
# SASKATOON LIGHT & POWER

## Interconnection Guideline

October 2022

# INTERCONNECTION GUIDELINE

IG2022 Rev. 0

For the Connection of Distributed Generation to the Saskatoon Light & Power Electrical Distribution System

March 2022

All questions regarding this document and regarding Distributed Generation within the Saskatoon Light & Power franchise area should be directed to:


Saskatoon Light & Power
322 Brand Road
Saskatoon, SK
S7K 0J5
Phone: 306.975.2414
Fax: 306.975.3057
Website: www.saskatoon.ca

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# 1 General Information

## 1.1 Authority

Saskatoon Light & Power (SL&P), the electric utility owned by the City of Saskatoon (City), is authorized to be the sole distributor of electricity within the City's electrical franchise boundaries. Pursuant to this, SL&P is authorized to determine the characteristics of power, and to determine and enforce standards for the security, reliability, and quality control of the transmission and distribution lines within its franchise area. The determination of these items by SL&P are final and binding on the user. SL&P, also herein referred to as the utility, has developed the following Interconnection Guideline for Distributed Generation.

## 1.2 Disclaimer

All information contained in this document has been made available for the sole and limited purpose of providing general and technical information regarding customer owned generation connected to the SL&P distribution system. Nothing stated in this information should be construed as a promise, assurance, or warranty given by SL&P regarding the obligations of SL&P with respect to the customer owned generation.

This document is not intended to be used as a handbook, design specification, or an instruction manual by the Distributed Generation (DG) Proponent or the DG Owner, its employees, or agents. All persons using this information are to do so at no risk to SL&P and they must rely solely upon themselves to ensure that their use of all, or part, of this document is appropriate in the particular circumstance.

Those considering the development of a generation facility intended for connection to the SL&P distribution system should engage the services of individuals who are qualified to provide the design and consulting services for such electrical interconnection facilities. The DG Owner, employees, or agents must recognize that they are, at all times, solely responsible for the design, construction, and operation of the generation facility. The comments and advice by SL&P employees or agents, that the generation plant design or equipment meets certain SL&P requirements, does not mean, expressly or by implication, that any or all of the requirements of the law or good engineering practices have been met. The comments regarding the design or equipment shall not be construed by the owner or others as an endorsement or warranty by SL&P. Neither SL&P, nor it's employees or agents, will become an agent of the proponent in any manner howsoever arising.

## 1.3 Purpose

The purpose of the Interconnection Guideline is to assist proponents of Non-Utility Generation (NUG) projects with the understanding of the processes needed, and the technical parameters given for the assessment, design, and operation of the generation facility.

The intent is to mandate a safe, functional, and effective interconnection that protects and safeguards the SL&P personnel, system, and equipment; the customers facilities and personnel; and the public. This document establishes and defines guidelines and specifies the technical requirements for interconnection of Distributed Resources (DR), that are not exclusively owned by SL&P, to the SL&P distribution system. The Guideline contains information regarding the characteristics of the SL&P distribution system, outlines major interconnection process steps, and identifies items which require consideration at various stages of a DR project.

In an effort to provide consistency, minimize confusion, and to limit discrepancies between the Interconnection Guidelines provided by SL&P and by the provincial electrical utility, SaskPower, this Guideline has adopted much of the philosophical direction and technical limits used in the SaskPower Interconnection Requirements document. It must be noted, however, that differences do exist, and the user of this Guideline must not assume that all philosophies and tenets are the same.

This document does not constitute an offer to, or express an interest in, purchasing energy from any non-utility generation proponent. All enquiries regarding commercial agreements for the purchase and receipt of electrical energy from non-utility generation projects should be independently made to:

Saskatoon Light & Power
322 Brand Road
Saskatoon, SK  S7K 0J5
Phone: 306.975.2414
Fax: 306.975.3057

## 1.4 Scope

This guideline applies to all single phase and three phase, single site, non-utility generation facilities that are connected to, and operate in synchronism with, the SL&P distribution system. It covers all Distributed Resources interconnected with the distribution systems at voltages of 25 kV or less. This includes the primary voltage distribution and secondary voltage distribution systems as follows:

- Primary Distribution
  25kV, 14.4kV, and 4.16kV
- Secondary Distribution:
  347/600 volts and 120/208 volts 3 phase
  120/240 volts 1 phase

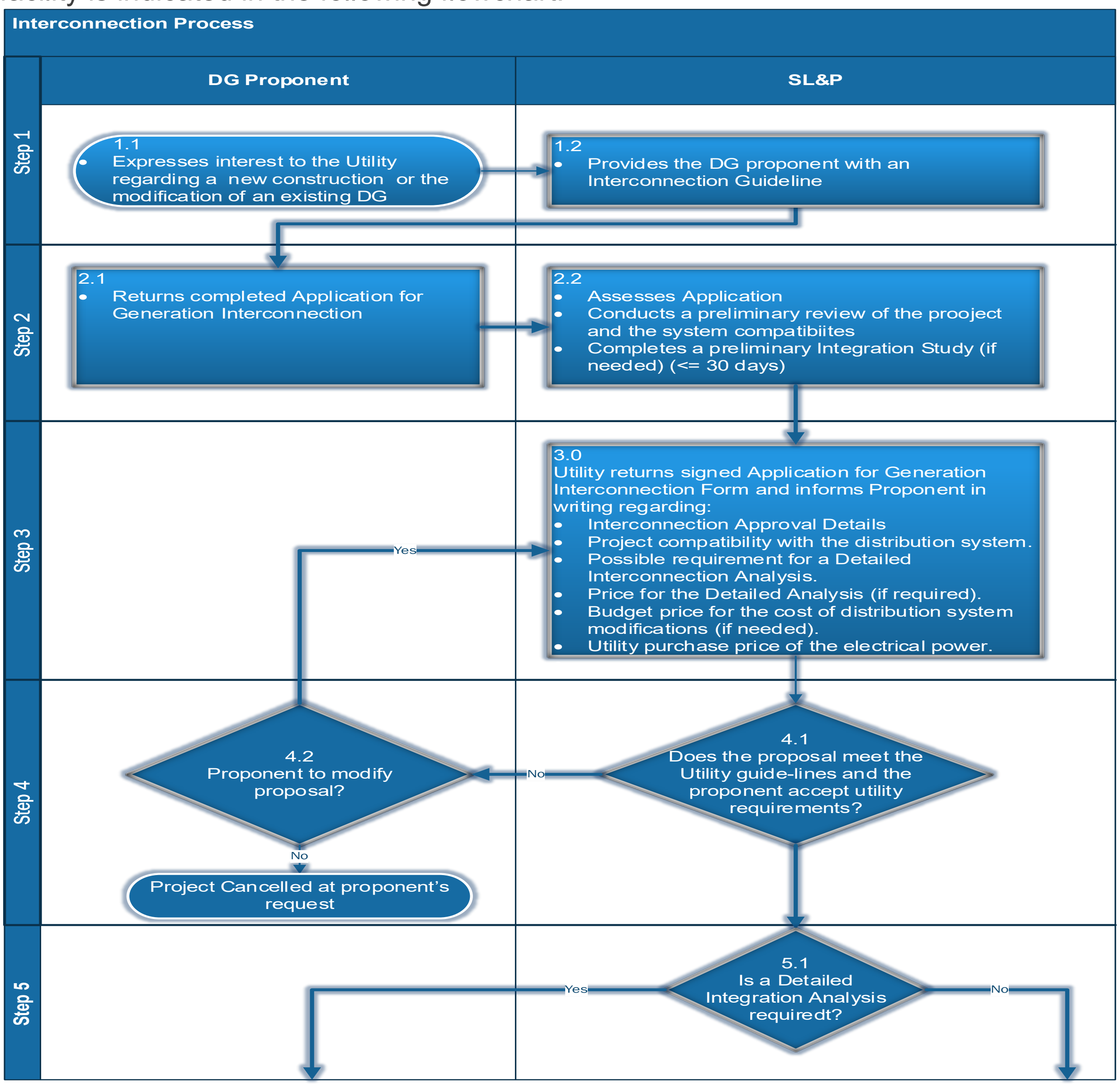
Single generation facilities at single site locations are restricted to a maximum of 100 kW. Maximum allowable generation facilities to the SL&P downtown 600 volt network system is assessed by SL&P on DG proponent’s request. This document addresses three phase generation up to a maximum of 1000 kW.

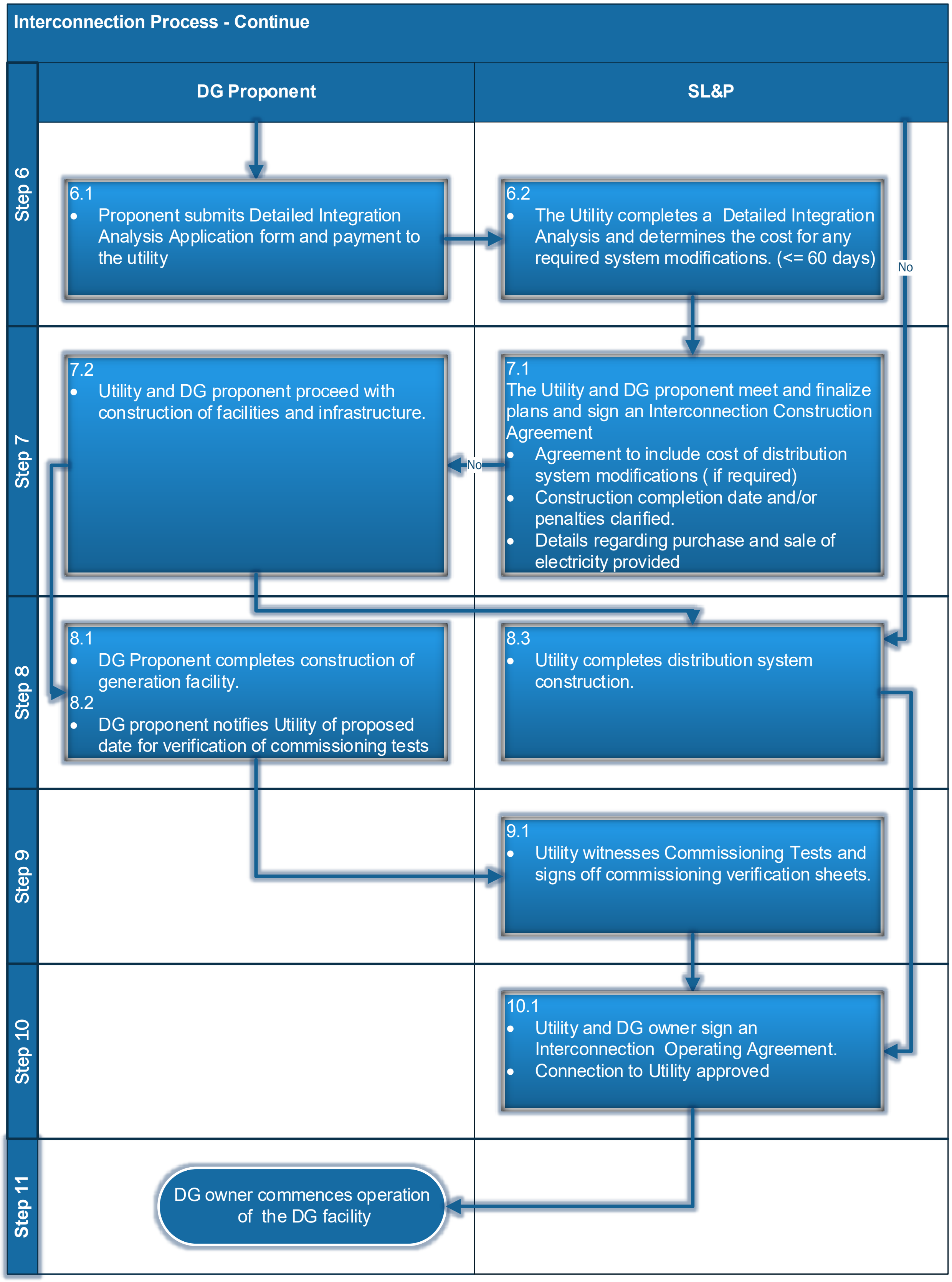
Generation plants in excess of 1000 kW, or operating at voltages above 25 kV, may be acceptable but need to be addressed independently by SL&P on a case-by-case basis. This document does not address metering rates or tariffs. General and rate information regarding the sale and/or purchase of electrical power by SL&P is available in the Administrative Policy No. A07-022, Power Producer Policy, which can be found at the City website: https://www.saskatoon.ca/sites/default/files/documents/city-clerk/civic-policies/A07-022.pdf

# 1.5 Interconnection Process

## 1.5.1 Flowchart

The summarized process for the creation or modification of a Distributed Generation facility is indicated in the following flowchart:




Interconnection Process - Continue
DG Proponent
SL&P
Step 6
6.1
• Proponent submits Detailed Integration Analysis Application form and payment to the utility
6.2
• The Utility completes a Detailed Integration Analysis and determines the cost for any required system modifications. (<= 60 days)
No
Step 7
7.2
• Utility and DG proponent proceed with construction of facilities and infrastructure.
No
7.1
The Utility and DG proponent meet and finalize plans and sign an Interconnection Construction Agreement
• Agreement to include cost of distribution system modifications ( if required)
• Construction completion date and/or penalties clarified.
• Details regarding purchase and sale of electricity provided
Step 8
8.1
• DG Proponent completes construction of generation facility.
8.2
• DG proponent notifies Utility of proposed date for verification of commissioning tests
8.3
• Utility completes distribution system construction.
Step 9
9.1
• Utility witnesses Commissioning Tests and signs off commissioning verification sheets.
Step 10
10.1
• Utility and DG owner sign an Interconnection Operating Agreement.
• Connection to Utility approved
Step 11
DG owner commences operation of the DG facility

### 1.5.2 Comments

Comments regarding the individual points in the Interconnection Process Flowchart are as follows:

Step 1

All approvals associated with the addition of new DG facilities must be obtained from SL&P. The same process and approval system must be maintained for any and all changes to an existing DG connection facility.

Step 2

The Application for Generation Interconnection is contained in the Appendices – Section 8.6. There is no charge assessed by SL&P for the provision of the Preliminary Integration Study. In the majority of cases, where the size of the proposed generation is small, the Integration Study may not be needed.

Steps 3, 5, and 6

In some cases, where the size of the proposed generation facility is large, an in-depth Interconnection Analysis Study will be required. SL&P will perform this study but the cost of it will be the responsibility of the DG proponent. The application form for the Detailed Analysis is contained in Section 8.6. In the cases where the addition of the DG facility necessitates initial or future modifications of the SL&P distribution system, the modifications will be carried out by SL&P, but the costs will be the responsibility of the DG proponent.

SL&P is the sole purchaser and/or recipient of any and all electrical power generated onto the SL&P distribution system.

Step 7

The Interconnection Construction Agreement is to cover the legal and contractual details regarding the construction of the connection of the generation source to the Utility.

Step 10

The Interconnection Operating Agreement includes legal and contractual details regarding the technical and operating requirement, energy purchase rate and billing practices, term and termination, etc. The following agreements are available:

- Net Metering Interconnection Operating Agreement for the generator (≤ 100 kW)
- Small Power Producer Interconnection Operating Agreement for the generator ( ≤ 100 kW)
- Interconnection Operating Agreement for the generator (>100 kW)

## 1.6 Ownership and Responsibilities

The DG proponent is responsible for all materials and costs associated with the design, construction, commissioning, retesting, maintenance, inspections, and operation of all equipment and facilities on the generation side of the Point of Delivery. SL&P will own, operate, and maintain all equipment and facilities on the utility side of the Point of Delivery. In cases where SL&P requires SCADA equipment to be placed in the customer's equipment and on his premises, the ownership, maintenance, and operation of this equipment is the responsibility of SL&P. The Customer must provide the utility with unrestricted access to this SCADA equipment at all times.

The DG Owner is responsible for the total initial and future costs associated with the design, provision, and installation of any utility interconnection facilities and system modifications required to couple the DG facilities to the distribution system. Any and all reviews conducted by the utility and/or SaskPower Electrical Inspections will be conducted at the risk and expense of the Generation Owner.

The DG facility's equipment and construction practices shall meet the requirements of the Canadian Electrical Code and City bylaws.

## 1.7 Agreements and Requirements

The completion of the following forms and agreements with SL&P is required prior to the connection of the DG facility to the SL&P distribution system.

For single phase 120/240 volt systems connected to the utility secondary distribution system:

- Application for Generation Interconnection
- Interconnection Agreement for Small Generators (≤ 100 kW)
- Commissioning Verification Form
- Operating Agreement.

For all 3 phase secondary distribution and for all single and 3 phase primary distribution systems:

- Application for Generation Interconnection
- Application for Detailed Generation Interconnection Analysis (if required)
- Interconnection Agreement for Small Generators (≤ 100 kW)
- Interconnection Agreement for Large Generators (> 100 kW)
- Commissioning Verification Form
- Operating Agreement.

Application forms are provided in Section 8.6.

# 2 System Characteristics

The following information provides the characteristics of the SL&P distribution system.

## 2.1 General Configuration

The SL&P distribution system incorporates nominal 25 kV, 14.4 kV, and 4.16 kV 3 phase 4 wire wye connected primary voltage systems. It also utilizes secondary voltage distribution at 347/600 volts 3 phase 4 wire, 120/208 volts 3 phase 4 wire, and 120/240 volts single phase.

SL&P's primary and secondary distribution systems are considered to be solidly and effectively grounded and typically operate as radial systems. Occasionally, during momentary switching, the distribution feeders may be energized from more than one point of supply.

## 2.2 Voltage

During normal operating conditions the voltages at the points of delivery for the primary voltage distribution system may vary between the acceptable limits of 94% and 106% of nominal voltage.

The SL&P distribution system is a balanced 3 phase system that incorporates single phase and 3 phase loads. During normal steady state operation, phase to phase voltage unbalance is limited to less than 3%; however, during and following momentary fault conditions the unbalance may be higher.

Unbalance, as defined by NEMA MG1-14.34 standard, is:

$$\text{Unbalance (\%)} = \frac{100 \times (\text{Maximum deviation from average phase to phase voltage})}{\text{Average phase to phase voltage}}$$

Temporary abnormal voltages (transients, sags, surges) will also occasionally occur. These are typically caused by lightning, switching conditions, sudden load changes, and ground faults.

## 2.3 Frequency

The distribution system operates at a nominal steady state value of 60 Hertz $\pm$ 0.2 Hertz. Frequency deviations outside this range may occur as a result of system disturbances.

## 2.4 Power Quality

The power supplied by the utility will meet the voltage flicker and harmonic voltage and current limits as defined in Section 3.2 of this guide, and in the SL&P "Customer Information Guide."

## 2.5 Phasing

The conductor phasing throughout the distribution system is typically but not necessarily standardized as A, B, C (Red, Yellow, Blue) phase sequence.

## 2.6 Power Interruption and Faults

Momentary and sustained feeder faults and outages do occur occasionally.

## 2.7 Automatic Reclosing

The distribution system may utilize feeder automatic reclosing functions to maintain system reliability.

## 2.8 Grounding

The Primary and Secondary distribution systems are designed and operated as “effectively grounded.”

## 2.9 Transformer Windings

The utility’s Primary distribution system is supplied by substation transformers with high voltage/low voltage winding configurations of either Delta/Grounded Wye or Grounded Wye/Delta (with a ground referencing transformer on the distribution side).

The transformers supplying power to the secondary voltage distribution systems incorporate 3 phase, 4 wire grounded secondaries or, in the case of the single-phase systems, neutral grounded center tapped configurations.

## 2.10 Network System

SL&P utilizes a 347/600V (3 phase, 4 wire) network distribution system in the downtown core area. The functionality of the network system allows for interconnection to DG only under certain conditions. Please see Section 4 for the requirements in this regard.

# 3 General Interconnection Requirements

It is imperative that the characteristics and ratings of the proposed DG system and all associated apparatus match and accommodate the characteristics of the utility to which it is connected. In addition, all installations shall meet the requirements of the SL&P "Customer Information Guide." The DG proponent must take this into consideration in regards to the DG system design, staffing, operation, remote monitoring, auto-restart capabilities, reliability, and economics.

All DG's design, installation and operation should meet the requirements of IEEE Standard No. 1547-2003, as amended by IEEE Standard No. 1547a-2014, at a minimum. To the extent that it is reasonable to do so, SL&P will require that DG installations conform with IEEE Standard No. 1547-2018.

All equipment shall be CSA and ULC approved.

## 3.1 Interconnection Facilities

The Interconnection Facilities shall meet the requirements as stated in this document and SL&P's "Customer Information Guide". In cases where conflicts do exist between this document and the Customer Information Guide requirements, this document shall prevail.

### 3.1.1 Isolation Devices

The utility will designate the Point of Common Coupling (PCC) during the initial design stage of the generating facility. The DG Owner will be responsible for the design, construction, operation, and maintenance of the facility on the generation side of the PCC. The utility will be responsible for the design, construction, operation, and maintenance of the facilities on the distribution side of the PCC.

### 3.1.2 Isolation Devices

A load break disconnect switch or breaker is required to provide isolation between the DG facility and the utility distribution system. This isolation device is needed to meet safety, maintenance, and operational requirements.

This disconnect device shall be readily accessible somewhere outside the building, lockable in both the open and closed positions, and has contact operation verifiable by direct visible means. For 3 phase generating facilities, the switch shall be 3 phase gang operated.

In unique circumstances, locating the disconnect switch outdoors may not be practical.

In such cases, the Customer may request SL&P to approve the location of the switch to be inside the designated electric room where it should be readily accessible for operation and locking by utility personnel.

Whenever SL&P approves an indoor disconnect switch location, the Customer should provide a permanent sign, of a type approved by SL&P, mounted on the building near the electric service entrance that reads, “Customer Owned Generation – Disconnect Switch Inside.” Posting of specific directions and/or a lockbox may also be required to locate and access the switch.

In both the primary distribution and secondary distribution generator connected systems, the isolation device will be owned by the DG Owner. In all cases the utility reserves the right to maintain unrestricted 24-hour access to open and lock open the device.

All isolation devices between the generator and the PCC shall be clearly labelled referencing the two voltage sources.

The utility Disconnect Switch must meet Canadian Electrical Code 2015 Edition Rules 64-060, 64-074(2)(3), 84-022; 84-024(a)(b), and 84-030.

Refer to Section 8.5 for single line diagrams.

### 3.1.3 Fault Interrupting Devices

The DG facility must incorporate fault interrupting devices which, in the event of a fault within the generation facility, are capable of safely interrupting the fault current and isolating the generation facility from the utility. The DG facility must also be designed in consideration of the present and future fault current contributions from both the utility and the DG sources. The utility existing and anticipated future fault current levels will be provided by the utility at the proponent’s request and are to be used by the proponent in the determination of preferred equipment.

### 3.1.4 Metering

For DG systems connected to the utility single phase secondary distribution system and for all 3 phase systems, a four quadrant, revenue approved metering capable of recording real and reactive energy and power is required. The metering must be capable of separately recording the energy and demand to the generation facility from the utility and to the utility from the generation source. The utility is responsible for the provision of the meter, however the cost of the provision of the four-quadrant meter will be the responsibility of the DG proponent.

For generation companies, with utility supplied transformation, the metering will be required at the secondary voltage level. For generation companies, who supply their own transformation, the metering will be required at the primary voltage side.

The generation owner shall provide all communication/interface facilities that the utility may require to communicate with the metering units.

### 3.1.5 Transformer

In cases where customer owned transformation is required, the generator transformer shall be sized to deliver rated generator system kVA. This sizing shall take into consideration the power factor and, for 3 phase transformation, the possibility of zero sequence currents due to load imbalance.

The determination of the suitable transformer winding configuration is affected by the type of generation source (synchronous/non-synchronous). The transformation chosen also affects how system faults are detected and the type of protection required.

All customer owned transformation shall be reviewed and approved by the utility prior to purchase and installation.

### 3.1.6 Grounding

The DG facility must be grounded to properly interface with the distribution system. Grounding of the DG system shall be designed and implemented to provide the following:

- Solidly grounded generation and interconnection facilities that meet manufacturer's recommendations and the Canadian Electrical Code.
- Fault detection that isolates all fault contributing sources.
- Protection of the low voltage and high voltage apparatus from damage due to high fault currents.
- Proper ground connection interface between the DG source and the distribution system.

## 3.2 Power Quality

The DG facility shall ensure that the electrical characteristics of its load and generating equipment will meet the utility's power quality requirements. Deviations beyond true sine waveform, and short term or steady state voltage or frequency limits as specified, are not permitted.

### 3.2.1 Voltage

The DG facility voltages shall match the phasing and voltage levels of the utility distribution system to which it is connected. The utility phase sequence/direction of rotation and voltage levels must be determined by the Generation proponent during the design stage of the project. This information will be provided by the utility at the proponent's request. Single-phase generators are not permitted to cause unbalance to the utility 3 phase system.

Both the utility and the Generation facility are required to operate within the normal and extreme operating limits as defined in Table 1.

**Table 1: Operating Voltage Limits**

| Nominal System Voltages | Recommended Voltage Variation Limits for Circuits up to 1000 Volts, Applicable at Service Entrance | | | |
|---|---|---|---|---|
| | Extreme Operating Conditions | | | |
| | | Normal Operating Conditions | | |
| Single Phase<br>120/240<br>240<br>480<br>600 | <br>106/212<br>212<br>424<br>530 | <br>110/220<br>220<br>440<br>550 | <br>125/250<br>250<br>500<br>625 | <br>127/254<br>254<br>508<br>635 |
| Three Phase<br>4 – Conductor<br>120/208Y<br>240/416Y<br>277/480Y<br>347/600Y | <br><br>110/190<br>220/380<br>245/424<br>306/530 | <br><br>112/194<br>224/388<br>254/440<br>318/550 | <br><br>125/216<br>250/432<br>288/500<br>360/625 | <br><br>127/220<br>254/440<br>293/508<br>367/635 |
| Three Phase<br>3 - Conductor<br>240<br>480<br>600 | <br><br>212<br>424<br>530 | <br><br>220<br>440<br>550 | <br><br>250<br>500<br>625 | <br><br>254<br>508<br>635 |

CSA Standard CAN-3-C235-95 “Preferred Voltage Levels for AC Systems, 0 - 50,000V”

The DG owner must ensure that the operation of the generation facility does not cause voltage sags, swells, or flicker on the distribution system resulting in customer concerns. Voltage flicker shall not exceed the borderline of irritation limit as given in Section 8.4.

The phase-to-phase voltage unbalance must not exceed 1% when measured at no-load and at 3 phase balanced load situations. Single-phase generator or unbalanced load situations shall not cause the distribution system voltage unbalance to exceed 3%.

### 3.2.2 Frequency

When entering service, the DG shall not energize the SL&P distribution system until the system frequency is within the range of 59.5 to 60.1 Hertz. This requirement applies equally for return to service after trip as well.

The Generation facility interconnected with the utility distribution system must remain synchronously connected to the utility and be able to operate over a frequency range of 58.8 to 61.0 Hertz without tripping.

### 3.2.3 Power Factor

Inverters and static power converters must be capable of adjusting the power factor of the output power to between 0.90 lagging and 0.95 leading at the PCC.

Since induction generators consume reactive power (vars) the DG system must provide reactive compensation to correct the power factor of the generated power to between 0.90 lagging and 0.95 leading at the PCC.

The utility retains the right to define power factor requirements on a case-by-case basis.

### 3.2.4 Voltage Regulation

The DG system should be capable of fulfilling the voltage regulation requirement at PCC by changes of reactive power and, for higher penetration area, by changes of active power as stated in IEEE Standard No. 1547-2018, Clause 5.

DG systems must operate satisfactorily within the extreme voltage level limits as defined in Table 1.

### 3.2.5 Harmonic Distortion

The possibility f harmonic resonance should be considered as part of the design and operation of the generating facility. The potential modes of resonance include:

- Transformer Ferro-resonance
- Sub-synchronous resonance
- Harmonic resonance with capacitor systems

The harmonic distortion at the Point of Delivery shall meet the requirements as defined in IEEE Standard No. 1547-2018, Clause 7.3. In addition, voltage harmonic distortion, as a percentage of the nominal frequency voltage, shall not exceed 3% for any individual harmonic and 5% for the total harmonic distortion. The total rated current distortion (TRD) shall not exceed 5% of rated current.

Individual harmonic current distortion limits shall meet the requirements as defined in Table 2.

**Table 2: Harmonic Current Limits in Percent of Rated Current**

| Harmonic Numbers | Maximum Distortion (%) | |
|---|---|---|
| | Even Harmonics | Odd Harmonics |
| 2nd thru 10th | | 4.0 |
| 2nd | 1 | |
| 4th | 2 | |
| 6th | 3 | |
| 11th thru 16th | 2 | 2 |
| 17th thru 22nd | 1.5 | 1.5 |
| 23rd thru 34th | 0.6 | 0.6 |
| 35th thru 50th | 0.3 | 0.3 |

The DG system shall not inject a DC current greater than 0.5% of the unit rated output current after a period of six cycles following connection to the distribution system.

### 3.2.6 Self Excitation

The possibility of self excitation (as evident when induction generators are used) and the associated resultant power islanding needs to be assessed and addressed at the design stage. Such generation facilities are not permitted to connect to, or remain connected to, a utility distribution system that is de-energized.

## 3.3 Protection

### 3.3.0 General Comments

The DG facility protection must be designed to provide protection for fault situations that occur within the DG facility and for situations where the utility distribution feeder becomes de-energized.

Protection functions and requirements vary depending on the specifics of the generation system. Typical specific differences include the following:

- Generator size
- Power source - induction machine, inverter, synchronous machine
- Phase connections - single phase, three phase
- Utility connection - secondary distribution, primary distribution.

In general, the protection schemes for all groups must include:

- Generator Protection (GP) - internal faults, loss of excitation, reverse power, and frequency drift
- Synchronization Protection (SP) - synchronization functions, over/under frequency, and over/under voltage
- Utility Protection (UP) - system faults
- Anti-Islanding Protection (AIP).

It is the responsibility of the DG Proponent to verify that the protection provided will work as intended. The DG proponent is responsible for ensuring that the generation plant protection devices fully co-ordinate with the utility system protection devices. The DG Proponent must submit a complete protection design package including all relay settings, tripping schemes, and schematics to the utility for review and approval prior to installation.

Relays, circuit breakers, and reclosers should comply with the most current version of the following standards:

- ❖ Relays
  - ANSI/IEEE C37.90-1989 (R1994), IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus
  - ANSI/IEEE C37.9.01-1989 (R1994), IEEE Standard Surge Withstand (SWC) Tests for Protective Relays and Relay Systems.
  - ANSI/IEEE C37.90.2-1995, IEEE Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

- ❖ Circuit Breakers
  - IEEE C37.13.1-2016, IEEE Standard for Definite-Purpose Switching Devices for use in Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
  - IEC 62271-100, IEC standard for High-Voltage Switchgear and Control Gear

- ❖ Reclosers
  - IEEE/IEC 62271-111, ANSI C37.60, 2012

For larger scale systems, the utility may require that a telemetry system be provided for remote indication and/or tripping functions.

### 3.3.1 Overcurrent

The over current protection in the DG facility must detect over current situations in the DG facility for 3 phase, phase to phase, and phase to ground faults. The over current protection must promptly isolate the fault area for fault conditions in the DG system. The over current protection must co-ordinate with Utility protection devices and shall meet the approval of the utility.

### 3.3.2 Over and Under Voltage

All DG facilities shall have under and over voltage protection schemes that disconnect the generator source from the utility in the event of abnormal voltages. Also where there are concerns regarding self-excitation or ferro-resonance, a very high speed over voltage protection scheme is required.

The protection at the generation facility must have the capability to detect any and all of the single phase or 3 phase to ground voltages that may occur outside the prescribed limits. The protection must then trip the generator breaker within the appropriate time limits. Trip time limits will be as specified in the group specific sections. The under voltage and over voltage protection pickup and time settings shall all be independent of each other and shall include adjustment capabilities over the complete range of voltages and times.

During feeder fault situations where the utility feeder auto-reclose function is active, it is imperative that the generator is disconnected from the distribution system prior to the first auto-reclose of the utility devices.

The generating facility may be reconnected to the utility distribution once the system has stabilized and the distribution system RMS voltage has returned to normal operating levels for a minimum of 5 minutes.

### 3.3.3 Over and Under Frequency

All DG projects shall have under frequency and over frequency protection schemes that disconnect the generator from the utility in the event of abnormal frequencies.

The under frequency and over frequency pickup and time delays settings shall be independent of each other and shall include adjustment capabilities between 55 and 65 Hertz and 0 to 18,000 cycles.

Frequency trip settings and time limits will be as specified in the group specific sections.

### 3.3.4 Power Flow

All DG systems which are generating power to the utility grid, but which do not have contractual agreements for the receipt of power, shall have directional power flow protection. This protection shall isolate the DG facility from the utility for conditions in which power flows from the utility to the generating facility.

In addition, all DG systems which are generating power for load reduction only and do not have contractual agreements to supply power to the utility shall also have power flow protection. This protection shall isolate the DG facility from the utility for conditions in which power flows from the generating facility to the utility.

The power level and time settings must be independent and fully adjustable and will be determined by the Utility at the time of design approval stage.

### 3.3.5 Anti-Islanding

DG facilities connected to the utility's distribution system are not permitted to operate as an island and must not remain connected to a distribution system or portion thereof that is disconnected from the utility source. As such, Anti-Islanding Protection (AIP) is required at the point of interconnection between the DG facility and the utility to detect the island, cease to energize the SL&P distribution system, and trip within 2 seconds of the formation of an island.

The AIP is required to:

- Prevent hazardous situations to utility personnel from back fed distribution systems
- Avoid out of phase reclosing between the DG facility and the utility
- Prevent over voltage due to self excitation.

The AIP will be required to automatically disconnect the DG facility when the distribution system becomes de-energized. This will provide protection for:

- All types of faults on the utility distribution system
- A single phase loss or loss of phase condition
- Operation of a utility breaker supplying power to the DG facility.

### 3.3.6 Synchronization

Any DG system, that can generate voltage while disconnected from the distribution system, will require synchronization protection functions.

These functions will restrict the generation system from connecting to the utility distribution in any manner when the DG and distribution voltages, frequencies, and/or rate of change of frequencies differ. Auto resynchronization is subject to the same restrictions as start up synchronization but shall also include a 5 minute reconnection delay period.

Inverter type line following equipment and induction generators, that act as motors during start up, do not require synchronization facilities.

## 3.4 Commissioning, Inspections and Testing

The utility reserves the right to inspect the DG system equipment, associated documentation, and installation procedures, and to witness commissioning tests, prior to the initial energization of the DG system.

The utility's interest in commissioning is to ensure that the DG system does not pose any safety hazards, that it meets the performance criteria of power quality and system reliability during normal and abnormal conditions, and that it does not adversely affect the operation of the utility distribution system.

Involvement of utility personnel in commissioning does not mean, expressly or by implication, that all or any of the requirements of the law or good Engineering practices have been met by the DG system.

The DG Owner shall notify the utility at least 2 weeks prior to the commissioning of the DG apparatus.

For all systems rated ≤ 100 kW the DG Owner shall provide the protective device settings to the utility. In addition, the Owner shall demonstrate to the utility representative that the DG system ceases to operate in parallel with the utility distribution when the utility is not in normal operating mode.

The DG system must also be verified to remain inoperable for the required 5 minute period of time after utility restoration.

For all systems rated > 100 kW, step-by-step commissioning and energizing procedures, as well as a complete set of protection settings and commissioning manuals, shall be provided to the utility prior to DG system commissioning. Wherever practical, inspection timing and scheduling shall be mutually agreed upon by the DG Owner and the utility representative.

The DG Owner shall have all associated protective devices field-tested and calibrated by qualified personnel. Calibration shall include on-site testing of trip set points and timing characteristics of the protective functions.

All inverters shall be certified to CSA Standard 107.1-01, UL 1741 / UL1741SA or be demonstrated to meet the anti-islanding test in the same standard as part of another product certification requirement.

If microprocessor controlled protective functions are used, and factory line testing has been done to verify conformance, then a repeat of the production line testing in the field is not required. Recommended manufacturer testing is required.

If batteries are used, it must be verified that the protection settings are stored in non-volatile memory. Disconnection or removal of batteries for a minimum of 10 minutes without change of protection settings is an acceptable method of demonstrating non-volatile memory. Any DG system that depends on a battery for trip power shall be verified to be of fail-safe design by the disconnection of the battery and the verification that the system ceases to energize the distribution system.

In order to qualify as certified for any interconnection procedures, generators must comply with the following standards:

- IEEE Standard No. 1547-2003 Standard for Interconnecting Distributed Resources with Electric Power Systems as amended by IEEE Standard No. 1547-2018 at minimum. To the extent that it is reasonable to do so, SL&P requires that DER installations conform with IEEE Standard No. 1547-2018.
- UL 1741/UL1741SA Inverters, Converters, and Controllers for Use in Independent Power Systems.

The DG Owner has full responsibility for commissioning of the interconnection equipment. All commissioning and maintenance must be performed by competent personnel employed or contracted by the DG Owner. The owner shall retain a signed copy of all commissioning and maintenance test reports.

At the time of witness verifications, the DG Owner shall demonstrate in the presence of the Utility representative that:

- Relay and logic controller device settings are consistent with the original design settings.
- The operation of each protective device results in the proper tripping and timing functions and the associated annunciation responses.
- The DG system is capable of synchronizing with the utility.
- The DG system properly disconnects from the utility distribution under simulated disturbance conditions. The anti-islanding function shall be checked by operating a disconnecting means to verify that the DG system ceases to energize the distribution system and does not energize the distribution system for the required time delay after the system is restored to normal.
- The utility has proper indication and control of any applicable remote sensing/control functions.

The DG facility must not be interconnected with the utility distribution facilities until written authorization is provided from the utility.

Unauthorized interconnections could result in injury to persons and/or damage to equipment or property for which the DG proponent may be liable.

## 3.5 Maintenance and Operation

The DG Owner has full responsibility for routine maintenance of the DG system and shall keep proper maintenance records.

DG system protection function operations shall, apart from manufacturer's recommendations, be verified annually. The verification method shall include operation of the disconnection device and subsequent verification that the DG system automatically ceases to energize the distribution system and does not energize the distribution system until the distribution system is restored to normal.

Failure to conduct maintenance to industry and Canadian Electrical Code standards may result in the utility refusing to interconnect to the DG system.

## 3.6 Interoperability Requirements

The DG shall have provisions for a local DG interface capable of communicating to support the information exchange requirements specified in the IEEE Standard No. 1547-2018 for all applicable functions that are supported in the DG.

# 4 Specific Interconnection Requirements – DG on Secondary Network System

## 4.1 Generation Size Limitation

SL&P utilizes a 600 volt network distribution system in the downtown core area. The DG integration into the network system depends on the existing load and capacity of the network.

The limiting factor in accommodating DG in a Network distribution system is in the inherent design of Network Protectors which are used by the utility to ensure a forward power flow into a shared secondary collector bus. The amount of power supplied through each individual Network Protector to the bus, minus the average amount of power supplied to the bus by every Network Protector, determines the capacity of allowable DG for a particular Spot Network.

The utility needs to determine these values to ensure that the addition of a DG source will not cause a Network Protector to trip or cycle. In addition, the utility must consider the impact of DG sources in contingency scenarios.

## 4.2 Requirement

Distributed Generation is permitted in the Secondary Network System subject to the fulfillment of the following criteria, at the sole discretion of SL&P:

I. PV system inverter(s) meets IEEE Standard No. 1547-2003 and IEEE Standard No. 1547.1-2005.

II. DG Owner or customer must maintain a utility specified minimum amount of daytime load.

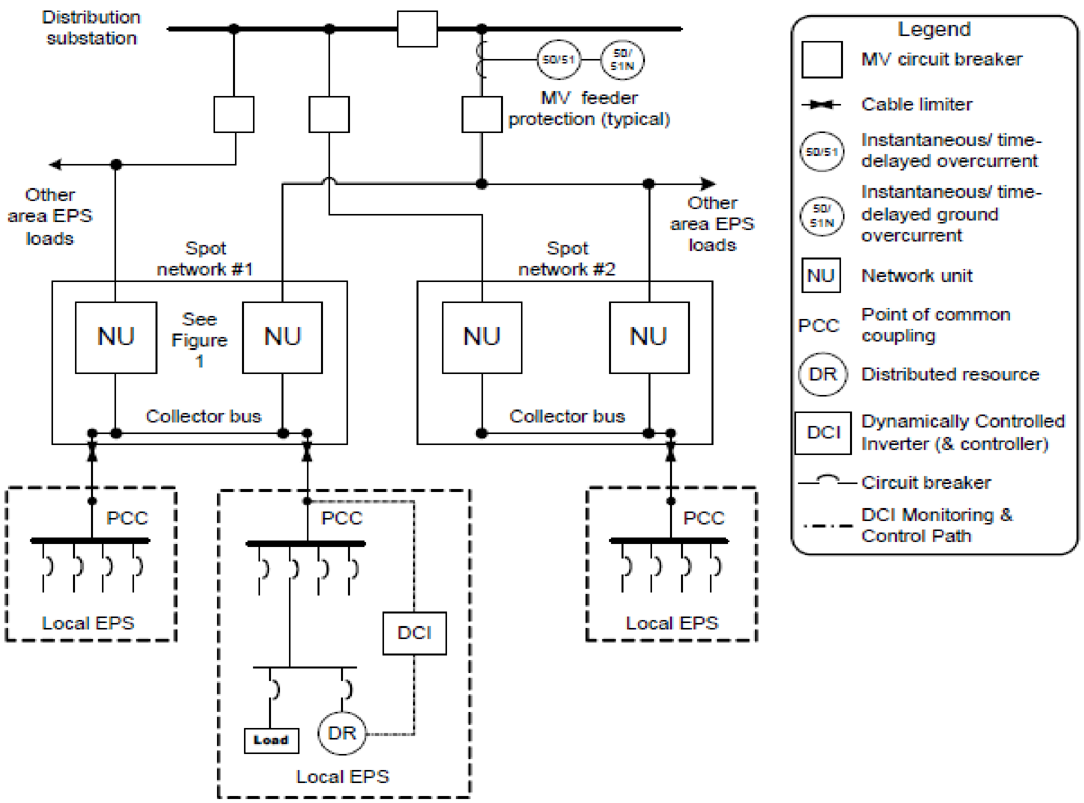
III. Either a Minimum Import Relay (MIR) or a Reverse Power Relay (RPR) or a Dynamically Controlled Inverter (DCI) is installed as in Figure 4.3.1.

IV. For customers with generation that does not exceed 10% of the customer’s minimum demand, the requirement of installing MIR/RPR/DCI may be waived at the discretion of the SL&P’s Engineer.

V. The capacity of allowable DG for a Spot Network will be allotted to customers on a first-come, first-served basis. DG sources will not be permitted once a Spot Network has reached or is nearing capacity.

VI. The utility can request at any time that a customer disconnects their DG source for the purposes of maintenance or safety concerns.

**Figure 4.3.1 – Illustrative example of DG interconnection using a dynamically controlled inverte**r. (Source IEEE Standard No. 1547.6-2011, Figure 6)



# 5 Specific Interconnection Requirements – Standby Generator Systems

## 5.1 Generator Limitations

Standby (emergency) generators intended for use only during emergency situations and outages are not intended to operate in parallel with the utility electrical system and must remain isolated from the utility.

## 5.2 Open Transition Switching

Standby generators, which utilize open transition (break before make) transfer between the utility supply and the DG system supply, are not required to meet the requirements of this Interconnection Guideline. These generators are not able to operate in parallel with the utility distribution system.

## 5.3 Closed Transition Switching

In some cases, in order to avoid the momentary switching outage associated with the transfer of load between the utility and the standby source, standby generator systems may incorporate “make before break” or “closed transition” transfer schemes.

Standby generators, which utilize closed transition switching, and have a transition time of greater than 6 cycles (> 100 milliseconds) are considered to be operating in parallel with the utility. Such facilities must meet the requirements of this Interconnection Guideline.

Standby generators which utilize closed transition switching, and have a transition time of less than or equal to 6 cycles (≤ 100 milliseconds) are not required, with the exception of the following comments, to meet the requirements of the Interconnection Guideline.

## 5.4 Protection Requirements

The standby generating system must provide the following protection functions:

- Over Voltage
- Under Voltage
- Over Current
- Over Frequency
- Under Frequency
- Synchronizing Check

Refer to single line diagram in Section 8.5.

## 5.5 Interconnection Agreement

All standby generator proponents, of systems incorporating closed transition switching with transition times of ≤ 6 cycles, must still sign an Interconnection Agreement with the Utility. This process is required to ensure that the proponent fully understands the ≤ 6 cycle transition requirements. Refer to Section 8.6 for Interconnection Agreement document.

# 6 Specific Interconneciton Requirements – DG ≤ 100 kW

## 6.1 Generator Limitations

The only type of generators permitted will be induction generators or generation methods that utilize non self-commutating power inverters. All generators shall not be capable of operating as an isolated power island connected to utility customers. Such generators shall also not be able to contribute fault current to the utility side of the PCC for periods longer than 10 cycles for faults on the utility primary or secondary distribution systems.

Inverter type generators must be certified to UL 1741 and CSA 22.2:107.1 standards and shall meet the requirements of IEEE Standard No. 929 - Recommended Practice for Utility Interface of Photovoltaic (PV) Systems.

## 6.2 Isolation Devices

Please follow the guideline provided in Section 3.1.2.

## 6.3 Fault Current Interrupting Devices

The DG facility shall include a fault current interrupting device which, in the event of a fault within the generation facility, shall be capable of interrupting the fault current and isolating the DG facility from the utility distribution system. The interrupting device shall incorporate fuses or a molded case type circuit breaker and shall be capable of interrupting all the hot legs. The device may be located on the generator side of the metering point. Refer to Section 8.6 for the single line diagram.

## 6.4 Voltage Regulation

The utility provides voltage regulation on distribution circuits to maintain the service supply voltage for end use customers within acceptable limits. Uncompensated induction generators and inverters are seen by the distribution system as a reactive power load which may significantly affect the voltage control on the distribution feeder. Please see Section 3.2.4 for voltage regulation requirement at PCC.

## 6.5 Protection

The DG system shall include the protection devices as referenced in Table 3.

**Table 3: Interconnection Protection Function Requirements**

| Protection Device | Description |
|---|---|
| ID | Islanding Detection |
| 89 | Interconnect Disconnect Device |
| 89G | Generator Disconnect Device |
| 59 | Over Voltage |
| 27 | Under Voltage |
| 81O | Over Frequency |
| 81U | Under Frequency |
| 50 | Timed Over Current |
| 51 | Instantaneous Over Current |

### 6.5.1 Over Current

The DG system must detect, cease to energize, and trip promptly for any short circuit faults on the SL&P distribution system where the DG system is connected to comply with IEEE Standard No. 1547-2018 Clause 6.2.

### 6.5.2 Over and Under Voltage

#### 6.5.2.1 Mandatory Voltage Tripping Requirements

System shall detect any applicable voltage that is less than an undervoltage threshold, or greater than an overvoltage threshold, cease to energize the SL&P distribution system and trip within the respective clearing time as indicated in Table 4 unless specifically required by and approved by SL&P.

**Table 4: Voltage Protection Settings** (source: IEEE Standard No. 1547-2018, Table 13)

| | Default Settings | | Ranges of Allowable Settings | |
|---|---|---|---|---|
| Shall Trip Function | Voltage (p.u. of nominal voltage) | Clearing time (s) | Voltage (p.u. of nominal voltage) | Clearing time (s) |
| OV2 | 1.20 | 0.16 | Fixed at 1.20 | Fixed at 0.16 |
| OV1 | 1.10 | 13.0 | 1.10-1.20 | 1.0-13.0 |
| UV1 | 0.88 | 21.0 | 0.00-0.88 | 21.0-50.0 |
| UV2 | 0.50 | 1.2 | 0.0-0.50 | 2.0-21.0 |

OV – Over Voltage; UV – Under Voltage

Default settings is the maximum clearing time setting for the generation smaller than 100 kW.

#### 6.5.2.2 Voltage Disturbance Ride Through Requirement

DG shall be designed to provide the voltage disturbance ride-through capability as specified in Table 5 (Source: IEEE Std 1547-2018, Table 16):

**Table 5: Voltage Ride Through Requirements for DG**

| Voltage Range (p.u. of nominal voltage) | Operating Mode/Response | Minimum Ride-Through Time (s) (Design criteria) | Maximum Response Time (s) (Design criteria) |
|---|---|---|---|
| V>1.20 | Cease to Energize | N/A | 0.10 |
| 1.10<V<1.20 | Momentary Cessation | 12 | 0.0836 |
| 0.88 ≤ V≤1.10 | Continuous Operation | Infinite | N/A |
| 0.70≤V≤0.88 | Mandatory Operation | 20 | N/A |
| 0.50≤V≤0.70 | Mandatory Operation | 10 | N/A |
| V<0.50 | Momentary Cessation | 1 | 0.083 |

During a valid unintentional islanding conditions the above ride through requirement shall be inhibited by the unintentional islanding detection requirements specified in Section 3.3.5.

### 6.5.3 Over and Under Frequency

#### 6.5.3.1 Mandatory Frequency Tripping Requirements

The over and under frequency protection shall detect the frequency on all the phase voltages. The DG shall cease to energize the SL&P distribution system and trip within a clearing time indicated in Table 6.

The frequency and clearing time set points shall be field adjustable and may be remotely adjustable.

**Table 6: Frequency Protection Settings** (source: IEEE Std 1547-2018, Table 18)

| | Default Settings | | Ranges of Allowable Settings | |
|---|---|---|---|---|
| Shall Trip Function | Frequency (Hz) | Clearing time (s) | Frequency (Hz) | Clearing time (s) |
| OF2 | 62.0 | 0.16 | 61.8-66.0 | 0.16-1000.0 |
| OF1 | 61.2 | 300.0 | 61.0-66.0 | 180.0-1000.0 |
| UF1 | 58.5 | 300.0 | 50.0-59.0 | 180.0-1000.0 |
| UF2 | 56.5 | 0.16 | 50.0-57.0 | 0.16-1000.0 |

OF – Over Frequency; UF – Under Frequency

Default settings shall be the maximum clearing time for the generation smaller than 100kW.

#### 6.5.2.2 Frequency Disturbance Ride Through Requirement

DG shall be designed to provide the frequency disturbance ride through capability as specified in Table 7 (source: IEEE Standard No. 1547-2018, Table 19):

**Table 7: Frequency Ride Through Requirements for DG of Abnormal Operating Performance**

| Frequency Range | Operating Mode/Response | Minimum Ride Through Time (s) (Design criteria) |
|---|---|---|
| f>62.0 | No ride-through requirements apply to this range | N/A |
| 61.2<f≤61.8 | Mandatory Operation | 299 |
| 58.8 ≤ f≤61.2 | Continuous Operation | Infinite |
| 57.0≤f≤58.8 | Mandatory Operation | 299 |
| f<57.0 | No ride through requirements apply to this range | N/A |

The above requirement is not applicable is active power export to the SL&P distribution system is less than 10% of DG rating. Or at least 90% of the local load is shed within 0.1 s of when DG ceases to energize the SL&P system.

### 6.5.4 Synchronization

Inverter type, line commutating, voltage following equipment and induction generators that act as motors during start-up, do not require synchronization facilities.

# 7 Specific Interconnection Requirements – DG > 100kW

Distributed Generation larger than 100kW will be permitted behind-the-meter and subject to the following requirement, at the sole discretion of SL&P.

a. A thorough inter connection study is done at customer cost and the suggested inter connection requirements are fulfilled and provided to SL&P.
b. Under no circumstances may the DG facility supply electrical energy to SL&P's system.
c. DG system must be able to disconnect from SL&P's system.
d. The fulfillment of the requirements as set out in the section 5.0 Specific Interconnection Requirements – Standby Generator Systems.

Distributed generation larger than 100kW, if permitted to operate in parallel and supply energy to SL&P system, must follow the requirements in following sections.

## 7.1 Generator Limitations

Only 3 phase generators are permitted above 100 kW.

SL&P's objective is to minimize the impact of distributed generation connected on the operation of its distribution system and to minimize or avoid the use of apparatus, communication systems, or protection schemes that are not normally applied at distribution voltages.

SL&P strongly recommends against the use of synchronous generators or other generator technologies that can act as voltage sources. Synchronous generators act as sustained sources of fault current which complicates, or many preclude the coordination of the protection systems on the distribution system. Synchronous or voltage source generators can support power islands, which is an unacceptable operating condition. To deal with the adverse impact of synchronous or voltage source generators it will likely require the application of communication or protection schemes that are not normally applied at the distribution level.

Inverter type generators must be certified to UL 1741 and CSA 22.2:107.1 standards and shall meet the requirements of IEEE Standard No. 929 - Recommended Practice for Utility Interface of Photovoltaic (PV) Systems

## 7.2 Isolation Devices

Please follow the guideline provided in Section 3.1.2.

## 7.3 Fault Current Interrupting Devices

The generation facility shall be equipped with a high voltage device capable of isolating the transformer from SL&P's distribution system in the event of a fault within the transformer or generation facilities. Fuses may be acceptable for applications using nonsynchronous generators; however, the DG Owner should assess the risk of damage resulting from single phasing in the event of a single fuse failure. Nonsynchronous generation installations utilizing step-up transformers with a delta winding configuration on the utility side of the transformer must utilize a circuit breaker or similar 3 phase interrupting device to avoid ferro resonance. Where fused protection is used on the high side of the transformer, the generation substation shall be equipped with a low voltage circuit breaker or contractor for tripping the generator.

Generation projects utilizing a synchronous generator shall be equipped with a 3 phase circuit breaker on the high voltage side of the transformer.

The DG Owner is responsible for ensuring that the high voltage fault interrupting device coordinates with SL&P's feeder protection. The DG Owner shall submit proposed relay or fuse settings to SL&P for review of protection coordination.

## 7.4 Transformer Windings

### 7.4.1 Configuration for Non-Synchronous Generators

SL&P requires that there be no zero-sequence current contribution from induction generator-based generation facilities during faults on SL&P's 15 or 25 kV system. The reason for this is that SL&P does not want the presence or operation of the generation facility to affect the coordination of its fused protection on single-phase taps with the main feeder protection.

To achieve this objective, the generation transformer connection must be:

- Delta on the 15 or 25 kV system with a grounded Wye on the low voltage side, or
- Grounded Wye on the 15 or 25 kV system with a grounded or ungrounded Wye on the low voltage side. The grounded Wye connection on the low voltage side is only acceptable if the generator has s Delta or ungrounded Wye winding connection.

### 7.4.2 Configuration for Synchronous Generators/Self Commutating Inverters

The SL&P electrical system is designed as an "effectively grounded" system. All generation projects that utilize synchronous generators and self-commutate inverters must have a step-up transformer configuration that provides a ground current source which qualifies as 'effectively grounded.' Therefore, the interconnecting transformer must have:

- a solidly grounded Wye connected high voltage winding with a delta connected low voltage winding, or
- a delta connected high voltage winding with a separate grounding transformer connected to the high voltage terminals of the interconnecting transformer. In this circumstance the grounding transformer shall be

connected directly to the interconnecting transformer terminals without an isolating device. The grounding transformer shall be in the same zone of protection as the interconnecting transformer.

To qualify as effectively grounded, the ratio of the zero-sequence reactance to the positive sequence reactance $X_{zero}/X_{positive}$ as seen looking into the generation facilities at the Point of Delivery from SL&P's system (with the generator operating) shall be equal to or less than 3.0 and the ratio of the zero-sequence resistance to the positive sequence reactance $R_{zero}/X_{positive}$ is not greater than one. For the purposes of calculating this ratio, the DG Owner shall use the generator's direct axis transient reactance.

## 7.5 Power Quality

### 7.5.1 Voltage

I. At PCC, the DG operation should not cause any violation of the CSA Standard CAN3-C235-83 preferred voltage levels for AC systems 0 to 50,000 V as shown in Table 1, Section 3.2.1.

II. PCC voltage shall be maintained within 0.94~1.06 p.u. and shall not be lower than pre-connection voltage.

III. The Generator facility shall not actively regulate the voltage at the PCC.

IV. The DER shall not cause step or ramp changes in the RMS voltage at the PCC exceeding 3% of nominal and exceeding 3% per second averaged over a period of one second.

V. Voltage variations at the PCC shall be limited in accordance with the "Voltage Fluctuations (Flicker) Requirements" in Section 7.5.3.

VI. DG facility shall not contribute to short-term voltage fluctuation anywhere on the feeder by more than 1%.

VII. Tripping of all DG facilities connected to the station shall not cause an abrupt change more than 110% of nominal bus voltage, or less than 90% of nominal bus voltage, after a single contingency and before the station Underload Load Tap Changer (ULTC)/feeder operates. The operating power factor of the DG facility at the PCC shall be as required in Section 7.5.6 Item (v).

VIII. During normal operation, the DG facility shall be loaded and unloaded gradually to allow adequate time for regulating devices on SL&P's distribution system to respond and avoid excessive voltage fluctuations.

IX. The DG facility shall protect itself from abnormal voltage conditions which the distribution system is subjected to. These may include but are not limited to:

   a. voltage transients; and
   b. sags and swells caused by lightning, switching, faults, and the loss or switching of customer loads.

X. Insulation levels and protective equipment at the DG facility shall be capable of withstanding abnormal voltages from SL&P's distribution system.

### 7.5.2 Voltage and Current Unbalance

I. The generation facility shall not cause voltage unbalance beyond 3% and current unbalance beyond 10% at the PCC.
II. The DG facility shall be capable of operating under existing unbalance conditions.
III. The DG facility shall not cause deterioration of existing unbalance voltage and current conditions at the PCC and in the distribution system.
IV. The DG facility shall protect itself from highly unbalanced voltages and currents, especially when connected to SL&P's distribution system where single-phase reclosing is used.
V. The DG facility and its interconnection transformer's design shall take into consideration the unbalance current it may supply to the unbalanced load on the feeder.

### 7.5.3 Voltage Fluctuations (Flicker)

I. The DG facility shall not create objectionable flicker for other customers on SL&P's distribution system.
II. The voltage dip at the PCC should not be more than 4% on connecting the single largest generation unit in the facility and should remain within 10% of nominal voltage when the entire DG facility and all other DG facilities on the interconnected feeder trip.
III. Item (I) above shall include flicker caused by energization inrush.
IV. The DG Owner shall take steps to make sure that flicker requirements in Items (I) and (II) are met - may need to add loss of synchronism protection, stagger generator energization, etc.
V. The DG facility shall conform to the flicker requirements in CAN/CSA C61000-3-7 and meet the Pst and Plt limits shown below in Table 8.

**Table 8: $P_{st}$ and $P_{lt}$ Flicker Limits**

| | 25/14.4/4.16kV |
|---|---|
| $P_{st}$ | 0.9 |
| $P_{lt}$ | 0.7 |

Source: CSA/CAN C61000-3-7

VI. Flicker measurements shall be conducted by the DG Owner using a device that conforms to CAN/CSA-C61000-4-15 if requested by SL&P. SL&P shall request this measurement if flicker complaints are received in the surrounding area.
VII. Induction generators and inverter-based generators that do not produce fundamental voltage before the paralleling device is closed, and double-

fed generators whose excitation is precisely controlled by power electronics to produce a voltage with magnitude, phase angle, and frequency that match those of the distribution system shall be tested to determine the maximum start-up current. The results shall be used, along with the distribution system source impedance for the proposed location, to estimate the starting voltage magnitude change and verify that the unit will not cause a voltage fluctuation at the PCC greater than ± 4% of the prevailing voltage level of the distribution system at the PCC.

VIII. Induction generators may be connected and brought up to synchronous speed by direct application of rated voltage provided that they meet the requirement of voltage drop given above and/or they do not exceed flicker limits at the PCC. Otherwise, other methods such as reduced voltage starting or speed matching using the prime mover prior to connection must be used to respect these voltage drop and flicker limits.

IX. Large DG facilities with multiple generator units, shall stagger the generator reconnections SL&P's distribution system to meet the above requirements.

### 7.5.4 Voltage and Current Harmonics

I. The DG facility shall not inject harmonic current that causes unacceptable voltage distortion on SL&P's distribution system.

II. The DG facility shall follow the requirements of CAN/CSA C61000-3-06.

III. The DG facility shall operate within the voltage and current distortion limits as indicated in Section 3.2.5 and in SL&P's "Customer Information Guide."

### 7.5.5 Frequency

I. The generators at the DG facility shall operate at a nominal frequency of 60 Hz.

II. The generators at the DG facility shall remain synchronously connected over the frequency range presented below in Table 9.

III. The generators shall trip in the time required in accordance with Section 7.6.7.1 for any frequencies beyond what is presented in Table 9.

**Table 9: Operating Frequency Range**

| Generator Size | Frequency Range (Hz) | |
|---|---|---|
| | Low Range | High Range |
| ≥ 100 kW | 57.0 - 59.8 (Adjustable set point) | 61.0 |

### 7.5.6 Power Factor

I. DG facilities shall be capable of operating in constant power factors anywhere between 0.95 leading and 0.95 lagging.

II. If warranted by local distribution system conditions (such as causing a violation of CSA/CAN3-C235-83 voltage limits at the PCC), this range may be narrower or wider and will be specified by SL&P in the CIA.

III. The DG facility shall be capable of operating within lagging and leading power factor ranges with or without other DG facilities in service on the feeder.
IV. SL&P shall determine the required operating power factor of the DG facility during the CIA study and shall specify this to the DG Owner.
V. Power factor correction or reactive power compensation techniques may be required.
VI. Induction generators consume reactive power, and the DG Owner shall be required to provide reactive power compensation to correct the power factor at the PCC.

## 7.6 Protection

### 7.6.1 General Requirements

I. All protective device settings and protection scheme designs must be submitted to SL&P for review.
II. Protections must not be interlocked with the position of any isolating/interrupting devices.
III. Protection settings may be required to be changed over time to maintain adequate system protection as the system configuration changes.
IV. All protection operations shall ensure that the generator(s) and all HV Ground Sources are isolated SL&P's distribution system within the required time from the start of the disturbance.
V. All protection designs must:
   a. ensure proper coordination with SL&P's protection;
   b. be failsafe; and
   c. ensure that both the DG facility and SL&P's distribution system, customers', and the general public's safety are maintained.
VI. The design of the protections at the DG facility shall be performed by a qualified professional engineer to ensure that the overall protection scheme will ensure a safe and reliable interconnection to SL&P's distribution system.
VII. Protection relays shall be "utility grade" and shall meet the minimum requirements specified in IEEE Standard No. C37.90, "Standard for Relays and Relay Systems Associated with Electrical Power Apparatus," latest edition.
VIII. Protection functions shall remain operational after distribution system disturbances or loss of supply from the distribution system for the required period of time needed to operate properly.
IX. Communication facilities between SL&P's Substation and recloser and the DG facility may be required as a result of DG facility interconnections.
X. The interconnection protection is required to have a dedicated device but if the DG Owner decides to combine some of the protection functions in other relays, this would be subject to SL&P's approval.

### 7.6.2 Sensitivity and Coordination

I. The DG facility's interconnection protection shall provide adequate sensitivity to detect abnormal conditions and isolate its generator and if present, it's HV ground source, from SL&P's distribution system within required time as specified in individual interconnection study.

II. The design of the DG facility's interconnection protection system shall coordinate with other SL&P protection system devices.

### 7.6.3 Breaker Fail (BF)

I. DG facilities with an aggregate output > 500 kW shall provide breaker failure protection for the primary interrupting device (i.e. breaker, HVI, LVI) that is responsible for disconnecting the generator and/or the HV ground sources from SL&P's distribution system.

II. The breaker failure protection should have a maximum pickup time delay of 0.3s after initiation.

III. In the event of an HVI breaker fail condition, the breaker fail protection shall:
   a. trip the next zone at the DG facility, specifically the upstream isolation device and all LV breakers shall be tripped; and
   b. remove the prime mover and excitation system as appropriate.

IV. In the event of an LVI breaker fail condition, the breaker fail protection shall ensure that a fault in the DG facility is cleared and will not affect the distribution system by:
   a. tripping the HVI if an HVI exists;
   b. opening the motorized disconnect switch (Isolation Device) as explained in Item (VI) below if an HVI does not exist;
   c. removing the prime mover and excitation system as appropriate.

V. The motorized disconnect switch (see requirements in Section 3.1.7 Item (iii)(b)) shall be opened by a separate auxiliary relay in the event of a breaker fail condition to ensure that the DG facility is properly isolated from SL&P's distribution system.

VI. The motorized disconnect switch shall be used to automatically isolate the DG facility from the distribution system. In the event that an alternate interrupting means (fuses or otherwise) is not provided by the DG facility or if such alternate interrupting means fail to coordinate with the opening of the motorized disconnect switch, then the disconnect switch may incur significant damage when attempting to interrupt a sustained fault current condition as it is not rated for breaking fault current. The design of the DG facility shall take this into consideration when deciding on a location for the Isolation Device to ensure that safety of the DG facility personnel, SL&P's personnel and the general public will be ensured.

VII. In the case of a circuit switcher being used, the interrupter and the motorized disconnect shall be specifically chosen to operate independently and no additional BF protection shall be required. If the motorized disconnect switch in the circuit switcher is not rated to break load, an additional load break switch shall be required to satisfy the requirement in Section 3.1.7.

VIII. The design of the BF protection for the HVI shall be submitted to SL&P for review and acceptance.

IX. DG facilities ≤ 500 kW shall be exempted from Items (I) through (VIII) above but shall have an alternate means of disconnecting the DG facility generation energy source from the distribution system when the associated breaker fails to open for any interconnection protection operations.

This can be achieved by the opening of the isolation device, disabling an inverter, or by removing the prime mover and excitation system as appropriate.

### 7.6.4 Three Phase Generators

I. Three-phase DG facilities shall have the minimum protection requirements as shown below in Table 10 and are mandatory for all generators to which the GIR is applicable.

II. Inverter type generators shall be compliant with CSA Standard No, C22:2.107.1 “General use Power Supply” and CAN/CSA 22.2 No 257-06 “Interconnecting inverter based micro distributed resources to distribution system.”

III. All 3 phase DG facilities, including those using multiple 3 phase inverters or multiple single phase inverters, shall meet the following conditions:
   a. be able to maintain a balanced 3 phase output under all operating conditions.
   b. be able to detect the loss of voltage in one or more phases of SL&P’s distribution system and automatically cease to energize all phases from the interconnected system, and
   c. be able to detect the loss of voltage in one or more phases of the DG facility’s electric power production source and automatically cease to energize all phases from the interconnected system.

IV. The final design of the protection system shall be submitted to SL&P for approval.

**Table 10: Three-Phase Minimum Protection Requirements**

| Function Requirement | Element Function | Device | Synchronous | Induction | Inverter | Section |
|---|---|---|---|---|---|---|
| Basic Anti-Islanding | Over-Voltage | 59 | Req. | Req. | Req. | 7.6.8, 7.6.9 iii) |
| | Under-Voltage | 27 | Req. | Req. | Req. | |
| | Over-Frequency | 81O | Req. | Req. | Req. | 7.6.8, 7.6.9 iii) |
| | Under-Frequency | 81U | Req. | Req. | Req. | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Other passive Anti-islanding (Application Specific) | Rate of Change of Frequency | 81R | ≤ 500 kW | ≤ 500 kW | Not req 16 | 7.6.9 |
| | Vector Surge | 78 | ≤ 500 kW | ≤ 500 kW | Not req | |
| | Directional Reactive Power Relay 17 | 32R | ≤ 500 kW | ≤ 500 kW | Not req | |
| Phase Fault Protection | Phase Over-current | 50 | Req. | Req. | Req. | 7.6.5 |
| | Phase Inverse Timed Over-current 18 | 51 | See 18 | See 18 | See 18 | |
| | Voltage Controlled Over-current 18,19 | 51V | See 18,19 | See 18,19 | See 18,19 | |
| | Directional Phase Over-current 20 | 67 | Req. 20 | Req. 20 | Req. 20 | |
| | Phase Distance 19, 20 | 21 | See 19,20 | See 19,20 | See 19,20 | |
| | Under-Voltage 21 | 27 | See 21 | See 21 | See 21 | |
| Ground Fault Protection | Neutral Over-current | 50N | Req. | Req. | Req. | |
| | Neutral Inverse Timed | 51N | See 18 | See 18 | See 18 | |
| | Directional Neutral Over-current 20 | 67N | Req 20 | Req 20 | Req 20 | |
| | Ground Distance 19,20 | 21N | See 19,20 | See 19,20 | See 19,20 | |
| | Under - Voltage 21 | 27 | See 21 | See 21 | See 21 | |
| | Ground Overvoltage 22 | 59G | Req. 22 | Req. 22 | Req. 22 | |
| Open Phase and Phase Unbalance | Negative Sequence Current | 46 | see Section | see Section | see Section | 7.5.2 7.6.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Negative Sequence Voltage | 47 | see Section | see Section | see Section | |
| Ferro-resonance | Peak detecting Overvoltage | 59I | | | | 7.6.6 |
| Synchronization | Synchronizing | 25 | Required | see Section | See Section | 3.3.6 |

[16] Other passive anti-islanding protection functions may not be required if inverters have active anti-islanding controls.
[17] Directional Reactive Power relay is an alternative to 78 (Vector Surge) provided that there is a predictable reverse reactive power flow for island conditions.
[18] An alternative or complement to Over-current (50, 50N). Special caution is needed for selection of inverse-time characteristics that meet time constraints.
[19] May be used to provide distinction between normal load and feeder-end fault conditions when basic over-current (50, 50N) is insufficient.
[20] May be used to provide distinction between internal and external faults for the reconnection of DG facility.
[21] May be used to provide fault protection for DG facilities where fault current in-feed levels are too small for practical detection by overcurrent or distance elements.
[22] Required for DG facilities that do not contribute ground current to ground faults on SL&P's distribution system.

### 7.6.5 Phase and Ground Fault Protection

I. The DG facility's interconnection protection shall ensure that the DG facility will detect and isolate itself and any HV ground sources from SL&P's distribution system for:
   a. All internal faults within the DG facility; and
   b. All external faults on the interconnected feeder including single-phase lateral taps. This applies to all phase-phase and phase-ground faults.

II. Phase and ground protections shall always be operational whenever phase and ground current can be sourced from the DG facility.

III. The protective device selectivity and sensitivity shall be maintained over the full range of minimum to maximum fault currents (present and anticipated future levels) with the DG's infeed.

IV. The DG facility shall be capable of selectively detecting faults on the DG facility side of the HVI and shall disable the HVI auto-reclosure scheme.

V. The total clearing time for faults on SL&P's distribution system or for faults in the DG facility shall be no more than 200ms. This can be relaxed to 500ms if the DG Owner can demonstrate that the DG facility fault contributions will not encroach on SL&P's distribution system minimum fuse melt characteristic.

   [Note: The total clearing time is measured from the start of the abnormal condition to the time that the DG facility ceases to energize SL&P's distribution system].

### 7.6.6 Phase Loss Protection

I. The DG facility's interconnection protection must be capable of detecting the loss of any phase to which the DG facility is connected which occurs within the DG facility or on the interconnected feeder.

II. Upon the detection of the open-phase condition the DG protection shall disconnect the generation from the distribution system within 500ms.

### 7.6.7 Over Frequency/Under Frequency Protection

#### 7.6.7.1 Mandatory Frequency Tripping Requirement

I. The DG facility's interconnection protection scheme shall have the capability of detecting abnormal frequencies shown in Table 6 in Section 6.5.3.

II. The DG facility shall disconnect from SL&P's distribution system in the clearing times specified in Table 6.

III. The clearing time in Table 6 shall be measured from the start of the abnormal condition until the time that the DG facility ceases to energize SL&P's distribution system.

IV. DG facilities shall have the frequency set point field adjustable.

#### 7.6.7.2 Frequency Disturbance Ride Through Requirement

DG facility shall fulfill frequency disturbance ride through requirement described in Section 6.5.3.2

### 7.6.8 Over Voltage/Under Voltage Protection

#### 7.6.8.1 Mandatory Voltage Tripping Requirement

I. The DG facility's interconnection protection scheme shall have the capability of detecting abnormal voltages shown in Table 4 in Section 6.5.2.

II. The DG facility shall disconnect from SL&P's distribution system in the clearing times specified in Table 4.

III. Voltage shall be measured:
   a. phase-neutral for grounded Wye-Wye transformer configurations; or
   b. phase-phase for all other installations.

IV. The voltages shall be detected at the PCC.

V. If the requirement in Item (IV) above is not practical or feasible, estimated values may be used if approved by SL&P.

VI. The clearing time in Table 4 shall be measured from the start of the abnormal condition until the time that the DG facility ceases to energize SL&P's distribution system.

VII. DG facilities shall have the voltage set point field adjustable.

VIII. Under voltage relays should be time-delayed to avoid unnecessary tripping while over voltage relays may be instantaneous.

IX. High speed instantaneous voltage protection may be considered for detecting ferro resonance and self-excitation conditions.

#### 7.6.8.2 Frequency Disturbance Ride Through Requirement

DG facility shall fulfill frequency disturbance ride through requirement described in Section 6.5.2.2

### 7.6.9 Anti-Islanding Protection

I. Upon loss of voltage in one or more phases of SL&P's distribution system, the DG facility shall automatically disconnect from SL&P's distribution system within 500ms.

II. The DG Owner shall demonstrate to SL&P that it shall not sustain an island for longer than the time requirements in Item (I) above.

III. All DG facilities shall have anti-islanding protection. This may involve different protection functions; however, all DG facilities shall have:
   a. Under/Over Frequency protection (Section 7.6.7);
   b. Under/Over Voltage protection (Section 7.6.8); and
   c. Transfer Trip for anti-islanding protection may be required

### 7.6.10 Special Interconnection Protection

I. Other protections not specified in this requirements document may be required depending on the application.

II. The DG Owner shall be aware of site-specific conditions and the nature of DG's distribution system to properly assess the need for additional protections.

### 7.6.11 Protection Scheme Failures

I. The DG facility generation and HV ground sources shall be disconnected from DG's distribution system and notify DG's Controlling Authority if:
   a) The DG facility's local interconnection protection system fails
   b) The breaker trip coil or interrupting device fails
   c) The DC supply is lost
   d) The Transfer Trip (TT) signal channel, if recommended, fails

II. With the exception of Item (I.)(d) above, disconnection shall be automatic and immediate (no intentional time delay).

III. The device(s) used to disconnect the generation shall remain open until such a time when the affected system is returned to normal service condition and the EG facility is safe for reconnection to DG's distribution system.

IV. The interconnection protection design submitted to DG during the implementation phase of the Connection Process shall provide sufficient detail to ensure that the protection scheme failure requirements outlined in Item (I) above are addressed.

V. In designs where self-diagnostic features do not trip the appropriate breakers upon failure, sufficient backup and/or redundancy protections shall be provided.

VI. If electro-mechanical relays are used, the protection and control design shall be of a failsafe nature to ensure the integrity of the protection scheme under malfunctioning conditions.

### 7.6.12 Interconnection Protection Acceptance

I. The DG Owner shall provide DG with complete documentation on the proposed DG facility's interconnection protection scheme to ensure compliance with the requirements of the GIR and all applicable standards. Documentation shall include, but is not limited to:

   a. a detailed single line diagram;
   b. an overall description on how the protection will function;
   c. a description on failure modes;
   d. detailed engineering drawings that include design details on protection and control, teleprotection and telemetering schemes and components including manufacturer and model number;
   e. the protection element settings (pickup, timers, etc.);
   f. details on monitoring for the protection system performance (DFR, SER, and telemetry);
   g. details on backup supply to any critical loads;
   h. details on the Breaker Failure protection if required; and
   i. details on the disconnecting and interrupting device.

II. If DG proposes any changes from the review in Item (i) above, the DG Owner shall revise and re-submit the protection information to DG.

III. All documentation must be submitted together.

IV. The latest submissions will be filed by DG and MUST MATCH the documentation retained by the DG Owner.

## 7.7 Synchronous Generators

I. Any DG facility that is capable of generating its own voltage while disconnected from DG's distribution system shall require proper synchronization facilities before connection is permitted.

II. Interconnection shall be prevented if the DG facility and DG's distribution system are operating outside the limits specified in Item (III) below.

III. Synchronous generators, self-excited induction generators or inverter-based generators that produce fundamental voltage before the paralleling device is closed shall only parallel with DG's distribution system when the frequency, voltage, and phase angle differences are within the ranges at the moment of synchronization given below in Table 12.

IV. For synchronous generators, an approved automatic synchronization device shall be required if the plant is unattended (IEEE device number 25) to ensure that the DG facility will not connect to an energized feeder out of synchronism.

V. Induction generators and inverter-based generators that do not produce fundamental voltage before the paralleling device is closed, and double-fed generators whose excitation is precisely controlled by power electronics to produce a voltage with magnitude, phase angle, and frequency that match those of the distribution system may not require synchronization facilities.

VI. Any proposed synchronizing scheme shall be submitted to DG prior to installation and shall be able to accommodate automatic reclosing on DG's distribution facilities.

**Table 12: Resynchronization Requirements**

| Aggregate Rating of Generators (kVA) | Frequency Difference ($\Delta$ f, Hz) | Voltage Difference ($\Delta$ V, %) | Phase Angle Difference ($\Delta$ $\Phi$, °) |
|---|---|---|---|
| 0-500 | 0.3 | 10 | 20 |
| >500-1500 | 0.2 | 5 | 15 |
| >1500 | 0.1 | 3 | 10 |

# 8 Appendices

## 8.1 Technical Notes

### 8.1.1 Power Sources

There are a number of different electrical power generation sources. The list of power sources used for distributed generation is as follows:

Generators

Generators convert mechanical energy into electricity. The electrical output can be either AC or DC. The prime mover for the supply of the horsepower can be a turbine or a combustion engine.

The source of mechanical power for a turbine can be wind, water, steam, or gas. The fuel sources for a combustion type generator include oil, diesel, gasoline, natural gas, digester gas, and landfill gas.

DC generators often use inverters when the prime mover shaft speed is not constant. Typical situations for this include some wind and water turbine applications.

AC generators can be single phase or three phase and can be induction or synchronous types.

Induction Generators

Induction generators are basically induction motors that utilize a mechanical power source to produce electricity by rotating the shaft at slightly greater than the units motoring speed. Induction generators are often started as a motor and do not require synchronizing equipment for starting. Wind turbines are a standard application for induction generators. Induction generators do produce real power but require reactive power from the utility. This can affect utility voltage and losses. In many cases capacitors are installed to provide the reactive power portion.

Synchronous Generators

Synchronous generators use a DC field for excitation and can supply both real power (Watts) and reactive power (Vars). Such generators can supply stable AC power independent of the utility system. The majority of emergency back-up generators and distributed generation sources interconnected for parallel operation are three phase synchronous generators.

Direct Energy Converters

Direct Energy Converters (DECs) are usually semiconductor-based devices that convert one form of energy into direct current electricity. Typical examples of such energy converters include solar cells, fuel cells, and thermionic cells.

Inverters

An inverter is a solid-state device that converts DC electricity into AC electricity. The conversion is typically to 60 Hz. In most DG inverter applications, the inverter needs to sense the Utility voltage in order to sustain operation. In cases where the inverter does have the ability to operate independently of the utility, the DG facility must include synchronizing and anti-islanding protection.

Static Power Converters

Static Power Converters (SPCs) are similar to inverters except they convert higher frequency AC electricity to 60 Hz electricity. Typical applications include micro-turbine generators and some wind turbines.

### 8.1.2 Types of Operation

Standby or Emergency Generation

These facilities are not intended to operate in parallel with the utility electrical system. Such systems include the provision of a transfer switch which disconnects the customer's load from the utility prior to the connection of the load to the generator. Conversely, the transfer scheme must disconnect the generator from the load prior to the reconnection of the load to the utility.

In some cases, standby generators may parallel momentarily with the utility to avoid the momentary switching outage associated with the transfer.

Load Reduction Generation

These facilities are designed to operate in parallel with the Utility distribution system; however, the intent of such DG systems is only to reduce the customers overall electrical requirements from the utility. Additional protection must be provided to restrict the DG system from providing electrical power to the utility.

Power Supply Generation

These facilities are designed to operate in parallel with the utility distribution system. The intent of such DG systems includes the sale of electrical power to the utility.

## 8.2 Acronyms and Definitions

Alternating Current (AC)

Electric current that periodically alternates direction of flow and is zero at some point during its period. Typical frequency is 60 cycles per second.

ANSI

American National Standards Institute

Automatic Circuit Recloser (ACR)

Also known as an auto-recloser. An over current protection device used by utilities to detect faults on distribution feeders. It has the ability to open, then reclose after a specified time, allowing enough time for temporary faults to clear.

CIA

A Connection Impact Assessment is a detailed assessment of a project's impact on the grid. The results include a technical report outlining project feasibility, technical specifications needed for the project and the impacts the project would have on the distribution system.

CSA

Canadian Standards Association

Cogeneration

A process that uses excess energy biproducts produced by a facility's process to drive a generator and produce electricity.

Closed Transition

A phrase that refers to the operation of a transfer switch in the transfer of load between a generation source and the utility. The two types are: momentary ( ≤ 100 mS) and sustained ( >100 mS).

Direct Current (DC)

Electric current that flows in one direction only.

Distributed Generation (DG)

Electric power generation facilities interconnected with the electric utility.

DG Owner

The owner of the distributed generation facility.

DG Proponent

Those proposing and constructing a DG facility. This is typically the owner or developer of the facility.

DG System

The complete system that includes the electric generator, inverters, control systems, switchgear, sensing devices, and protective devices that interconnects to the utility at the Point of Common Coupling. Often referred to as the Distributed Generation facility.

Distributed Resource (DR)

A collective term referring to all sources of electrical power that are not connected to the bulk power transmission system. This includes both generators and electrical energy storage devices.

Distribution System

The part of the utility that operates at 25,000 volts or less and distributes electric power between the utility substations and the customers.

Effectively Grounded System

A system, or portion of a system, can be said to be effectively grounded when for all points on the system, or specified portion thereof, the ratio of zero-sequence reactance to positive sequence reactance is not greater than three and the ratio of zero-sequence reactance to positive sequence reactance is not greater than one for any condition of operation and for any amount of generator capacity.

Generation Customer

The Owner or operator of the DG facility.

Generation Facility

See Distributed Generation.

Hertz (HZ)

A measure of the number of times or cycles that a periodic signal repeats in a second, also denoted as cycles per second.

Institute of Electrical and Electronic Engineers (IEEE)

An organization that develops voluntary standards relating to electrical safety and product performance.

Interconnection Agreement

An agreement between the customer and the utility covering the terms and conditions governing the interconnection and operation of the generating facility.

Interconnection Facilities

This includes but is not limited to:

- Electric overhead power lines and underground cables required to connect the generation to the utility distribution system
- Apparatus at both the generation site and at the utility substation; this may include current transformers, potential transformers, high voltage visible break lockable isolating switch, high voltage fault interrupting device, and lockable ground switch
- Generator step-up transformer complete with on load tap changer
- Communications, protection, and control facilities
- Metering equipment
- Special protection systems.

Inverter

A power electronic device that converts DC power to AC power.

Islanding

An unacceptable condition occurring when a distributed generation facility and a portion of the utility distribution separates from the remainder of the utility system and continues to operate in an energized state.

NEMA

National Electrical Manufacturers Association.

Non-Utility Generation (NUG)

Another term for Distributed Generation.

Parallel Operation

The operation of a DG system that is electrically interconnected with the utility distribution system, either on a momentary or sustained basis.

Point of Common Coupling (PCC)

The location of the electrical connection between a power producer's distributed generation facility and the utility's distribution system. It is the physical location where the utility's service conductors are connected to the customer's service conductors and where the power transfer occurs. It can be located on either the primary or the secondary of the transformer depending on who owns the transformation.

This is typically the location where ownership changes from the utility to the generation owner. It is also often referred to as the Point of Interconnection (POI), Point of Delivery (POD), or Point of Delivery and Receipt (PODR).

$P_{st}$ & $P_{lt}$ (**flicker** Perceptibility)

A short-term **flicker** Perceptibility (**$P_{st}$**) measurement of 1 describes the point at which 50% of the population actually becomes irritated by the **flicker,** while long term (**$P_{lt}$**) indicates the irritations caused by irregular **flicker** effects over a long period.

Telemetering

Transmission of measured electrical signals using telecommunication techniques

Total Harmonic Distortion (THD)
A measure of the total sum of squares of harmonic frequency signals compared to the fundamental frequency signal.

Transfer Switch
An automatic or non-automatic device for transferring one or more load conductor connections from one power source to another.

Underwriters Laboratory (UL)
An accredited standards development organisation within the United States of America.

Utility
The company that owns and operates the electrical distribution system to which the generation facility is connected.

Voltage Follower Mode
An inverter operation mode that follows the waveform of an external source and depends on the external source to initiate and maintain its operation while delivering power to that source.

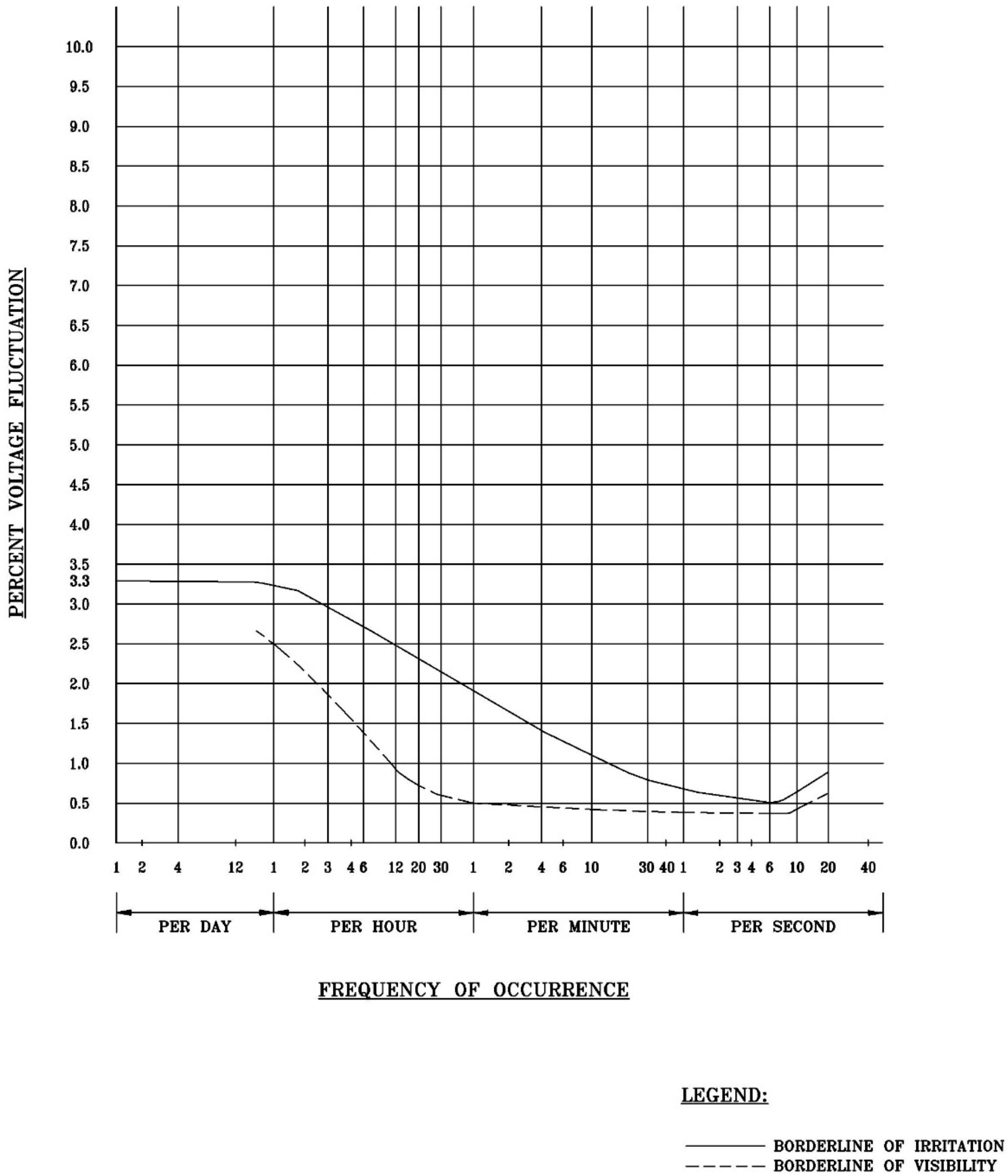
## 8.3 Protection Nomenclature

The following table (Table 13) provides the information regarding the relay identifications and functions:

**Table 13: Protection Nomenclature**

| Relay | Function |
|---|---|
| TT | Transfer Trip. This is a trip signal from the utility feeder protection to the DG facility protection. The intent of the trip is to ensure that the DG facility is isolated whenever the associated utility feeder protection trips. |
| 25 | Synchronism Check. This prevents the DG source from paralleling with the utility when the two systems are beyond voltage, frequency, or phase limits. |
| 27 | Under Voltage Trip. This detects an under-voltage situation. The intent of the trip is to disconnect the Distributed Generation source from the utility whenever the utility feeder breaker trips. The DG breaker is to trip after the utility feeder breaker trips but before the utility feeder breaker recloses. |
| 32 | Power Direction. This is used to detect and provide tripping or control functions from reverse power situations. |
| 40 | Loss of Excitation. This is used to detect generator loss of excitation. |
| 46 | Negative Sequence Current. This is used to detect and provide tripping for unbalanced faults or unbalanced load conditions. |
| 47 | Negative Sequence Voltage. This is used to prohibit the closing in of the generator onto a single-phase bus condition. |
| 51 | Over Current. This is set to co-ordinate with the DG generator over current protection and protection on the local load. |
| 51N | Neutral Over Current. This detects and provides alarming/tripping for ground faults or feeder load imbalance conditions. |
| 51V | Voltage Restrained Over Current. This provides fast tripping for feeder over current faults where reduced voltages and fault current levels occur. |
| 59 | Over Voltage Trip. This is used to detect and provide tripping or control functions for over voltage conditions. |
| 59G | Ground Over Voltage. This is used to detect and provide tripping functions from zero sequence over voltages caused by system faults. |
| 59I | High Speed Over Voltage. This detects and provides prompt tripping for the ferro resonance or high voltage conditions that may occur during islanding. |
| 59T | Timed Over Voltage. This is used to detect feeder back feed (islanding) and system over voltage conditions. The intent of the trip is to disconnect the Distributed Generation source from the utility whenever an over voltage condition occurs. The DG breaker is to trip after the utility feeder breaker trips but before the utility feeder breaker recloses. |
| 67 | Directional Over Current. This relay is used to detect and provide tripping for reverse current flow situations. |
| 81/O | Over Frequency. This provides fast tripping functions due to over frequency conditions. |
| 81/U | Under Frequency. This provides fast tripping functions due to under frequency conditions. |

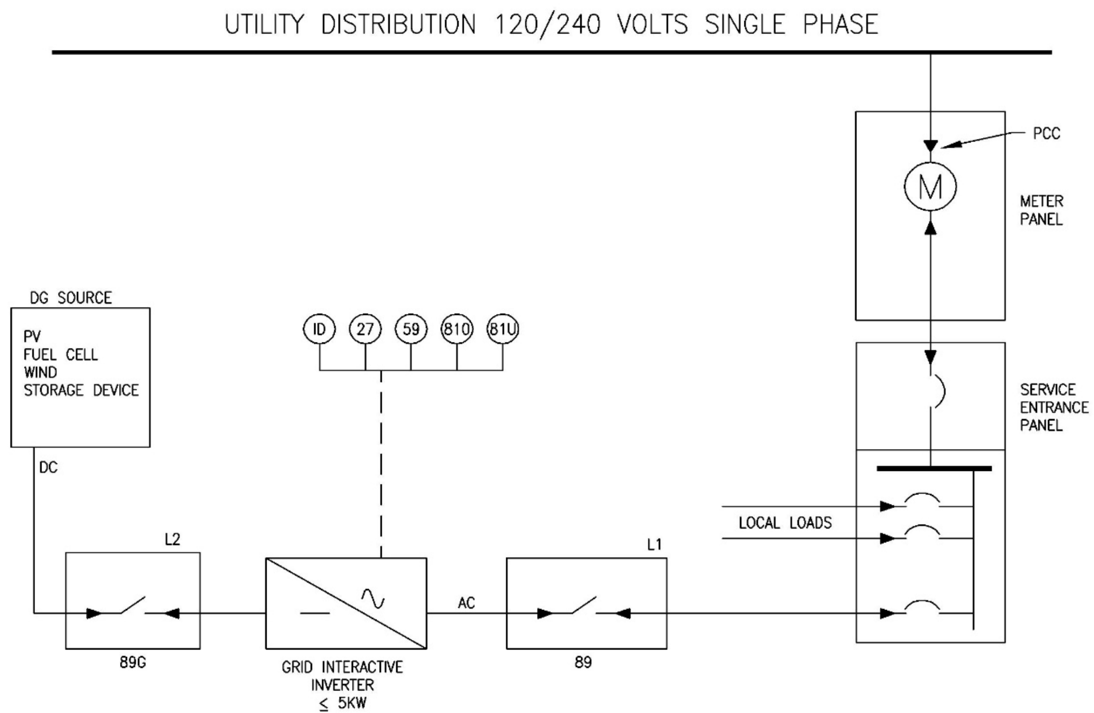
# 8.4 Voltage Flicker Limits




| LATEST REVISION | | ORIGINAL | | - City of Saskatoon - SASKATOON LIGHT & POWER | REF DWGS | |
|---|---|---|---|---|---|---|
| REVISED BY | | DRAWN BY | YH | DISTRIBUTED GENERATION VOLTAGE FLICKER LIMITS | SCALE Horizontal NTS Vertical NTS | REV. NO 0 |
| DATE | | DATE | NOV. 1/06 | | | |
| CHECKED BY | | DESIGNED BY | ROD N | | DRAWING NUMBER | |
| DATE | | DATE | OCT. 31/06 | | Gs-326 | |
| APPROVED BY | | APPROVED BY | ROD N | | | |
| DATE | | DATE | OCT.31/06 | | | |

## 8.5 Single Line Diagrams

### 8.5.1 Distributed Generation Connection for Secondary Distribution System @ 120/240 Volts ≤ 100 kW Inverter Based Supply




NOTES

1. INVERTERS MAY, OR MAY NOT, CONTAIN INTERNAL DISCONNECT DEVICES.
2. INVERTER CONTAINS INTERNAL TRANSFER SWITCH
3. DG SYSTEM DISCONNECT (89) TO BE LOCATED ON THE BUILDING EXTERIOR ADJACENT TO THE UTILITY METER PANEL.
4. DG SYSTEM DISCONNECT (89) AND DG SOURCE DISCONNECT (89G) SWITCHES TO INCLUDE SAFETY LABELS INDICATING "DUAL VOLTAGE SOURCE."
5. DG SYSTEM DISCONNECT (89) AND DG SOURCE DISCONNECT (89G) SWITCHES TO INCLUDE VISIBLE BREAK INDICATIONS AND MUST BE LOCKABLE IN THE OPEN POSITION.

LEGEND

| | |
|---|---|
| 27 | UNDER VOLTAGE |
| 59 | OVER VOLTAGE |
| 81O | OVER FREQUENCY |
| 81U | UNDER FREQUENCY |
| 89 | DG SYSTEM DISCONNECT SWITCH |
| 89G | DG SOURCE DISCONNECT SWITCH |
| DG | DISTRIBUTED GENERATION |
| ID | ISLANDING DETECTION |
| L1 | LABEL 1 "DG SYSTEM DISCONNECT" |
| L2 | LABEL 2 "DG SOURCE DISCONNECT" |
| M | UTILITY METER |
| PCC | POINT OF COMMON COUPLING |
| PV | PHOTOVOLTAIC |

** THIS SINGLE LINE DIAGRAM IS INTENDED FOR USE FOR THE APPLICATION FOR INTERCONNECTION. IT IS NOT INTENDED TO BE USED FOR SYSTEM DESIGN OR INSTALLATION.

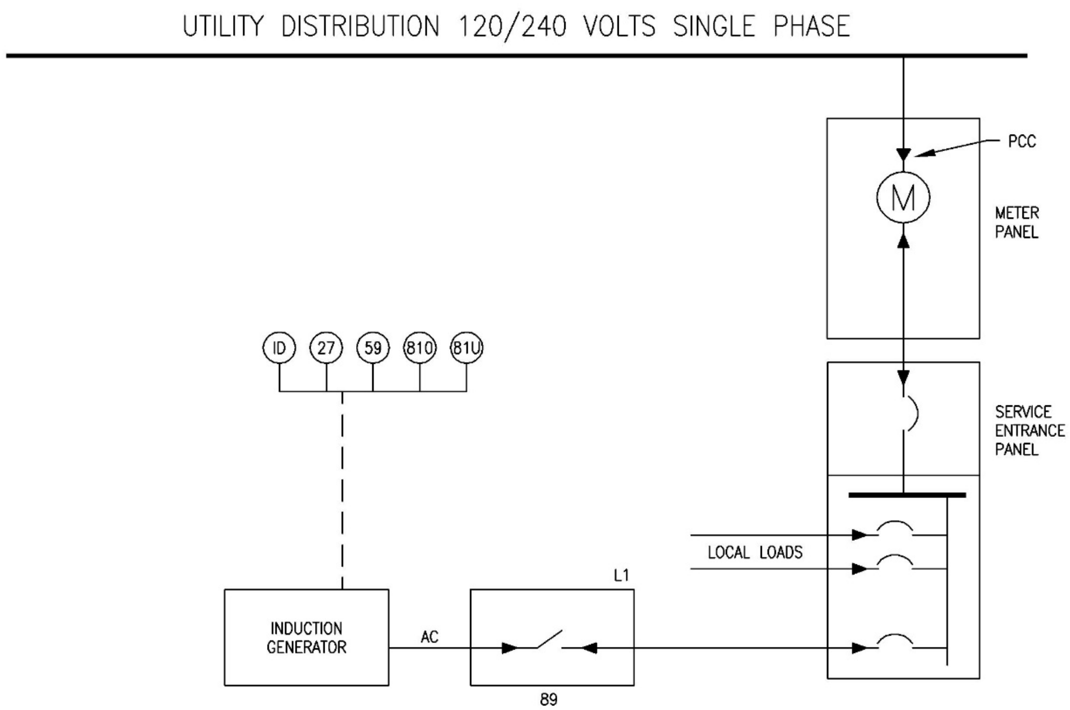
| LATEST REVISION | | ORIGINAL | |
|---|---|---|---|
| REVISED BY | RH | DRAWN BY | YH |
| DATE | 05/02/07 | DATE | OCT. 20/06 |
| CHECKED BY | | DESIGNED BY | ROD N |
| DATE | | DATE | OCT. 19/06 |
| APPROVED BY | | APPROVED BY | ROD N |
| DATE | | DATE | OCT.19/06 |

– City of Saskatoon –
SASKATOON LIGHT & POWER

DISTRIBUTED GENERATION CONNECTION FOR SINGLE PHASE SECONDARY DISTRIBUTION SYSTEM @120/240 VOLTS ≤ 5KW INVERTER BASED SUPPLY SINGLE LINE DIAGRAM

| | |
|---|---|
| REF DWGS | |
| SCALE Horizontal | NTS |
| SCALE Vertical | NTS |
| REV. NO | 2 |
| DRAWING NUMBER | Gs-324 |

### 8.5.2 Distributed Generation Connection for Single Phase Secondary Distribution System @ 120/240 Volts ≤ 100 kW Induction Generator Supply




NOTES

1. DG SYSTEM DISCONNECT (89) TO BE LOCATED ON THE BUILDING EXTERIOR ADJACENT TO THE UTILITY METER PANEL.
2. DG SYSTEM DISCONNECT (89) SWITCH TO INCLUDE SAFETY LABEL INDICATING "DUAL VOLTAGE SOURCE."
3. DG SYSTEM DISCONNECT (89) SWITCH TO INCLUDE VISIBLE BREAK INDICATIONS AND MUST BE LOCKABLE IN THE OPEN POSITION.

LEGEND

| | |
|---|---|
| 27 | UNDER VOLTAGE |
| 59 | OVER VOLTAGE |
| 81O | OVER FREQUENCY |
| 81U | UNDER FREQUENCY |
| 89 | DG SYSTEM DISCONNECT SWITCH |
| DG | DISTRIBUTED GENERATION |
| ID | ISLANDING DETECTION |
| L1 | LABEL 1 "DG SYSTEM DISCONNECT" |
| M | UTILITY METER |
| PCC | POINT OF COMMON COUPLING |
| PV | PHOTOVOLTAIC |

** THIS SINGLE LINE DIAGRAM IS INTENDED FOR USE FOR THE APPLICATION FOR INTERCONNECTION. IT IS NOT INTENDED TO BE USED FOR SYSTEM DESIGN OR INSTALLATION.

| LATEST REVISION | | ORIGINAL | | – City of Saskatoon – SASKATOON LIGHT & POWER | REF DWGS | |
|---|---|---|---|---|---|---|
| REVISED BY | RH | DRAWN BY | YH | DISTRIBUTED GENERATION CONNECTION FOR SINGLE PHASE SECONDARY DISTRIBUTION SYSTEM @120/240 VOLTS ≤ 5KW INDUCTION GENERATOR SUPPLY SINGLE LINE DIAGRAM | SCALE Horizontal NTS Vertical NTS | REV. NO 2 |
| DATE | 05/02/07 | DATE | OCT. 20/06 | | | |
| CHECKED BY | | DESIGNED BY | ROD N | | DRAWING NUMBER | |
| DATE | | DATE | OCT. 19/06 | | Gs-325 | |
| APPROVED BY | | APPROVED BY | ROD N | | | |
| DATE | | DATE | OCT.19/06 | | | |

## 8.6 Forms

### 8.6.1 Application for Generation Interconnection

**Solar Photovoltaic Self-Generation Application** SASKATOON LIGHT & POWER

**Customer Information** Program Applying for: ☐ Net Metering ☐ Small Power Producer

Will the generation system be installed as part of a new or existing service? ☐ New ☐ Existing

Is this a new application or an update to an existing application? ☐ New ☐ Update

Customer Name: ______________________ Service Account No: __________

Address: ______________________________________________
*(Mailing Address)*

Daytime Number: ______________ Alternative Phone Number: ____________

Email: ______________________________________________

Generating Facility Address: ________________________________________
*(If Different than the mailing address)*

**Supplier/Contractor Information**

Company Name: ______________________________________________

Contact Name: ______________________________________________

Company Address: ____________________________________________

Daytime Number: ______________ Alternative Phone Number: ____________

Email: ______________________________________________

**Photovoltaic Specifics**

Manufacturer and Model: ________________________________________

Nominal Rating (kW) / module: ________ # of Panels: _____ Total Rating (kW): ________

Mounting? ☐ Fixed ☐ Seasonal Adjusted ☐ Tracking

**Inverter Specifics**

Manufacturer and Model: ________________________________________

Micro-Inverter ☐ String-Inverter ☐ Other ☐ ______________________________

Optimizers ☐ Yes ☐ No If yes, Type: ______________________________

Are the inverters 'line communicating'? ☐ Yes ☐ No

Nominal Rating (kW) / inverter: ______________

Number of Inverters: ______________ Total Rating (kW): ________________

Electrical Service Mains: ____________(Volts) __________(Amps)

Generation System Voltage: ☐ 120V ☐ 240V ☐ 120/208V ☐ Other: ________

Production Capacity Range: Max (kW) __________ Min (kW) ______________

Expected power generation (kWh/year): ______________________________

**Interconnection**

Will there be a Step-Up Transformer? ☐ Yes ☐ No Interconnection Voltage: ________Volts

Size of Transformer ____________ Winding Configuration ____________

Will electrical energy be exported back to the Distribution System? ☐ Yes ☐ No

Is there one lockable Utility Disconnect Switch located outside in an accessible location? ☐ Yes

**Owner Certification**

I hereby certify that to the best of my knowledge, this application form has been filled out correctly and accurately.

Applicant Name (Print): ________________________________________

Owner (signed): ______________________ Date: ______________

**For Internal Use** Approved for Interconnection: ☐ Yes ☐ No ☐ Conditional

Approved By (Print): ________________________________________

Signature (signed): ______________________ Date: ______________

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## 8.6.2 Application for Detailed Generation Interconnection Analysis

**Request for Preliminary Interconnection Study & Self-Generation Application**

SASKATOON LIGHT & POWER

**Customer Information** Program Applying for: ☐ Net Metering ☐ Small Power Producer

Will the generation system be installed as part of a new or existing service? ☐ New ☐ Existing

Is this a new application or an update to an existing application? ☐ New ☐ Update

Customer Name: ______________________ Service Account No:__________

Address: ______________________________________________

*(Mailing Address)*

Daytime Number:______________ Alternative Phone Number:__________

Email: ______________________________________________

Generating Facility Address: ______________________________________

*(If Different than the mailing address)*

**Supplier/Contractor Information**

Company Name: ______________________________________________

Contact Name: ______________________________________________

Company Address: ____________________________________________

Daytime Number:______________ Alternative Phone Number:__________

Email: ______________________________________________

**Generation Type**

Type of Generation: __________________________________________

Manufacturer and Model: ______________________________________

# Of Generators: ________ Size of Generators (kVA): ________________

☐ Synchronous ☐ Induction Min Output (kVA)): ________________

☐ Single Phase ☐ Three Phase Max Output (kVA)): ________________

If Generation Type is Photovoltaic, attach a copy of filled “Solar Photovoltaic Self-Generation Application” form in Section 8.6.1

**Interconnection**

Will there be a Step-Up Transformer? ☐ Yes ☐ No Interconnection Voltage:_ Volts

Size of Transformer ____________ Winding Configuration ____________

Will electrical energy be exported back to the Distribution System? ☐ Yes ☐ No

Standby – Open Transition ☐ Yes ☐ No

Standby – Closed Transition ☐ Yes ☐ No Transition Time:____________

Parallel Operation with Utility? ☐ Yes ☐ No

Expected operating periods:

**Owner Certification**

I hereby certify that to the best of my knowledge; this application form has been filled out correctly and accurately.

Applicant Name (Print): ______________________________________

Owner (signed): __________________________ Date:____________

**For Internal Use**

| | | | |
|---|---|---|---|
| Project Compatible with the Utility System? | ☐ Yes | ☐ No | |
| Utility System Improvements Required? | ☐ Yes | ☐ No | |
| Approved for Interconnection | ☐ Yes | ☐ No | ☐ Conditional |

Comments:

Approved By (Print): ______________________________________

Signature (signed): __________________________ Date:____________

## 8.7 Standard Operating Practices

Operating practices are site specific but may include, but not be limited to, the following items:

- Equipment “lock out” procedures
- Communication procedures and contact details for both normal and emergency situations
- Synchronization requirements for initial energization, post maintenance, and post fault (system restoration) conditions
- Alarm and fault reporting procedures
- Protection settings including implementation and verifications
- Voltage scheduling and control
- Definitions of maintenance and operating interface devices
- Identification of protective equipment and safety procedure requirements
- Requirements for utility personnel entering the DG facility.

# 9 References

BC Hydro document, *Net Metering Interconnection Requirements, 50kW & Below,* October 2003.

CSA Standard 2002 Canadian Electrical Code Part 1, Nineteenth Edition, C22.1-02, *Safety Standards for Electrical Installations* (CE Code).

CSA Standard C22.2 No. 107.1-01 *General Use Power Supplies*.

CSA CAN-3-C235-1995, *Preferred Voltage Levels for AC Systems, 0 to 50,000 Volts, Canadian Utility Distribution Systems*.

IEEE Draft Standard P1547, *Draft Standard for Interconnecting Distributed Resources with Electric Power Systems*, August 2001.

IEEE Standard 519-1992, *IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.*

IEEE Standard 1547-2018 *IEEE Standard for Interconnection and interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*

Manitoba Hydro DRG2003 Rev 00., *Interconnection Guideline - For connecting Distributed Resources to the Manitoba Hydro Distribution System.*

Power Stream *Embedded Generation Technical Interconnection Requirement*, April 10, 2017

National Rural Electric Cooperative Association, *Business and Contract Guide for Distributed Generation (DG) Interconnection,* March 2002.

SaskPower document *Generation Interconnection Requirements at Voltages 34.5 kV and Below*, March 2005.

*Technical Interconnection Requirements and Study Criteria for Distributed Energy Resources Interconnected to Distribution Systems, April 2021*