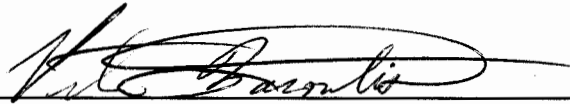


TORONTO HYDRO-ELECTRIC SYSTEM LTD.

PARALLEL GENERATION REQUIREMENTS

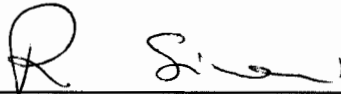
REVISION #2: JANUARY 23, 2007

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CERTIFICATE OF APPROVAL	
THIS TECHNICAL SPECIFICATION MEETS THE SAFETY REQUIREMENTS OF SECTION 4 OF ONTARIO REGULATION 22/04	
 Romano Sironi, P. Eng.	<u>Jan. 23, 2007</u> Date

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Introduction

The technical requirements for parallel generation are in place to ensure public and employee safety, protect the integrity of Toronto Hydro's system, and guarantee reliable and quality service to Toronto Hydro customers. The technical requirements in this document are for the protection of Toronto Hydro's facilities, and the Generator should satisfy itself as to any requirements for the protection of its own facilities.

The requirements below are primarily from Appendix F.2 of the Distribution System Code's ("DSC"), Institute of Electrical and Electronics Engineers ("IEEE") Standard 1547, and CAN/CSA C22.2 No. 257-06. Generators are encouraged to consult the listed references for more details about every item. In situations where modifications are required to the incoming supply arrangement, the Generation facility shall also satisfy the following: "Toronto Hydro Requirements for Design and Construction of Customer-Owned Substation High Voltage Substations". It is the Generator's responsibility to ensure that all requirements are met. Additional requirements may be necessary to address unique situations, and Generators will be advised of any additional requirements at the appropriate assessment stage.

Toronto Hydro accepts no responsibility or liability for any of the information provided in this document, which has been provided for informational purposes only. Meeting these requirements does not necessarily constitute an acceptable facility design. Toronto Hydro reserves the right to amend any of these requirements at any time.

1 Connection Impact Assessment – Initial Review

Technical requirements for interconnection of the Generator with Toronto Hydro are checked during the Impact Assessment stage. This initial review is intended to determine the viability of the Generator’s project and to provide the applicant an opportunity to evaluate the situation before making further investments.

1.1 Facility Design Overview

1.1.1 Single Line Diagram (“SLD”)

For the initial review, a high-level single line diagram of the proposed facilities is required. Major equipment such as the transformer, disconnection device, and the generator and their respective ratings should be included. Please see the *Embedded Generation Connection Application Form* for information to be submitted.

A typical arrangement of a generation facility connected to the utility distribution system is shown below in Figure 1. Various configurations, however, are possible in accordance with design requirements and generation facility use.

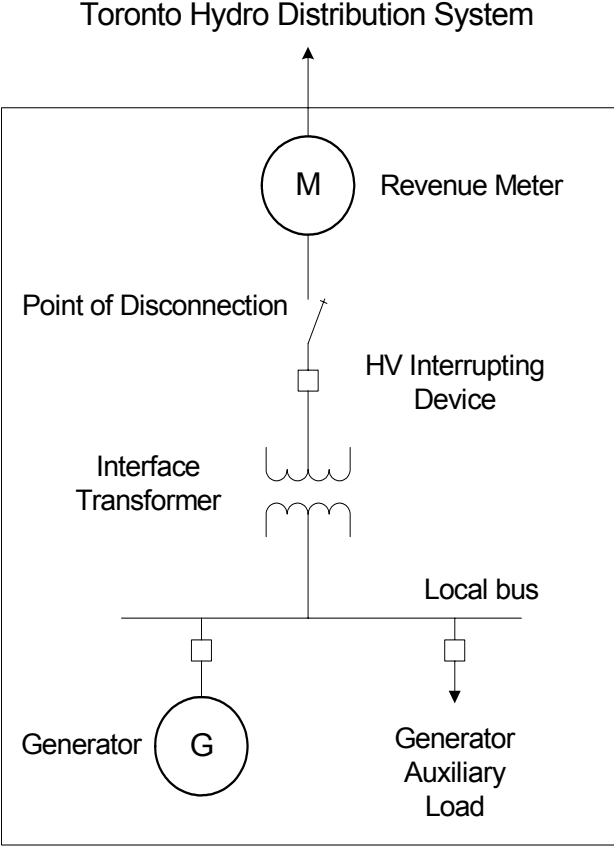


Figure 1 Typical Single Line Diagram Required at the Connection Impact Assessment Stage

1.1.2 Point of Disconnection - Safety

A point of disconnection is required to isolate the embedded generator for the purpose of work protection of Toronto Hydro crews. Switching, lockout and tagging procedures shall be coordinated with Toronto Hydro.

Reference codes and standards that apply to the disconnect or isolation device are as follows: Ontario Electrical Safety Code (“OESC”) rule 84-026, IEEE Standard 1547 Clause 4.1.7, CAN/CSA-C22.2 No. 257-06 Clause 5.3.4 and DSC Appendix F.2 Section 1.

1.1.3 Preferred Interface Transformer Configuration and HV Interrupting Device

Preferred configurations for the Generation facility interface transformer are outlined in Table 1. The interface transformer connection significantly affects the generator interaction with the distribution system under steady state and fault conditions. Careful selection and design are required to mitigate adverse effects.

Selecting an appropriate configuration is dependent on the local distribution system at the point of connection. The configurations suggested in table 1 are only general guidelines that are applicable for the majority of connections. Toronto Hydro will assess each connection individually to determine the required configuration based on the local conditions. In situations where generator neutral impedance or a grounding transformer may be required, effective grounding criteria of the distribution system shall be maintained. This will ensure the maximum overvoltage on the distribution system is within 125% of the nominal voltage. The suggested HV interrupting device is a breaker capable of withstanding 220% of the interconnection system rated voltage.

Table 1

System Voltage	Distribution System Grounding Impedance (Low , High)	Preferred Interface Transformer (HV:LV)
27.6, 13.8 kV	Low (effectively grounded)	Wye Ground / Delta
13.8 kV	High (downtown)	Delta / Wye Ground
27.6,13.8 kV, 4.16 kV	Low (effectively grounded)	Wye Ground / Wye Ground (Generation < 1MW)

1.2 Equipment Rating and Requirements	Reference
<p>The generation facility interface equipment shall be compatible with Toronto Hydro equipment design and ratings under all operating conditions. During both on-line and off-line interconnection scenarios of the generation equipment, the distribution equipment shall be within its operating rating. Equipment ratings to be reviewed shall be as follows:</p> <ul style="list-style-type: none"> - Equipment thermal loading limits. This equipment includes feeder conductor/cable, station breaker and transformer ratings. - Impact of generation facility fault contribution on equipment rating - If power is to be exported to the distribution system then all metering devices shall be suitable for <i>bi-directional flow</i>. 	DSC Appendix F.2 Section 5

1.3 Voltage Regulation	Reference																
<p>Voltage variations at the point of common coupling (“PCC”) are limited to +/- 6% of the nominal voltage.</p> <p>The generation facility should not actively regulate the voltage at the PCC.</p> <p>During normal operation, the generation facilities must be loaded and unloaded gradually to allow adequate time for regulating devices to respond and avoid excessive voltage fluctuation.</p> <p>The generation facility shall not cause objectionable voltage and current unbalance conditions. The generation facility shall not cause voltage unbalance beyond 3% and current unbalance beyond 10% at the PCC.</p>	<p>CSA CAN3-C235 IEEE 1547 Clause 4.1.1</p> <p>DSC Appendix F.2 Section 3 CAN CSA C22.2 No. 257-06 Section 5.2.3</p>																
1.4 Synchronization	Reference																
<p>The generation facility shall parallel with the distribution system without causing a voltage fluctuation of more than 5% at the PCC.</p> <p>Interconnection shall take place only when the differences in frequency, voltage and phase angle are within the limits shown below.</p> <p>Table 2</p> <table border="1" data-bbox="204 800 1109 1031"> <thead> <tr> <th>Total DR System Capacity</th> <th>Frequency Difference</th> <th>Voltage Difference</th> <th>Phase Angle Difference</th> </tr> </thead> <tbody> <tr> <td>0-500 kVA</td> <td>0.3 Hz</td> <td>10 %</td> <td>20°</td> </tr> <tr> <td>>500-1500 kVA</td> <td>0.2 Hz</td> <td>5 %</td> <td>15°</td> </tr> <tr> <td>> 1500 kVA</td> <td>0.1 Hz</td> <td>3 %</td> <td>10°</td> </tr> </tbody> </table>	Total DR System Capacity	Frequency Difference	Voltage Difference	Phase Angle Difference	0-500 kVA	0.3 Hz	10 %	20°	>500-1500 kVA	0.2 Hz	5 %	15°	> 1500 kVA	0.1 Hz	3 %	10°	<p>CAN CSA C22.2 No. 257-06 Section 5.3.21</p> <p>IEEE 1547 Clauses 4.1.3, 5.1.2</p> <p>DSC Appendix F.2 Section 3.2 OESC rule 84-006</p>
Total DR System Capacity	Frequency Difference	Voltage Difference	Phase Angle Difference														
0-500 kVA	0.3 Hz	10 %	20°														
>500-1500 kVA	0.2 Hz	5 %	15°														
> 1500 kVA	0.1 Hz	3 %	10°														
1.5 Feeder Relay Directioning	Reference																
<p>To prevent sympathetic tripping of the generator feeder due to faults on adjacent feeders, breaker protection may need a directional feature for reverse fault current conditions.</p>	<p>DSC Appendix F.2 Section 8</p>																
1.6 Monitoring	Reference																
<p>A generation facility with total capacity rated greater than 250 kVA at the PCC, shall have provision for monitoring items a) to d) below. If monitoring data is not required at the time of connection, the design shall include provisions for future installation.</p> <ul style="list-style-type: none"> a) Connection status b) Real power output c) Reactive power output d) Voltage at PCC or aggregate connection <p>For a generation facility with total capacity rated 2.5 MW or greater, items a) to d) shall be actively monitored. In this case, monitoring typically includes status of load interrupting switches, circuit breakers and interface protection annunciation. Communication media options will be mutually agreed upon.</p>	<p>DSC Appendix F.2 Section 9</p> <p>IEEE 1547 Clause 4.1.6</p> <p>CAN CSA C22.2 No. 257-06 Clause 5.3.22</p>																

1.7 Power Factor	Reference
<p>The generation facility operation shall not adversely affect voltage at the PCC. The preferred power factor range of operation is ± 0.9. This range may be narrower if required in some situations. Systems of 30 kW or less are generally not required to be capable of adjusting power factor.</p> <p>For large facilities that are IESO impactive, the generator units shall have sufficient reactive power compensation such that there is no material increase at the transmission system terminal station.</p>	<p>DSC Appendix F.2 Section 4</p> <p>CAN CSA C22.2 No. 257-06 Clause 5.3.13</p>
1.8 Maximum Power Transfer & Synchronous Stability	Reference
<p>To ensure distribution system stability and prevent adverse effects on the steady state voltage profile of the feeder, the maximum power export of a generating facility shall be limited so as to not exceed 10° phase shift between line ends.</p> <p>For typical distribution feeders on Toronto Hydro's system at 27.6 kV and 13.8 kV the limit is 50 MW and 20 MW, respectively. Other distribution constraints well below these limits however may govern the maximum power transfer such as feeder rated capacity.</p>	<p>Toronto Hydro Requirement</p>

2 Design Review

The design review ensures detailed engineering is in compliance with Toronto Hydro requirements. It is recommended that this review be completed before proceeding with equipment purchase.

A sample single line diagram below provides the details required at this stage.

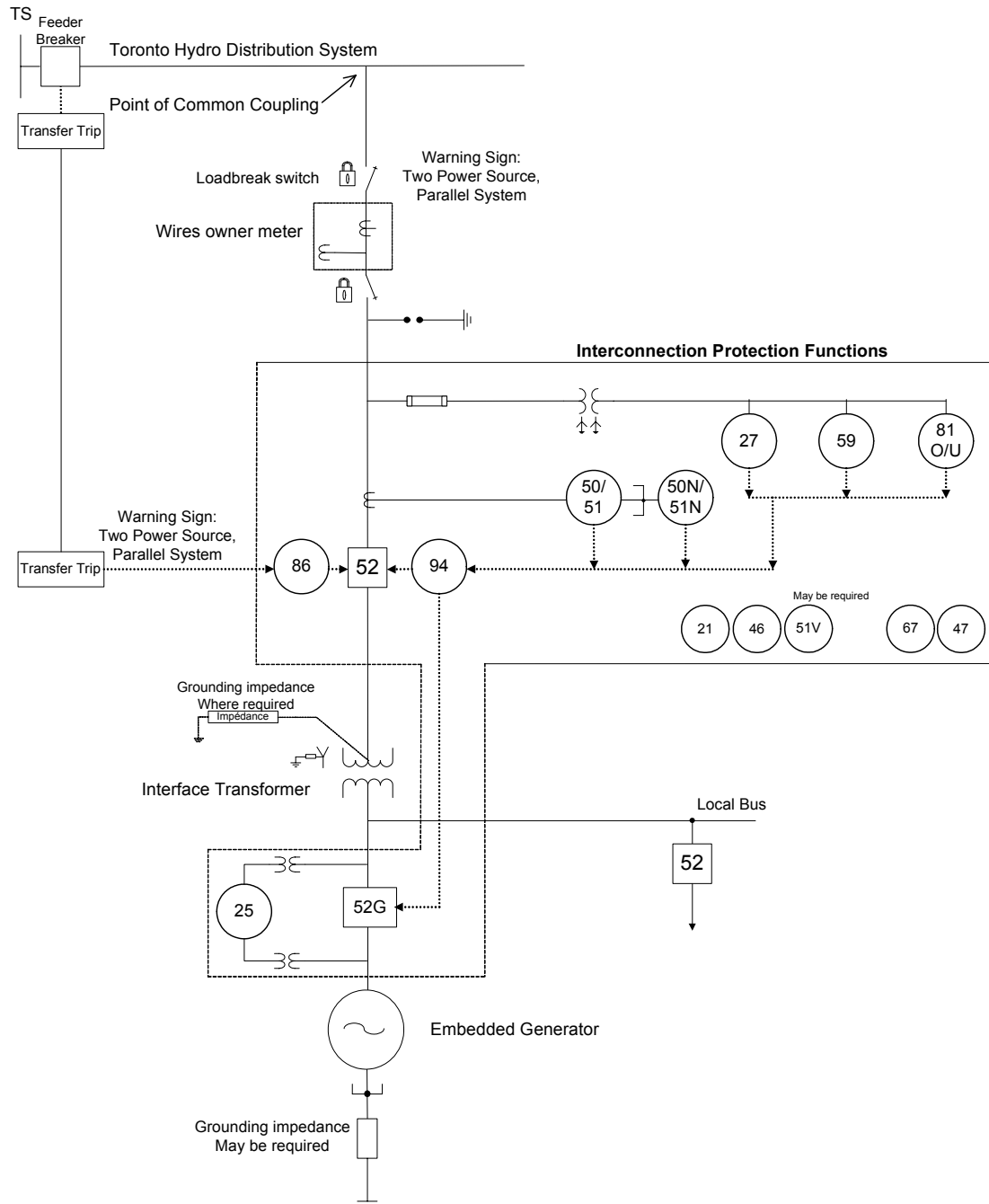


Figure 2 Typical Single-Line Diagram Required at the Design Review Stage

2.1 Cease to Energize	Reference														
<p>2.1.1 <u>Distribution System Faults and Customer Facility Faults</u></p> <p>Interface protection of the generation facility shall cease to energize Toronto Hydro's distribution system under the following conditions:</p> <p>Internal Faults at the Customer's Facility.</p> <p>External Faults on the Toronto Hydro Distribution System.</p> <p>Equipment and Conductors energized from both directions shall have suitable protection from each supply source.</p>	<p>DSC Appendix F.2 Section 6.4 IEEE 1547 Clause 4.2.1 OESC 84-014</p> <p>CAN CSA C22.2 No. 257-06 Clause 5.3.8</p>														
<p>2.1.2 <u>Feeder Breaker Reclosing Coordination</u></p> <p>The generation facility shall cease to energize Toronto Hydro's feeder before automatic reclosing of the breaker takes place.</p> <p>Toronto Hydro's 27.6 kV feeders incorporate an autoreclose operation typically half a second in duration. Underground 13.8 kV feeders in the downtown area do not have an automatic reclosing scheme.</p>	<p>IEEE 1547 Clause 4.2.2 DSC Appendix F.2 Section 6 CAN CSA C22.2 No. 257-06 Clause 5.2.9</p>														
<p>2.1.3 <u>Over-Voltage and Under-Voltage Protection</u></p> <p>The typical range of protection settings shall comply with the following table:</p> <p>Response to abnormal voltages</p> <table border="1" data-bbox="203 926 1096 1304"> <thead> <tr> <th>Voltage at PCC</th> <th>Clearing Time Range</th> </tr> </thead> <tbody> <tr> <td>V < 50%</td> <td>Instantaneous to 0.16 s</td> </tr> <tr> <td>50% ≤ V < 88%</td> <td>Instantaneous to 2 s*</td> </tr> <tr> <td>106% < V ≤ 110%</td> <td>0.5 s to 2 minutes</td> </tr> <tr> <td>110% < V ≤ 120%</td> <td>Instantaneous to 2 minutes</td> </tr> <tr> <td>120% < V < 137%</td> <td>Instantaneous to 2 s*</td> </tr> <tr> <td>137% ≤ V</td> <td>Instantaneous</td> </tr> </tbody> </table> <p>* To satisfy system requirements 2 over-voltage and under-voltage set points may be required.</p> <p>The actual clearing times may vary within the above range due to distribution system conditions and generation facility protection design.</p>	Voltage at PCC	Clearing Time Range	V < 50%	Instantaneous to 0.16 s	50% ≤ V < 88%	Instantaneous to 2 s*	106% < V ≤ 110%	0.5 s to 2 minutes	110% < V ≤ 120%	Instantaneous to 2 minutes	120% < V < 137%	Instantaneous to 2 s*	137% ≤ V	Instantaneous	<p>IEEE 1547 Clause 4.2.3</p> <p>DSC Appendix F.2 Section 6.5</p> <p>CAN CSA C22.2 No. 257-06 Clause 5.3.9</p> <p>Toronto Hydro Requirement</p>
Voltage at PCC	Clearing Time Range														
V < 50%	Instantaneous to 0.16 s														
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137% ≤ V	Instantaneous														
<p>2.1.4 <u>Over-Frequency and Under-Frequency Protection</u></p> <p>The generation facility shall cease to energize Toronto Hydro's distribution system at the frequency set points and clearing times outlined in the table below.</p> <p>Response to abnormal frequency</p> <table border="1" data-bbox="203 1661 800 1803"> <thead> <tr> <th>Adjustable Set Point</th> <th>Clearing Time</th> </tr> </thead> <tbody> <tr> <td>59.3 to 55.5 Hz</td> <td>0.1 to 300 s</td> </tr> <tr> <td>60.7 to 63.5 Hz</td> <td>0.1 to 180 s</td> </tr> </tbody> </table> <p>To satisfy system requirements 2 over-frequency and under-frequency set points may be required.</p>	Adjustable Set Point	Clearing Time	59.3 to 55.5 Hz	0.1 to 300 s	60.7 to 63.5 Hz	0.1 to 180 s	<p>IEEE 1547 Clause 4.2.4</p> <p>DSC Appendix F.2 Section 6.5</p> <p>CAN CSA C22.2 No. 257-06 Clause 5.3.10</p> <p>Toronto Hydro Requirement</p>								
Adjustable Set Point	Clearing Time														
59.3 to 55.5 Hz	0.1 to 300 s														
60.7 to 63.5 Hz	0.1 to 180 s														

<p>2.1.5 Interface Protection System</p> <p>The interface protection study shall include coordination of key interface protection elements, along with the proposed relays and settings to be used at the point of common coupling. The protection study submission shall include required AC & DC schematics and wiring diagram.</p>	<p>DSC Appendix F.2 Section 6 Toronto Hydro Requirement</p>
<p>2.2 Connection to Toronto Hydro System</p>	<p>Reference</p>
<p>Connection to Toronto Hydro's System following a grid disturbance shall take place only when the voltage at the PCC is within 6% and frequency between 59.3 and 60.5 Hz.</p> <p>The generation facility shall reconnect no less than 5 minutes after the system has stabilized within the above voltage and frequency ranges. Where multiple units on the same feeder are involved, staggering the reconnection times may be required.</p> <p>For mid-sized generating facilities that incorporate transfer trip protection, a lockout relay (86) shall prevent resynchronization until enabled by Toronto Hydro System Control.</p>	<p>DSC Appendix F.2 Section 6 IEEE 1547 Clause 4.2.6 Toronto Hydro Requirement</p>
<p>2.3 Anti-Islanding Protection and Transfer Trip Requirements</p>	<p>Reference</p>
<p>The generation facility shall disconnect from Toronto Hydro's System upon the loss of utility supply voltage in one or more phases.</p> <p>For mid-sized generating facilities with capacity greater than 50% of the minimum feeder load, the design shall include a Transfer Trip scheme to prevent islanding. In this case, Embedded Generator End Open (EGEO) logic is to be included to supervise the autoreclose operation of the feeder breaker.</p>	<p>DSC Appendix F.2 Section 6.1.2 IEEE 1547 Clause 4.4.1 OESC rule 84-008 CAN CSA C22.2 No. 257-06 Clause 5.3.11 Toronto Hydro Requirement</p>
<p>2.4 Grounding at the Generation Facility</p>	<p>Reference</p>
<p>The generation facility's grounding scheme shall not cause over voltages that exceed the rating of Toronto Hydro equipment. The distribution system primarily consists of effectively grounded feeders with surge arresters suitably rated. To meet these requirements at the point of connection the following criteria shall be met:</p> <p>$X0 / X1 \leq 3, R0/X1 \leq 1.$</p> <p>The generation facility shall not disrupt the coordination of ground fault protection on Toronto Hydro's distribution system.</p> <p>Wind generation facilities shall not connect to the distribution system neutral.</p>	<p>DSC Appendix F.2 Section 2 IEEE 1547 Clause 4.1.2 OESC rule 84-030 CAN CSA C22.2 No. 257-06 Clause 5.3.6 Toronto Hydro Requirement</p>

3 Warning Signs and Diagrams

The following warning sign shall be posted on the point of disconnection, generator feeder cell and switch room door to warn people of the presence of embedded generation:

**WARNING
TWO POWER SOURCE
PARALLEL SYSTEM**

As well, a single line, permanent and legible diagram of the switching arrangement shall be placed at the **Customer's** control room and the switch room to indicate the position of the embedded generators and isolation points with their interlocking arrangements.

Operating designations will be assigned to the switching equipment of the generation system as required by Toronto Hydro. The **Customer** shall update the single line electrical diagram and operating diagram to include the assigned operating designations, and the switching equipment shall be identified by the operating designations as well.

4 Commissioning and Witnessing Requirements

The **Customer** shall apply for **ESA** electrical inspection and provide Toronto Hydro with the Certificate of Inspection once requirements are satisfied. Following this Toronto Hydro will also receive a copy of the Authorization to Connect from ESA.

Prior to commencing with commissioning and placing embedded generation facility in-service, Toronto Hydro shall be given an opportunity to review and confirm the proposed commissioning plan meets system requirements.

In addition, before the embedded generator is brought into synchronization, as per the Conditions of Service 4.5.4 and the DSC 6.2.19, Toronto Hydro will require a utility representative to:

- Witness successful tests of the protection system as far as it affects the Interconnection of the embedded generator to the Toronto Hydro distribution system.
- Verify interface equipment and test associated interlocking facilities.

The customer shall advise Toronto Hydro a minimum of fifteen working days in advance of scheduled commissioning tests, exclusive of Saturday, Sunday and Statutory Holidays, to enable Toronto Hydro to witness the commissioning tests. All testing shall be completed during Toronto Hydro's normal working hours with the Customer being responsible for all costs incurred for time spent beyond said hours.

Alternatively, Toronto Hydro may elect to accept a commissioning test report certified by a Professional Engineer. The commissioning verification report shall contain all interface protection settings and confirm key protective functions and interlocking requirements as previously agreed to by Toronto Hydro Policy & Standards Department. The commissioning report shall be submitted for approval before the operation of embedded generation facility.

On small generating units (less than 500 kVA), Toronto Hydro may elect to forego witness testing. All results shall be documented and a copy forwarded to Toronto Hydro.