INTERCONNECTION GUIDELINE

IG2007 Rev. 0

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

May 2007

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

Customer Relations Manager
Saskatoon Light & Power
322 Brand Road
Saskatoon, Saskatchewan
S7K 0J5
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Fax: 306.975.3057
Website: www.saskatoon.ca

TABLE OF CONTENTS

1.0 General Information

1.1 Authority

Saskatoon Light & Power (SL&P), the electric utility owned by the City of Saskatoon, is authorized to be the sole distributor of electricity within the City of Saskatoon'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 it's franchise area. The determination of these items by SL&P are final and binding on the user. Saskatoon Light & Power, 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 Distributed Generation 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 insure 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:

Customer Relations Manager
Saskatoon Light & Power
322 Brand Road
Saskatoon, Saskatchewan
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

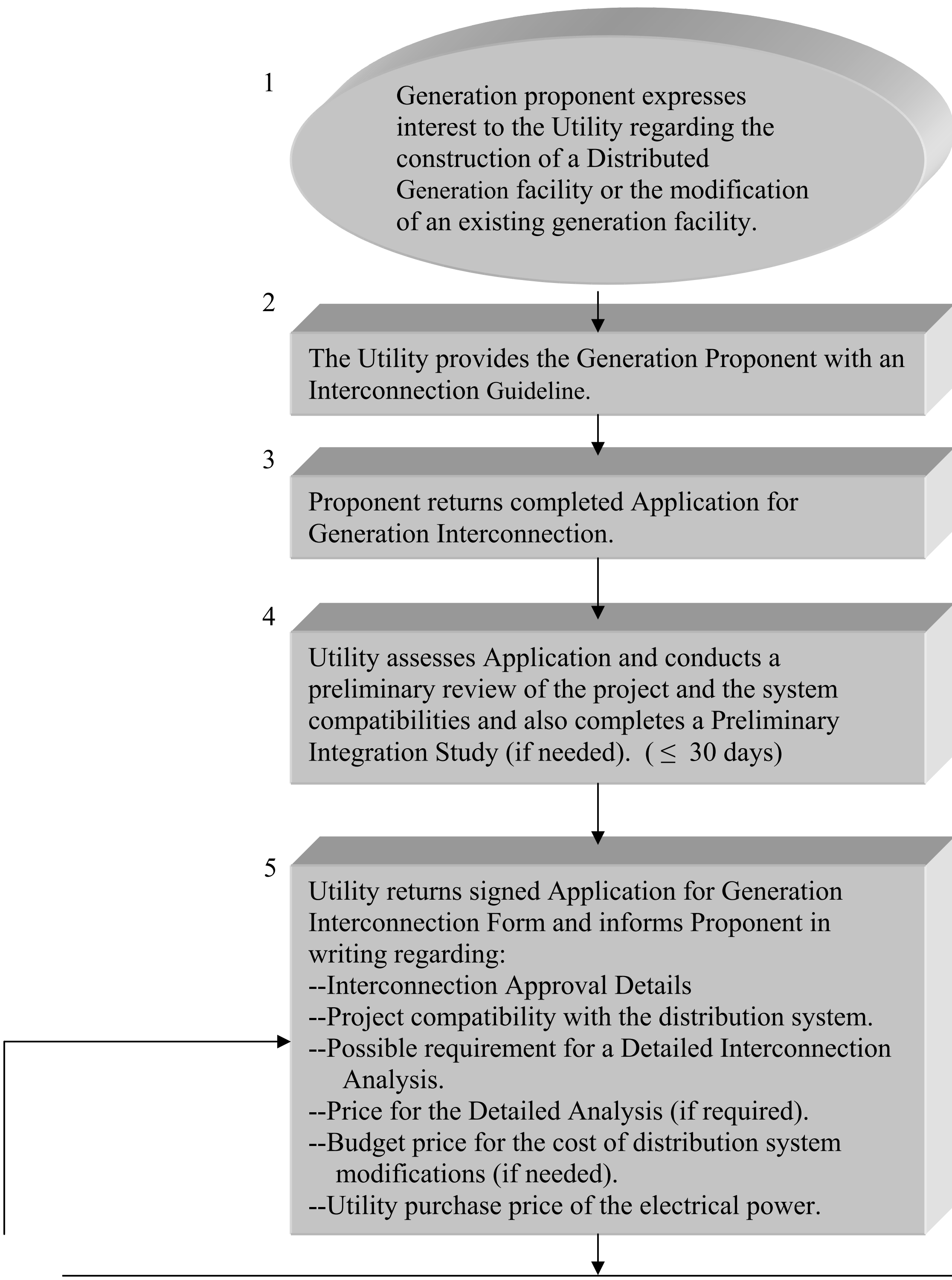
Single phase generation facilities at single site locations are restricted to a maximum of 100 kWatts. Interconnection of generation facilities to the SL&P downtown 600 volt network system is not permitted.

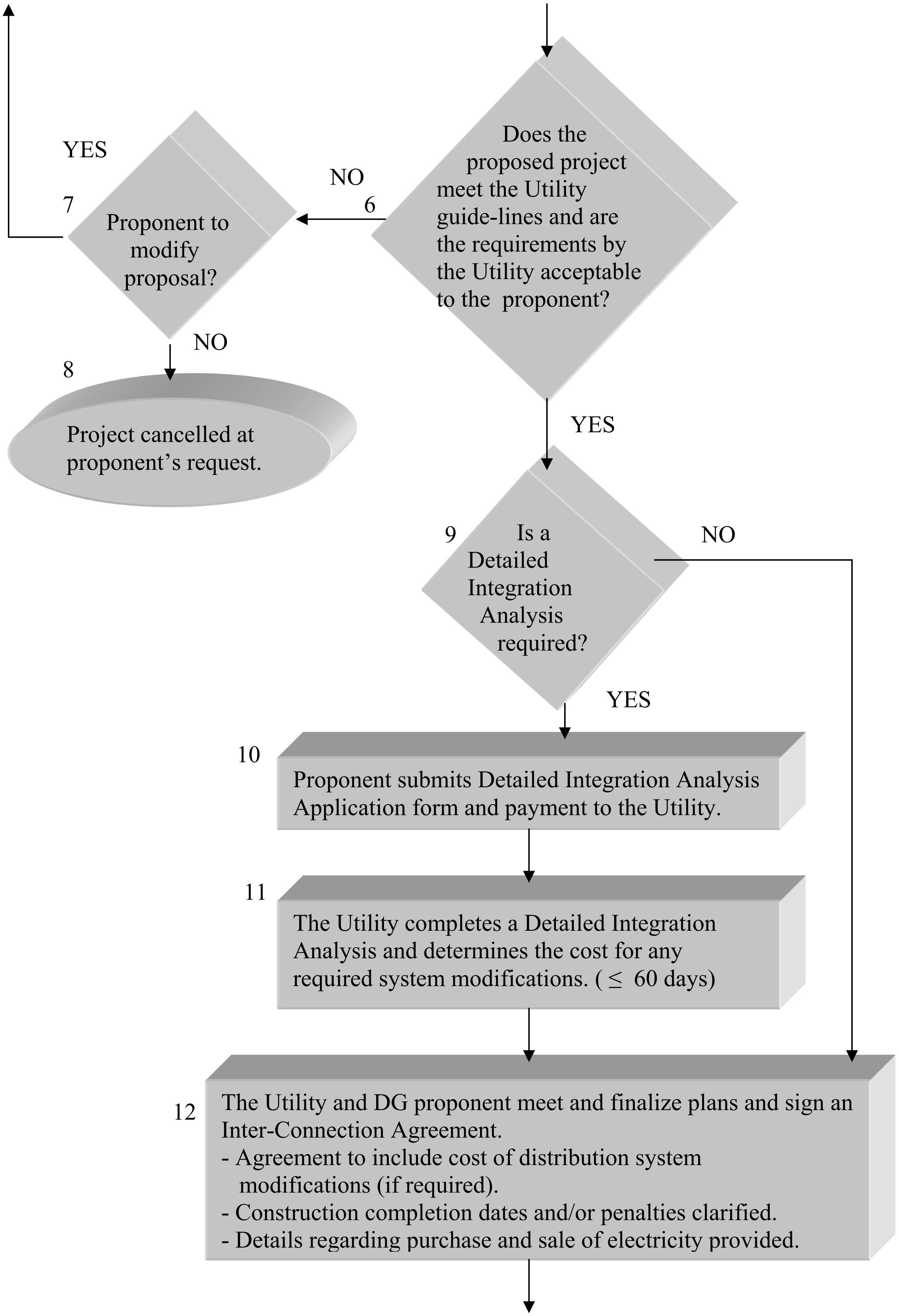
This document addresses three phase generation up to a maximum of 1000 kWatts. Generation plants in excess of 1000 kWatts, or operating at voltages above 25 kV, may need to be acceptable but need to be addressed independently by SL&P on a case by case basis. This document does not address metering rates or tariffs. General and rate information regarding the sale and/or purchase of electrical power by SL&P is available at the City of Saskatoon website: http://www.city.saskatoon.sk.ca/org/electrical

1.5 Interconnection Process

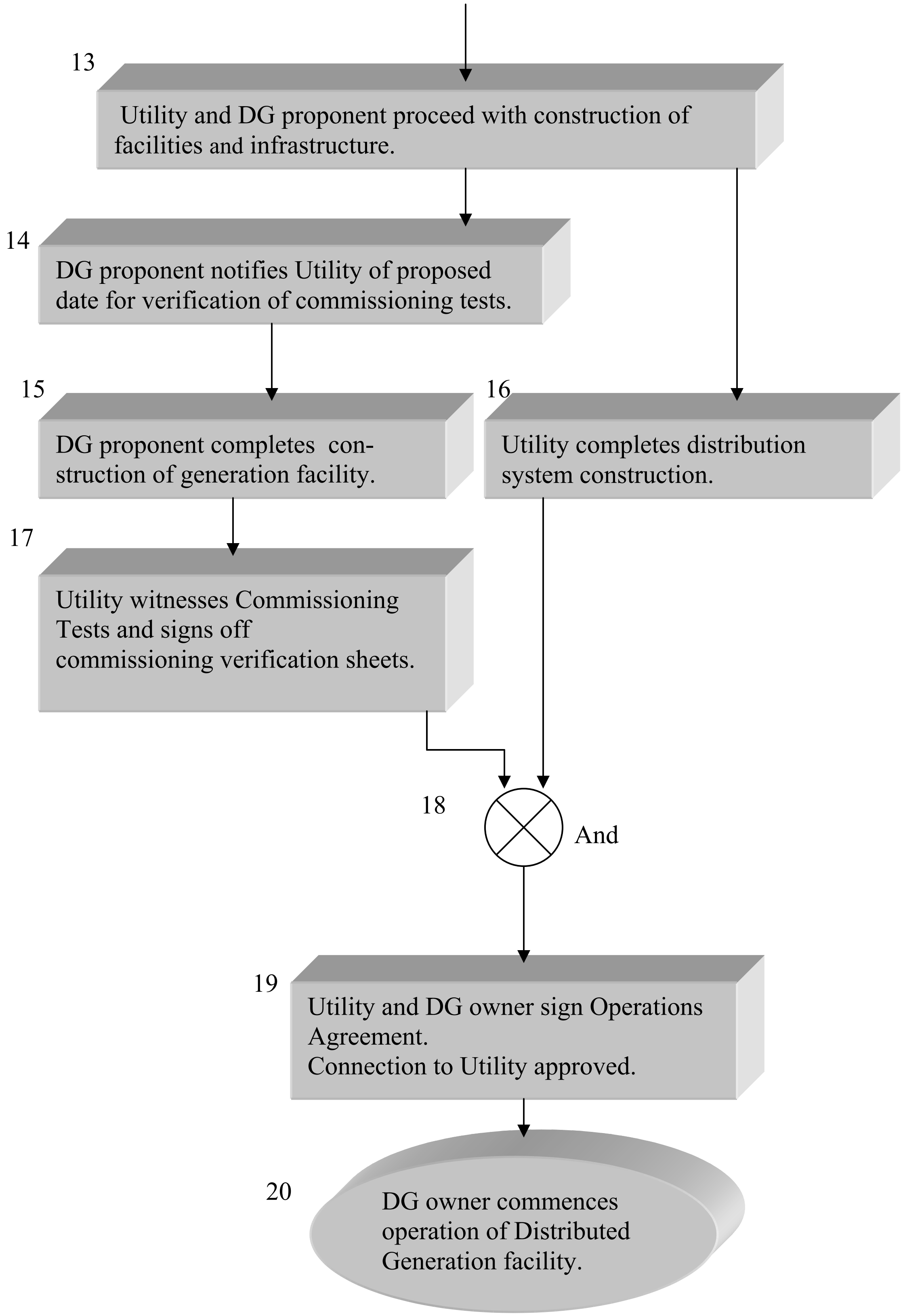
1.5.1 Flowchart

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





Does the proposed project meet the Utility guide-lines and are the requirements by the Utility acceptable to the proponent?
NO
6
YES
7
Proponent to modify proposal?
NO
8
Project cancelled at proponent's request.
YES
9
Is a Detailed Integration Analysis required?
NO
YES
10
Proponent submits Detailed Integration Analysis Application form and payment to the Utility.
11
The Utility completes a Detailed Integration Analysis and determines the cost for any required system modifications. (≤ 60 days)
12
The Utility and DG proponent meet and finalize plans and sign an Inter-Connection Agreement.
- Agreement to include cost of distribution system modifications (if required).
- Construction completion dates and/or penalties clarified.
- Details regarding purchase and sale of electricity provided.


13
Utility and DG proponent proceed with construction of facilities and infrastructure.
14
DG proponent notifies Utility of proposed date for verification of commissioning tests.
15
DG proponent completes construction of generation facility.
16
Utility completes distribution system construction.
17
Utility witnesses Commissioning Tests and signs off commissioning verification sheets.
18
And
19
Utility and DG owner sign Operations Agreement.
Connection to Utility approved.
20
DG owner commences operation of Distributed Generation facility.

1.5.2 Comments

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

Item 1

All approvals associated with the addition of new Distributed Generation 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.

Item 3

The Application for Generation Interconnection is contained in the Appendices – Section 10.6.

Item 4

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.

Items 5, 9, 10, and 11

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 10.6. 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.

Item 12

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

The Interconnection Agreement is divided into 2 sections:

- Interconnection Agreement for Small Generators ($\leq$ 100 kWatts)
- Interconnection Agreement for Large Generators (> 100 kWatts).

Item 19

The Operating Agreement includes standard operating practices as referenced in the Appendix – Section 10.7.

1.6 Ownership and Responsibilities

The Distributed Generation 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 Distributed Generation 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 of Saskatoon 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 Distributed Generation 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 ($\leq$ 100 kWatts)
- Commissioning Verification Form
- Operating Agreement.

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

- Application for Generation Interconnection
- Application for Detailed Generation Interconnection Analysis (if required)
- Interconnection Agreement for Small Generators ($\leq$ 100 kWatts)
- Interconnection Agreement for Large Generators ($>$ 100 kWatts)
- Commissioning Verification Form
- Operating Agreement.

Application forms are provided in Section 10.6

2.0 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 25kV, 14.4kV, and 4.16kV three phase 4 wire sye connected primary voltage systems. It also utilizes secondary voltage distribution at 347/600 volts, 120/208 volts, 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 three phase system that incorporates single 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 and in the Saskatoon Light & Power "Service 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 600 volt network distribution system in the downtown core area. The functionality of the network system does not allow for interconnection to DG.

3.0 General Interconnection Requirements

It is imperative that the characteristics and ratings of the proposed Distributed Generation 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 Saskatoon Light & Power "Service 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 equipment shall be CSA and ULC approved.

3.1 Interconnection Facilities

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

3.1.1 Point of Delivery

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.

For all synchronous generation systems, this disconnect device shall also provide visible isolation and shall be lockable in both the open and closed positions. For 3 phase generating facilities, the switch shall be 3 phase gang operated.

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.

DG sources wishing to have access to Utility power when their Generation is not carrying load may choose to provide an additional visible break, lockable isolation device for the generator. All isolation devices between the generator and the PCC shall be clearly labelled referencing the two voltage sources.

Refer to Section 10.6 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 (≤ 5 kW) connected to the Utility single phase secondary distribution system, the metering will not rotate backwards nor record reverse power situations. For single phase DG systems larger than 5 kW, and for all 3 phase systems, 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 any and 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. A listing of suitable transformer winding configurations is provided in Table 1.

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 Distributed Generation facility shall ensure that the electrical characteristics of it's 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				
120/240	106/212	110/220	125/250	127/254
240	212	220	250	254
480	424	440	500	508
600	530	550	625	635
Three Phase 4 – Conductor				
120/208Y	110/190	112/194	125/216	127/220
240/416Y	220/380	224/388	250/432	254/440
277/480Y	245/424	254/440	288/500	293/508
347/600Y	306/530	318/550	360/625	367/635
Three Phase 3- Conductor				
240	212	220	250	254
480	424	440	500	508
600	530	550	625	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 10.4.

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

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 59.5 to 60.5 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 shall neither attempt to regulate the voltage nor affect the voltage at the PCC. Voltage regulation is a Utility responsibility and voltage regulation schemes should not be employed by DG systems except under agreement with the Utility. DG systems must operate satisfactorily within the extreme voltage level limits as defined in Table 1.

3.2.5 Harmonic Distortion

The possibility of 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 519. 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 current harmonic distortion 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

Harmonic Numbers	Maximum Distortion (%)	
	Even Harmonics	Odd Harmonics
2nd thru 9th	1.0	4.0
10th thru 15th	0.5	2.0
16th thru 21st	0.4	1.5
22nd thru 33rd	0.2	0.6
Above 33rd	0.1	0.33

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.

As such, protection requirements for each specific group will be specifically and individually addressed in the following sections of this guideline.

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 insuring 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. Utility grade relays that are specifically designed to protect and control electrical power apparatus, and tested in accordance with the following ANSI/IEEE Standards, are required:

- ANSI/IEEE C37.90-1994 Standard for Relays and Relay Systems Associated with Electrical Power Apparatus
- ANSI/IEEE C37.90.1-1994 Standard Surge Withstand (SWC) Tests for Protective Relays and Relay Systems
- ANSI/IEEE C39.90.2-1995 Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

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 three 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 ferroresonance, 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 three 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.

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 is able to 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.

Frequency limits will be as specified in the group specific sections.

Inverter type line following equipment and induction generators, that act as motors during startup, 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 ≤ 5kW 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 > 5kW, 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 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 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems.
- IEEE 929 Standard for Inverters less than 10 kW
- UL 1741 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.

4.0 Specific Interconnection Requirements – Standby Generator Systems

4.1 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.

4.2 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.

4.3 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.

4.4 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 10.6

4.5 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 10.6 for Interconnection Agreement document.

5.0 Specific Interconnection Requirements – Single Phase Secondary Distribution Systems @ 120/240 volts ≤ 5 kW

5.1 Generator Limitations

Only single phase generators can be connected to the Utility 120/240 volt single phase secondary distribution system. The standard maximum permissible size for single phase installations connected to this distribution system is 5 kW. Depending on the location of the DG System, there may be other restrictions that limit the maximum size of generator. Single phase secondary distribution installations rated larger than 5kW may be permitted but will require special consideration.

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 Point of Common Coupling 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 929 - Recommended Practice for Utility Interface of Photovoltaic (PV) Systems.

5.2 Isolation Devices

A disconnection switch shall be provided between the DG System and the Utility distribution system. The purpose of the disconnecting means is to provide safe isolation between the Distribution System and the DG System for safe work purposes. The isolation device shall be lockable in the open position and shall provide visible break indication for the hot legs and the neutral conductors. The switch shall meet the requirements of the Canadian Electrical Code Section 84.

Approved warning labels shall be affixed to the exterior of the isolation device indicating the presence of dual voltage sources.

5.3 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 both hot legs. The device may be located on the generator side of the metering point. Refer to Section 10.6 for the single line diagram.

5.4 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. Typically, a 5kW DG System is too small to adversely affect the distribution system voltage regulation. However, in situations where the Utility deems it necessary, the Utility reserves the right to require the DG System to maintain its power factor between 0.90 lagging and 0.95 leading.

5.5 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

5.5.1 Over Current

The DG System must detect and promptly de-energize the DG system for all over current fault conditions in the DG System.

5.5.2 Over and Under Voltage

The over and under voltage protection on the single phase 120/240 volt DG System shall detect the voltages from both phase to neutral. Voltage trip limits and times shall be as indicated in Table 4.

Table 4 VOLTAGE PROTECTION SETTINGS

Voltage Condition	Max. Number of Cycles till Disconnection
V < 50%	6
50% < V < 137%	120
110% < V < 137%	120
137% < V	2

5.5.3 Over and Under Frequency

The over and under frequency protection shall detect the frequency on both phase to neutral voltages. Frequency limits and tripping times areas indicated in Table 5.

Table 5 FREQUENCY PROTECTION SETTINGS

Frequency Condition	Max. Number of Cycles till Disconnection
F < 59.5 Hz	6
F > 60.5 Hz	6

5.5.4 Synchronization

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

6.0 Specific Interconnection Requirements – Three Phase Secondary Distribution Systems ≤ 50 kW

Yet to be determined

7.0 Specific Interconnection Requirements – Single Phase Primary Distribution Systems $\leq$ 100 kW

Yet to be determined

8.0 Specific Interconnection Requirements – Three Phase Primary Distribution Systems ≤ 100 kW

Yet to be determined

9.0 Specific Interconnection Requirements – Three Phase Primary Distribution Systems > 100 kW ≤ 1000 kW

Yet to be determined

10.0 Appendices

10.1 Technical Notes

10.1.1 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.

10.1.2 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 Customers 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.

10.2 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 autorecloser. 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.

CEA

Canadian Electrical Association

<u>CSA</u>
Canadian Standards Association

<u>Cogeneration</u>
A process that uses excess energy bi-products produced by a facility's process to drive a generator and produce electricity.

<u>Closed Transition</u>
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 ($\leq$ 100 mS) and sustained (>100 mS).

<u>Direct Current (DC)</u>
Electric current that flows in one direction only.

<u>Distributed Generation (DG)</u>
Electric power generation facilities interconnected with the electric Utility.

<u>Distributed Generation Owner</u>
The owner of the distributed generation facility.

<u>Distributed Generation Proponent</u>
Those proposing and constructing a DG facility. This is typically the owner or developer of the facility.

<u>Distributed Generation System</u>
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.

<u>Distributed Resource (DR)</u>
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.

<u>Distribution System</u>
The part of the Utility that operates at 25,000 volts or less and distributes electric power between the Utility substations and the customers.

<u>Effectively Grounded System</u>
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 tapchanger
- 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).

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.

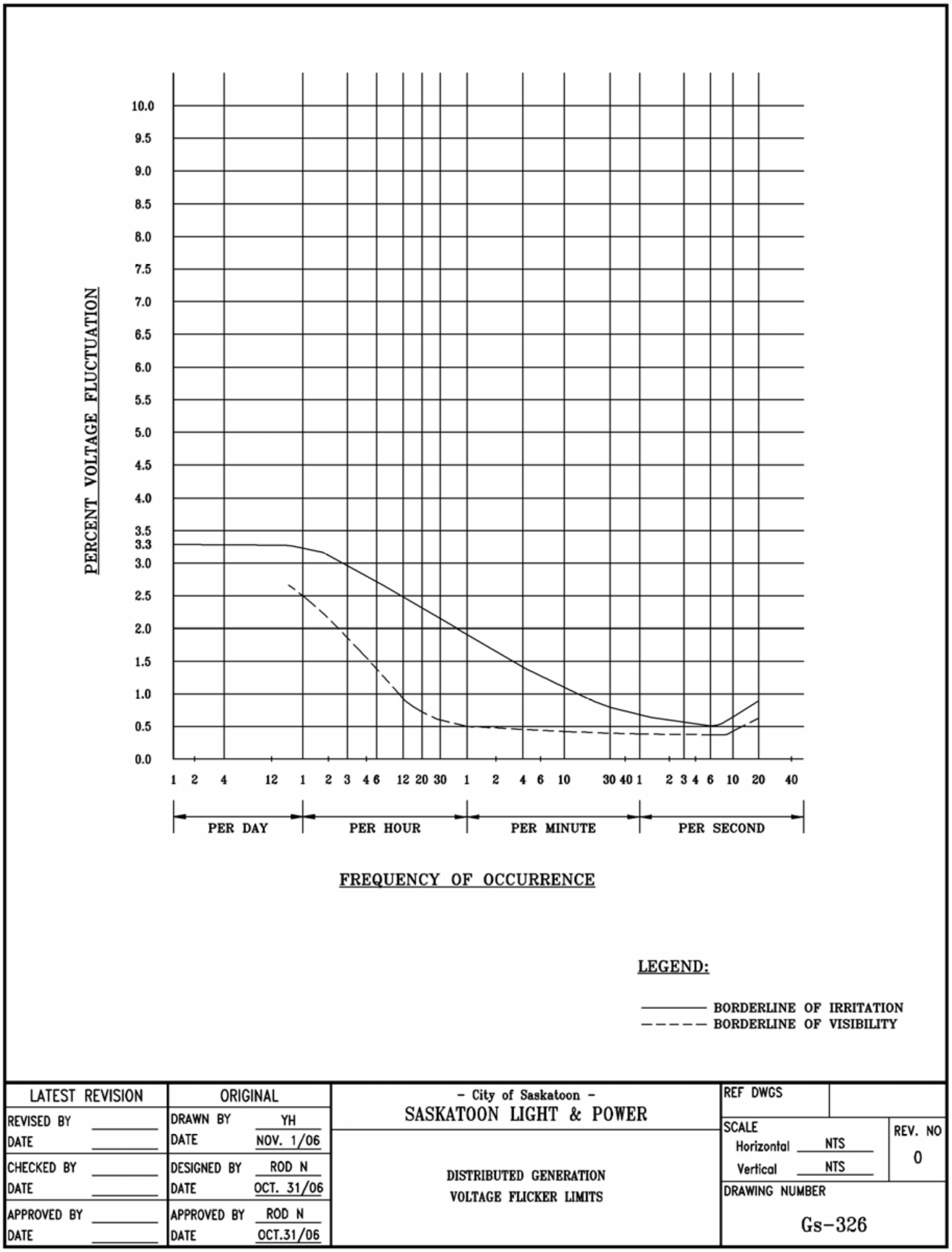
10.3 Protection Nomenclature

The following table (Table 6) provides the information regarding the relay identifications and functions:

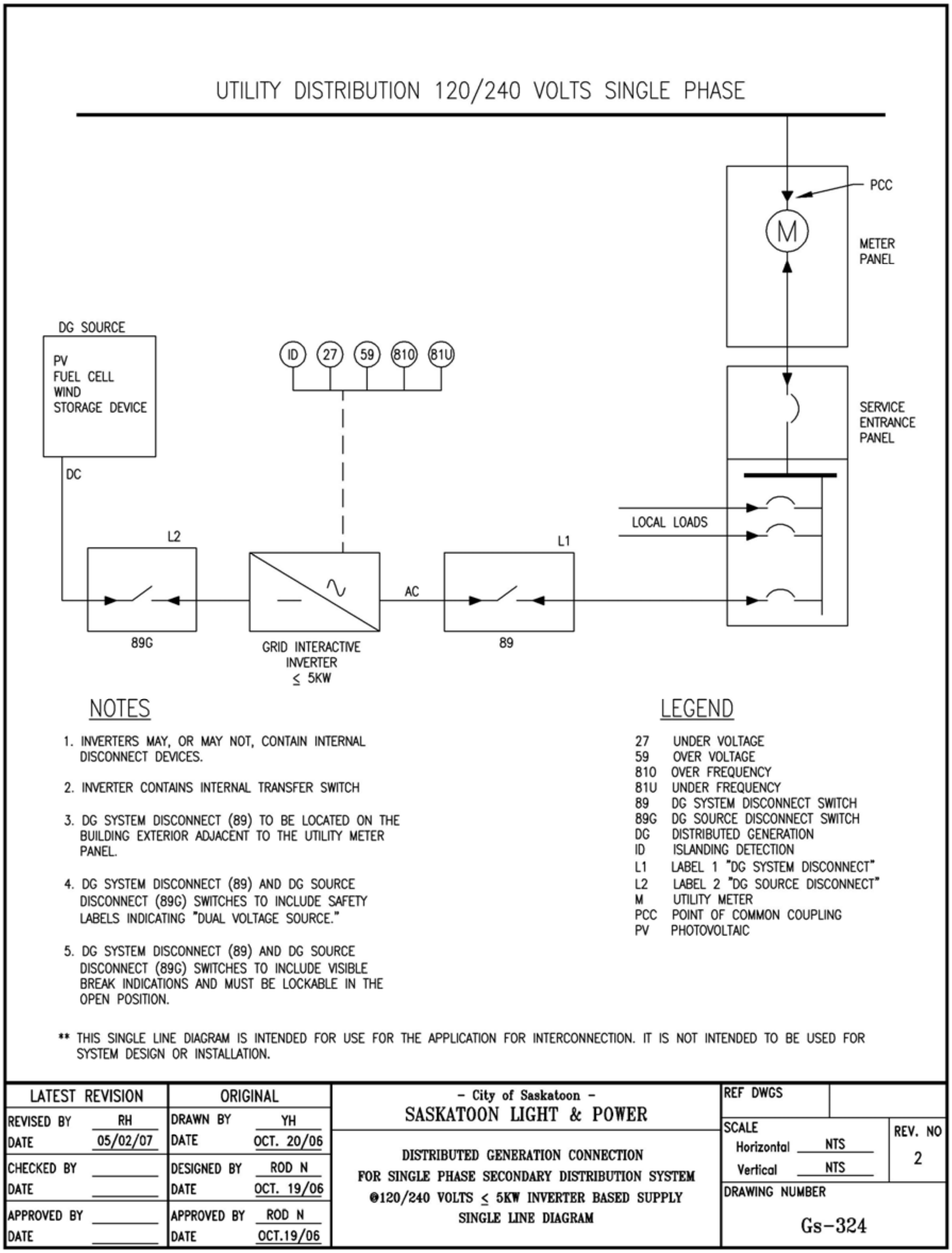
Table 6 PROTECTION NOMENCLATURE

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 ferroresonance or high voltage conditions that may occur during islanding.
59T	Timed Over Voltage. This is used to detect feeder backfeed (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.

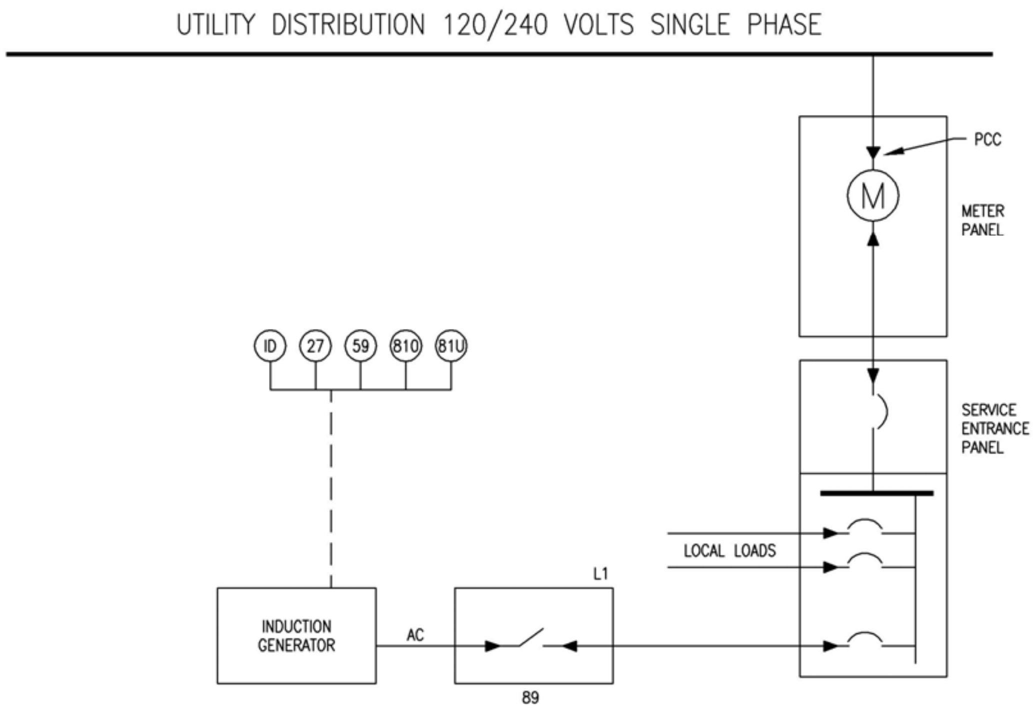
10.4 Voltage Flicker Limits



10.5.1 Distributed Generation Connection For Single Phase Secondary Distribution System @ 120/240 Volts ≤ 5 kW Inverter Based Supply



10.5.2 Distributed Generation Connection For Single Phase Secondary Distribution System @ 120/240 Volts ≤ 5 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	REV. NO
DATE	05/02/07	DATE	OCT. 20/06		Vertical NTS	2
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			

10.6.1 Application for Generation Interconnection

SASKATOON LIGHT & POWER

Application for Generation Interconnection

Distributed Generation Proponent

Company Name: Service Account #:

Mailing Address:

Generation Facility Address: Same as above ☐

Contact Person

Name: Title:

Mailing Address: Same as above ☐

Tel: Fax: Email address:

Equipment Description

Power Generation Data	Inverter Data N/A ☐	Transformer Data N/A ☐
# of Generators: ______	# of Inverters: ______	# of Transformers: ______
Manufacturer: ______	Manufacturer: ______	Manufacturer: ______
Model: ______	Model: ______	Rating (kVA): ______
Serial Number: ______	Serial Number: ______	HV Winding Connection: ______
Power Factor: ______	Power Rating (kVA): ______	LV Winding Connection: ______
Min. Power Output (kVA): ______		Pos. Sequence Impedance: (%) ______
Max. Power Output (kVA): ______		Zero Sequence Impedance: (%) ______

Generator Type

Standby – Open Transition No ☐ Yes ☐

Standby – Closed Transition No ☐ Yes ☐ Transition Time (msec): ______

Parallel Operation with Utility No ☐ Yes ☐

Synchronous ☐ Induction ☐ Direct Energy Converter ☐

Single Phase ☐ Three Phase ☐

Inverter Output No ☐ Yes ☐ **If Yes:** Line Commutating ☐ or Self Commutating ☐

Fuel Source

Diesel ☐ Natural Gas ☐ Wind ☐ Hydraulic ☐ Solar ☐ Fuel Cell ☐ Other ☐ ______

Interconnection Voltage: 120V ☐ 240V ☐ 120/208V ☐ 347/600V ☐ 4.16kV ☐ 14.4kV ☐ 25kV ☐

Will Electrical Power be exported back to the Electrical Utility? No ☐ Yes ☐

Expected operating periods? ______

Expected power generation (kWhs/year)? ______

Additional Information To Be Included With Application

- Protective Device Information – Manufacturer's Name, Model #, Settings, Protection Scheme
- Site Plan showing Generator, Inverter, and Transformer Locations
- Electrical One-Line Diagram

Applicant Name: (print) ______

Signature: ______ **Date:** ______

For Utility Use Only

Approved for Interconnection: No ☐ Yes ☐ Conditional Approval ☐

More Information Required ☐ Detailed Analysis Required ☐

Signature: ______ **Title:** ______ **Date:** ______

Comments: ______

10.6.2 Application for Detailed Generation Interconnection Analysis

SASKATOON LIGHT & POWER

Application for Detailed Generation Interconnection Analysis

Distributed Generation Proponent

Company Name: Service Account #:

Mailing Address:

Generation Facility Address: Same as above ☐

Contact Person

Name: Title:

Mailing Address**:** Same as above ☐

Tel: Fax: Email address:

Equipment Information

Synchronous Machine Data

Generator Rating (kVA) ________
Speed (RPM) ________
Power Factor at Rated Output (%) ________
Inertia Constant H (Generator and Prime Mover) ________
Direct Axis Synchronous Reactance (Xd) ________
Direct Axis Transient Reactance (X'd) ________
Direct Axis Subtransient Reactance (X"d) ________
Quadrature Axis Synchronous Reactance (Xq) ________
Quadrature Axis Transient Reactance (X'q) ________
Quadrature Axis Subtransient Reactance (X"q) ________
Open Circuit Direct Axis Transient Time Constant (T'do) ________
Short Circuit Direct Axis Transient Time Constant (T'd) ________
Open Circuit Direct Axis Subtransient Time Constant (T"do) ________
Short Circuit Direct Axis Subtransient Time Constant (T"d) ________
Quadrature Axis Transient Time Constant (T'qo) ________
Quadrature Axis Subtransient Time Constant (T"qo) ________
Armature Resistance (Ra) ________
Stator Leakage Reactance (Xl) ________
Armature Short Circuit Time Constant (Ta) ________
Saturation Factor at 1.0 per-unit flux ________
Saturation Factor at 1.2 per-unit flux ________
Negative Sequence Resistance (R2) ________
Negative Sequence Reactance (X2) ________
Zero Sequence Resistance (R0) ________
Zero Sequence Reactance (X0) ________

Induction Machine Data

Generator Rating (kVA) ________
Speed (RPM) ________
Power Factor at Rated Output (%) ________
Inertia Constant H (Generator & Prime Mover) ________
Stator Resistance (Rs) ________
Stator Reactance (Xs) ________
Rotor Resistance (Rr) ________
Rotor Reactance (Xr) ________
Armature Magnetizing Reactance (Xm) ________

Transformer Data

Rating ONAN/ONAF (kVA) ________
HV Winding Connection ________
LV Winding Connection ________
Pos. Sequence Impedance ________
Zero Sequence Impedance ________
On-load Tap Range (%) ________
On-load Tap Size (%) ________
Off-load Tap Range (%) ________
Off Load Tap Size (%) ________

Substation Data

Type of Interrupting Device ________
Interrupting Rating (Amperes) ________
Operating Speed (RPM) ________

Note: All machine impedances expressed in per unit on machine base. All transformer impedances expressed in % at ONAN base.

Additional Information To Be Included With Application

- Electrical three line diagram
- A description of the excitation system or proposed voltage/power factor control system
- A description of the proposed governor or power control system
- A description of the expected frequency and power output variations and rates of change
- The expected worst case harmonic current injection into the Utility for all harmonics up to the 35th

Applicant Name: (print) ____

Signature: ____________________________ **Date:** ____________________

For Utility Use Only

Project Compatible with the Utility System? No ☐ Yes ☐

Utility System Improvements Required? No ☐ Yes ☐

Approved for Interconnection: No ☐ Conditional Approval ☐

More Information Required ☐ Subject to Commissioning Verifications ☐

Modification Details/Comments: ____

____

____

Signature: ____________________ **Title:** ____________________ **Date:** ____________

10.7 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.

11.0 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.*

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

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.