REPORT

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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

FINAL Draft REPORT

Project: Holland TS
Applicant: Hydro One Networks Inc.

CAA ID 2006-211 Phase II

Transmission Assessments & Performance Department

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System Impact Assessment Report

Holland TS

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Approval of the proposed connection is based on information provided to the IESO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by the transmitter(s) at the request of the IESO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. Approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, connection approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that it is using the most recent version of this report.

HYDRO ONE

Special Notes and Limitations of Study Results

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPGI) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed connection have been identified to the extent permitted by a preliminary assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

System Impact Assessment Report

SIA Findings

SIA Conclusions

This System Impact Assessment has examined the benefits and impact of new transformer station in the New Market area on the reliability of the IESO-Controlled grid. The installation of the new station is a development project that will relieve current station overloads and provide the adequate level of supply to the area loads. The need for this development was originally identified by Hydro One in a study that was jointly performed with the local utilities. The need for the new DESN was reconfirmed in the OPA in the York Region Supply Study together with other development plans which provide solutions in the long term.

Study Conclusions

The studies concluded that:

1. The proposed project will not have a material adverse effect on the reliability of the IESO-Controlled grid.

2. The proposed project will relieve the transformer station over-loadings currently occurring in York Region at Armitage MTS#1 and #2.

3. The addition of the new station will result in a small increase in short circuit currents due to the grounding of the transformers but there is no material increase in the short circuit fault levels.

4. The thermal capability of the double circuit line B82V & B83V, which is restricted by the Woodbridge JCT to Holland Marsh JCT section of the line, is expected to be adequate beyond 2014 assuming that local and system generation is available during peak load conditions.

5. Post-contingency voltage decline on the Holland TS 44 kV bus, prior to transformer ULTCs response, will be within the 10% decline criterion for the new station loading within its LTR.

6. The transmission capability of B82V/B83V circuits is currently limited to about 375 MW due to voltage collapse considerations. This problem will diminish with the incorporation of the new station.

7. An escalation of Holland TS load would result in decay of Armitage TS 230 kV voltage. The IESO’s minimal pre-contingency voltage limit of 220 kV will be exceeded for the Holland load greater than 154 MW (2013).

Notification of Approval for Connection Proposal

It is recommended that a Notification of Conditional Approval for connection be issued to Hydro One, subject to IESO's Requirements for Connection listed below, and any further requirements that may be identified by Hydro One Networks Inc. in the Customer Impact Assessment.

IESO's Requirements for Holland TS Connection

The IESO requirements for the connection of the proposed Holland TS are as follows:

- The connection applicant must ensure that load power factor, when measured at the defined meter point location meets the Market Rules requirements.
- Hydro One is required to confirm that UFLS will be installed at the station to meet the Market Rules requirements.
- Hydro One must provide 3% or 5% voltage reduction capability that can be implemented in five minutes.
- Hydro One must install all the equipment needed to monitor the information required by the IESO on a continuous basis.
- All high voltage equipment must be capable of operating continuously with a system voltage as high as 250 kV.
- All equipment must be capable of operating during the re-preparation period with a system voltage as high as 260 kV.
- Hydro One is required to implement a plan for the above identified issues.

IESO's Recommendations for Holland TS Connection

- It is recommended that Hydro One replace the Claireville - Minden Overload Protection Scheme (VMOPS) with a load shedding scheme to mitigate the severity of load disruptions following contingencies.
- The IESO concurs with the findings of the OPA's York Region study and recommends that a new transmission line be built into the area and/or local generation be installed and connected to 230kV system in York Region to solve the identified problems, by 2011.

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1. Project Description

Hydro One Networks is proposing to construct a DESN, Holland TS, located in the vicinity of Holland Marsh Junction. The proposed Holland TS will relieve the Armitage TSs No. 1 & No. 2 as well as provide additional capacity to accommodate future load growth in the local areas supplied by Newmarket Hydro, Aurora Hydro & Hydro One Retail.

The peak summer loads on the two 230/44kV DESN stations at Armitage TS have exceeded the limited-time-ratings of the existing facilities. Summer 2005 peak load at Armitage TS was 366 MW, about 13.4% above the planning limit of 317 MW. Load growth in the area is averaging about 3% per year. The OPA, in their “Northern York Region Electricity Supply Study” dated September 30, 2005 (Section 6.2 – Phase 1 – York Region) recommended the following projects to develop a solution to address the ongoing load growth:

1. Increase the amount of static capacitors at Armitage TS by the summer of 2006.

2. Establish a new 215.5/44 kV, 75/125 MVA DESN station at Holland Junction, along with static capacitors at this station.

Hydro One has requested the IESO to proceed with a CAA study for the new Holland TS and the replacement of capacitor banks at Armitage TS. The replacement of capacitors at Armitage TS was assessed (CAA ID 2006-211) as Phase I of this CAA study and a NOA was granted to Hydro One in June 2006.

The proposed Holland TS is scheduled for completion by summer 2007 and the in-service for the proposed larger capacitor banks is targeted by summer of 2006.

This connection assessment study will examine the proposed connection arrangement for the new facilities and their impact on reliability of the IESO-controlled grid.

– End of Section –

2. Review of Connection Proposal

2.1 Connection Arrangement

The proposed Holland TS will be a 75/125 MVA, 215.5/44 kV DESN that is to be connected to the 230 kV Claireville TS to Brown Hill TS circuits, B82V and B83V. Location of tap for the preferred station site is just over 1/2 km from Holland Marsh Jct on the Claireville TS side. The tap length itself is about 350 meters.

The existing transmission configuration as well as the location of proposed Holland TS is shown in Figure 1.

The proposed Holland TS will be equipped with two new 215.5/44 kV dual winding transformers. Each transformer will be connected to the IESO-controlled grid via one 230 kV motorized disconnect switch. The transformers are both identical and configured with a wye winding on the high side (neutral grounded) and wye (neutral grounded via a 5 ohms reactor) winding on the low voltage side. Each transformer is equipped with under-load tap changer located on the high voltage winding with a range of about ±40 kV that is to be achieved in 32 steps. The transformer impedance is 13% based on 75 MVA.

Two low-voltage shunt capacitor banks (2×32.4 MVAr rated at 46 kV) with associated breakers, surge arresters and reactors will be installed at the proposed Holland TS. One capacitor bank is to be connected to each 44 kV bus.

Low voltage side isolation of each transformer is to be provided by a 2500 A, 44 kV circuit breakers. The LV bus-tie breaker, rated for 2000 A, is to be operated normally closed. The station will have eight feeders and each feeder position is to be equipped with one 1200 A breaker as the same as the capacitor breakers. The short circuit interrupting capability for all above breakers is 20 kA.

The 350 m 230 kV line taps are to meet the following requirements:

- Nominal system voltage 230 kV
- Maximum continuous operating voltage 250 kV
- Ampacity (Continuous) 500 A
- 1 hour emergency 630 A
- Short circuit capacity (ultimate) 63 kA

The points of connection or defined meter points will be located on the high voltage side of the transformer. The exact location of the revenue meter has to be provided by the connection applicant as part of the Facility Registration process.

Proposed Holland DESN single line diagram is shown in Figure 2.

2.2 Power Factor

The Market Rules (Appendix 4.3) require that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range 90% lagging to 90% leading as measured at the defined meter point. Hydro One did not provide load information for Holland TS but proposed to install two 32.4 MVAr capacitor banks at the new DESN to provide load power factor correction.

> The connection applicant must ensure that load power factor, when measured at the defined meter point location meets the Market Rules requirements.

2.3 Underfrequency Load Shedding Requirements

The Market Rules (Chapter 5 section 10.4) require that each distributor and connected wholesale customer, in conjunction with the relevant transmitter, make arrangements to enable the automatic disconnection of up to 35% of its peak demand for conditions of system under-frequency. To meet this requirement an under frequency load shedding (UFLS) scheme must be installed at the station. The single line diagram does not show the presence of the UFLS scheme.

The under frequency automatic load shedding should be provided by tripping 44 kV feeder breakers to achieve:

- Automatic load shedding of 12% of station load at a nominal set point of 59.3 Hz and
- Automatic load shedding of an additional 23% of station load at a nominal set point of 58.8 Hz, for a total load reduction of 35% of the total station load.

The under frequency threshold relays shall be set to a nominal operating time of 0.30 second, from the time when frequency passes through the set point to the time of circuit breaker trip initiation (including any communications time delay), when the rate of frequency decay is 0.2 Hertz per second.

Hydro One will identify the UFLS feeder selection closer to the commissioning date and review the selection through the initial loading stages.

> Hydro One is required to commit that UFLS facilities will be installed at the station to meet the Market Rules requirements.

2.4 Voltage Reduction Facilities Requirements

The Market Rules (Chapter 4 Appendix 4.3) require that distributors connected to the IESO controlled grid with directly connected load facilities of aggregated rating of 20 MVA or more and the capability to regulate distribution voltage under load, shall install and maintain facilities to provide voltage reduction capability to achieve load reduction during periods when supply resources are limited. Voltage reduction capability represents the capability of reducing demand by lowering the customer voltage by 3% and 5% and having the controlling authority to be able to effect the voltage reduction within five minutes of receipt of the direction from the IESO.

> Hydro One is required to commit to install voltage reduction capability that provides 3% and 5% voltage reduction within five minutes.

2.5 On-line Monitoring

The Market Rules (Chapter 4 section 7.4) require that each transmitter shall provide the IESO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. Hydro One must install all the equipment needed to monitor the information required by the IESO on a continuous basis.

The IESO requires that the following quantities at Holland be provided to the IESO on a continual basis via approved communication protocols:

1. The voltage on the high/low tension buses
2. The status of the bus tie breaker
3. The status of the transformer low voltage breakers
4. The status of the capacitor breakers
5. The status of the transformer high voltage disconnect switches
6. The real and reactive power flow through both transformers
7. The transformer tap position for both transformers

2.6 Protection Systems

With respect to the protection and telecommunication requirements, the connection applicant must follow the Transmission System Code technical requirements for tapped transformer stations supplying load.

The applicant has indicated that the station equipment and station control/protection were designed to meet the intent of the Transmission System Code. The diagram that was provided by the applicant shows each transformer being separated from the transmission system via a motorized disconnection switch. For this particular arrangement the Transmission System Code requires that the distributor send transfer trip to the Transmitter's breakers at the line terminal stations for transformer faults or for a condition of failure to operate of the LV transformer breakers.

The protection systems associated with B82V/B83V are to be revised as required.

– End of Section –

3. Data Verification

The proposed new Holland TS will be a standard DESN arrangement with two 75/100/125 MVA transformers. Based on standards for supply of municipal electrical utilities the capability of a DESN station is defined as the maximum load that one transformer can carry for a predefined period of time. This value is usually computed using specific transformer data and daily load curves, and temperature data specific to the transformer location. Hydro One has provided a 10 day summer Limited Time Rating of 170 MVA.

The high voltage motorized disconnect switches are designed to meet the requirements as specifies for 230 kV line taps with maximum continuous operating voltage of 250 kV. The applicant has advised that each disconnect switch shall be rated to interrupt the maximum magnetizing current of the specified 75/100/125 MVA transformer.

The system performance standards listed in the Transmission System Code requires that the 44 kV system fault level not exceed 20 kA. This indicates that 44 kV equipments must be sized to interrupt 20 kA. The LV breakers proposed for installation at Holland TS meet the interrupting capability recommended by the Transmission System Code.

A full description of the connection arrangement of the proposed Holland TS is included in Section 2.1 of this report.

– End of Section –

4. Fault Level Assessment

The customer has advised that there is no generation or large synchronous motors connected to their distribution system.

In general, radial loads do not have a large impact on the system fault levels, but a small contribution in short circuit currents can be observed due to the grounding of the transformers. In the case of Holland TS the high voltage winding is ungrounded, hence line-to-ground faults occurring on the distribution side will have no impact on the short circuit levels.

– End of Section –

5. Impact on System Reliability

This connection assessment study concentrated on identifying the effect of the proposed DESN on thermal loading of the transmission lines and transformers, voltage stability, voltage changes for capacitor switching and system voltages for pre and post contingencies.

5.1 Study Assumptions

For this connection assessment the July 2006 base case was used with the following assumptions:

1. New 4 × 32.4 MVAr at Armitage TS
2. Keele Valley GS I/S with two generating scenarios:
   - GS power output of 30 MW (maximum power output)
   - GS power output of 22 MW (power output during summer peak day of August 1)
3. Des Joachims I/S and O/S
4. Load power factor of 0.87 was assumed
5. Constant MVA load model was used for voltage stability studies while voltage decline and thermal assessment studies were done with load modeled as voltage-dependant (50% constant impedance and 50% constant current for active power and 100% constant impedance for reactive power).

5.2 Load Forecasts and Load Supply Deliverability

In 2003 Hydro One and York Region utilities performed a study (York Region Supply Study: Adequacy of Transmission Facilities And Transmission Supply Plan 2003-2013) to review the area load growth in York Region and the adequacy of the existing transmission system to supply the demand for the next ten years. The study concluded that the load in the York Region was expected to increase at a rate of about 4.0% annually to 2008 and the long term growth rate from 2008 to 2013 was about 3.4%.

Based on the York Region Supply Study and the load growth rates provided by Hydro One, the load growth rates and the load forecasting for the stations supplied by B82V/B83V and M80B/M81B are summarized in Table 1 and Table 2, respectively. Since the load at Armitage TS in 2005 has already exceeded its load meeting capabilities, load at this station is limited to station capability (317 MW). The Armitage TS load in excess of 317 MW and the load growth based on 366.5 MVA by 3.25% per year will be included in the load forecast for the new Holland TS.

Table 1: Load Growth Rate

Station	Summer Peak for 2005 (MW)	Load Growth Rate (%)
Armitage	366.5	3.25
Brown Hill TS	68.9	0.75
Beaverton TS	60.4	1.55
Lindsay TS	70.5	0.45

Table 2: Load Forecast (MW)

Station	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Armitage	366.5	378.4	317	317	317	317	317	317	317	317	317	317	317
Holland	0	0	73.7	86.4	99.5	113.1	127.0	141.5	156.4	171.8	187.6	204.0	221.0
Brown Hill	68.9	69.4	69.9	70.4	70.9	71.5	72.0	72.6	73.1	73.6	74.2	74.8	75.3
Beaverton	60.4	61.3	62.3	63.2	64.2	65.2	66.2	67.3	68.3	69.4	70.4	71.5	72.6
Lindsay	70.5	70.9	71.2	71.5	71.8	72.1	72.5	72.8	73.1	73.4	73.8	74.1	74.4

Load forecast for the Armitage & Holland stations supplied by B82V and B83V will be used with the simulation results to determine the year when constrains will occur.

The load security and restoration criteria for IESO-controlled grid are defined in the Ontario Resource and Transmission Assessment Criteria document as follows:

"With any one element out of service, equipment loading must be within applicable long-term emergency ratings, voltages must be within applicable emergency ranges, and transfers must be within applicable normal condition stability limits. Not more than 150MW of load may be interrupted by configuration. Planned load curtailment or load rejection, excluding voluntary demand management, is not permissible.

With any two elements out of service voltages must be within applicable emergency ranges. Equipment may be loaded up to applicable short-term emergency ratings immediately following a contingency, but must be reduced to the long-term emergency ratings in the time afforded by the short-term ratings. Not more than 600MW of load may be interrupted as a result of the contingency, and this may include up to 150MW of planned load curtailment or load rejection, excluding voluntary demand management.

The transmission system must be planned such that, following design criteria contingencies on the transmission system, affected loads can be restored within the restoration times listed below:

All load must be restored within approximately 8 hours.

When the amount of load interrupted is greater than 150MW, the amount of load in excess of 150MW must be restored within approximately 4 hours.

When the amount of load interrupted is greater than 250MW, the amount of load in excess of 250MW must be restored within 30 minutes."

It should be noted that based on the load forecasts in Table 2 the load supplied exclusively by the 230 kV circuits B82V & B83V and M80B & M81B which include load at Armitage TS, Holland TS Brown Hill TS Beaverton TS and Lindsay TS, is above 600 MW guideline level starting in 2008. For the permanent loss of either the north or south section of the Claireville to Minden line, rapid isolation of the faulted section and restoration of the supply to some of the loads ca be achieved by the operation of the Brown Hill in-line breakers. However, the permanent loss of B82V/B83V will result in the loss of more than 250 MW without the ability of restoring the load in excess of 250 MW in 30 minutes, which exceeds the above mentioned criteria.

5.3 Thermal Loading Assessment

This section covers an investigation of thermal loading capability of 230 kV circuits supplying the new project.

A power flow analysis was performed under summer peak load conditions for all elements in service and for single element contingencies. Two generation scenarios were considered, with all eight units at Des Joachims GS in service and out of service.

Increasing output at Des Joachims GS will increase flows on M80B & M81B and will decrease flows on B82V & B83V circuits and vice versa.

The ratings used to evaluate the thermal capability of the Claireville TS to Minden TS 230 kV transmission corridor are shown in Appendix A. The table lists the continuous ratings and the 15 minute limited time ratings of all the line sections. For these circuits it was assumed that the long term emergency rating is the same as the continuous rating. As it appears from the listed ratings, there are four sections of circuits B82V & B83V. The circuit section (2) from Woodbridge JCT to Holland Marsh JCT has the lowest rating and therefore is the most limiting section. The most limiting section for the M80B & M81B circuits is section (9) from Minden TS to Beaverton JCT.

The ratings were calculated for the summer peak conditions, i.e. temperature of 35°C, wind speed of 5 km/h and for the day time. Pre-load dependant LTRs were calculated assuming circuit pre-contingency loading of 75%.

It should be noted that pre-contingency voltages based on historical data were used to convert ampacity to a MVA rating in Appendix A. The pre and post-contingency MVA ratings used in table 3 were calculated using post-contingency voltages.

The criteria applied in assessing the thermal loading capability of the 230 kV circuits is the following:

- With all elements in-service, loading of any line shall be within their continuous rating.
- For the single circuit contingency, post-contingency flow on any circuit shall not exceed the 15 minute limited time rating.

The results of 2014 case studies including pre and post contingency flows are summarized in Table 3.

The study results indicate that:

With all elements in service pre-contingency, the power flows on all transmission circuits are below circuit continuous rating.

When all Des Joachims GS units are in-service, contingencies involving either B82V or B83V circuit would load the remaining circuit above its continuous rating but below its 15-minute LTR. If Des Joachims units are out-of-service, loss of BxV circuit would result in overloading of the companion circuit above circuit’s 15-min LTR. In the latter case, load shedding is the only control action available to reduce the loading of the remaining circuit below the continuous rating. Load shedding following a single contingency in this case violates IESO's load supply criteria. However, this problem will be alleviated by the addition of either a new transmission line and/or local generation into the area, as recommended by the OPA in the York Region Supply Study.

The assessment of M80B & M81B circuits' thermal capability indicates that thermal overloading of one of these circuits following the contingency of companion circuit is not a concern.

Table 3: Pre and Post Contingency Circuit Loadings in 2014

CIRCUIT	LIMITING SECTION	LIMITING SECTION'S CONT & LTR RATING POST-CONT (MVA)	POST-CONTINGENCY FLOWS (MVA)									
			Element Out-of-Service									
			Des Joachims Out-of-Service					Des Joachims In-Service				
			Pre-contingency Flows (MVA) % of Cont Rating	B82V % of Cont Rating	B83V % of Cont Rating	Tap Line #1 % of Cont Rating	Tap Line #2 % of Cont Rating	Pre-contingency Flows (MVA) % of Cont Rating	B82V % of Cont Rating	B83V % of Cont Rating	M80B % of Cont Rating	M81B % of Cont Rating
B82V	WOODBRGJ TO HOLMARSJ	416 480	236.6 53.3%	0	500.6 ***120.3%*** ***104.2%****	143.3 34.4%	335.9 80.7%	192.1 43.26%	0	449.2 **108%**	257.3 61.8%	196.1 47.1%
B83V	WOODBRGJ TO HOLMARSJ		240.6 54.2%	505.6 ***121.5%*** ***105.3%****	0	344 82.7%	148.9 35.8%	196.3 44.2%	455.7 **109.5%**	0	205.2 49.3%	253.4 60.9%
Tap Line #1		469 539	150.5 30.7%	0	308 65.7%	0	304.6 64.9%	150.6 30.7%	0	308.4 65.7%	137.9 29.4%	160.2 34.1%
Tap Line #2			147.2 30%	307 65.4%	0	306.6 64.5%	0	147.3 30.1%	307.3 65.5%	0	157.1 33.5%	135.7 28.9%
M80B	BEAVERTJ TO MINDEN	309 396	109.6 33.9%	80.7 26.1%	157.8 51.1%	90.3 29.2%	127.6 41.3%	165.2 51.2%	91.9 29.7%	216.2 69.9%	0	228.3 73.9%
M81B	BEAVERTJ TO MINDEN		116.8 36.2%	168.3 54.5%	93.7 30.3%	136 44%	97.7 31.6%	171.8 53.2%	226.3 73.2%	105.4 34.1 %	234.4 75.8%	0

*: % of LTR for post-contingency flow above circuit's 15-min LTR

It is evident that future load growth in the area will aggravate the loading problems of 230 kV B82V & B83V circuits. Table 4 summarizes the dependence of the system capability to supply the yearly peak demand to the availability of the generation. When available to run, the existing local (Keele Valley) and system (Des Joachims) generation will provide a benefit of relieving the loading on the circuits. In the best case scenario which assumes both Keele Valley GS and Des Joachims GS running, the circuit's load meeting capability would be exceeded by summer 2013, as shown in Table 4.

Table 4: Post-contingency Line Loadings

DES JOACHIMS GS & KEELE VALLEY GS OUT-OF-SERVICE				
Year	B83V Out-of-service		B82V Out-of-service	
	Flow on B82V (MVA)	% of Continuous Rating	Flow on B83V (MVA)	% of Continuous Rating
2008	*417*	*95.9 %*	*430*	*98.8 %*
2009	***443***	***104.2 %***	***453***	***106.6 %***
2010	***466***	***109.6 %***	***471***	***110.8 %***
DES JOACHIMS GS OUT-OF-SERVICE & KEELE VALLEY GS IN-SERVICE				
Year	B83V Out-of-service		B82V Out-of-service	
	Flow on B82V (MVA)	% of Continuous Rating	Flow on B83V (MVA)	% of Continuous Rating
2010	*420*	*96.6 %*	*427*	*98.2 %*
2011	***442***	***104 %***	***447***	***105.2 %***
2012	***466***	***109.6 %***	***470***	***110.6 %***
DES JOACHIMS GS IN-SERVICE & KEELE VALLEY GS IN-SERVICE				
2013	*420*	*98.8%*	***428***	***100.7%***
2014	***456***	***109.6%***	***449***	***107.9%***

It is apparent from the study results that if Keele Valley GS is not available for service, the circuit would be loaded to above its continuous rating following the loss of the companion circuit starting in 2009. With Keele Valley in-service and generating 30 MW of power, the occurrence of the circuits post-contingency overloading would be deferred until summer 2011.

However, historical data shows that during the peak day in August Keele Valley power output was about 22 MW. In this case, post-contingency circuit overloading for second and third generating scenarios in the above table would occur in 2010 and 2012 respectively. Keel Valley historical generating data are shown in Appendix B.

5.4 Voltage Profile Assessment

Different system conditions and contingencies were studied to identify the worst case study scenario. The loss of B82V circuit was identified as the most critical single element contingency while the system condition with all Des Joachims generating units out-of-service was found to be the most limiting study condition

It should be noted that voltage assessment study results were based on the initial information provided to the IESO, i.e. Holland TS connected to Armitage TS tap lines, 2 km south of Holland Marsh Junction. The revised Holland TS connection point will result in slightly better voltage performance than that reported so the studies were not repeated.

5.4.1 Voltage Decline Study

The following IESO criteria must be satisfied before any new equipment is connected to the transmission system:

1. The pre-contingency voltage on 230 kV buses can not be less than 220 kV.
2. The post-contingency voltage on 230 kV buses can not be less than 207 kV.
3. The voltage drop following a contingency can not exceed 10% pre-ULTC and 10% post-ULTC.

Power flow studies were performed to assess the pre and post contingency voltages and to identify any voltage requirement violations. With loads modeled as voltage-dependant, the following assumptions were made in determining the voltage decline following the loss of B82V:

- Load at Armitage TS was limited to its LTR of 317 MW.
- Load at Holland TS was escalated to the station LTR of 170 MW.

The study results including pre and post-contingency voltages and voltage changes are summarized in Table 5. The results are given for the scenario 1 e.g. Keele Valley power output of 30 MW.

Table 5: Voltage Change Study Results for Loss of B82V (Year 2014)

ARMITAGE TS & HOLLAND TS LOADED TO 317 MW & 169 MW RESPECTIVELY					
BUS	**PRE-CONTINGENCY (kV)**	**B82V CONTINGENCY**			
		PRE-ULTC (kV)	**VOLTAGE DECLINE (%)**	**POST-ULTC (kV)**	**VOLTAGE DECLINE/RISE (%)**
Holland 230 kV	237.7	226.3	4.78	221.1	6.96
Holland 44 kV	*45.2*	*40.7*	*9.87*	*45.6*	*-0.87*
Armitage 230 kV	236.8	224.3	5.27	218.7	7.63
Armitage 44 kV (1)	45.1	40.9	9.22	45.1	0
Armitage 44 kV (2)	45.1	41.5	7.96	45.4	-0.54
ARMITAGE TS & HOLLAND TS LOADED TO 317 MW & 172 MW RESPECTIVELY					
	PRE-	**B82V CONTINGENCY**			

BUS	CONTINGENCY (kV)	PRE-ULTC (kV)	VOLTAGE DECLINE (%)	POST-ULTC (kV)	VOLTAGE DECLINE/RISE (%)
Holland 230 kV	237.41	225.9	4.85	220.7	7.06
Holland 44 kV	***45.6***	***41.0***	***10.04***	***45.4***	***0.52***
Armitage 230 kV	236.6	223.9	5.34	218.3	7.75
Armitage 44 kV (1)	45.0	40.8	9.32	45.5	-1.05
Armitage 44 kV (2)	45.1	41.4	8.05	45.3	-0.40

The above study results indicate that:

- If loading of Holland TS is below or equal to 169 MW, post-contingency voltage declines on the 230 kV buses before and after ULTCs action, would be within the IESO's criterion of 10%. Immediate post contingency voltage decline on the 44 kV buses, prior to the ULTCs response, would also be within 10 %.

- For the Holland TS load greater than 169 MW, pre-ULTC voltage decline on Holland TS 44 kV bus would exceed 10% limit.

Sensitivity studies showed that there is no significant difference in voltage change when Keele Valley power output was lowered to 22 MW.

5.4.2 Voltage Stability

This study was performed to evaluate the risk of voltage collapse in Armitage area. Figure 3 shows the Holland TS 230 kV and 44 kV bus voltages as a function of the new station loading following the loss of B82V circuit. The curve was generated assuming that Armitage TS load is constant and equal to its LTR (317 MW), and that Keele Valley output is 30 MW.

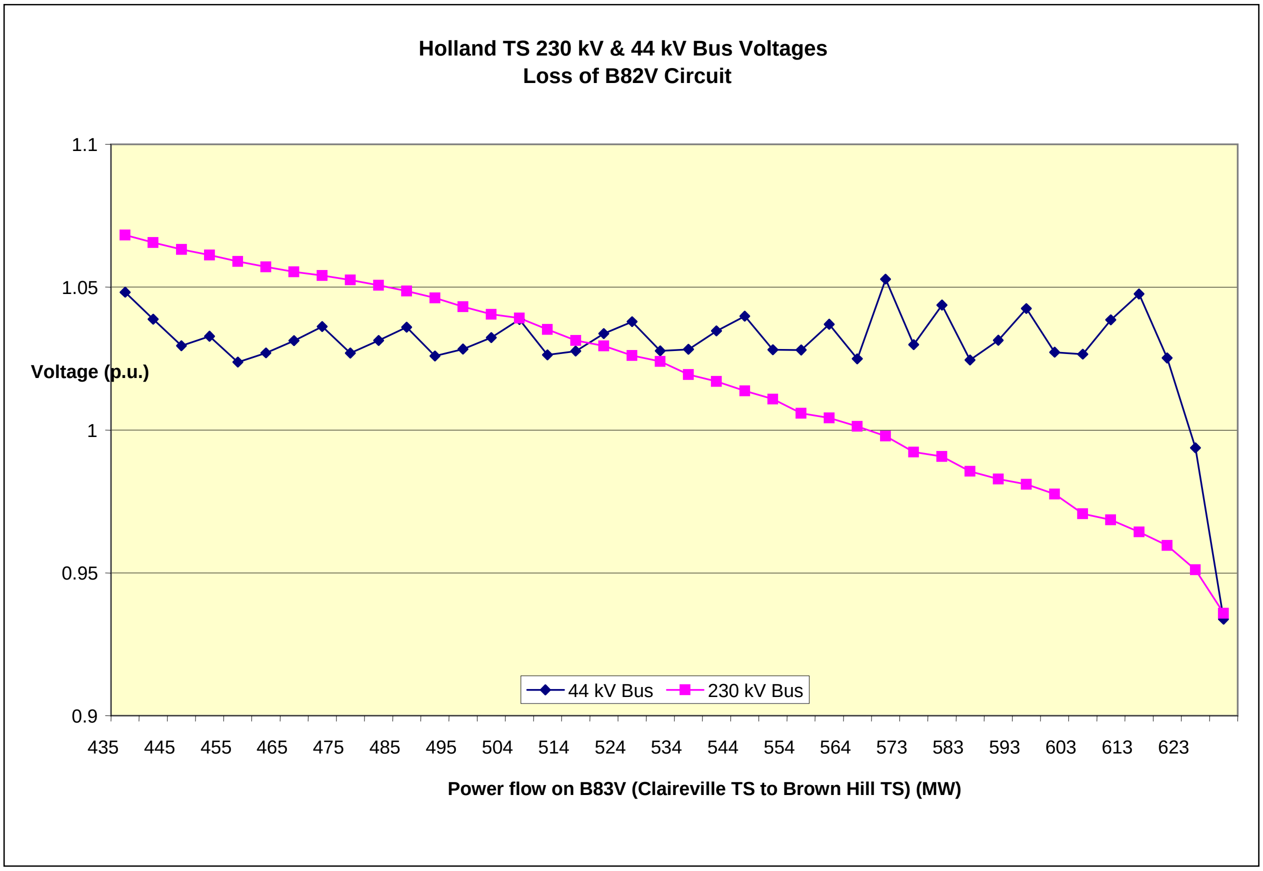

Figure 3: Power-Voltage (P-V) Curve for Holland TS

With the loads modeled as constant MVA, the total peak load that could be supplied by B83V is 626 MW. Allowing a 5% margin gives a load meeting capability of about 595 MW. This would allow Holland TS being to be loaded at 202 MW.

If power output from Keele Valley is 22 MW, load meeting capability of B83V would decrease to 582 MW resulting in Holland TS loading capability being limited to 183 MW. Since load meeting capability exceeds the station design capacity of 170 MW, it can be concluded that transmission capability of B82V & B83V circuits will not be limited by the voltage stability problem.

However, the results summarized in Table 6 indicate that with the escalation of Holland TS load, the 230 kV bus voltages would be approaching the IESO’s minimum acceptable voltage limit of 220 kV for all elements in service pre-contingency, or with one element out of service after permissible control actions. For the Keele Valley power output of 30 MW, this limit would be exceeded for the new station loads greater than 159 MW. However, for the power output of 22 MW the limit would be exceeded for the station loading of 154 MW.

Table 6: Pre-contingency and Post-contingency 230 kV Bus Voltages

BUS	INFLOW (MW)	HOLLAND LOAD (MW)	PRE-CONTINGENCY VOLTAGE (KV)	PRE-ULTC VOLTAGE (KV)	POST-ULTC VOLTAGE (KV)
Holland 230 kV	448	159	223.1	222.7	222.4
Armitage 230 kV			220.8	220.4	220.1
Holland 230 kV	452	154	222.6	221.6	221.3
Armitage 230 kV			***220.3***	***219.3***	***218.9***

INFLOW = Post-contingency power flow on B83V into Holland TS & Armitage TS

5.4.3 Capacitor Switching

Two 32.4 MVAr capacitor banks will be installed at Holland TS. This study was performed to examine the effect of capacitor switching on 44 kV bus voltages at Holland TS. As per Chapter 4 of Market Rules, voltage changes shall not normally exceed 4 % of steady state rms for capacitor switching operations.

IESO Transmission Assessment Criteria specifies that voltage-dependant model should be used for capacitor switching studies. However, since the voltage characteristic of the new station load is not available, sensitivity studies were done using both voltage dependant and constant MVA load models. The study results are shown in Table 7.

Results show that the voltage change due to capacitor switching meets the Market Rules criterion.

However, in reality excessive voltage changes could occur if the load at the new station has a constant MVA characteristic.

Table 7: Steady State Voltage Change

LOAD MODEL	VOLTAGE (KV)		VOLTAGE CHANGE	
	Pre-switching	Post-switching	(kV)	(%)
Voltage-dependant (50, 50, 0, 100)	46.28	47.76	1.48	*3.20%*
Constant MVA	46.28	48.41	2.13	***4.60 %***

5.5 Claireville - Minden Overload Protection Scheme

Claireville-Minden Overload Protection Scheme (VMOPS) was installed in 1993 to prevent post-contingency overloads. The scheme was designed to detect loss of B82V or B83V and then trip the in-line breaker of the remaining circuit at Brown Hill with a time delay of 30 seconds. The cross-tripping overload protection scheme is non-duplicated. The scheme has not been used since it was installed. For loss of B82V or B83V, tripping the in-line breaker on the other circuit B83V or B82V would overload it and lead to voltage collapse.

Given the difficulties experienced in the recent past enhancing the system near New Market, there is merit in considering to replace VMOPS with a load shedding scheme to mitigate the severity of load disruptions following contingencies.

5.6 Summary of Findings

Supply conditions in York region are very tight. The triggers and need dates for enhancements to the York Region are summarized in Table 8.

Table 8: Timeline of Supply Constraints to the New Market Area

CONSTRAINTS	HOLLAND LOAD (MW)	YEAR	COMMENTS
SCENARIO 1: KEELE VALLEY OUTPUT 30 MW			
THERMAL Woodbridge JCT to Holland Marsh JCT	99.5	2009	Keele Valley GS out-of-service
	127	2011	KeeleValley GS in-service
PRE-CONTINGENCY VOLTAGE DECLINE	159	2014	Armitage TS 220 kV bus
POST-CONTINGENCY VOLTAGE DECLINE	169	2014	Holland TS 44 kV bus
TRANSFER CAPABILITY	170	2014	Both Holland TS and Armitage TS loaded to stations' LTRs
SCENARIO 2: KEELE VALLEY OUTPUT 22 MW			
THERMAL Woodbridge JCT to Holland Marsh JCT	99.5	2009	Keele Valley GS out-of-service
	113	2010	KeeleValley GS in-service
PRE-CONTINGENCY VOLTAGE DECLINE	154	2013	Armitage TS 220 kV bus
POST-CONTINGENCY VOLTAGE DECLINE	169	2014	Holland TS 44 kV bus
TRANSFER CAPABILITY	170	2014	Both Holland TS and Armitage TS loaded to stations' LTRs

A solution to the above identified issues can be provided by means of either:

- installing local generation connected to 230 kV system or
- building a new transmission line into the area

The work is required to be completed before the summer of 2010. This would not only provide the relief to B82V and B83V line but would also improve 230 kV system voltages in the Armitage area and increase the level of security of supply to the area.

Also, new transformation capability would be needed in the area by the summer of 2014 when loading of both Armitage TS and Holland TS is forecasted to reach stations' design capacities.

It is suggested that Hydro One to replace VMOPS with a load shedding scheme to mitigate the severity of load disruptions following contingencies.

– End of Section –

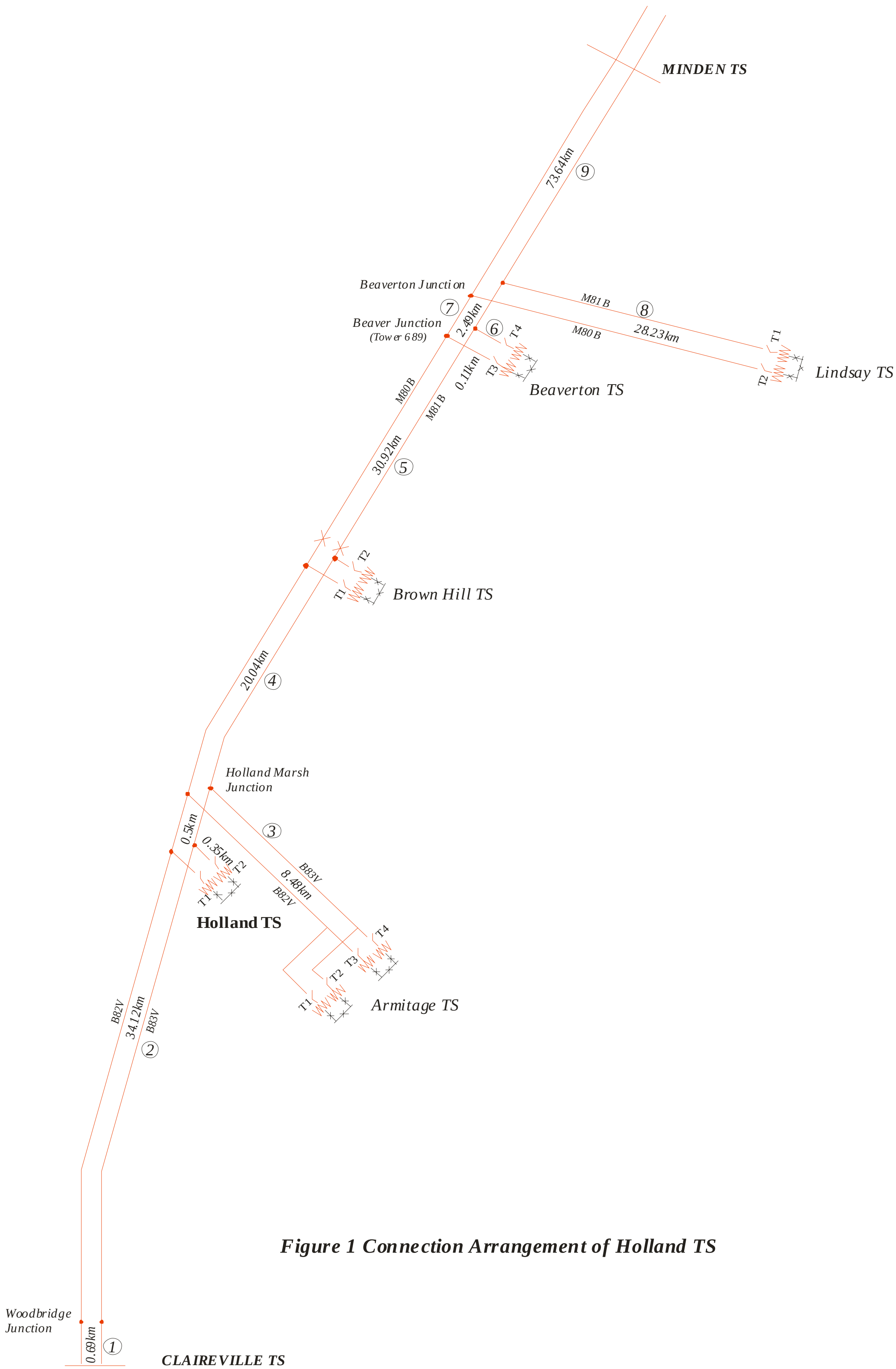

Figure 1 Connection Arrangement of Holland TS

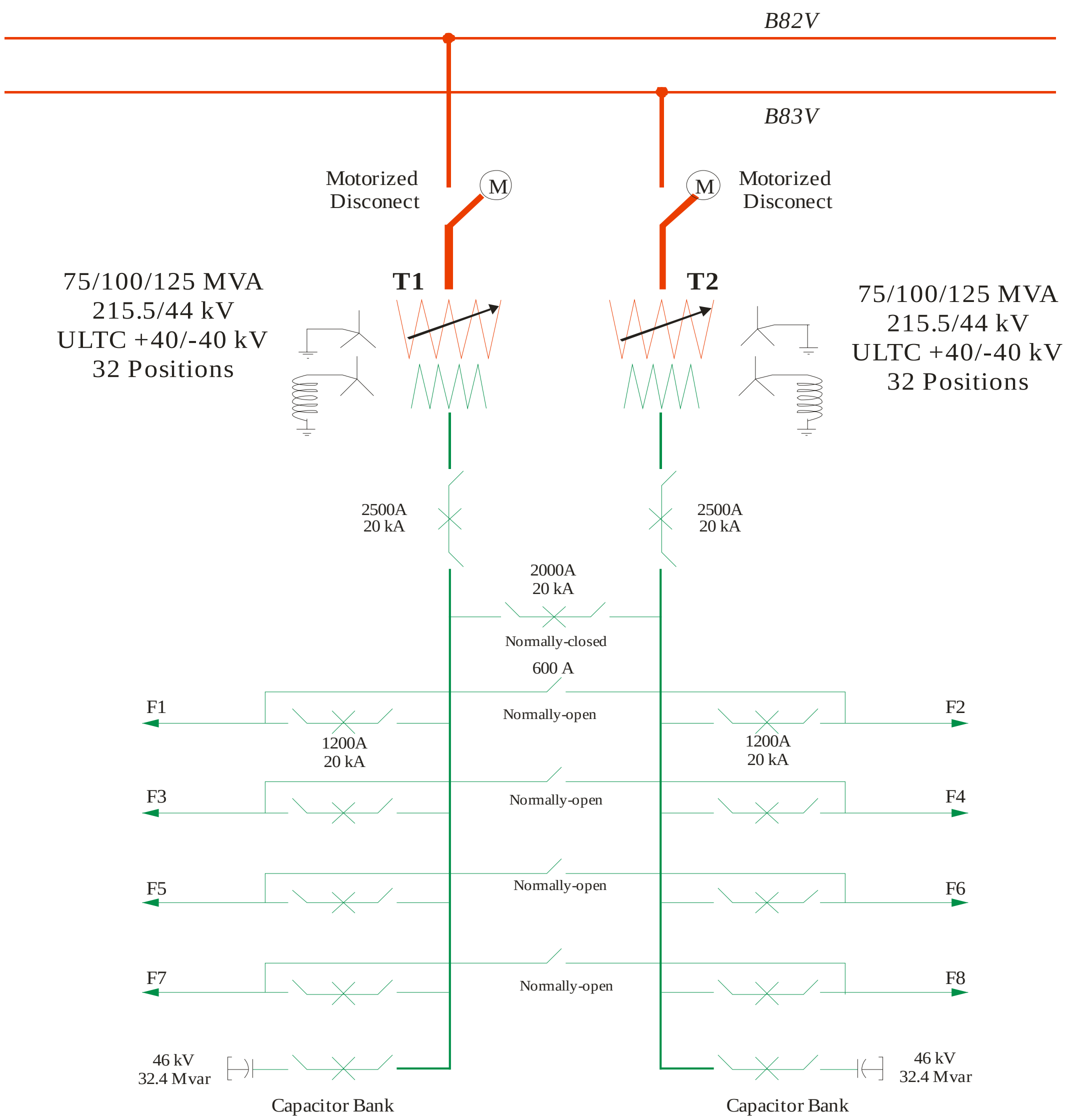

Figure 2. Holland TS Single Line Diagram

Appendix A. Thermal Ratings

230 kV Line Rating: Claireville to Minden						
Ratings at 35℃ Ambient, 5 km/h Wind						
Circuit	*Conductor*	*Max Operating Temperature*	*Continuous Rating*		*15-MIN LTR (Pre-load of 75%)*	
***B82C & B83C: Claireville to Brown Hill TS**, MVA at 235 / 230* kV*						
Claireville to Woodbridge JCT (1)	*1843.2 kcmil 72/7*	*127℃*	*1796 A*	*731 MVA*	*2241 A*	*912 MVA*
Woodbridge JCT to Holland Marsh JCT (2)	*795 kcmil 26/7*	*127℃*	*1092 A*	*444 MVA*	*1260 A*	*512 MVA*
*Holland Marsh JCT to Armitage TS (3)**	*795 kcmil 26/7*	*150℃*	*1230* A*	*490* MVA*	*1414* A*	*563* MVA*
Holland Marsh JCT to Brown Hill TS (4)	*795 kcmil 26/7*	*127℃*	*877 A*	*356 MVA*	*998 A*	*406 MVA*
***M80B: Minden to Brown Hill TS**, MVA at 235 kV*						
Minden TS to Beaverton JCT (9)	*795 kcmil 26/7*	*104℃*	*793 A*	*322 MVA*	*1017 A*	*413 MVA*
Beaverton JCT to Beaver JCT (7)	*795 kcmil 26/7*	*134℃*	*1136 A*	*462 MVA*	*1309 A*	*532 MVA*
Beaver JCT to Beaverton TS (6) *Beaverton JCT to Lindsay TS (8)*	*795 kcmil 26/7*	*150℃*	*1230 A*	*500 MVA*	*1414 A*	*575 MVA*
Beaver JCT to Brown Hill TS (5)	*795 kcmil 26/7*	*127℃*	*877 A*	*356 MVA*	*998 A*	*406 MVA*
***M81B: Minden to Brown Hill TS**, MVA at 235 kV*						
Minden TS to Beaverton JCT (9)	*795 kcmil 26/7*	*104℃*	*793 A*	*322 MVA*	*1017 A*	*413 MVA*
Beaverton JCT to Beaver JCT (7)	*795 kcmil 26/7*	*104℃*	*928 A*	*362 MVA*	*1074 A*	*419 MVA*
Beaver JCT to Beaverton T S (6)	*795 kcmil 26/7*	*150℃*	*1230 A*	*500 MVA*	*1414 A*	*575 MVA*
Beaverton JCT to Lindsay TS (8)	*795 kcmil 26/7*	*127℃*	*1085 A*	*432 MVA*	*1252 A*	*509 MVA*
Beaver JCT to Brown Hill TS (5)	*795 kcmil 26/7*	*127℃*	*877 A*	*356 MVA*	*998 A*	*406 MVA*

Appendix B. Keele Valley Power Output