

REPORT



System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Addendum-Final

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Project: Nanticoke Solar Project

Applicant: Nanticoke Solar LP

Engineering Studies Department
Independent Electricity System Operator

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System Impact Assessment Report

Acknowledgement

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

Disclaimers

IESO

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

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One 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 Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed project to the IESO-controlled grid. However, the conditional 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, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. 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 the most recent version of this report is being used.

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of this 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 facilities on load and generation customers.

In this report, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection applicant 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 project 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 facilities have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional project 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.

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Executive Summary

Project Description

Nanticoke Solar LP. (the “connection applicant”) has proposed to develop a 44 MW photovoltaic (PV) generation station (GS) (the “project”) that will connect to the existing 230 kV P1 bus at Hydro One’s (the “transmitter”) Nanticoke TS via a 230 kV circuit breaker.

The project was originally designed to consist of two collector circuits, C1 and C2, having 8 and 17 PV inverters, respectively. Each PV inverter, capable of producing 2 MW, was to be capped at 1.76 MW to limit the project’s total active power injection into the grid to a maximum of 44 MW. The PV inverters were to be connected in daisy-chain fashion with each PV inverter connected to one of the collector circuits through a 2 MVA, 0.575/ 34.5 kV transformer. The original single line diagram of the project is presented in Figure 1. The IESO performed a System Impact Assessment (SIA) for the original design and issued the SIA report on September 29, 2017.

Recently the connection applicant submitted material changes for the project, requiring further assessments by the IESO. The proposed changes include:

- (1) The proposed inverters have been changed from Conext SmartGen CS 2000 inverters to Conext SmartGen CS 2200 inverters. The new inverters are rated at 2.2 MW each and will be capped at 1.913 MW to limit the project’s total active power injection into the grid to a maximum of 44 MW;
- (2) The collector system has been re-designed to have two collector circuits, C1 and C2, having 14 and 9 PV inverters, respectively;
- (3) The detailed design of the project control system shows; specifically, that voltage will be controlled at the 34.5 kV collector bus without droop.

The single line diagram of the revised project is presented in Figure 2. The project in-service date has also been updated to March, 2019.

Conditional Approval for Connection

This assessment concludes that the proposed connection of the project, operating up to 44 MW, is expected to have no material adverse impact on the reliability of the integrated power system, provided that all requirements in this report and the original SIA report are implemented. Therefore, the assessment supports the release of the Notification of Conditional Approval for Connection of the project.

Findings

The following are additional findings related to this addendum. Note, all other findings in the original SIA are still applicable.

- (1) The revised connection arrangement of the project shown in Figure 2 is acceptable to the IESO.
- (2) Assuming an ambient temperature of 43° C or lower, the project will meet the reactive power requirements of the Market Rules. More details in section 3.1.
- (3) The project will meet the voltage ride through requirement with the proposed voltage protection settings listed in Section 2.8 of this report. More details in section 3.3.
- (4) The project will meet the frequency ride through requirement with the proposed frequency protection settings listed in Section 2.9 of this report.

(5) The functions of the project's power plant controller meet the requirements in the Market Rules.

IESO Requirements for Connection

The following are additional requirements related to this addendum. Note, all requirements in the original SIA are still applicable.

Transmitter Requirements

There are no additional requirements for the transmitter in this report.

Connection Applicant Requirements

- (1) The connection applicant is required to provide the final functional description of the project's solar farm control system for the IESO's approval before the project is allowed to connect.
- (2) According to finding #2, when the ambient temperature exceeds 43° C, the connection applicant is required to decrease the active power output of the project to a level that meets the reactive power requirements in the Market Rules.

– End of Section –

1. Project Description

Nanticoke Solar LP. (the “connection applicant”) has proposed to develop a 44 MW photovoltaic (PV) generation station (GS) (the “project”) that will connect to the existing 230 kV P1 bus at Hydro One’s (the “transmitter”) Nanticoke TS via a 230 kV circuit breaker.

The project was originally designed to consist of two collector circuits, C1 and C2, having 8 and 17 PV inverters, respectively. Each PV inverter, capable of producing 2 MW, was to be capped at 1.76 MW to limit the project’s total active power injection into the grid to a maximum of 44 MW. The PV inverters were to be connected in daisy-chain fashion with each PV inverter connected to one of the collector circuits through a 2 MVA, 0.575/ 34.5 kV transformer. The original single line diagram of the project is presented in Figure 1. The IESO performed a System Impact Assessment (SIA) for the original design and issued the SIA report on September 29, 2017.

Recently the connection applicant submitted material changes for the project, requiring further assessments by the IESO. The proposed changes include:

- (4) The proposed inverters have been changed from Conext SmartGen CS 2000 inverters to Conext SmartGen CS 2200 inverters. The new inverters are rated at 2.2 MW each and will be capped at 1.913 MW to limit the project’s total active power injection into the grid to a maximum of 44 MW;
- (5) The collector system has been re-designed to have two collector circuits, C1 and C2, having 14 and 9 PV inverters, respectively;
- (6) The detailed design of the project control system shows; specifically, that voltage will be controlled at the 34.5 kV collector bus without droop.

The single line diagram of the revised project is presented in Figure 2. The project in-service date has also been updated to March, 2019.

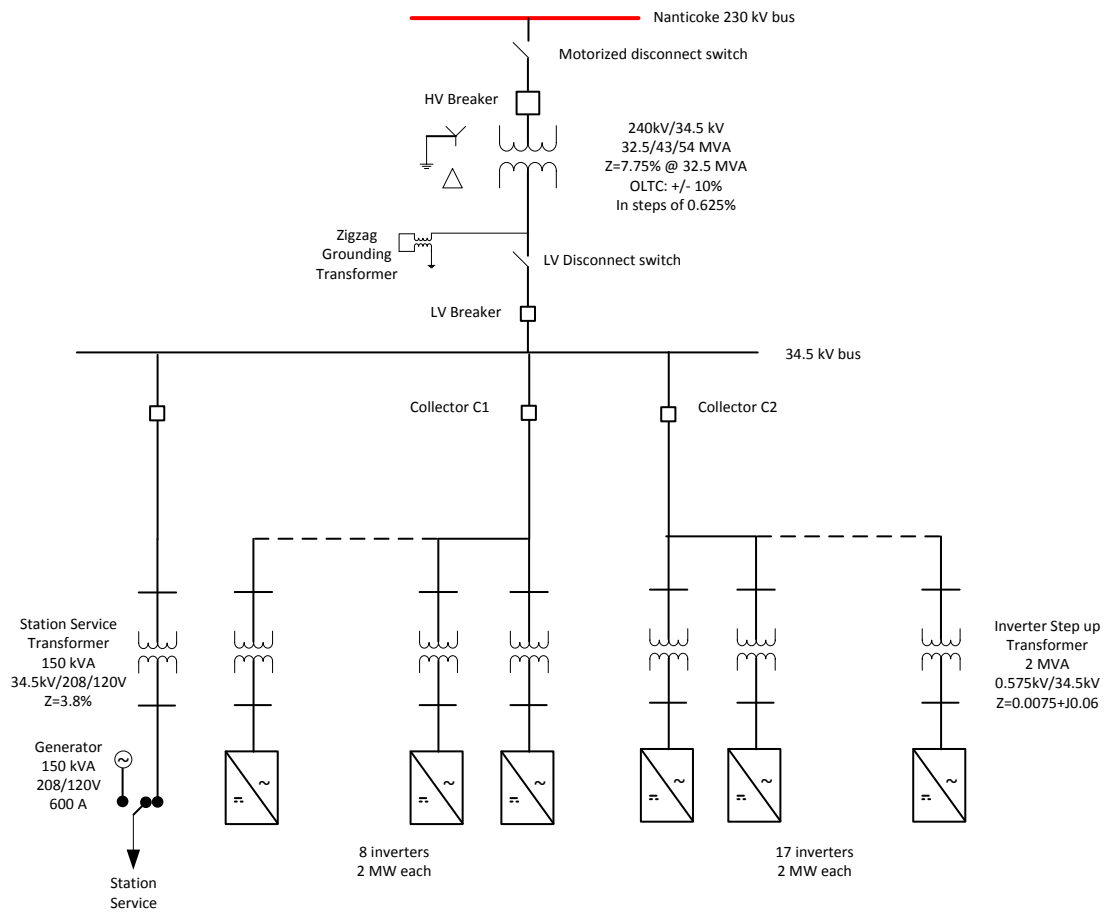


Figure 1: Nanticoke Solar-Original Design

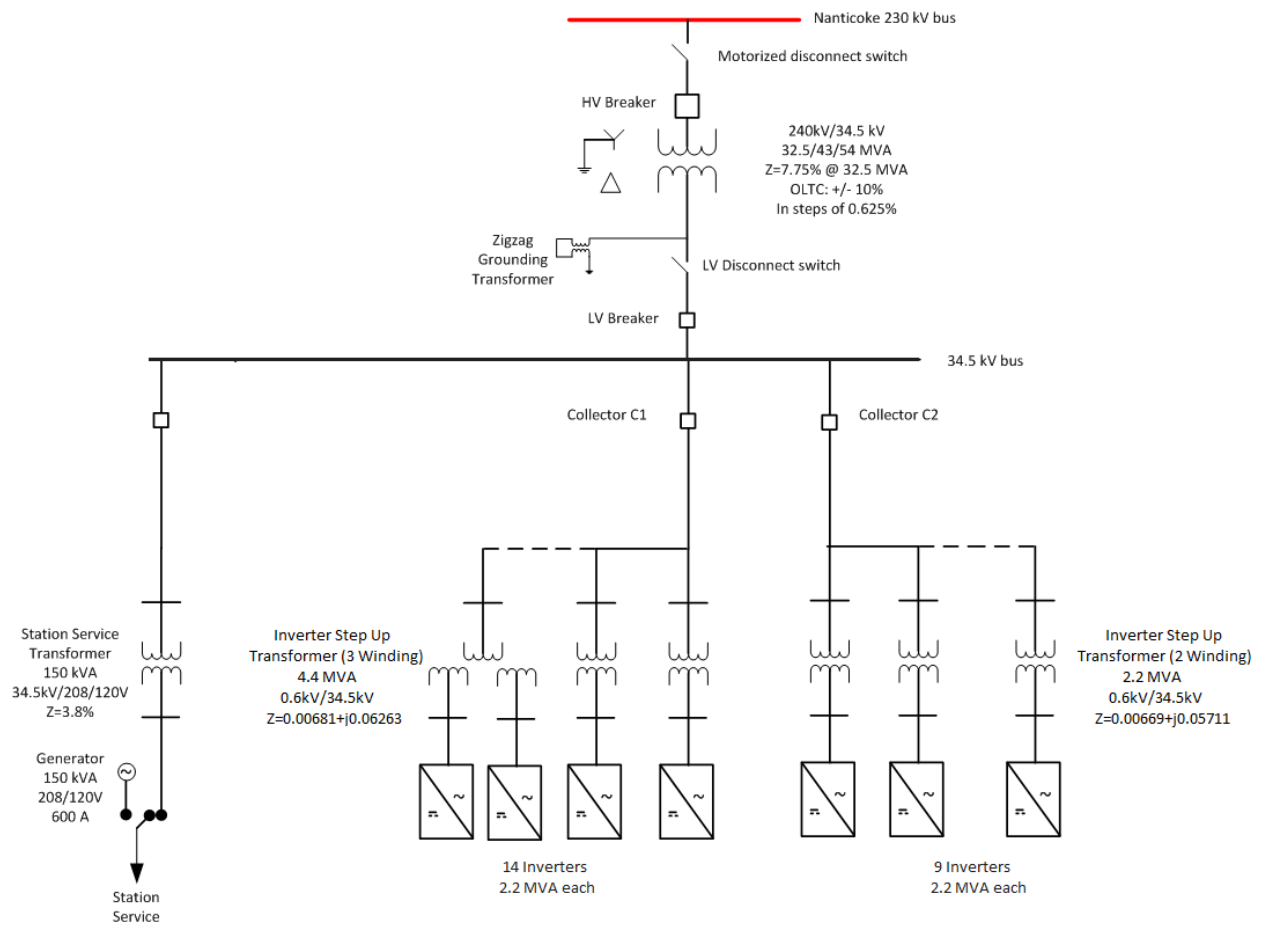


Figure 2: Nanticoke Solar-New Design

– End of Section –

2. Data Verification

2.1 Connection Arrangement

The revised connection arrangement of the project shown in Figure 2 will not adversely impact the reliability of the integrated power system and is, therefore, acceptable to the IESO.

2.2 Conext SmartGen CS 2200 Inverters

The project will adopt Conext SmartGen CS 2200 inverters whose specifications are shown in Table 1.

Table 1: Specifications of Conext SmartGen CS 2000 Inverters

Type	Rated Voltage	Rated MVA	Rated MW	Transformer		Qmax (MVar)	Qmin (MVar)	Id'' (pu)
				MVA	X			
Conext SmartGen CS 2200	600 V	2.2	2.2 (Capped at 1.913 MW)	2.2	5.75%	1.086 (0.87 Lagging)	-1.086 (0.87 Leading)	1.06
				4.4	6.3%			

2.3 Main Step-Up Transformers

No change.

2.4 Collector System

The revised collector parameters are shown in Table 2.

Table 2: Equivalent impedance of collector circuits

	Circuit	Unit#	MW	Positive-Sequence Impedance (pu, SB=100MVA)			Zero-Sequence Impedance (pu, SB=100MVA)		
				R	X	B	R	X	B
				New Design	C1	14	26.782	0.02033	0.05959
	C2	9	17.217	0.00723	0.01066	0.00088	0.02627	0.04545	0.00087

2.5 230 kV Switches

No change.

2.6 230 kV Circuit Breakers

No change.

2.7 Tap Line

No change.

2.8 Voltage Ride-Through Capability

The proposed voltage settings of the inverters at the project are shown in Table 3.

Table 3: Conext SmartGen CS 2000-Voltage ride through capability

VRT	Proposed voltage threshold (%V _{nominal})	Proposed trip time (s)
OV3	131	0.3
OV2	115	0.5
OV1	110	1
UV3	88	2
UV2	60	1
UV1	0	0.3

The voltage ride-through capability for the project was found to be adequate in time-domain simulations detailed in section 3.3.

2.9 Frequency Ride-Through capability

Table 4 shows the proposed frequency settings of the inverters of the project. These settings comply with the Market Rules requirements and are therefore acceptable to the IESO.

Table 4: Conext SmartGen CS 2000-Frequency ride through capability

FRT	Proposed Frequency threshold (Hz)	Proposed trip time (s)
OF2	62	1
OF1	60.7	2
UF1	58.9	300.1
UF2	56.9	3.4

-End of Section-

3. System Impact Studies

The proposed changes to the project design are expected to have no impact on the assessments done in the original SIA including the thermal loading of transmission lines, the system voltage performance of local buses, and the transient stability of the surrounding generation units. Therefore, these subjects were not reassessed in this Addendum. The technical studies in this Addendum primarily assessed the reactive power capability of the project, voltage and frequency ride through capabilities, and the performance of the proposed control system.

3.1 Reactive Power Compensation

The Market Rules require that generation facilities inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the IESO. A generation unit with a power factor range of 0.90 lagging and 0.95 leading at rated active power connected via impedance between the generation unit and the connection point not greater than 13% based on rated apparent power provides the required range of dynamic reactive capability at the connection point to meet the Market Rules requirements.

Dynamic reactive compensation (e.g. D-VAR or SVC) is required for a generation facility which cannot provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power. For a renewable energy generation facility with impedance between the generation unit and the connection point greater than 13% based on rated apparent power, the IESO accepts that the renewable energy generation facility compensates for excessive reactive losses in its collector system with static shunts (e.g. capacitors and reactors) provided its inverters have the capability to provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power.

Dynamic Reactive Power Capability

The reactive power capability of the Conext SmartGen CS 2200 PV inverters at the project is dependent on the terminal voltage and ambient temperature. Since each PV inverter is capped at 1.913 MW for active power, the dynamic capability of the inverters was assessed at 1.913MW. The connection applicant provided the reactive power capability of the Conext SmartGen CS2200 PV inverters at ambient temperatures of 40° C and 50° C which are shown in Figure 3 and Figure 4, respectively. The thermal derating graph of these PV inverters is shown in Figure 5.

Table 5 shows the comparison between the Market Rules reactive power requirement and the reactive power capability of the new proposed inverters at a rated terminal voltage of 1.0 pu. It shows the reactive power capability of the inverters cannot meet the Market Rules requirements when the ambient temperature is 50° C.

Table 5: Conext SmartGen CS 2000 Dynamic Reactive Power Capability

	Rated	Rated	Ambient	Reactive Power Capability
Market Rules Requirement	575 V or 600 V	44 MW	N/A	Qmax = $44 \times \tan [\cos^{-1} (0.9)] = 21.3$ Mvar Qmin = $-44 \times \tan [\cos^{-1} (0.95)] = -14.46$ Mvar
Conext SmartGen CS 2200 Capability	600 V	44 MW	40° C	Qmax = 24.978 Mvar (1.086 Mvar per PV inverter)
				Qmin = -24.978 Mvar (-1.086 Mvar per PV inverter)
			50° C	Qmax = 17.577 Mvar (0.764 Mvar per PV inverter)
				Qmin = -17.577 Mvar (-0.764 Mvar per PV inverter)

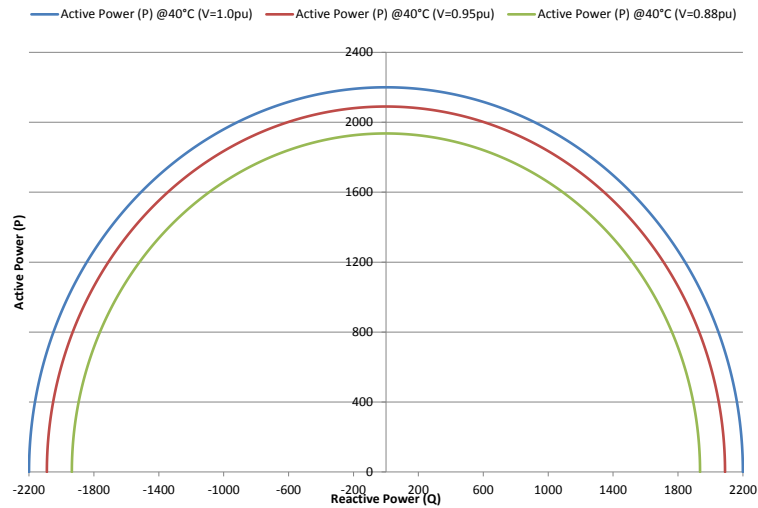


Figure 3: Conext SmartGen CS 2200 Variation of Q (Kvar) with P (KW) at Rated Terminal Voltage and 40° C

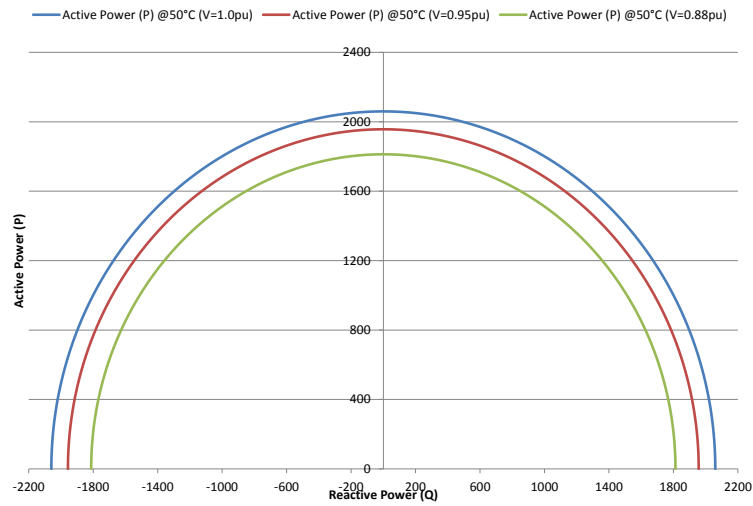


Figure 4: Conext SmartGen CS 2200 Variation of Q (Kvar) with P (KW) at Rated Terminal Voltage and 50° C

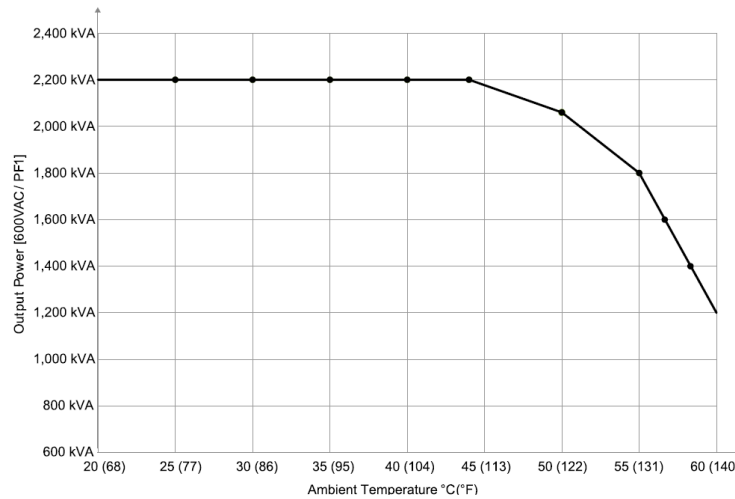


Figure 5: Thermal De-rating of Conext SmartGen CS 2200 inverters

By further investigating the thermal de-rating curve of these inverters as shown in Figure 5, the PV inverters have adequate dynamic reactive power capability at their terminals as long as the ambient temperature is below 43° C. When the ambient temperature increases above 43° C, the MVA rating of the proposed inverters starts to de-rate and their reactive power capability decreases under the same active power output. However, since in Ontario, the probability of the ambient temperature exceeding 43° C is very low, there is no need to install any additional dynamic reactive compensation at the project.

In the future, during the life time of the project, if the ambient temperature exceeds 43° C, the connection applicant will be required to decrease the active power output of the project to a level that supports the reactive power requirements in the Market Rules.

Static Reactive Power Capability

In addition to the dynamic reactive power requirement identified above, the connection applicant has to compensate for the reactive power losses within the project to ensure that it has the capability to inject or withdraw reactive power up to 33% of its rated active power at the connection point. The IESO accepts this compensation to be made with switchable shunt devices.

The reactive power capability in lagging power factor of the project was assessed under the following assumptions:

Test 1

- ambient temperature of 43° C;
- low voltage of 238.2 kV at the connection point (2% below the average voltage at Nanticoke 230 kV bus);
- maximum active power output from the project's equivalent inverter units;
- maximum reactive power output (lagging power factor) from the project's equivalent inverter units, unless limited by their maximum acceptable terminal voltage;
- the main step-up transformer ULTC was used to adjust the project's 34.5 kV (LV) bus voltage as close as possible to 1 pu.

The reactive power capability in leading power factor of the project was assessed under the following assumptions:

Test 2

- ambient temperature of 43° C;
- high voltage of 248.1 kV at the connection point (2% above the average voltage at Nanticoke 230 kV bus);
- Maximum active power output from the project's equivalent inverter units;

- maximum reactive power consumption (leading power factor) from the project's equivalent inverter units, unless limited by their minimum acceptable terminal voltage;
- the main step-up transformer ULTC was used to adjust the project's LV bus voltage as close as possible to 1 pu.

Test 3

- ambient temperature of 43° C;
- high voltage of 248.1 kV at the connection point (2% above the average voltage at Nanticoke 230 kV bus);
- zero active power output from the project's equivalent inverter units;
- maximum reactive power consumption (leading power factor) from the equivalent inverter units, unless limited by their minimum acceptable terminal voltage;
- the main step-up transformer ULTC was used to adjust the project's LV bus voltage as close as possible to 1 pu.

Studies showed that under these test conditions the project would be able to inject 15.8 Mvar and absorb 34.9 Mvar at rated active power and absorb 27 Mvar at zero active power output at the point of connection. Thus the project meets the static reactive power capability requirement. Table 6 summarizes the test conditions and results of the static reactive power capability tests.

Table 6: Reactive power capability of the project at the connection point

Test Number and Operation Mode	230 kV Voltage (kV)	Tap position of the main transformer T1	34.5 kV Bus Voltage (pu)	Inverter Terminal Voltage (pu)	Inverter voltage set point (pu)	Reactive Power at the 230 kV Connection Point (Mvar)	IESO Requirement (Mvar)	Additional Required Reactive Compensation at the Project's 34.5 kV Bus
Test 1: P=44 MW, Lagging PF	238.3	248.5	1.005	1.05	1.05	15.8	14.52	Not required
Test 2: P=44 MW, Leading PF	247.8	232	1.001	0.97	0.95	-34.9	-14.52	Not required
Test 3: P=0 MW, Leading PF	247.9	233.5	1.003	0.965	0.95	-27.2	-14.52	Not required

3.2 Power Plant Controller

3.2.1 Point of Control Location of Power Plant Controller

The connection applicant advised that the power meter used by the Power Plant Controller (PPC) will be installed on the 34.5 kV side of the 34.5/230kV main transformer as recommended by the IESO in the original SIA. Given that the point of control is on the 34.5 kV side, the on-load tap changer (OLTC) of the 34.5/230kV transformer will be set to manual mode of operation.

The connection applicant also advised that during voltage control operation, the total reactive power output will be limited at $\pm 33\%$ of the rated active power at the point of control level (i.e. 34.5 kV side of the main transformer), and due to the main transformer losses and inductive effect, the maximum reactive power output on the 230 kV side will then be different from $\pm 33\%$ of the rated active power.

However, regardless of the location of the point of control, the project is still required to have the $\pm 33\%$ reactive power capability at the point of connection (i.e. on the HV side of the main transformer) in order to meet the Market Rules requirements.

3.2.2 Reactive Power and Voltage Control

The Market Rules requires a generation facility regulate automatically voltage within $\pm 0.5\%$ of any set point within $\pm 5\%$ of rated voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal.

The PPC voltage control will be operated at the point of control (i.e. on the 34.5 kV side of the main transformer) with a 0% default droop that can be adjusted through PPC configuration during commissioning tests.

For a given deviation of the voltage set-point as measured at the point of control the PPC voltage control function will compute the total reactive power expected at the point of control. This total reactive power is then dispatched to the available inverters.

In the event that the project's voltage control becomes unavailable, the IESO requires that each PV inverter be in reactive power control and maintain its reactive power output to the value prior to the loss of signal from the solar farm voltage control. Depending on system conditions, further action such as curtailing the output of the project may be required for reliability purposes.

3.2.3 Frequency Control

The Market Rules require that a generation facility directly connected to the IESO-controlled grid regulate speed/ frequency with an average droop based on the maximum active power adjustable between 3% and 7% and set at 4% unless otherwise specified by the IESO. Regulation dead band shall not be wider than $\pm 0.06\%$.

The PPC frequency control will be responsible for the frequency response at the point of control. In the event of a system over-frequency, the controller will compute an active power participation factor to send to the inverters to help arrest the over-frequency. The amount computed will be based on the frequency deviation to nominal frequency (60Hz) and a droop defined between 3% and 7% (set at 4% per default). The droop expression is based on the maximum active power output (44MW, rated active power). This means that for a frequency deviation of 4% the active power participation would reach 100% of the rated active power output (44MW). This droop can be adjusted through PPC configuration during commissioning tests.

A deadband of $\pm 0.06\%$ (± 36 mHz) will also be implemented to prevent active power reduction for small frequency deviation.

The maximum active power reduction during over-frequency will be set to -10% of the rated active power of the plant (-4.4MW). For a droop set at 4% and a frequency deadband defined at $\pm 0.06\%$ this maximal active power reduction will be reached for frequency over 60.276Hz as shown in Figure 6.

The active power participation factor will be applied on the PV plant power output memorized at the beginning of the frequency event and will be limited so that the total active power set-point of the plant does not go under 0 MW.

The response time of the frequency support for over-frequency will be under 5s to reach 95% of the expected active power reduction.

In the event of an under-frequency, there will be no response from the PPC and inverters even when the PPC is applying an active power limitation following IESO dispatch order (no release of the active power limitation).

Overnight, the frequency support will not be available as inverters will be offline.

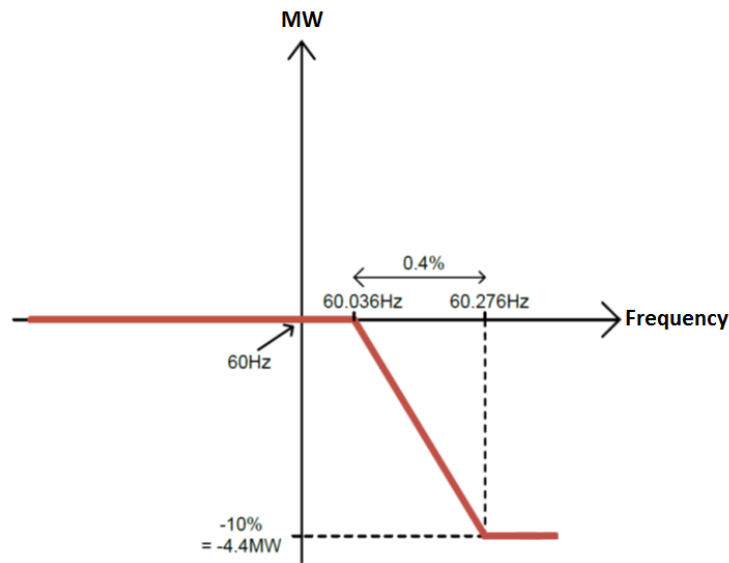


Figure 6: PPC frequency control

3.2.4 Ramp Rate Control

In the case of a dispatch order sent by the IESO to increase or decrease the maximum output power of the project, the PPC will apply a ramp rate so that the active power limitation applied by the PPC will change at a fix ramp rate of $20\% P_{\text{site}}/\text{min}$ (P_{site} being the contracted active power, i.e. 44 MW) at the Point of Control. This means that the power limitation would increase from 0% to 100% in 5 minutes.

Neither the PPC, nor the SmartGen inverters, will apply a ramp rate control on the active power variation due to irradiance fluctuation.

3.2.5 Conclusions

It is concluded that the functions of the proposed PPC meets the Market Rules requirements. The connection applicant is required to provide the final functional description of the project's plant control system for the IESO's approval before the project is allowed to connect.

3.3 Voltage Ride-Through Capability

The Market Rules require that all generation units and associated equipment that are directly connected to the IESO-controlled grid have the ability to withstand transient voltages and remain connected to the IESO-controlled grid following a recognized contingency unless the generation units are removed from service by configuration. This requirement is commonly referred to as the voltage ride-through (VRT) capability.

The compliance of the proposed VRT capability of the PV inverters with the Market Rules requirements was assessed based on the terminal voltages of the PV inverters under simulated contingencies presented in Table 7. The assumptions for this study are the same as those in the original SIA.

Table 7: Simulated contingencies and Fault Clearing Times (FCT) for VRT study

ID	Contingency	Fault location	FCT @ local station (ms)	FCT @remote station (ms)	Transfer Trip/ Remote Trip
SC 1	3-ph fault on N5M (normal clearing)	Nanticoke TS	Nanticoke TS	Middleport TS	Grand Wind CGS
			81	100	140
SC 2	3-ph fault on N6M (normal clearing)	Nanticoke TS	Nanticoke TS	Middleport TS	115 kV circuit C9
			65	106	106
SC 3	1-ph fault on N580M+N581M (normal clearing)	Nanticoke TS	Nanticoke TS	Middleport TS	-
			65(N580M)/ 65 (N581M)	90(N580M)/ 106(N581M)	-
SC 4	Fault on N5M+L5F Brk fail@ Nanticoke (normal clearing)	Nanticoke TS	Nanticoke TS	Middleport TS	Caledonia TS
			178	110	139
SC 5	Fault on N5M+L5F Brk fail@ Middleport (normal clearing)	Middleport TS	Middleport TS	Nanticoke TS	Caledonia TS
			76	194	139

The plots in Appendix A: Voltage Ride-Through Results show the terminal voltages of the PV inverters at collector circuits C1 and C2 under simulated contingencies. Based on the simulation results it is concluded that the proposed VRT settings, in section 2.8, of the PV inverters did not result in the trip of the project for the recognized contingencies. Therefore the proposed VRT setting meet the Market Rules' requirements and acceptable to the IESO.

However, when the project is incorporated into the IESO-controlled grid, if actual operation shows that the PV inverters trip for contingencies for which they are not removed by configuration, the IESO will require the voltage ride-through capability be enhanced by the connection applicant to prevent such tripping.

The voltage ride-through capability must also be demonstrated during commissioning by monitoring several variables under a set of IESO specified field tests and the results should be verifiable using the PSS/E model.

-End of Section-

Appendix A: Voltage Ride-Through Results

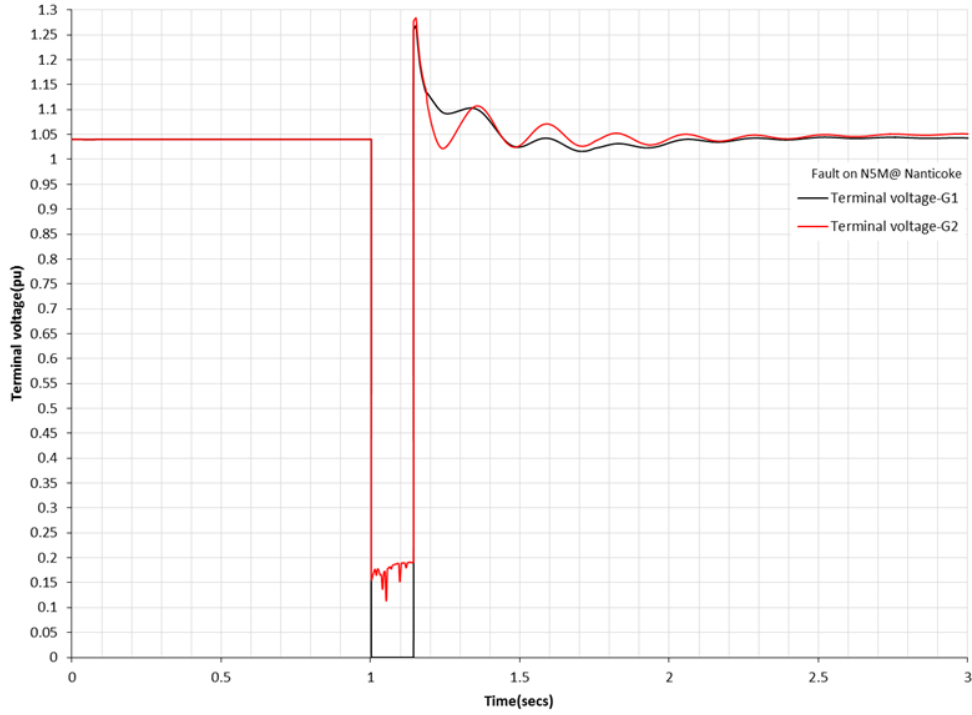


Figure 7: PV terminal voltages following a 3-phase fault on N5M near Nanticoke TS

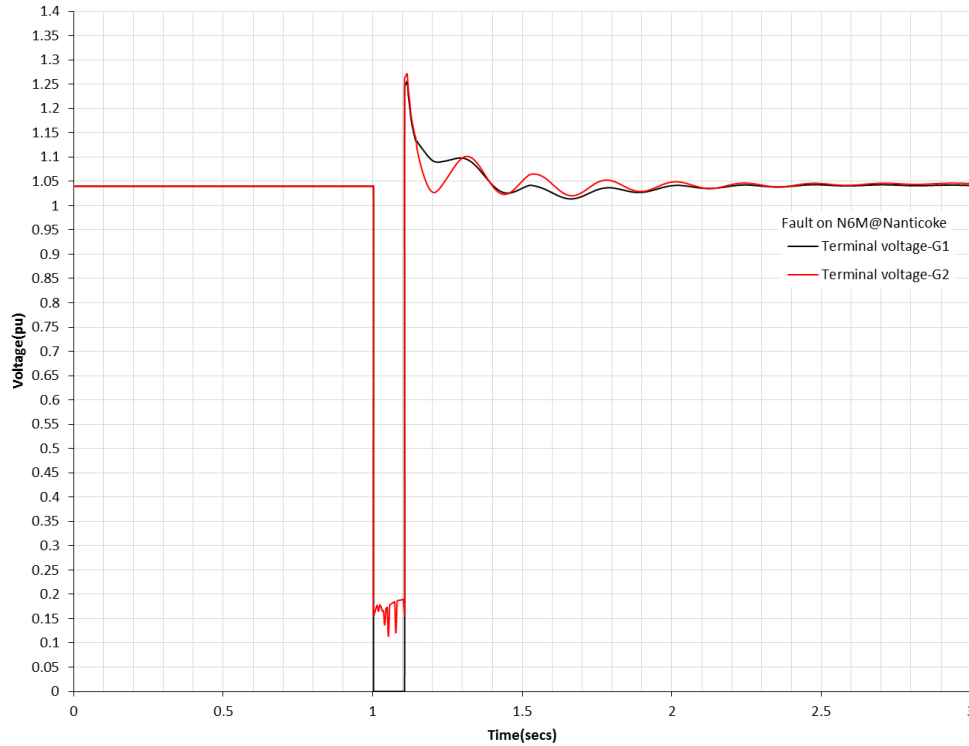


Figure 8: PV terminal voltages following a 3-phase fault on N6M near Nanticoke TS

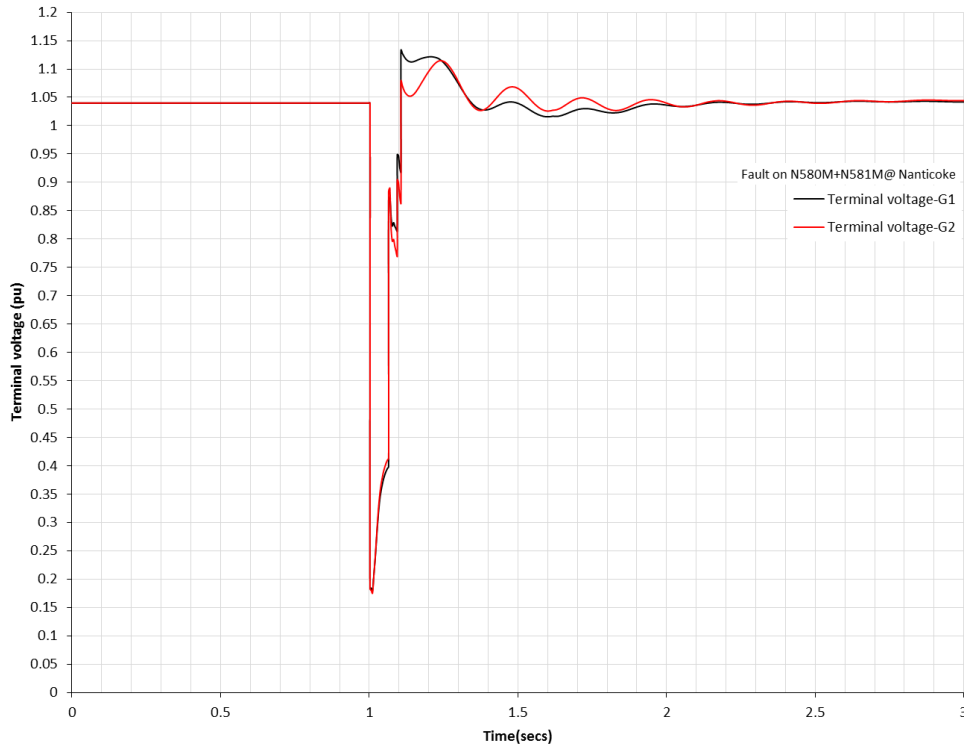


Figure 9: PV terminal voltages following a LLG fault on circuits N580M and N581M near Nanticoke TS

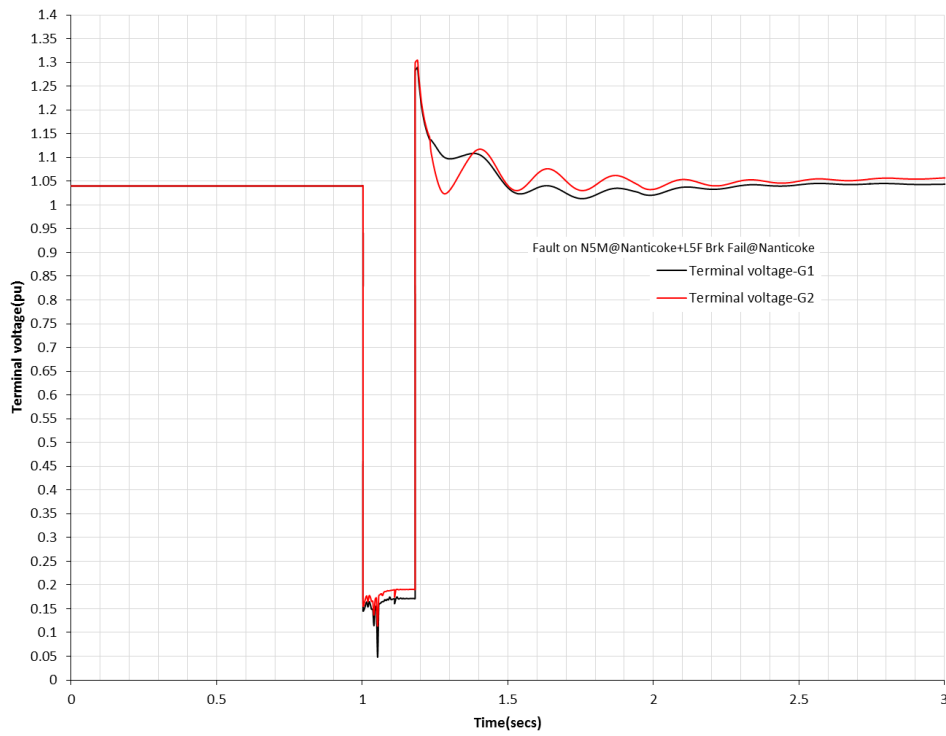


Figure 10: PV terminal voltages following a 3-phase fault on N5M near Nanticoke TS and L5F breaker failure at Nanticoke TS

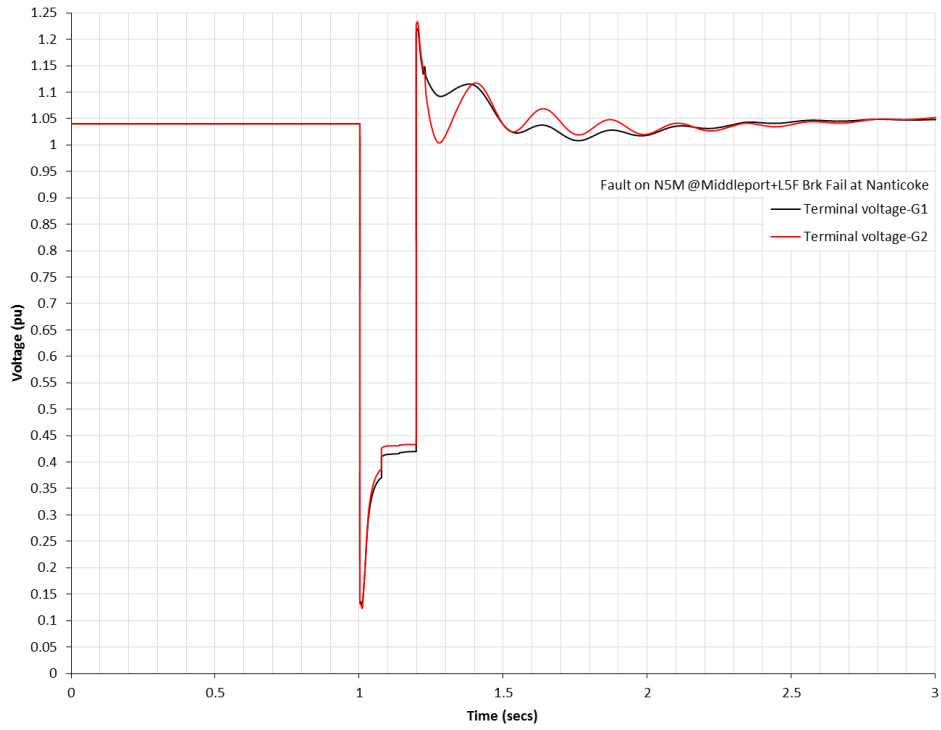


Figure 11: Generator terminal voltages following a 3-phase fault on N5M near Middleport TS and L5F breaker failure at Nanticoke TS

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