated to UFLS. For example, Transmission Planning Criteria allows bulk system voltages to be as high as 1.1 pu for n-1 contingencies in the system. If the bulk system can experience voltages up to 1.1 pu (due to whatever contingency may arise), then the underlying 66 kV will also see high voltages until tap changers have had a chance to respond and bring the 66 kV voltage back down.

Further investigation is required by NP to determine the timing of tap-changer action to see if the timing of the 1.07 pu trip settings can be better coordinated to work with the possibility of high voltages in the bulk system.

4. Restoration of Load after UFLS

After UFLS has occurred and Island generation is available, the loads that were shed need to be restored while adhering to system operating limits. Simulations were performed to determine the maximum sizes of load blocks that can be placed back into service at a time without causing the IIS frequency to drop below 59 Hz and risk further UFLS to occur. It is assumed in each of these cases that the LIL bipole has tripped and is out-of-service when the load is being restored.

Restoring loads in five areas of the Island (Avalon, Burin, West, St. Johns, Central) was tested for IIS demand from extreme light to peak conditions. It was determined that the location of the load being restored does not significantly affect the maximum allowable size. The maximum allowable size correlates to the IIS generation dispatch; higher generation means more inertia on the system, which results in better frequency response to a sudden increase in load, allowing larger blocks of load to be restored at once.

Table 4-1 summarizes the maximum blocks of load that can be placed back into service based on post-contingency IIS demand conditions and generation dispatch. Having the ML frequency controller in-service increases the size of load blocks that can be placed back into service at one time. If the ML frequency controller is not in-service, the block sizes are significantly reduced. Therefore, if the ML frequency controller is not in-service it is recommended to restore the load in accordance with historic practices, which is to switch individual feeders back in one at a time through close coordination with Newfoundland Power, rather than following the maximum load block sizes presented in this report. It is worth noting that the ML frequency controller should rarely be disabled.

Note: Imports from NS cannot be assumed during restoration. The real power provided by the ML frequency controller (150 MW) is temporary (or transient) and it should be assumed unavailable after 10 minutes. Therefore, the operator must ensure generation is available within 10 minutes after switching in a block.

Table 4-1. Maximum blocks of load during restoration

ML Exports/ Imports (Pre-Cont.)	ML Exports/ Imports (Post-Cont.)[4]	Island Demand (Post-Cont.)	Island Gen. (Post-Cont.)[5]	Max Blocks ML Frequency Controller Enabled	Max Blocks ML Frequency Controller Disabled
500	0	1291	1339	268	Limit to Individual Feeders - In Accordance with Historic Practice
		906	1008	142	
		570	650	137	
		459	458	133	
		362	382	132	
158	0	971	1039	140	
		770	769	129	

[4] When ML is exporting or importing less than 150MW the ML frequency controller can operate at full capacity (150 MW) post contingency.

[5] This would be the Island Generation following the loss of the LIL. The power required to restore each block would be provided transiently using the ML frequency controller (150 MW) and/or AGC. Ten minutes following the event, it is expected that additional generation would have to be dispatched to offset the temporary 150 MW imports provided by the ML F/C and to ensure spinning reserve requirements are satisfied on the IIS.

ML Exports/ Imports (Pre-Cont.)	ML Exports/ Imports (Post-Cont.)[4]	Island Demand (Post-Cont.)	Island Gen. (Post-Cont.)[5]	Max Blocks ML Frequency Controller Enabled	Max Blocks ML Frequency Controller Disabled
		568	567	108	
		456	455	126	
		437	436	120	
-150	-150	964	813	125	
		729	469	73	
		698	437	76	
		675	424	73	
-320	-320	985	664	N/A*	
		774	453	N/A*	
		771	450	N/A*	
		693	482	N/A*	

*No ML F/C Capacity when imports are greater than 170MW

Using the results from Table 4-1, with the ML frequency controller in-service, maximum load block sizes were plotted against IIS generation. An overall trendline[6] was drawn to ensure the maximum load block size would remain below the values determined in this study for various ML levels. This ensures some margin in keeping the frequency above 59 Hz to avoid triggering UFLS while restoring load.

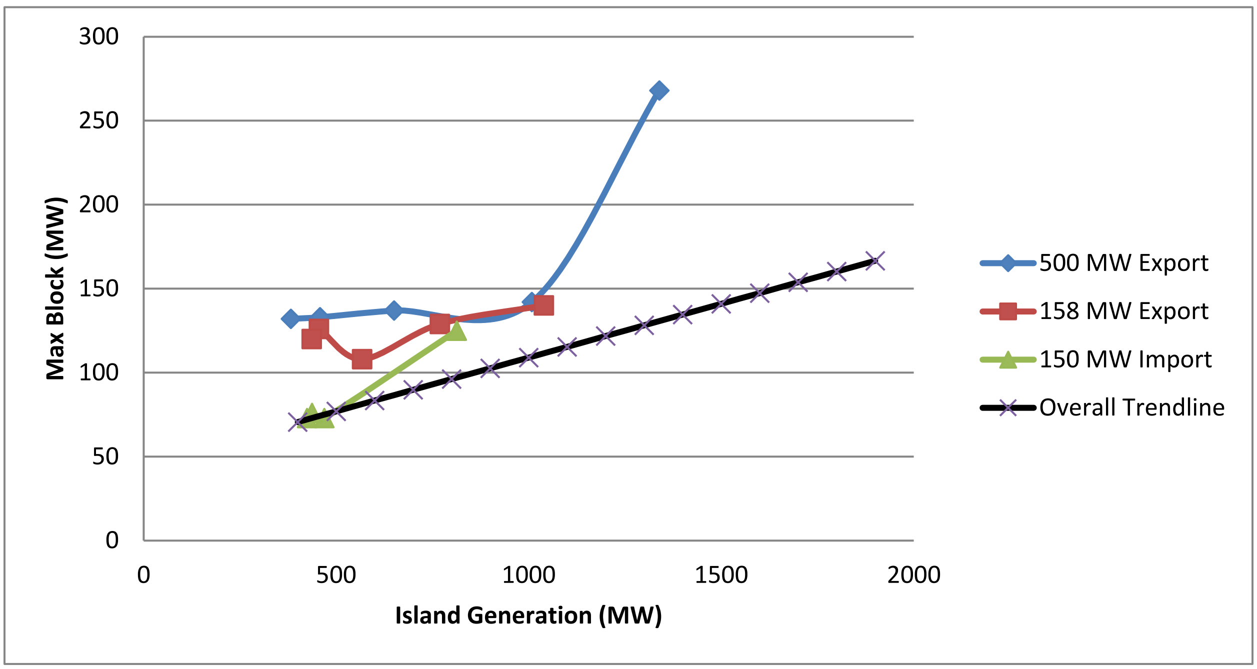

Figure 4–1. Maximum load blocks (from Table 4-1) versus IIS generation

[6] The overall trendline for all plots was developed based on each individual plot trendline. The overall trendline remains below each individual trendline for the entire range of Island Generation.

Based on this trendline, an equation (below) was derived to calculate the maximum load block size based on IIS generation, which can be used when the ML frequency controller is in-service.

MAX BLOCK (MW) = 0.064 * Island Generation (MW) – 45

APPENDIX 1

- Redesigned UFLS Scheme
- UFLS for Loss of LIL bipole

Bus	Station	Area	PEAK LOAD (MW)	EXCLUDED (MW)	%	REDESIGNED UFLS 59	58.8	58.7	58.6	58.5	58.4	58.3	58.2	58.1	58	
196565	KEN NP 66.000	STJOHNS	53.97		1	53.97										15 s delay
195135	GLV NP 138.00	CENTRAL	11.6		1	11.6										15 s delay
196546	BLK NPT3 66.000	AVALON	36.7	5.4	0.85286104		31.3									
196221	GRH_NP 12.500	BURIN	13.6		1						13.6					
195624	MDR B2B3 66.000	WEST	88.9	25.8	0.70978628			63.1								
196570	KBR NP 66.000	STJOHNS	16.1		1			16.1								
195144	CLV NP 138.00	CENTRAL	56.3	10	0.82238011				46.3							
196568	SJM NP 66.000	STJOHNS	50.3	4.5	0.91053678				23.5							
195126	GFS NP 138.00	CENTRAL	40.9	6.2	0.84841076						34.7					
196572	RRD NP 66.000	STJOHNS	37.9		1							37.9				
195132	GAN NP 138.00	CENTRAL	24.4	9.4	0.6147541			15								
196573	VIR NP 66.000	STJOHNS	70.5	8.9	0.87375887								41.16			
195655	HWD B7B8 66.000	STJOHNS	52.5		1							38.1				
195130	COB NP 138.00	CENTRAL	28.5	11.9	0.58245614						16.6					
195167	BRB NP 138.00	AVALON	23.5		1				23.5							
196562	BCV NP 66.000	STJOHNS	26.9	6.4	0.76208178								20.5			
196564	GOU NP 66.000	STJOHNS	29.4		1										29.4	
196560	KEL NP 66.000	STJOHNS	23.9	8.9	0.62761506							15				
196567	SLA NP 66.000	STJOHNS	49.1		1										49.1	
196563	GDL NP 66.000	STJOHNS	53.6		1					53.6						
196574	PUL NP 66.000	STJOHNS	39.9	9.6	0.7593985					30.3						
195133	GAM NP 138.00	CENTRAL	29.3		1						29.3					
195157	MSY NP 138.00	BURIN	16.8		1										16.8	
195165	BLK NP 138.00	AVALON	11.3		1									11.3		
196561	CHA NP 66.000	STJOHNS	54.5		1		54.5									
195432	BDE B14 25.000	BDE-HERM	6.7		1					6.7						
195409	PPD T1 12.500	GNP	1.3		1		1.3									
195407	RHR B1 12.500	GNP	3.9		1		3.9									
195408	CHD T1 12.500	GNP	1.8		1		1.8									
195435	CRV T1 12.500	BDE-HERM	2.7		1							2.7				
195436	EHW T1 25.000	BDE-HERM	2.7		1								2.7			
195437	BCX T1 25.000	BDE-HERM	7.2		1								7.2			
195635	SVL B2 66.000	WEST	52.2		1									52.2		
196566	MOL NP 66.000	STJOHNS	49.8		1									28.9		
195127	BFS NP 138.00	CENTRAL	22.6		1								22.6			

TOTALS (MW)	66	93	94	93	91	94	94	94	92	95
Frequency (Hz)	59	58.8	58.7	58.6	58.5	58.4	58.3	58.2	58.1	58

Note: loads in the EXCLUDED column are part of NP's critical customer list and are currently excluded from NP's UFLS scheme. There are additional feeders included in NP's UFLS scheme that are not part of the Stage 4E modified UFLS scheme totaling 36.4 MW, which would also be excluded from a modified UFLS scheme.

	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	DC Faults on Both Poles with Unsuccessful Restarts (Loss of LIL Bipole)							
					One Restart (500ms)		Two Restarts (900ms)		Three Restarts (1400ms)		Four Restarts (1750ms)	
					UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	278	58.52	556	58.31/61.16	671	58.04/62.23		
Ipeak	1428	1094	500	900	343	58.38	550	58.00/61.66	620	57.75/63.00		
Int	1038	703	500	900	249	58.26	404	57.79/60.94	404	57.27/61.00		
Light	812	476	500	900	224	58.05	279	57.74/60.50	279	56.85		
ExLight	575	401	500	750	105	58.34	174	57.94/60.70	174	57.21/60.77		
Peak	1821	1285	300	900	554	58.29	676	58.13/60.9	832	57.93/62.45		
Ipeak	1400	915	300	900	511	58.10	620	57.81/60.84	620	57.65/60.86		
Int	994	589	300	810	405	57.93	405	57.91	405	57.50		
Light	760	452	300	690	280	57.96	280	57.91	280	57.58		
ExLight	553	409	300	470	99	58.41	97	58.39	137	58.18		
Peak	1815	1303	158	900	673	58.03	821	57.98/60.98	839	57.94/60.99		
Ipeak	1391	889	158	850	618	57.94	618	57.93	620	57.75		
Int	980	548	158	650	405	57.91	405	57.93	405	57.95		
Light	742	433	158	500	280	57.99	280	58.00	280	57.98		
ExLight	537	402	158	300	106	58.40	99	58.40	106	58.39		
Peak	1820	1330	0	900	658	58.03	835	58.03	835	57.95	835	57.96
Ipeak	1391	906	0	840	616	57.93	616	57.91	617	57.83	617	57.83
Int	972	538	0	575	397	58.00	405	58.00	405	58.00	405	57.99
Light	734	403	0	340	171	58.39	171	58.39	171	58.39	171	58.39
ExLight	535	404	0	130	-	59.05	-	59.05	-	59.05	-	59.05
Peak	1815	1049	-150	900	783	58.00	835	57.98	835	57.95	835	57.95
Ipeak	1389	757	-150	820	618	57.91	618	57.89	618	57.77	618	57.77
Int	972	424	-150	410	244	58.37	244	58.38	244	58.39	244	58.38
Light	740	402	-150	190	60	58.79	60	58.79	60	58.79	60	58.79
ExLight	536	400	-46	90	-	59.13	-	59.13	-	59.13	-	59.13
Peak	1824	998	-320	700	675	58.02	840	57.93/60.86	840	57.92/61.05	840	57.93/61.06
Ipeak	1402	422	-320	680	620	57.87	620	57.87	620	57.87	620	57.87
Int	987	421	-320	250	223	58.38	223	58.38	223	58.38	223	58.38
Light	750	400	-260	90	60	58.77	60	58.77	60	58.77	60	58.77

at minimum IIS generation

APPENDIX 2

66 kV Pre/Post UFLS due to Loss of LIL Bipole

66 kV Bus	Bus Names	Peak Demand, ML= 500 MW			Int_Peak Demand, ML= 500 MW			Intermediate Demand, ML= 500 MW			Extreme Light Demand, ML= 500 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0389	1.0487	0.0098	1.0389	1.0463	0.0074	1.0368	1.0501	0.0133	1.0426	1.0515	0.0089
195601	WDL TAP	1.0331	1.0499	0.0168	1.0361	1.0485	0.0124	1.0367	1.0532	0.0166	1.0452	1.0556	0.0104
195602	WDL B1	1.0330	1.0498	0.0168	1.0361	1.0485	0.0124	1.0367	1.0533	0.0166	1.0453	1.0557	0.0104
195603	GLB L29	1.0299	1.0467	0.0168	1.0341	1.0466	0.0124	1.0358	1.0524	0.0166	1.0455	1.0559	0.0104
195604	RHR TAP	1.0255	1.0516	0.0261	1.0311	1.0502	0.0191	1.0340	1.0549	0.0208	1.0450	1.0572	0.0123
195605	RHR B1	1.0248	1.0516	0.0268	1.0306	1.0502	0.0196	1.0337	1.0549	0.0212	1.0448	1.0573	0.0124
195606	BHL T1	0.9973	1.0324	0.0351	1.0120	1.0405	0.0285	0.9999	1.0509	0.0510	1.0070	1.0511	0.0441
195607	SCV L27	0.9964	1.0333	0.0369	1.0117	1.0415	0.0298	1.0000	1.0519	0.0519	1.0075	1.0521	0.0446
195608	CHD B1	0.9944	1.0339	0.0395	1.0103	1.0420	0.0317	0.9992	1.0524	0.0532	1.0075	1.0526	0.0451
195609	PPD L27	1.0349	1.0782	0.0434	1.0493	1.0839	0.0347	1.0461	1.1036	0.0575	1.0451	1.0931	0.0480
195610	DHR B1B2	1.0363	1.0776	0.0412	1.0501	1.0833	0.0332	1.0464	1.1029	0.0565	1.0449	1.0924	0.0476
195611	PBN B2	1.0367	1.0776	0.0409	1.0503	1.0832	0.0329	1.0464	1.1028	0.0563	1.0448	1.0923	0.0475
195612	HBY B1	1.0204	1.0614	0.0410	1.0395	1.0725	0.0330	1.0404	1.0969	0.0565	1.0435	1.0912	0.0477
195620	DLP B1B4	1.0402	1.0492	0.0090	1.0403	1.0472	0.0069	1.0398	1.0510	0.0112	1.0444	1.0517	0.0072
195621	PAS B1	1.0235	1.0371	0.0136	1.0244	1.0351	0.0107	1.0260	1.0410	0.0150	1.0329	1.0424	0.0095
195622	MMT NP	1.0198	1.0367	0.0169	1.0197	1.0329	0.0132	1.0202	1.0379	0.0176	1.0273	1.0380	0.0107
195624	MDR B2B3	1.0173	1.0632	0.0459	1.0207	1.0555	0.0348	1.0205	1.0627	0.0422	1.0279	1.0617	0.0338
195625	MDR B4	1.0197	1.0378	0.0181	1.0190	1.0331	0.0141	1.0188	1.0373	0.0186	1.0256	1.0367	0.0110
195626	CBPP B	1.0119	1.0262	0.0143	1.0113	1.0225	0.0112	1.0113	1.0259	0.0146	1.0159	1.0224	0.0065
195627	CBPP D	1.0119	1.0264	0.0145	1.0113	1.0226	0.0113	1.0113	1.0260	0.0147	1.0159	1.0227	0.0068
195628	CBPP E	1.0120	1.0264	0.0144	1.0114	1.0227	0.0113	1.0114	1.0260	0.0147	1.0161	1.0227	0.0066
195629	CBP&P A	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001
195630	DLP 50HZ	1.0386	1.0387	0.0001	1.0386	1.0387	0.0001	1.0386	1.0387	0.0001	1.0386	1.0387	0.0001
195631	BRKFIELD	1.0072	1.0073	0.0001	1.0072	1.0073	0.0001	1.0072	1.0073	0.0001	1.0072	1.0073	0.0001
195632	CBP&P C	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001
195633	WATSONS	1.0060	1.0061	0.0001	1.0060	1.0061	0.0001	1.0060	1.0061	0.0001	1.0060	1.0061	0.0001
195635	SVL B2	1.0097	1.0249	0.0153	1.0167	1.0487	0.0319	1.0228	1.0500	0.0272	1.0306	1.0508	0.0202
195636	BBK T2	1.0601	1.0758	0.0157	1.0409	1.0549	0.0139	1.0327	1.0489	0.0162	1.0204	1.0350	0.0146
195637	DLS B1	1.0479	1.0621	0.0143	1.0389	1.0517	0.0127	1.0481	1.0629	0.0148	1.0570	1.0706	0.0137
195639	BUC B2	1.0275	1.0780	0.0504	1.0348	1.0699	0.0351	1.0297	1.0902	0.0605	1.0369	1.0903	0.0534
195640	DPD L64	1.0292	1.0798	0.0506	1.0366	1.0717	0.0352	1.0314	1.0920	0.0606	1.0386	1.0921	0.0536
195641	SLK L80	1.0443	1.0950	0.0507	1.0474	1.0841	0.0368	1.0452	1.1060	0.0608	1.0482	1.1036	0.0554
195643	ACG GFL	0.9928	0.9999	0.0072	1.0020	1.0065	0.0045	0.9942	1.0029	0.0087	0.9982	1.0060	0.0079
195644	ACG BFL	1.0077	1.0129	0.0052	1.0141	1.0173	0.0032	1.0087	1.0150	0.0063	1.0115	1.0172	0.0058
195650	WAV B2	1.0423	1.0720	0.0297	1.0393	1.0442	0.0049	1.0438	1.0883	0.0445	1.0548	1.1137	0.0589
195652	HRD B6B7	1.0340	1.0578	0.0238	1.0227	1.0341	0.0113	1.0325	1.0600	0.0275	1.0387	1.0647	0.0260
195654	OPD B2B5	1.0241	1.0504	0.0263	1.0204	1.0359	0.0154	1.0251	1.0544	0.0293	1.0327	1.0596	0.0269
195655	HWD B7B8	1.0198	1.0462	0.0264	1.0139	1.0296	0.0156	1.0232	1.0529	0.0297	1.0248	1.0503	0.0255
195675	CHF T601	1.0088	1.0172	0.0084	1.0088	1.0172	0.0084	1.0088	1.0171	0.0083	1.0162	1.0226	0.0064
195676	CHF T602	1.0088	1.0172	0.0084	1.0088	1.0172	0.0084	1.0088	1.0171	0.0083	1.0162	1.0226	0.0064
195677	CHF AIRPORT	1.0073	1.0158	0.0085	1.0073	1.0158	0.0085	1.0073	1.0157	0.0084	1.0148	1.0212	0.0064
195678	BRDG CAMP	1.0050	1.0135	0.0086	1.0050	1.0135	0.0086	1.0050	1.0135	0.0085	1.0125	1.0190	0.0065
195679	LOGANTWR	1.0055	1.0140	0.0085	1.0055	1.0140	0.0085	1.0055	1.0140	0.0085	1.0130	1.0195	0.0065
195680	WHITEFISH	1.0040	1.0126	0.0086	1.0040	1.0126	0.0086	1.0040	1.0125	0.0085	1.0116	1.0181	0.0065
195681	JACOPIE	1.0041	1.0126	0.0086	1.0041	1.0126	0.0086	1.0041	1.0126	0.0085	1.0116	1.0181	0.0065
195682	TWIN TAP	1.0044	1.0131	0.0086	1.0044	1.0131	0.0086	1.0044	1.0130	0.0085	1.0120	1.0185	0.0065
195683	ATIKONAK	0.9881	0.9970	0.0089	0.9881	0.9970	0.0089	0.9881	0.9969	0.0088	0.9959	1.0027	0.0067
195684	LOB LODGE	0.9876	0.9965	0.0089	0.9876	0.9965	0.0089	0.9876	0.9964	0.0088	0.9954	1.0021	0.0068
195685	LOBSTICK	0.9825	0.9914	0.0089	0.9825	0.9914	0.0089	0.9825	0.9914	0.0088	0.9904	0.9972	0.0068
195686	LOB TAP	0.9870	0.9959	0.0089	0.9870	0.9959	0.0089	0.9870	0.9959	0.0088	0.9948	1.0016	0.0068
195687	GABBRO	0.9858	0.9946	0.0089	0.9858	0.9947	0.0089	0.9858	0.9946	0.0088	0.9936	1.0003	0.0068
195688	JWF TAP	1.0048	1.0134	0.0086	1.0048	1.0134	0.0086	1.0048	1.0133	0.0085	1.0124	1.0189	0.0065
195824	STG MID2	1.0067	1.0219	0.0152	1.0117	1.0434	0.0317	1.0161	1.0430	0.0269	1.0270	1.0472	0.0201
195843	GOU MID1	1.0089	1.0391	0.0302	1.0068	1.0257	0.0189	1.0176	1.0506	0.0330	1.0237	1.0515	0.0278
195844	MOB MID3	1.0031	1.0257	0.0226	1.0044	1.0191	0.0147	1.0140	1.0375	0.0235	1.0211	1.0411	0.0200
195845	CHA MID1	1.0130	1.0465	0.0336	1.0086	1.0292	0.0206	1.0204	1.0539	0.0335	1.0250	1.0527	0.0278
195870	CHF T601	1.0088	1.0172	0.0084	1.0088	1.0172	0.0084	1.0088	1.0171	0.0083	1.0162	1.0226	0.0064
196312	OPD T3Y	1.0068	1.0263	0.0194	1.0115	1.0201	0.0086	1.0214	1.0456	0.0242	1.0159	1.0402	0.0243
196316	OPD T1Y	1.0068	1.0263	0.0194	1.0115	1.0201	0.0086	1.0214	1.0456	0.0242	1.0159	1.0402	0.0243
196318	HWD T4Y	1.0120	1.0286	0.0166	1.0151	1.0207	0.0057	1.0217	1.0438	0.0221	1.0189	1.0424	0.0236
196324	HWD T1Y	1.0120	1.0286	0.0166	1.0151	1.0207	0.0057	1.0217	1.0438	0.0221	1.0189	1.0424	0.0236
196326	MDR T3Y	0.9775	1.0129	0.0354	0.9904	1.0181	0.0277	0.9872	1.0242	0.0371	0.9919	1.0226	0.0308
196330	MDR T1Y	0.9775	1.0129	0.0354	0.9904	1.0181	0.0277	0.9872	1.0242	0.0371	0.9919	1.0226	0.0308
196334	DLS T1Y	0.9840	0.9981	0.0142	0.9828	0.9955	0.0127	0.9884	1.0032	0.0148	0.9847	0.9981	0.0134
196336	DLK T1Y	0.9974	1.0262	0.0288	1.0036	1.0271	0.0235	0.9972	1.0443	0.0472	0.9996	1.0413	0.0417
196338	BHL T1Y	1.0069	1.0407	0.0337	1.0213	1.0488	0.0276	1.0211	1.0724	0.0513	1.0155	1.0595	0.0441
196340	PBN T1Y	1.0113	1.0490	0.0377	1.0340	1.0649	0.0309	1.0405	1.0955	0.0550	1.0240	1.0700	0.0461
196348	MKS T1Y	1.0073	1.0427	0.0354	1.0160	1.0236	0.0075	1.0182	1.0620	0.0438	1.0326	1.0887	0.0561
196500	DLK NP	1.0387	1.0481	0.0094	1.0389	1.0461	0.0072	1.0378	1.0501	0.0123	1.0433	1.0514	0.0081
196501	STX NP	1.0098	1.0251	0.0153	1.0166	1.0485	0.0319	1.0224	1.0495	0.0271	1.0306	1.0509	0.0202
196502	STG NP	1.0102	1.0254	0.0152	1.0164	1.0483	0.0319	1.0218	1.0489	0.0271	1.0309	1.0510	0.0202
196503	HAR NP	1.0097	1.0250	0.0153	1.0168	1.0487	0.0320	1.0229	1.0501	0.0272	1.0306	1.0509	0.0202
196504	GAL NP	1.0097	1.0250	0.0153	1.0168	1.0488	0.0320	1.0229	1.0501	0.0272	1.0306	1.0509	0.0202
196505	WHE TAP	1.0097	1.0250	0.0153	1.0168	1.0487	0.0320	1.0229	1.0501	0.0272	1.0306	1.0509	0.0202
196506	WHE NP	1.0605	1.0762	0.0157	1.0413	1.0553	0.0140	1.0331	1.0493	0.0162	1.0208	1.0355	0.0147
196507	GBY NP	0.9950	1.0080	0.0130	1.0003	1.0118	0.0116	1.0216	1.0352	0.0135	1.0396	1.0522	0.0125
196508	PAB NP	0.9923	1.0053	0.0130	0.9983	1.0099	0.0116	1.0204	1.0339	0.0135	1.0391	1.0516	0.0125
196509	LGL NP	0.9836	0.9955	0.0119	0.9908	1.0014	0.0106	1.0127	1.0251	0.0124	1.0292	1.0408	0.0115
196517	GFS NPT1	1.0370	1.0977	0.0607	1.0386	1.0784	0.0398	1.0324	1.1042	0.0718	1.0355	1.1035	0.0679
196518	RUS NP	1.0379	1.0985	0.0606	1.0395	1.0792	0.0397	1.0334	1.1050	0.0716	1.0364	1.1042	0.0678
196519	SBK NP	1.0441	1.1039	0.0598	1.0456	1.0849	0.0393	1.0401	1.1107	0.0706	1.0428	1.1097	0.0669
196520	RBK NP	1.0209	1.0790	0.0581	1.0281	1.0632	0.0351	1.0316	1.0982	0.0667	1.0376	1.0990	0.0613
196521	NDJ NP	0.9982	1.0582	0.0600	1.0092	1.0434	0.0341	1.0173	1.0847	0.0673	1.0258	1.0863	0.0606
196522	LEW NP	0.9747	1.0343	0.0596	0.9921	1.0261	0.0340	1.0063	1.0735	0.0672	1.0202	1.0806	0.0604

ML = 500 MW Export

66 kV Bus	Bus Names	Peak Demand, ML= 500 MW			Int_Peak Demand, ML= 500 MW			Intermediate Demand, ML= 500 MW			Extreme Light Demand, ML= 500 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196523	GAN NPT2	1.0225	1.0856	0.0631	1.0236	1.0571	0.0335	1.0234	1.0921	0.0687	1.0220	1.0821	0.0601
196524	COB NPT2	0.9942	1.0688	0.0746	1.0123	1.0539	0.0416	1.0083	1.0895	0.0813	0.9837	1.0541	0.0705
196525	CLK NP	0.9518	1.0294	0.0776	0.9968	1.0403	0.0435	0.9998	1.0837	0.0839	0.9979	1.0705	0.0726
196526	BOY NP	0.9119	0.9909	0.0789	0.9759	1.0205	0.0445	0.9861	1.0715	0.0854	1.0017	1.0754	0.0737
196527	FHD L54	0.9045	0.9832	0.0787	0.9711	1.0155	0.0444	0.9831	1.0685	0.0854	1.0006	1.0743	0.0737
196528	GAM NPT2	0.9554	1.0369	0.0815	0.9851	1.0279	0.0428	0.9912	1.0743	0.0832	1.0204	1.0989	0.0786
196529	HBS NP	0.9576	1.0393	0.0817	0.9874	1.0304	0.0429	0.9935	1.0769	0.0834	1.0228	1.1016	0.0788
196530	TRN NP	0.9591	1.0410	0.0819	0.9890	1.0321	0.0431	0.9951	1.0787	0.0836	1.0244	1.1034	0.0790
196531	GPD NP	0.9602	1.0422	0.0820	0.9901	1.0332	0.0431	0.9961	1.0798	0.0837	1.0255	1.1046	0.0791
196532	WES NP	0.9603	1.0424	0.0820	0.9902	1.0334	0.0432	0.9963	1.0800	0.0837	1.0257	1.1048	0.0791
196533	CLV NPT1	0.9961	1.0504	0.0543	1.0085	1.0274	0.0189	1.0085	1.0681	0.0596	1.0245	1.0915	0.0670
196534	MIL NP	0.9979	1.0523	0.0544	1.0099	1.0289	0.0189	1.0099	1.0696	0.0597	1.0255	1.0925	0.0671
196535	LET NP	1.0007	1.0552	0.0545	1.0120	1.0310	0.0190	1.0120	1.0719	0.0598	1.0267	1.0938	0.0671
196536	SMV NP	1.0026	1.0572	0.0546	1.0132	1.0323	0.0190	1.0132	1.0731	0.0599	1.0271	1.0942	0.0671
196537	LOK NP	1.0029	1.0576	0.0547	1.0134	1.0325	0.0190	1.0134	1.0733	0.0599	1.0271	1.0942	0.0671
196538	PUN NP	1.0025	1.0571	0.0547	1.0131	1.0321	0.0190	1.0131	1.0730	0.0599	1.0268	1.0939	0.0671
196539	CAT NPT1	0.9996	1.0541	0.0545	1.0111	1.0301	0.0190	1.0111	1.0709	0.0598	1.0261	1.0932	0.0671
196540	SPT NP	1.0392	1.0677	0.0285	1.0261	1.0356	0.0095	1.0285	1.0577	0.0292	1.0367	1.0771	0.0404
196541	LAU NP	1.0364	1.0520	0.0156	1.0298	1.0291	-0.0007	1.0364	1.0475	0.0110	1.0388	1.0608	0.0221
196542	STL WIND	1.0371	1.0500	0.0129	1.0305	1.0278	-0.0028	1.0372	1.0456	0.0084	1.0395	1.0582	0.0187
196543	WEBCV_NP	1.0365	1.0586	0.0221	1.0325	1.0377	0.0053	1.0397	1.0548	0.0150	1.0367	1.0669	0.0303
196544	GRH NP	1.0381	1.0634	0.0253	1.0348	1.0430	0.0082	1.0419	1.0589	0.0170	1.0356	1.0699	0.0343
196545	GAR NP	1.0377	1.0647	0.0270	1.0296	1.0385	0.0089	1.0345	1.0580	0.0235	1.0362	1.0737	0.0375
196546	BLK NPT3	1.0295	1.0678	0.0383	1.0281	1.0394	0.0113	1.0327	1.0804	0.0478	1.0298	1.0874	0.0576
196547	NHR NP	1.0217	1.0565	0.0348	1.0193	1.0285	0.0093	1.0243	1.0700	0.0457	1.0217	1.0771	0.0554
196548	ISL NP	1.0111	1.0418	0.0307	1.0074	1.0142	0.0068	1.0130	1.0561	0.0431	1.0109	1.0634	0.0525
196549	HCT NP	1.0033	1.0310	0.0277	0.9987	1.0037	0.0050	1.0048	1.0459	0.0410	1.0032	1.0534	0.0502
196550	NCH NP	1.0049	1.0326	0.0277	1.0011	1.0061	0.0050	1.0062	1.0473	0.0410	1.0047	1.0549	0.0502
196551	OPL NP	1.0052	1.0329	0.0277	1.0013	1.0064	0.0050	1.0065	1.0476	0.0411	1.0050	1.0553	0.0502
196552	CAR NP	0.9861	1.0073	0.0213	0.9792	0.9798	0.0006	0.9880	1.0243	0.0363	0.9874	1.0326	0.0452
196553	VIC NP	0.9862	1.0075	0.0213	0.9794	0.9800	0.0006	0.9881	1.0245	0.0363	0.9875	1.0327	0.0452
196554	HGR NP	0.9843	1.0053	0.0211	0.9772	0.9777	0.0005	0.9861	1.0222	0.0361	0.9855	1.0304	0.0449
196555	ILC NP	0.9811	1.0012	0.0202	0.9735	0.9735	0.0000	0.9829	1.0183	0.0354	0.9824	1.0265	0.0441
196556	BRB T2T3	0.9766	0.9961	0.0195	0.9685	0.9681	-0.0004	0.9783	1.0130	0.0347	0.9779	1.0212	0.0433
196557	ULT TAP	1.0323	1.0565	0.0242	1.0215	1.0333	0.0118	1.0315	1.0594	0.0279	1.0379	1.0640	0.0261
196558	ULT NP	1.0323	1.0565	0.0242	1.0215	1.0333	0.0118	1.0315	1.0594	0.0279	1.0379	1.0640	0.0261
196559	SCV NP	1.0305	1.0552	0.0247	1.0203	1.0325	0.0122	1.0306	1.0589	0.0283	1.0371	1.0634	0.0263
196560	KEL NP	1.0184	1.0471	0.0287	1.0119	1.0279	0.0160	1.0240	1.0560	0.0319	1.0306	1.0583	0.0277
196561	CHA NP	1.0130	1.0466	0.0336	1.0086	1.0292	0.0206	1.0204	1.0539	0.0335	1.0250	1.0528	0.0278
196562	BCV NP	1.0058	1.0321	0.0263	1.0036	1.0192	0.0156	1.0166	1.0514	0.0348	1.0213	1.0496	0.0282
196563	GDL NP	1.0092	1.0428	0.0336	1.0069	1.0280	0.0212	1.0181	1.0521	0.0339	1.0232	1.0514	0.0282
196564	GOU NP	1.0096	1.0399	0.0303	1.0078	1.0267	0.0189	1.0183	1.0513	0.0330	1.0243	1.0522	0.0279
196565	KEN NP	1.0164	1.0433	0.0269	1.0137	1.0298	0.0162	1.0215	1.0517	0.0302	1.0284	1.0553	0.0268
196566	MOL NP	1.0127	1.0399	0.0272	1.0107	1.0296	0.0189	1.0198	1.0519	0.0321	1.0269	1.0546	0.0278
196567	SLA NP	1.0171	1.0446	0.0275	1.0148	1.0317	0.0169	1.0219	1.0528	0.0310	1.0297	1.0572	0.0276
196568	SJM NP	1.0115	1.0414	0.0299	1.0101	1.0288	0.0187	1.0192	1.0516	0.0324	1.0269	1.0550	0.0281
196569	MUN NP	1.0144	1.0429	0.0285	1.0130	1.0307	0.0178	1.0206	1.0520	0.0313	1.0294	1.0572	0.0278
196570	KBR NP	1.0127	1.0425	0.0298	1.0119	1.0309	0.0190	1.0198	1.0516	0.0318	1.0293	1.0575	0.0282
196571	PEP NP	1.0112	1.0411	0.0299	1.0108	1.0304	0.0195	1.0191	1.0512	0.0321	1.0290	1.0573	0.0284
196572	RRD NP	1.0181	1.0473	0.0292	1.0160	1.0339	0.0179	1.0223	1.0533	0.0310	1.0310	1.0588	0.0278
196573	VIR NP	1.0106	1.0408	0.0302	1.0105	1.0316	0.0211	1.0189	1.0518	0.0330	1.0291	1.0580	0.0289
196574	PUL NP	0.9980	1.0379	0.0399	1.0013	1.0295	0.0282	1.0129	1.0504	0.0375	1.0259	1.0573	0.0313
196575	BIG NP	1.0066	1.0345	0.0279	1.0066	1.0241	0.0175	1.0173	1.0477	0.0304	1.0239	1.0497	0.0258
196576	MOB NP	1.0078	1.0297	0.0219	1.0100	1.0237	0.0137	1.0200	1.0434	0.0234	1.0270	1.0469	0.0199
196577	TCV NP	1.0082	1.0301	0.0219	1.0104	1.0241	0.0137	1.0204	1.0438	0.0234	1.0274	1.0473	0.0198
196578	ROP NP	1.0077	1.0290	0.0214	1.0099	1.0231	0.0132	1.0198	1.0424	0.0226	1.0269	1.0461	0.0192
196579	MRP NP	1.0078	1.0292	0.0214	1.0100	1.0233	0.0133	1.0198	1.0425	0.0227	1.0268	1.0460	0.0192
196580	HCP TAP NP	1.0072	1.0249	0.0177	1.0098	1.0201	0.0103	1.0197	1.0374	0.0177	1.0274	1.0421	0.0148
196581	HCP NP	1.0075	1.0253	0.0179	1.0099	1.0204	0.0105	1.0196	1.0373	0.0177	1.0273	1.0420	0.0148
196582	CAB NP	1.0069	1.0227	0.0158	1.0099	1.0185	0.0087	1.0202	1.0354	0.0152	1.0281	1.0407	0.0125
196583	FER NP	1.0093	1.0126	0.0032	1.0133	1.0089	-0.0043	1.0245	1.0243	-0.0002	1.0333	1.0319	-0.0014
196584	FER WIND	1.0096	1.0122	0.0026	1.0135	1.0086	-0.0050	1.0248	1.0238	-0.0010	1.0336	1.0314	-0.0022
196585	SUM NP	0.9119	0.9909	0.0789	0.9759	1.0205	0.0445	0.9861	1.0715	0.0854	1.0017	1.0754	0.0737
196586	TWG NP	0.9018	0.9817	0.0799	0.9725	1.0176	0.0452	0.9842	1.0705	0.0863	1.0041	1.0783	0.0742
196587	HRD OUTS	1.0329	1.0570	0.0241	1.0219	1.0335	0.0116	1.0319	1.0596	0.0278	1.0382	1.0643	0.0261

ML = 300 MW Export

66 kV Bus	Bus Names	Peak Demand, ML= 300 MW			Int_Peak Demand, ML= 300 MW			Intermediate Demand, ML= 300 MW			Light Demand, ML= 300 MW			Extreme Light Demand, ML= 300 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0406	1.0465	0.0059	1.0366	1.0435	0.0069	1.0390	1.0448	0.0057	1.0419	1.0483	0.0065	1.0441	1.0472	0.0030
195601	WDL TAP	1.0349	1.0478	0.0129	1.0337	1.0457	0.0120	1.0390	1.0478	0.0088	1.0432	1.0518	0.0086	1.0468	1.0497	0.0029
195602	WDL B1	1.0347	1.0476	0.0129	1.0337	1.0457	0.0120	1.0390	1.0478	0.0088	1.0432	1.0519	0.0086	1.0468	1.0498	0.0029
195603	GLB L29	1.0317	1.0446	0.0129	1.0317	1.0437	0.0120	1.0381	1.0469	0.0088	1.0429	1.0516	0.0086	1.0471	1.0500	0.0029
195604	RHR TAP	1.0273	1.0494	0.0221	1.0287	1.0473	0.0187	1.0363	1.0493	0.0130	1.0418	1.0534	0.0116	1.0465	1.0494	0.0029
195605	RHR B1	1.0266	1.0494	0.0228	1.0282	1.0474	0.0192	1.0360	1.0493	0.0133	1.0416	1.0534	0.0118	1.0464	1.0493	0.0029
195606	BHL T1	1.0062	1.0299	0.0237	0.9954	1.0235	0.0281	0.9948	1.0168	0.0220	0.9906	1.0138	0.0232	0.9996	1.0110	0.0114
195607	SCV L27	1.0054	1.0309	0.0255	0.9950	1.0244	0.0294	0.9949	1.0177	0.0229	0.9909	1.0147	0.0238	1.0002	1.0116	0.0114
195608	CHD B1	1.0034	1.0314	0.0281	0.9936	1.0250	0.0313	0.9941	1.0182	0.0241	0.9905	1.0152	0.0247	1.0001	1.0115	0.0114
195609	PPD L27	1.0443	1.0752	0.0309	1.0449	1.0793	0.0343	1.0399	1.0643	0.0244	1.0356	1.0609	0.0253	1.0371	1.0477	0.0106
195610	DHR B1B2	1.0457	1.0746	0.0289	1.0458	1.0786	0.0328	1.0402	1.0637	0.0234	1.0357	1.0603	0.0246	1.0369	1.0475	0.0106
195611	PBN B2	1.0461	1.0746	0.0285	1.0460	1.0786	0.0326	1.0403	1.0636	0.0233	1.0357	1.0602	0.0245	1.0368	1.0474	0.0106
195612	HBY B1	1.0300	1.0586	0.0286	1.0351	1.0678	0.0327	1.0342	1.0575	0.0233	1.0320	1.0566	0.0245	1.0355	1.0461	0.0106
195620	DLP B1B4	1.0416	1.0471	0.0055	1.0401	1.0461	0.0060	1.0421	1.0472	0.0051	1.0445	1.0502	0.0057	1.0462	1.0493	0.0032
195621	PAS B1	1.0249	1.0331	0.0082	1.0270	1.0353	0.0082	1.0301	1.0373	0.0071	1.0342	1.0421	0.0078	1.0364	1.0413	0.0049
195622	MMT NP	1.0208	1.0310	0.0101	1.0236	1.0335	0.0098	1.0257	1.0342	0.0085	1.0303	1.0395	0.0092	1.0320	1.0378	0.0058
195624	MDR B2B3	1.0321	1.0626	0.0305	1.0283	1.0548	0.0266	1.0217	1.0416	0.0199	1.0347	1.0549	0.0203	1.0267	1.0373	0.0106
195625	MDR B4	1.0206	1.0315	0.0108	1.0233	1.0337	0.0104	1.0247	1.0336	0.0089	1.0293	1.0390	0.0096	1.0307	1.0368	0.0061
195626	CBPP B	1.0126	1.0214	0.0088	1.0144	1.0230	0.0086	1.0154	1.0229	0.0075	1.0185	1.0265	0.0080	1.0194	1.0250	0.0056
195627	CBPP D	1.0127	1.0215	0.0089	1.0144	1.0231	0.0087	1.0154	1.0230	0.0076	1.0185	1.0267	0.0082	1.0195	1.0252	0.0057
195628	CBPP E	1.0128	1.0216	0.0088	1.0145	1.0231	0.0086	1.0155	1.0231	0.0076	1.0187	1.0267	0.0081	1.0196	1.0252	0.0056
195629	CBP&P A	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0057	0.0000	1.0057	1.0064	0.0007	1.0057	1.0058	0.0001
195630	DLP 50HZ	1.0386	1.0387	0.0001	1.0386	1.0386	0.0001	1.0386	1.0385	-0.0001	1.0386	1.0389	0.0003	1.0386	1.0386	0.0000
195631	BRKFIELD	1.0072	1.0073	0.0001	1.0072	1.0073	0.0001	1.0072	1.0072	0.0000	1.0072	1.0079	0.0007	1.0072	1.0073	0.0001
195632	CBP&P C	1.0057	1.0058	0.0001	1.0057	1.0058	0.0001	1.0057	1.0057	0.0000	1.0057	1.0064	0.0007	1.0057	1.0058	0.0001
195633	WATSONS	1.0060	1.0061	0.0001	1.0060	1.0061	0.0001	1.0060	1.0060	0.0000	1.0060	1.0066	0.0006	1.0060	1.0060	0.0001
195635	SVL B2	1.0097	1.0462	0.0365	1.0167	1.0443	0.0275	1.0228	1.0389	0.0161	1.0276	1.0436	0.0160	1.0306	1.0321	0.0016
195636	BBK T2	1.0601	1.0704	0.0103	1.0409	1.0505	0.0096	1.0327	1.0377	0.0050	1.0193	1.0263	0.0070	1.0204	1.0215	0.0011
195637	DLS B1	1.0479	1.0572	0.0094	1.0389	1.0477	0.0088	1.0481	1.0525	0.0044	1.0491	1.0559	0.0068	1.0570	1.0577	0.0007
195639	BUC B2	1.0377	1.0604	0.0227	1.0349	1.0583	0.0235	1.0328	1.0545	0.0217	1.0305	1.0562	0.0257	1.0246	1.0343	0.0097
195640	DPD L64	1.0394	1.0623	0.0228	1.0366	1.0602	0.0236	1.0346	1.0562	0.0217	1.0322	1.0579	0.0258	1.0263	1.0360	0.0096
195641	SLK L80	1.0486	1.0732	0.0247	1.0474	1.0725	0.0251	1.0465	1.0695	0.0230	1.0455	1.0739	0.0284	1.0430	1.0525	0.0095
195643	ACG GFL	1.0017	1.0049	0.0032	1.0037	1.0073	0.0036	1.0029	1.0064	0.0035	1.0021	1.0075	0.0053	1.0032	1.0047	0.0015
195644	ACG BFL	1.0139	1.0163	0.0023	1.0153	1.0179	0.0026	1.0147	1.0172	0.0025	1.0142	1.0180	0.0038	1.0149	1.0160	0.0010
195650	WAV B2	1.0469	1.0546	0.0077	1.0405	1.0640	0.0235	1.0394	1.0590	0.0196	1.0472	1.0748	0.0276	1.0397	1.0439	0.0042
195652	HRD B6B7	1.0335	1.0546	0.0211	1.0246	1.0535	0.0289	1.0219	1.0318	0.0099	1.0308	1.0431	0.0123	1.0262	1.0203	-0.0059
195654	OPD B2B5	1.0257	1.0525	0.0269	1.0224	1.0544	0.0320	1.0226	1.0341	0.0115	1.0258	1.0389	0.0130	1.0230	1.0173	-0.0057
195655	HWD B7B8	1.0214	1.0468	0.0254	1.0158	1.0484	0.0326	1.0145	1.0263	0.0118	1.0227	1.0356	0.0129	1.0184	1.0132	-0.0052
195675	CHF T601	1.0088	1.0170	0.0083	1.0088	1.0171	0.0083	1.0088	1.0160	0.0072	1.0159	1.0246	0.0087	1.0165	1.0220	0.0055
195676	CHF T602	1.0088	1.0170	0.0083	1.0088	1.0171	0.0083	1.0088	1.0160	0.0072	1.0159	1.0246	0.0087	1.0165	1.0220	0.0055
195677	CHF AIRPORT	1.0073	1.0157	0.0083	1.0073	1.0157	0.0083	1.0073	1.0146	0.0073	1.0145	1.0233	0.0087	1.0151	1.0207	0.0056
195678	BRDG CAMP	1.0050	1.0134	0.0084	1.0050	1.0134	0.0085	1.0050	1.0124	0.0074	1.0122	1.0210	0.0088	1.0128	1.0184	0.0056
195679	LOGANTWR	1.0055	1.0139	0.0084	1.0055	1.0139	0.0084	1.0055	1.0129	0.0074	1.0127	1.0215	0.0088	1.0133	1.0189	0.0056
195680	WHITEFISH	1.0041	1.0125	0.0084	1.0040	1.0125	0.0085	1.0041	1.0115	0.0074	1.0113	1.0201	0.0088	1.0119	1.0175	0.0056
195681	JACOPIE	1.0041	1.0125	0.0084	1.0041	1.0125	0.0085	1.0041	1.0115	0.0074	1.0113	1.0201	0.0088	1.0119	1.0175	0.0056
195682	TWIN TAP	1.0045	1.0129	0.0085	1.0044	1.0129	0.0085	1.0045	1.0119	0.0074	1.0117	1.0206	0.0089	1.0123	1.0179	0.0056
195683	ATIKONAK	0.9881	0.9969	0.0087	0.9881	0.9969	0.0088	0.9881	0.9958	0.0077	0.9956	1.0047	0.0091	0.9962	1.0020	0.0058
195684	LOB LODGE	0.9876	0.9963	0.0087	0.9876	0.9964	0.0088	0.9876	0.9953	0.0077	0.9951	1.0041	0.0091	0.9957	1.0015	0.0058
195685	LOBSTICK	0.9825	0.9913	0.0087	0.9825	0.9913	0.0088	0.9826	0.9902	0.0077	0.9901	0.9992	0.0091	0.9907	0.9965	0.0058
195686	LOB TAP	0.9870	0.9958	0.0087	0.9870	0.9958	0.0088	0.9871	0.9947	0.0077	0.9945	1.0036	0.0091	0.9951	1.0009	0.0058
195687	GABBRO	0.9858	0.9945	0.0087	0.9858	0.9945	0.0088	0.9858	0.9935	0.0077	0.9933	1.0023	0.0091	0.9939	0.9997	0.0058
195688	JWF TAP	1.0048	1.0132	0.0084	1.0048	1.0133	0.0085	1.0048	1.0122	0.0074	1.0120	1.0209	0.0088	1.0126	1.0183	0.0056
195824	STG MID2	1.0067	1.0430	0.0363	1.0117	1.0391	0.0273	1.0161	1.0320	0.0159	1.0249	1.0408	0.0159	1.0270	1.0286	0.0016
195843	GOU MID1	1.0103	1.0403	0.0301	1.0085	1.0464	0.0379	1.0106	1.0258	0.0152	1.0171	1.0302	0.0132	1.0164	1.0118	-0.0046
195844	MOB MID3	1.0036	1.0262	0.0226	1.0050	1.0333	0.0282	1.0094	1.0184	0.0091	1.0144	1.0067	-0.0077	1.0158	1.0079	-0.0078
195845	CHA MID1	1.0142	1.0464	0.0322	1.0105	1.0489	0.0384	1.0114	1.0270	0.0157	1.0203	1.0367	0.0165	1.0175	1.0141	-0.0034
195870	CHF T601	1.0088	1.0170	0.0083	1.0088	1.0171	0.0083	1.0088	1.0160	0.0072	1.0159	1.0246	0.0087	1.0165	1.0220	0.0055
196312	OPD T3Y	0.9954	1.0128	0.0173	1.0134	1.0369	0.0236	1.0155	1.0227	0.0072	1.0171	1.0271	0.0100	1.0177	1.0108	-0.0070
196316	OPD T1Y	0.9954	1.0128	0.0173	1.0134	1.0369	0.0236	1.0155	1.0227	0.0072	1.0171	1.0271	0.0100	1.0177	1.0108	-0.0070
196318	HWD T4Y	1.0014	1.0145	0.0132	1.0169	1.0369	0.0199	1.0185	1.0237	0.0052	1.0190	1.0275	0.0085	1.0200	1.0123	-0.0076
196324	HWD T1Y	1.0014	1.0145	0.0132	1.0169	1.0369	0.0199	1.0185	1.0237	0.0052	1.0190	1.0275	0.0085	1.0200	1.0123	-0.0076
196326	MDR T3Y	0.9913	1.0123	0.0210	0.9976	1.0174	0.0198	1.0012	1.0169	0.0157	1.0000	1.0165	0.0166	1.0036	1.0121	0.0085
196330	MDR T1Y	0.9913	1.0123	0.0210	0.9976	1.0174	0.0198	1.0012	1.0169	0.0157	1.0000	1.0165	0.0166	1.0036	1.0121	0.0085
196334	DLS T1Y	0.9840	0.9933	0.0093	0.9828	0.9916	0.0088	0.9884	0.9928	0.0044	0.9783	0.9847	0.0064	0.9847	0.9854	0.0007
196336	DLK T1Y	1.0064	1.0241	0.0178	0.9993	1.0229	0.0236	1.0045	1.0255	0.0209	0.9992	1.0213	0.0221	1.0046	1.0172	0.0127
196338	BHL T1Y	1.0159	1.0382	0.0223	1.0169	1.0444	0.0275	1.0283	1.0504	0.0222	1.0115	1.0346	0.0231	1.0205	1.0323	0.0118
196340	PBN T1Y	1.0202	1.0460	0.0257	1.0298	1.0604	0.0307	1.0474	1.0702	0.0228	1.0162	1.0398	0.0236	1.0290	1.0398	0.0108
196348	MKS T1Y	1.0147	1.0264	0.0117	1.0084	1.0301	0.0218	1.0099	1.0284	0.0185	1.0206	1.0435	0.0229	1.0158	1.0182	0.0024
196500	DLK NP	1.0402	1.0459	0.0057	1.0376	1.0441	0.0065	1.0401	1.0455	0.0054	1.0428	1.0489	0.0061	1.0449	1.0480	0.0031
196501	STX NP	1.0098	1.0463	0.0365	1.0166	1.0441	0.0275	1.0224	1.0384	0.0160	1.0278	1.0438	0.0160	1.0306	1.0322	0.0016
196502	STG NP	1.0102	1.0466	0.0364	1.0164	1.0439	0.0275	1.0218	1.0379	0.0160	1.0282	1.0442	0.0160	1.0309	1.0324	0.0016
196503	HAR NP	1.0097	1.0462	0.0365	1.0168	1.0443	0.0275	1.0229	1.0390	0.0161	1.0277	1.0436	0.0160	1.0306	1.0322	0.0016
196504	GAL NP	1.0097	1.0463	0.0365	1.0168	1.0444	0.0275	1.0229	1.0390	0.0161	1.0277	1.0437	0.0160	1.0306	1.0322	0.0016
196505	WHE TAP	1.0097	1.0462	0.0365	1.0168	1.0443	0.0275	1.0229	1.0390	0.0161	1.0277	1.0436	0.0160	1.0306	1.0322	0.0016
196506	WHE NP	1.0605	1.0708	0.0103	1.0413	1.0510	0.0096	1.0331	1.0381	0.0050	1.0197	1.0267	0.0070	1.0208	1.0219	0.0011
196507	GBY NP	0.9950	1.0035	0.0085	1.0003	1.0083	0.0080	1.0216	1.0256	0.0040	1.0263	1.0326	0.0063	1.0396	1.0403	0.0006
196508	PAB NP	0.9923	1.0008	0.0085	0.9983	1.0063	0.0080	1.0204	1.0244	0.0040	1.0254	1.0317	0.0063	1.0391	1.0397	0.0006
196509	LGL NP	0.9836	0.9914	0.0078	0.9908	0.9982	0.0074	1.0127	1.0164	0.0037	1.0159	1.0219	0.0060	1.0292	1.0298	0.0006
196517	GFS NPT1	1.0399	1.0768	0.0369	1.0381	1.0779	0.0397	1.0322	1.0649	0.0327	1.0326	1.0701	0.0376	1.0334	1.0462	0.0128
196518	RUS NP	1.0407	1.0775	0.0368	1.0390	1.0786	0.0397	1.0331	1.0658	0.0326	1.0335	1.0710	0.0375	1.0344	1.0471	0.0127
196519	SBK NP	1.0467	1.0831	0.0364	1.0451	1.0843	0.0392	1.0399	1.0719	0.0320	1.0402	1.0769	0.0367	1.0410	1.0533	0.0123
196520	RBK NP	1.0221	1.0574	0.0353	1.0281	1.0675	0.0394	1.0316	1.0615	0.0299	1.0329	1.0672	0.0343	1.0364	1.0436	0.0072
196521	NDJ NP	0.9991	1.0353	0.0362	1.0095	1.0506	0.0411	1.0175	1.0480	0.0305	1.0193	1.0540	0.0347	1.0245	1.0297	0.0052
196522	LEW NP	0.9755	1.0116	0.0360	0.9924	1.0333	0.0409	1.0065	1.0369	0.0304	1.0101	1.0447	0.0346	1.0189	1.0241	0.0052
196523	GAN NPT2	1.0231	1.0610	0.0379	1.0243	1.0679	0.0436	1.0239	1.0555	0.0316	1.0211	1.0567	0.0356	1.0209	1.0238	0.0030
196524	COB NPT2	0.9992	1.0439	0.0448	1.0073	1.0587	0.0514	1.0111	1.0509	0.0398	0.9675	1.0090	0.0415	0.9765	0.9847	0.0082
196525	CLK NP	0.9570	1.0036	0.0466	0.9903	1.0437	0.0534	1.0087	1.0493	0.0406	0.9767	1.0190	0.0423	0.9906	0.9984	0.0078
196526	BOY NP	0.9173	0.9648	0.0475	0.9684	1.0229	0.0545	0.9986	1.0396	0.0410	0.9755	1.0183	0.0428	0.9941	1.0019	0.0077
196527	FHD L54	0.9100	0.9573	0.0473	0.9635	1.0179	0.0543	0.9957	1.0366	0.0409	0.9735	1.0162	0.0427	0.9930	1.0008	0.0077
196528	GAM NPT2	0.9656	1.0144	0.0488	0.9806	1.0345	0.0539	0.9906	1.0336	0.0430	1.0057	1.0525	0.0467	1.0139	1.0223	0.0084
196529	HBS NP	0.9679	1.0168	0.0489	0.9828	1.0370	0.0541	0.9929	1.0360	0.0431	1.0081	1.0549	0.0468	1.0162	1.0246	0.0084
196530	TRN NP	0.9694	1.0185	0.0490	0.9844	1.0387	0.0542	0.9945	1.0376	0.0432	1.0097	1.0566	0.0469	1.0179	1.0262	0.0084
196531	GPD NP	0.9704	1.0196	0.0491	0.9855	1.0398	0.0543	0.9955	1.0387	0.0432	1.0108	1.0577	0.0469	1.0190	1.0273	0.0083
196532	WES NP	0.9706	1.0198	0.0491	0.9856	1.0400	0.0543	0.9957	1.0389	0.0432	1.0110	1.0579	0.0470	1.0191	1.0275	0.0083
196533	CLV NPT1	1.0049	1.0288	0.0239	1.0024	1.0359	0.0334	1.0033	1.0308	0.0275	1.0154	1.0476	0.0321	1.0132	1.0190	0.0059

ML = 300 MW Export

66 kV Bus	Bus Names	Peak Demand, ML= 300 MW			Int_Peak Demand, ML= 300 MW			Intermediate Demand, ML= 300 MW			Light Demand, ML= 300 MW			Extreme Light Demand, ML= 300 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196534	MIL NP	1.0064	1.0304	0.0240	1.0041	1.0376	0.0335	1.0049	1.0325	0.0275	1.0167	1.0488	0.0321	1.0145	1.0203	0.0058
196535	LET NP	1.0087	1.0328	0.0241	1.0065	1.0401	0.0336	1.0073	1.0349	0.0276	1.0184	1.0505	0.0322	1.0163	1.0221	0.0058
196536	SMV NP	1.0101	1.0342	0.0241	1.0080	1.0417	0.0337	1.0088	1.0364	0.0276	1.0192	1.0514	0.0322	1.0173	1.0231	0.0058
196537	LOK NP	1.0103	1.0345	0.0241	1.0083	1.0419	0.0337	1.0090	1.0366	0.0276	1.0193	1.0515	0.0322	1.0174	1.0232	0.0058
196538	PUN NP	1.0100	1.0341	0.0241	1.0079	1.0416	0.0337	1.0086	1.0362	0.0276	1.0190	1.0512	0.0322	1.0171	1.0229	0.0058
196539	CAT NPT1	1.0078	1.0318	0.0240	1.0055	1.0391	0.0336	1.0063	1.0339	0.0276	1.0176	1.0498	0.0322	1.0155	1.0213	0.0058
196540	SPT NP	1.0448	1.0589	0.0141	1.0206	1.0383	0.0177	1.0226	1.0334	0.0108	1.0322	1.0351	0.0029	1.0260	1.0247	-0.0013
196541	LAU NP	1.0413	1.0465	0.0052	1.0250	1.0306	0.0057	1.0314	1.0371	0.0058	1.0315	1.0438	0.0124	1.0280	1.0256	-0.0025
196542	STL WIND	1.0420	1.0450	0.0030	1.0257	1.0291	0.0034	1.0321	1.0365	0.0044	1.0322	1.0451	0.0129	1.0288	1.0256	-0.0031
196543	WEBCV_NP	1.0407	1.0532	0.0125	1.0283	1.0397	0.0114	1.0354	1.0451	0.0097	1.0284	1.0430	0.0145	1.0259	1.0262	0.0003
196544	GRH NP	1.0420	1.0580	0.0161	1.0310	1.0453	0.0143	1.0379	1.0495	0.0116	1.0272	1.0431	0.0159	1.0249	1.0266	0.0017
196545	GAR NP	1.0425	1.0575	0.0151	1.0249	1.0410	0.0161	1.0295	1.0406	0.0111	1.0297	1.0386	0.0089	1.0254	1.0255	0.0001
196546	BLK NPT3	1.0332	1.0506	0.0175	1.0283	1.0603	0.0320	1.0349	1.0588	0.0239	1.0320	1.0627	0.0307	1.0271	1.0324	0.0053
196547	NHR NP	1.0251	1.0398	0.0147	1.0190	1.0492	0.0302	1.0249	1.0472	0.0223	1.0239	1.0529	0.0290	1.0183	1.0224	0.0041
196548	ISL NP	1.0143	1.0257	0.0115	1.0064	1.0345	0.0281	1.0115	1.0318	0.0203	1.0129	1.0397	0.0268	1.0064	1.0090	0.0026
196549	HCT NP	1.0063	1.0155	0.0092	0.9973	1.0237	0.0264	1.0019	1.0206	0.0187	1.0050	1.0301	0.0250	0.9979	0.9993	0.0014
196550	NCH NP	1.0075	1.0167	0.0092	0.9999	1.0264	0.0265	1.0037	1.0224	0.0187	1.0064	1.0314	0.0250	1.0004	1.0018	0.0014
196551	OPL NP	1.0078	1.0170	0.0093	1.0002	1.0267	0.0265	1.0040	1.0227	0.0187	1.0067	1.0317	0.0250	1.0007	1.0021	0.0014
196552	CAR NP	0.9885	0.9928	0.0043	0.9768	0.9994	0.0226	0.9822	0.9972	0.0150	0.9887	1.0099	0.0212	0.9794	0.9781	-0.0013
196553	VIC NP	0.9887	0.9929	0.0043	0.9771	0.9996	0.0226	0.9824	0.9974	0.0150	0.9889	1.0100	0.0212	0.9796	0.9783	-0.0013
196554	HGR NP	0.9868	0.9910	0.0042	0.9747	0.9971	0.0225	0.9800	0.9949	0.0149	0.9869	1.0079	0.0210	0.9773	0.9758	-0.0015
196555	ILC NP	0.9836	0.9871	0.0035	0.9708	0.9928	0.0219	0.9763	0.9906	0.0143	0.9838	1.0042	0.0204	0.9738	0.9719	-0.0019
196556	BRB T2T3	0.9792	0.9824	0.0032	0.9656	0.9871	0.0215	0.9710	0.9849	0.0139	0.9793	0.9991	0.0199	0.9687	0.9665	-0.0022
196557	ULT TAP	1.0318	1.0534	0.0216	1.0234	1.0529	0.0296	1.0211	1.0314	0.0103	1.0300	1.0426	0.0126	1.0256	1.0198	-0.0058
196558	ULT NP	1.0318	1.0535	0.0216	1.0234	1.0529	0.0296	1.0211	1.0314	0.0103	1.0300	1.0426	0.0126	1.0256	1.0198	-0.0058
196559	SCV NP	1.0302	1.0523	0.0221	1.0221	1.0523	0.0302	1.0202	1.0309	0.0107	1.0292	1.0421	0.0129	1.0250	1.0193	-0.0057
196560	KEL NP	1.0188	1.0454	0.0267	1.0138	1.0497	0.0359	1.0142	1.0285	0.0142	1.0234	1.0391	0.0157	1.0206	1.0159	-0.0046
196561	CHA NP	1.0142	1.0465	0.0322	1.0105	1.0489	0.0384	1.0114	1.0271	0.0157	1.0203	1.0367	0.0165	1.0175	1.0142	-0.0033
196562	BCV NP	1.0074	1.0327	0.0253	1.0055	1.0461	0.0406	1.0078	1.0248	0.0170	1.0169	1.0343	0.0174	1.0149	1.0097	-0.0052
196563	GDL NP	1.0107	1.0438	0.0331	1.0087	1.0480	0.0393	1.0106	1.0268	0.0162	1.0181	1.0334	0.0153	1.0162	1.0128	-0.0035
196564	GOU NP	1.0111	1.0413	0.0301	1.0097	1.0476	0.0380	1.0119	1.0272	0.0153	1.0184	1.0315	0.0132	1.0169	1.0124	-0.0045
196565	KEN NP	1.0180	1.0452	0.0272	1.0156	1.0490	0.0334	1.0169	1.0293	0.0124	1.0220	1.0356	0.0135	1.0198	1.0144	-0.0054
196566	MOL NP	1.0143	1.0451	0.0308	1.0126	1.0490	0.0364	1.0146	1.0289	0.0143	1.0204	1.0355	0.0151	1.0186	1.0133	-0.0053
196567	SLA NP	1.0187	1.0472	0.0285	1.0167	1.0514	0.0347	1.0183	1.0314	0.0132	1.0226	1.0367	0.0141	1.0206	1.0152	-0.0054
196568	SJM NP	1.0131	1.0435	0.0305	1.0120	1.0489	0.0369	1.0145	1.0291	0.0146	1.0198	1.0341	0.0143	1.0185	1.0138	-0.0047
196569	MUN NP	1.0160	1.0458	0.0298	1.0149	1.0502	0.0353	1.0173	1.0308	0.0136	1.0215	1.0361	0.0146	1.0201	1.0150	-0.0051
196570	KBR NP	1.0143	1.0459	0.0316	1.0138	1.0499	0.0360	1.0168	1.0308	0.0141	1.0209	1.0360	0.0151	1.0198	1.0150	-0.0048
196571	PEP NP	1.0128	1.0452	0.0324	1.0128	1.0492	0.0365	1.0162	1.0305	0.0143	1.0203	1.0357	0.0154	1.0195	1.0147	-0.0048
196572	RRD NP	1.0197	1.0500	0.0302	1.0179	1.0527	0.0347	1.0196	1.0328	0.0132	1.0233	1.0378	0.0145	1.0214	1.0164	-0.0050
196573	VIR NP	1.0122	1.0468	0.0346	1.0125	1.0503	0.0378	1.0162	1.0313	0.0152	1.0201	1.0364	0.0163	1.0195	1.0147	-0.0047
196574	PUL NP	0.9996	1.0438	0.0442	1.0033	1.0482	0.0449	1.0102	1.0300	0.0198	1.0149	1.0352	0.0203	1.0162	1.0140	-0.0022
196575	BIG NP	1.0080	1.0356	0.0277	1.0082	1.0431	0.0349	1.0114	1.0250	0.0135	1.0175	1.0222	0.0047	1.0172	1.0116	-0.0055
196576	MOB NP	1.0087	1.0304	0.0217	1.0111	1.0384	0.0273	1.0154	1.0247	0.0093	1.0203	1.0119	-0.0085	1.0218	1.0143	-0.0075
196577	TCV NP	1.0091	1.0308	0.0217	1.0116	1.0388	0.0272	1.0159	1.0251	0.0093	1.0208	1.0123	-0.0085	1.0222	1.0147	-0.0075
196578	ROP NP	1.0086	1.0297	0.0211	1.0110	1.0375	0.0265	1.0153	1.0241	0.0089	1.0202	1.0105	-0.0097	1.0217	1.0140	-0.0077
196579	MRP NP	1.0087	1.0299	0.0212	1.0111	1.0377	0.0266	1.0153	1.0242	0.0089	1.0202	1.0106	-0.0096	1.0217	1.0140	-0.0076
196580	HCP TAP NP	1.0080	1.0254	0.0175	1.0107	1.0325	0.0218	1.0152	1.0213	0.0061	1.0202	1.0048	-0.0154	1.0222	1.0132	-0.0090
196581	HCP NP	1.0082	1.0258	0.0176	1.0108	1.0327	0.0219	1.0150	1.0213	0.0063	1.0201	1.0047	-0.0153	1.0220	1.0130	-0.0090
196582	CAB NP	1.0077	1.0232	0.0155	1.0108	1.0300	0.0192	1.0156	1.0202	0.0046	1.0207	1.0032	-0.0175	1.0229	1.0133	-0.0096
196583	FER NP	1.0101	1.0124	0.0023	1.0142	1.0180	0.0038	1.0199	1.0180	-0.0019	1.0253	1.0209	-0.0045	1.0281	1.0180	-0.0101
196584	FER WIND	1.0104	1.0120	0.0016	1.0145	1.0175	0.0030	1.0202	1.0180	-0.0023	1.0256	1.0219	-0.0037	1.0283	1.0182	-0.0101
196585	SUM NP	0.9173	0.9648	0.0475	0.9684	1.0229	0.0545	0.9986	1.0396	0.0410	0.9755	1.0183	0.0428	0.9941	1.0019	0.0077
196586	TWG NP	0.9072	0.9553	0.0481	0.9645	1.0196	0.0551	0.9969	1.0381	0.0412	0.9785	1.0215	0.0430	0.9966	1.0043	0.0077
196587	HRD OUTS	1.0325	1.0539	0.0214	1.0238	1.0531	0.0293	1.0214	1.0315	0.0101	1.0302	1.0428	0.0125	1.0258	1.0200	-0.0058

ML = 158 MW Export

66 kV Bus	Bus Names	Peak Demand, ML= 158 MW			Int_Peak Demand, ML= 158 MW			Intermediate Demand, ML= 158 MW			Light Demand, ML= 158 MW			Extreme Light Demand, ML= 158 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0323	1.0396	0.0073	1.0379	1.0420	0.0041	1.0405	1.0434	0.0030	1.0437	1.0471	0.0034	1.0444	1.0451	0.0007
195601	WDL TAP	1.0264	1.0408	0.0144	1.0351	1.0441	0.0090	1.0404	1.0463	0.0060	1.0451	1.0506	0.0055	1.0471	1.0476	0.0006
195602	WDL B1	1.0263	1.0407	0.0144	1.0350	1.0440	0.0090	1.0404	1.0464	0.0060	1.0451	1.0506	0.0055	1.0471	1.0477	0.0006
195603	GLB L29	1.0232	1.0376	0.0144	1.0331	1.0420	0.0090	1.0395	1.0455	0.0059	1.0448	1.0503	0.0055	1.0473	1.0479	0.0005
195604	RHR TAP	1.0187	1.0424	0.0237	1.0300	1.0456	0.0156	1.0378	1.0479	0.0101	1.0437	1.0521	0.0084	1.0468	1.0474	0.0005
195605	RHR B1	1.0180	1.0424	0.0244	1.0295	1.0456	0.0161	1.0375	1.0479	0.0105	1.0435	1.0522	0.0087	1.0467	1.0472	0.0005
195606	BHL T1	0.9911	1.0199	0.0288	1.0010	1.0167	0.0157	1.0006	1.0113	0.0107	0.9984	1.0107	0.0122	1.0016	1.0037	0.0021
195607	SCV L27	0.9902	1.0209	0.0306	1.0006	1.0176	0.0170	1.0007	1.0122	0.0115	0.9987	1.0116	0.0128	1.0021	1.0042	0.0021
195608	CHD B1	0.9881	1.0214	0.0333	0.9992	1.0181	0.0189	1.0000	1.0127	0.0127	0.9984	1.0121	0.0137	1.0021	1.0042	0.0021
195609	PPD L27	1.0434	1.0805	0.0371	1.0507	1.0697	0.0190	1.0458	1.0575	0.0118	1.0438	1.0574	0.0136	1.0391	1.0399	0.0008
195610	DHR B1B2	1.0449	1.0799	0.0350	1.0515	1.0691	0.0176	1.0461	1.0569	0.0108	1.0438	1.0568	0.0130	1.0389	1.0397	0.0008
195611	PBN B2	1.0452	1.0799	0.0347	1.0517	1.0691	0.0174	1.0461	1.0568	0.0107	1.0438	1.0567	0.0129	1.0388	1.0396	0.0008
195612	HBY B1	1.0291	1.0639	0.0348	1.0409	1.0583	0.0174	1.0401	1.0508	0.0107	1.0402	1.0531	0.0129	1.0376	1.0383	0.0007
195620	DLP B1B4	1.0372	1.0432	0.0060	1.0413	1.0449	0.0037	1.0434	1.0462	0.0028	1.0461	1.0492	0.0031	1.0466	1.0478	0.0012
195621	PAS B1	1.0237	1.0317	0.0080	1.0286	1.0337	0.0051	1.0320	1.0360	0.0040	1.0362	1.0408	0.0045	1.0373	1.0395	0.0022
195622	MMT NP	1.0216	1.0311	0.0095	1.0254	1.0315	0.0061	1.0279	1.0327	0.0049	1.0325	1.0380	0.0055	1.0331	1.0359	0.0027
195624	MDR B2B3	1.0207	1.0499	0.0292	1.0323	1.0497	0.0174	1.0267	1.0384	0.0116	1.0396	1.0514	0.0118	1.0292	1.0331	0.0039
195625	MDR B4	1.0220	1.0321	0.0101	1.0251	1.0316	0.0065	1.0270	1.0321	0.0051	1.0316	1.0374	0.0058	1.0319	1.0349	0.0029
195626	CBPP B	1.0136	1.0218	0.0083	1.0157	1.0214	0.0057	1.0170	1.0218	0.0048	1.0202	1.0254	0.0053	1.0203	1.0236	0.0033
195627	CBPP D	1.0136	1.0219	0.0083	1.0157	1.0215	0.0058	1.0170	1.0219	0.0048	1.0202	1.0256	0.0054	1.0204	1.0237	0.0033
195628	CBPP E	1.0137	1.0220	0.0083	1.0159	1.0215	0.0057	1.0171	1.0219	0.0048	1.0203	1.0256	0.0053	1.0205	1.0238	0.0032
195629	CBP&P A	1.0057	1.0058	0.0001	1.0057	1.0056	0.0000	1.0057	1.0057	0.0000	1.0057	1.0059	0.0003	1.0057	1.0057	0.0001
195630	DLP 50HZ	1.0386	1.0387	0.0001	1.0386	1.0385	-0.0001	1.0386	1.0385	0.0000	1.0386	1.0386	0.0001	1.0386	1.0386	0.0000
195631	BRKFIELD	1.0072	1.0073	0.0001	1.0072	1.0072	0.0000	1.0072	1.0072	0.0000	1.0072	1.0074	0.0002	1.0072	1.0073	0.0001
195632	CBP&P C	1.0057	1.0058	0.0001	1.0057	1.0057	0.0000	1.0057	1.0057	0.0000	1.0057	1.0059	0.0003	1.0057	1.0057	0.0001
195633	WATSONS	1.0060	1.0061	0.0001	1.0060	1.0059	0.0000	1.0060	1.0060	0.0000	1.0060	1.0062	0.0002	1.0060	1.0060	0.0000
195635	SVL B2	1.0097	1.0443	0.0346	1.0167	1.0375	0.0207	1.0228	1.0344	0.0116	1.0276	1.0393	0.0117	1.0306	1.0289	-0.0016
195636	BBK T2	1.0601	1.0685	0.0084	1.0409	1.0435	0.0026	1.0327	1.0332	0.0005	1.0193	1.0221	0.0028	1.0204	1.0184	-0.0020
195637	DLS B1	1.0479	1.0555	0.0076	1.0389	1.0413	0.0024	1.0481	1.0484	0.0003	1.0491	1.0518	0.0027	1.0570	1.0549	-0.0021
195639	BUC B2	1.0308	1.0542	0.0234	1.0404	1.0515	0.0111	1.0303	1.0384	0.0081	1.0270	1.0376	0.0105	1.0355	1.0347	-0.0008
195640	DPD L64	1.0325	1.0560	0.0235	1.0421	1.0532	0.0111	1.0320	1.0401	0.0081	1.0288	1.0393	0.0105	1.0372	1.0364	-0.0008
195641	SLK L80	1.0456	1.0703	0.0247	1.0497	1.0626	0.0129	1.0454	1.0543	0.0088	1.0441	1.0565	0.0124	1.0476	1.0471	-0.0005
195643	ACG GFL	1.0023	1.0063	0.0041	1.0047	1.0068	0.0020	1.0045	1.0060	0.0015	1.0034	1.0059	0.0024	1.0061	1.0060	-0.0001
195644	ACG BFL	1.0143	1.0172	0.0029	1.0160	1.0174	0.0014	1.0158	1.0169	0.0010	1.0151	1.0169	0.0017	1.0170	1.0169	-0.0001
195650	WAV B2	1.0403	1.0773	0.0369	1.0470	1.0621	0.0151	1.0388	1.0466	0.0078	1.0439	1.0552	0.0113	1.0425	1.0383	-0.0041
195652	HRD B6B7	1.0192	1.0638	0.0445	1.0256	1.0463	0.0208	1.0270	1.0324	0.0054	1.0283	1.0357	0.0074	1.0252	1.0183	-0.0069
195654	OPD B2B5	1.0218	1.0719	0.0500	1.0237	1.0473	0.0235	1.0245	1.0314	0.0069	1.0262	1.0349	0.0087	1.0236	1.0169	-0.0068
195655	HWD B7B8	1.0126	1.0602	0.0475	1.0172	1.0412	0.0240	1.0153	1.0226	0.0073	1.0188	1.0275	0.0087	1.0164	1.0105	-0.0058
195675	CHF T601	1.0088	1.0171	0.0083	1.0088	1.0165	0.0077	1.0088	1.0144	0.0056	1.0165	1.0224	0.0059	1.0166	1.0199	0.0033
195676	CHF T602	1.0088	1.0171	0.0083	1.0088	1.0165	0.0077	1.0088	1.0144	0.0056	1.0165	1.0224	0.0059	1.0166	1.0199	0.0033
195677	CHF AIRPORT	1.0073	1.0157	0.0084	1.0073	1.0151	0.0078	1.0073	1.0130	0.0056	1.0151	1.0210	0.0059	1.0152	1.0185	0.0033
195678	BRDG CAMP	1.0050	1.0135	0.0085	1.0050	1.0129	0.0079	1.0050	1.0107	0.0057	1.0128	1.0188	0.0060	1.0128	1.0162	0.0034
195679	LOGANTWR	1.0055	1.0140	0.0085	1.0055	1.0134	0.0079	1.0055	1.0112	0.0057	1.0133	1.0193	0.0060	1.0134	1.0167	0.0034
195680	WHITEFISH	1.0041	1.0126	0.0085	1.0041	1.0119	0.0079	1.0040	1.0098	0.0057	1.0119	1.0179	0.0060	1.0119	1.0153	0.0034
195681	JACOPIE	1.0041	1.0126	0.0085	1.0041	1.0120	0.0079	1.0041	1.0098	0.0057	1.0119	1.0179	0.0060	1.0119	1.0153	0.0034
195682	TWIN TAP	1.0045	1.0130	0.0085	1.0045	1.0124	0.0079	1.0044	1.0102	0.0057	1.0123	1.0183	0.0060	1.0123	1.0157	0.0034
195683	ATIKONAK	0.9881	0.9969	0.0088	0.9881	0.9963	0.0082	0.9881	0.9941	0.0059	0.9962	1.0024	0.0062	0.9963	0.9997	0.0035
195684	LOB LODGE	0.9876	0.9964	0.0088	0.9876	0.9958	0.0082	0.9876	0.9935	0.0059	0.9956	1.0018	0.0062	0.9957	0.9992	0.0035
195685	LOBSTICK	0.9825	0.9914	0.0088	0.9826	0.9907	0.0082	0.9825	0.9885	0.0059	0.9906	0.9968	0.0062	0.9907	0.9942	0.0035
195686	LOB TAP	0.9870	0.9959	0.0088	0.9870	0.9952	0.0082	0.9870	0.9930	0.0059	0.9951	1.0013	0.0062	0.9952	0.9987	0.0035
195687	GABBRO	0.9858	0.9946	0.0088	0.9858	0.9940	0.0082	0.9858	0.9917	0.0059	0.9938	1.0000	0.0062	0.9939	0.9974	0.0035
195688	JWF TAP	1.0048	1.0133	0.0085	1.0048	1.0127	0.0079	1.0048	1.0105	0.0057	1.0126	1.0186	0.0060	1.0127	1.0160	0.0034
195824	STG MID2	1.0067	1.0411	0.0344	1.0117	1.0323	0.0206	1.0161	1.0276	0.0115	1.0249	1.0365	0.0116	1.0270	1.0254	-0.0016
195843	GOU MID1	1.0029	1.0585	0.0556	1.0097	1.0388	0.0291	1.0117	1.0223	0.0106	1.0151	1.0271	0.0120	1.0148	1.0094	-0.0054
195844	MOB MID3	1.0012	1.0419	0.0407	1.0059	1.0253	0.0194	1.0102	1.0147	0.0044	1.0128	1.0194	0.0066	1.0150	1.0062	-0.0088
195845	CHA MID1	1.0044	1.0601	0.0557	1.0118	1.0417	0.0298	1.0130	1.0241	0.0111	1.0166	1.0287	0.0121	1.0156	1.0116	-0.0040
195870	CHF T601	1.0088	1.0171	0.0083	1.0088	1.0165	0.0077	1.0088	1.0144	0.0056	1.0165	1.0224	0.0059	1.0166	1.0199	0.0033
196312	OPD T3Y	0.9943	1.0322	0.0379	1.0147	1.0305	0.0158	1.0108	1.0136	0.0028	1.0125	1.0168	0.0043	1.0197	1.0115	-0.0082
196316	OPD T1Y	0.9943	1.0322	0.0379	1.0147	1.0305	0.0158	1.0108	1.0136	0.0028	1.0125	1.0168	0.0043	1.0197	1.0115	-0.0082
196318	HWD T4Y	1.0012	1.0341	0.0329	1.0185	1.0308	0.0123	1.0156	1.0163	0.0007	1.0168	1.0194	0.0025	1.0229	1.0141	-0.0088
196324	HWD T1Y	1.0012	1.0341	0.0329	1.0185	1.0308	0.0123	1.0156	1.0163	0.0007	1.0168	1.0194	0.0025	1.0229	1.0141	-0.0088
196326	MDR T3Y	0.9936	1.0134	0.0198	1.0014	1.0124	0.0110	1.0061	1.0138	0.0077	1.0047	1.0131	0.0084	1.0061	1.0080	0.0020
196330	MDR T1Y	0.9936	1.0134	0.0198	1.0014	1.0124	0.0110	1.0061	1.0138	0.0077	1.0047	1.0131	0.0084	1.0061	1.0080	0.0020
196334	DLS T1Y	0.9840	0.9916	0.0076	0.9828	0.9851	0.0023	0.9884	0.9887	0.0003	0.9783	0.9808	0.0025	0.9847	0.9826	-0.0021
196336	DLK T1Y	0.9904	1.0129	0.0225	1.0050	1.0182	0.0132	1.0107	1.0209	0.0102	1.0071	1.0184	0.0113	1.0066	1.0100	0.0034
196338	BHL T1Y	1.0007	1.0281	0.0274	1.0226	1.0376	0.0150	1.0343	1.0448	0.0105	1.0195	1.0315	0.0120	1.0225	1.0248	0.0023
196340	PBN T1Y	1.0064	1.0376	0.0312	1.0353	1.0513	0.0160	1.0532	1.0635	0.0103	1.0241	1.0364	0.0122	1.0311	1.0321	0.0010
196348	MKS T1Y	0.9989	1.0357	0.0368	1.0131	1.0277	0.0146	1.0086	1.0159	0.0072	1.0112	1.0196	0.0084	1.0134	1.0084	-0.0050
196500	DLK NP	1.0338	1.0405	0.0067	1.0388	1.0427	0.0039	1.0414	1.0443	0.0029	1.0445	1.0478	0.0032	1.0453	1.0462	0.0009
196501	STX NP	1.0098	1.0444	0.0346	1.0166	1.0373	0.0207	1.0224	1.0340	0.0116	1.0278	1.0395	0.0117	1.0306	1.0290	-0.0016
196502	STG NP	1.0102	1.0447	0.0345	1.0164	1.0371	0.0207	1.0218	1.0334	0.0115	1.0282	1.0399	0.0116	1.0309	1.0292	-0.0016
196503	HAR NP	1.0097	1.0443	0.0346	1.0168	1.0375	0.0207	1.0229	1.0345	0.0116	1.0277	1.0393	0.0117	1.0306	1.0290	-0.0016
196504	GAL NP	1.0097	1.0444	0.0346	1.0168	1.0375	0.0207	1.0229	1.0345	0.0116	1.0277	1.0393	0.0117	1.0306	1.0290	-0.0016
196505	WHE TAP	1.0097	1.0443	0.0346	1.0168	1.0375	0.0207	1.0229	1.0345	0.0116	1.0277	1.0393	0.0117	1.0306	1.0290	-0.0016
196506	WHE NP	1.0605	1.0690	0.0084	1.0413	1.0439	0.0026	1.0331	1.0336	0.0005	1.0197	1.0225	0.0028	1.0208	1.0188	-0.0020
196507	GBY NP	0.9950	1.0019	0.0069	1.0003	1.0024	0.0022	1.0216	1.0219	0.0003	1.0263	1.0288	0.0025	1.0396	1.0377	-0.0020
196508	PAB NP	0.9923	0.9993	0.0069	0.9983	1.0004	0.0022	1.0204	1.0206	0.0003	1.0254	1.0278	0.0025	1.0391	1.0371	-0.0020
196509	LGL NP	0.9836	0.9899	0.0064	0.9908	0.9928	0.0020	1.0127	1.0130	0.0003	1.0159	1.0182	0.0024	1.0292	1.0275	-0.0018
196517	GFS NPT1	1.0346	1.0806	0.0460	1.0423	1.0689	0.0266	1.0332	1.0511	0.0180	1.0390	1.0597	0.0207	1.0388	1.0391	0.0004
196518	RUS NP	1.0355	1.0815	0.0459	1.0431	1.0696	0.0265	1.0341	1.0520	0.0179	1.0398	1.0605	0.0206	1.0396	1.0399	0.0003
196519	SBK NP	1.0420	1.0874	0.0454	1.0488	1.0748	0.0260	1.0407	1.0582	0.0174	1.0459	1.0661	0.0202	1.0457	1.0458	0.0001
196520	RBK NP	1.0194	1.0672	0.0478	1.0298	1.0568	0.0270	1.0314	1.0483	0.0169	1.0362	1.0557	0.0195	1.0391	1.0381	-0.0011
196521	NDJ NP	0.9969	1.0480	0.0511	1.0105	1.0396	0.0291	1.0166	1.0345	0.0179	1.0220	1.0422	0.0201	1.0267	1.0254	-0.0013
196522	LEW NP	0.9733	1.0241	0.0508	0.9934	1.0224	0.0290	1.0056	1.0234	0.0179	1.0129	1.0329	0.0201	1.0211	1.0198	-0.0014
196523	GAN NPT2	1.0217	1.0775	0.0557	1.0244	1.0564	0.0321	1.0222	1.0416	0.0194	1.0232	1.0443	0.0212	1.0226	1.0210	-0.0015
196524	COB NPT2	0.9834	1.0453	0.0619	1.0154	1.0541	0.0386	1.0118	1.0365	0.0247	0.9729	0.9976	0.0247	0.9817	0.9828	0.0011
196525	CLK NP	0.9380	1.0025	0.0645	0.9995	1.0390	0.0395	1.0095	1.0344	0.0249	0.9819	1.0069	0.0250	0.9962	0.9964	0.0002
196526	BOY NP	0.8964	0.9621	0.0657	0.9784	1.0182	0.0398	0.9996	1.0245	0.0250	0.9806	1.0058	0.0252	1.0002	0.9998	-0.0004
196527	FHD L54	0.8888	0.9543	0.0655	0.9735	1.0133	0.0398	0.9966	1.0216	0.0249	0.9786	1.0038	0.0252	0.9991	0.9987	-0.0004
196528	GAM NPT2	0.9530	1.0219	0.0690	0.9882	1.0300	0.0418	0.9924	1.0196	0.0272	1.0087	1.0366	0.0278	1.0180	1.0217	0.0037
196529	HBS NP	0.9552	1.0244	0.0692	0.9905	1.0324	0.0418	0.9947	1.0219	0.0272	1.0111	1.0390	0.0279	1.0203	1.0240	0.0036
196530	TRN NP	0.9567	1.0261	0.0694	0.9921	1.0340	0.0419	0.9963	1.0236	0.0272	1.0127	1.0406	0.0279	1.0220	1.0256	0.0036
196531	GPD NP	0.9577	1.0272	0.0695	0.9932	1.0351	0.0419	0.9974	1.0246	0.0273	1.0138	1.0417	0.0279	1.0231	1.0266	0.0036
196532	WES NP	0.9579	1.0274	0.0695	0.9933	1.0353	0.0419	0.9975	1.0248	0.0273	1.0140	1.0419	0.0279	1.0233	1.0268	0.0036
196533	CLV NPT1	0.9947	1.0448	0.0501	1.0074	1.0306	0.0232	1.0033	1.0170	0.0137	1.0100	1.0248	0.0148	1.0125	1.0105	-0.0020

ML = 158 MW Export

66 kV Bus	Bus Names	Peak Demand, ML= 158 MW			Int_Peak Demand, ML= 158 MW			Intermediate Demand, ML= 158 MW			Light Demand, ML= 158 MW			Extreme Light Demand, ML= 158 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196534	MIL NP	0.9966	1.0468	0.0502	1.0089	1.0321	0.0232	1.0049	1.0185	0.0137	1.0114	1.0262	0.0148	1.0138	1.0118	-0.0020
196535	LET NP	0.9994	1.0498	0.0504	1.0110	1.0342	0.0232	1.0073	1.0209	0.0136	1.0134	1.0282	0.0148	1.0156	1.0136	-0.0020
196536	SMV NP	1.0014	1.0518	0.0505	1.0123	1.0355	0.0232	1.0087	1.0224	0.0136	1.0145	1.0293	0.0148	1.0167	1.0146	-0.0021
196537	LOK NP	1.0017	1.0522	0.0505	1.0125	1.0357	0.0232	1.0090	1.0226	0.0136	1.0147	1.0295	0.0148	1.0168	1.0147	-0.0021
196538	PUN NP	1.0013	1.0518	0.0505	1.0121	1.0353	0.0232	1.0086	1.0222	0.0136	1.0143	1.0292	0.0148	1.0165	1.0144	-0.0021
196539	CAT NPT1	0.9983	1.0486	0.0503	1.0101	1.0333	0.0232	1.0063	1.0199	0.0136	1.0125	1.0273	0.0148	1.0148	1.0128	-0.0020
196540	SPT NP	1.0254	1.0546	0.0292	1.0240	1.0346	0.0106	1.0216	1.0251	0.0035	1.0224	1.0189	-0.0035	1.0170	1.0102	-0.0068
196541	LAU NP	1.0244	1.0392	0.0148	1.0279	1.0353	0.0073	1.0305	1.0328	0.0024	1.0216	1.0275	0.0060	1.0190	1.0127	-0.0064
196542	STL WIND	1.0251	1.0371	0.0120	1.0287	1.0345	0.0058	1.0312	1.0327	0.0015	1.0223	1.0289	0.0065	1.0198	1.0130	-0.0068
196543	WEBCV_NP	1.0261	1.0479	0.0218	1.0309	1.0435	0.0127	1.0346	1.0406	0.0060	1.0185	1.0263	0.0078	1.0169	1.0127	-0.0042
196544	GRH NP	1.0285	1.0537	0.0252	1.0333	1.0487	0.0153	1.0372	1.0450	0.0078	1.0173	1.0262	0.0089	1.0159	1.0128	-0.0030
196545	GAR NP	1.0259	1.0532	0.0273	1.0278	1.0406	0.0128	1.0286	1.0341	0.0055	1.0198	1.0221	0.0023	1.0165	1.0114	-0.0051
196546	BLK NPT3	1.0220	1.0715	0.0495	1.0359	1.0596	0.0237	1.0271	1.0400	0.0129	1.0312	1.0468	0.0155	1.0280	1.0259	-0.0021
196547	NHR NP	1.0150	1.0621	0.0470	1.0280	1.0500	0.0220	1.0178	1.0295	0.0117	1.0227	1.0370	0.0143	1.0203	1.0174	-0.0029
196548	ISL NP	1.0056	1.0497	0.0441	1.0172	1.0372	0.0200	1.0053	1.0155	0.0101	1.0112	1.0239	0.0127	1.0099	1.0059	-0.0040
196549	HCT NP	0.9985	1.0405	0.0420	1.0093	1.0278	0.0185	0.9963	1.0052	0.0089	1.0028	1.0143	0.0115	1.0024	0.9975	-0.0048
196550	NCH NP	1.0009	1.0430	0.0421	1.0102	1.0286	0.0185	0.9991	1.0080	0.0089	1.0045	1.0160	0.0115	1.0041	0.9992	-0.0049
196551	OPL NP	1.0012	1.0433	0.0421	1.0105	1.0289	0.0185	0.9994	1.0083	0.0089	1.0048	1.0162	0.0115	1.0044	0.9995	-0.0049
196552	CAR NP	0.9810	1.0186	0.0375	0.9925	1.0075	0.0150	0.9763	0.9823	0.0061	0.9852	0.9939	0.0087	0.9859	0.9792	-0.0067
196553	VIC NP	0.9812	1.0187	0.0375	0.9926	1.0076	0.0150	0.9765	0.9825	0.0061	0.9854	0.9941	0.0087	0.9861	0.9793	-0.0067
196554	HGR NP	0.9793	1.0167	0.0373	0.9908	1.0057	0.0149	0.9741	0.9800	0.0060	0.9833	0.9919	0.0086	0.9841	0.9773	-0.0068
196555	ILC NP	0.9761	1.0128	0.0367	0.9877	1.0021	0.0144	0.9703	0.9758	0.0056	0.9799	0.9881	0.0082	0.9810	0.9739	-0.0071
196556	BRB T2T3	0.9718	1.0080	0.0362	0.9834	0.9975	0.0141	0.9650	0.9702	0.0053	0.9752	0.9830	0.0078	0.9765	0.9692	-0.0073
196557	ULT TAP	1.0178	1.0631	0.0453	1.0243	1.0457	0.0214	1.0260	1.0318	0.0058	1.0275	1.0352	0.0077	1.0246	1.0179	-0.0067
196558	ULT NP	1.0178	1.0631	0.0453	1.0243	1.0457	0.0214	1.0260	1.0318	0.0058	1.0275	1.0352	0.0077	1.0246	1.0179	-0.0067
196559	SCV NP	1.0163	1.0624	0.0461	1.0231	1.0451	0.0220	1.0250	1.0312	0.0062	1.0266	1.0347	0.0080	1.0240	1.0174	-0.0066
196560	KEL NP	1.0067	1.0599	0.0532	1.0149	1.0425	0.0276	1.0176	1.0273	0.0097	1.0204	1.0314	0.0110	1.0192	1.0137	-0.0055
196561	CHA NP	1.0044	1.0602	0.0558	1.0118	1.0417	0.0299	1.0130	1.0241	0.0111	1.0167	1.0288	0.0121	1.0156	1.0116	-0.0040
196562	BCV NP	0.9985	1.0569	0.0584	1.0069	1.0389	0.0320	1.0087	1.0211	0.0124	1.0130	1.0262	0.0132	1.0128	1.0070	-0.0058
196563	GDL NP	1.0029	1.0602	0.0573	1.0101	1.0407	0.0306	1.0117	1.0232	0.0115	1.0152	1.0279	0.0128	1.0147	1.0105	-0.0042
196564	GOU NP	1.0043	1.0601	0.0559	1.0110	1.0403	0.0293	1.0131	1.0237	0.0107	1.0162	1.0282	0.0120	1.0158	1.0104	-0.0054
196565	KEN NP	1.0125	1.0633	0.0508	1.0170	1.0419	0.0249	1.0185	1.0263	0.0078	1.0210	1.0305	0.0094	1.0196	1.0132	-0.0063
196566	MOL NP	1.0083	1.0629	0.0546	1.0140	1.0418	0.0279	1.0161	1.0258	0.0097	1.0190	1.0301	0.0111	1.0180	1.0119	-0.0062
196567	SLA NP	1.0140	1.0671	0.0531	1.0181	1.0442	0.0261	1.0200	1.0286	0.0086	1.0222	1.0325	0.0102	1.0207	1.0144	-0.0063
196568	SJM NP	1.0075	1.0630	0.0554	1.0134	1.0416	0.0282	1.0161	1.0260	0.0100	1.0188	1.0302	0.0115	1.0181	1.0125	-0.0056
196569	MUN NP	1.0115	1.0655	0.0540	1.0163	1.0430	0.0267	1.0190	1.0280	0.0090	1.0214	1.0320	0.0106	1.0204	1.0143	-0.0061
196570	KBR NP	1.0101	1.0653	0.0552	1.0152	1.0427	0.0275	1.0186	1.0281	0.0095	1.0210	1.0320	0.0110	1.0203	1.0145	-0.0058
196571	PEP NP	1.0086	1.0645	0.0559	1.0141	1.0421	0.0279	1.0180	1.0277	0.0098	1.0204	1.0317	0.0113	1.0199	1.0141	-0.0058
196572	RRD NP	1.0157	1.0693	0.0536	1.0193	1.0455	0.0262	1.0215	1.0301	0.0086	1.0236	1.0338	0.0102	1.0220	1.0160	-0.0060
196573	VIR NP	1.0082	1.0661	0.0579	1.0139	1.0432	0.0293	1.0180	1.0286	0.0106	1.0204	1.0325	0.0121	1.0200	1.0143	-0.0058
196574	PUL NP	0.9955	1.0631	0.0676	1.0046	1.0410	0.0364	1.0121	1.0273	0.0152	1.0152	1.0312	0.0161	1.0168	1.0135	-0.0033
196575	BIG NP	1.0019	1.0532	0.0513	1.0094	1.0356	0.0262	1.0125	1.0214	0.0089	1.0155	1.0260	0.0105	1.0161	1.0097	-0.0064
196576	MOB NP	1.0044	1.0450	0.0406	1.0120	1.0312	0.0192	1.0163	1.0211	0.0048	1.0188	1.0255	0.0067	1.0209	1.0125	-0.0084
196577	TCV NP	1.0049	1.0454	0.0405	1.0124	1.0316	0.0192	1.0167	1.0215	0.0048	1.0192	1.0259	0.0067	1.0214	1.0130	-0.0084
196578	ROP NP	1.0045	1.0441	0.0396	1.0118	1.0304	0.0186	1.0161	1.0205	0.0044	1.0186	1.0249	0.0063	1.0208	1.0122	-0.0086
196579	MRP NP	1.0046	1.0443	0.0396	1.0119	1.0305	0.0186	1.0162	1.0206	0.0045	1.0186	1.0249	0.0063	1.0208	1.0123	-0.0086
196580	HCP TAP NP	1.0043	1.0381	0.0337	1.0115	1.0261	0.0146	1.0160	1.0180	0.0020	1.0186	1.0221	0.0035	1.0213	1.0114	-0.0099
196581	HCP NP	1.0048	1.0386	0.0337	1.0115	1.0263	0.0148	1.0159	1.0180	0.0021	1.0185	1.0221	0.0036	1.0212	1.0113	-0.0099
196582	CAB NP	1.0041	1.0349	0.0308	1.0115	1.0241	0.0125	1.0165	1.0172	0.0008	1.0191	1.0213	0.0021	1.0221	1.0117	-0.0104
196583	FER NP	1.0065	1.0206	0.0141	1.0149	1.0187	0.0037	1.0208	1.0175	-0.0033	1.0238	1.0194	-0.0044	1.0272	1.0169	-0.0104
196584	FER WIND	1.0068	1.0200	0.0132	1.0152	1.0185	0.0033	1.0211	1.0175	-0.0036	1.0240	1.0193	-0.0047	1.0275	1.0172	-0.0104
196585	SUM NP	0.8964	0.9621	0.0657	0.9784	1.0182	0.0398	0.9996	1.0245	0.0250	0.9806	1.0058	0.0252	1.0002	0.9998	-0.0004
196586	TWG NP	0.8855	0.9521	0.0666	0.9747	1.0147	0.0401	0.9979	1.0230	0.0250	0.9834	1.0087	0.0253	1.0029	1.0022	-0.0007
196587	HRD OUTS	1.0183	1.0633	0.0450	1.0248	1.0459	0.0212	1.0264	1.0320	0.0056	1.0278	1.0354	0.0076	1.0248	1.0180	-0.0068

ML = 0 MW

66 kV Bus	Bus Names	Peak Demand, ML=0 MW			Int_Peak Demand, ML=0 MW			Intermediate Demand, ML=0 MW			Light Demand, ML=0 MW			Extreme Light Demand, ML=0 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0334	1.0366	0.0033	1.0382	1.0408	0.0027	1.0412	1.0423	0.0011	1.0441	1.0440	-0.0001	1.0463	1.0448	-0.0016
195601	WDL TAP	1.0276	1.0376	0.0100	1.0353	1.0428	0.0074	1.0411	1.0452	0.0040	1.0454	1.0453	-0.0002	1.0490	1.0473	-0.0017
195602	WDL B1	1.0274	1.0374	0.0100	1.0353	1.0427	0.0074	1.0412	1.0452	0.0040	1.0455	1.0453	-0.0002	1.0490	1.0473	-0.0017
195603	GLB L29	1.0243	1.0343	0.0100	1.0333	1.0407	0.0074	1.0403	1.0443	0.0040	1.0452	1.0450	-0.0002	1.0493	1.0475	-0.0017
195604	RHR TAP	1.0198	1.0391	0.0193	1.0303	1.0443	0.0140	1.0385	1.0467	0.0082	1.0441	1.0438	-0.0002	1.0487	1.0470	-0.0017
195605	RHR B1	1.0191	1.0391	0.0200	1.0298	1.0443	0.0145	1.0382	1.0467	0.0085	1.0439	1.0436	-0.0002	1.0486	1.0469	-0.0017
195606	BHL T1	0.9970	1.0101	0.0130	1.0052	1.0151	0.0099	1.0047	1.0088	0.0041	1.0013	1.0011	-0.0003	0.9982	0.9930	-0.0052
195607	SCV L27	0.9962	1.0110	0.0147	1.0049	1.0160	0.0111	1.0048	1.0097	0.0049	1.0017	1.0014	-0.0003	0.9987	0.9935	-0.0052
195608	CHD B1	0.9941	1.0115	0.0173	1.0035	1.0165	0.0130	1.0041	1.0102	0.0061	1.0013	1.0010	-0.0003	0.9987	0.9935	-0.0053
195609	PPD L27	1.0498	1.0665	0.0167	1.0551	1.0667	0.0116	1.0499	1.0541	0.0042	1.0469	1.0451	-0.0018	1.0484	1.0414	-0.0070
195610	DHR B1B2	1.0512	1.0659	0.0147	1.0559	1.0660	0.0101	1.0502	1.0535	0.0033	1.0470	1.0451	-0.0018	1.0482	1.0412	-0.0070
195611	PBN B2	1.0516	1.0660	0.0144	1.0561	1.0660	0.0099	1.0502	1.0534	0.0032	1.0469	1.0451	-0.0018	1.0481	1.0411	-0.0070
195612	HBY B1	1.0356	1.0500	0.0144	1.0453	1.0553	0.0099	1.0442	1.0474	0.0031	1.0434	1.0415	-0.0019	1.0469	1.0398	-0.0071
195620	DLP B1B4	1.0383	1.0411	0.0029	1.0419	1.0444	0.0024	1.0441	1.0453	0.0012	1.0466	1.0471	0.0005	1.0482	1.0471	-0.0011
195621	PAS B1	1.0252	1.0291	0.0039	1.0300	1.0334	0.0034	1.0330	1.0349	0.0020	1.0371	1.0385	0.0014	1.0392	1.0379	-0.0014
195622	MMT NP	1.0233	1.0279	0.0047	1.0270	1.0311	0.0041	1.0289	1.0313	0.0024	1.0335	1.0353	0.0018	1.0351	1.0334	-0.0017
195624	MDR B2B3	1.0244	1.0415	0.0171	1.0353	1.0480	0.0128	1.0286	1.0351	0.0065	1.0280	1.0313	0.0033	1.0331	1.0284	-0.0047
195625	MDR B4	1.0237	1.0287	0.0050	1.0268	1.0312	0.0044	1.0280	1.0306	0.0026	1.0326	1.0346	0.0020	1.0339	1.0321	-0.0018
195626	CBPP B	1.0149	1.0193	0.0044	1.0170	1.0211	0.0041	1.0178	1.0206	0.0028	1.0209	1.0234	0.0025	1.0218	1.0205	-0.0013
195627	CBPP D	1.0149	1.0194	0.0045	1.0170	1.0212	0.0042	1.0178	1.0207	0.0029	1.0210	1.0235	0.0026	1.0218	1.0205	-0.0013
195628	CBPP E	1.0150	1.0195	0.0045	1.0171	1.0213	0.0041	1.0179	1.0207	0.0028	1.0211	1.0236	0.0025	1.0220	1.0207	-0.0013
195629	CBP&P A	1.0057	1.0055	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0057	0.0000	1.0057	1.0057	0.0000
195630	DLP 50HZ	1.0386	1.0384	-0.0002	1.0386	1.0384	-0.0001	1.0386	1.0384	-0.0001	1.0386	1.0385	-0.0001	1.0386	1.0385	0.0000
195631	BRKFIELD	1.0072	1.0071	-0.0001	1.0072	1.0071	-0.0001	1.0072	1.0071	-0.0001	1.0072	1.0072	0.0000	1.0072	1.0072	0.0000
195632	CBP&P C	1.0057	1.0056	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0057	0.0000	1.0057	1.0057	0.0000
195633	WATSONS	1.0060	1.0058	-0.0001	1.0060	1.0059	-0.0001	1.0060	1.0059	-0.0001	1.0060	1.0060	0.0000	1.0060	1.0060	0.0000
195635	SVL B2	1.0097	1.0348	0.0251	1.0167	1.0332	0.0165	1.0228	1.0309	0.0081	1.0276	1.0243	-0.0033	1.0306	1.0266	-0.0039
195636	BBK T2	1.0601	1.0587	-0.0014	1.0409	1.0391	-0.0018	1.0327	1.0297	-0.0030	1.0193	1.0156	-0.0037	1.0204	1.0161	-0.0043
195637	DLS B1	1.0479	1.0467	-0.0012	1.0389	1.0372	-0.0018	1.0481	1.0451	-0.0031	1.0491	1.0454	-0.0037	1.0570	1.0527	-0.0042
195639	BUC B2	1.0346	1.0373	0.0026	1.0423	1.0460	0.0037	1.0321	1.0316	-0.0005	1.0291	1.0241	-0.0049	1.0335	1.0237	-0.0099
195640	DPD L64	1.0363	1.0389	0.0026	1.0440	1.0477	0.0037	1.0339	1.0333	-0.0006	1.0308	1.0258	-0.0050	1.0353	1.0253	-0.0099
195641	SLK L80	1.0473	1.0494	0.0021	1.0505	1.0537	0.0032	1.0462	1.0450	-0.0012	1.0449	1.0390	-0.0059	1.0468	1.0356	-0.0112
195643	ACG GFL	1.0030	1.0038	0.0007	1.0050	1.0060	0.0010	1.0048	1.0048	0.0000	1.0038	1.0031	-0.0007	1.0051	1.0034	-0.0018
195644	ACG BFL	1.0148	1.0153	0.0005	1.0162	1.0168	0.0007	1.0160	1.0160	-0.0001	1.0154	1.0148	-0.0006	1.0163	1.0150	-0.0013
195650	WAV B2	1.0455	1.0457	0.0003	1.0443	1.0570	0.0128	1.0453	1.0538	0.0085	1.0431	1.0400	-0.0031	1.0407	1.0170	-0.0237
195652	HRD B6B7	1.0272	1.0423	0.0150	1.0312	1.0500	0.0187	1.0290	1.0393	0.0103	1.0241	1.0218	-0.0023	1.0355	1.0119	-0.0235
195654	OPD B2B5	1.0255	1.0459	0.0204	1.0253	1.0465	0.0213	1.0182	1.0301	0.0119	1.0168	1.0149	-0.0018	1.0341	1.0100	-0.0241
195655	HWD B7B8	1.0163	1.0355	0.0191	1.0219	1.0435	0.0216	1.0184	1.0305	0.0121	1.0104	1.0095	-0.0009	1.0260	1.0034	-0.0226
195675	CHF T601	1.0088	1.0167	0.0079	1.0088	1.0165	0.0077	1.0088	1.0136	0.0048	1.0165	1.0203	0.0038	1.0166	1.0179	0.0014
195676	CHF T602	1.0088	1.0167	0.0079	1.0088	1.0165	0.0077	1.0088	1.0136	0.0048	1.0165	1.0203	0.0038	1.0166	1.0179	0.0014
195677	CHF AIRPORT	1.0073	1.0153	0.0080	1.0073	1.0151	0.0078	1.0073	1.0122	0.0049	1.0151	1.0190	0.0038	1.0152	1.0165	0.0014
195678	BRDG CAMP	1.0050	1.0131	0.0081	1.0050	1.0128	0.0079	1.0050	1.0099	0.0050	1.0128	1.0167	0.0039	1.0129	1.0143	0.0014
195679	LOGANTWR	1.0055	1.0136	0.0081	1.0055	1.0133	0.0078	1.0055	1.0104	0.0049	1.0133	1.0172	0.0039	1.0134	1.0148	0.0014
195680	WHITEFISH	1.0041	1.0122	0.0081	1.0041	1.0119	0.0079	1.0040	1.0090	0.0050	1.0119	1.0158	0.0039	1.0120	1.0133	0.0014
195681	JACOPIE	1.0041	1.0122	0.0081	1.0041	1.0119	0.0079	1.0041	1.0090	0.0050	1.0119	1.0158	0.0039	1.0120	1.0134	0.0014
195682	TWIN TAP	1.0045	1.0126	0.0082	1.0045	1.0124	0.0079	1.0044	1.0094	0.0050	1.0123	1.0162	0.0039	1.0124	1.0138	0.0014
195683	ATIKONAK	0.9881	0.9965	0.0084	0.9881	0.9963	0.0081	0.9881	0.9933	0.0051	0.9962	1.0002	0.0040	0.9963	0.9977	0.0014
195684	LOB LODGE	0.9876	0.9960	0.0084	0.9876	0.9957	0.0081	0.9876	0.9927	0.0051	0.9957	0.9997	0.0040	0.9958	0.9972	0.0014
195685	LOBSTICK	0.9826	0.9910	0.0084	0.9826	0.9907	0.0082	0.9825	0.9877	0.0052	0.9907	0.9947	0.0040	0.9908	0.9922	0.0014
195686	LOB TAP	0.9871	0.9955	0.0084	0.9871	0.9952	0.0081	0.9870	0.9922	0.0051	0.9952	0.9991	0.0040	0.9952	0.9966	0.0014
195687	GABBRO	0.9858	0.9942	0.0084	0.9858	0.9939	0.0081	0.9858	0.9909	0.0051	0.9939	0.9979	0.0040	0.9940	0.9954	0.0014
195688	JWF TAP	1.0048	1.0129	0.0081	1.0048	1.0127	0.0079	1.0048	1.0098	0.0050	1.0127	1.0165	0.0039	1.0127	1.0141	0.0014
195824	STG MID2	1.0067	1.0317	0.0250	1.0117	1.0281	0.0163	1.0161	1.0241	0.0080	1.0249	1.0216	-0.0033	1.0270	1.0231	-0.0039
195843	GOU MID1	1.0068	1.0299	0.0231	1.0128	1.0392	0.0264	1.0127	1.0272	0.0144	1.0067	1.0069	0.0001	1.0241	1.0011	-0.0231
195844	MOB MID3	1.0025	1.0163	0.0138	1.0077	1.0227	0.0150	1.0102	1.0167	0.0066	1.0071	1.0028	-0.0043	1.0219	0.9998	-0.0221
195845	CHA MID1	1.0089	1.0349	0.0260	1.0167	1.0442	0.0274	1.0159	1.0318	0.0159	1.0089	1.0110	0.0021	1.0254	1.0026	-0.0227
195870	CHF T601	1.0088	1.0167	0.0079	1.0088	1.0165	0.0077	1.0088	1.0136	0.0048	1.0165	1.0203	0.0038	1.0166	1.0179	0.0014
196312	OPD T3Y	0.9977	1.0096	0.0119	1.0079	1.0218	0.0139	1.0129	1.0208	0.0079	1.0028	0.9987	-0.0041	1.0305	1.0060	-0.0245
196316	OPD T1Y	0.9977	1.0096	0.0119	1.0079	1.0218	0.0139	1.0129	1.0208	0.0079	1.0028	0.9987	-0.0041	1.0305	1.0060	-0.0245
196318	HWD T4Y	1.0046	1.0124	0.0078	1.0130	1.0234	0.0105	1.0161	1.0221	0.0060	1.0071	1.0020	-0.0051	1.0336	1.0087	-0.0249
196324	HWD T1Y	1.0046	1.0124	0.0078	1.0130	1.0234	0.0105	1.0161	1.0221	0.0060	1.0071	1.0020	-0.0051	1.0336	1.0087	-0.0249
196326	MDR T3Y	0.9971	1.0053	0.0082	1.0042	1.0108	0.0065	1.0079	1.0106	0.0027	1.0065	1.0067	0.0002	1.0098	1.0052	-0.0046
196330	MDR T1Y	0.9971	1.0053	0.0082	1.0042	1.0108	0.0065	1.0079	1.0106	0.0027	1.0065	1.0067	0.0002	1.0098	1.0052	-0.0046
196334	DLS T1Y	0.9840	0.9828	-0.0012	0.9828	0.9810	-0.0018	0.9884	0.9854	-0.0030	0.9783	0.9747	-0.0036	0.9847	0.9806	-0.0041
196336	DLK T1Y	0.9963	1.0062	0.0099	1.0094	1.0180	0.0086	1.0149	1.0190	0.0041	1.0100	1.0111	0.0011	1.0153	1.0115	-0.0039
196338	BHL T1Y	1.0067	1.0184	0.0117	1.0270	1.0361	0.0092	1.0385	1.0423	0.0037	1.0225	1.0223	-0.0002	1.0315	1.0262	-0.0053
196340	PBN T1Y	1.0123	1.0245	0.0123	1.0396	1.0485	0.0089	1.0573	1.0602	0.0028	1.0272	1.0257	-0.0015	1.0402	1.0336	-0.0067
196348	MKS T1Y	1.0110	1.0162	0.0052	1.0117	1.0235	0.0117	1.0188	1.0242	0.0054	1.0069	1.0033	-0.0036	1.0204	0.9977	-0.0226
196500	DLK NP	1.0348	1.0379	0.0031	1.0393	1.0419	0.0026	1.0422	1.0433	0.0011	1.0450	1.0452	0.0002	1.0470	1.0457	-0.0013
196501	STX NP	1.0098	1.0349	0.0251	1.0166	1.0330	0.0164	1.0224	1.0305	0.0081	1.0278	1.0245	-0.0033	1.0306	1.0267	-0.0039
196502	STG NP	1.0102	1.0353	0.0251	1.0164	1.0329	0.0164	1.0218	1.0299	0.0080	1.0282	1.0249	-0.0033	1.0309	1.0269	-0.0039
196503	HAR NP	1.0097	1.0348	0.0251	1.0168	1.0333	0.0165	1.0229	1.0310	0.0081	1.0277	1.0243	-0.0033	1.0306	1.0267	-0.0039
196504	GAL NP	1.0097	1.0349	0.0251	1.0168	1.0333	0.0165	1.0229	1.0310	0.0081	1.0277	1.0244	-0.0033	1.0306	1.0267	-0.0039
196505	WHE TAP	1.0097	1.0348	0.0251	1.0168	1.0333	0.0165	1.0229	1.0310	0.0081	1.0277	1.0243	-0.0033	1.0306	1.0267	-0.0039
196506	WHE NP	1.0605	1.0591	-0.0014	1.0413	1.0395	-0.0018	1.0331	1.0301	-0.0031	1.0197	1.0160	-0.0037	1.0208	1.0165	-0.0043
196507	GBY NP	0.9950	0.9940	-0.0010	1.0003	0.9986	-0.0016	1.0216	1.0188	-0.0028	1.0263	1.0228	-0.0034	1.0396	1.0357	-0.0039
196508	PAB NP	0.9923	0.9913	-0.0010	0.9983	0.9967	-0.0016	1.0204	1.0175	-0.0028	1.0254	1.0219	-0.0034	1.0391	1.0351	-0.0039
196509	LGL NP	0.9836	0.9826	-0.0009	0.9908	0.9893	-0.0015	1.0127	1.0101	-0.0026	1.0159	1.0127	-0.0032	1.0292	1.0256	-0.0036
196517	GFS NPT1	1.0385	1.0593	0.0208	1.0431	1.0636	0.0205	1.0355	1.0457	0.0102	1.0363	1.0380	0.0017	1.0384	1.0264	-0.0120
196518	RUS NP	1.0394	1.0601	0.0207	1.0439	1.0643	0.0204	1.0364	1.0465	0.0102	1.0372	1.0388	0.0016	1.0393	1.0273	-0.0120
196519	SBK NP	1.0455	1.0656	0.0201	1.0495	1.0694	0.0199	1.0428	1.0526	0.0098	1.0435	1.0449	0.0014	1.0454	1.0334	-0.0120
196520	RBK NP	1.0213	1.0415	0.0202	1.0290	1.0501	0.0211	1.0326	1.0428	0.0102	1.0350	1.0356	0.0006	1.0388	1.0247	-0.0141
196521	NDJ NP	0.9985	1.0206	0.0220	1.0085	1.0321	0.0235	1.0176	1.0292	0.0116	1.0211	1.0220	0.0008	1.0263	1.0109	-0.0154
196522	LEW NP	0.9749	0.9969	0.0219	0.9914	1.0148	0.0234	1.0067	1.0182	0.0116	1.0120	1.0128	0.0008	1.0207	1.0054	-0.0153
196523	GAN NPT2	1.0229	1.0476	0.0247	1.0211	1.0479	0.0268	1.0232	1.0366	0.0135	1.0229	1.0241	0.0012	1.0221	1.0053	-0.0169
196524	COB NPT2	0.9947	1.0254	0.0308	1.0316	1.0653	0.0337	1.0102	1.0285	0.0184	0.9646	0.9683	0.0036	0.9791	0.9635	-0.0156
196525	CLK NP	0.9524	0.9838	0.0314	1.0171	1.0510	0.0338	1.0018	1.0207	0.0189	0.9731	0.9759	0.0028	0.9935	0.9766	-0.0169
196526	BOY NP	0.9126	0.9440	0.0314	0.9969	1.0307	0.0338	0.9882	1.0074	0.0192	0.9716	0.9739	0.0023	0.9974	0.9798	-0.0176
196527	FHD L54	0.9052	0.9365	0.0314	0.9922	1.0259	0.0337	0.9852	1.0045	0.0193	0.9696	0.9719	0.0023	0.9963	0.9787	-0.0176
196528	GAM NPT2	0.9642	0.9996	0.0354	0.9894	1.0264	0.0370	0.9986	1.0196	0.0210	1.0020	1.0098	0.0078	1.0181	0.9993	-0.0188
196529	HBS NP	0.9664	1.0019	0.0354	0.9917	1.0288	0.0370	1.0010	1.0219	0.0209	1.0043	1.0121	0.0078	1.0205	1.0016	-0.0189
196530	TRN NP	0.9680	1.0035	0.0355	0.9933	1.0304	0.0370	1.0026	1.0235	0.0209	1.0059	1.0136	0.0077	1.0221	1.0032	-0.0190
196531	GPD NP	0.9690	1.0045	0.0355	0.9944	1.0314	0.0370	1.0036	1.0246	0.0209	1.0070	1.0147	0.0077	1.0232	1.0042	-0.0190
196532	WES NP	0.9692	1.0047	0.0355	0.9946	1.0316	0.0370	1.0038	1.0247	0.0209	1.0072	1.0149	0.0077	1.0234	1.0044	-0.0190
196533	CLV NPT1	1.0063	1.0191	0.0128	1.0067	1.0261	0.0194	1.0120	1.0225	0.0105	1.0063	1.0063	0.0000	1.0174	0.9948	-0.0225
196534	MIL NP	1.0078	1.0205	0.0128	1.0082	1.0276	0.0194	1.0134	1.0238	0.0104	1.0078	1.0078	-0.0001	1.0185	0.9960	-0.0226
196535	LET NP	1.0100	1.0227	0.0128	1.0104	1.0297	0.0194	1.0153	1.0257	0.0104	1.0100	1.0099	-0.0001	1.0201	0.9975	-0.0226
196536	SMV NP	1.0113	1.0240	0.0128	1.0117	1.0310	0.0194	1.0163	1.0267	0.0104	1.0114	1.0112	-0.0001	1.0209	0.9982	-0.0227

ML = 0 MW

66 kV Bus	Bus Names	Peak Demand, ML=0 MW			Int_Peak Demand, ML=0 MW			Intermediate Demand, ML=0 MW			Light Demand, ML=0 MW			Extreme Light Demand, ML=0 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196537	LOK NP	1.0115	1.0242	0.0128	1.0119	1.0312	0.0194	1.0164	1.0268	0.0104	1.0116	1.0114	-0.0001	1.0210	0.9983	-0.0226
196538	PUN NP	1.0111	1.0239	0.0128	1.0115	1.0309	0.0194	1.0161	1.0265	0.0104	1.0112	1.0111	-0.0001	1.0206	0.9980	-0.0226
196539	CAT NPT1	1.0090	1.0218	0.0128	1.0094	1.0288	0.0194	1.0144	1.0249	0.0104	1.0091	1.0090	-0.0001	1.0194	0.9968	-0.0226
196540	SPT NP	1.0437	1.0501	0.0064	1.0231	1.0306	0.0075	1.0288	1.0304	0.0015	1.0180	1.0141	-0.0039	1.0307	1.0084	-0.0223
196541	LAU NP	1.0404	1.0493	0.0089	1.0272	1.0350	0.0078	1.0368	1.0389	0.0021	1.0172	1.0148	-0.0025	1.0327	1.0137	-0.0190
196542	STL WIND	1.0411	1.0490	0.0079	1.0279	1.0347	0.0068	1.0375	1.0390	0.0015	1.0180	1.0150	-0.0030	1.0335	1.0149	-0.0185
196543	WEBCV_NP	1.0399	1.0548	0.0149	1.0302	1.0425	0.0123	1.0400	1.0454	0.0054	1.0141	1.0150	0.0009	1.0306	1.0106	-0.0200
196544	GRH NP	1.0412	1.0590	0.0178	1.0328	1.0473	0.0145	1.0421	1.0491	0.0070	1.0129	1.0154	0.0025	1.0296	1.0092	-0.0204
196545	GAR NP	1.0416	1.0533	0.0117	1.0270	1.0378	0.0107	1.0348	1.0388	0.0040	1.0154	1.0145	-0.0009	1.0302	1.0087	-0.0214
196546	BLK NPT3	1.0285	1.0389	0.0104	1.0330	1.0545	0.0215	1.0286	1.0427	0.0140	1.0319	1.0328	0.0009	1.0311	1.0070	-0.0241
196547	NHR NP	1.0201	1.0278	0.0077	1.0251	1.0449	0.0198	1.0209	1.0339	0.0130	1.0223	1.0220	-0.0003	1.0244	1.0004	-0.0240
196548	ISL NP	1.0086	1.0133	0.0047	1.0144	1.0322	0.0178	1.0104	1.0220	0.0116	1.0094	1.0076	-0.0018	1.0153	0.9914	-0.0239
196549	HCT NP	1.0002	1.0028	0.0026	1.0066	1.0229	0.0163	1.0027	1.0133	0.0106	1.0000	0.9971	-0.0029	1.0086	0.9848	-0.0238
196550	NCH NP	1.0023	1.0049	0.0025	1.0078	1.0241	0.0163	1.0044	1.0150	0.0106	1.0022	0.9993	-0.0029	1.0096	0.9857	-0.0238
196551	OPL NP	1.0026	1.0051	0.0025	1.0080	1.0243	0.0163	1.0047	1.0152	0.0106	1.0025	0.9995	-0.0029	1.0098	0.9860	-0.0239
196552	CAR NP	0.9808	0.9788	-0.0020	0.9895	1.0024	0.0129	0.9858	0.9939	0.0081	0.9801	0.9747	-0.0053	0.9940	0.9701	-0.0239
196553	VIC NP	0.9810	0.9790	-0.0021	0.9896	1.0026	0.0129	0.9860	0.9941	0.0081	0.9803	0.9749	-0.0053	0.9941	0.9702	-0.0239
196554	HGR NP	0.9789	0.9768	-0.0021	0.9878	1.0006	0.0128	0.9840	0.9921	0.0081	0.9779	0.9725	-0.0054	0.9925	0.9686	-0.0239
196555	ILC NP	0.9754	0.9727	-0.0027	0.9846	0.9970	0.0124	0.9808	0.9886	0.0077	0.9742	0.9684	-0.0058	0.9897	0.9658	-0.0239
196556	BRB T2T3	0.9706	0.9676	-0.0030	0.9803	0.9924	0.0121	0.9764	0.9839	0.0075	0.9689	0.9628	-0.0061	0.9858	0.9621	-0.0238
196557	ULT TAP	1.0256	1.0411	0.0155	1.0300	1.0493	0.0193	1.0280	1.0387	0.0107	1.0231	1.0210	-0.0021	1.0348	1.0113	-0.0235
196558	ULT NP	1.0256	1.0412	0.0155	1.0300	1.0493	0.0193	1.0280	1.0387	0.0107	1.0231	1.0210	-0.0021	1.0348	1.0113	-0.0235
196559	SCV NP	1.0240	1.0400	0.0161	1.0287	1.0487	0.0199	1.0270	1.0381	0.0111	1.0221	1.0202	-0.0019	1.0341	1.0107	-0.0235
196560	KEL NP	1.0129	1.0335	0.0206	1.0202	1.0456	0.0253	1.0200	1.0346	0.0146	1.0144	1.0143	-0.0001	1.0291	1.0060	-0.0231
196561	CHA NP	1.0089	1.0349	0.0261	1.0167	1.0442	0.0275	1.0159	1.0319	0.0160	1.0089	1.0110	0.0021	1.0254	1.0026	-0.0227
196562	BCV NP	1.0022	1.0213	0.0191	1.0117	1.0412	0.0295	1.0118	1.0291	0.0173	1.0045	1.0036	-0.0009	1.0225	0.9999	-0.0226
196563	GDL NP	1.0066	1.0332	0.0266	1.0141	1.0422	0.0281	1.0130	1.0292	0.0162	1.0067	1.0086	0.0020	1.0243	1.0014	-0.0229
196564	GOU NP	1.0079	1.0314	0.0235	1.0143	1.0410	0.0267	1.0130	1.0281	0.0152	1.0077	1.0079	0.0002	1.0254	1.0023	-0.0231
196565	KEN NP	1.0162	1.0371	0.0209	1.0196	1.0421	0.0225	1.0153	1.0280	0.0127	1.0119	1.0106	-0.0013	1.0298	1.0062	-0.0236
196566	MOL NP	1.0120	1.0365	0.0244	1.0168	1.0423	0.0255	1.0138	1.0284	0.0146	1.0099	1.0088	-0.0011	1.0282	1.0047	-0.0234
196567	SLA NP	1.0177	1.0398	0.0220	1.0202	1.0440	0.0238	1.0153	1.0289	0.0135	1.0130	1.0118	-0.0012	1.0311	1.0072	-0.0238
196568	SJM NP	1.0112	1.0352	0.0239	1.0159	1.0417	0.0258	1.0131	1.0278	0.0147	1.0098	1.0097	-0.0001	1.0282	1.0046	-0.0236
196569	MUN NP	1.0152	1.0386	0.0234	1.0182	1.0426	0.0244	1.0140	1.0279	0.0139	1.0121	1.0113	-0.0008	1.0308	1.0069	-0.0239
196570	KBR NP	1.0138	1.0390	0.0252	1.0170	1.0421	0.0252	1.0130	1.0274	0.0144	1.0116	1.0113	-0.0003	1.0307	1.0067	-0.0240
196571	PEP NP	1.0124	1.0383	0.0259	1.0159	1.0415	0.0256	1.0123	1.0270	0.0147	1.0110	1.0107	-0.0003	1.0304	1.0064	-0.0240
196572	RRD NP	1.0194	1.0432	0.0238	1.0209	1.0448	0.0239	1.0154	1.0291	0.0136	1.0141	1.0136	-0.0006	1.0324	1.0084	-0.0240
196573	VIR NP	1.0119	1.0401	0.0281	1.0155	1.0425	0.0270	1.0120	1.0275	0.0156	1.0109	1.0107	-0.0002	1.0305	1.0065	-0.0240
196574	PUL NP	0.9993	1.0371	0.0378	1.0063	1.0403	0.0341	1.0060	1.0262	0.0202	1.0057	1.0095	0.0039	1.0274	1.0034	-0.0240
196575	BIG NP	1.0051	1.0256	0.0205	1.0122	1.0355	0.0233	1.0125	1.0251	0.0126	1.0078	1.0067	-0.0012	1.0249	1.0020	-0.0229
196576	MOB NP	1.0067	1.0208	0.0141	1.0138	1.0296	0.0158	1.0162	1.0234	0.0072	1.0132	1.0094	-0.0038	1.0278	1.0060	-0.0218
196577	TCV NP	1.0071	1.0212	0.0140	1.0142	1.0300	0.0157	1.0166	1.0238	0.0072	1.0136	1.0098	-0.0038	1.0282	1.0064	-0.0218
196578	ROP NP	1.0066	1.0202	0.0136	1.0136	1.0287	0.0151	1.0160	1.0228	0.0068	1.0131	1.0091	-0.0040	1.0277	1.0059	-0.0217
196579	MRP NP	1.0068	1.0204	0.0136	1.0137	1.0288	0.0152	1.0161	1.0229	0.0068	1.0132	1.0092	-0.0040	1.0276	1.0059	-0.0217
196580	HCP TAP NP	1.0062	1.0169	0.0106	1.0130	1.0242	0.0113	1.0160	1.0198	0.0039	1.0132	1.0079	-0.0053	1.0282	1.0069	-0.0213
196581	HCP NP	1.0066	1.0172	0.0106	1.0129	1.0243	0.0114	1.0158	1.0198	0.0040	1.0132	1.0080	-0.0052	1.0281	1.0067	-0.0213
196582	CAB NP	1.0060	1.0152	0.0092	1.0131	1.0224	0.0093	1.0164	1.0188	0.0024	1.0137	1.0076	-0.0061	1.0289	1.0079	-0.0210
196583	FER NP	1.0084	1.0147	0.0062	1.0165	1.0206	0.0041	1.0207	1.0197	-0.0010	1.0184	1.0119	-0.0065	1.0341	1.0167	-0.0174
196584	FER WIND	1.0087	1.0148	0.0061	1.0167	1.0205	0.0038	1.0210	1.0198	-0.0012	1.0187	1.0121	-0.0065	1.0343	1.0171	-0.0172
196585	SUM NP	0.9126	0.9440	0.0314	0.9969	1.0307	0.0338	0.9882	1.0074	0.0192	0.9716	0.9739	0.0023	0.9974	0.9798	-0.0176
196586	TWG NP	0.9025	0.9340	0.0315	0.9935	1.0273	0.0338	0.9864	1.0057	0.0194	0.9744	0.9763	0.0020	1.0000	0.9821	-0.0179
196587	HRD OUTS	1.0262	1.0416	0.0153	1.0304	1.0496	0.0191	1.0284	1.0389	0.0106	1.0234	1.0213	-0.0022	1.0350	1.0115	-0.0235

ML = 150 MW Import

66 kV Bus	Bus Names	Peak Demand, ML= -150 MW			Int_Peak Demand, ML= -150 MW			Intermediate Demand, ML= -150 MW			Light Demand, ML= -150 MW			Extreme Light Demand, ML= -150 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0331	1.0376	0.0046	1.0383	1.0399	0.0016	1.0417	1.0407	-0.0010	1.0440	1.0421	-0.0019	1.0470	1.0454	-0.0016
195601	WDL TAP	1.0272	1.0387	0.0115	1.0355	1.0418	0.0063	1.0417	1.0405	-0.0012	1.0453	1.0433	-0.0020	1.0496	1.0479	-0.0018
195602	WDL B1	1.0271	1.0386	0.0115	1.0355	1.0418	0.0063	1.0417	1.0405	-0.0012	1.0454	1.0433	-0.0020	1.0497	1.0480	-0.0018
195603	GLB L29	1.0240	1.0355	0.0115	1.0335	1.0398	0.0063	1.0408	1.0396	-0.0012	1.0451	1.0430	-0.0021	1.0499	1.0481	-0.0018
195604	RHR TAP	1.0195	1.0403	0.0208	1.0305	1.0434	0.0129	1.0391	1.0379	-0.0012	1.0439	1.0419	-0.0021	1.0494	1.0476	-0.0018
195605	RHR B1	1.0188	1.0403	0.0215	1.0300	1.0434	0.0134	1.0388	1.0376	-0.0012	1.0437	1.0417	-0.0021	1.0493	1.0475	-0.0018
195606	BHL T1	0.9967	1.0143	0.0176	1.0075	1.0136	0.0061	1.0087	1.0052	-0.0034	1.0029	0.9967	-0.0062	1.0011	0.9952	-0.0058
195607	SCV L27	0.9959	1.0153	0.0193	1.0071	1.0145	0.0074	1.0088	1.0053	-0.0035	1.0032	0.9970	-0.0062	1.0016	0.9957	-0.0059
195608	CHD B1	0.9938	1.0158	0.0219	1.0058	1.0150	0.0092	1.0081	1.0046	-0.0035	1.0029	0.9967	-0.0062	1.0016	0.9957	-0.0059
195609	PPD L27	1.0354	1.0586	0.0232	1.0573	1.0649	0.0076	1.0538	1.0485	-0.0054	1.0486	1.0406	-0.0080	1.0515	1.0439	-0.0076
195610	DHR B1B2	1.0369	1.0580	0.0211	1.0582	1.0643	0.0061	1.0541	1.0488	-0.0054	1.0487	1.0407	-0.0080	1.0512	1.0437	-0.0076
195611	PBN B2	1.0372	1.0580	0.0208	1.0584	1.0642	0.0059	1.0542	1.0488	-0.0054	1.0486	1.0407	-0.0080	1.0511	1.0436	-0.0076
195612	HBY B1	1.0209	1.0418	0.0208	1.0477	1.0535	0.0059	1.0482	1.0428	-0.0054	1.0451	1.0370	-0.0080	1.0499	1.0423	-0.0076
195620	DLP B1B4	1.0381	1.0418	0.0037	1.0422	1.0437	0.0016	1.0446	1.0444	-0.0002	1.0466	1.0453	-0.0013	1.0488	1.0476	-0.0012
195621	PAS B1	1.0250	1.0299	0.0049	1.0303	1.0326	0.0023	1.0335	1.0338	0.0004	1.0372	1.0357	-0.0015	1.0399	1.0385	-0.0015
195622	MMT NP	1.0230	1.0288	0.0059	1.0273	1.0301	0.0028	1.0293	1.0300	0.0007	1.0335	1.0318	-0.0017	1.0359	1.0341	-0.0018
195624	MDR B2B3	1.0233	1.0437	0.0204	1.0355	1.0447	0.0092	1.0286	1.0305	0.0019	1.0272	1.0254	-0.0018	1.0349	1.0299	-0.0050
195625	MDR B4	1.0234	1.0297	0.0062	1.0271	1.0300	0.0029	1.0283	1.0291	0.0008	1.0326	1.0307	-0.0019	1.0347	1.0328	-0.0020
195626	CBPP B	1.0147	1.0200	0.0054	1.0172	1.0203	0.0031	1.0180	1.0195	0.0015	1.0209	1.0196	-0.0013	1.0224	1.0210	-0.0014
195627	CBPP D	1.0147	1.0201	0.0054	1.0173	1.0204	0.0031	1.0181	1.0196	0.0016	1.0210	1.0197	-0.0013	1.0224	1.0210	-0.0014
195628	CBPP E	1.0148	1.0202	0.0054	1.0174	1.0205	0.0031	1.0182	1.0197	0.0015	1.0211	1.0198	-0.0013	1.0226	1.0212	-0.0014
195629	CBP&P A	1.0057	1.0057	0.0000	1.0057	1.0057	0.0000	1.0057	1.0056	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0056	0.0000
195630	DLP 50HZ	1.0386	1.0385	0.0000	1.0386	1.0385	-0.0001	1.0386	1.0385	-0.0001	1.0386	1.0385	-0.0001	1.0386	1.0385	-0.0001
195631	BRKFIELD	1.0072	1.0072	0.0000	1.0072	1.0072	0.0000	1.0072	1.0071	-0.0001	1.0072	1.0071	-0.0001	1.0072	1.0072	0.0000
195632	CBP&P C	1.0057	1.0057	0.0000	1.0057	1.0057	0.0000	1.0057	1.0056	-0.0001	1.0057	1.0056	-0.0001	1.0057	1.0057	0.0000
195633	WATSONS	1.0060	1.0060	0.0000	1.0060	1.0060	0.0000	1.0060	1.0059	-0.0001	1.0060	1.0059	-0.0001	1.0060	1.0059	0.0000
195635	SVL B2	1.0097	1.0381	0.0284	1.0167	1.0321	0.0154	1.0228	1.0187	-0.0041	1.0276	1.0231	-0.0045	1.0306	1.0266	-0.0039
195636	BBK T2	1.0601	1.0622	0.0021	1.0409	1.0381	-0.0029	1.0327	1.0282	-0.0045	1.0193	1.0145	-0.0048	1.0204	1.0162	-0.0042
195637	DLS B1	1.0479	1.0498	0.0019	1.0389	1.0363	-0.0027	1.0481	1.0438	-0.0043	1.0491	1.0444	-0.0047	1.0570	1.0528	-0.0042
195639	BUC B2	1.0333	1.0425	0.0091	1.0421	1.0382	-0.0039	1.0307	1.0199	-0.0107	1.0264	1.0121	-0.0143	1.0376	1.0272	-0.0103
195640	DPD L64	1.0351	1.0442	0.0092	1.0438	1.0398	-0.0040	1.0324	1.0216	-0.0108	1.0281	1.0137	-0.0143	1.0393	1.0289	-0.0104
195641	SLK L80	1.0467	1.0563	0.0096	1.0504	1.0452	-0.0053	1.0456	1.0336	-0.0120	1.0438	1.0283	-0.0155	1.0485	1.0368	-0.0117
195643	ACG GFL	1.0029	1.0049	0.0021	1.0050	1.0052	0.0002	1.0045	1.0029	-0.0017	1.0033	1.0008	-0.0026	1.0065	1.0046	-0.0018
195644	ACG BFL	1.0147	1.0162	0.0015	1.0162	1.0163	0.0001	1.0159	1.0146	-0.0012	1.0150	1.0132	-0.0019	1.0172	1.0158	-0.0013
195650	WAV B2	1.0452	1.0703	0.0250	1.0434	1.0541	0.0107	1.0463	1.0296	-0.0166	1.0376	1.0168	-0.0208	1.0421	1.0173	-0.0249
195652	HRD B6B7	1.0269	1.0640	0.0371	1.0266	1.0446	0.0180	1.0370	1.0222	-0.0148	1.0190	1.0007	-0.0183	1.0351	1.0103	-0.0248
195654	OPD B2B5	1.0251	1.0670	0.0419	1.0210	1.0416	0.0205	1.0330	1.0188	-0.0142	1.0219	1.0014	-0.0205	1.0292	1.0039	-0.0252
195655	HWD B7B8	1.0160	1.0559	0.0399	1.0136	1.0346	0.0209	1.0287	1.0153	-0.0134	1.0145	0.9960	-0.0185	1.0219	0.9982	-0.0237
195675	CHF T601	1.0088	1.0158	0.0070	1.0088	1.0165	0.0077	1.0087	1.0119	0.0032	1.0166	1.0186	0.0020	1.0166	1.0175	0.0009
195676	CHF T602	1.0088	1.0158	0.0070	1.0088	1.0165	0.0077	1.0087	1.0119	0.0032	1.0166	1.0186	0.0020	1.0166	1.0175	0.0009
195677	CHF AIRPORT	1.0073	1.0144	0.0071	1.0073	1.0151	0.0078	1.0073	1.0105	0.0032	1.0152	1.0172	0.0021	1.0152	1.0161	0.0009
195678	BRDG CAMP	1.0050	1.0122	0.0072	1.0050	1.0128	0.0079	1.0049	1.0082	0.0032	1.0129	1.0150	0.0021	1.0129	1.0138	0.0009
195679	LOGANTWR	1.0055	1.0127	0.0072	1.0055	1.0133	0.0078	1.0055	1.0087	0.0032	1.0134	1.0155	0.0021	1.0134	1.0143	0.0009
195680	WHITEFISH	1.0041	1.0112	0.0072	1.0041	1.0119	0.0079	1.0040	1.0073	0.0032	1.0120	1.0140	0.0021	1.0119	1.0129	0.0009
195681	JACOPIE	1.0041	1.0112	0.0072	1.0041	1.0119	0.0079	1.0040	1.0073	0.0032	1.0120	1.0140	0.0021	1.0120	1.0129	0.0009
195682	TWIN TAP	1.0045	1.0117	0.0072	1.0045	1.0124	0.0079	1.0044	1.0077	0.0033	1.0124	1.0145	0.0021	1.0124	1.0133	0.0009
195683	ATIKONAK	0.9881	0.9956	0.0074	0.9881	0.9963	0.0081	0.9881	0.9915	0.0034	0.9963	0.9984	0.0021	0.9963	0.9972	0.0010
195684	LOB LODGE	0.9876	0.9950	0.0074	0.9876	0.9957	0.0081	0.9876	0.9909	0.0034	0.9957	0.9979	0.0021	0.9957	0.9967	0.0010
195685	LOBSTICK	0.9826	0.9900	0.0074	0.9825	0.9907	0.0082	0.9825	0.9859	0.0034	0.9908	0.9929	0.0021	0.9907	0.9917	0.0010
195686	LOB TAP	0.9871	0.9945	0.0074	0.9870	0.9952	0.0082	0.9870	0.9904	0.0034	0.9952	0.9974	0.0021	0.9952	0.9962	0.0010
195687	GABBRO	0.9858	0.9932	0.0074	0.9858	0.9939	0.0082	0.9857	0.9891	0.0034	0.9940	0.9961	0.0021	0.9939	0.9949	0.0010
195688	JWF TAP	1.0048	1.0120	0.0072	1.0048	1.0127	0.0079	1.0048	1.0080	0.0032	1.0127	1.0148	0.0021	1.0127	1.0136	0.0009
195824	STG MID2	1.0067	1.0349	0.0283	1.0117	1.0270	0.0152	1.0161	1.0121	-0.0040	1.0249	1.0204	-0.0045	1.0270	1.0231	-0.0039
195843	GOU MID1	1.0065	1.0541	0.0476	1.0068	1.0326	0.0257	1.0232	1.0114	-0.0117	1.0106	0.9914	-0.0192	1.0202	0.9962	-0.0241
195844	MOB MID3	1.0024	1.0360	0.0336	1.0044	1.0197	0.0153	1.0184	1.0046	-0.0137	1.0097	0.9913	-0.0184	1.0188	0.9962	-0.0226
195845	CHA MID1	1.0085	1.0566	0.0480	1.0090	1.0358	0.0268	1.0258	1.0158	-0.0100	1.0115	0.9962	-0.0152	1.0218	0.9980	-0.0238
195870	CHF T601	1.0088	1.0158	0.0070	1.0088	1.0165	0.0077	1.0087	1.0119	0.0032	1.0166	1.0186	0.0020	1.0166	1.0175	0.0009
196312	OPD T3Y	0.9973	1.0277	0.0304	1.0057	1.0189	0.0132	1.0168	1.0007	-0.0161	1.0083	0.9871	-0.0211	1.0252	0.9994	-0.0257
196316	OPD T1Y	0.9973	1.0277	0.0304	1.0057	1.0189	0.0132	1.0168	1.0007	-0.0161	1.0083	0.9871	-0.0211	1.0252	0.9994	-0.0257
196318	HWD T4Y	1.0042	1.0295	0.0253	1.0110	1.0207	0.0097	1.0205	1.0032	-0.0173	1.0127	0.9910	-0.0216	1.0287	1.0026	-0.0261
196324	HWD T1Y	1.0042	1.0295	0.0253	1.0110	1.0207	0.0097	1.0205	1.0032	-0.0173	1.0127	0.9910	-0.0216	1.0287	1.0026	-0.0261
196326	MDR T3Y	0.9961	1.0074	0.0113	1.0045	1.0075	0.0031	1.0079	1.0061	-0.0018	1.0057	1.0009	-0.0048	1.0116	1.0067	-0.0049
196330	MDR T1Y	0.9961	1.0074	0.0113	1.0045	1.0075	0.0031	1.0079	1.0061	-0.0018	1.0057	1.0009	-0.0048	1.0116	1.0067	-0.0049
196334	DLS T1Y	0.9840	0.9859	0.0019	0.9828	0.9801	-0.0027	0.9884	0.9841	-0.0043	0.9783	0.9737	-0.0046	0.9847	0.9806	-0.0041
196336	DLK T1Y	0.9961	1.0090	0.0129	1.0116	1.0165	0.0049	1.0191	1.0172	-0.0018	1.0115	1.0067	-0.0048	1.0182	1.0136	-0.0046
196338	BHL T1Y	1.0064	1.0226	0.0162	1.0292	1.0346	0.0053	1.0426	1.0392	-0.0034	1.0241	1.0179	-0.0062	1.0344	1.0285	-0.0059
196340	PBN T1Y	1.0119	1.0302	0.0183	1.0418	1.0467	0.0049	1.0613	1.0561	-0.0051	1.0289	1.0213	-0.0076	1.0432	1.0360	-0.0073
196348	MKS T1Y	1.0108	1.0364	0.0256	1.0116	1.0173	0.0057	1.0224	1.0086	-0.0137	1.0052	0.9810	-0.0242	1.0162	0.9934	-0.0229
196500	DLK NP	1.0346	1.0388	0.0042	1.0395	1.0411	0.0016	1.0427	1.0420	-0.0007	1.0449	1.0433	-0.0016	1.0476	1.0462	-0.0014
196501	STX NP	1.0098	1.0382	0.0284	1.0166	1.0319	0.0153	1.0224	1.0183	-0.0041	1.0278	1.0233	-0.0045	1.0306	1.0267	-0.0039
196502	STG NP	1.0102	1.0386	0.0284	1.0164	1.0318	0.0153	1.0218	1.0178	-0.0041	1.0282	1.0237	-0.0045	1.0309	1.0269	-0.0039
196503	HAR NP	1.0097	1.0381	0.0284	1.0168	1.0321	0.0154	1.0229	1.0188	-0.0041	1.0277	1.0232	-0.0045	1.0306	1.0267	-0.0039
196504	GAL NP	1.0097	1.0382	0.0284	1.0168	1.0322	0.0154	1.0229	1.0188	-0.0041	1.0277	1.0232	-0.0045	1.0306	1.0267	-0.0039
196505	WHE TAP	1.0097	1.0381	0.0284	1.0168	1.0321	0.0154	1.0229	1.0188	-0.0041	1.0277	1.0232	-0.0045	1.0306	1.0267	-0.0039
196506	WHE NP	1.0605	1.0626	0.0021	1.0413	1.0385	-0.0029	1.0331	1.0286	-0.0045	1.0197	1.0149	-0.0048	1.0208	1.0166	-0.0042
196507	GBY NP	0.9950	0.9968	0.0018	1.0003	0.9978	-0.0025	1.0216	1.0177	-0.0040	1.0263	1.0220	-0.0043	1.0396	1.0357	-0.0039
196508	PAB NP	0.9923	0.9941	0.0018	0.9983	0.9958	-0.0025	1.0204	1.0164	-0.0040	1.0254	1.0210	-0.0043	1.0391	1.0352	-0.0039
196509	LGL NP	0.9836	0.9852	0.0016	0.9908	0.9885	-0.0023	1.0127	1.0091	-0.0037	1.0159	1.0119	-0.0040	1.0292	1.0257	-0.0036
196517	GFS NPT1	1.0385	1.0734	0.0348	1.0439	1.0578	0.0138	1.0422	1.0371	-0.0051	1.0361	1.0193	-0.0168	1.0427	1.0300	-0.0128
196518	RUS NP	1.0394	1.0741	0.0347	1.0447	1.0584	0.0138	1.0429	1.0378	-0.0051	1.0369	1.0202	-0.0168	1.0435	1.0307	-0.0128
196519	SBK NP	1.0455	1.0796	0.0342	1.0502	1.0636	0.0134	1.0487	1.0435	-0.0052	1.0433	1.0266	-0.0167	1.0492	1.0365	-0.0127
196520	RBK NP	1.0214	1.0607	0.0393	1.0302	1.0452	0.0150	1.0354	1.0296	-0.0057	1.0343	1.0152	-0.0191	1.0414	1.0272	-0.0142
196521	NDJ NP	0.9988	1.0429	0.0440	1.0104	1.0277	0.0173	1.0194	1.0137	-0.0057	1.0200	0.9992	-0.0208	1.0289	1.0136	-0.0153
196522	LEW NP	0.9753	1.0191	0.0438	0.9933	1.0105	0.0172	1.0084	1.0027	-0.0057	1.0108	0.9901	-0.0208	1.0233	1.0080	-0.0153
196523	GAN NPT2	1.0236	1.0739	0.0503	1.0238	1.0442	0.0204	1.0237	1.0182	-0.0055	1.0214	0.9985	-0.0228	1.0248	1.0082	-0.0166
196524	COB NPT2	0.9907	1.0473	0.0567	1.0164	1.0422	0.0258	1.0110	1.0076	-0.0035	0.9602	0.9393	-0.0210	0.9828	0.9670	-0.0158
196525	CLK NP	0.9476	1.0062	0.0586	1.0007	1.0265	0.0258	1.0084	1.0044	-0.0040	0.9688	0.9464	-0.0224	0.9971	0.9800	-0.0170
196526	BOY NP	0.9073	0.9667	0.0594	0.9797	1.0053	0.0257	0.9983	0.9939	-0.0043	0.9674	0.9441	-0.0232	1.0010	0.9831	-0.0179
196527	FHD L54	0.8999	0.9591	0.0592	0.9748	1.0004	0.0256	0.9953	0.9910	-0.0043	0.9653	0.9421	-0.0232	0.9999	0.9820	-0.0179
196528	GAM NPT2	0.9622	1.0208	0.0586	0.9890	1.0185	0.0295	1.0064	1.0053	-0.0011	0.9976	0.9735	-0.0241	1.0195	1.0007	-0.0189
196529	HBS NP	0.9644	1.0231	0.0587	0.9913	1.0208	0.0295	1.0088	1.0076	-0.0012	1.0000	0.9757	-0.0243	1.0219	1.0030	-0.0190
196530	TRN NP	0.9659	1.0248	0.0588	0.9929	1.0224	0.0295	1.0104	1.0092	-0.0013	1.0016	0.9772	-0.0244	1.0236	1.0045	-0.0190
196531	GPD NP	0.9670	1.0259	0.0589	0.9939	1.0235	0.0295	1.0115	1.0102	-0.0013	1.0026	0.9782	-0.0244	1.0246	1.0056	-0.0191
196532	WES NP	0.9671	1.0261	0.0589	0.9941	1.0236	0.0295	1.0117	1.0104	-0.0013	1.0028	0.9784	-0.0244	1.0248	1.0057	-0.0191
196533	CLV NPT1	1.0058	1.0414	0.0356	1.0067	1.0197	0.0130	1.0160	1.0047	-0.0113	1.0046	0.9783	-0.0263	1.0147	0.9920	-0.0227
196534	MIL NP	1.0074	1.0430	0.0356	1.0082	1.0212	0.0130	1.0172	1.0059	-0.0113	1.0061	0.9798	-0.0263	1.0160	0.9932	-0.0228
196535	LET NP	1.0096	1.0453	0.0357	1.0104	1.0233	0.0130	1.0188	1.0075	-0.0114	1.0084	0.9820	-0.0264	1.0177	0.9949	-0.0228
196536	SMV NP	1.0109	1.0467	0.0357	1.0117	1.0246	0.0129	1.0197	1.0083	-0.0114	1.0098	0.9834	-0.0265	1.0186	0.9957	-0.0229
196537	LOK NP	1.0111	1.0469	0.0357	1.0119	1.0248	0.0129	1.0198	1.0084	-0.0114	1.0101	0.9836	-0.0265	1.0187	0.9959	-0.0229
196538	PUN NP	1.0108	1.0465	0.0357	1.0115	1.0245	0.0129	1.0195	1.0081	-0.0114	1.0097	0.9832	-0.0265	1.0184	0.9955	-0.0228
196539	CAT NPT1	1.0087	1.0443	0.0357	1.0095	1.0224	0.0130	1.0181	1.0067	-0.0114	1.0075	0.9811	-0.0264	1.0169	0.9941	-0.0228
196540	SPT NP	1.0389	1.0594	0.0205	1.0230	1.0154	-0.0076	1.0314	1.0215	-0.0099	1.0163	0.9957	-0.0207	1.0199	0.9976	-0.0223

ML = 150 MW Import

66 kV Bus	Bus Names	Peak Demand, ML= -150 MW			Int_Peak Demand, ML= -150 MW			Intermediate Demand, ML= -150 MW			Light Demand, ML= -150 MW			Extreme Light Demand, ML= -150 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196541	LAU NP	1.0361	1.0505	0.0144	1.0271	1.0339	0.0069	1.0390	1.0340	-0.0050	1.0156	1.0013	-0.0143	1.0219	1.0025	-0.0194
196542	STL WIND	1.0369	1.0491	0.0122	1.0278	1.0356	0.0078	1.0397	1.0346	-0.0051	1.0163	1.0024	-0.0140	1.0227	1.0037	-0.0190
196543	WEBCV_NP	1.0363	1.0575	0.0213	1.0301	1.0389	0.0088	1.0420	1.0404	-0.0016	1.0125	0.9997	-0.0128	1.0198	0.9995	-0.0203
196544	GRH NP	1.0379	1.0625	0.0247	1.0327	1.0425	0.0098	1.0439	1.0441	0.0001	1.0112	0.9992	-0.0120	1.0188	0.9981	-0.0207
196545	GAR NP	1.0375	1.0599	0.0224	1.0270	1.0274	0.0004	1.0370	1.0318	-0.0052	1.0137	0.9972	-0.0166	1.0194	0.9978	-0.0216
196546	BLK NPT3	1.0282	1.0659	0.0377	1.0316	1.0511	0.0195	1.0343	1.0223	-0.0120	1.0291	1.0127	-0.0164	1.0306	1.0055	-0.0251
196547	NHR NP	1.0197	1.0551	0.0354	1.0223	1.0403	0.0179	1.0262	1.0130	-0.0132	1.0204	1.0030	-0.0174	1.0238	0.9988	-0.0250
196548	ISL NP	1.0083	1.0410	0.0327	1.0099	1.0259	0.0160	1.0151	1.0005	-0.0146	1.0087	0.9900	-0.0186	1.0146	0.9897	-0.0249
196549	HCT NP	0.9999	1.0307	0.0308	1.0009	1.0154	0.0146	1.0070	0.9914	-0.0156	1.0001	0.9806	-0.0195	1.0078	0.9830	-0.0248
196550	NCH NP	1.0021	1.0328	0.0308	1.0028	1.0174	0.0146	1.0081	0.9925	-0.0157	1.0022	0.9827	-0.0195	1.0089	0.9841	-0.0248
196551	OPL NP	1.0023	1.0331	0.0308	1.0031	1.0177	0.0146	1.0084	0.9928	-0.0157	1.0025	0.9830	-0.0195	1.0092	0.9843	-0.0248
196552	CAR NP	0.9804	1.0071	0.0266	0.9811	0.9923	0.0112	0.9897	0.9716	-0.0181	0.9811	0.9597	-0.0214	0.9929	0.9681	-0.0248
196553	VIC NP	0.9806	1.0073	0.0267	0.9813	0.9925	0.0112	0.9898	0.9717	-0.0181	0.9812	0.9598	-0.0214	0.9930	0.9682	-0.0248
196554	HGR NP	0.9785	1.0050	0.0265	0.9790	0.9902	0.0111	0.9879	0.9697	-0.0182	0.9791	0.9576	-0.0215	0.9914	0.9666	-0.0248
196555	ILC NP	0.9750	1.0009	0.0259	0.9754	0.9861	0.0107	0.9847	0.9662	-0.0185	0.9755	0.9538	-0.0217	0.9886	0.9638	-0.0247
196556	BRB T2T3	0.9702	0.9957	0.0255	0.9703	0.9807	0.0104	0.9803	0.9616	-0.0187	0.9706	0.9487	-0.0219	0.9846	0.9600	-0.0246
196557	ULT TAP	1.0252	1.0631	0.0379	1.0252	1.0439	0.0186	1.0361	1.0215	-0.0146	1.0183	1.0001	-0.0182	1.0343	1.0096	-0.0247
196558	ULT NP	1.0252	1.0631	0.0379	1.0252	1.0439	0.0186	1.0361	1.0215	-0.0146	1.0184	1.0002	-0.0182	1.0343	1.0096	-0.0247
196559	SCV NP	1.0236	1.0623	0.0387	1.0239	1.0431	0.0192	1.0352	1.0208	-0.0143	1.0177	0.9996	-0.0181	1.0335	1.0088	-0.0247
196560	KEL NP	1.0126	1.0582	0.0457	1.0141	1.0388	0.0247	1.0290	1.0166	-0.0124	1.0131	0.9963	-0.0168	1.0272	1.0029	-0.0243
196561	CHA NP	1.0085	1.0566	0.0481	1.0090	1.0359	0.0269	1.0258	1.0158	-0.0100	1.0115	0.9962	-0.0152	1.0219	0.9980	-0.0238
196562	BCV NP	1.0019	1.0526	0.0507	1.0033	1.0322	0.0289	1.0221	1.0088	-0.0133	1.0087	0.9902	-0.0185	1.0183	0.9947	-0.0236
196563	GDL NP	1.0063	1.0557	0.0494	1.0067	1.0342	0.0275	1.0240	1.0139	-0.0101	1.0109	0.9920	-0.0189	1.0201	0.9962	-0.0239
196564	GOU NP	1.0076	1.0555	0.0480	1.0078	1.0339	0.0260	1.0244	1.0127	-0.0117	1.0119	0.9927	-0.0192	1.0212	0.9970	-0.0242
196565	KEN NP	1.0158	1.0587	0.0428	1.0140	1.0358	0.0219	1.0286	1.0150	-0.0136	1.0167	0.9969	-0.0198	1.0251	1.0004	-0.0247
196566	MOL NP	1.0117	1.0583	0.0466	1.0109	1.0357	0.0248	1.0267	1.0132	-0.0134	1.0146	0.9950	-0.0196	1.0236	0.9990	-0.0246
196567	SLA NP	1.0174	1.0623	0.0450	1.0152	1.0383	0.0231	1.0294	1.0158	-0.0135	1.0179	0.9978	-0.0201	1.0262	1.0013	-0.0250
196568	SJM NP	1.0109	1.0583	0.0474	1.0104	1.0355	0.0251	1.0262	1.0139	-0.0122	1.0144	0.9947	-0.0198	1.0236	0.9989	-0.0247
196569	MUN NP	1.0149	1.0607	0.0459	1.0134	1.0371	0.0237	1.0282	1.0151	-0.0131	1.0170	0.9971	-0.0200	1.0259	1.0009	-0.0250
196570	KBR NP	1.0134	1.0605	0.0471	1.0124	1.0369	0.0245	1.0275	1.0150	-0.0125	1.0166	0.9969	-0.0198	1.0258	1.0007	-0.0251
196571	PEP NP	1.0120	1.0597	0.0478	1.0113	1.0363	0.0250	1.0269	1.0144	-0.0125	1.0160	0.9962	-0.0199	1.0255	1.0004	-0.0251
196572	RRD NP	1.0191	1.0645	0.0454	1.0165	1.0398	0.0232	1.0302	1.0174	-0.0128	1.0192	0.9990	-0.0202	1.0275	1.0023	-0.0252
196573	VIR NP	1.0116	1.0613	0.0497	1.0111	1.0374	0.0263	1.0268	1.0144	-0.0124	1.0160	0.9958	-0.0202	1.0256	1.0004	-0.0252
196574	PUL NP	0.9989	1.0583	0.0594	1.0018	1.0352	0.0334	1.0209	1.0130	-0.0078	1.0108	0.9906	-0.0202	1.0224	0.9972	-0.0251
196575	BIG NP	1.0048	1.0485	0.0437	1.0066	1.0292	0.0226	1.0229	1.0105	-0.0124	1.0116	0.9925	-0.0190	1.0210	0.9972	-0.0238
196576	MOB NP	1.0065	1.0402	0.0337	1.0100	1.0252	0.0152	1.0243	1.0110	-0.0133	1.0157	0.9977	-0.0181	1.0248	1.0024	-0.0224
196577	TCV NP	1.0069	1.0406	0.0337	1.0104	1.0256	0.0152	1.0248	1.0115	-0.0133	1.0162	0.9981	-0.0181	1.0252	1.0029	-0.0224
196578	ROP NP	1.0064	1.0393	0.0329	1.0099	1.0245	0.0146	1.0241	1.0107	-0.0134	1.0156	0.9976	-0.0180	1.0247	1.0024	-0.0223
196579	MRP NP	1.0066	1.0394	0.0329	1.0100	1.0247	0.0146	1.0241	1.0107	-0.0134	1.0157	0.9977	-0.0180	1.0246	1.0024	-0.0222
196580	HCP TAP NP	1.0061	1.0337	0.0276	1.0098	1.0208	0.0110	1.0241	1.0100	-0.0141	1.0156	0.9980	-0.0175	1.0252	1.0034	-0.0217
196581	HCP NP	1.0064	1.0341	0.0277	1.0099	1.0210	0.0111	1.0240	1.0098	-0.0141	1.0154	0.9980	-0.0174	1.0250	1.0032	-0.0218
196582	CAB NP	1.0058	1.0309	0.0251	1.0099	1.0191	0.0092	1.0245	1.0102	-0.0143	1.0161	0.9987	-0.0174	1.0259	1.0045	-0.0214
196583	FER NP	1.0082	1.0216	0.0133	1.0133	1.0181	0.0048	1.0288	1.0161	-0.0128	1.0207	1.0061	-0.0146	1.0311	1.0130	-0.0180
196584	FER WIND	1.0085	1.0212	0.0127	1.0135	1.0181	0.0046	1.0291	1.0164	-0.0127	1.0210	1.0066	-0.0144	1.0313	1.0135	-0.0178
196585	SUM NP	0.9073	0.9667	0.0594	0.9797	1.0053	0.0257	0.9983	0.9939	-0.0043	0.9674	0.9441	-0.0232	1.0010	0.9831	-0.0179
196586	TWG NP	0.8970	0.9570	0.0600	0.9761	1.0017	0.0256	0.9965	0.9921	-0.0044	0.9701	0.9464	-0.0237	1.0036	0.9853	-0.0183
196587	HRD OUTS	1.0258	1.0634	0.0376	1.0257	1.0441	0.0184	1.0364	1.0217	-0.0147	1.0186	1.0003	-0.0182	1.0346	1.0098	-0.0248

ML = 320 MW Import

66 kV Bus	Bus Names	Peak Demand, ML= -320 MW			Int Peak Demand, ML= -320 MW			Intermediate Demand, ML= -320 MW			Light Demand, ML= -320 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
195600	DLK B2	1.0326	1.0384	0.0058	1.0376	1.0396	0.0020	1.0406	1.0406	0.0000	1.0436	1.0432	-0.0004
195601	WDL TAP	1.0268	1.0398	0.0130	1.0348	1.0416	0.0068	1.0405	1.0405	0.0000	1.0450	1.0445	-0.0005
195602	WDL B1	1.0266	1.0397	0.0130	1.0348	1.0415	0.0068	1.0405	1.0405	0.0000	1.0450	1.0446	-0.0005
195603	GLB L29	1.0235	1.0366	0.0131	1.0328	1.0396	0.0068	1.0397	1.0396	0.0000	1.0447	1.0442	-0.0005
195604	RHR TAP	1.0190	1.0415	0.0225	1.0298	1.0432	0.0134	1.0379	1.0379	0.0000	1.0436	1.0431	-0.0005
195605	RHR B1	1.0183	1.0415	0.0232	1.0293	1.0432	0.0139	1.0376	1.0376	0.0000	1.0434	1.0429	-0.0005
195606	BHL T1	0.9996	1.0390	0.0394	1.0072	1.0138	0.0066	1.0075	1.0071	-0.0004	1.0037	1.0015	-0.0022
195607	SCV L27	0.9988	1.0400	0.0412	1.0069	1.0147	0.0078	1.0076	1.0072	-0.0004	1.0040	1.0018	-0.0022
195608	CHD B1	0.9967	1.0406	0.0438	1.0055	1.0152	0.0097	1.0069	1.0065	-0.0004	1.0036	1.0014	-0.0022
195609	PPD L27	1.0384	1.0892	0.0507	1.0435	1.0520	0.0085	1.0531	1.0520	-0.0011	1.0494	1.0464	-0.0030
195610	DHR B1B2	1.0399	1.0885	0.0486	1.0444	1.0514	0.0070	1.0534	1.0523	-0.0011	1.0495	1.0464	-0.0030
195611	PBN B2	1.0402	1.0885	0.0483	1.0446	1.0513	0.0068	1.0535	1.0524	-0.0011	1.0494	1.0464	-0.0030
195612	HBY B1	1.0240	1.0725	0.0484	1.0336	1.0404	0.0068	1.0475	1.0464	-0.0012	1.0459	1.0428	-0.0031
195620	DLP B1B4	1.0381	1.0417	0.0036	1.0418	1.0436	0.0018	1.0439	1.0444	0.0005	1.0464	1.0466	0.0002
195621	PAS B1	1.0254	1.0338	0.0084	1.0299	1.0324	0.0026	1.0326	1.0340	0.0014	1.0368	1.0378	0.0010
195622	MMT NP	1.0233	1.0359	0.0125	1.0267	1.0299	0.0032	1.0281	1.0301	0.0020	1.0329	1.0344	0.0016
195624	MDR B2B3	1.0230	1.0739	0.0509	1.0332	1.0439	0.0107	1.0247	1.0303	0.0055	1.0381	1.0413	0.0032
195625	MDR B4	1.0238	1.0379	0.0141	1.0264	1.0298	0.0034	1.0270	1.0292	0.0022	1.0318	1.0336	0.0017
195626	CBPP B	1.0150	1.0239	0.0089	1.0168	1.0202	0.0034	1.0172	1.0197	0.0025	1.0205	1.0228	0.0023
195627	CBPP D	1.0150	1.0240	0.0090	1.0169	1.0203	0.0034	1.0173	1.0198	0.0025	1.0205	1.0229	0.0024
195628	CBPP E	1.0151	1.0241	0.0089	1.0170	1.0203	0.0034	1.0174	1.0199	0.0025	1.0206	1.0230	0.0023
195629	CBP&P A	1.0057	1.0049	-0.0007	1.0057	1.0056	-0.0001	1.0057	1.0057	0.0000	1.0057	1.0057	0.0001
195630	DLP 50HZ	1.0386	1.0382	-0.0003	1.0386	1.0385	-0.0001	1.0386	1.0386	0.0000	1.0386	1.0386	0.0000
195631	BRKFIELD	1.0072	1.0065	-0.0007	1.0072	1.0071	-0.0001	1.0072	1.0072	0.0000	1.0072	1.0073	0.0001
195632	CBP&P C	1.0057	1.0050	-0.0007	1.0057	1.0056	-0.0001	1.0057	1.0057	0.0000	1.0057	1.0058	0.0001
195633	WATSONS	1.0060	1.0052	-0.0007	1.0060	1.0059	-0.0001	1.0060	1.0060	0.0000	1.0060	1.0060	0.0001
195635	SVL B2	1.0097	1.0898	0.0801	1.0167	1.0328	0.0161	1.0228	1.0214	-0.0015	1.0276	1.0257	-0.0019
195636	BBK T2	1.0601	1.1139	0.0538	1.0409	1.0389	-0.0020	1.0327	1.0311	-0.0016	1.0193	1.0172	-0.0021
195637	DLS B1	1.0479	1.0960	0.0481	1.0389	1.0371	-0.0019	1.0481	1.0466	-0.0015	1.0491	1.0471	-0.0020
195639	BUC B2	1.0322	1.0678	0.0356	1.0375	1.0377	0.0002	1.0223	1.0193	-0.0030	1.0308	1.0251	-0.0057
195640	DPD L64	1.0339	1.0697	0.0358	1.0392	1.0394	0.0002	1.0241	1.0210	-0.0031	1.0325	1.0268	-0.0057
195641	SLK L80	1.0462	1.0872	0.0409	1.0485	1.0494	0.0009	1.0421	1.0395	-0.0026	1.0456	1.0403	-0.0054
195643	ACG GFL	1.0028	0.9973	-0.0055	1.0042	1.0047	0.0005	1.0028	1.0023	-0.0005	1.0020	1.0009	-0.0011
195644	ACG BFL	1.0147	1.0083	-0.0064	1.0157	1.0160	0.0003	1.0147	1.0143	-0.0004	1.0141	1.0133	-0.0008
195650	WAV B2	1.0460	1.0734	0.0274	1.0405	1.0515	0.0111	1.0394	1.0323	-0.0070	1.0407	1.0225	-0.0183
195652	HRD B6B7	1.0322	1.0682	0.0359	1.0243	1.0444	0.0201	1.0250	1.0187	-0.0063	1.0241	1.0029	-0.0212
195654	OPD B2B5	1.0236	1.0647	0.0411	1.0186	1.0413	0.0227	1.0175	1.0119	-0.0056	1.0208	0.9977	-0.0231
195655	HWD B7B8	1.0197	1.0593	0.0396	1.0113	1.0344	0.0231	1.0158	1.0111	-0.0047	1.0165	0.9943	-0.0222
195675	CHF T601	1.0088	1.0153	0.0066	1.0088	1.0145	0.0058	1.0087	1.0105	0.0018	1.0166	1.0175	0.0009
195676	CHF T602	1.0088	1.0153	0.0066	1.0088	1.0145	0.0058	1.0087	1.0105	0.0018	1.0166	1.0175	0.0009
195677	CHF AIRPORT	1.0074	1.0140	0.0066	1.0073	1.0132	0.0058	1.0073	1.0091	0.0018	1.0152	1.0161	0.0009
195678	BRDG CAMP	1.0050	1.0117	0.0067	1.0050	1.0109	0.0059	1.0049	1.0067	0.0019	1.0129	1.0138	0.0009
195679	LOGANTWR	1.0055	1.0122	0.0067	1.0055	1.0114	0.0059	1.0054	1.0073	0.0018	1.0134	1.0143	0.0009
195680	WHITEFISH	1.0041	1.0108	0.0067	1.0040	1.0100	0.0059	1.0040	1.0058	0.0019	1.0119	1.0129	0.0009
195681	JACOPIE	1.0041	1.0108	0.0067	1.0041	1.0100	0.0059	1.0040	1.0058	0.0019	1.0120	1.0129	0.0009
195682	TWIN TAP	1.0045	1.0112	0.0067	1.0044	1.0104	0.0059	1.0044	1.0062	0.0019	1.0124	1.0133	0.0009
195683	ATIKONAK	0.9882	0.9951	0.0070	0.9881	0.9943	0.0061	0.9881	0.9900	0.0019	0.9963	0.9972	0.0010
195684	LOB LODGE	0.9876	0.9946	0.0070	0.9876	0.9937	0.0061	0.9875	0.9894	0.0019	0.9957	0.9967	0.0010
195685	LOBSTICK	0.9826	0.9895	0.0070	0.9825	0.9887	0.0061	0.9825	0.9844	0.0019	0.9907	0.9917	0.0010
195686	LOB TAP	0.9871	0.9940	0.0070	0.9870	0.9932	0.0061	0.9870	0.9889	0.0019	0.9952	0.9962	0.0010
195687	GABBRO	0.9858	0.9928	0.0070	0.9858	0.9919	0.0061	0.9857	0.9876	0.0019	0.9939	0.9949	0.0010
195688	JWF TAP	1.0048	1.0115	0.0067	1.0048	1.0107	0.0059	1.0047	1.0066	0.0019	1.0127	1.0136	0.0009
195824	STG MID2	1.0067	1.0863	0.0796	1.0117	1.0277	0.0160	1.0161	1.0147	-0.0014	1.0249	1.0230	-0.0019
195843	GOU MID1	1.0087	1.0579	0.0492	1.0047	1.0328	0.0281	1.0104	1.0075	-0.0029	1.0120	0.9901	-0.0219
195844	MOB MID3	1.0030	1.0536	0.0506	1.0036	1.0217	0.0181	1.0088	1.0046	-0.0042	1.0104	0.9917	-0.0187
195845	CHA MID1	1.0125	1.0602	0.0477	1.0066	1.0356	0.0290	1.0130	1.0117	-0.0013	1.0140	0.9952	-0.0188
195870	CHF T601	1.0088	1.0153	0.0066	1.0088	1.0145	0.0058	1.0087	1.0105	0.0018	1.0166	1.0175	0.0009
196312	OPD T3Y	1.0063	1.0346	0.0284	1.0033	1.0184	0.0151	1.0264	1.0184	-0.0080	1.0057	0.9825	-0.0232
196316	OPD T1Y	1.0063	1.0346	0.0284	1.0033	1.0184	0.0151	1.0264	1.0184	-0.0080	1.0057	0.9825	-0.0232
196318	HWD T4Y	1.0123	1.0352	0.0229	1.0087	1.0203	0.0116	1.0272	1.0180	-0.0091	1.0094	0.9857	-0.0237
196324	HWD T1Y	1.0123	1.0352	0.0229	1.0087	1.0203	0.0116	1.0272	1.0180	-0.0091	1.0094	0.9857	-0.0237
196326	MDR T3Y	0.9957	1.0365	0.0408	1.0022	1.0068	0.0045	1.0041	1.0059	0.0018	1.0033	1.0034	0.0001
196330	MDR T1Y	0.9957	1.0365	0.0408	1.0022	1.0068	0.0045	1.0041	1.0059	0.0018	1.0033	1.0034	0.0001
196334	DLS T1Y	0.9840	1.0322	0.0482	0.9828	0.9809	-0.0019	0.9884	0.9868	-0.0015	0.9783	0.9763	-0.0020
196336	DLK T1Y	0.9990	1.0293	0.0303	1.0115	1.0164	0.0049	1.0175	1.0177	0.0002	1.0123	1.0107	-0.0015
196338	BHL T1Y	1.0093	1.0471	0.0378	1.0290	1.0348	0.0058	1.0414	1.0410	-0.0004	1.0249	1.0227	-0.0022
196340	PBN T1Y	1.0147	1.0592	0.0445	1.0415	1.0472	0.0058	1.0606	1.0595	-0.0010	1.0296	1.0268	-0.0028
196348	MKS T1Y	1.0138	1.0464	0.0326	1.0091	1.0190	0.0099	1.0122	1.0088	-0.0034	1.0074	0.9892	-0.0182
196500	DLK NP	1.0343	1.0391	0.0048	1.0390	1.0409	0.0019	1.0417	1.0420	0.0003	1.0446	1.0445	-0.0001
196501	STX NP	1.0098	1.0899	0.0800	1.0166	1.0327	0.0161	1.0224	1.0209	-0.0015	1.0278	1.0259	-0.0019
196502	STG NP	1.0102	1.0901	0.0799	1.0164	1.0325	0.0160	1.0218	1.0204	-0.0015	1.0282	1.0263	-0.0019
196503	HAR NP	1.0097	1.0898	0.0801	1.0168	1.0329	0.0161	1.0229	1.0214	-0.0015	1.0277	1.0257	-0.0019
196504	GAL NP	1.0097	1.0899	0.0801	1.0168	1.0329	0.0161	1.0229	1.0214	-0.0015	1.0277	1.0258	-0.0019
196505	WHE TAP	1.0097	1.0898	0.0801	1.0168	1.0329	0.0161	1.0229	1.0214	-0.0015	1.0277	1.0257	-0.0019
196506	WHE NP	1.0605	1.1143	0.0538	1.0413	1.0393	-0.0020	1.0331	1.0315	-0.0016	1.0197	1.0176	-0.0021
196507	GBY NP	0.9950	1.0383	0.0433	1.0003	0.9986	-0.0017	1.0216	1.0202	-0.0014	1.0263	1.0244	-0.0018
196508	PAB NP	0.9923	1.0357	0.0433	0.9983	0.9966	-0.0017	1.0204	1.0190	-0.0014	1.0254	1.0235	-0.0018
196509	LGL NP	0.9836	1.0228	0.0393	0.9908	0.9893	-0.0016	1.0127	1.0114	-0.0013	1.0159	1.0142	-0.0017
196517	GFS NPT1	1.0388	1.0860	0.0472	1.0423	1.0586	0.0163	1.0377	1.0355	-0.0022	1.0387	1.0293	-0.0093
196518	RUS NP	1.0396	1.0868	0.0472	1.0431	1.0593	0.0162	1.0385	1.0363	-0.0022	1.0395	1.0302	-0.0093
196519	SBK NP	1.0457	1.0928	0.0471	1.0488	1.0646	0.0158	1.0447	1.0425	-0.0023	1.0456	1.0363	-0.0093
196520	RBK NP	1.0210	1.0721	0.0511	1.0285	1.0473	0.0187	1.0321	1.0312	-0.0009	1.0351	1.0246	-0.0104

ML = 320 MW Import

66 kV Bus	Bus Names	Peak Demand, ML= -320 MW			Int Peak Demand, ML= -320 MW			Intermediate Demand, ML= -320 MW			Light Demand, ML= -320 MW		
		Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)	Voltage (pu)		delta (pu)
		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault		pre-fault	post-fault	
196521	NDJ NP	0.9979	1.0517	0.0538	1.0082	1.0299	0.0217	1.0157	1.0156	0.0000	1.0201	1.0087	-0.0113
196522	LEW NP	0.9743	1.0278	0.0535	0.9911	1.0127	0.0216	1.0047	1.0046	0.0000	1.0109	0.9996	-0.0113
196523	GAN NPT2	1.0222	1.0799	0.0577	1.0213	1.0468	0.0255	1.0198	1.0208	0.0010	1.0206	1.0082	-0.0124
196524	COB NPT2	0.9899	1.0502	0.0602	1.0365	1.0668	0.0302	0.9904	0.9917	0.0013	0.9613	0.9492	-0.0121
196525	CLK NP	0.9467	1.0102	0.0635	1.0209	1.0513	0.0304	0.9938	0.9948	0.0010	0.9700	0.9572	-0.0128
196526	BOY NP	0.9063	0.9717	0.0653	1.0000	1.0304	0.0304	0.9873	0.9881	0.0008	0.9686	0.9553	-0.0132
196527	FHD L54	0.8989	0.9640	0.0651	0.9953	1.0256	0.0303	0.9843	0.9851	0.0008	0.9665	0.9533	-0.0132
196528	GAM NPT2	0.9627	1.0267	0.0640	0.9840	1.0164	0.0324	0.9931	0.9994	0.0063	0.9981	0.9830	-0.0151
196529	HBS NP	0.9650	1.0293	0.0643	0.9863	1.0187	0.0324	0.9954	1.0017	0.0063	1.0004	0.9852	-0.0151
196530	TRN NP	0.9665	1.0311	0.0646	0.9879	1.0203	0.0324	0.9970	1.0033	0.0063	1.0020	0.9868	-0.0152
196531	GPD NP	0.9675	1.0323	0.0647	0.9889	1.0214	0.0324	0.9980	1.0043	0.0063	1.0031	0.9878	-0.0152
196532	WES NP	0.9677	1.0325	0.0647	0.9891	1.0216	0.0324	0.9982	1.0045	0.0063	1.0032	0.9880	-0.0152
196533	CLV NPT1	1.0080	1.0514	0.0435	1.0046	1.0207	0.0161	1.0065	1.0061	-0.0004	1.0059	0.9871	-0.0189
196534	MIL NP	1.0094	1.0530	0.0436	1.0061	1.0222	0.0161	1.0080	1.0076	-0.0004	1.0075	0.9885	-0.0189
196535	LET NP	1.0115	1.0553	0.0438	1.0084	1.0245	0.0161	1.0102	1.0098	-0.0005	1.0097	0.9907	-0.0190
196536	SMV NP	1.0128	1.0567	0.0439	1.0098	1.0259	0.0161	1.0115	1.0111	-0.0005	1.0110	0.9920	-0.0190
196537	LOK NP	1.0129	1.0569	0.0439	1.0101	1.0261	0.0161	1.0117	1.0113	-0.0005	1.0112	0.9922	-0.0190
196538	PUN NP	1.0126	1.0565	0.0439	1.0097	1.0258	0.0161	1.0114	1.0109	-0.0005	1.0109	0.9919	-0.0190
196539	CAT NPT1	1.0106	1.0544	0.0438	1.0075	1.0236	0.0161	1.0093	1.0089	-0.0005	1.0088	0.9898	-0.0189
196540	SPT NP	1.0364	1.0708	0.0344	1.0212	1.0281	0.0069	1.0242	1.0219	-0.0022	1.0185	1.0025	-0.0160
196541	LAU NP	1.0340	1.0609	0.0269	1.0255	1.0320	0.0064	1.0327	1.0304	-0.0023	1.0177	1.0041	-0.0136
196542	STL WIND	1.0347	1.0609	0.0262	1.0263	1.0316	0.0053	1.0335	1.0304	-0.0031	1.0184	1.0046	-0.0138
196543	WEBCV_NP	1.0344	1.0609	0.0265	1.0288	1.0402	0.0113	1.0366	1.0384	0.0018	1.0146	1.0037	-0.0109
196544	GRH NP	1.0361	1.0625	0.0263	1.0315	1.0453	0.0138	1.0390	1.0428	0.0038	1.0134	1.0037	-0.0096
196545	GAR NP	1.0353	1.0659	0.0306	1.0254	1.0355	0.0101	1.0309	1.0314	0.0006	1.0159	1.0029	-0.0129
196546	BLK NPT3	1.0261	1.0662	0.0401	1.0267	1.0472	0.0204	1.0266	1.0246	-0.0020	1.0298	1.0159	-0.0138
196547	NHR NP	1.0174	1.0549	0.0375	1.0190	1.0378	0.0189	1.0185	1.0152	-0.0033	1.0220	1.0070	-0.0150
196548	ISL NP	1.0056	1.0401	0.0345	1.0085	1.0255	0.0170	1.0076	1.0027	-0.0049	1.0114	0.9949	-0.0165
196549	HCT NP	0.9970	1.0293	0.0323	1.0007	1.0163	0.0156	0.9996	0.9936	-0.0060	1.0036	0.9861	-0.0175
196550	NCH NP	0.9997	1.0321	0.0324	1.0028	1.0184	0.0156	1.0018	0.9958	-0.0061	1.0051	0.9876	-0.0175
196551	OPL NP	1.0000	1.0324	0.0324	1.0030	1.0186	0.0156	1.0021	0.9960	-0.0061	1.0054	0.9879	-0.0175
196552	CAR NP	0.9765	1.0044	0.0279	0.9827	0.9953	0.0126	0.9811	0.9726	-0.0084	0.9862	0.9666	-0.0196
196553	VIC NP	0.9767	1.0046	0.0279	0.9829	0.9955	0.0126	0.9813	0.9728	-0.0084	0.9864	0.9668	-0.0196
196554	HGR NP	0.9745	1.0022	0.0276	0.9809	0.9934	0.0125	0.9792	0.9706	-0.0086	0.9845	0.9648	-0.0197
196555	ILC NP	0.9708	0.9978	0.0270	0.9776	0.9897	0.0121	0.9758	0.9669	-0.0089	0.9812	0.9612	-0.0200
196556	BRB T2T3	0.9658	0.9922	0.0264	0.9731	0.9849	0.0118	0.9711	0.9619	-0.0092	0.9768	0.9565	-0.0203
196557	ULT TAP	1.0305	1.0673	0.0367	1.0229	1.0436	0.0207	1.0240	1.0180	-0.0061	1.0233	1.0022	-0.0211
196558	ULT NP	1.0305	1.0673	0.0367	1.0229	1.0436	0.0207	1.0241	1.0180	-0.0061	1.0233	1.0022	-0.0211
196559	SCV NP	1.0288	1.0664	0.0376	1.0215	1.0429	0.0213	1.0231	1.0173	-0.0058	1.0226	1.0016	-0.0210
196560	KEL NP	1.0173	1.0621	0.0449	1.0117	1.0385	0.0268	1.0166	1.0128	-0.0038	1.0170	0.9970	-0.0200
196561	CHA NP	1.0125	1.0602	0.0477	1.0066	1.0357	0.0291	1.0130	1.0117	-0.0013	1.0140	0.9952	-0.0188
196562	BCV NP	1.0056	1.0561	0.0504	1.0009	1.0320	0.0312	1.0092	1.0045	-0.0047	1.0107	0.9885	-0.0222
196563	GDL NP	1.0090	1.0589	0.0500	1.0044	1.0342	0.0298	1.0108	1.0095	-0.0013	1.0123	0.9902	-0.0221
196564	GOU NP	1.0094	1.0586	0.0492	1.0055	1.0339	0.0283	1.0110	1.0081	-0.0029	1.0129	0.9908	-0.0221
196565	KEN NP	1.0160	1.0583	0.0423	1.0115	1.0356	0.0241	1.0140	1.0089	-0.0050	1.0167	0.9939	-0.0227
196566	MOL NP	1.0124	1.0586	0.0462	1.0084	1.0355	0.0270	1.0123	1.0075	-0.0048	1.0149	0.9923	-0.0226
196567	SLA NP	1.0167	1.0612	0.0445	1.0128	1.0381	0.0253	1.0143	1.0094	-0.0049	1.0174	0.9946	-0.0228
196568	SJM NP	1.0111	1.0587	0.0475	1.0080	1.0354	0.0274	1.0117	1.0082	-0.0035	1.0145	0.9919	-0.0225
196569	MUN NP	1.0140	1.0593	0.0453	1.0110	1.0369	0.0259	1.0130	1.0086	-0.0045	1.0164	0.9938	-0.0226
196570	KBR NP	1.0123	1.0587	0.0465	1.0099	1.0366	0.0267	1.0121	1.0083	-0.0039	1.0158	0.9934	-0.0224
196571	PEP NP	1.0107	1.0578	0.0471	1.0089	1.0360	0.0272	1.0114	1.0076	-0.0038	1.0152	0.9927	-0.0225
196572	RRD NP	1.0177	1.0624	0.0447	1.0141	1.0395	0.0254	1.0147	1.0105	-0.0042	1.0182	0.9954	-0.0228
196573	VIR NP	1.0101	1.0592	0.0490	1.0086	1.0371	0.0285	1.0112	1.0074	-0.0038	1.0150	0.9922	-0.0228
196574	PUL NP	0.9975	1.0562	0.0587	0.9993	1.0350	0.0356	1.0052	1.0061	0.0008	1.0098	0.9870	-0.0227
196575	BIG NP	1.0064	1.0558	0.0493	1.0045	1.0297	0.0251	1.0107	1.0075	-0.0032	1.0125	0.9914	-0.0210
196576	MOB NP	1.0076	1.0570	0.0494	1.0086	1.0265	0.0179	1.0148	1.0108	-0.0040	1.0164	0.9977	-0.0187
196577	TCV NP	1.0080	1.0574	0.0493	1.0090	1.0269	0.0179	1.0153	1.0112	-0.0040	1.0169	0.9982	-0.0187
196578	ROP NP	1.0075	1.0569	0.0494	1.0086	1.0258	0.0173	1.0147	1.0105	-0.0042	1.0163	0.9977	-0.0186
196579	MRP NP	1.0077	1.0570	0.0494	1.0087	1.0260	0.0173	1.0147	1.0106	-0.0041	1.0163	0.9978	-0.0185
196580	HCP TAP NP	1.0070	1.0561	0.0491	1.0086	1.0222	0.0136	1.0146	1.0095	-0.0051	1.0163	0.9985	-0.0178
196581	HCP NP	1.0073	1.0565	0.0492	1.0088	1.0225	0.0137	1.0144	1.0095	-0.0049	1.0161	0.9985	-0.0177
196582	CAB NP	1.0067	1.0555	0.0487	1.0087	1.0204	0.0118	1.0150	1.0093	-0.0058	1.0168	0.9992	-0.0176
196583	FER NP	1.0092	1.0521	0.0429	1.0121	1.0178	0.0058	1.0194	1.0105	-0.0088	1.0214	1.0044	-0.0170
196584	FER WIND	1.0095	1.0521	0.0426	1.0123	1.0178	0.0054	1.0196	1.0106	-0.0090	1.0217	1.0047	-0.0170
196585	SUM NP	0.9063	0.9717	0.0653	1.0000	1.0304	0.0304	0.9873	0.9881	0.0008	0.9686	0.9553	-0.0132
196586	TWG NP	0.8960	0.9626	0.0667	0.9966	1.0270	0.0304	0.9888	0.9895	0.0007	0.9714	0.9579	-0.0135
196587	HRD OUTS	1.0312	1.0676	0.0364	1.0234	1.0439	0.0205	1.0244	1.0182	-0.0061	1.0236	1.0025	-0.0212

Engineering Support Services for:

RFI Studies

Newfoundland and Labrador Hydro

Attention: Mr. Rob Collett

Operational Considerations of LIL Restarts and ML Runbacks

Technical Note: TN1205.77.09
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Prepared By:
TransGrid Solutions Inc.
100-78 Innovation Dr.
Winnipeg, MB R3T 6C2
CANADA

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Appendices

1. Summary

This report provides operating guidelines for how many restart attempts the Labrador Island Link ("LIL") can make after a DC fault has occurred on one or both LIL poles. LIL controls are equipped with up to four restarts attempts, which can be enabled/disabled by the Operator.

This report also provides updated LIL transfer limits based on the final redesigned Underfrequency Load Shedding ("UFLS") scheme[1] and based on the number of permissible LIL restart attempts.

1.1 Number of LIL Restart Attempts Permitted

In order to meet frequency-related Transmission Planning Criteria, Table 1-1 lists the number of LIL restart attempts that can be permitted. The number of restarts that are allowed depends on whether the Maritime Link ("ML") is exporting and runbacks are required following a LIL bipole or pole trip, or if the ML is importing and ML runbacks are not required/possible. The number also depends on whether the LIL and/or ML frequency controllers are in or out of service. Please note the following related to Table 1-1:

- The final Stage 4D and Stage 4E LIL transfer limits considering LIL restarts[2] are provided in Appendices 1 and 2 of this report.
- LIL transfer limits are determined by the IIS underfrequency response and the UFLS that occurs when the LIL bipole trips. The number of allowable LIL restart attempts for these LIL transfer limits are driven mainly by limiting overfrequency that can occur in the IIS following events that involve UFLS, which is particularly important in scenarios when the ML and/or LIL frequency controllers are not in-service, and in scenarios when the LIL poles successfully restart.
- During the transitional period (Stage 4D), it is possible that fewer than two SOP synchronous condensers are in-service. The number of allowable restarts listed in Table 1-1 is not impacted by the number of SOP units online (except as noted in the table under footnote [9]), however, reduced LIL transfer limits are provided as referenced in the table under footnote [8].
- For scenarios where ML export is less than 150 MW or ML is importing, fewer LIL restart attempts are allowed once the redesigned UFLS scheme is implemented (i.e. Stage 4E) if the ML and/or LIL frequency controllers are not in-service as compared to when the existing UFLS scheme is still in place (i.e. Stage 4D[3]). This is because the redesigned UFLS scheme contains approximately double the amount of load shed in order to accommodate higher LIL power transfers, but means that:
    - o If the LIL frequency controller is out of service, and if DC faults occur on both LIL poles and both poles successfully restart, the time between DC fault inception and successful restart must be short enough to limit the amount of UFLS that takes place during this time,

[1] TGS report TN1205.84.09, "Redesign of UFLS Scheme for High Power Operation", dated March 17, 2021.

[2] LIL transfer limits are the same with and without restarts, with the one exception noted in this report; when the ML is importing and its frequency controller is out-of-service under high demand conditions in Stage 4E. In this case, LIL transfer limits increase by approximately 100 MW under these specific conditions if LIL restarts are disabled.

[3] Please note that if full LIL functionality is available when the existing UFLS is still in place (i.e. prior to the implementation of the redesigned UFLS scheme), the higher number of restarts as presented in the Stage 4D results would apply for when the ML and/or LIL frequency controller is out of service.

otherwise the system can experience large overfrequency or instability as the LIL poles will recover to the pre-fault power transfer levels regardless of the load shed that has occurred.

- If the ML frequency controller is out of service, and if DC faults occur on both LIL poles and neither pole successfully restarts, the IIS is left to operate without the ML or LIL frequency controllers. This makes the IIS susceptible to high overfrequency if too much load shed occurs during the DC line faults. The largest amount of load shed occurs under high IIS demand conditions (because there is more load available to shed) and these cases are particularly sensitive to overfrequency. Therefore, for this particular scenario, two sets of LIL transfer limits are provided when the ML frequency controller is out-of-service; one with restarts disabled to allow higher LIL transfer, and another with restarts enabled to improve system reliability during severe weather conditions, but require reduced LIL transfer limits.

Table 1-1. Guidelines for number of LIL restart attempts permitted

Frequency Controller		LIL restarts permitted	ML Transfer	Reason to limit the number of LIL restarts[4]
ML	LIL			
Stage 4E – Long Term Operation[5]				
IN	IN	2	ML export > 150 MW	If delayed by more than 900 ms (2 restart attempts), the system may not recover from the underfrequency if neither pole recovers. Additionally, if the system does recover after the LIL poles have tripped, there is potential for large overfrequency to occur because the entire UFLS scheme has operated in addition to the full runback of ML export, which is more than what is required in some cases.
		4	ML export < 150 MW or ML import	Because an ML runback is not utilized (and is therefore not delayed due to restart attempts), all 4 LIL restart attempts can be used since delaying the tripping of the pole(s) has no impact on the system response if neither pole successfully restarts. Additionally, if one or both poles successfully restart, the LIL and ML frequency controllers are able to keep the IIS frequency below 62 Hz after the successful pole restart(s) considering the UFLS occurs if there are faults on both LIL poles, and the post-event system is left with lower demand then that of the pre-event system.
IN	OUT	1	All ML transfer levels	Without the LIL frequency controller, a large overfrequency and potential for system instability occurs if both LIL poles successfully recover after both LIL poles were faulted if more than 1 restart attempt (500 ms) is allowed, due to the large amount of load that is shed if up to 2 restart attempts (900ms) were allowed. More UFLS occurs with the new scheme contributing more to the over-frequency event in comparison to Stage 4D which utilizes the existing UFLS scheme.
OUT	IN	1	ML export > 150 MW	Without the ML frequency controller, a large overfrequency occurs if LIL bipole trips if more than 1 restart attempt (500ms)

[4] This study assumed the following maximum time durations would be required to allow for one to four restart attempts: 1 restart– 500ms, 2 restarts – 900ms, 3 restarts – 1400 ms, 4 restarts – 1750 ms.
[5] Long-term operation assumes LIL is operating at full functionality, including 2 pu overload capability and frequency controller, and the newly redesigned UFLS has been implemented.

Frequency Controller ML	Frequency Controller LIL	LIL restarts permitted	ML Transfer	Reason to limit the number of LIL restarts[4]
				is allowed. If 2 restart attempts (900 ms delay in ML runback) were allowed, all of the UFLS scheme would operate prior to the ML runback and then the full runback of ML export would also occur at 900 ms. The combination of the entire UFLS and ML runback is more than what is required under high ML export scenarios. This causes an overfrequency which cannot be improved via frequency controller action because the ML frequency controller is out of service and the LIL bipole has tripped.
		2[6]	ML export < 150 MW or ML import	If the ML frequency controller is not in service, frequency greater than 62 Hz occurs under high IIS demand conditions because too much loadshed can occur when there are faults on both LIL poles and when both poles successfully recover as there is not enough room to reduce LIL transfer sufficiently after restarting.
OUT	OUT	0	All ML transfer levels	If neither frequency controller is in-service, a large overfrequency can occur if one or both LIL poles successfully restart after both poles have been faulted due to the load that is shed during the time when both poles are faulted.
Stage 4D – Transitional Period[7]				
IN	OUT	1[8]	ML export > 150 MW	The ML runback required for loss of a LIL pole cannot be delayed by longer than 1 restart attempt (500 ms), otherwise frequency can drop below 59 Hz. Additionally, if more than one restart attempt were allowed and if there were DC line faults on both poles and they both restarted successfully, the IIS would experience a large overfrequency or even instability because of the UFLS that takes place during the faults, and because the LIL would recover to its pre-fault transfer without the frequency controller available to adjust LIL power which is required because of lower post-fault load.
		3[9]	ML export < 150 MW or ML import	If both LIL poles experience DC faults, overfrequency greater than 62 Hz can occur if both poles successfully restart because of the UFLS that occurs if it were to take longer than 3 restart attempts (1400ms) to successfully restart the poles. Less UFLS occurs with the existing scheme contributing less to the over-frequency event in comparison to Stage 4E when the redesigned UFLS scheme is in operation and only 2 restart attempts are allowed.

[6] Please note that Table 4-2 provides an alternative set of increased LIL transfer limits for this specific scenario if LIL restarts are disabled. The Operator may select the appropriate mode of operation based on system and weather conditions.
[7] Transitional period assumes LIL 2 pu overload capability and LIL frequency controller are not yet in-service, and that the existing UFLS is still in place.
[8] During the transitional period, if there are no SOP synchronous condensers in-service, reduced LIL transfer limits are required under high ML export scenarios as described in Section 3.2.2 in order to allow a 500 ms delay in ML runback (one restart attempt) if there is a DC line fault on one pole.
[9] If no SOP synchronous condensers are online, LIL restarts should be limited to two instead of three in this scenario.

Frequency Controller		LIL restarts permitted	ML Transfer	Reason to limit the number of LIL restarts[4]
ML	LIL			
OUT	OUT	1	ML export > 150 MW	The ML runback required for loss of a LIL pole cannot be delayed by longer than 1 restart attempt (500 ms), otherwise frequency can drop below 59 Hz. Additionally, if more than one restart attempt were allowed and if there were DC line faults on both poles and they both restarted successfully, the IIS would experience a large overfrequency or even instability because of the UFLS that takes place during the faults, and because the LIL would recover to its pre-fault transfer without the frequency controller available to adjust LIL power which is required because of lower post-fault load.
		2	ML export < 150 MW or ML import	If both LIL poles experience DC faults, overfrequency greater than 62 Hz can occur if both poles successfully restart because of the UFLS that occurs if it were to take longer than 2 restart attempts (900ms) to successfully restart the poles. Less UFLS occurs with the existing scheme contributing less to the over-frequency event in comparison to Stage 4E when the redesigned UFLS scheme is in operation and no restarts are allowed.

1.2 Updated LIL Transfer Limits

Updated LIL transfer limits based on the final redesigned Underfrequency Load Shedding ("UFLS") scheme and based on the number of permissible LIL restart attempts identified in this report are provided in Appendix 1 for the Transitional Period (Stage 4D) and in Appendix 2 for Long Term Operation (Stage 4E). The LIL transfer limits in Appendices 1 and 2 supersede the LIL transfer limits defined in earlier Stage 4D and Stage 4E reports.

2. Study Assumptions/Methodology

2.1 LIL Restarts

LIL controls are equipped with up to four restarts attempts as shown in Figure 2–1. The number of restart attempts that are enabled can be set by the Operator.

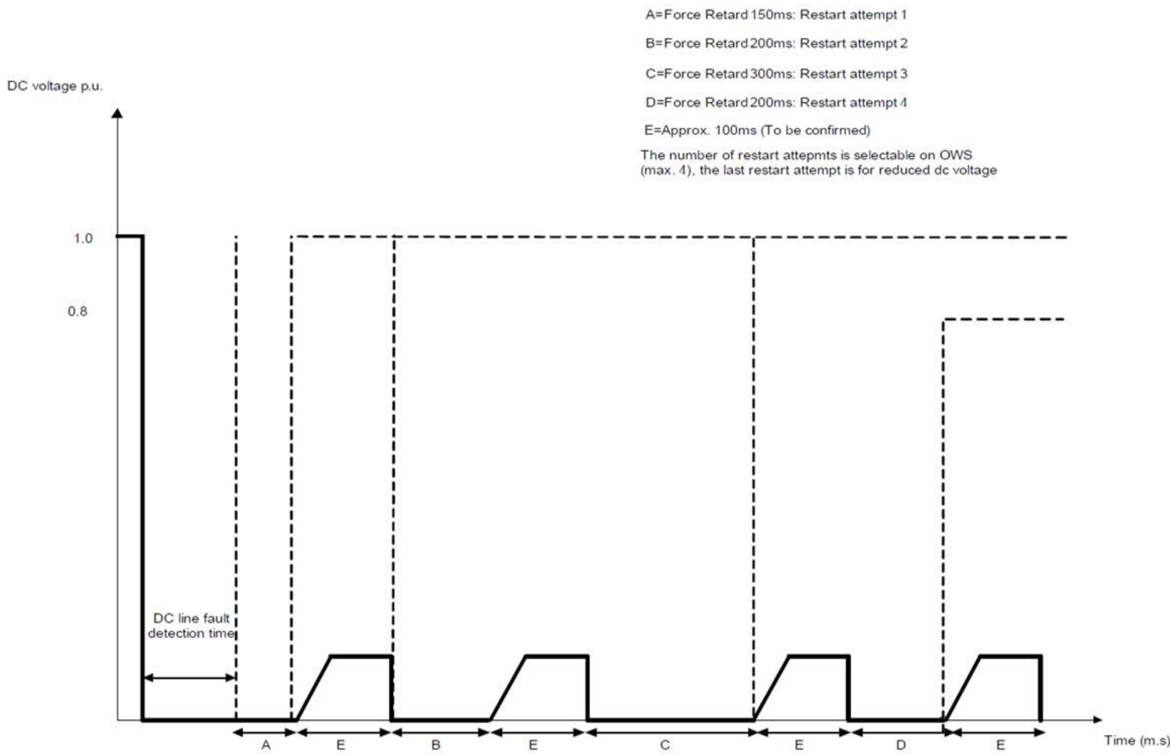


Figure 2–1. Timing for LIL restart attempts

For the purposes of this study, the following worst-case durations are assumed to be required for the number of LIL restart attempts:

- One restart attempt – 500 ms
- Two restart attempts – 900 ms
- Three restart attempts – 1400 ms
- Four restart attempts – 1750 ms

The LIL transfer limits for the transitional period[10] and for long term operation[11] are re-visited in this study to determine the number of LIL restart attempts that can be permitted, while ensuring that IIS frequency will remain above 59 Hz if there is a DC line fault on one pole, and ensuring that the IIS frequency will recover in a stable manner after controlled UFLS if there are simultaneous DC line faults

[10] According to Table 3-1 of the Stage 4D report.

[11] According to Table 3-1 of the Stage 4E report.

on both poles, whether neither pole recovers or whether one or both poles successfully restart. The DC line faults considered in this study are described in more detail below. Please note that when reference is made to a LIL pole tripping due to a DC line fault, it means that the LIL pole has not successfully restarted after the allowed number of restart attempts have been made.

1. **DC Line Fault on One Pole**
   This study determines the maximum time delay from the inception of a DC line fault to the faulted LIL pole tripping. Tripping of the LIL pole triggers an ML runback, which is used to cover for the net loss of LIL infeed resulting from increased DC line losses when operating with only one healthy pole using its short term overload capacity. The ML runback is especially important during the transitional period if the LIL bipole is transferring more than 450 MW and the LIL's 2pu overload capability is not yet available. The ML runback and/or ML frequency controller action are required to ensure the IIS frequency remains at or above 59 Hz to avoid UFLS if a LIL pole trips. The maximum delay in initiation of ML runback will determine how many LIL restart attempts can be applied while keeping IIS frequency above 59 Hz if the LIL restart attempts on the faulted pole were not successful.

2. **DC Line Fault on Both Poles**
   This study also investigates the scenario in which both LIL poles experience DC lines faults, whether simultaneous or staggered within a short period of time. Since this scenario involves faults on both poles, controlled UFLS is allowed and IIS frequency is permitted to drop as far as approximately 58 Hz but it must recover in a stable manner. In addition to UFLS, if the ML is exporting more than 150 MW, ML runback is triggered if one or both poles trip. The maximum time delay in initiating the ML runback will determine how many LIL restart attempts can be made while ensuring that IIS frequency can recover and system stability is maintained if the LIL restart attempt(s) were not successful and one or both poles trip. The availability of the ML and LIL frequency controllers impact the number of restart attempts that are permitted. The longer the delay in a pole(s) recovering, the more UFLS takes place, and the greater the importance of the frequency controller(s) to re-balance the system and keep the IIS frequency within acceptable limits if one or both poles successfully restart since it is restarting into a system with less load.

2.2 ML and LIL Runbacks

ML runbacks are triggered when a LIL pole(s) trips, if the ML is exporting more than 150 MW. ML runback values are specified on the basis of LIL power transfer to compensate for the capacity lost during a LIL contingency.

2.3 IIS System Conditions

The study is performed using IIS base cases that represent demand levels ranging from extreme light (approximately 500 MW) to peak (approximately 1800 MW). IIS base case conditions also represent various ML power transfers ranging from 500 MW export to 320 MW import.

The following assumptions are made for this study:

- HRD unit 3 is operating as a synchronous condenser.
- Two Soldiers Pond synchronous condensers are in-service.

- ML frequency controller is in-service to provide up to 150 MW of frequency support if a LIL pole or the bipole is lost (or for other underfrequency events). It is assumed that if a ML runback has taken place in response to the loss of the LIL bipole, further action by the ML frequency controller to address the underfrequency will not occur in this situation.

Additional Assumptions for Long term operation (Stage 4E):

- LIL frequency controller is in-service.
- LIL 2 pu 10-minute overload is available.
- A re-designed UFLS scheme is in-service which allows higher LIL transfers than the existing UFLS.
- Sensitivity analysis was performed with the ML frequency controller out-of-service, and with the LIL frequency controller out-of-service.

Additional Assumptions for Transitional period operation (Stage 4D):

- Sensitivity analysis was performed with 0 and 1 synchronous condenser in-service.
- LIL frequency controller is not in-service.
- LIL 2 pu 10-minute overload is not available.
- The existing UFLS scheme is in-service.
- Sensitivity analysis was performed with the ML frequency controller out-of-service.

3. Transitional Period (Stage 4D)

During the transitional period, it is assumed that:

- The LIL frequency controller and LIL overload functionality are not yet available.
- The SOP synchronous condensers may or may not be available yet[12].
- The existing UFLS scheme is in place.

3.1 DC Line Faults on Both Poles

DC faults on both poles were simulated to determine the number of LIL restart attempts that can be allowed. Scenarios involving neither pole successfully restarting (i.e. tripping of both LIL poles after restart time) and scenarios involving one or both LIL poles successfully restarting (after restart time) were evaluated. Additionally, the status of the ML frequency controller (in/out) was considered.

The results are summarized in Table 3-1 for both ML frequency controller in-service and out-of-service, with discussion of these results following the table.

[12] The analysis in this study was performed with two SOP synchronous condensers in-service. Sensitivity analysis with fewer than two SOP synchronous condensers was also performed. Please note as per previous operational studies, the number of SOP synchronous condensers does not significantly impact the loss of LIL bipole cases because this scenario relies on UFLS (and ML runback if the ML is exporting) and so the inertia of the synchronous condensers plays a lesser role. However, the synchronous condensers do affect the scenario for loss of a LIL pole, because the frequency must remain above 59 Hz and no ULFS occurs, thereby increasing the importance of the inertial response of the IIS. Section 3.2 presents a discussion for loss of a LIL pole with and without SOP synchronous condensers.

Table 3-1. Faults on Both DC Poles – Transitional Period – Unsuccessful and Successful Restarts (ML frequency controller in-service)

					ML Frequency Controller IN													
					DC Faults on Both Pole with Unsuccessful Restarts (Loss of LIL Bipole)						Both Poles Successfully Restart							
					No Restarts (100ms)		One Restart (500ms)		Four Restarts (1750ms)		One Restart		Two Restarts		Three Restarts		Four Restarts	
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	313	58.08	279	58.09			0	58.90		58.37/61.1				
Ipeak	1428	1094	500	900	328	57.98	348	57.97			59	58.79/60.76		58/>65				
Int	1038	703	500	870	228	57.96	228	57.94			44	58.59/60.74		unstable				
Light	812	476	500	800	158	57.98	158	57.98			27	58.75/60.75		57.75/62.5				
ExLight	606	401	500	750	99	57.99	98	57.98			17	58.78/60.75		57.80/60.9				
Peak	1821	1285	300	780	471	57.97	472	57.95			0	59.06						
Ipeak	1400	915	300	730	349	57.86	349	57.89			0	58.97						
Int	994	589	300	610	229	58.00	229	57.96			0	59.03						
Light	760	452	300	540	158	57.98	158	57.98			0	59.05						
ExLight	553	409	300	470	65	58.01	74	58.00			0	59.14						
Peak	1815	1303	158	610	471	57.96	472	57.96			0	59.17						
Ipeak	1391	889	158	600	350	57.76	380	57.78			0	59.09						
Int	980	548	158	480	229	57.77	229	57.77			0	59.16						
Light	742	433	158	390	158	57.95	158	57.95			0	59.22						
ExLight	537	402	158	300	98	57.99	98	58.00			0	59.30						
Peak	1820	1330	0	570	472	57.98	472	57.96	472	57.95	0	59.20	45	58.7/60.6	182	58.17/61.0	340	58.07/62.56
Ipeak	1391	906	0	540	349	57.86	349	57.86	349	57.87	0	59.16	67	58.64/60.8	231	58.06/61.83	350	57.97/63.80
Int	972	538	0	450	229	57.90	249	57.91	249	57.89	0	59.18	25	58.67/60.7	108	58.19/60.91	229	58.00/62.10
Light	735	403	0	340	150	57.99	172	57.98	172	57.99	0	59.26	12	58.80	31	58.44/60.7	63	58.23/60.75
ExLight	535	404	0	130	0	59.04	0	59.04	0	59.75	0	59.72	0	59.52	0	59.27	0	59.12
Peak	1815	1049	-150	570	475	57.95	475	57.93	475	57.97	0	59.22	80	58.78/60.75	273	58.06/62.00	365	58.00/63.20
Ipeak	1389	757	-150	540	348	57.89	348	57.90	348	57.95	0	59.17	67	58.58/60.79	231	58.05/61.77	348	57.98/63.20
Int	972	424	-150	410	227	57.97	227	57.97	227	57.98	0	59.19	22	58.61/60.60	72	58.25/60.81	163	58.03/61.10
Light	740	402	-150	190	16	58.79	16	58.79	16	58.79	0	59.57	0	59.30	0	58.97	0	58.89
ExLight	536	400	-46	90	0	59.14	0	59.14	0	59.15	0	59.79	0	59.63	0	59.43	0	59.30
Peak	1824	998	-320	460	472	57.88	473	57.88	473	57.98	0	59.26	0	58.89	148	58.32/61.00	152	58.25/61.00
Ipeak	1402	724	-320	400	350	57.84	350	57.85	350	57.87	0	59.24	34	58.75/60.75	110	58.35/60.92	139	58.21/61.00
Int	987	421	-320	250	229	57.99	229	57.99	229	57.99	0	59.43	0	59.11	22	58.75/60.3	22	58.67/60.5
Light	750	400	-260	90	31	58.58	31	58.58	31	58.58	0	59.80	0	59.65	0	59.46	0	59.34

Not included in plot since not a limiting case
Minimum IIS Generation

Table 3-2. Faults on Both DC Poles – Transitional Period – Unsuccessful and Successful Restarts (ML frequency controller out-of-service)

				ML Frequency Controller OUT												
					DC Faults on Both Poles with Unsuccessful Restarts						Both Poles Successfully Restart					
					No Restarts (100ms)		One Restart (500ms)		Two Restarts (900ms)		One Restart		Two Restarts		Three Restarts	
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	313	58.08	279	58.09			35	58.76				
Ipeak	1428	1094	500	900	328	57.98	348	57.97			68	58.55/61.00				
Int	1038	703	500	870	228	57.97	228	57.94			76	58.35/61.50				
Light	812	476	500	800	158	57.99	158	57.98			33	58.50/61.00				
ExLight	606	401	500	750	99	57.99	98	57.98			19	58.50/60.77				
Peak	1821	1285	300	780	471	57.97	472	57.95			0	58.87				
Ipeak	1400	915	300	730	349	57.86	349	57.89			59	58.75/61.1				
Int	994	589	300	610	229	58	229	57.96			0	58.85				
Light	760	452	300	540	158	57.98	158	57.98			0	58.82				
ExLight	553	409	300	470	65	58.01	74	58.00			0	58.94				
Peak	1815	1303	158	610	471	57.96	472	57.96			0	59.08				
Ipeak	1391	889	158	600	350	57.76	380	57.78			0	59.10				
Int	980	548	158	480	229	57.77	229	57.77			0	59.16				
Light	742	433	158	390	158	57.95	158	57.95			0	59.22				
ExLight	537	402	158	300	98	57.99	98	58.00			0	59.30				
Peak	1820	1330	0	460	471	57.92	471	57.91	471	57.91	0	59.27	45	58.74/60.65	152	58.20/61.88
Ipeak	1391	906	0	400	349	57.88	350	57.87	350	57.87	0	59.31	0	58.81	110	58.35/62.15
Int	972	538	0	290	229	57.88	249	57.87	249	57.87	0	59.37	0	58.92	44	58.45/61.20
Light	735	403	0	210	159	57.99	160	57.97	160	57.97	0	59.55	0	59.25	0	58.84/60.29
ExLight	535	404	0	130	73	58.09	73	58.09	73	58.09	0	59.72	0	59.52	0	59.25
Peak	1815	1049	-150	460	474	57.84	474	57.85	474	57.84	0	59.27	35	58.77	149	58.30/62.10
Ipeak	1389	757	-150	400	349	57.85	349	57.84	349	57.84	0	59.25	34	58.76/60.79	115	58.23/62.32
Int	972	424	-150	290	228	57.93	229	57.94	229	57.94	0	59.37	0	58.93	44	58.45/61.11
Light	740	402	-150	190	159	57.99	159	57.99	159	57.99	0	59.57	0	59.28	0	58.89
ExLight	536	400	-46	90	40	58.3	40	58.30	40	58.30	0	59.79	0	59.63	0	59.42
Peak	1824	998	-320	460	472	57.88	473	57.88	473	57.88	0	59.21	45	58.69/60.70	271	58.09/63.70
Ipeak	1402	724	-320	400	350	57.84	350	57.85	350	57.85	0	59.18	34	58.66/60.78	232	58.07/64.50
Int	987	421	-320	250	229	57.99	229	57.99	229	57.99	0	59.43	0	59.02	44	58.87/61.18
Light	750	400	-260	90	45	58.58	31	58.57	31	58.57	0	59.80	0	59.65	0	59.46

Not included in plot since not a limiting case

Minimum IIS Generation

3.1.1 Successful restart of one or both poles

The most limiting scenario involving successful restart is when both poles successfully restart. This is because UFLS occurs during the simultaneous fault deionization period of both poles before they successfully restart. If both poles successfully restart, the IIS can experience a large overfrequency[13] (> 62 Hz) since the LIL frequency controller is not yet in-service during the transitional period and the LIL poles will recover to their pre-fault power transfer levels, even though the IIS load is significantly lower due to the load shed.

The results for successful restart of both LIL poles are summarized below, based on ML transfer levels/direction.

If ML Export > 150 MW:
The IIS frequency was acceptable if both LIL poles successfully restart on the first attempt (i.e. assumed 500 ms from DC fault inception to successful restart). An example is shown in Figure 3–1, with and without the ML frequency controller in-service. If time for two restart attempts is given, and both LIL poles restart successfully on the second attempt, the IIS frequency was observed to be as high as 65 Hz and in some cases the system became unstable. Therefore, only one restart attempt can be permitted under these conditions.

[13] Please note that two SOP synchronous condensers were in-service for this analysis, however sensitivity analysis was performed with no SOP synchronous condensers on-line. Where required, reduced limits on the number of allowable restarts are noted when no SOP synchronous condensers are on-line. When no SOP synchronous condensers on-line, more UFLS can occur prior to the successful restart of the pole(s), leading to higher overfrequency after the pole(s) restart.

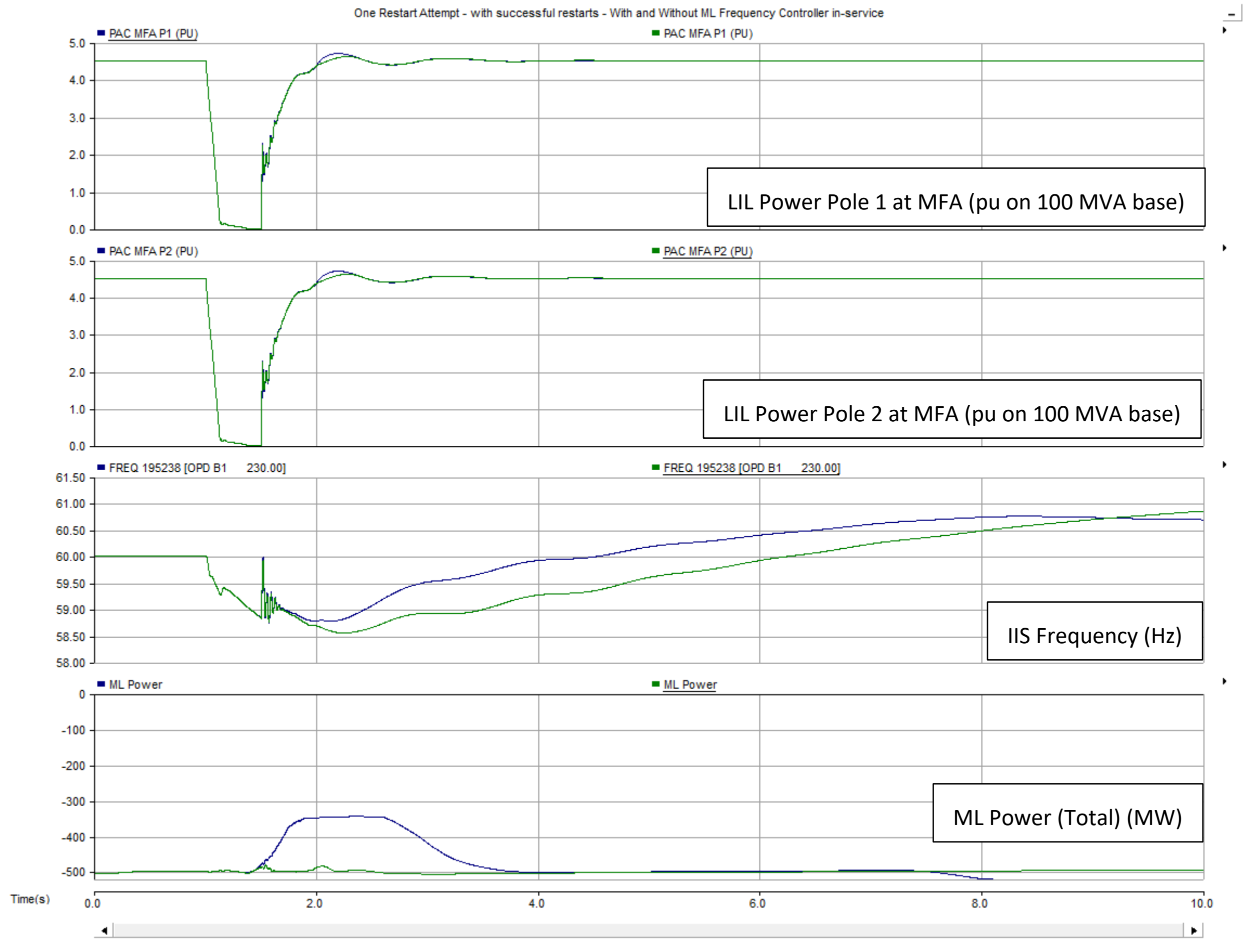


Figure 3–1. Faults on both LIL poles – successful restart on first attempt, with (blue) and without (green) ML frequency controller in-service

If ML Export < 150 MW or ML Import:

It was found that three (3)[14] restart attempts are possible if the ML frequency is in-service and two (2) restart attempts are possible if the ML frequency controller is out of service. If time for more restarts attempts is given, frequency greater than 62 Hz can occur if both poles successfully restart, as demonstrated in Figure 3–2, which shows the overfrequency that occurs if more than three restart attempts are used in a scenario with the ML frequency controller in-service. Frequency in this case reaches nearly 64 Hz after both LIL poles recover to their pre-fault transfer levels because of the load that was shed during the fault duration.

[14] Sensitivity analysis with no SOP synchronous condensers line found that only two (2) restart attempts are allowed in this scenario, otherwise frequency greater than 62 Hz can occur. This is because the initial frequency drop has a slightly faster decay rate without the synchronous condensers, leading to more UFLS prior to the successful restart of the poles.

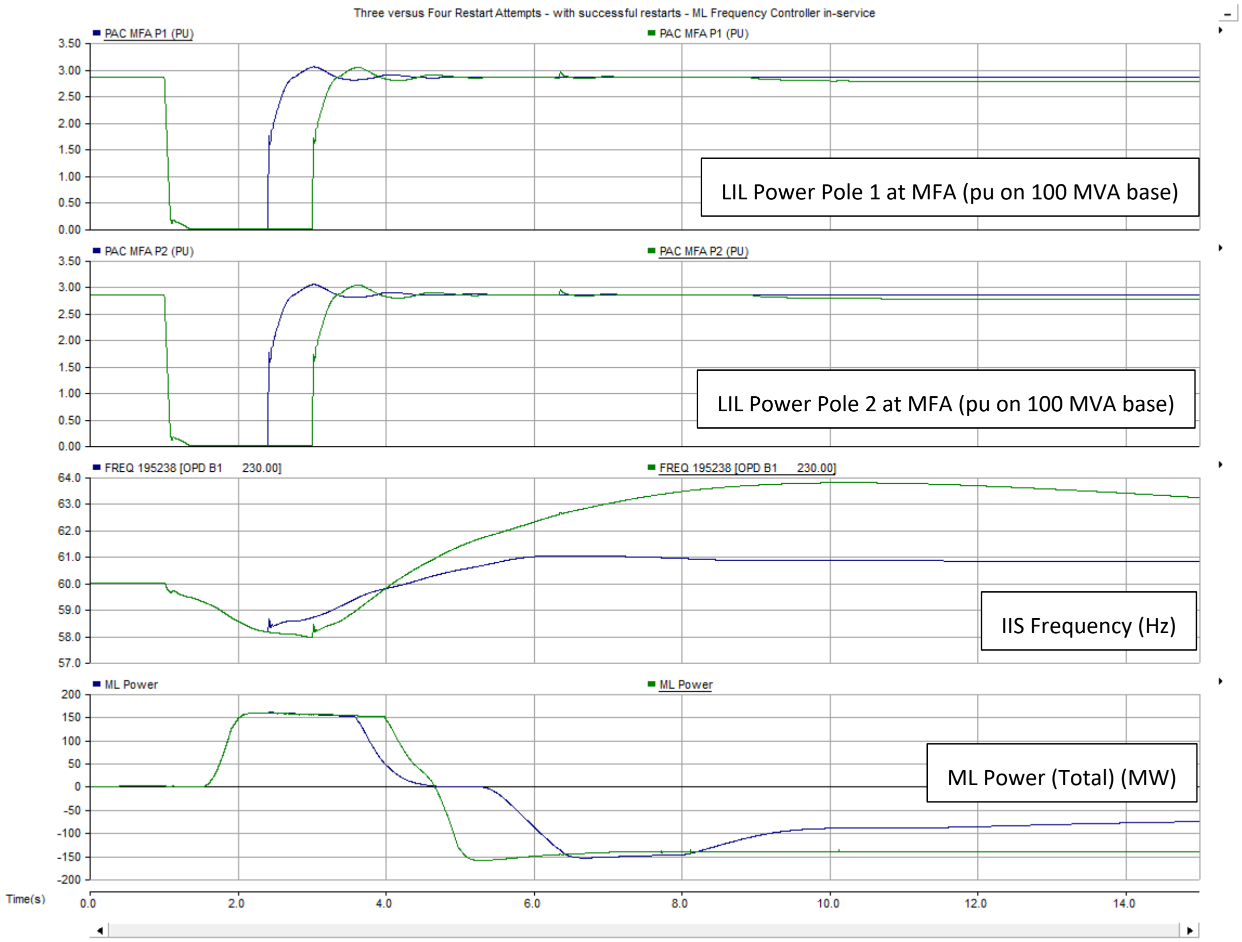


Figure 3–2. Three (blue) versus four (green) restart attempts with successful restart (ML frequency controller in-service)

3.1.2 Neither pole successfully restarts

Two scenarios of simultaneous DC line faults with unsuccessful restarts were simulated:

1. Both DC line faults occur at the same time.
2. A DC fault occurs on one pole and the IIS frequency begins to drop, and at the point in time when the IIS frequency has reached its minimum, the second LIL pole experiences a DC line fault.

It was found that the minimum frequency that occurs and the amount of load that is shed when neither pole restarts successfully is similar between these two scenarios, as shown in Figure 3–3. The only difference is the time it takes to reach the minimum frequency.

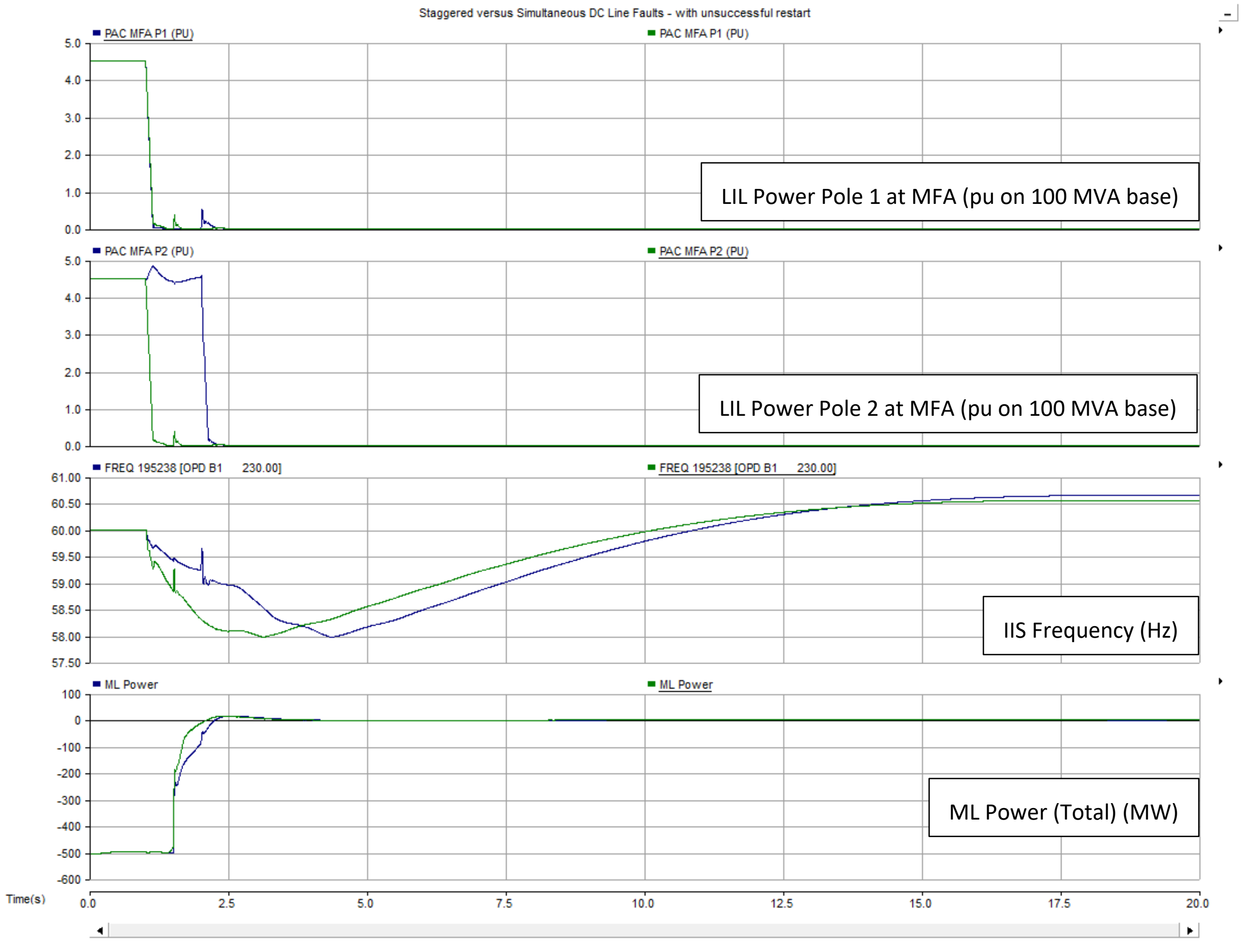


Figure 3–3. Simultaneous (green) versus staggered (blue) DC line faults

The results for unsuccessful restart of both LIL poles (i.e. loss of the LIL bipole) are summarized below, based on ML transfer levels/direction. Please refer to Appendix 1 for corresponding plots of LIL transfer limit versus IIS demand for the transitional period (Stage 4D).

If ML Export > 150 MW:
The scenario involving successful restart of both poles only allows one restart attempt if ML is exporting, as discussed in Section 3.1.1. The IIS frequency performance was found to be acceptable with a 500 ms delay in ML runback (one restart attempt) even if neither of the LIL poles successfully restart, whether the ML frequency controller is in or out-of-service. Figure 3–3 above is an example of such a case.

If ML Export < 150 MW or ML Import:
If ML is exporting less than 150 MW or if ML is importing, loss of the LIL bipole does not utilize an ML runback. The maximum number of permissible restarts identified in Section 3.1.1 (where both poles successfully restart) were tested and also found to be acceptable if neither pole successfully restarts, i.e. three restart attempts if the ML frequency controller is in-service (example shown in Figure 3–4) and two restart attempts if the ML frequency controller is not in-service (example shown in Figure 3–5).

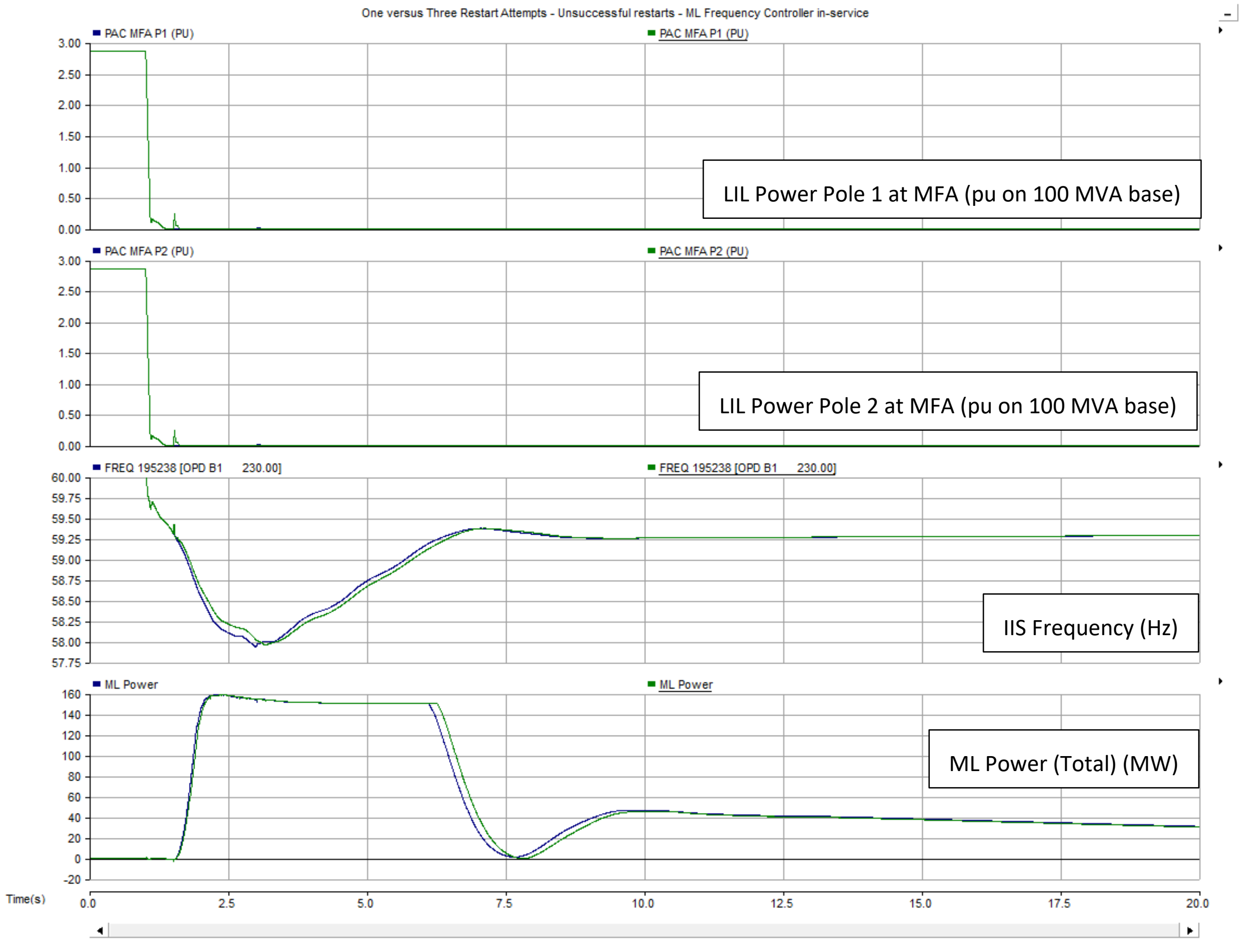


Figure 3–4. One (blue) and three (green) unsuccessful restart attempts (ML frequency controller in-service)

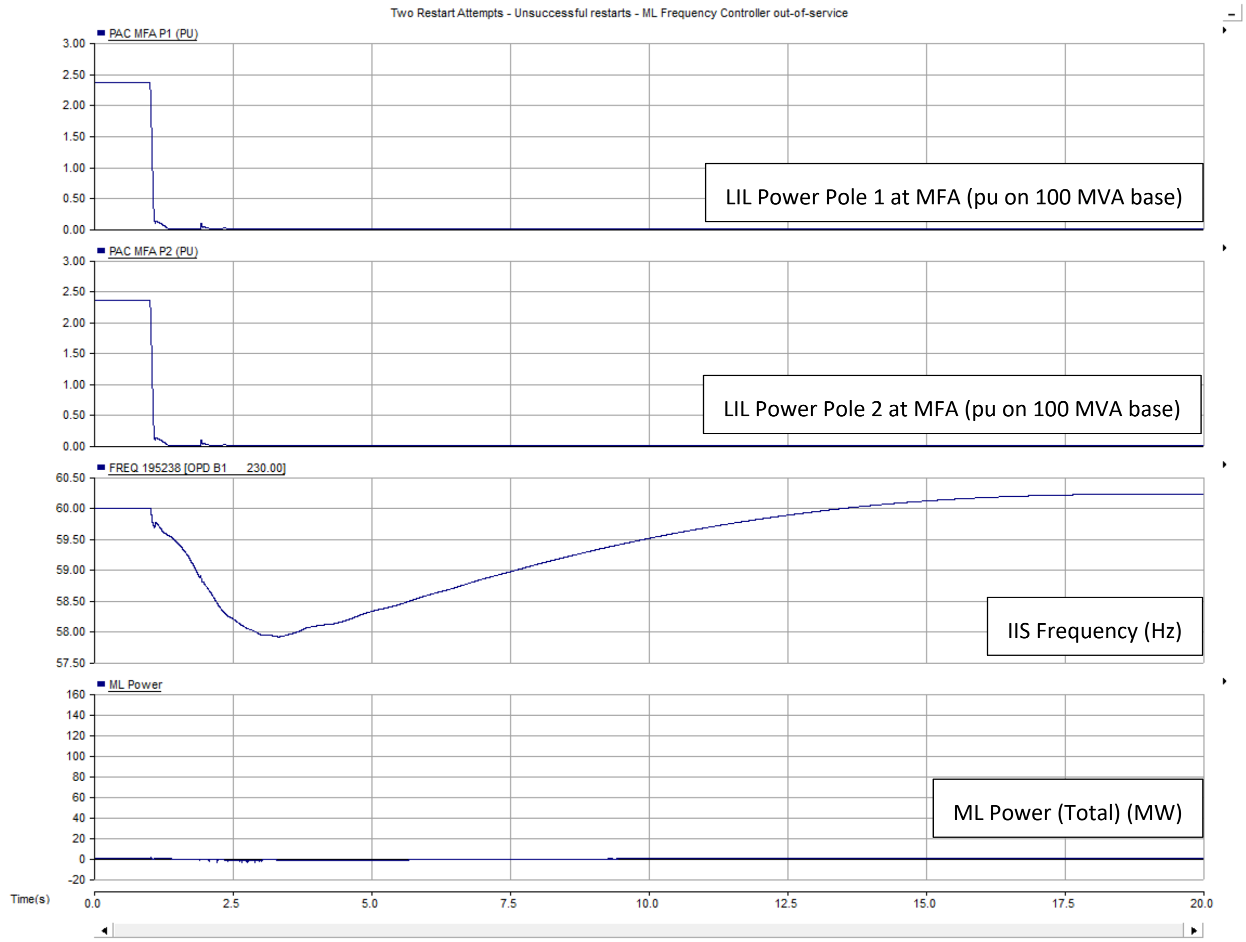


Figure 3–5. Two unsuccessful restart attempts (ML frequency controller out-of-service)

3.2 DC Line Fault on One Pole

A DC line fault on one pole with unsuccessful restart (i.e. loss of a LIL pole) was simulated to determine how long of a delay is permissible between the inception of the fault and the pole tripping, which triggers the ML to runback (if the ML is exporting) in the amount specified based pre-contingency LIL transfer level. The length of that delay determines the number of LIL restart attempts that are allowable, in order to ensure IIS frequency does not drop below 59 Hz.

A DC line fault with unsuccessful restart was first simulated with two SOP synchronous condensers in-service to determine the maximum delay possible in initiating the ML runback without resulting in a reduction of Stage 4D LIL transfer limits. The cases were then evaluated with 0[15] and 1 SOP synchronous condensers to determine if any reduction in LIL transfer limit is required to achieve the same delay in ML runback initiation.

[15] Based on previous analysis, if there are no SOP synchronous condensers in-service, a minimum of two HRD units must be in-service to meet short circuit level requirements. Therefore, HRD unit 1 dispatched at 70 MW and HRD unit 3 as a synchronous condenser were placed in-service in the cases with no SOP synchronous condensers in-service.

Since the 2 pu overload functionality is assumed not yet available at this stage, pole compensation on the healthy LIL pole is limited to 1 pu and there is no additional support from the LIL frequency controller, since it is also assumed not yet available. The LIL pole compensation doubles the DC current order of the healthy LIL pole when the other LIL pole is faulted and/or trips, up to a maximum of 1 pu.

The results of the DC line fault with unsuccessful restart (loss of a LIL pole) are summarized in Table 3-3, and discussed below.

3.2.1 2 SOP Synchronous Condensers In-Service

With two (2) SOP synchronous condensers in-service:

ML Export > 150 MW
One LIL restart attempt is permitted (500 ms delay before pole trips and triggers ML runback). If two restart attempts are made, the IIS frequency drops below 59 Hz if ML is exporting more than 300 MW.

ML Export < 150 MW or ML Import
All four restart attempts permitted (1750 ms delay before pole(s) trip) since tripping of the pole does not trigger an ML runback.

3.2.2 0 or 1 SOP Synchronous Condensers In-Service

If there are no SOP synchronous condensers in-service, reduction in LIL transfer limit is required during the ML 500 MW export scenarios to maintain the same 500 ms delay in ML runback initiation (shown in green highlighted cells in Table 3-3).

If there is one or more SOP synchronous condenser in-service, no reduction in LIL transfer limits is required.

Table 3-3. Loss of a LIL Pole – Transitional Period

				ML FREQUENCY CONTROLLER IN-SERVICE							ML FREQUENCY CONTROLLER OUT-OF-SERVICE								ML Frequency Controller	
					Loss of LIL Pole							Loss of LIL Pole							IN	OUT
					One Restart (500ms)				Two Restarts (900ms)			One Restart (500ms)				Two Restarts (900ms)		One Restart (500ms)		
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	ML Runback (MW)	Minimum/ Maximum Frequency - 2 SYNCS (Hz)	Minimum/ Maximum Frequency - 0 SYNCS (Hz)	Minimum/ Maximum Frequency - 1 SYNCS (Hz)	ML Runback (MW)	Minimum/ Maximum Frequency (Hz)	LIL Transfer Limit (MW)	ML Runback (MW)	Minimum/ Maximum Frequency - 2 SYNCS (Hz)	Minimum/ Maximum Frequency - 0 SYNCS (Hz)	Minimum/ Maximum Frequency - 1 SYNCS (Hz)	ML Runback (MW)	Minimum/ Maximum Frequency (Hz)	Reduced LIL Transfer Limits 0 SYNCS (MW)	Minimum/ Maximum Frequency - 0 SYNCS (Hz)	Minimum/ Maximum Frequency - 0 SYNCS (Hz)
Peak	1866	1530	500	900	440	59.31	58.97	59.19	440	58.87	900	440	59.34	59.00	59.23	440	58.83	875	59.02	59.06
Ipeak	1428	1094	500	900	440	59.18	58.84	59.03	440	58.74	900	440	59.23	58.85	59.06	440	58.65	825	59.09	59.13
Int	1038	703	500	870	414	59.15	58.78	58.97	414	58.71	870	414	59.19	58.72	58.98	414	58.57	780	59.03	59.05
Light	812	476	500	800	354	59.31	58.94	59.13	354	58.88	800	354	59.35/62.11*	58.92	59.17/62.0*	354	58.80	750	59.11	59.15
ExLight	606	401	500	750	310	59.37	unstable	59.22	310	58.96	750	310	59.41/63.00*	unstable	59.26/62.80*	310	58.90			
Peak	1821	1285	300	780	336 (300)	59.38	59.16		336 (300)	59.06	780	336 (300)	59.45	59.21		440	59.06			
Ipeak	1400	915	300	730	294	59.47	59.21		294	59.11	730	294	59.51	59.26		294	59.11			
Int	994	589	300	610	185	59.65	59.43		185	59.38	610	185	59.67	59.46		185	59.40			
Light	760	452	300	540	122	59.74	59.60		122	59.54	540	122	59.75	59.62		122	59.55			
ExLight	553	409	300	470	58	59.83	59.74		58	59.73	470	58	59.83	59.74		58	59.73			
Peak	1815	1303	158	610	185 (158)	59.36	59.32		185 (158)	59.30	610	185 (158)	59.38	59.29		265	59.26			
Ipeak	1391	889	158	600	177 (158)	59.56	59.41		177 (158)	59.35	600	177 (158)	59.59	59.46		177	59.39			
Int	980	548	158	480	67	59.74	59.69		67	59.65	480	67	59.74	59.70		67	59.66			
Light	742	433	158	390	32	59.91	59.86		32	59.86	390	32	59.91	59.86		32	59.86			
ExLight	537	402	158	300	20	59.95	59.95		20	59.92	300	20	59.95	59.95		20	59.93			
Peak	1820	1330	0	570		59.03	58.99				460		59.15	59.00						
Ipeak	1391	906	0	540		59.09	59.02				400		59.35	59.54						
Int	972	538	0	450		59.25	59.25				290		59.65	59.62						
Light	735	403	0	340		59.27	59.27				210		59.95	59.84						
ExLight	535	404	0	130		59.99					130		59.99							
Peak	1815	1049	-150	570		59.03	58.98				460		59.06	58.98						
Ipeak	1389	757	-150	540		59.07	59.03				400		59.25	59.47						
Int	972	424	-150	410		59.27	59.27				290		59.59	59.57						
Light	740	402	-150	190		59.96	59.63				190		59.96	59.64						
ExLight	536	400	-46	90		59.99					90		59.99							
Peak	1824	998	-320	460		59.17	59.29				460		59.17	59.29						
Ipeak	1402	724	-320	400		59.24	59.32				400		59.24	59.32						
Int	987	421	-320	250		59.79	59.71				250		59.79	59.71						
Light	750	400	-260	90		59.99	59.99				90		59.99	59.99						

At min generation, not a limiting case

*Without ML frequency controller, overfrequency occurs. K-factor for ML runback calculation may be needed to avoid violating 62 Hz limits.

Minimum IIS Generation

3.3 Summary of Permissible LIL Restart Attempts (Stage 4D)

The number of LIL restart attempts permitted for the Transitional Period (Stage 4D) is summarized in Table 3-4, based on ML transfer level/direction and status of the ML frequency controller (LIL frequency controller is assumed out-of-service).

Table 3-4. Stage 4D – Number of LIL Restart Attempts Permitted

Frequency Controller Status		LIL restarts permitted	ML Transfer	Reason to limit the number of LIL restarts
ML	LIL			
IN	OUT	1	ML export > 150 MW	The ML runback required for loss of a LIL pole cannot be delayed by longer than 1 restart attempt (500 ms), otherwise frequency can drop below 59 Hz. Additionally, if more than one restart attempt were allowed and if there were DC line faults on both poles and they both restarted successfully, the IIS would experience a large overfrequency or even instability. This is caused by the UFLS that takes place during the faults, and that the LIL would recover to its pre-fault transfer without the frequency controller available to adjust LIL power which is required because of lower post-fault load.
		3[16]	ML export < 150 MW or ML import	If both LIL poles experience DC faults, overfrequency greater than 62 Hz can occur if both poles successfully restart. This is because too much UFLS would occur if it were to take longer than 3 restart attempts (1400ms) to successfully restart the poles.
OUT	OUT	1	ML export > 150 MW	The ML runback required for loss of a LIL pole cannot be delayed by longer than 1 restart attempt (500 ms), otherwise frequency can drop below 59 Hz. Additionally, if more than one restart attempt were allowed and if there were DC line faults on both poles and they both restarted successfully, the IIS would experience a large overfrequency or even instability. This is caused by the UFLS that takes place during the faults, and because the LIL would recover to its pre-fault transfer without the frequency controller available to adjust LIL power which is required because of lower post-fault load.
		2	ML export < 150 MW or ML import	If both LIL poles experience DC faults, overfrequency greater than 62 Hz can occur if both poles successfully restart. This is because too much UFLS would occur if it were to take longer than 2 restart attempts (900ms) to successfully restart the poles.

[16] If no SOP synchronous condensers are online, LIL restarts should be limited to two instead of three in this scenario.

4. Long Term Operation (Stage 4E)

Long term operation assumes that:

- All LIL control functionality, including frequency controller and 2 pu overload, are in operation.
- There are at least two SOP synchronous condensers in-service.
- The new UFLS[17] is in place.

4.1 DC Line Faults on Both Poles

The Stage 4E LIL transfer limits were tested for DC faults on both poles to determine the number of restart attempts that would be permitted. Scenarios involving neither pole successfully restarting (i.e. tripping of both LIL poles after restart delay) and scenarios involving one or both LIL poles successfully restarting (after restart delay) were evaluated. Additionally, the statuses of the ML and LIL frequency controllers (in/out) were considered.

The results are summarized in Table 4-1 (ML frequency controller in-service) and Table 4-2 (ML frequency controller out-of-service), with a more detailed discussion of these results following the tables.

[17] TGS report TN1205.84.02, “Redesign of UFLS Scheme for High Power Operation”, dated January 18, 2021.

Table 4-1. Faults on Both DC Poles – Long Term Operation – ML Frequency Controller In-Service

				ML FREQUENCY CONTROLLER IN																		
				LIL FREQUENCY CONTROLLER IN																LIL FREQUENCY CONTROLLER OUT		
				Loss of LIL Bipole				DC Faults on Both Poles with Unsuccessful Restarts (Loss of LIL Bipole)								Both Poles Successfully Restart				Both Poles Successfully Restart		
				No restarts (100ms)				One Restart (500ms)		Two Restarts (900ms)		Three Restarts (1400ms)		Four Restarts (1750ms)		Two Restarts		Four Restarts		One Restart		Two Restarts
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	362	58.48	900	278	58.52	556	58.26/61.16	671	58.04/62.23			580	58.23/61.00			62	58.96/60.70	58.35/66
Ipeak	1428	1094	500	900	343	58.38	900	343	58.38	550	58.06/61.66	620	57.75/63.00			620	57.99/61.06			79	58.81/60.80	unstable
Int	1038	703	500	900	268	58.28	900	249	58.26	404	57.84/60.94	404	57.27/61.00			404	57.86/61.00			88	58.68/61.10	unstable
Light	812	476	500	900	217	58.15	900	224	58.05	279	57.74/60.50	279	56.85			279	57.75/60.82			114	58.59/61.60	unstable
ExLight	575	401	500	750	106	58.37	750	105	58.34	174	57.94/60.70	174	57.21/60.77			173	57.93/60.67			37	58.71/61.76	unstable
Peak	1821	1285	300	900	551	58.24	900	554	58.22	676	58.13/60.9	832	57.93/62.45			587	58.32/61.11			75	58.86/60.78	unstable
Ipeak	1400	915	300	900	520	58.11	900	511	58.10	620	57.81/60.84	620	57.65/60.86			620	57.93/61.19			170	58.62/61.08	unstable
Int	994	589	300	810	406	57.98	810	405	57.93	405	57.91	405	57.50			406	57.96/61.00			86	58.74/60.84	unstable
Light	760	452	300	690	280	57.99	690	280	57.99	280	57.91	280	57.58			280	57.90/60.73			60	58.78/60.82	unstable
ExLight	553	409	300	470	89	58.40	470	99	58.41	97	58.39	137	58.18			115	58.39/60.50			0	59.13	58.52/60.83
Peak	1815	1303	158	900	744	58.04/60.6	900	744	58.03	821	57.98/60.98	839	57.94/60.99			731	58.25/61.13			176	58.78/61.08	unstable
Ipeak	1391	889	158	850	618	57.96	850	618	57.94	618	57.93	620	57.75			618	57.96/61.25			136	58.67/61.0	unstable
Int	980	548	158	650	405	57.94	650	405	57.94	405	57.93	405	57.95			397	58.11/60.72			30	58.92/60.70	58.22/63.29
Light	742	433	158	500	208	57.99	500	280	57.99	280	58.00	280	57.98			206	58.38/60.50			0	59.10	58.46/61.00
ExLight	537	402	158	300	96	58.40	300	106	58.40	99	58.40	106	58.39			31	58.78			0	59.29	58.89
Peak	1820	1330	0	900	741	58.07	900	741	58.06	835	58.03	835	57.95	835	57.96			839	57.82/60.77	175	58.79/61.26	unstable
Ipeak	1391	906	0	840	613	57.95	840	616	57.93	616	57.91	617	57.83	617	57.83			616	57.84/60.5	130	58.76/61.00	unstable
Int	972	538	0	575	359	58.06	575	397	58.00	405	58.00	405	58.00	405	57.99			333	58.03	0	58.96	58.30/63.00
Light	734	403	0	340	156	58.40	340	171	58.39	171	58.39	171	58.39	171	58.39			114	58.5/60.5	0	59.29	58.84
ExLight	535	404	0	130	-	59.04	130	-	59.05	-	59.05	-	59.05	-	59.05			0	59.19	0	59.75	59.52
Peak	1815	1049	-150	900	741	58.06	900	783	58.00	835	57.98	835	57.95	835	57.95			835	57.91/60.8	175	58.71/61.37	unstable
Ipeak	1389	757	-150	820	617	57.96	820	618	57.91	618	57.89	618	57.77	618	57.77			618	57.79/60.5	154	58.6/61.0	unstable
Int	972	424	-150	410	223	58.38	410	244	58.37	244	58.38	244	58.39	244	58.38			244	58.36	0	59.19	58.62/60.84
Light	740	402	-150	190	31.3	58.79	190	60	58.79	60	58.79	60	58.79	60	58.79			0	58.93	0	59.57	59.31
ExLight	536	400	-46	90	-	59.14	90	-	59.13	-	59.13	-	59.13	-	59.13			0	59.13	0	59.80	59.63
Peak	1824	998	-320	700	688	58.06	700	675	58.02	840	57.93/60.86	840	57.92/61.05	840	57.93/61.06			835	57.94/61.9	62	58.95/61.28	unstable
Ipeak	1402	422	-320	680	620	57.90	680	620	57.87	620	57.87	620	57.87	620	57.87			620	57.8/60.7	125	58.74/61.00	unstable
Int	987	421	-320	250	224	58.38	250	223	58.38	223	58.38	223	58.38	223	58.38			82	58.74	0	59.43	59.03
Light	750	400	-260	90	62	58.70	90	62	58.70	60	58.77	60	58.77	60	58.77			0	58.77	0		59.65
Not included in plot since not a limiting case																						
Minimum IIS Generation																						

Table 4-2. Faults on Both DC Poles – Long Term Operation – ML Frequency Controller Out-of-Service

				ML Frequency Controller OUT																		
				LIL FREQUENCY CONTROLLER IN-SERVICE																		LIL FREQUENCY CONTROLLER OUT
				Loss of LIL Bipole				DC Faults on Both Poles with Unsuccessful Restarts (Loss of LIL Bipole)						Both Poles Successfully Restart								
				No restarts (100ms)				One Restart (500ms)		Two Restarts (900ms)		Four Restarts (1750ms)		One Restart		Two Restarts		Three Restarts		Four Restarts		One Restart
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	LIL Transfer Limit (MW)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	UFLS (MW)	Minimum/ Maximum Frequency (Hz)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	355	58.48	900	355	58.48	566	58.21/62.5			231	58.5/60.5							58.79/61.27
Ipeak	1428	1094	500	900	345	58.35	900	345	58.39	620	57.9/65			271	58.55/60.6							58.62/>62
Int	1038	703	500	900	262	58.31	900	301	58.25	404	57.54/63.1			396	58.3/60.6							unstable
Light	812	476	500	900	219	58.13	900	244	58.07	279	57.43/60.5			279	58.17/60.5							58.49/<65
ExLight	575	401	500	750	106	58.37	750	96	58.31	174	57.68/61.5			153	58.5/60.4							unstable
Peak	1821	1285	300	900	555	58.26	900	555	58.27	732	58.0/63			317	58.62							unstable
Ipeak	1400	915	300	900	539	58.08	900	539	58.08	620	57.63/>62			490	58.32							unstable
Int	994	589	300	810	406	57.96	810	405	57.94	405	57.69			315	58.35							unstable
Light	760	452	300	690	280	57.99	690	280	57.98	280	57.71			236	58.56							unstable
ExLight	553	409	300	470	97	58.4	470	97	58.41	106	58.31			23	58.91							58.95
Peak	1815	1303	158	900	731	58.16	900	731	58.16	839	>62 Hz			405	58.71/60.65							unstable
Ipeak	1391	889	158	850	618	57.97	850	618	57.97	618	57.74			510	58.33/60.66							unstable
Int	980	548	158	650	405	57.94	650	405	57.93	405	57.89			179	58.69							58.79/62.0
Light	742	433	158	500	280	57.98	500	280	57.99	280	57.97			37	58.97							58.90
ExLight	537	402	158	300	106	58.4	300	106	58.40	106	58.4			0	59.25							59.29
Peak	1820	1330	0	700	724	58.09/61.14	600					646	58.17	0	58.90	353	58.59	746	57.99/62.93	675	58.14/62.18	58.63/>64.0
Ipeak	1391	906	0	675	615	57.95	600					613	57.98/61.5	0	58.90	550	58.17/61.3	613	57.97/62.5	613	57.97/62.5	58.66/>62.0
Int	972	538	0	450	402	57.98	450					402	57.98	0	59.04	290	58.6/60.6	399	58.05/61.6	402	57.97/61.75	58.86/61.5
Light	734	403	0	340	298	57.98	340					298	57.98	0	59.20	121	58.86	253	58.35/60.6	280	58.14/60.7	59.25
ExLight	535	404	0	130	80	58.47	130					80	58.47	0	59.64	0	59.50	0	59.23	11	59.04	59.75
Peak	1815	1049	-150	675	677	58.1	550					616	58.18	0	58.90	233	58.79	698	58.15/63.4	623	58.14/62.4	unstable
Ipeak	1389	757	-150	650	616	57.96	550					536	58.05	0	58.90	497	58.21/61.43	610	58.03/63.1	610	58.03/63.1	unstable
Int	972	424	-150	410	402	57.99	410					402	57.99	0	59.08	260	58.44	398	58.1/63	398	58.05/63	59.08
Light	740	402	-150	190	160	58.39	190					160	58.39	0	59.52	0	59.25	39	58.85	121	58.62/60.95	59.57
ExLight	536	400	-46	90	70	58.6	90					70	58.6	0	59.80	0	59.66	0	59.49	0	59.41	59.80
Peak	1824	998	-320	650	652	58.1	550					616	58.18	0	58.90	448	58.43	674	58.15/63.4	645	58.14/63.13	58.95/63.3
Ipeak	1402	422	-320	625	614	57.97	500					480	58.13	0	59.00	410	58.35	509	58.13/62.4	509	58.14/62.5	58.84/63.0
Int	987	421	-320	250	223	58.40	250					223	58.40	0	59.52	0	58.99	86	58.5/60.5	163	58.4/63.0	59.43
Light	750	400	-260	90	60	58.77	90					60	58.77	0	59.80	0	59.60	0	59.41	0	59.25	59.80

Not included in plot since not a limiting case
Minimum IIS Generation

4.1.1 Unsuccessful restart of both poles

Two scenarios of DC line faults on both LIL poles were simulated:

1. Both DC line faults occur at the same time.
2. A DC fault occurs on one pole and the IIS frequency drops, and at the point in time when the IIS frequency has reached its minimum, the second LIL pole experiences a DC line fault.

In IIS conditions where the loss of both LIL poles does not result in all blocks of load being shed, the minimum frequency that occurs is lower and the amount of load that is shed is higher if the DC line faults are staggered, as shown in Figure 4–1. In this example, 249 MW of load was shed and frequency dips to 58.4 Hz if the line faults occur at the same time, and 318 MW of load was shed and frequency dips to 58.2 Hz if the pole faults are staggered.

However, if the loss of both LIL poles results in the 58 Hz block of load being shed, then there is no impact to the minimum frequency and the same amount of load is shed, whether the DC line faults occur simultaneously or staggered, as shown in Figure 4–2. The only difference is that the minimum frequency occurs later in time with the staggered DC faults scenario[18].

[18] Although not discussed in Section 3.1, which involves DC faults on both LIL poles for Stage 4D, similar conclusions regarding impact of staggered versus simultaneously occurring DC faults would apply to Stage 4D. The only difference in Stage 4D is that for all scenarios where the LIL is operating at its transfer limit, loss of the LIL bipole results in operation of the entire UFLS scheme. This is because there is less load shed in the existing UFLS scheme (Stage 4D) than in the redesigned UFLS scheme (Stage 4E), and all of that existing load shed is required to occur for Stage 4D transfer limits. If loss of the LIL bipole were simulated in Stage 4D with the LIL operating below the transfer limit and if that scenario did not require the entire UFLS scheme to occur, then, similar to the plots shown in Figure 4-1, more UFLS would occur in the case of the staggered DC faults, and hence, a lower minimum frequency.

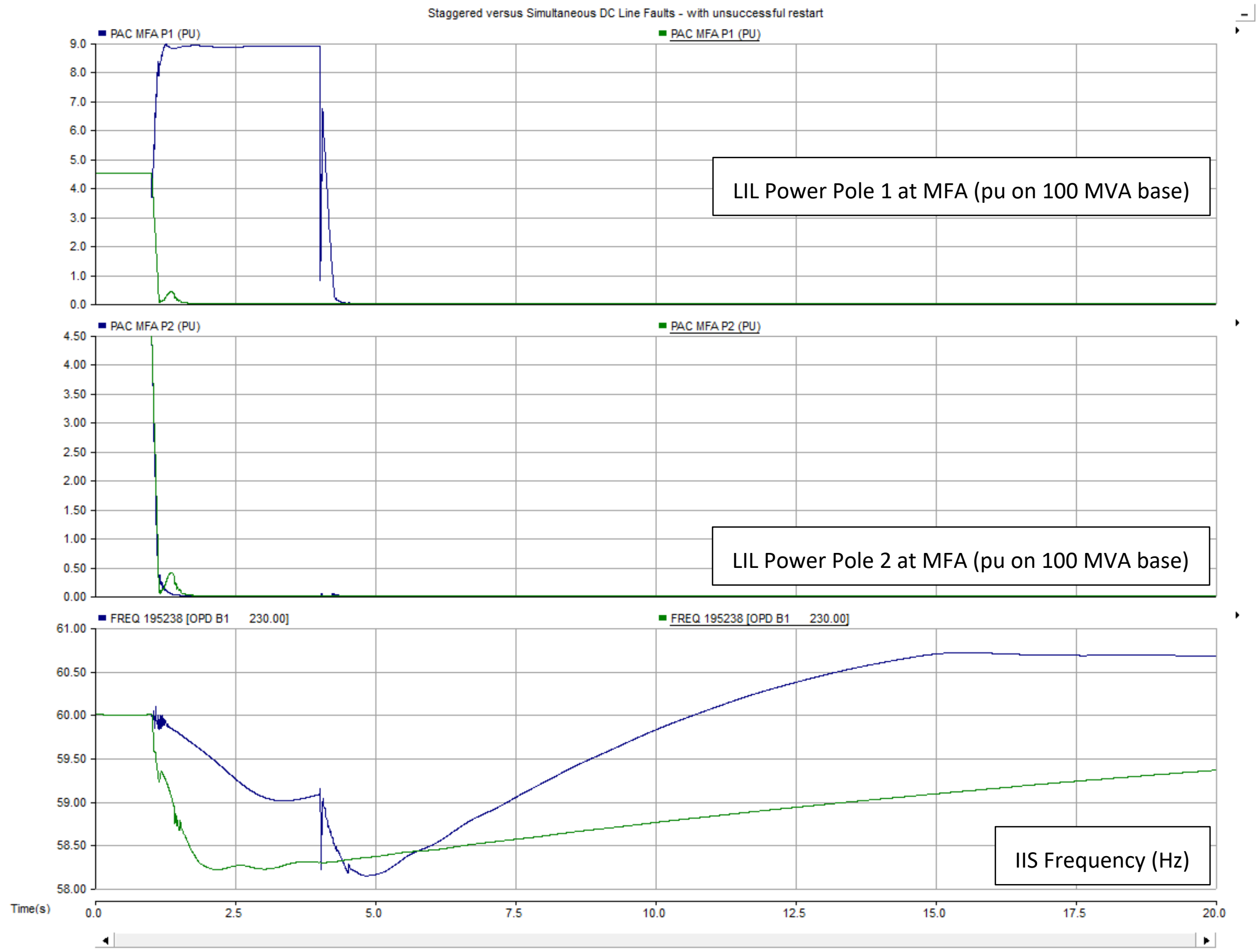


Figure 4–1. Simultaneous (green) versus staggered (blue) DC line faults, 58 Hz block of load not shed

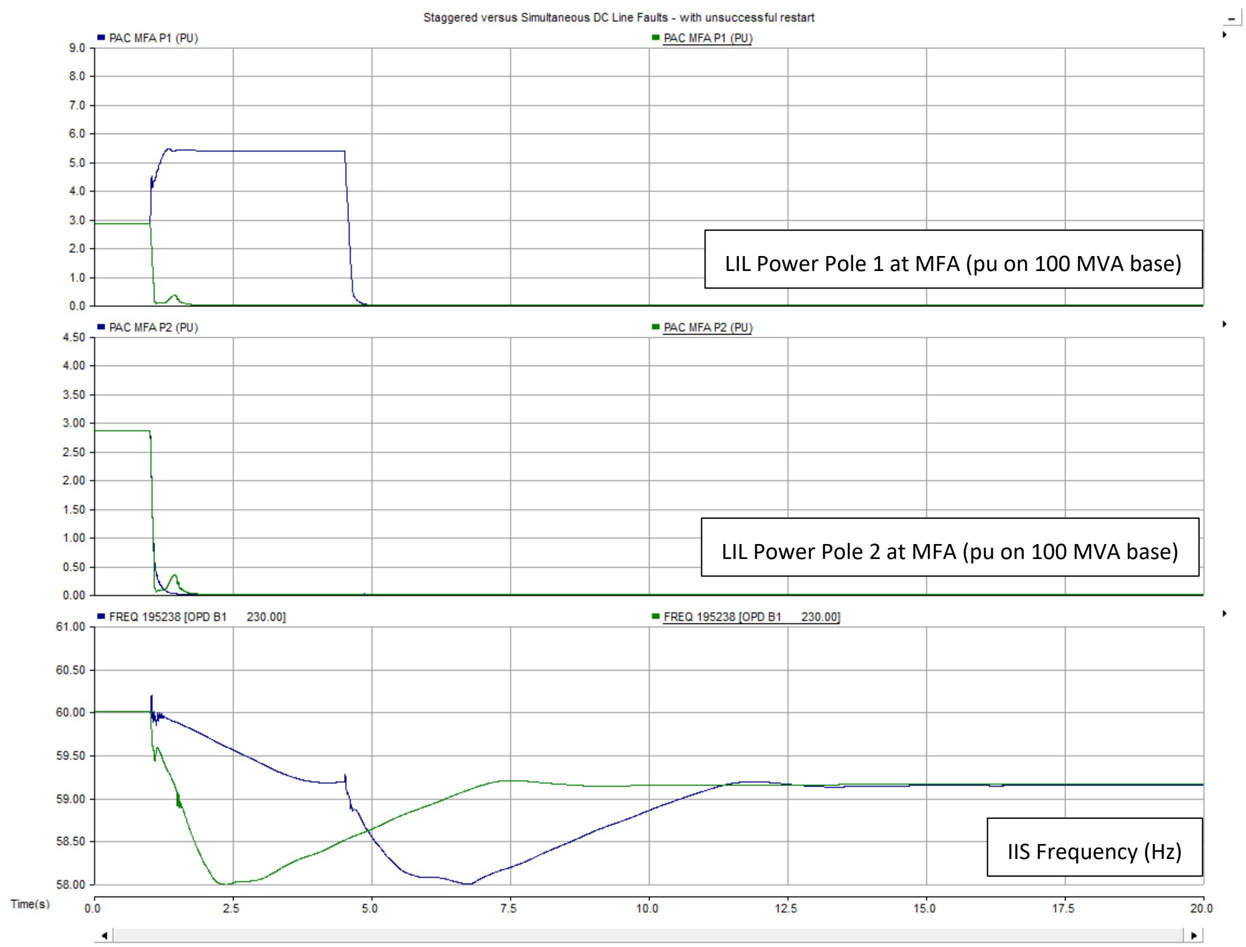


Figure 4–2. Simultaneous (green) versus staggered (blue) DC line faults, 58 Hz block of load is shed

The results for unsuccessful restart of both LIL poles (i.e. loss of the LIL bipole) are summarized below, based on ML transfer levels/direction. Please refer to Appendix 2 for a plot of LIL transfer limits versus IIS demand for long term operation (Stage 4E).

If ML Export > 150 MW:

If the ML frequency controller is in-service, the IIS frequency was acceptable with a 900 ms delay in ML runback if neither of the LIL poles successfully restart, which equates to two LIL restart attempts. If the ML frequency controller is out of service, the maximum number of LIL restart attempts is reduced to one.

If more LIL restart attempts are made, frequency greater than 62 Hz can occur, because more load is shed during the longer fault duration, prior to the LIL poles tripping to trigger ML runback, which can lead to frequency imbalance when the system recovers. Figure 4–3 shows an example comparing a case when the ML runback is delayed by two restart attempts (900 ms) and by three restart attempts (1400 ms). The scenario with three restart attempts results in frequency greater than 62 Hz after the LIL poles have tripped because more load was shed prior to the ML runback.

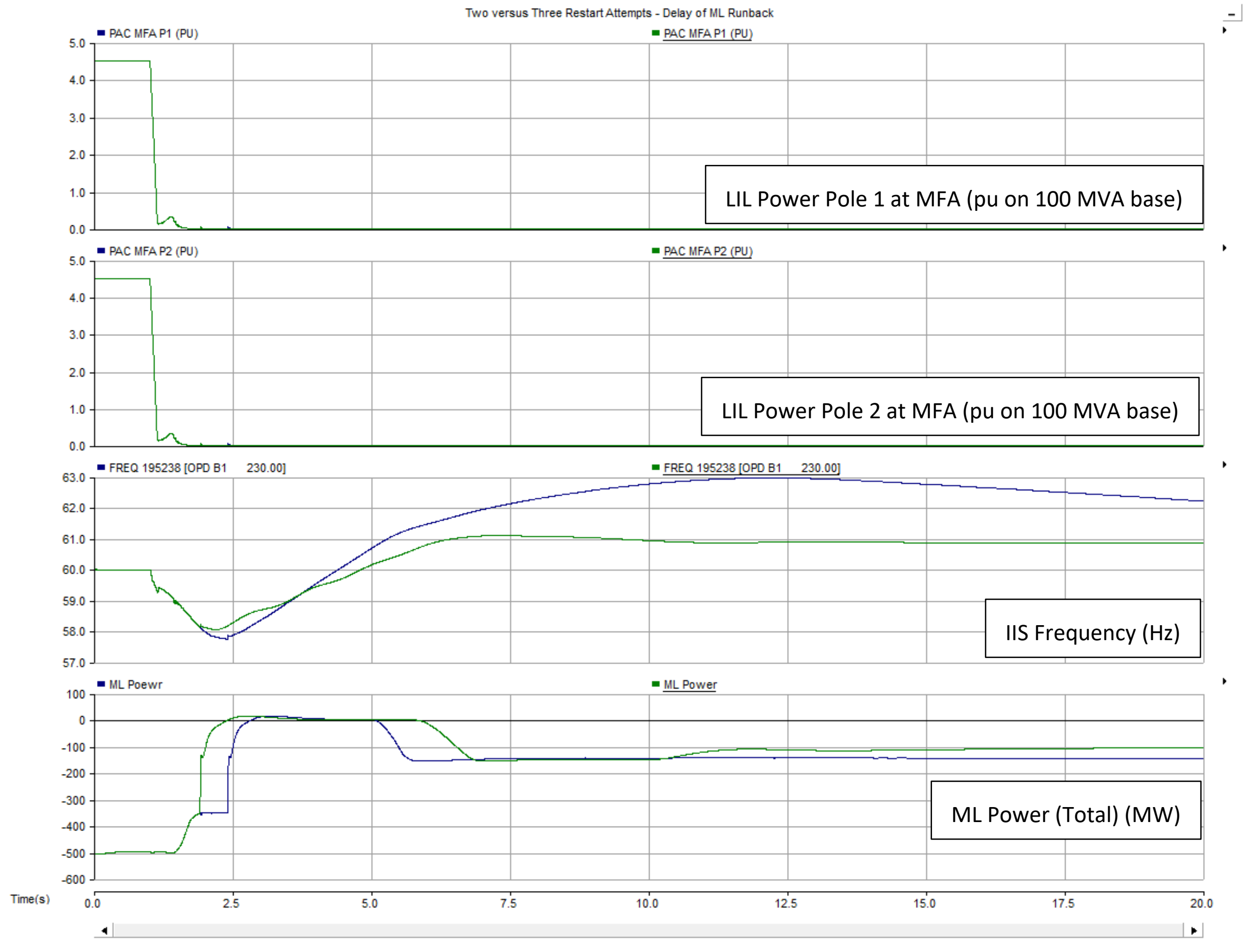


Figure 4–3. Example of delaying ML runback from two (green) to three (blue) restarts (ML frequency controller in-service)

If ML Export < 150 MW or ML Import:

If ML is exporting less than 150 MW or importing, ML runback is not utilized for loss of the LIL bipole, and all four restart attempts are allowable if neither of the LIL poles successfully restart. Figure 4–4 shows an example of allowing one restart attempt and four restart attempts – the response is the same.

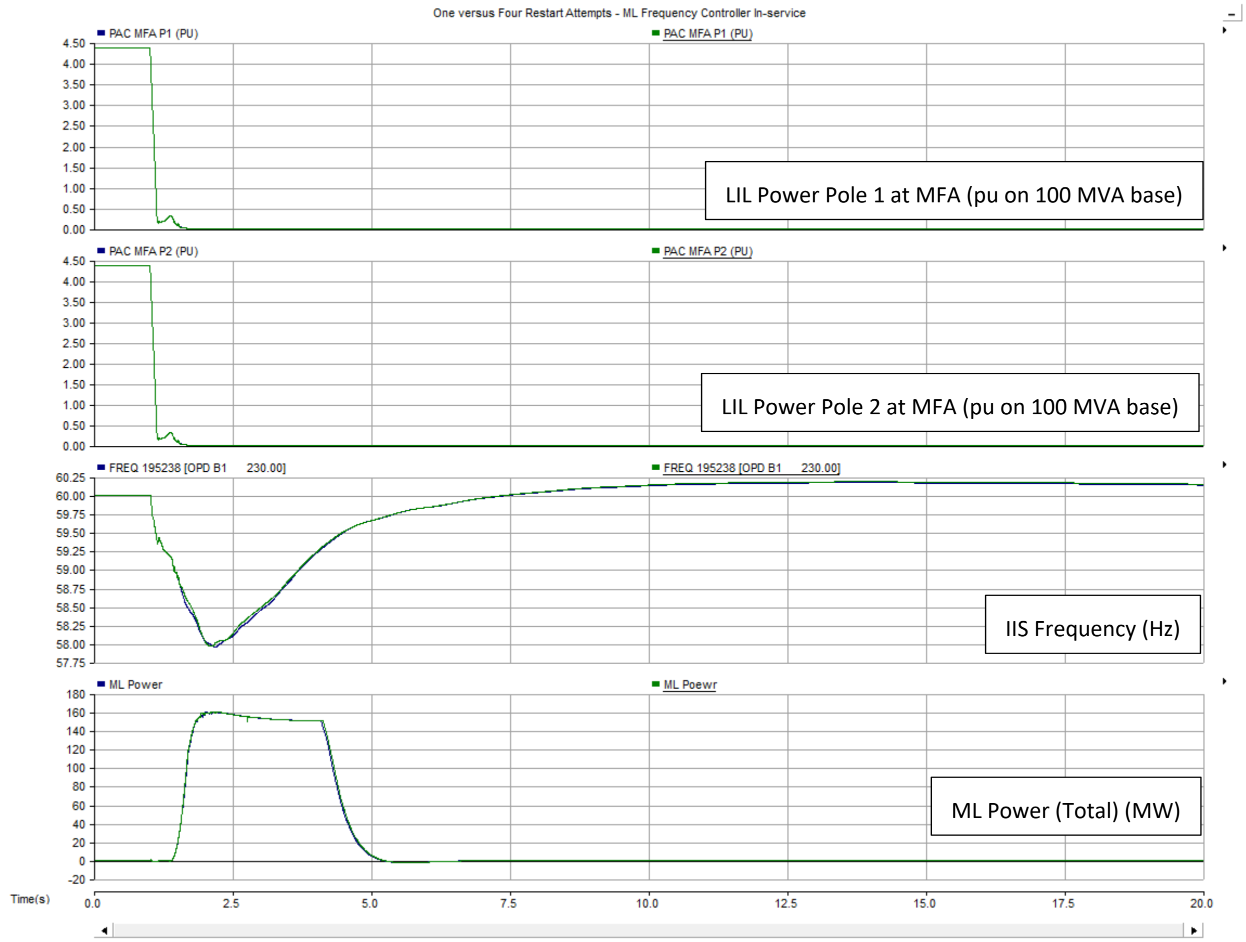


Figure 4–4. One versus Four Restart Attempts when ML runback not required (ML frequency controller in-service)

4.1.2 Successful restart of one or both poles

The most limiting scenario involving successful restart is when both poles successfully restart. This is because UFLS occurs during the simultaneous fault deionization period of both poles and if both poles successfully restart, the IIS can experience overfrequency if the LIL frequency controller is not in-service, as explained below.

LIL Frequency Controller In-Service

If the LIL frequency controller is in-service, the LIL poles will adjust their post-fault power transfer automatically after successfully restarting to control the IIS frequency and adjust for the fact that load was shed during the fault duration[19].

If ML Export > 150 MW:

Section 4.1.1 indicated a maximum of two restart attempts are allowed if the ML frequency controller is in-service and one restart attempt if the ML frequency controller is not in-service if

[19] It is noted that the voltage and frequency performance in the Labrador system were observed to be acceptable in this study for the loss of LIL bipole and for DC line faults with successful restart and subsequent LIL frequency controller action.

both neither pole successfully restarts and the LIL bipole trips. These same number of restart attempts was tested and found to be acceptable for successful restart of both poles as well.

If ML Export < 150 MW or ML Import:
Section 4.1.1 indicated that all four restart attempts are permitted if the LIL bipole trips.

If ML Frequency controller is in-service: All four restart attempts are also permitted if both LIL poles successfully restart. Figure 4–5 shows an example of the LIL frequency controller adjusting LIL power transfer to minimum LIL power (45 MW per pole) after successfully restarting on the fourth attempt into a system that has shed the 58 Hz block of load. IIS frequency remains within Transmission Planning Criteria and therefore four restart attempts are permitted.

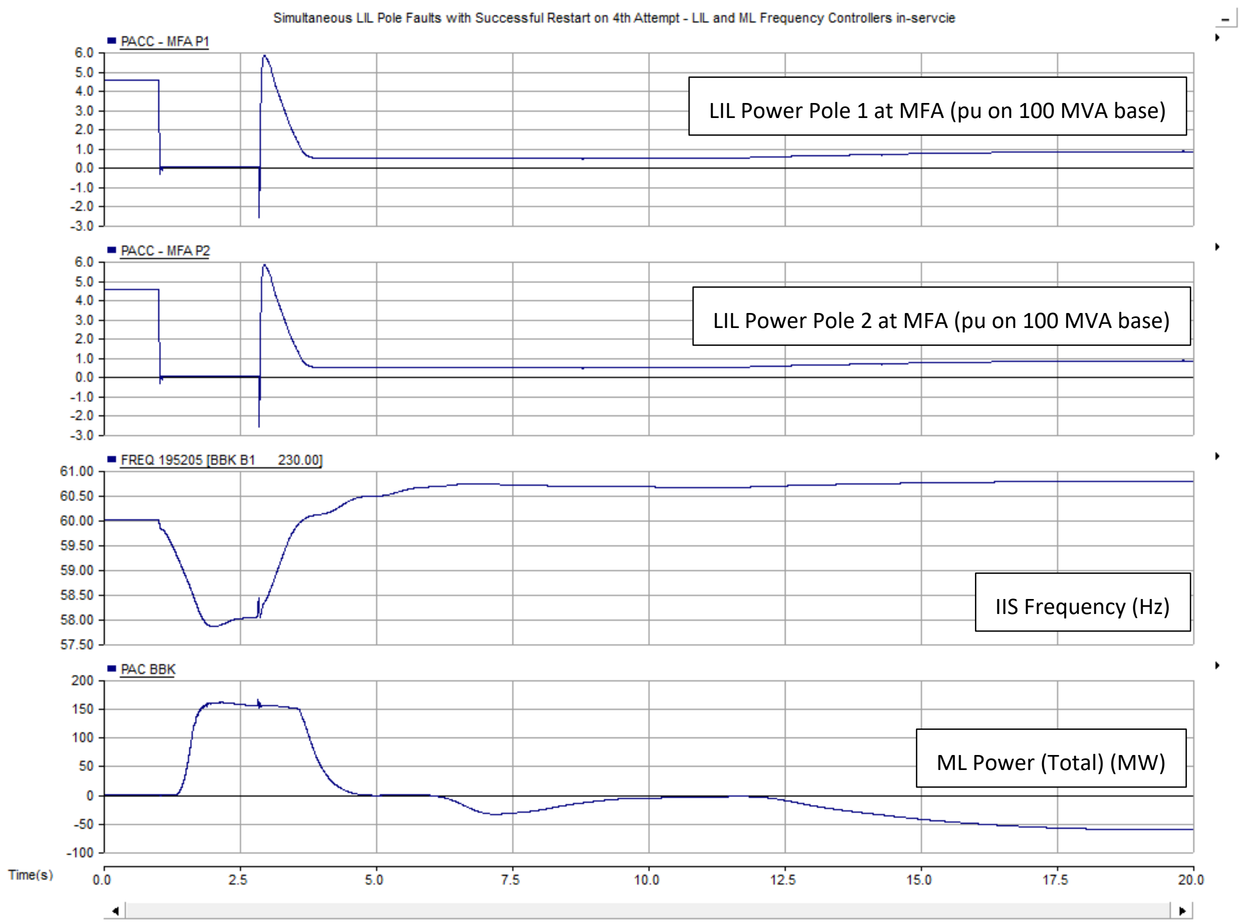


Figure 4–5. Successful restart after 4th attempt, LIL frequency controller in-service

If the ML frequency controller is not in-service: Only two restart attempts are permitted. If more than two restart attempts are permitted, too much loadshed can occur during the faults and, when the LIL poles successfully restart, the LIL frequency controller does not have sufficient room to reduce the LIL power transfer to avoid IIS frequencies greater than 62 Hz. In case higher LIL power transfers are required in this scenario, Table 4-2 also lists the LIL transfer limits that are permissible when the ML frequency controller is out of service if LIL restarts are disabled.

LIL Frequency Controller not in-service

If the LIL frequency controller is not in-service, the LIL poles recover to their pre-fault power transfer levels and the IIS can experience large overfrequency because of the UFLS that takes place during the DC line faults. In this case, if the ML frequency controller is in-service, restart attempts are limited to one, as demonstrated in Figure 4–6. If the ML frequency controller is not in-service, no restart attempts are permitted since the overfrequency cannot be controlled when the LIL poles restart to their pre-fault transfer level.

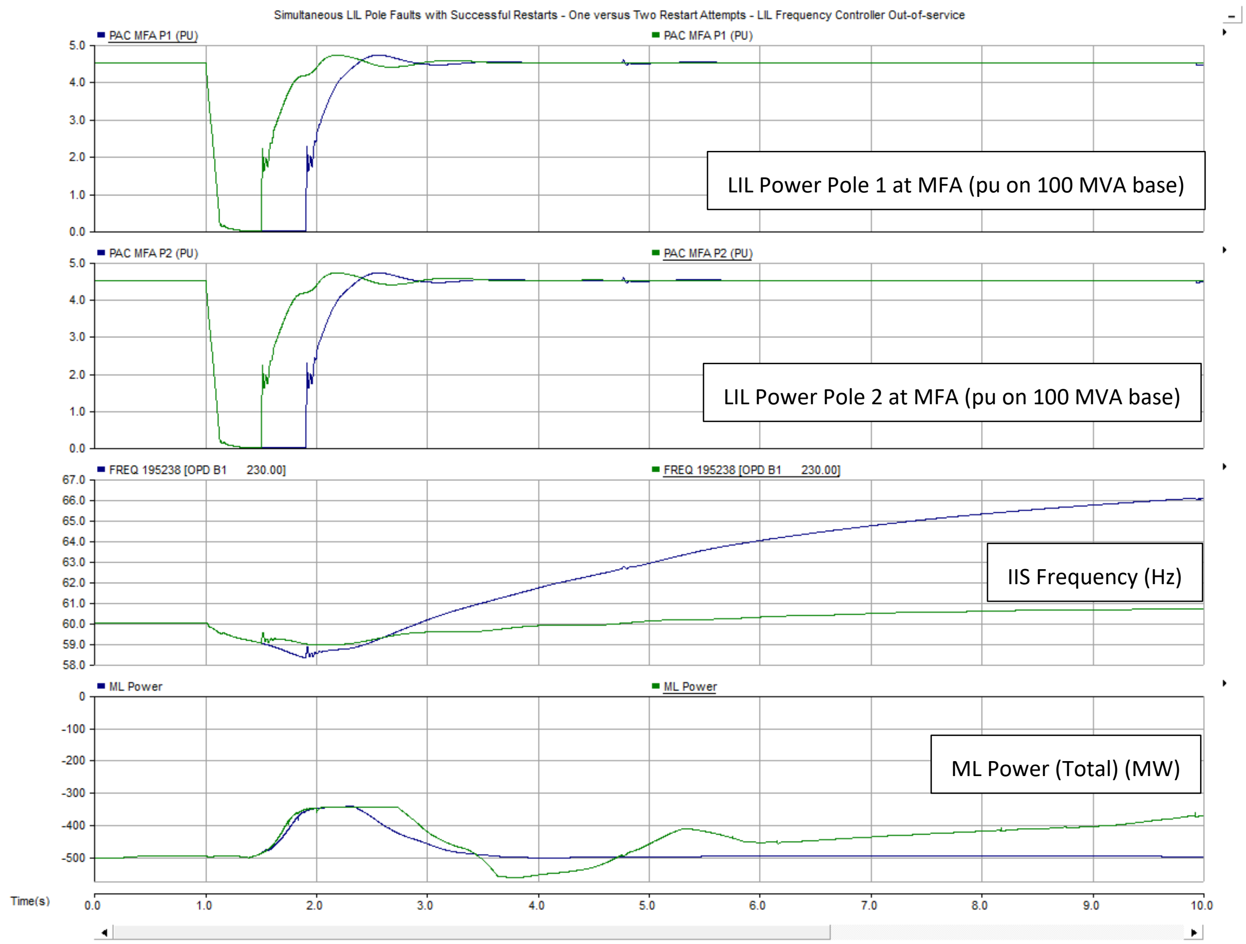


Figure 4–6. Successful restart after one (green) and two (blue) restart attempts, LIL frequency controller not in-service, ML frequency controller in-service

4.2 DC Fault on One Pole

A DC line fault on one pole with unsuccessful restart was simulated to determine how long of a delay is permissible between the inception of the fault and the pole tripping, which triggers the ML to runback (if the ML is exporting). The length of that delay determines the number of LIL restart attempts that are allowable, in order to ensure IIS frequency does not drop below 59 Hz.

With the 2 pu overload functionality available, pole compensation on the healthy LIL pole can be up to 2 pu, and the LIL frequency controller will also provide additional support as needed (within the 2 pu short-term overload rating). The LIL pole compensation doubles the DC current order of the healthy LIL pole when the other LIL pole is faulted and/or trips, up to a maximum of 2 pu DC current.

Even with the 2 pu overload capability available, loss of a LIL pole will trigger an ML runback to a specified amount based on the pre-contingency LIL transfer level if the ML is exporting. The ML runback covers the net loss of infeed at SOP that occurs because of increased losses on the LIL during the 2 pu overload operation on one pole. If the ML is importing, the ML controller (if in-service) is available to support IIS frequency.

The results of the loss of a LIL pole analysis with delayed ML runback are summarized in Table 4-3, and discussed below.

LIL Frequency Controller In-Service

If ML Export > 150 MW:
Section 4.1.1 indicated a maximum of two restart attempts are allowed if the ML frequency controller is in-service and one restart attempt if the ML frequency controller is not in-service. The same number of restart attempts were tested and found to be acceptable for loss of a LIL pole as well.

If ML Export < 150 MW or ML Import:
Section 4.1.2 indicated that all four restart attempts are permitted if the ML frequency controller is in-service, and one restart attempt if the ML frequency controller is not in-service. The same number of restart attempts were tested and found to be acceptable for loss of a LIL pole as well.

LIL Frequency Controller Out-of-Service

Section 4.1.2 indicated that if the ML frequency controller is in-service, but LIL frequency controller is not in-service, restart attempts are limited to one. If the ML frequency controller and the LIL frequency controller are both out of service, no restart attempts are permitted. The same number of restart attempts were tested and found to be acceptable for loss of a LIL pole as well.

Table 4-3. Loss of a LIL Pole – Long Term Operation

					ML FREQUENCY CONTROLLER IN-SERVICE				ML FRQEQUENCY CONTROLLER OUT-OF-SERVICE			
					LIL FREQUENCY CONTROLLER IN			LIL FREQUENCY CONTROLLER OUT		LIL FREQUENCY CONTROLLER IN		
					Loss of LIL Pole					Loss of LIL Pole		
					Two Restarts (900ms)		Four Restarts	Two Restarts		One Restart (500ms)		Four Restarts
	Demand (MW)	Generation (MW)	ML (MW)	LIL Transfer Limit (MW)	ML Runback (MW)	Minimum/ Maximum Frequency (Hz)	Minimum/ Maximum Frequency (Hz)	Minimum/ Maximum Frequency (Hz)	LIL Transfer Limit (MW)	ML Runback (MW)	Minimum/ Maximum Frequency (Hz)	Minimum/ Maximum Frequency (Hz)
Peak	1866	1530	500	900	130	59.48	59.18	59.48	900	130	59.63	59.16
Ipeak	1428	1094	500	900	130	59.41	59.10	59.41	900	130	59.61	59.05
Int	1038	703	500	900	130	59.29	58.99	59.29	900	130	59.49	58.79
Light	812	476	500	900	130	59.21	58.95	59.21	900	130	59.34	58.73
ExLight	575	401	500	750	94	59.49	59.27	59.45	750	94	59.69	59.26
Peak	1821	1285	300	900	130	59.36	59.13	59.36	900	130	59.50	59.09
Ipeak	1400	915	300	900	130	59.29	59.00	59.29	900	130	59.34	58.82
Int	994	589	300	810	106	59.46	59.19	59.32	810	106	59.62	59.15
Light	760	452	300	690	81	59.57	59.36	59.54	690	81	59.69	59.36
ExLight	553	409	300	470	43	59.77	59.61	59.77	470	43	59.84	59.61
Peak	1815	1303	158	900	130	59.34	59.10	59.34	900	130	59.46	59.04
Ipeak	1391	889	158	850	116	59.49	59.16	59.49	850	116	59.67	59.12
Int	980	548	158	650	72	59.61	59.43	59.45	650	72	59.65	59.43
Light	742	433	158	500	48	59.69	59.59	59.69	500	48	59.76	59.59
ExLight	537	402	158	300	20	59.90	59.83	59.90	300	20	59.94	59.83
Peak	1820	1330	0	900			59.06	59.06	700			59.34
Ipeak	1391	906	0	840			59.10	59.02	700			59.29
Int	972	538	0	575			59.45	59.22	450			59.52
Light	734	403	0	340			59.64	59.48	340			59.65
ExLight	535	404	0	130			59.99	59.99	130			59.99
Peak	1815	1049	-150	900			59.04	59.04	700			59.36
Ipeak	1389	757	-150	820			59.13	59.02	700			59.30
Int	972	424	-150	410			59.57	59.27	410			59.57
Light	740	402	-150	190			59.67	59.67	190			59.67
ExLight	536	400	-46	90			59.99	59.99	90			59.99
Peak	1824	998	-320	700			59.10	58.76	700			59.10
Ipeak	1402	422	-320	680			59.30	58.76	680			59.30
Int	987	421	-320	250			59.67	59.60	250			59.67
Light	750	400	-260	90			59.93	59.93	90			59.93

At min generation, not at a transfer limit

Minimum IIS Generation

4.3 Summary of Permissible LIL Restart Attempts (Stage 4E)

The number of LIL restarts permitted for long term operation (Stage 4E) is summarized in Table 4-4 based on ML transfer, and status of the ML and LIL frequency controllers.

Table 4-4. Stage 4E – Number of LIL Restart Attempts Permitted

Frequency Controller Status		Number of LIL restarts allowed	ML Transfer	Reason to limit the number of LIL restarts
ML	**LIL**			
IN	IN	2	ML export > 150 MW	If delayed by more than 900 ms (2 restarts), the system may not recover from the underfrequency if neither pole recovers. Additionally, if the system does recover after the LIL poles have tripped, there is potential for large overfrequency to occur. This is because all of the UFLS scheme has operated in addition to the full runback of ML export, which is more than what is required in some cases.
		4	ML export < 150 MW or ML import	Because an ML runback is not utilized (and is therefore not delayed due to restart attempts), all 4 LIL restart attempts can be used since delaying the tripping of the pole(s) has no impact on the system response if neither pole successfully restarts. Additionally, if one or both poles successfully restart, the LIL and ML frequency controllers are able to keep the IIS frequency < 62 Hz after the successful pole restart(s) considering the UFLS that takes place if there are faults on both LIL poles, and the post-event system is left with lower demand that the pre-event system.
IN	OUT	1	All ML transfer levels	Without the LIL frequency controller, a large overfrequency and potential for system instability occurs if both LIL poles successfully recover after both LIL poles were faulted if more than 1 restart attempt (500 ms) is allowed, due to the large amount of load that is shed if up to 2 restart attempts (900ms) were allowed.
OUT	IN	1	ML export > 150 MW	Without the ML frequency controller, a large overfrequency occurs if LIL bipole trips (i.e. neither pole successfully recovers) if more than 1 restart attempt (500ms) is allowed. This is because all of the UFLS scheme has operated in addition to the full runback of ML export, which is more than what is required under high ML export scenarios.
		2[20]	ML export < 150 MW or ML import	If the ML frequency controller is not in service, frequency greater than 62 Hz occurs under high IIS demand conditions because too much loadshed can occur when there are faults on both LIL poles and when both poles successfully recover as there is not enough room to reduce LIL transfer sufficiently after restarting.

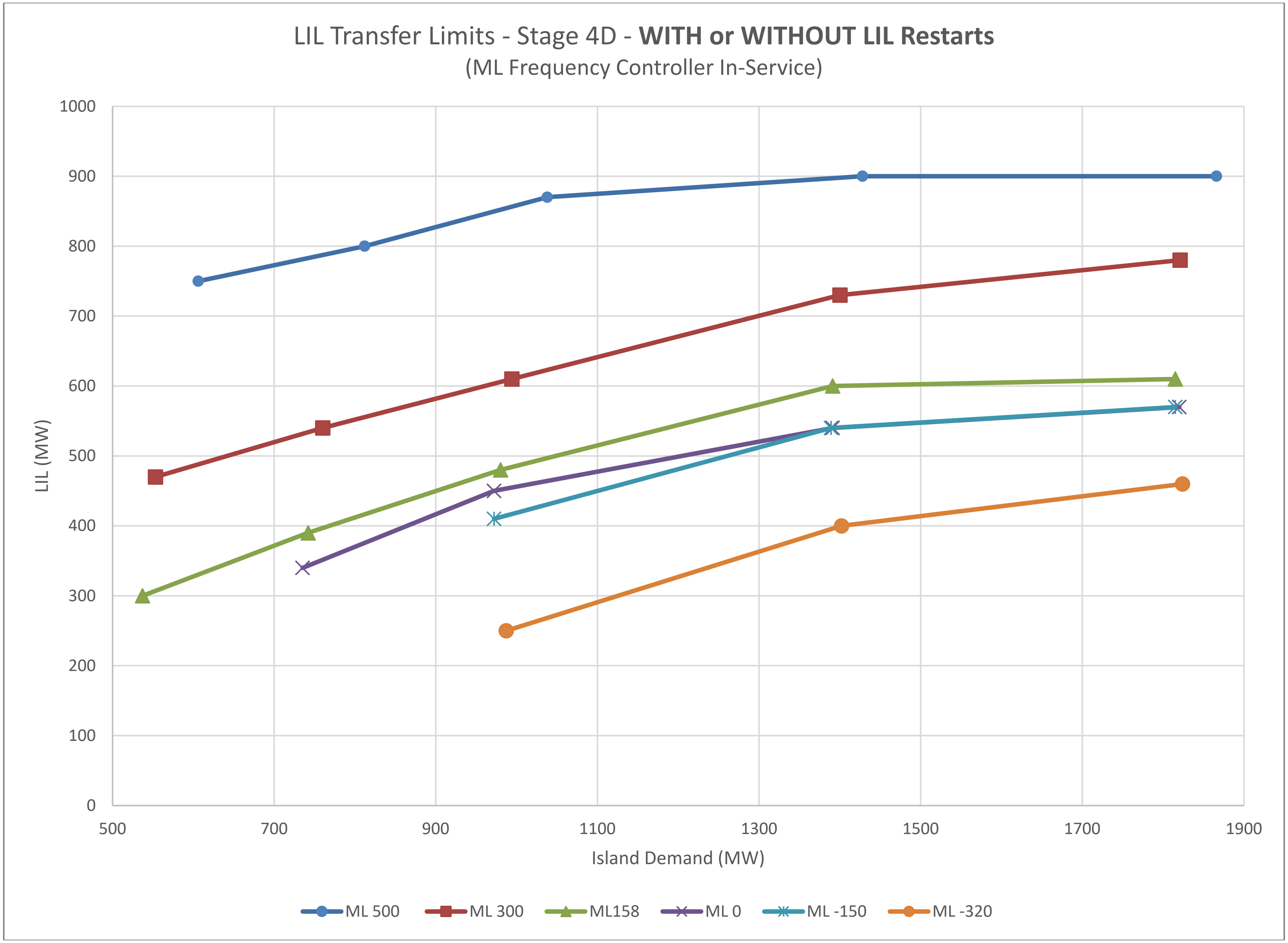
[20] Please note that Table 4-2 and Appendix 2 provides an alternative set of increased LIL transfer limits for this scenario if LIL restarts are disabled. The Operator may select the appropriate mode of operation based on system conditions.

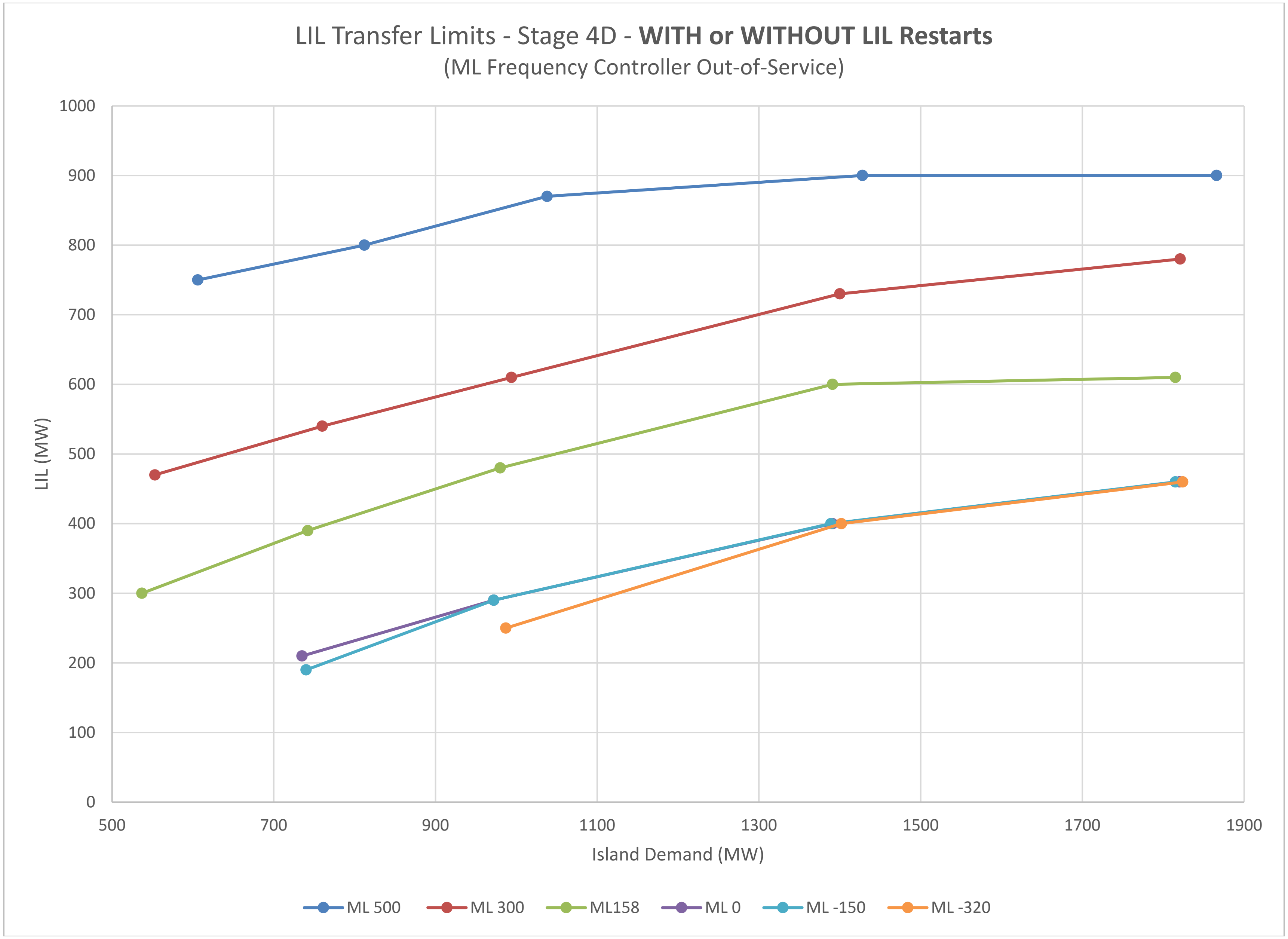
Frequency Controller Status		Number of LIL restarts allowed	ML Transfer	Reason to limit the number of LIL restarts
ML	**LIL**			
OUT	OUT	0	All ML transfer levels	If neither frequency controller is in-service, a large overfrequency can occur if one or both LIL poles successfully restart after both poles have been faulted due to the load that is shed during the time when both poles are faulted.

APPENDIX 1

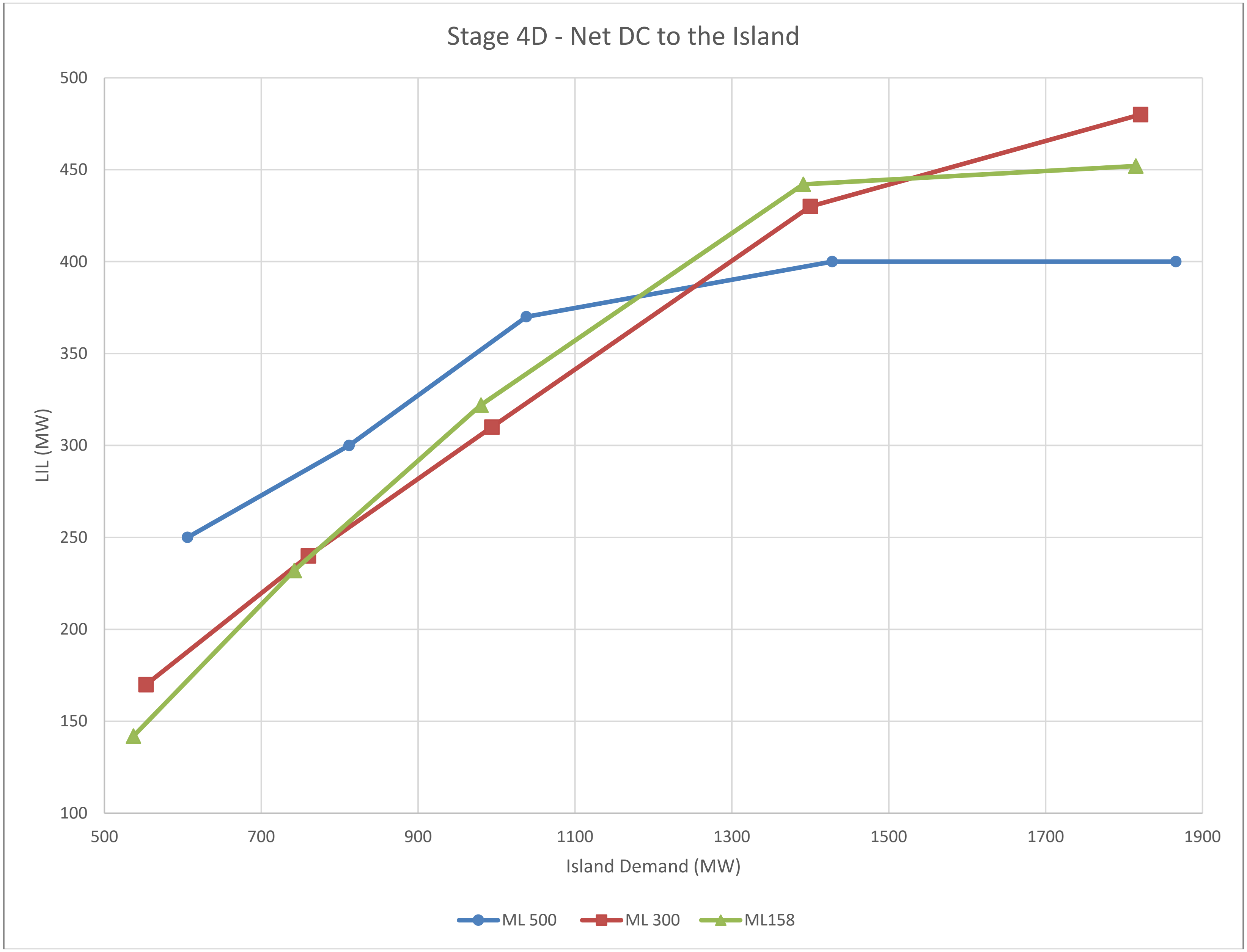
Stage 4D LIL Transfer Limits

*LIL transfer limits are the same with and without LIL restarts enabled.


LIL Transfer Limits - Stage 4D - **WITH or WITHOUT LIL Restarts**
(ML Frequency Controller In-Service)
1000
900
800
700
600
500
400
300
200
100
0
LIL (MW)
500
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158
ML 0
ML -150
ML -320



LIL Transfer Limits - Stage 4D - **WITH or WITHOUT LIL Restarts**
(ML Frequency Controller Out-of-Service)
LIL (MW)
1000
900
800
700
600
500
400
300
200
100
0
500
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158
ML 0
ML -150
ML -320

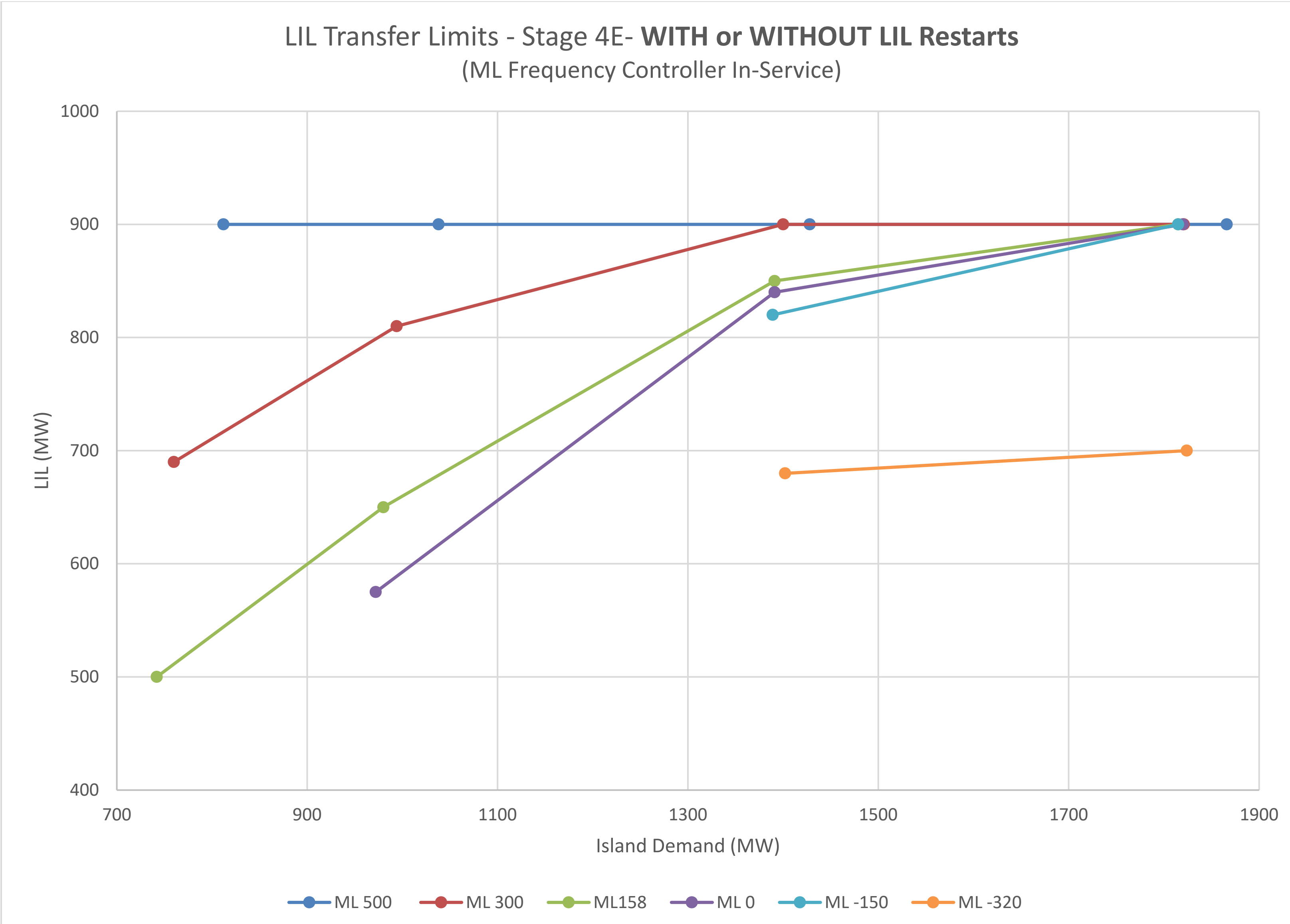


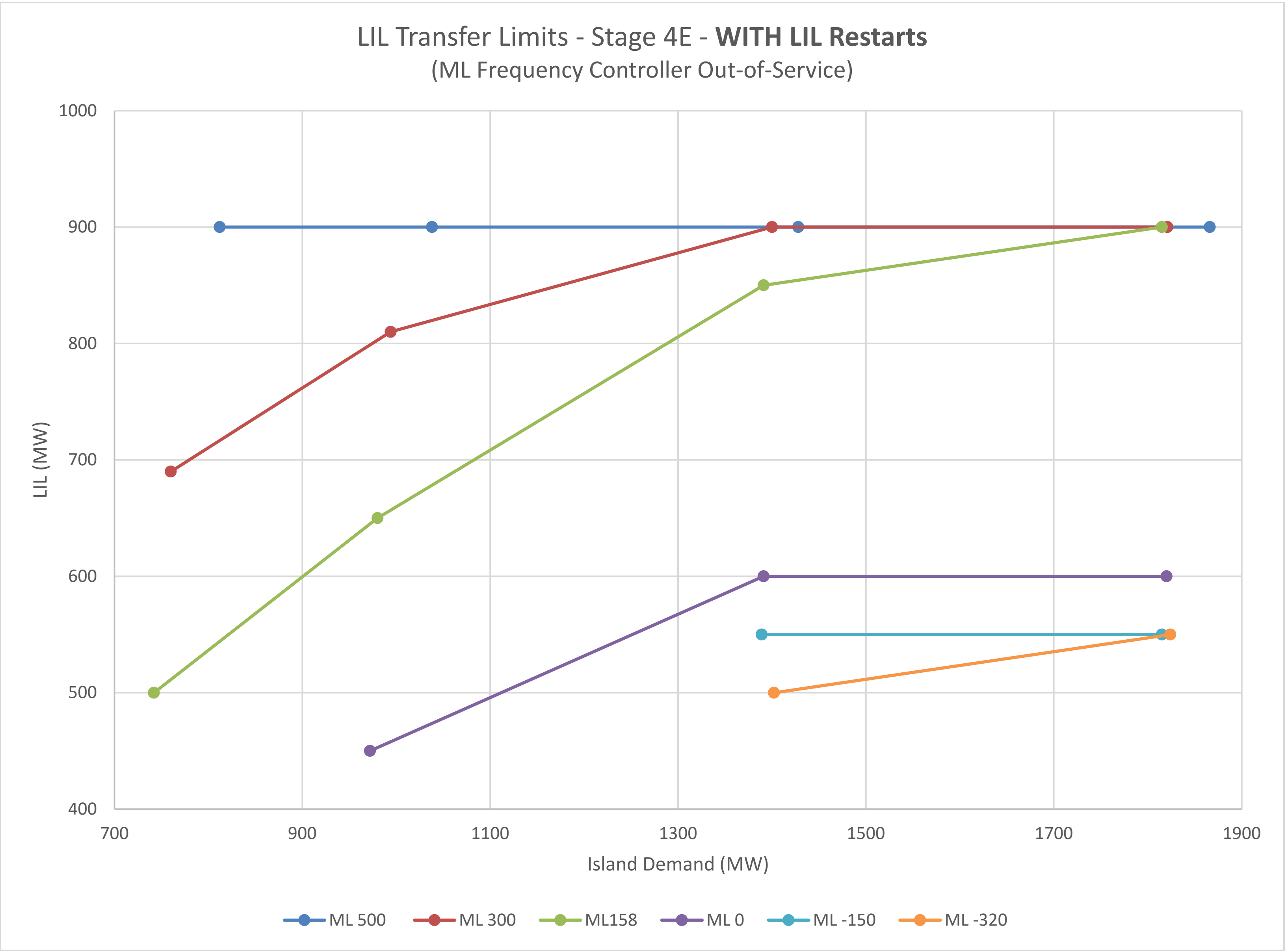
Stage 4D - Net DC to the Island
500
450
400
350
300
250
200
150
100
LIL (MW)
500
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158

APPENDIX 2

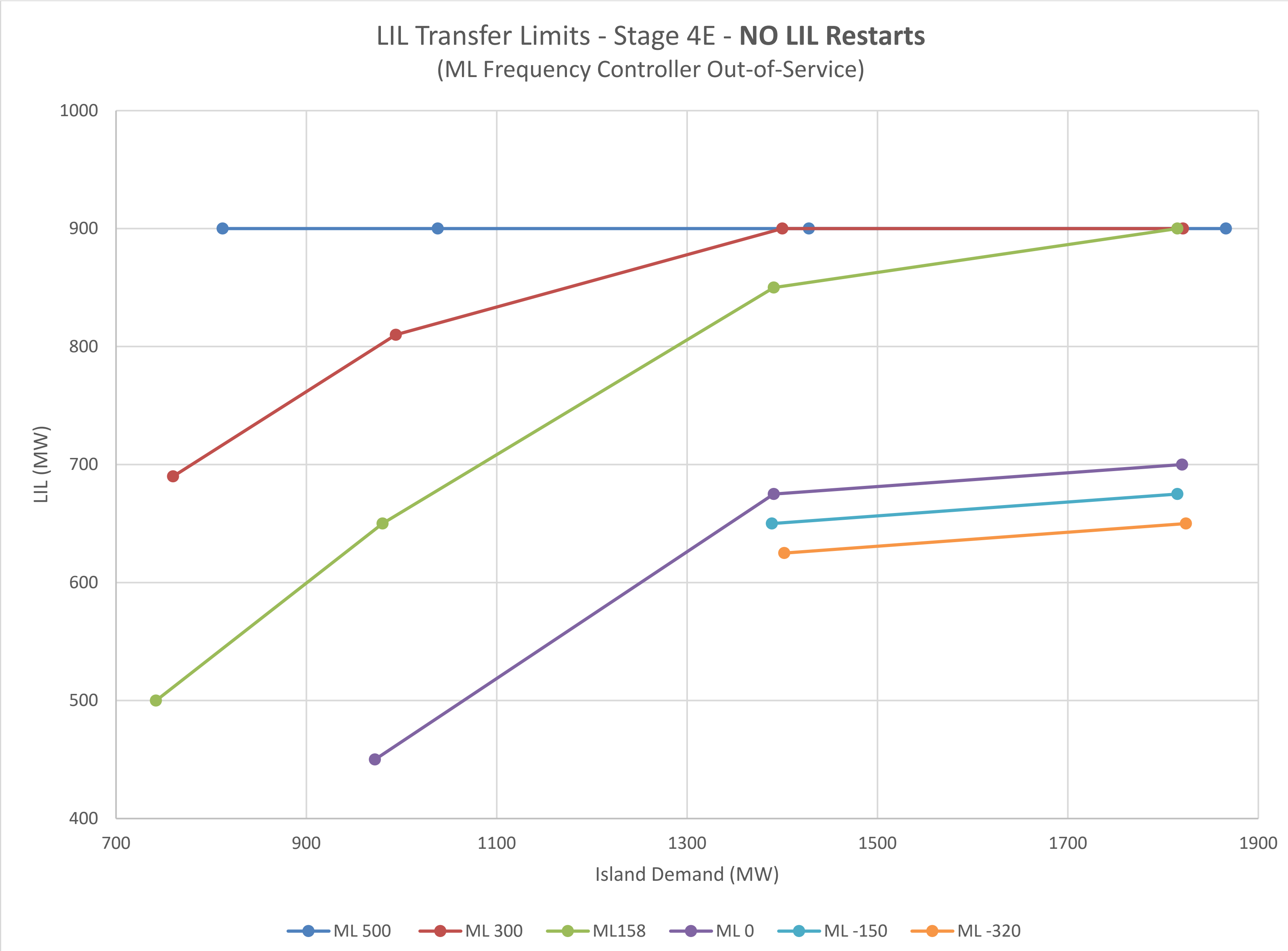
Stage 4E LIL Transfer Limits

*LIL transfer limits are the same with and without LIL restarts enabled, except as provided for the scenario when the ML frequency controller is not in-service.

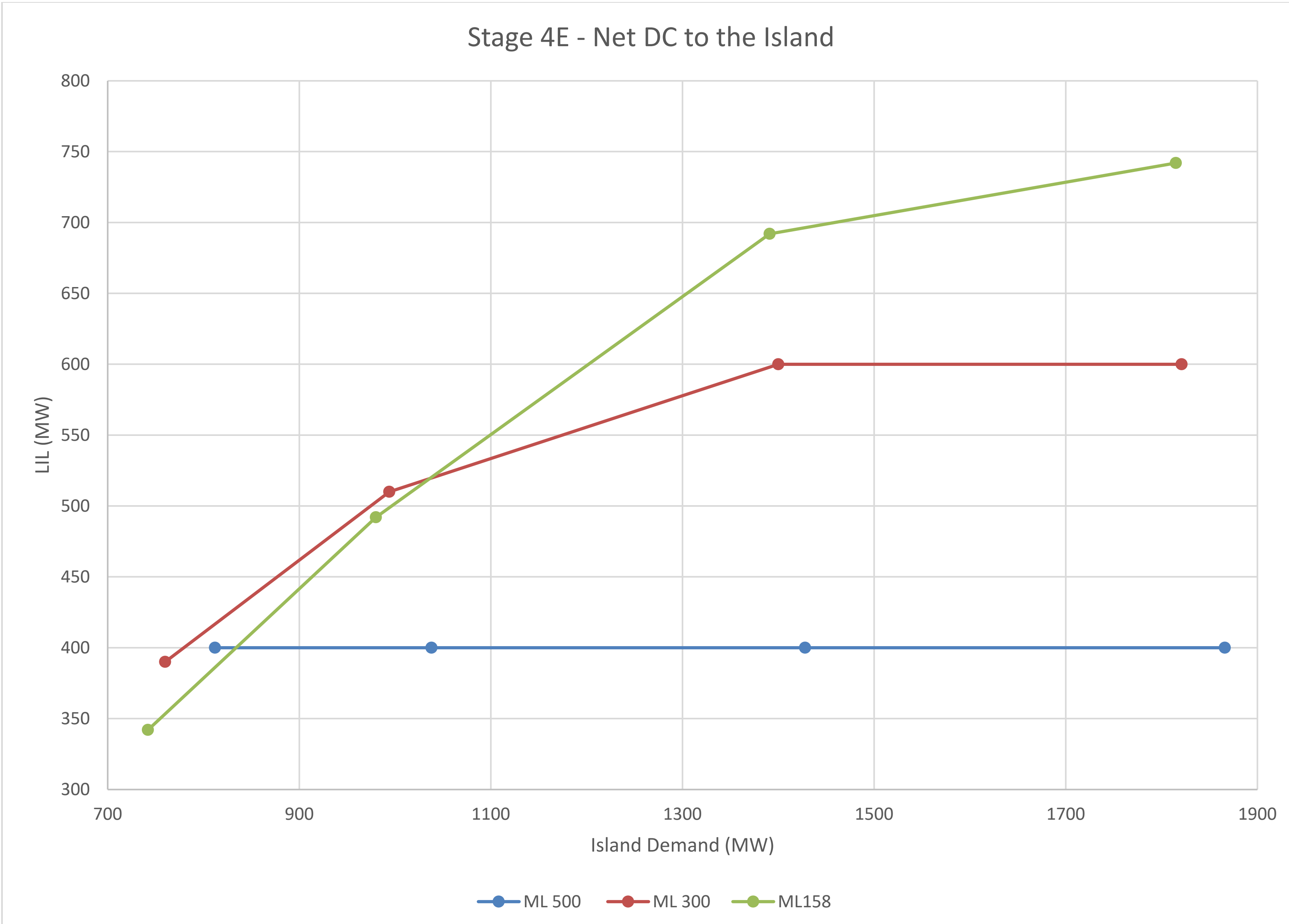

LIL Transfer Limits - Stage 4E- **WITH or WITHOUT LIL Restarts**
(ML Frequency Controller In-Service)
1000
900
800
700
600
500
400
LIL (MW)
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158
ML 0
ML -150
ML -320



LIL Transfer Limits - Stage 4E - **WITH LIL Restarts**
(ML Frequency Controller Out-of-Service)
1000
900
800
700
600
500
400
LIL (MW)
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158
ML 0
ML -150
ML -320



LIL Transfer Limits - Stage 4E - **NO LIL Restarts**
(ML Frequency Controller Out-of-Service)
1000
900
800
700
600
500
400
LIL (MW)
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158
ML 0
ML -150
ML -320


Stage 4E - Net DC to the Island
800
750
700
650
600
550
500
450
400
350
300
LIL (MW)
700
900
1100
1300
1500
1700
1900
Island Demand (MW)
ML 500
ML 300
ML158

Engineering Support Services for:

RFI Studies

Newfoundland and Labrador Hydro

Attention: Mr. Rob Collett

Critical Clearing Time Study (138 kV / 66 kV Systems)

Technical Note: TN1205.81.06
Date of issue: March 20, 2021

Prepared By:
TransGrid Solutions Inc.
100-78 Innovation Dr.
Winnipeg, MB R3T 6C2
CANADA

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Revisions

Project Name:	RFI Studies
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00	DFC	R. Ostash / R. Brandt	C. Karawita	November 6, 2020	Draft Issued for review by Hydro
01	DFC	R. Ostash / R. Brandt		November 16, 2020	Draft report updated with results for CCT for SLGFs
02	IFA	R. Ostash / R. Brandt		February 3, 2021	Report updated with CCT results in 138 kV/66 kV loop between Sunnyside and Stony Brook, with system updates in that area.
03	IFA	R. Ostash / R. Brandt		February 18, 2021	Report updated based on comments received Feb 18.
04	IFA	R. Ostash / R. Brandt		February 19, 2021	Report updated based on comments received Feb 19.
05	IFA	R. Ostash / R. Brandt		March 17, 2021	Report updated to include NL Hydro's 66 kV and 138 kV buses.
06	ABC	R. Ostash / R. Brandt		March 20, 2021	Report finalized based on comments from Executive review.

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Issued for Comments	IFC	Returned for Correction	RFC

Table of Contents

1. Summary

The purpose of this study is to identify the critical clearing times ("CCT") on all 138 kV and 66 kV buses within the Island Interconnected System ("IIS"). Critical clearing times are the longest duration a fault can be present at a certain location before Transmission Planning Criteria on the bulk IIS is violated.

This technical note provides:

- A table of CCT results for each bus (Table 3-1 in Section 3)
- The criteria applicable to the bulk IIS that was used to determine the CCT (Section 2.2)
- The study procedure used to determine the CCTs (Section 2.3)
- The PSSE base cases used to perform the study (Section 2.1).

2. Study Methodology

2.1 Base Cases

The 230 kV network of the IIS is shown in Figure 2–1.

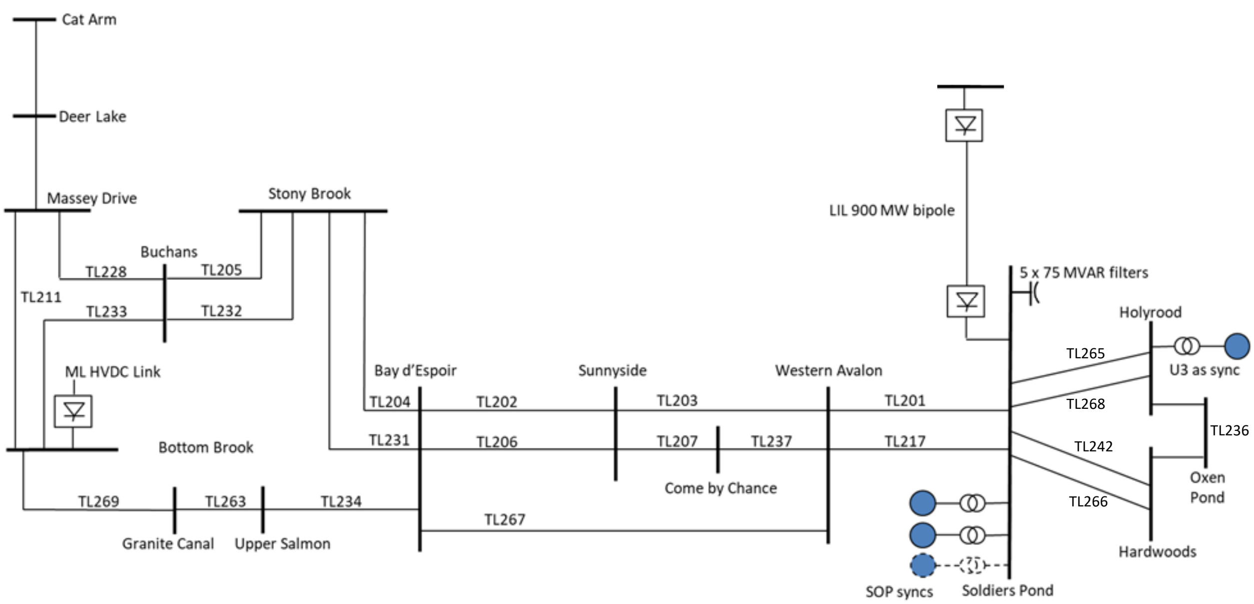

Figure 2–1. Interconnected Island System 230 kV grid

Three base cases were used to perform this study: Light, Intermediate and Peak demand scenarios as summarized in Table 2-1. A variety of LIL and ML transfers were considered.

Table 2-1. Base cases

Load Condition	Island Demand (MW)[1]	Island Generation (MW)	LIL Power Transfer (at MFA) (MW)	ML Power Transfer (at BBK) (MW)
Peak	1802	993	870	0
Intermediate	1391	536	560	-320
Light	811	478	900	500

2.2 Study Assumptions

The following assumptions are made for this study:

- Thermal generation from HRD units (1,2,3) is decommissioned. HRD unit 3 is operating as a synchronous condenser.
- Two Soldiers Pond synchronous condensers are in-service.

[1] Island Demand includes load and losses.

- LIL frequency controller is in-service.
- ML frequency controller is in-service.
- A new Newfoundland Power substation near the airport was not included in the cases in this study. AIR station is proposed to be installed between OPD (195654) and KEN (196565) stations, tapping off of 35L. Analysis for the CCT of this station can be performed at the time of approval. The analysis provided in this report for the OPD and KEN stations can provide a good indication of the expected CCT at the AIR station.
- The study was performed with the power system stabilizers (PSSes) in the system enabled. Sensitivity analysis was performed without the PSSes on select CCTs, and the impact of the PSSes on these CCTs was observed to be minimal.

2.3 Study Criteria

The following Transmission Planning Criteria are applicable to this study and are monitored for the bulk transmission system (230 kV).

- Post fault recovery voltages on the ac system shall be as follows:
  - Transient undervoltages following fault clearing should not drop below 70%
  - The duration of the voltage below 80% following fault clearing should not exceed 20 cycles
- Post fault system frequencies shall not drop below 58 Hz and shall not rise above 62 Hz
- Voltage variations should remain within the criteria defined in Table 2-2.

Table 2-2. Power Frequency Voltage Variations During Transient Conditions

Power Frequency Voltage Variations During Transient Conditions – Island of Newfoundland	
Voltage (pu)	**Duration**
V = 0.00	0.15 seconds
0. 0 ≤ V < 0.80	1 second
0.85 ≤ V < 0.90	300 seconds
0.90 ≤ V < 1.10	Steady State
1.10 ≤ V < 1.20	3 seconds
1.10 ≤ V < 1.30	0.5 seconds
1.30 ≤ V < 1.50	0.1 seconds

2.4 Study Procedure

Typically, the critical clearing time (CCT) is defined as the longest fault clearing time for a particular contingency in order to maintain transient stability of the system (i.e. stable recovery from fault). However, limits for reliable operation as specified in the system performance criteria defined in Section

2.3 force the CCT to be more stringent. In this study, the CCT values were determined in order to ensure Transmission Planning Criteria is met on the 230 kV bulk system.

Typically, the CCT would be defined for a particular contingency, for example a 66 kV line fault. However, this study is looking at the impact on the 230 kV bulk system from faults on the 66 kV or 138 kV network, and it was found that whether the fault is a 138 kV or 66 kV bus fault or whether is it a 138 kV or 66 kV line fault, the fault had the same impact on the bulk system (i.e. whether the 66 kV line was tripped to clear the fault, or whether the fault was applied to a bus and cleared without tripping a line had the same impact on the bulk system). Therefore, the CCT was calculated by applying a fault on each of the 66 kV and 138 kV buses, and not on specific lines.

A custom python script was created to run faults at each 66 kV and 138 kV bus for increasing fault durations. The IIS bulk system buses were monitored during the simulations to check each of the criteria listed in Section 2.3. Once the first criteria violation was flagged, the CCT was determined.

Typically, the weakest system conditions are most determining for CCTs. Therefore, the light load case was first used as the basis for determining the CCT at each 138 kV and 66 kV bus. Once the CCT was determined for the light load case, the faults with those CCT durations were simulated in the intermediate and peak load cases to ensure Transmission Planning Criteria was met. If criteria violations were found using the intermediate or peak load cases for those CCT durations, a more limiting CCT duration was determined to meet criteria for all IIS demand scenarios studied.

3. Study Results

The CCT for three-phase faults ("3PF") and single-line-to-ground faults ("SLGF") for each 66 kV and 138 kV bus is listed in Table 3-1, along with the criteria that determined the CCT. If the fault were to be sustained longer than the CCT duration listed, the criteria stated in the 'Limiting Factor' column was violated.

There were three main criteria violations that came up in the study:

1) **Voltage < 0.8 pu for 1 sec**
   The fault on the 66 kV or 138 kV bus caused the voltage at a IIS bulk system bus(es) to be less than 0.8 pu > 1 second.

2) **Frequency < 59 Hz**
   If the location of the 66 kV or 138 kV bus is close enough to the SOP (LIL inverter) bus, it causes the LIL to experience commutation failures during the fault, which reduces LIL infeed and causes the IIS frequency to drop. If the fault is too long, the IIS frequency can drop below 59 Hz and cause underfrequency load shedding (UFLS).

3) **Oscillations**
   In a few 66 kV or 138 kV bus locations an excessively long duration fault resulted in poorly damped oscillations in the IIS bulk system after the fault was cleared.

The 66 kV and 138 kV locations that did not result in violations were tested up to a maximum fault duration of 5 seconds.

It is noted that the CCTs at OPD/HWD and in the nearby 66 kV area are limited by the "Frequency < 59 Hz" criteria explained above. In this area, the CCTs become shorter in duration as the fault location moves further down the 66 kV network even though the 66 kV buses are becoming further away electrically from SOP (the LIL inverter bus). For example, from Table 3-1, PUL (CCT = 0.31s) is electrically further away from SOP than VIR (CCT = 0.43s), but has a shorter CCT. This is because the faults that are farther away from the SOP bus result in less of a voltage drop at SOP (LIL inverter) during the fault. However, the voltage drop at SOP is still enough to cause the LIL to fail commutation resulting in temporary loss/reduction of power infeed at SOP, which causes the IIS frequency to start dropping. In the case that has a higher SOP voltage during the fault (e.g. if the fault is at PUL) during the time when LIL power infeed feed is interrupted, the loads in the IIS draw more power during the fault than if the SOP voltage were lower (e.g. if the fault is at VIR), therefore the fault at PUL results in more of a frequency drop and therefore has a shorter CCT than a fault at VIR.

Newfoundland Power and Newfoundland and Labrador Hydro confirm that the critical clearing times established in this report are met. In all cases, the updated critical clearing times have increased slightly from where they were previously[2]. Therefore, the existing critical clearing times will not need to be modified as their operation will be slightly faster than the critical clearing times established in the report. Protection systems are reviewed on a regular basis and updates are applied as required.

[2] All buses supplying Hydro customers have a critical clearing time greater than 5 seconds.

Newfoundland Power has identified in its 2022 Capital Budget Application a 2-year project to replace the existing St. John's Teleprotection System used to provide telecommunications for its differential protection relays used to protect its 66 kV transmission network in St. John's and surrounding areas. The differential protection relays are key to meeting the critical clearing time specifications. The existing teleprotection system installed in 2002 has become obsolete with increasing failures, which have depleted the supply of spare parts. The replacement teleprotection system will allow Newfoundland Power to continue to meet the critical clearing times into the future.

Table 3-1. CCT at 138 kV and 66 kV Buses

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
BBK B2	195177	>5.0	-	>5.0	
BBK B3	195178	>5.0	-	>5.0	
BBK T2	195636	>5.0	-	>5.0	
BCV B1	195106	>5.0	-	>5.0	-
BCV NP	196562	0.32	frequency < 59.0 Hz	>5.0	
BCV R1	196362	>5.0	-	>5.0	-
BCX L20	195648	>5.0	-	>5.0	-
BDE B13	195645	>5.0	-	>5.0	-
BFS NP	195127	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BHL B1	195100	>5.0	-	>5.0	-
BHL T1	195606	>5.0	-	>5.0	-
BIG NP	196575	0.32	frequency < 59.0 Hz	>5.0	
BLA L12	195154	>5.0	-	>5.0	
BLA NLH WHLD	195156	>5.0	-	>5.0	-
BLK NP	195165	0.4	frequency < 59.0 Hz	>5.0	
BLK NPT3	196546	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BOY NP	196526	>5.0	-	>5.0	
BRB NP	195167	0.33	frequency < 59.0 Hz	>5.0	
BRB T2T3	196556	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
BUC B2	195639	>5.0	-	>5.0	
BVA NP	195146	>5.0	-	>5.0	
BWT L60	195118	>5.0	-	>5.0	-
CAB NP	196582	>5.0	-	>5.0	-
CAM L53	196516	>5.0	-	>5.0	
CAR NP	196552	>5.0	-	>5.0	
CAT NP	195145	>5.0	-	>5.0	
CAT NPT1	196539	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
CHA NP	196561	0.38	frequency < 59.0 Hz	>5.0	
CHD B1	195608	>5.0	-	>5.0	-
CLK NP	196525	>5.0	-	>5.0	
CLV NP	195144	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
CLV NPT1	196533	>5.0	-	>5.0	
COB NP	195130	>5.0	-	>5.0	
COB NPT2	196524	>5.0	-	>5.0	
COL NP	195171	0.33	frequency < 59.0 Hz	>5.0	
CRV L20	195646	>5.0	-	>5.0	-
DHR B1B2	195610	>5.0	-	>5.0	-
DLK B1	195111	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
DLK B2	195600	0.26	Oscillations	>5.0	
DLK NP	196500	0.23	Oscillations	>5.0	
DLS B1	195637	>5.0	-	>5.0	
DLS L14	195179	>5.0	-	>5.0	
DPD L64	195640	>5.0	-	>5.0	
EHW L20	195647	>5.0	-	>5.0	-
FER NP	196583	>5.0	-	>5.0	-
FER WIND	196584	>5.0	-	>5.0	-
FHD L54	196527	>5.0	-	>5.0	
GAL NP	196504	>5.0	-	>5.0	
GAM NP	195133	>5.0	-	>5.0	
GAM NPT2	196528	>5.0	-	>5.0	
GAN NP	195132	>5.0	-	>5.0	
GAN NPT2	196523	>5.0	-	>5.0	
GAR NP	196545	>5.0	-	>5.0	
GBK L50	195182	>5.0	-	>5.0	
GBY NP	196507	>5.0	-	>5.0	
GDL NP	196563	0.38	frequency < 59.0 Hz	>5.0	
GFS NP	195126	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
GFS NPT1	196517	>5.0	-	>5.0	
GLB L29	195603	>5.0	-	>5.0	-
GLN NP	195129	>5.0	-	>5.0	
GLV NP	195135	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
GOU NP	196564	0.37	frequency < 59.0 Hz	>5.0	
GPD NP	196531	>5.0	-	>5.0	
GRH NP	196544	>5.0	-	>5.0	
HAR NP	196503	>5.0	-	>5.0	
HBS NP	196529	>5.0	-	>5.0	
HBY B1	195612	>5.0	-	>5.0	-
HCP NP	196581	>5.0	-	>5.0	-
HCP TAP NP	196580	>5.0	-	>5.0	
HCT NP	196549	>5.0	-	>5.0	
HDN L51	196512	>5.0	-	>5.0	-
HGR NP	196554	>5.0	-	>5.0	
HLK L43	195113	>5.0	-	>5.0	
HLY B1	195112	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
HLY L51	196510	>5.0	-	>5.0	
HOL NP	195173	0.39	frequency < 59.0 Hz	>5.0	
HRD B6B7	195652	0.32	frequency < 59.0 Hz	>5.0	
HRD B8	195175	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
HRD OUTS	196587	0.32	frequency < 59.0 Hz	>5.0	
HWD B7B8	195655	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
ILC NP	196555	>5.0	-	>5.0	
IRV B1	195115	>5.0	-	>5.0	
ISL NP	196548	>5.0	-	>5.0	
JAM L52	196514	>5.0	-	>5.0	-
KBR NP	196570	0.42	frequency < 59.0 Hz	>5.0	
KEL NP	196560	0.32	frequency < 59.0 Hz	>5.0	
KEN NP	196565	0.43	frequency < 59.0 Hz	>5.0	
LAU NP	196541	>5.0	-	>5.0	
LET NP	196535	>5.0	-	>5.0	
LEW NP	195134	>5.0	-	>5.0	
LEW NP	196522	>5.0	-	>5.0	
LGL NP	196509	>5.0	-	>5.0	
LLK NP	195155	>5.0	-	>5.0	
LOK NP	196537	>5.0	-	>5.0	
MBK L57	195617	>5.0	-	>5.0	-

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
MDR B2B3	195624	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
MIL NP	196534	>5.0	-	>5.0	
MKS L12	195153	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
MMT NP	195622	0.21	Oscillations	>5.0	
MOB NP	196576	>5.0	-	>5.0	
MOL NP	196566	0.38	frequency < 59.0 Hz	>5.0	
MRP NP	196579	>5.0	-	>5.0	
MSY NP	195157	>5.0	-	>5.0	
MUN NP	196569	0.42	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
NCH NP	196550	>5.0	-	>5.0	
NDJ NP	196521	>5.0	-	>5.0	
NHR NP	196547	>5.0	-	>5.0	
NWB NP	195151	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
OPD B2B5	195654	0.33	frequency < 59.0 Hz	0.33	frequency < 59.0 Hz
OPL NP	196551	>5.0	-	>5.0	
PAB NP	196508	>5.0	-	>5.0	
PAS B1	195621	0.55	Oscillations	>5.0	
PBD NP	195141	>5.0	-	>5.0	
PBD TAP	195140	>5.0	-	>5.0	
PBN B1	195102	>5.0	-	>5.0	-
PBN B2	195611	>5.0	-	>5.0	-
PEP NP	196571	0.44	frequency < 59.0 Hz	>5.0	
PPD L27	195609	>5.0	-	>5.0	-
PPT B1	195104	>5.0	-	>5.0	-
PPT R1	196360	>5.0	-	>5.0	-
PPT R2	196361	>5.0	-	>5.0	-
PUL NP	196574	0.31	frequency < 59.0 Hz	>5.0	
PUN NP	196538	>5.0	-	>5.0	
RBK L53	196515	>5.0	-	>5.0	
RBK NP	196520	>5.0	-	>5.0	
RHR B1	195605	>5.0	-	>5.0	-
RHR TAP	195604	>5.0	-	>5.0	-
ROP NP	196578	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
RRD NP	196572	0.43	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
RUS NP	196518	>5.0	-	>5.0	
RWC B1	195618	>5.0	-	>5.0	-
SBK NP	196519	>5.0	-	>5.0	
SCR NLH WHLD	195116	>5.0	-	>5.0	-
SCR NP	195117	>5.0	-	>5.0	
SCV L27	195607	>5.0	-	>5.0	-
SCV NP	196559	0.32	frequency < 59.0 Hz	>5.0	
SDP L61	195616	>5.0	-	>5.0	-
SJM NP	196568	0.39	frequency < 59.0 Hz	>5.0	
SLA NP	196567	0.34	frequency < 59.0 Hz	0.34	frequency < 59.0 Hz
SLK L80	195641	>5.0	-	>5.0	
SMV NP	196536	>5.0	-	>5.0	
SOK L22	195122	4.36	frequency < 59.0 Hz	>5.0	
SPF NP	195169	0.32	frequency < 59.0 Hz	>5.0	
SPL B1	195120	4.7	frequency < 59.0 Hz	>5.0	
SPL NLH WHLD	195121	>5.0	-	>5.0	-
SPO NP	195159	>5.0	-	>5.0	
SPT NP	196540	>5.0	-	>5.0	
SSD B2B3	195152	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
STA B1	195615	>5.0	-	>5.0	-
STA L58	195108	>5.0	-	>5.0	-
STB B3	195124	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
STG NP	196502	>5.0	-	>5.0	
STL WIND	196542	>5.0	-	>5.0	
STX NP	196501	>5.0	-	>5.0	
SUM NP	196585	>5.0	-	>5.0	-
SVL B2	195635	>5.0	-	>5.0	
TCV NP	196577	>5.0	-	>5.0	
TL252TAP	196511	>5.0	-	>5.0	
TL253TAP	196513	>5.0	-	>5.0	
TNS NP	195136	>5.0	-	>5.0	

Bus Name	Bus Number	3PF		SLGF	
		CCT (sec)	Limiting Factor	CCT (sec)	Limiting Factor
TRN NP	196530	>5.0	-	>5.0	
TWG NP	196586	>5.0	-	>5.0	-
ULT NP	196558	0.34	frequency < 59.0 Hz	>5.0	
ULT TAP	196557	0.32	frequency < 59.0 Hz	>5.0	
VIC NP	196553	>5.0	-	>5.0	
VIR NP	196573	0.43	frequency < 59.0 Hz	>5.0	
WAV B2	195650	0.99	Voltage < 0.8 pu for 1 sec	>5.0	
WAV B4	195163	0.48	frequency < 59.0 Hz	0.99	Voltage < 0.8 pu for 1 sec
WDL B1	195602	>5.0	-	>5.0	-
WDL TAP	195601	>5.0	-	>5.0	-
WEBCV_NP	196543	>5.0	-	>5.0	
WES NP	196532	>5.0	-	>5.0	
WHE NP	196506	>5.0	-	>5.0	
WHE TAP	196505	>5.0	-	>5.0	