Q. (Reference 2017 GRA Volume I, page 2.16) With respect to the net metering program, please provide Hydro's connection standards and schemes.

A. Please refer to CA-NLH-101, Attachment 1, *Net Metering Interconnection Requirements*, which detail Hydro's connection standards.

Net Metering
Interconnection Requirements

Customer Generation Capacity Not Exceeding 100 kW

Date: 2017-07-01

Version: 1

newfoundland labrador hydro
a nalcor energy company

Revision History

Date	Rev.	Description
July 01, 2017	1	Initial release

Table of Contents

1.0 Purpose

This document establishes the minimum requirements for safe and effective operation of small-scale generation interconnected with the distribution systems of Newfoundland and Labrador Hydro ("the Utility"). This guide describes the Utility interconnection requirements associated with the provision of Net Metering Service. The requirements outline the minimum design standards that the generator and related equipment associated with a customer's Net Metering Service (the "Customer Facility") must conform to, and a range of normal and emergency system conditions the Customer Facility could encounter while connected to the Utility's distribution system.

Customers considering the Net Metering Service Option should discuss project plans with the Utility before purchasing or installing equipment, as requirements will vary depending on capacity, type, location and the existing distribution infrastructure in the vicinity of the Customer Facility.

Implementing the requirements contained in this document will help to ensure that the Customer Facility does not operate in a manner that would compromise the safe operation, reliability or power quality of the distribution system. The customer is required to install, operate and maintain the Customer Facility in accordance with manufacturer's recommendations to ensure good working order and fitness for service at all times.

This guideline is based on the following assumptions and principles:

- The addition of the customer's Net Metering equipment to the utility distribution system will not appreciably change the distribution system and its characteristics.
- The installation meets the installation requirements of the latest edition of the Canadian Electrical Code (CE Code) Part 1 and the equipment is certified to the relevant CE Code Part 2 product standard. Other local and provincial construction and installation regulations may apply.

- The safety of the utility personnel, the public and equipment is of primary concern in the design and operation of the interconnection systems.

1.1 Customer Generation

A Net Metering customer may be permitted to operate, in parallel with the Utility's distribution system, a Customer Facility consisting of generators with a maximum aggregate capacity of 100 kW and operated at 60 Hz, provided the Customer Facility meets or exceeds the requirements set out in this document. In all cases, establishment of a Net Metering Interconnection Agreement and conformance with the Utility's Net Metering Service Option Rules and Regulations is required.

1.2 Limitations

The criteria and requirements of this document are applicable to all renewable generation technologies. Customer Facilities will be interconnected with radial Distribution Systems at nominal primary voltage of 25,000 V phases to phase or less and nominal secondary voltages of 600 V or less.

Customer Facilities shall be sized to not exceed the annual energy requirements of the buildings or facilities located on the Customer's Serviced Premises. The capacity required to meet the energy requirements of a building or facility can be estimated using the following equation:

$$\text{Maximum Capacity (kW)} = \frac{Annual\ consumption(kWh)}{8760\ (h) \times Utilization\ factor}$$

Where, the Utilization Factor is the ratio of actual energy output to output at rated capacity for an entire year, as a percentage. This ratio is determined by the designer of the Customer Facility.

This document does not apply to emergency backup generators utilizing automatic or manual transfer schemes in which load is transferred between the backup generation and the Utility distribution system in a momentary "break-before-make" operation.

The requirements in this guideline are not intended to provide protection of the Net Metering customer's equipment. The Net Metering customer is fully responsible for protecting customer equipment in such a manner that faults or other disturbances on the Utility's system do not cause damage to customer equipment, and the Utility shall not be liable for any such fault, damage or disturbance.

2.0 Getting Connected – The Interconnection Process

The first step in getting connected is to have the project assessed. This is initiated by completing and submitting a Net Metering Application Form. The form can be found on Hydro's website and may be submitted as follows:

Newfoundland and Labrador Hydro - Net Metering
Hydro Place, 500 Columbus Drive
P.O. Box 12400
St. John's, NL A1B 4K7

By e-mail: customerservices@nlh.nl.ca
Subject: Net Metering Application

The basic steps in the process are as follows:

1. The Utility will acknowledge receipt of the Net Metering Application Form and will undertake a review of the interconnection request and the field conditions. This review will identify any new utility equipment or upgrades to the existing distribution system that are required to enable the connection of the generator. This review takes into account the size, type and location of the proposed generation equipment.

2. The Utility will develop specific interconnection requirements and cost estimates for required system additions/upgrades, including changes to the Utility revenue metering equipment.
3. The cost estimates for the required system additions or changes will be provided to the customer for review. Once the customer accepts the requirements and pays the identified costs, the required construction work can be scheduled to commence.
4. Following installation of the generating equipment, the customer will be required enter into an Interconnection Agreement with the Utility.
5. As part of the electrical and generating equipment installation, the customer's electrician must obtain an Electrical Permit from the applicable electrical inspection authority and arrange to have all required electrical inspections performed and passed.
6. After the electrical inspections are performed and passed, and the Interconnection Agreement is signed, the Utility will advise the customer that interconnection of the generator with the Utility's system can proceed.
7. At this stage, the Utility may require and/or witness the commissioning and testing of the generation equipment.

3.0 Safety and Associated Regulatory Requirements

3.1. Utility Safety Requirements

Safe work procedures described in the Utility safety codes and operational procedures will be followed by the Utility in providing isolation for work on any part of the interconnected distribution system.

3.2 Public Safety Act and the Canadian Electrical Code

The Net Metering customer's generation installation must meet all applicable national, provincial and municipal electrical construction and safety codes, including, without limitation, the provincial Public Safety Act and Electrical Regulations.

Reference should be made to the latest versions of the Canadian Electrical Code Part 1, CSA C22.3 No. 9 - Interconnection of Distributed Resources and Electricity Supply Systems, and CSA C22.2 No. 257 - Interconnecting Inverter-based Micro-distributed Resources to Distribution Systems.

Except as expressly permitted by law, all electrical equipment that is part of the Customer Facility must have Canadian Standards Association ("CSA") or equivalent approval.

Installation of wind turbines and associated structures may be a regulated activity requiring approval from various governing authorities. Customers considering wind generation are required to familiarize themselves and ensure compliance with all applicable regulations and bylaws with respect to the installation of wind turbines.

3.3 Permission to Operate

Under no circumstances shall the Net Metering customer begin parallel operation of the generator until final written approval is given by the Utility.

4.0 Interconnected Systems

An interconnected system is defined as a system in which the customer's generation is connected at a point common with the Utility distribution system. As a result of this interconnection, the generator system becomes an integral part of the Utility distribution system.

Section 4.1 lists the typical distribution system operating and power quality conditions within which the customer's equipment must operate. It lists representative values of parameters that the distribution system normally maintains and some abnormal conditions that the generating equipment needs to be designed to withstand. It is the Customer's responsibility to ensure that the generating equipment operates correctly in this environment.

4.1 The Utility Distribution System

4.1.1 Distribution System Configuration

The Utility's primary distribution system is a 3-phase, 4-wire multi-grounded common neutral system (“effectively grounded-wye”) operated at three typical voltage levels:

- 4,160 Volts line to line (4 kV);
- 12,470 Volts line to line (12 kV); and
- 24,940 Volts line to line (25 kV).

Distribution transformers, which step the primary voltage down to utilization voltages, are mainly single-phase units with primaries and secondary’s connected phase to ground. Three phase distribution transformers are normally configured grounded wye- grounded wye. This generally provides a single intentional ground path for short-circuit currents (one zero-sequence path) and has been utilized in the design of short-circuit protection applied to distribution feeder systems. The utility’s standard secondary voltages are:

- 120/240 Volts 1-Phase;
- 120/208 Volts Solidly Grounded Wye 3-Phase, 4-Wire; and
- 347/600 Volts Solidly Grounded Wye 3-Phase, 4-Wire.

4.1.2 System Grounding

Distribution Systems are typically three-phase 4-wire multi-grounded systems incorporating single-phase distribution taps. They are typically operated as effectively (solidly) grounded.

Following the addition of the Customer Facility, the distribution system must remain effectively grounded at all locations.

4.1.3 Phasing

Phasing is not standardized across distribution systems. For three phase generation, the phase sequence and the direction of rotation must be coordinated with the Utility’s distribution system.

4.1.4 System Frequency

The distribution system operates at 60 Hz. Frequency deviations are typically greater than the larger integrated North American utility systems.

4.1.5 System Voltage

Net Metering customers' systems must be capable of operating satisfactorily within the extreme voltage level variation limits shown in Table 1.

Table 1
Normal Service Voltage Variation Limits

Nominal System Voltages	Recommended Voltage Variation Limits for Circuits Up to 1000 volts, Applicable at Service Entrance			
	Extreme Operating Conditions	Normal Operating Conditions		Extreme 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

Source: CSA CAN3-C235 - Preferred Voltage Levels for AC Systems, 0 to 50 000V- Canadian Standards Association

4.1.6 Flicker and Voltage Distortion

Standard IEEE-519 establishes the quality of power that the Utility is to deliver to the customer and describes the typical voltage and current waveforms that exist throughout the distribution system. Transient conditions exceeding the limits may be encountered. Remote sections of rural distribution system may not meet the limits. IEEE 519 recommends that the voltage distortion limits as a percentage of the nominal fundamental frequency voltage should not exceed 3 percent for any individual harmonic, and 5 percent for the total voltage harmonic distortion THD. Transient conditions exceeding the limits may be encountered. Remote sections of the Utility's rural distribution systems may not meet the limits.

4.1.7 Voltage Unbalance

The voltage unbalance on the distribution system under normal operating conditions is typically under 3 percent but may reach 5 percent due to the unbalanced loading and single-phase voltage regulation.

Voltage unbalance is calculated using RMS voltage levels measured phase to phase at the service entrance under no load conditions:

Voltage unbalance (percent) = 100 x [(max. deviation from average) / (average)]

4.1.8 Voltage and Current Surges

The distribution system may experience voltage and current surges, which vary by location due to the effects of other types of equipment connected to the distribution system, including switched loads, other generating equipment, switched power factor correction capacitors, and voltage regulation equipment.

4.1.9 Fault and Line Clearing

The Utility's power lines are subject to a variety of natural and man-made hazards. The resulting electric problems are principally short circuits, grounded conductors, and broken conductors. These fault conditions require that the damaged equipment be de-energized as

soon as possible because of the hazards they pose to the public and the operation of the Utility's distribution system.

To maintain the reliability of the distribution system, the Utility uses automatic re-closing to automatically re-energize the power lines after a fault has occurred. The Net Metering customer must be aware of line re-closing when selecting and setting up their generator protection schemes to ensure that the generator ceases to energize the distribution system prior to any automatic re-close of the Utility's circuit breakers or reclosers.

4.1.10 Fault Levels

Fault levels on distribution circuits will vary depending on circuit configuration. The Utility will provide information on fault levels at a given site upon request by the customer.

4.2 Generator Types

Although it is anticipated that the majority of generators encountered in this size category will be either induction or inverter-interface types; synchronous units may also be utilized as well.

4.2.1 Synchronous Generators

Synchronous generators are generally capable of supplying sustained current for faults occurring on the Utility distribution system. Re-closing by the Utility onto synchronous units must be blocked to prevent out-of-synchronous paralleling and to prevent the energising of a de-energised Utility line.

For this type of generator, synchronizing equipment must be provided by the Net Metering customer to ensure proper synchronizing of the customer's equipment to the Utility system. Sufficient time must be allowed to ensure the Utility system has stabilized following a protection operation.

4.2.2 Induction Generators

Induction generators are basically induction motors that are mechanically driven above synchronous speed to produce electric power. Reactive power supply for induction generators may pose design problems, depending on the generator size. Special considerations for induction generators are:

- Capacitors may be necessary to limit the adverse effects of reactive power flow on the Utility's system voltage regulation;
- Self-excitation of the induction generator due to installed capacitors can produce abnormal high magnitude, distorted voltages; and
- Voltage flicker resulting from induction generators starting, particularly on low capacity distribution systems may be unacceptable to the Utility.

4.2.3 Power Electronic Converter (Inverter) Systems

Inverters convert direct current (dc) power to alternating current (ac) power by means of electronic switching devices. Switching can be controlled by the ac voltage waveform of the Utility's supply system (grid-dependent) or by internal electronic circuitry (grid-independent). Inverters are generally not capable of supplying sustained fault current. Grid-independent inverters are capable of supplying load current independently of the Utility supply systems. Excessive harmonic output of power inverters may interfere with other Utility customers.

5.0 General Requirements for Interconnection

5.1 Isolation – Safety Disconnect Switch

As per CEC Part 1 – Section 84, a manual disconnecting device for isolation purposes must be provided by the Customer. The form of this switch will vary with the service voltage and capacity but in all cases must be capable of providing a visible break (air gap) that can be confirmed via visual inspection, opening all phases simultaneously (group-operated), being locked in the open position and be accessible at all times to Utility personnel. Location and form of the device is subject to approval by the Utility.

In addition to a manual disconnecting device, the Customer Facility must be complete with an automatic disconnect device to automatically operate as required by protection functions to disconnect the customer generator from the distribution system.

The Customer shall install warning labels at the revenue meter location and at the disconnect device as required by CEC Part 1 – Section 84. A single-line, permanent, legible diagram of the Customer Facility shall be installed in a conspicuous place at the disconnecting device. Where instrument transformers are used for revenue metering, the revenue meter and the instrument transformer enclosure each require a warning label required by CEC Part 1 – Section 84.

5.2 Grounding

The equipment comprising the Customer Facility must be grounded in accordance with the most stringent requirements of the manufacturer's recommendations, the CEC, and the normal practices of the Utility.

Interconnection of three phase transformers, and transformer grounding systems on three phase distribution systems, shall be coordinated with the Utility and shall not cause voltage disturbances nor disrupt coordination of the Utility distribution system ground fault protection.

5.3 Protection

The Customer Facility shall be equipped with protective functions or devices designed to:

- Ensure the Customer Facility cannot, in any circumstance, energize a de-energized Utility distribution system;
- Prevent parallel operation of the Customer Facility with the Utility distribution system unless the voltage and frequency are within normal limits;
- Prevent isolated operation of the Customer Facility (islanding) with any part of the Utility distribution system; and
- Automatically interrupt the maximum available fault current at the point of connection with the Utility distribution system.

6.0 Interconnection Protection Requirements

6.1 Response to Abnormal Voltage Levels

Every interconnected generator requires under/over voltage protection.

Three-phase generator systems shall automatically shut down or disconnect from the Utility systems when any individual phase-to-neutral voltage on a grounded-wye system or any individual phase-to-phase voltage on an ungrounded-wye or delta system goes outside the Normal Operation range of Table 2. Single-phase inverter systems shall detect the phase-to-neutral voltage if connected to neutral. Single-phase equipment connected line-to-line but not to the neutral conductor shall detect the line-to-line voltage.

When any voltage is outside the normal range of Table 2, the Customer's generating equipment shall disconnect from the Utility's distribution system within the maximum clearing time.

Table 2

Response to Abnormal Voltage Levels

Voltage Range		Maximum Clearing Time	
On 120V Base	**% Of Base Voltage**	**Cycles**	**Seconds**
V ≤ 60	V ≤ 50%	Instantaneous	Instantaneous
60 < V < 106	50% < V < 88%	120 cycles	2 sec.
106 ≤ V ≤ 127	**88% ≤ V ≤ 106%**	**"Normal Range" of Operation**	
127 < V < 144	106% < V < 120%	30 cycles	0.5 sec.
V ≥ 144	V ≥ 120%	Instantaneous	Instantaneous

6.2 Response to Abnormal Frequencies

Every interconnected generator requires under/over frequency protection.

When a system frequency is in a range given in Table 3, the Customer's equipment shall automatically shut down or disconnect from the Utility distribution system. Adjustable under-frequency settings shall be coordinated with the Utility.

Table 3

Response to Abnormal Frequencies

Utility Voltage Condition	Frequency Condition	Maximum number of cycles to disconnect	Seconds
Normal Voltage	>61	10	0.16
Normal Voltage	<59	10	0.16

6.3 Over-current Protection

The Customer's interconnection equipment must detect and disconnect for over-current fault conditions.

6.4 Harmonics

Harmonic current injection by the Customer's equipment into the Utility distribution system shall not exceed the limits listed in Table 4.

Table 4

Current Harmonic Limits

Individual Harmonic Order "n" (odd)[1]	n<11	11≤n<17	17≤n<23	23≤n<35	35≤n≤50	Total Demand Distortion (TDD)
Percent (%)	4.0	2.0	1.5	0.6	0.3	5

6.5 Flicker

The Customer's equipment shall not create objectionable flicker for other customers served from the Utility distribution system. It is recognized that flicker is a site dependent condition.

Voltage flicker and deviation is governed by the flicker curve attached as Appendix A. This shows the permissible voltage fluctuation and frequency based on the annoyance factor of lamp flicker.

6.6 Fault Clearing (Reconnection to Utilities Distribution System)

Following an outage on the Utility's distribution system, the Customer Facility may reconnect only when the distribution system voltage and frequency return to normal range (Tables 2 & 3) and are stabilized for a period of at least five minutes.

6.7 Synchronizing

The Customer Facility must be capable of synchronizing with the Utility's distribution system. It shall synchronize to the distribution system while meeting the flicker requirements of Section 6.5 and without causing voltage variation at the point of interconnection of greater than 5%. The Customer Facility may synchronize to the Utility's distribution system only if the

distribution system is stable and operating within the normal limits of Table 2 and Table 3 for a period of at least five minutes following an outage

6.8 Islanding

Islanding is not permitted.

The Customer Facility shall be equipped with an approved non-islanding protection function design to prevent the generator from being connected to the Utility distribution system when the Utility generation is not energizing the Utility distribution system. Alternatives to this protection function will be considered at the Utility's discretion.

All inverters shall be "non-islanding type" as defined by CSA C22.2 No. 107.1.

6.9 Voltage Control

The Customer's equipment shall not actively regulate the voltage at the local distribution system and the Customer's equipment shall not cause the voltage level of the local distribution system to be sustained outside the limits of Table 1, Normal Operating Conditions Range, measured at the point of interconnection.

The generator is not required to be capable of adjusting the power factor, but each generating unit shall be capable of operating within a range of 0.95 power factor lag to 0.95 power factor lead.

6.10 Inverter Protection Requirements Summary

Inverters meeting each of the following technical requirements meet the protection requirements of Table 2, 3 and 4:

- Output rating of inverter is less than 30 kW;
- Systems are rated and connected at a secondary voltage level, i.e. less than 600V;
- nominal, measured line to line;

- Systems meet CSA C22.2 No.107.1 - Standard "Power Conversion Equipment"; and
- are so marked.

6.11 Protection Requirements Summary

Table 5

Protection Requirements Summary

Guide Section	Device Category	Protection Element
5.1	Manual Disconnect Device (lockable, accessible, visible)	-
5.1	Automatic Disconnect Device	52
6.1	Over-Voltage Trip	59
6.1	Under-Voltage Trip	27
6.2	Over/Under Frequency Trip	81O/81U
6.8	Anti-Islanding	AI
6.3	Overcurrent Trip/Shutdown	50/51
6.7	Synchronizing/Synch Check*	25
*** Synchronous Types Only**		

7.0 Metering

7.1 Customer Requirements

The Customer is required to provide and install, at their expense, meter sockets and metering cabinets in a suitable location at the Customer Facility to permit access by the Utility.

7.2 Bi-directional Metering

Where required, additional revenue-class metering will be installed so that kWh (in) and kWh (out) are separately recorded. Hydro may require four quadrant metering. The Customer shall pay all costs to upgrade the metering equipment for Net Metering Service if the existing electrical meter at the Service Premises is not capable of safely and reliably measuring both the energy supplied to the Customer by the Utility and the energy supplied to the Utility by the Customer.

7.3 Meter Testing

All revenue metering equipment is routinely tested in accordance with Measurement Canada requirements. At any time, either the Customer or the Utility may request a test of the accuracy of the revenue metering equipment at their own expense. The results of meter calibrations or tests shall be available for examination by both parties at all times. If the meter accuracy disclosed by the requested test is not within Measurement Canada's allowable limits, the Utility shall correct the inaccuracy or replace the meter as soon as possible and, if the Customer requested and paid for the test, reimburse the Customer for the reasonably-incurred cost of the test. If the meter is found to be within allowable limits, no adjustment or reimbursement will be required.

7.4 Generation Meter

The Utility may require the output of the Customer's generation to be metered separately, at the Utility's expense. In that case, the Customer shall provide Hydro with the access necessary to install and maintain the required metering equipment.

8.0 Operating Requirements

8.1 General Operating Requirements

The Utility may require operational control over the customer's interconnection equipment, as necessary, to ensure safety, reliability or serviceability of the Utility distribution system.

8.2 Interconnection Agreement

Prior to operation of the interconnected generating equipment, an Interconnection Agreement shall be established between the Customer and the Utility to identify key contacts, desired electrical operating characteristics, and other relevant operating responsibilities considerations.

Once the Interconnection Agreement has been established, the Customer shall not be permitted to modify or make additions to the Customer Facility without the prior written consent of the Utility.

8.3 Testing

Prior to interconnection, all protective devices or functions supplied to satisfy the requirements in Section 6 shall be tested by qualified personnel at the Customer's expense. Reports and findings of this routine testing shall include the "in service" settings. Test reports will promptly be made available to the Utility.

Special tests may also be requested by the Utility to investigate apparent mis-operations of the Customer Facility that may have had an adverse effect on the Utility's distribution system. The Customer shall conduct, or allow the Utility to conduct, such tests. The cost of such tests will be at Customer's expense. Should a test disclose no fault, irregularity or mis-operation of the Customer Facility, the Utility will reimburse the Customer for the reasonably-incurred cost of the test.

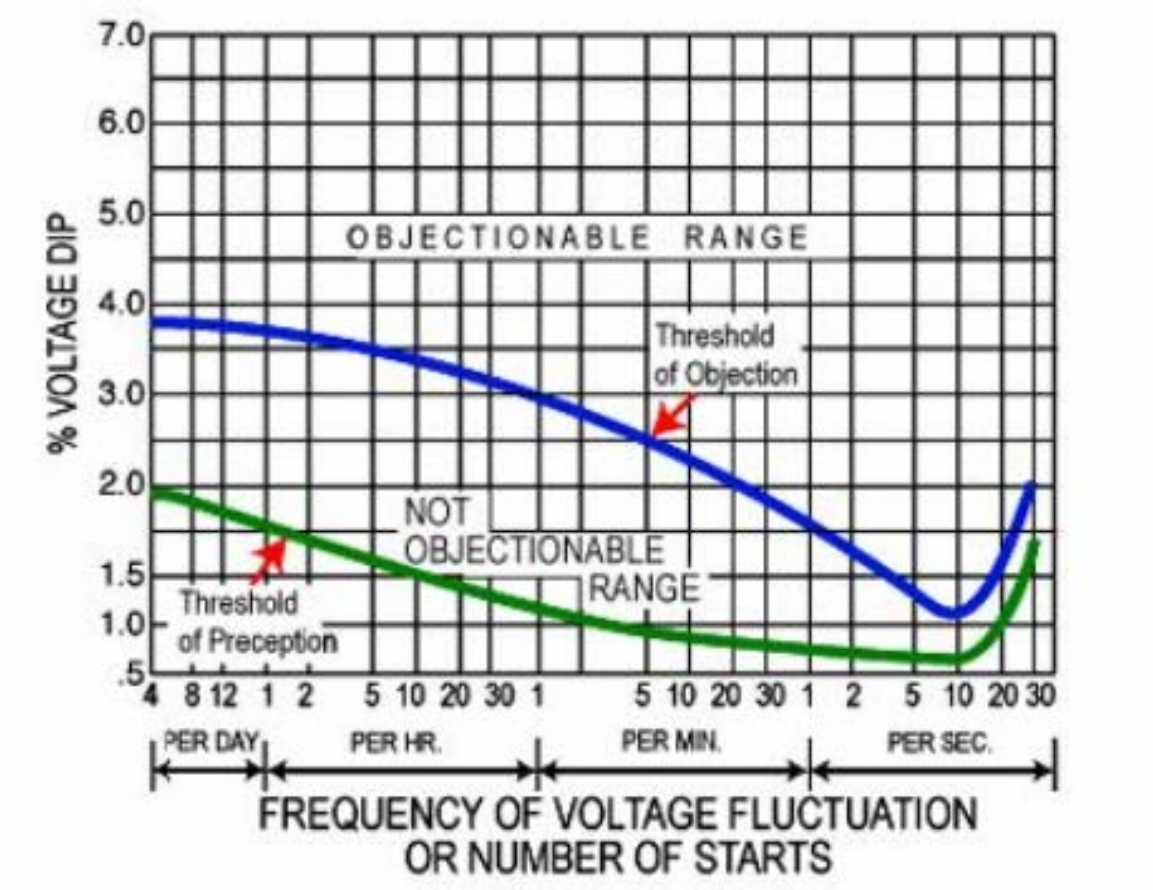
9.0 Responsibility for Costs

The Customer is responsible for all capital, operating and maintenance costs of all equipment on the customer side of the point of delivery.

Where upgrades and/or revisions are required to the existing Utility systems, to accommodate interconnection of the Customer Facility, the Customer shall pay the actual cost of the installation/changes. The Customer shall pay a capital contribution for any required line extensions necessary to extend the Utility distribution system to the point of interconnection.

Appendix A:

Standard Voltage Flicker Curve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FREQUENCY OF VOLTAGE FLUCTUATION OR NUMBER OF STARTS