FINAL DRAFT REPORT

Project: Great Northern Tri-Gen Facility
Applicant: Hydro One
Proponent: Soave Hydroponics

CAA ID 2007-255
Transmission Assessments & Performance Department

Nov 29, 2007
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 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 System Impact 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 System Impact 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.
# Table of Contents

SIA Summary .................................................................................................................. 1  
Conclusions and Recommendation ............................................................................. 1  
IESO Requirements for Connection ........................................................................... 2  
Notification of Approval for Connection Proposal ........................................................ 3  

1.0 Project Description .................................................................................................. 4  

2.0 Review of Connection Proposal ............................................................................. 5  
   2.1 Connection Arrangement ....................................................................................... 5  
   2.2 On-line Monitoring ............................................................................................... 7  
   2.3 Protection Systems ............................................................................................... 7  
   2.4 Under Frequency Tripping .................................................................................. 8  
   2.5 Kingsville TS Power Factor .................................................................................. 8  

3.0 Data Verification ..................................................................................................... 11  

4.0 System Description .................................................................................................. 15  
   4.1 Existing Transmission and Distribution ................................................................. 15  
   4.2 Area Load and Load Growth ............................................................................... 18  

5.0 Short Circuit Assessment ....................................................................................... 23  

6.0 System Impact Studies ............................................................................................ 24  
   6.1 Description ........................................................................................................... 24  
   6.2 Study Assumptions ............................................................................................... 24  
   6.3 Thermal Loading Assessment .............................................................................. 27  
   6.4 Voltage Assessment ............................................................................................ 29  
   6.5 Transient Stability Assessment ............................................................................ 33  
      6.5.1 Three Phase Fault at Kinsville LV Bus ............................................................. 34  
      6.5.2 Three Phase Fault on K2Z ............................................................................. 38  
      6.5.3 Three Phase Fault on K6Z ............................................................................. 41
SIA Summary

Conclusions and Recommendations

Project Description

Soave Hydroponics was successful in obtaining a contract with the Ontario Power Authority (OPA) as part of the Combined Heat and Power Request for Proposal. The proponent is planning to develop a 12 MW gas cogeneration plant consisting of four 3.75 MVA generators designed as Great Northern Tri-Gen (Tri-Gen). The new generation facility would be embedded into the Hydro One distribution system at Kingsville TS, and would connect to the 27.6 kV feeder 3M3, at 6 km from the transformer station.

Hydro One identified that there are other embedded generators connected or proposed to be connected to the Kingsville TS distribution system ahead of this project in the Hydro One queue position, totalizing 54.2 MW of generation.

The simplified connection arrangement is shown in Figure 1 of this report.

The proposed facility is an embedded generation facility. At this time, the proponent will not be participating in the Ontario Electricity Markets. The generators will operate independent of dispatch instructions from the IESO.

The Ontario Market Rules requires that any embedded generation facility not participating in the IESO administered markets but is larger that 10 MW must have a System Impact Assessment conducted by the IESO before being allowed to connect.

The study results concluded the following:

This System Impact Assessment has examined the effect of the new generation facility on the reliability of the IESO-Controlled Grid (ICG). The studies concluded that the proposed generation facility:

(a) would displace part of the Kingsville TS load, but would not result in a net injection of power into the ICG during peak and normal load conditions;

(b) would inject power into the ICG at Kingsville TS during light load conditions, when all existing and planned embedded generation ahead of Tri-Gen plant in the Hydro One queue are generating, but the amount would not pose any thermal risk on the ICG;

(c) would raise questions with regards to the proper operation of protections and voltage regulation facilities (ULTC) at Kingsville TS and Lauzon TS during the reverse power flow. Hydro One (transmission) has conducted a Customer Impact Assessment (CIA) to address these concerns;

(d) would increase the short circuit current at the station to which it connects, but would not result in short circuit levels in excess of the high voltage breakers capability in the ICG;

(e) would raise questions at Kingsville TS with regards to the high short-circuit level on the 27.6 kV bus. A CIA was conducted by Hydro One (transmission) to address this concern;
(f) would result in thermal relief of the heavily loaded transmission facilities in Windsor area, including 115 kV circuits J3E and J4E, and K2Z and K6Z;

(g) has a range of reactive power capability between 0.8 lagging power to 0.97 leading power factor, but will operate in power factor control at unity power factor, as requested by the Distributor;

(h) would improve voltage performance in the Kingsville area, pre and post-contingency, even by operating in reactive power control at unity power factor;

(i) by operating at unity power factor, and injecting just active power into the system, the power factor at Kingsville TS would become lower, as measured at the defined meter point. However, with the existing switchable shunt capacitors at Kingsville TS, the power factor can be maintained within the range of 0.9 lagging to 0.9 leading, as per Market Rules requirements. When the voltages in the area are too high to allow the shunt capacitors to be switched in, a lower power factor would be allowed;

(j) is transient unstable for faults close to the 27.6 kV bus at Kingsville, resulting in Tri-Gen generators tripping for the ‘out-of-zone’ faults, but there is no negative impact on the ICG;

(k) is stable during transient stability analysis for faults on the transmission system.

**IESO’s Requirements for Connection**

The Market Rules does not specify performance standards for non-market participant embedded generators which are smaller than 10 MVA, unless the facility is comprise of generation units whose net output is greater than 50 MVA. However, where a new facility could negatively impact the IESO Controlled Grid, the IESO would request the applicant and the proponent to meet minimum technical requirements, regardless of the size of the facility.

Therefore, IESO has the following minimum requirements for the Tri-Gen generation facility.

(1) The Distributor is required to be capable to operate within the range of 0.9 lagging power factor to 0.9 leading power factor as measured at the defined meter point at Kingsville TS. To meet the power factor requirement, the Distributor could direct the embedded generators and connected loads to operate at the appropriate power factor. However, when the voltages in the area are too high to allow the shunt capacitors to be switched in, a lower power factor would be allowed.

(2) With the large amount of existing and proposed embedded generation at Kingsville TS, the Distributor must provide the IESO with MW and MVAr real time monitoring data in an aggregated form for all embedded generation connected to the distribution system at Kingsville TS, as measured at the point of supply into the distribution system. Where the Distributor does not have real time monitoring for the already connected embedded generators, the estimate MW and MVAr data are acceptable to be used in the calculation until real time data becomes available to the Distributor. For Great North Tri-Gen and all future generator connections to Kingsville TS, including those projects ahead of Great North Tri-Gen on the Hydro One Queue, real time monitoring is required for calculation, as allowed by the Distribution System Code.

(3) The requirement for monitoring performance standards must be as specified for medium performance facilities in Chapter 4, Appendix 4.19 of the Market Rules.

(4) The generators must not trip for under-frequency conditions in the area above the curve in Figure 2 of this report.

(5) The units must be equipped with protection systems able to detect the out-of-step conditions which must instantaneously trip the generators if these conditions occur.
(6) The performance of the equipment must meet or exceed the predicted performance observed in simulations done by the IESO for the SIA. The Distributor may be required to take corrective actions if the performance of the Embedded Generation would result in adverse impact on the ICG, e.g. sustained oscillations or excessive voltage decline.

(7) The Distributor must respect the requirements from Distribution System Code, as specified in Section 6.2 and Appendix F.

(8) The Distributor has the obligation to revise protection settings at the generation facility interconnection point to ensure that they are coordinated with the distribution system protections. The existing distribution protection settings must be revised, as required.

(9) The Transmitter (Hydro One transmission) has provided the IESO and the Proponent with the Customer Impact Assessment (CIA) report. The following are the conclusions and requirements from the CIA, and become part of this final SIA.

If any of generation proponents ahead of Great North Tri-Gen in the Hydro One queue proceed with their respective connections to Hydro One’s distribution system, and any of those connections cause the fault level at Kingsville TS 27.6 kV bus to exceed TSC limits, Great North Tri-Gen will be disconnected until mitigation measures are implemented.

If any of those connections cause reverse power flow, protections at both Lauzon TS and Kingsville TS, and voltage regulation at Kingsville TS will be reviewed by the Transmitter to ensure proper operation.

(10) The Proponent is required to complete the IESO Facility Registration process in a timely manner before the IESO final approval is granted. Finalized data must be provided to the IESO.

Notification of Approval for Connection Proposal

From the information provided, our review concludes that the proposed connection will not result in a material adverse effect on the reliability of the IESO-controlled grid, provided that all the above requirements are implemented.

It is recommended that a Notification of Conditional Approval for Connection be issued for this project subjected to implementation of above requirements. If the generation facilities either do not meet the specified performance standard when installed or are subsequently determined not to meet those performance standards, the IESO connection approval may be withdrawn until the specified performance standards or their equivalent can be demonstrated.

– End of Section –
1. Project Description

Soave Hydroponics is proposing to develop a cogeneration plant consisting of four 3.75 MVA gas generators in the Winsor area, under a power purchase contract with the OPA.

This System Impact Assessment examined the impact of the proposed Great Northern Tri-Gen generation facility on the reliability of the IESO Controlled Grid.

The new generation facility would be embedded into the Hydro One distribution system, and connect to the 27.6 kV feeder 3M3, at 6 km from Kingsville TS. The feeder is normally connected to the 27.6 kV Kingsville TS Y bus. The 27.6 kV Y and B buses are supplied by four 115 / 27.6 kV - 25 / 41.7 MVA (ONAN/ONAF) transformers at the Kingsville TS.

The existing simplified connection arrangement is shown in Figure 1 of this report.

The proposed facility would be an embedded generation facility. At this time, the proponent will not be participating in the Ontario Electricity Markets, and the generators will operate independent of dispatch instructions from the IESO.

The Ontario Market Rules requires that any embedded generation facility not participating in the IESO administered markets but is larger than 10 MW must have a System Impact Assessment conducted by the IESO before being allowed to connect.

For embedded generation, the Distribution System Code obligates the distributors to perform an impact assessment that “shall set out the impact of the proposed generation facility on the distributor’s distribution system and any customers of the distributor including:

(a) any voltage impacts, impacts on current loading settings and impacts on fault currents;
(b) the connection feasibility;
(c) the need for any line or equipment upgrades;
(d) the need for transmission system protection modifications; and
(e) any metering requirements.”

The IESO has received a copy of the Connection Impact Assessment on the distribution system performed by Hydro One. The assessment has not identified any negative impact of the new generation plant on the Hydro One distribution system. However, it does point out to certain concerns at Kingsville TS, including the potential reverse power flow and high short-circuit level on the 27.6 kV side of station.

The new generation plant is scheduled to be in service in October 2007 for commissioning, with a permanent in service date of December 2007.

– End of Section –
2. Review of Connection Proposal

2.1 Connection Arrangement

The new generation facility would consist of four 3.75 MVA gas generators connected to a 4.16 kV bus.

A 15 MVA transformer would step-up the voltage to the to 27.6 kV level at Tri-Gen location. The initial proposal was to have a Yo/d transformer connection, but Hydro One (distribution) Connection Impact Assessment required a D/d connected transformer. In this SIA it was assumed that the proponent will comply with the distributor’s requirement, and a D/d transformer connection was used.

The plant will connect to the Hydro One distribution system on the 27.6 kV feeder 3M3, at 6 km from Kingsville TS. This feeder is normally connected to the 27.6 kV Kingsville TS Y bus.

The simplified connection arrangement is shown in Figure 1 below.
Figure 1: Tri-Gen Simplified Connection Arrangement

Single Line Diagram
2.2 On-line Monitoring

The *Market Rules* (Chapter 4 section 7.3) require that for generation facilities which do not participate in the IESO administered market monitoring information to be provided to the IESO on a continual basis from facilities including a generation unit rated at greater than 20 MVA or that comprises generation units the ratings of which in the aggregate exceeds 20 MVA.

Since the proposed generator plant is below the above thresholds, telemetry for on-line monitoring of the proposed facility is not required by the IESO at this time.

However, with the high penetration of embedded generation of almost 70 MW in the Kingsville distribution system, the IESO requires the aggregate generation output to be monitored and telemetered to the IESO.

The *Distributor* must provide the IESO with MW and MVAr real time monitoring data in an aggregated form for all embedded generation connected to the distribution system at Kingsville TS, as measured at the *point of supply* into the distribution system. Where the *Distributor* does not have real time monitoring for the already connected embedded generators, the estimate MW and MVAr data are acceptable to be used in the calculation until real time data becomes available to the *Distributor*. For *Great North Tri-Gen* and all future generator connections to Kingsville TS, including those projects ahead of *Great North Tri-Gen* on the Hydro One Queue, real time monitoring is required for calculation, as allowed by the *Distribution System Code*.

The monitoring requirements performance standards must be as specified for *medium performance facilities* in Chapter 4, Appendix 4.19 of the *Market Rules*.

2.3 Protection Systems

Hydro One will have to follow the *Distribution System Code* technical requirements for adequate protection at Kingsville TS.

The initial proposal was to have a Yo/d connectivity of the step-up transformer, but Hydro One *Connection Impact Assessment* required a D/d connectivity.

The *proponent* (Tri-Gen) is responsible to revise the protection schemes at the plant to reflect the new transformer connectivity.

The *Distributor* has the obligation to revise protection settings at the generation facility interconnection point to ensure that they are coordinated with the distribution system protections. The existing distribution protection settings must be revised, as required.

During this SIA and Hydro One’s *Connection Impact Assessment* it was identified that, assuming that all the proposed embedded generation ahead of this proposal in the Hydro One queue position materializes, there would be a reverse power flow of up to 20.3 MW through the 115 / 27.6 kV transformers at Kingsville TS under minimum load and maxim generation conditions.
Hydro One \textit{transmission} is required to address through a \textit{Customer Impact Assessment} the impact of the reverse power flow on the station protections and the operation of the tap changers.

### 2.4 Under-Frequency Tripping

Reference #3 of \textit{Appendix 4.2} of the \textit{Market Rules} requires that generating facilities be capable of operating continuously at full power for a system frequency range between 59.4 to 60.6 Hz. For under-frequency system conditions, generators shall not trip for frequency variations that are above the curve shown in Figure 2.

The \textit{Proponent} confirmed that the interface and generator protections will be set such as the facilities operating in the area above the curve would not trip.  

\textit{Figure 2: Standard for Setting Under-Frequency Trip Protection for New Generators}

![Figure 2: Standard for Setting Under-Frequency Trip Protection for New Generators](image)

### 2.5 Kingsville TS Power Factor

By operating at unity power factor, as required by the \textit{Distributor}, and Tri-Gen facility injecting just MW into the system, the active power as measured at the Kingsville TS defined meter point would be reduced, while the reactive power would remain roughly unchanged. Under these conditions, the load power factor at Kingsville TS, as measured at the defined meter point, would become lower.

As presented in Figures 3 and 4 below, the historical power factor at Kingsville TS has been mostly above 0.9, with some spikes below 0.9, typically during the off-peak hours, when the transmission voltages were high and the Kingsville shunt capacitors were removed from service.
With the existing four switchable shunt capacitors for a total of 60 MVAr installed at Kingsville TS, it is expected that the load power factor can be maintained within acceptable range with the proposed Tri-Gen facility connected to the distribution system. However, when the voltages in the area are too high to allow the shunt capacitors to be switched in service, a lower power factor would be allowed.
The *Distributor* is required to be capable to operate within the range of 0.9 lagging power factor to 0.9 leading power factor as measured at the defined meter point at Kingsville TS. To meet the power factor requirement, the *Distributor* could direct the embedded generators and connected loads to operate at the appropriate power factor. However, when the voltages in the area are too high to allow the shunt capacitors to be switched in service, a lower power factor would be allowed.
3. Data Verification

The following data have been made available to the IESO at the time of this System Impact Assessment. If any of the data are inaccurate, the applicant and the proponent should provide the correct data to the IESO prior to the completion of IESO Facility Registration process.

(a) Generators

<table>
<thead>
<tr>
<th>Type</th>
<th>Salient pole</th>
<th>Open Circuit Time Constants:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated capability</td>
<td>3.75 MVA</td>
<td>( T'_{do} ) 4.3 sec</td>
</tr>
<tr>
<td>Terminal Voltage</td>
<td>4.16 kV</td>
<td>( T''_{do} ) 0.02 sec</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.8</td>
<td>( T'_{qo} ) 8.6 sec</td>
</tr>
<tr>
<td>Speed</td>
<td>1800 rpm</td>
<td>( T''_{qo} ) 0.152 sec</td>
</tr>
<tr>
<td>Total Rotational Inertia H</td>
<td>0.819 kW-sec/kVA</td>
<td>( X_d ) 2.49 pu</td>
</tr>
<tr>
<td>Speed Dumping</td>
<td>0</td>
<td>( X_q ) 1.8 pu</td>
</tr>
<tr>
<td>Saturation factors:</td>
<td></td>
<td>( X'_{d} ) 0.204 pu</td>
</tr>
<tr>
<td>( S_{1.0} )</td>
<td>0.15</td>
<td>( X'_{q} ) 1.8 pu</td>
</tr>
<tr>
<td>( S_{1.2} )</td>
<td>0.96</td>
<td>( X''_{d} ) 0.15 pu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X''_{q} ) 0.28 pu*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X_l ) 0.1 pu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X_2 ) 0.217 pu</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( X_0 ) 0.035 pu</td>
</tr>
</tbody>
</table>

*For simulations purposes, \( X''_q \) was assumed to be equal with \( X''_d \).

The proponent has stated that the generators will be capable to operate in both power factor control and in voltage control, between 0.97 leading to 0.8 lagging power factor.

The Market Rules does not specify performance standards for non-market participant embedded generators which are smaller than 10 MVA, unless the facility is comprise of generation units whose net output is greater than 50 MVA. Then, the synchronous generators shall have the capability to supply or absorb reactive power from 0.9 lag to 0.95 lead power factor based on rated active power output and rated voltage.

Although this requirement does not specifically apply to the proposed facility assessed in this SIA, its range of reactive power capability meets the Market Rules requirements for the lagging power, but falls short from meeting the minimum leading power factor.

The Distributor has requested the proposed generators to operate in power factor control at unity power factor.
(b) Automatic Excitation Systems

For the excitation systems, the proponent sent a model similar with the IEEET2 excitation system. The model provided and its parameters are given below.

- Regulator Forward Gain (KA) 500
- Feedback Gain (KF) 0.04
- Input Filter Constant (TR) 0.01 sec
- Amplifier Time Constant (TA) 0.1 sec
- Feedback Time Constant (TF1) 0.7 sec
- Feedback Time Constant (TF2) 0.05 sec
- Minimum AVR output (VR Min) 0
- Maximum AVR output (VR Max) 100
- Maximum rate of change (DM) 200
- Exciter Gain (KE) 1
- Exciter Voltage Offsets (KEF) 0
- Exciter Voltage Offsets (KV) 0
- Exciter current F/B gain (KC) 0
- Exciter time constant (TE1) 0.91
- Exciter time constant (TE2) 0
- Exciter time constant (TE3) 0
- Maximum Exciter output (EC1) 100
- Minimum Exciter output (EC2) 0
- Exciter Saturation @ 75% (SE1) 110%
- Exciter Saturation @ 100% (SE2) 190%
The above model was translated into the IEEET2 excitation system with the following constants:

\[
\begin{align*}
T_R & = 0.01 \\
K_A & = 500 \\
T_A & = 0.1 \\
V_{R_{\text{max}}} & = 100 \\
V_{R_{\text{min}}} & = 0 \\
K_E & = 1 \\
T_E & = 0.91 \\
K_F & = 0.04 \\
T_{F1} & = 0.7 \\
T_{F2} & = 0.05 \\
E_1 & = 0.75 \\
S_E(E_1) & = 1.1 \\
E_2 & = 1 \\
S_E(E_2) & = 1.9
\end{align*}
\]

The proponent was advised that some parameters appear to be out of normal range, but no corrections to these parameters were sent to the IESO: KA, VRmax, VRmin, E1, E2, SE(E1) and SE(E2).

(c) Step up transformer

Voltage \quad 27.6 / 4.16 kV
Connection \quad \text{Delta} / \delta^* \\
Rating \quad 15 \text{ MVA} \\
Impedance \quad 0.00625 + j 0.075 \text{ pu, on 15MVA base}^* \\
*as per Hydro One CIA

The proponent has indicated that the new transformers will be equipped with off-load tap changing facilities. For the study purposes, it was assumed that the transformation ratio is 1 pu: 0.95 pu (-2 x 2.5% on the 4.16 kV side).
(d) Distribution Line Data

Feeder impedance in ohms from Kingsville TS to the point of connection was provided by the Distributor, as follows:

\[
\begin{align*}
R_1 &= 0.604 \\
R_0 &= 1.637 \\
X_1 &= 2.390 \\
X_0 &= 6.480 \\
\text{Length} &= 6 \text{ km}
\end{align*}
\]

The applicant is advised that if the actual parameters will significantly differ from those used in this assessment, the results of this SIA would have to be revised.

– End of Section –
4. System Description

4.1 Existing Transmission and Distribution

The Great Northern Tri-Gen generation plant would be embedded into the 27.6 kV distribution system supplied from Kingsville TS. The transformer station includes four step-down 115/27.6 kV, 25/41.7 MVA (ONAN/ONAF) transformers, supplying the 27.6 kV Y and B buses.

The plant will connect to the Hydro One’s feeder 3M3, at 6 km from Kingsville TS. This feeder is normally connected to the 27.6 kV Kingsville TS Y bus.

Hydro One identified that there are other embedded generators connected or proposed to be connected to the Kingsville TS distribution system ahead of this proposal in the Hydro One queue position, totaling 54.2 MW of generation, as follows:

<table>
<thead>
<tr>
<th>Existing EG</th>
<th>Proposed EG ahead in the H1 queue position:</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 kW on M1 feeder</td>
<td>#127 - 9000 kW on M4 feeder</td>
</tr>
<tr>
<td>1800 kW on M2 feeder</td>
<td>#128 - 9000 kW on M5 feeder</td>
</tr>
<tr>
<td>2500 kW on M3 feeder</td>
<td>#129 - 9000 kW on M8 feeder</td>
</tr>
<tr>
<td>8200 kW on M4 feeder</td>
<td>#194 – 8439 kW on M8 feeder</td>
</tr>
<tr>
<td>3800 kW on M6 feeder</td>
<td>35.4 MW</td>
</tr>
<tr>
<td>300 kW on M8 feeder</td>
<td></td>
</tr>
<tr>
<td>1600 kW on M9 feeder</td>
<td></td>
</tr>
<tr>
<td>18.8 MW</td>
<td></td>
</tr>
</tbody>
</table>

Kingsville TS is supplied by two radial 115 kV circuits from Lauzon TS: K2Z and K6Z. Both circuits supply also Belleriver TS, and in addition K2Z supplies radial two more load stations: Tilbury West DS and Tilbury TS. There is normal separation between the 115 kV lines K2Z and K6Z at Belleriver Junction and Tilbury Junction, as presented in Figure 5 below.

There is a normal open point between 115 kV circuits K2Z and N5K, but under certain conditions Tilbury TS and Tilbury West DS loads may be supplied from Sarnia Scott TS via N5K, and reversely, Wallaceburg load may be transferred from Sarnia Scott System to the Windsor 115 kV System. The new connection would not impact the load transfer options.

Kingsville TS is part of the Winsor Area, presented in Figure 5. It encompasses two 230 kV and 115 kV transmission paths between Keith TS and Lauzon TS, and the radial 115 kV circuits E8F and E9F supplying automobile manufacturing plants in Windsor, and the radial K2Z and K6Z circuits.

There are three customer-owned generating plants in the area, Brighton Beach CGS, West Windsor Power CGS and Windsor TransAlta CGS, with a combined generating capacity of about 825 MW.

Voltage support is provided in the area by capacitor banks at 115 kV level at Keith TS and Lauzon TS, and at LV level at Crawford TS, Essex TS, Kingsville TS, Walker TS, Keith TS, Lauzon TS and Malden TS. Belleriver TS will have two 10 MVAR shunt capacitors installed in 2007.
The Windsor Area is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. The issues mentioned above occur under certain operation conditions, mainly during high level of load on the 115 kV system concurrent with high power flows transfers through the area.

Another concern to be mentioned is that the 115 kV circuits J3E and J4E between Keith TS and Essex TS are operating often close to their continuous thermal line rating limits.

As a result, a number of special protection schemes (SPS) are employed to facilitate operation of the area:

- Voltage Dependent L/R at Kingsville: manages voltages by rejecting load at Kingsville following low voltage detection at 115 kV Kingsville TS;
- Connectivity Based L/R: manages voltages by tripping K2Z and K6Z circuits at Lauzon TS if the 230/115 kV connection at Lauzon is lost (C23Z+Lauzon T1 and C24Z+Lauzon T2);
- Windsor Area Overload Protection schemes: manages thermal overload by splitting the bus at Essex or rejecting generation at Brighton Beach based on detection of pre-selected system connectivity that includes the loss of Keith x Essex J3E/J4E circuit, the loss of Essex x Lauzon Z1E/Z7E circuit, loss of Keith T11/T12 autotransformer, the loss of Keith x Chatham C21J/C22J circuit and the loss of Keith J5D interconnection to Michigan.

However, most of the concerns are under outage conditions, when certain elements are out of service. With all the elements in service, the recognized contingencies which may result in unacceptable conditions are:

- the loss of C23Z + Lauzon T1 or the loss of C24Z + Lauzon T2 when power is exported on J5D may result in large voltage declines;
- the loss of J5D is the most severe contingency and results in the largest voltage declines under heavy imports on J5D;
- the K6Z contingency can result in excessive voltage declines at the Kingsville and Tilbury 27.6 kV load buses, and overloading of K2Z. A K2Z contingency is less severe than a K6Z contingency.
Figure 5: Windsor Area System
4.2 Area Load and Load Growth

The load forecast increase for the Western zone is 0.71% for the next year, with increases from 0.26 to 0.44% in the next 4 years.

Figure 6 below shows the Winsor area load connected to the 115 kV system between Lauzon TS and Keith TS during May to July, 2006.

Figure 7 shows the flows on the 115 kV circuits J3E and J5E at Keith TS, respectively on the 115 kV circuits Z1E and Z7E at Lauzon TS.

It is of interest to notice that the power flows predominately from Keith to Lauzon, with even periods of reverse flows at Lauzon TS on the Z1E and Z7E circuits. This power circulation is mainly the result of the existing area generation which is located close to Keith TS, on both 115 kV and 230 kV systems.

Under certain conditions the flow on circuits J3E and J4E approaches the continuous rating of the lines (250 MVA).

Naturally, any generation connected closer to Lauzon end would back off some of the above mentioned flow on J3E and J4E.
Figure 6: Windsor 115kV Area Load

Figure 7: Flows on J3/4E and Z1/7E
Figure 8 presents the flows on the 230/115 kV autotransformers at Keith and Lauzon TS.

Figure 8: Keith and Lauzon 230/115 kV Transfers

It can be seen that usually more power is transferred from Lauzon than from Keith into the 115 kV system. This is a consequence of the fact that Lauzon autotransformers are larger (250MVA) than Keith autotransformers (115 MVA), and also because the proximity of the 115 kV local generation to the Keith TS backs off some of the 230 to 115 kV power transfer at this station.

It can be noticed that there are periods when the flows through Keith autotransformers significantly increase along with flows through Lauzon autotransformers decreasing. These situations occur mostly when the 230 kV Brighton Beach generation is in service, or there are high imports on J5D, resulting in parallel flow through the Windsor 115 kV path.
Closer to the connection of the proposed Tri-Gen facility, the flows on the radial 115 kV circuits K2Z and K6Z supplying the area load for May – July 2006 and May – June 2007 are presented in Figure 9 and Figure 10, respectively.

**Figure 9: K2Z & K6Z Flows and Kingsville Load May-July 2006**

![Figure 9: K2Z & K6Z Flows and Kingsville Load May-July 2006](image)

**Figure 10: K2Z & K6Z Flows and Kingsville Load May-June 2007**

![Figure 10: K2Z & K6Z Flows and Kingsville Load May-June 2007](image)
The maximum total flow on K2Z and K6Z of 201 MW occurred on Jul 17, 2006, when Kingsville TS also recorded the absolute peak load of 135 MW, and Belleriver TS was loaded at 26 MW and Tilbury stations at 35 MW.

The minimum total flow on K2Z and K6Z of 59.4 MW occurred on May 21, 2006 at HE3. Since then, Belleriver TS was commissioned, and the new minimum load of 65 MW occurred on May 20, 2007, with Kingsville TS loaded at 47 MW, Belleriver TS loaded at 9 MW and Tilbury stations at 8 MW.

The non-coincident minimum load at Kingsville TS of 45.9 MW was recorded on the same day, May 20, 2007, 2 hours earlier.

– End of Section –
5. Short Circuit Assessment

As part of the SIA, the IESO investigates the impact of the new connections on the IESO Controlled Grid (ICG) fault levels and the adequacy of the high voltage breakers to interrupt the faults.

The existing short circuit levels at the stations in the area were calculated in the Connection Impact Assessment conducted by Hydro One for the proposed East Winsor Cogeneration Connection in April 2007. The short circuit interrupting capability of the 115 kV breakers at Lauzon TS were obtained from Hydro One 2002 Breaker Survey. The values for Lauzon TS are presented in table 1 below.

Table 1 - Lauzon Shortcircuit Analysis

<table>
<thead>
<tr>
<th>Station</th>
<th>Minimum Breaker Rating (kA)</th>
<th>Fault Levels (kA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Symmetrical</td>
<td>Asymmetrical</td>
</tr>
<tr>
<td>Lauzon 115 kV</td>
<td>39.3</td>
<td>45.5</td>
</tr>
</tbody>
</table>

In general, small embedded generation facilities behind step-up transformer and distribution feeder impedances, like the one proposed in this SIA, do not have a significant impact on the transmission system fault levels. With the low contribution of the new development to the area fault levels and the existing large margin between short-circuit level and breaker interrupting capability, it is considered that the high voltage breakers at Keith TS are adequate to accommodate the new connection. Therefore, no detailed fault level studies were required to be conducted by Hydro One for the SIA.

The impact of the new facility on the distribution system has been conducted by the Hydro One (distribution) as part of the Connection Impact Assessment. The analysis included the short-circuit adequacy of the 27.6 kV distribution equipment, including fuses, reclosers and breakers. Hydro One study confirms that the impact of the embedded new facility on their distribution system is acceptable.

However, the results of Hydro One (transmission) Customer Impact Assessment (CIA) studies identified that, with all existing and proposed generation at Kingsville TS (all projects ahead of and including Great North Tri-Gen) in-service, the short circuit level on the 27.6 kV bus will exceed the limit established by the Transmission System Code (17 kA for a 3-phase fault and 12 kA for a single line to ground fault). Soave Hydroponics has decided to proceed with the CIA assessment based on the connection of Great North Tri-Gen ahead of the number of generation proponents that are higher in the Hydro One queue. This CIA resulted in acceptable short circuit levels.

If any of generation proponents ahead of Tri-Gen in the Hydro One queue proceed with their respective connections to Hydro One’s distribution system, and any of those connections cause the fault level at Kingsville TS 27.6 kV bus to exceed TSC limits, Great North Tri-Gen will be disconnected until mitigation measures are implemented.

– End of Section –

23
6. System Impact Studies

6.1 Description

This system impact studies focused on identifying the impact of the new generation plant on thermal loading of the transmission lines and transformers at the high voltage transformer stations, on system voltages performance pre and post contingency, and the transient stability and system voltages in the studied area.

The studies were performed for the 2008 summer peak load and 2008 spring light load conditions with all elements in service.

The peak load scenario was used to identify post-contingency steady state voltage performance for the loss of the proposed generation plant. Under this scenario, all local distribution generators excepting Tri-Gen were assumed to be zero, to minimize their voltage support.

A generation facility would normally offload transmission elements during peak load conditions. This is especially true in radial systems. Therefore, the light load scenario was used to analyze the thermal loading of the transmission elements. Under this scenario, all local distributed generation (existing and ahead of this proposal in the Hydro One queue) was assumed to be in service.

For comparison purposes, the peak load scenario was also used to evaluate the effect of the new connection on the thermal loading of the transmission elements and on the voltage performance post-contingency.

An additional voltage performance study was conducted under the peak load conditions with all the generation in service, simulating the loss of all embedded generation. This simulation reflects the possible poor transient stability for close faults of the embedded generators operating in power factor control, when the excitation system may not respond and has no contribution during the first swing.

At Transmitter’s request, two supplementary studies with all distributed generation in service were performed to monitor the voltage performance for transmission contingencies: a peak load scenario and a light load scenario.

6.2 Study Assumptions

(a) System Modeling

The IESO Summer 2007 base case was used to perform the technical studies for the proposed connection, with the following adjustments.

Based on the information provided by Hydro One and Soave Hydroponics, the four new generators were added into the base case connected at 6 km from Kingsville TS to the 27.6 kV feeder M3. The parameters used for simulation are listed in chapter 3 of this report.
The IESO base case model does not include the Hydro One distribution system. Therefore, all the existing and future generators ahead of this proposal in the Hydro One queue were lumped together and modeled connected directly to the 27.6 kV bus at Kingsville TS, operating at constant unity power factor. Hydro One advised the IESO that some embedded generators operate in slightly leading power factor, absorbing VARs. It was assumed that the reduction in losses when these generators operate offsets this reactive consumption at generators.

Similarly, the entire load connected to the distribution system at Kingsville TS was modeled connected directly to the LV bus, having a 0.9 leading power factor.

For peak load scenario, the Western Zone load was scaled to 3,460 MW, to match the IESO summer peak demand for normal growth extreme weather conditions, produced in Q1 2007. For the light load scenario, the Western Zone was reduced to 40% of the peak load.

The load growth forecast for the stations in the studied area was assumed to be 0.5% for 2007 and 0.71 for 2008, similar to the IESO load forecast increase for the Western Zone. Subsequently, the load of the individual stations connected to K2Z and K6Z circuits were adjusted to match the 2008 peak and light load forecast, as presented in Table 3. The load power factor was assumed to be 0.9.

Table 3 - Load Assumptions

<table>
<thead>
<tr>
<th>Station</th>
<th>2006 Actual Peak (MW)</th>
<th>2008 Peak</th>
<th>2008 Light*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingsville TS</td>
<td>135</td>
<td>136.6</td>
<td>47*</td>
</tr>
<tr>
<td>Belleriver TS</td>
<td>26</td>
<td>26.3</td>
<td>9*</td>
</tr>
<tr>
<td>Tilbury TS+DS</td>
<td>35</td>
<td>35.4</td>
<td>8*</td>
</tr>
<tr>
<td>Winsor 115 kV</td>
<td>600</td>
<td>607.2</td>
<td>240*</td>
</tr>
<tr>
<td>Western Area</td>
<td>3,460</td>
<td>1,384</td>
<td></td>
</tr>
</tbody>
</table>

* Assumed identical to 2006 minimum load

The generation dispatch in the Windsor Area used in the analysis is presented in table 4. The generation assumptions for the large generators reflect the actual output recorded in 2006.

Table 4 - Generation Assumptions

<table>
<thead>
<tr>
<th>Plant</th>
<th>Generation (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008 Peak</td>
</tr>
<tr>
<td>Brighton Beach 115</td>
<td>150</td>
</tr>
<tr>
<td>Brighton Beach 230</td>
<td>360</td>
</tr>
<tr>
<td>West Windsor</td>
<td>133</td>
</tr>
<tr>
<td>TA Winsor</td>
<td>62</td>
</tr>
<tr>
<td>Kingsville Distribution</td>
<td>0</td>
</tr>
</tbody>
</table>
(b) Thermal ratings

The thermal ratings used for the existing transmission elements were confirmed or provided by Hydro One, who is the equipment owner, and are presented in table 5.

The continuous ampacity rating for the overhead conductors was calculated at 35°C ambient temperature and 4 km/h wind speed. The 15 minute-LTR, or short term emergency rating was calculated for a pre-load equal with 75% of the continuous rating of the overhead line.

The continuous and short term emergency MVA ratings for lines were calculated assuming 118 kV voltage at the 115 kV level.

Table 5 – Line Thermal Ratings

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>From Station</th>
<th>To Station</th>
<th>Temp deg C</th>
<th>Wind km/hr</th>
<th>Illum</th>
<th>Continuous MVA</th>
<th>15 Min LTR MVA</th>
<th>Pre-load %</th>
</tr>
</thead>
<tbody>
<tr>
<td>K6Z</td>
<td>LAUZON</td>
<td>LAUZONJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>1070</td>
<td>1200</td>
<td>245</td>
</tr>
<tr>
<td>K6Z</td>
<td>LAUZONJ</td>
<td>ROURKELJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>1070</td>
<td>1200</td>
<td>245</td>
</tr>
<tr>
<td>K6Z</td>
<td>ROURKELJ</td>
<td>BELRIVEJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>1070</td>
<td>1200</td>
<td>245</td>
</tr>
<tr>
<td>K6Z</td>
<td>BELRIVEJ</td>
<td>KINGSVLE</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>690</td>
<td>720</td>
<td>147</td>
</tr>
<tr>
<td>K2Z</td>
<td>LAUZON</td>
<td>LAUZONJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>1210</td>
<td>1350</td>
<td>276</td>
</tr>
<tr>
<td>K2Z</td>
<td>LAUZONJ</td>
<td>WOODSLEJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>870</td>
<td>930</td>
<td>190</td>
</tr>
<tr>
<td>K2Z</td>
<td>WOODSLEJ</td>
<td>KINGSVLE</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>800</td>
<td>860</td>
<td>176</td>
</tr>
<tr>
<td>K2Z</td>
<td>WOODSLEJ</td>
<td>TILBURYJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>570</td>
<td>610</td>
<td>125</td>
</tr>
<tr>
<td>K2Z</td>
<td>ROURKELJ</td>
<td>BELRIVEJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>1070</td>
<td>1200</td>
<td>245</td>
</tr>
<tr>
<td>K2Z</td>
<td>TILBURYJ</td>
<td>TILBURWJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>590</td>
<td>610</td>
<td>125</td>
</tr>
<tr>
<td>K2Z</td>
<td>TILBURWJ</td>
<td>TILBRYWS</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>590</td>
<td>610</td>
<td>125</td>
</tr>
<tr>
<td>K2Z</td>
<td>TILBURWJ</td>
<td>TILBURY</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>590</td>
<td>610</td>
<td>125</td>
</tr>
<tr>
<td>K2Z</td>
<td>BELRIVEJ</td>
<td>TILBURYJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>500</td>
<td>510</td>
<td>104</td>
</tr>
<tr>
<td>K2Z</td>
<td>TILBURYJ</td>
<td>KENTJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>520</td>
<td>550</td>
<td>112</td>
</tr>
<tr>
<td>K2Z</td>
<td>KENT</td>
<td>KENTJ</td>
<td>35</td>
<td>4</td>
<td>day</td>
<td>420</td>
<td>420</td>
<td>86</td>
</tr>
</tbody>
</table>

The continuous, long term emergency (10-Day LTR) and the 15-minute LTR ratings used for the Kingsville transformers were obtained from the Hydro One secure website. Transformer ratings are presented in table 6.

Table 6 – Transformers Thermal Ratings

<table>
<thead>
<tr>
<th>Station</th>
<th>Transformer</th>
<th>Summer Continuous (MVA)</th>
<th>Summer 10_Day_LTR (MVA)</th>
<th>Summer 15_Min_LTR (MVA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingsville TS</td>
<td>T1</td>
<td>41.67</td>
<td>49.3</td>
<td>68.6</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>41.67</td>
<td>56.3</td>
<td>67.4</td>
</tr>
<tr>
<td></td>
<td>T3</td>
<td>41.67</td>
<td>73.7</td>
<td>84.9</td>
</tr>
<tr>
<td></td>
<td>T4</td>
<td>41.67</td>
<td>64.2</td>
<td>74.9</td>
</tr>
</tbody>
</table>
(c) Load Modeling

Usually, the load is modeled as a constant MVA for the thermal assessment; for steady-state voltage decline studies, the load in the studied area is modeled as voltage dependant (P modeled as 50% constant current and 50% constant impedance; Q modeled as 100% constant impedance) prior to the tap changer response, and as constant MVA after the transformer tap changers responded.

For transient studies, the load in Ontario is modeled as voltage dependant (P modeled as 50% constant current and 50% constant impedance; Q modeled as 100% constant impedance).

6.3 Thermal Loading Assessment

Examining the two extreme conditions, peak load and light load scenarios, it resulted that the new generation plant does not have a negative thermal impact on the IESO controlled grid. Contrary, under peak load conditions, it helps relieving the high flows on circuits K2Z and K6Z, as well as on circuits J4E and J3E. However, under light load conditions, about 20 MW of reverse power flow could be recorded through Kingsville transformers.

(a) Peak Load Conditions

Under peak load conditions, when the Kingsville TS load is about 136 MW, the incorporation of 12 MW of new generation into the Kingsville TS distribution network essentially reduces the power flow into Kingsville transformers, but does not result in a net power injection into the ICG. The loading impact of the new generation plant and the generation distribution factors are presented in table 7 below.

<table>
<thead>
<tr>
<th>Element</th>
<th>All EG out of service MW flow</th>
<th>12 MW Tri-Gen in service MW flow</th>
<th>Generation Distribution Factors %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kingsville</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>35.6</td>
<td>32.3</td>
<td>27.5</td>
</tr>
<tr>
<td>T2</td>
<td>36.7</td>
<td>33.6</td>
<td>25.8</td>
</tr>
<tr>
<td>T3</td>
<td>27.5</td>
<td>25</td>
<td>20.8</td>
</tr>
<tr>
<td>T4</td>
<td>37.4</td>
<td>34.3</td>
<td>25.8</td>
</tr>
<tr>
<td>K2Z at Lauzon</td>
<td>120.8</td>
<td>114.1</td>
<td>55.8</td>
</tr>
<tr>
<td>K6Z at Lauzon</td>
<td>84.3</td>
<td>78.2</td>
<td>50.8</td>
</tr>
<tr>
<td>J4E at Keith</td>
<td>221.0</td>
<td>217.9</td>
<td>25.8</td>
</tr>
<tr>
<td>J3E at Keith</td>
<td>221.7</td>
<td>218.6</td>
<td>25.8</td>
</tr>
</tbody>
</table>

It can be seen that the new generation would be fairly evenly distributed on the 4 transformers at Kingsville, less on T3, and on the two radial 115 kV circuits at Lauzon TS. It also contributes by about one half of the generation output to back off the flow on the Keith to Essex 115 kV path.

The sum of the distribution factors on the 115 kV radial circuits at Lauzon is above 100% as a result of loss reduction in the system: with the 12 MW of power flow being backed off by the proposed generators, there is 0.7 MW reduction in transmission losses in the area.
During the K2Z or K6Z contingency simulations, with no generation in service and constant MVA load (post-ULTC) at peak, the load flow could not be solved, which normally indicates a voltage problem in the system. If the Kingsville peak load is to be restored at the pre-contingency values post-ULTC, it is expected that the Voltage-Dependent Load Rejection scheme will trip feeders at Kingsville TS. This scheme trips feeders M2, M5, M6 and M7 when the voltage declines below 106 kV for 7 seconds, and feeders M1, M3, M4 and M8 if the voltage declines below 106 kV for 10 seconds.

The worst contingency in the area supplied by K2Z and K6Z is the loss of K6Z, which removes one supply to the loads in the area, removes Belleriver T2 and Kingsville T2+T4, and leaves the entire area load connected to K2Z; Kingsville T2 would be transferred to K2Z after about 20-30 seconds by the Kingsville High Voltage Switching Scheme. A K2Z contingency would remove Tilbury load by configuration, therefore the loading on the remaining K6Z is not as critical. Moreover, as can be seen in Table 5 above, the thermal ratings of K2Z are lower than the ratings of K6Z.

For comparison purposes, K6Z contingency was simulated with and without the new generation facility in service. All the simulations were done with voltage dependent loads at the stations connected to K2Z and K6Z. It was also assumed that the two 10 MVAr shunt capacitor at Belleriver, planned to be installed in 2007, are in service. The results are presented in Table 8 below.

### Table 8 – Peak Load – Post-contingency comparison

<table>
<thead>
<tr>
<th>Loss of K6Z</th>
<th>Kingsville TS</th>
<th>K2Z</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak load conditions</strong></td>
<td><strong>Voltage</strong></td>
<td><strong>Flows</strong></td>
</tr>
<tr>
<td></td>
<td>115 kV</td>
<td>27.6 kV</td>
</tr>
<tr>
<td>Pre-contingency</td>
<td>Continuous</td>
<td>41.7</td>
</tr>
<tr>
<td></td>
<td>Long Term</td>
<td>49.3</td>
</tr>
<tr>
<td></td>
<td>15-Minute</td>
<td>68.6</td>
</tr>
<tr>
<td><strong>Stage 1:</strong></td>
<td>Zero generation</td>
<td>118.7</td>
</tr>
<tr>
<td>2 transformers pre-ULTC</td>
<td>Tri-Gen in service</td>
<td>119.4</td>
</tr>
<tr>
<td><strong>Stage 2:</strong></td>
<td>Zero generation</td>
<td>109.5</td>
</tr>
<tr>
<td>3 transformers pre-ULTC</td>
<td>Tri-Gen in service</td>
<td>111.4</td>
</tr>
<tr>
<td><strong>Stage 3:</strong></td>
<td>Zero generation</td>
<td>110.9</td>
</tr>
<tr>
<td>3 transformers post-ULTC</td>
<td>Tri-Gen in service</td>
<td>112.5</td>
</tr>
<tr>
<td><strong>Stage 2:</strong></td>
<td>Zero generation</td>
<td>108.2</td>
</tr>
<tr>
<td>3 transformers post-ULTC</td>
<td>Tri-Gen in service</td>
<td>110</td>
</tr>
</tbody>
</table>

**Note:** loads modeled as voltage dependent to solve the load flow

The first stage simulates the loss of K6Z, Belleriver T2 and Kingsville T2+T4, with loads modelled as voltage dependant, and pre-ULTC action. In this stage, T1 load exceeds the 10-Day LTR and approaches the 15 minute LTR.

The second stage reflects T2 transformer transferred to K2Z by the Kingsville High Voltage Switching Scheme, in addition to T1 and T3, pre-ULTC action. All transformers are below the 10-day LTR.
The third stage simulates the flows after the ULTC action, but the loads are still voltage dependent and below their initial value. It can be seen that the K2Z loading exceeds the long term rating on the section Lauzon Jct to Woodsley Jct.

It can be observed in the above table that the addition of the new plant helps alleviate the overloading of the 115 kV circuit K2Z which occurs post-ULTC action, once the loads are restored close to their initial levels. If this contingency occurs and load is not tripped by the Kingsville Voltage-Dependent Load Rejection, the operators would have to curtail load connected to K2Z in 15 minutes to reduce the flow below the K2Z long-term emergency rating. The addition of the 12 MW generation plant would reduce the load curtailment needs by 12 MW.

Moreover, the addition of new generation plant helps maintaining healthier voltages pre and post contingency in all three stages, as presented in Table 8 above.

(b) Light Load Conditions

Assuming that all the existing new generation, and proposals of new generation ahead in the Hydro One queue of this proposal, and the assessed 12 MW of generation are in service at the time when the minimum load occurs, there may be reverse power flow through the Kingsville transformers. Based on historical data as presented in Figures 9 and 10 above, the minimum load connected to the 27.6 kV buses at Kingsville TS was 45.9 MW on the 20th of May, 2007. With a total of 66.2 MW (18.8+35.4+12) of generation to be installed in the distribution system at Kingsville, it would result in 20.3 MW (66.2-45.9) of reverse flow through Kingsville transformers. While this small reverse flow is not a thermal concern for any Kingsville transformer, some of the existing protections and voltage control devices (ULTC) may have difficulties operating correctly. These issues are to be addressed by the Hydro One in the Customer Impact Assessment.

The addition of the proposed embedded generators may also result in a net injection of active power at Lauzon TS: minimum load on K2Z+K6Z of 64 MW minus maximum generation of 66.2 MW results in up to 2 MW of reverse power flow. Hydro One is requested to address the potential impact of reverse power flow on the L2Z and L6Z line protections at Lauzon TS in the Customer Impact Assessment.

Assuming that all the embedded generators operate at a power factor close to unity, the reactive power circulation at Kingsville TS would remain roughly unchanged.

Therefore, it can be concluded without any detailed technical power flow simulations that the addition of the new facility will not negatively impact the thermal capability of the ICG pre or post-contingency.

6.4 Voltage Assessment

The IESO requires all the generation units connected to the ICG to be operated in voltage control mode. However, embedded generators have to comply with the voltage operating requirements as established by the Distributor in order to minimize the impact of the new connections on the distribution system. Hydro One distribution requirement from the Connection Impact Assessment was to have the new generation plant operating at constant unity power factor.

To analyze steady state voltage performance, load flow analysis were conducted for 2008 peak load conditions, assuming that the Tri-Gen plant is the only generation in service, which is a more conservative assumptions than having additional generation in service on the distribution system at Kingsville.
By adding a generator set to regulate the power factor close to unity, it normally helps the ICG voltage performance, both pre-contingency and post-contingency, unless the contingency disconnects the generator from the system. Therefore, the only contingency simulated was the loss of the generating plant under the peak load conditions.

Three cases were studied to assess the voltage impact of the new facility. In addition to the operating mode at unity power factor required by Hydro One distribution, two extreme conditions reflecting the minimum reactive requirements for generators connected to ICG were studied to observe the maximum post-contingency impact on the IESO-controlled grid: 0.9 lagging power factor and 0.95 leading power factor for the generation output. The results obtained under this maximum and minimum reactive output conditions are more conservative than any reactive output between the two limits.

All the simulations were conducted with load modeled as constant MVA, both before (pre-ULTC) and after the transformer tap changers responded (post-ULTC). The simulation results for the pre-ULTC simulations are conservative, since in reality the load is expected to decrease with the voltage reduction on the LV bus immediately post-contingency. Since these results are acceptable, the results with voltage depended load would be acceptable, as well.

The results of the three cases studied are presented in Table 9 below.

The *IESO Transmission Assessment Criteria* states that with all facilities in service pre-contingency, system voltage declines after a contingency are to be limited to 10% in the transmission system, both before and after transformer tap changer action, and the voltage on the 115 kV system is to be minimum 108 kV.

The post-contingency voltage declines at the transformer station LV buses are to be limited to 10% before tap changer action, and respectively 5% after tap changer action.

As shown in Table 9 below, the simulated contingency resulted in voltage changes well within the acceptable limits. Therefore, the *IESO Transmission Assessment Criteria* regarding voltage decline is respected.
Table 9 – Voltage Assessment: loss of Tri-Gen facility

<table>
<thead>
<tr>
<th>Bus</th>
<th>Generation at unity pf (all caps I/S)</th>
<th>Generation at 0.95 leading pf (2X20MX Kingsville caps)</th>
<th>Generation at 0.9 lagging pf (2x20MX Kingsville caps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre- and post-ULTC</td>
<td>Pre- and post-ULTC</td>
<td>Pre- and post-ULTC</td>
</tr>
<tr>
<td></td>
<td>kV</td>
<td>kV</td>
<td>% decline</td>
</tr>
<tr>
<td>Lauzon TS</td>
<td>115 kV</td>
<td>123.8</td>
<td>123.4</td>
</tr>
<tr>
<td>Belleriver TS</td>
<td>115 kV K2Z</td>
<td>123.0</td>
<td>122.6</td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>122.0</td>
<td>121.4</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>28.4</td>
<td>28.3</td>
</tr>
<tr>
<td>Kingsville TS</td>
<td>115 kV K2Z</td>
<td>118.3</td>
<td>117.2</td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>117.9</td>
<td>116.8</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.3</td>
<td>29.0</td>
</tr>
<tr>
<td>Tilbury West DS</td>
<td>115 kV</td>
<td>117.2</td>
<td>116.4</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.3</td>
<td>29.1</td>
</tr>
<tr>
<td>Tilbury TS</td>
<td>115 kV</td>
<td>117.2</td>
<td>116.4</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.3</td>
<td>29.1</td>
</tr>
</tbody>
</table>
An additional study was conducted to simulate the loss of all embedded generation under the peak load conditions. The intent of this simulation was to reflect the likely poor transient stability for close faults of the embedded generators operating in power factor control, when the AVR and excitation systems may not respond to terminal voltage changes, and the field voltage has no significant contribution to stability during the first rotor swing. With most of the embedded generators operating in power factor or reactive power control, there is a high chance of having a large volume of embedded generators tripping for faults close to the LV bus at Kingsville TS.

The results of this simulation are presented in Table 10. It can be observed that the voltage decline is still within acceptable limits.

**Table 10 – Voltage Assessment: loss of all embedded generation**

<table>
<thead>
<tr>
<th>Bus</th>
<th>Pre-contingency</th>
<th>Post-contingency - loss of all EG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EG’s I/S (67MW)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(kV)</td>
<td>Pre-ULTC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(kV)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% decline</td>
</tr>
<tr>
<td>Kingsville TS</td>
<td>115 kV K2Z</td>
<td>123.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>122.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.6 kV bus</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>118.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.80</td>
</tr>
</tbody>
</table>

At Transmitter’s request, two supplementary studies with all distributed generation in service were performed to monitor the voltage performance for transmission contingencies: a peak load scenario and a light load scenario. Their results are presented in Tables 11 and 12 below. As expected, despite of the fact that the embedded generators increase the reactive power at Kingsville TS by 7 MVAR, by producing significant active power the voltage performance under the peak load conditions are much improved from the case presented in Table 8 above, when no distributed generation was in service: with constant load, the post-contingency load flow converges, resulting in acceptable voltage declines, marginally above 10% pre-ULTC action at Kingsville TS, as shown in Table 11.

**Table 11 – Voltage Assessment: peak load and maximum EG - loss of K6Z**

<table>
<thead>
<tr>
<th>Bus</th>
<th>Pre-contingency</th>
<th>Loss of K6Z Two Transformers Pre ULTC</th>
<th>Loss of K6Z Two Transformers Post ULTC</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kV</td>
<td>kV</td>
<td>% decline</td>
<td>kV</td>
</tr>
<tr>
<td>Lauzon TS</td>
<td>115 kV</td>
<td>125.6</td>
<td>124.1</td>
<td>1.19</td>
</tr>
<tr>
<td>Belleriver TS</td>
<td>115 kV K2Z</td>
<td>125.5</td>
<td>124.2</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>124.9</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>28.7</td>
<td>28.6</td>
<td>0.35</td>
</tr>
<tr>
<td>Kingsville TS</td>
<td>115 kV K2Z</td>
<td>122.1</td>
<td>112.5</td>
<td>7.86</td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>122.3</td>
<td>0.0</td>
<td>100.00</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.2</td>
<td>26.0</td>
<td><strong>10.96</strong></td>
</tr>
<tr>
<td>Tilbury W DS</td>
<td>115 kV</td>
<td>120.1</td>
<td>114.6</td>
<td>4.58</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.5</td>
<td>29.7</td>
<td>-0.68</td>
</tr>
<tr>
<td>Tilbury TS</td>
<td>115 kV</td>
<td>120.1</td>
<td>114.6</td>
<td>4.58</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.7</td>
<td>28.3</td>
<td>4.71</td>
</tr>
</tbody>
</table>

Tri-Gen: 12 + 0j MVA  
Kingsville gen: 55 - 7j MVA  
Kingsville load: 136.6+ 66.2j MVA  
Kingsville net load on LV bus: 69.8 + 74.2j MVA  
70.2 MVAR shunt capacitors
### Table 12 – Voltage Assessment: light load and maximum EG - loss of K6Z

<table>
<thead>
<tr>
<th>Bus</th>
<th>Pre-continuity</th>
<th>Loss of K6Z Two Transformers Pre ULTC</th>
<th>Loss of K6Z Two Transformers Post ULTC</th>
<th>Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lauzon TS</td>
<td>115 kV</td>
<td>124.2 kV</td>
<td>124.0 kV % decline</td>
<td>Tri-Gen: 12 + 0j MVA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>123.8 kV 0.16</td>
<td>124.1 kV 0.08</td>
<td></td>
</tr>
<tr>
<td>Belleriver TS</td>
<td>115 kV K2Z</td>
<td>124.0 kV</td>
<td>123.8 kV 0.16</td>
<td>Kingsville gen: 55 - 4j MVA</td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>122.5 kV 0.0</td>
<td>100.00</td>
<td>Kingsville load: 46.0+ 25.4j MVA</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>28.6 kV 0.00</td>
<td>26.8 kV 0.00</td>
<td></td>
</tr>
<tr>
<td>Kingsville TS</td>
<td>115 kV K2Z</td>
<td>124.4 kV 0.16</td>
<td>119.1 kV 4.26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>115 kV K6Z</td>
<td>119.9 kV 0.0</td>
<td>100.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>29.2 kV 0.00</td>
<td>26.6 kV 8.90</td>
<td></td>
</tr>
<tr>
<td>Tilbury W DS</td>
<td>115 kV</td>
<td>123.8 kV 0.20</td>
<td>121.3 kV 2.02</td>
<td>Kingsville net load on LV bus:</td>
</tr>
<tr>
<td></td>
<td>27.6 kV</td>
<td>121.2 kV 2.39</td>
<td>122.9 kV 0.34</td>
<td>-20.8 + 30.4j MVA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28.6 kV 2.05</td>
<td>27.6 kV 0.03</td>
<td>0 MVAr shunt capacitors</td>
</tr>
</tbody>
</table>

### 6.5 Transient Stability Assessment

Excitation systems regulating generator output reactive power (VAr) or power factor (pf) to a user-specified set point would have a pf / VAr Regulator or Controller. In the case of a Controller, the AVR is equipped with a slow outer-loop control, which uses the error between the desired and measured pf, VAr, or reactive current signal to change the AVR's set-point, to maintain the desired unit reactive output. A pf / VAr Regulator eliminates the AVR terminal voltage feedback loop, and instead directly controls the unit's field voltage to regulate pf or VAr to the user's reference set point.

For transient analysis, it was assumed that the excitation system will not respond to terminal voltage changes. During a large disturbance, the field voltage would remain constant and have no significant contribution to generation stability during the first rotor swing.

Therefore, the generator was modeled with the AVR out of service, with parameters set as presented in Chapter 3 – Data verification- of this report.

The excitation system was not tested for Response Ratio Test or Open Circuit Step Response Test since it was assumed that it would not respond to voltage changes at generator terminal. The Governor Response Test was also not performed, as the proponent has not provided any governor model. The Market Rules does not specify performance standards for the control systems of non-market participant embedded generators which are smaller than 10 MVA, unless the facility is comprise of generation units whose net output is greater than 50 MVA.

To assess the transient stability of the proposed facility and its impact on the ICG, three major disturbances were simulated:

33
• three-phase fault on the Kingsville LV;
• three-phase fault on K2Z at Kingsville TS;
• three-phase fault on K6Z at Kingsville TS.

For each simulation three diagrams were included in this report. First diagram presents rotor angles for one generator at Tri-Gen, TA Sarnia, West Windsor and Brighton Beach. Second diagram presents variables related to Tri-Gen units: angle, field voltage, MVAr output and terminal voltage. A third diagram plots voltages at Lauzon TS and Kingsville TS, on the 115 kV and LV buses.

6.5.1 Three phase fault at Kingsville LV bus

This simulates a 3-phase fault on a feeder close to Kingsville TS, detected by the feeder protection in 40 ms, with a 4 ms auxiliary trip relay (ATR), 4 ms for the breaker trip module (BTM), and 133 ms (8 cycle) breaker opening time. The bus fault was cleared after 180 ms.

The results of the simulations presented in the diagrams 1 to 3 below conclude that the proposed generators are unstable for faults close to the 27.6 kV bus at Kingsville. This kind of fault resulted in Tri-Gen generators going “out-of-step”, and expected to be tripped by the out-of-step protection. The applicant confirmed that an out-of-step protection will be installed at generators.
As can be observed from Diagram 1, the generators connected to ICG are not significantly impacted by the proposed generators: they remain stable following the LV bus fault. Tri-Gen units are accelerating and finally loosing their synchronism with the system.
Diagram 2: Three phase fault at Kingsville LV bus – Tri-Gen Variables

Diagram 2 above shows that, eventually, the Tri-Gen units would be pulled back in synchronism, but only after they slip a number of poles, or about 720 degrees. It is expected that the out-of-step protection will trip the units fast enough (less than 0.5 seconds) to prevent damages for this undesirable operation.

It can also be observed that the field voltage remains constant during and after the disturbance, and the reactive output of the unit is almost zero.

As expected, the unit terminal voltage is being depressed during the fault. After the fault is cleared (180 ms after it was applied), the terminal voltage oscillates, as it is impacted by the generator pole slipping, and recovers only after the generator regains its synchronism, or, as it would happen in reality, it will become zero when the unit trips.
One of the main focuses during this assessment was to confirm that the Kingsville Voltage Dependent L/R scheme at Kingsville would not be inadvertently triggered by the proposed generators during transient disturbances. This was achieved by monitoring voltages on K2Z and K6Z at Kingsville TS and confirming that the voltages do not remain depressed below 106 kV for more than 7 seconds.

In Diagram 3 above can be observed that, even with the Tri-Gen units losing synchronism, the voltages in the transmission system and at the Kingsville LV bus are restored in less than 1 second.
6.5.2 Three phase fault on K2Z

This simulates a three phase fault on K2Z circuit close to Kingsville TS. The fault was cleared in 116 ms at Lauzon (25 ms protection time + 4 ms ATR + 4 ms BTM + 83 ms/5cycle breaker time) and in 144 ms at Kingsville T1+T3 LV and Belleriver T1 LV (25 ms protection time + 4 ms ATR + 28 ms transfer trip + 4 ms BTM + 83 ms/5cycle breaker time). It also disconnects Tilbury load.

The results of the simulations presented in the diagrams 4 to 6 below conclude that the proposed generators are stable for faults on K2Z.

Diagram 4: Three phase fault on K2Z – Rotor Angles

Diagram 4 shows that all monitored generators remain stable following the fault. The Tri-Gen rotor oscillations are dumped in about 2.5 seconds.
Diagram 5 above shows again that the Tri-Gen units are stable post-disturbance. It can also be observed that the field voltage remains constant during and after the disturbance, and the reactive output of the unit, with small changes during the fault, continues to be zero.

As expected, the unit terminal voltage is being depressed during the fault. After the fault is cleared, the terminal voltage oscillates, and recovers as the generator regains its angle stability.
Diagram 6: Three phase fault on K2Z – Transmission Voltages

All the transmission voltages are restored to acceptable values, except K2Z voltage, which trips to clear the fault. Tilbury load is lost by configuration.

The post-disturbance voltages at Kingsville are lower than their initial values, as K6Z is the only line left to supply the remaining load in the area. Nevertheless, the Kingsville high voltage level on K6Z is above the setting for the operation of the Kingsville Voltage Dependent L/R scheme.
6.5.3 Three phase fault on K6Z

This simulation is similar to the K2Z disturbance. A three phase fault on K6Z circuit close to Kingsville TS was cleared in 116 ms at Lauzon (25 ms protection time + 4 ms ATR + 4 ms BTM + 83 ms/5cycle breaker time) and in 144 ms at Kingsville T2+T3 LV and Belleriver T2 LV (25 ms protection time + 4 ms ATR + 28 ms transfer trip + 4 ms BTM + 83 ms/5cycle breaker time).

The results of the simulations presented in the diagrams 7 to 9 below are similar to the results obtained for the K2Z fault, and conclude that the proposed generators are stable for faults on K6Z.

Diagram 7: Three phase fault on K6Z – Rotor Angles
Diagram 8: Three phase fault on K6Z – Tri-Gen Variables
Diagram 9: Three phase fault on K6Z – Transmission Voltages

After K6Z trips to clear the fault, K2Z supplies the entire load in the area. No load is lost by configuration, as was the case for the K2Z contingency.

As expected, the steady state post-disturbance voltages at Kingsville are lower than their initial values, with 108.6 kV on the high voltage side, but above the setting for the operation of the Kingsville Voltage Dependent L/R scheme.

– End of Section –

– End of Report –