BED INTERCONNECTION TECHNICAL REQUIREMENTS

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BED INTERCONNECTION TECHNICAL REQUIREMENTS

Generation Units

This document provides a set of generic technical requirements to be addressed by small power producers and owners of co-generation units during the preliminary design of such installations. As such, they are not to be construed as a final and complete list of requirements which the applicant for an interconnection agreement will have to satisfy. Other requirements may need to be met by the owner of the generation project to ensure the final connection design meets all codes and required studies.

B. INTERCONNECTION PROCESSES

1. Vermont Public Service Board (PSB) Rule 5.500

The Interconnection Procedures and Application form in PSB Rule 5.500 are generally used for all proposed interconnections of generation resources over 150 KW with BED's distribution system that "are not (i) lawfully subject to ISO-NE interconnection rules or successor rules approved by FERC, or (ii) subject to the Board's net metering rule (Rule 5.100), for which the interconnection provisions of those rules will govern."

2. Vermont Public Service Board (PSB) Rule 5.100

PSB net metering Rule 5.100 establishes "the standards and procedures governing application for, and issuance or revocation of, a certificate of public good for net metering systems under the provisions of 30 V.S.A §§ 219a, 219b and 248. This rule also incorporates the technical specifications related to interconnection requirements and safety standards for net metering systems." The application form to Rule 5.500 is submitted to the Public Service Board and also to BED.

C. TECHNICAL REQUIREMENTS GOAL

The following minimum technical requirements define operating parameters and procedures for third-party generation connected in parallel with the Burlington Electric Department (BED) 13.8 kV distribution system. They were drafted with the intent of:

- ensuring no degradation of electrical service to BED customers;
- ensuring the safety of BED's personnel and contractor working on the distribution system;
- Protect and minimize the possible damage to the BED's electrical system and other customers' property; and
- Ensure the safety of utility customers and the general public.

Capitalized terms herein shall have the same meaning as ascribed to them in the Generation Interconnection Agreement. To the extent of any inconsistency between the terms of the Generation Interconnection Agreement and these Technical Requirements, the terms of the Generation Interconnection Agreement shall control.

D. GENERATOR INTERCONNECTION REQUIREMENTS

This section defines the minimum technical requirements for the electrical interconnection between the generation system and BED's distribution system. The applicant is responsible for providing protection for the generation system. The generation system protection is not provided in this Technical requirement. BED doesn't assume responsibility for protection of the generation system equipment.

The generation system and the electrical interconnection protection scheme shall automatically disconnect the generator from BED's electrical system in the event of a fault or other system abnormality.

1. Electrical Code Compliance

The generation interconnection applicant shall be responsible for complying with all applicable local, state, and federal codes such as National Electric Code (NEC), and National Electrical Safety Code (NESC).

The generation interconnection system and installation shall comply with the latest version standard of IEEE Std C37.90.1-2002, IEEE Std C37.90.2-1995, IEEE Std 1547, IEEE Std 1547.1, and UL1741.

2. Voltage Level

The primary voltage level at the Point of Interconnection shall be continuously monitored. Note: BED's nominal distribution system primary voltage is 13.8 kV. The Facility shall not actively regulate the voltage at the Point of Common Coupling. The Facility shall be operated in a manner that the voltage levels on BED's electrical system are in the same range as if the Facility was not connected to BED's electrical system. The Facility installation shall not cause BED's service at other customer locations to go outside the requirement of ANSI C84.1-1995 Range A.

The Facility's interconnection protection shall disconnect the Facility from BED's electrical system based on generator size, type, and set points per IEEE Std 1547-2003. Clearing time is the time between the start of the abnormal condition and the Facility ceasing to energize BED's electrical system. For a generator less than or equal to 30 KW in peak capacity, the voltage set point and clearing time shall be either fixed or field adjustable. For a generator greater than 30 KW, the voltage set point and clearing time shall be field adjustable and approved by BED.

Table 1- Interconnection system response to abnormal voltages (IEEE Std 1547-2003)

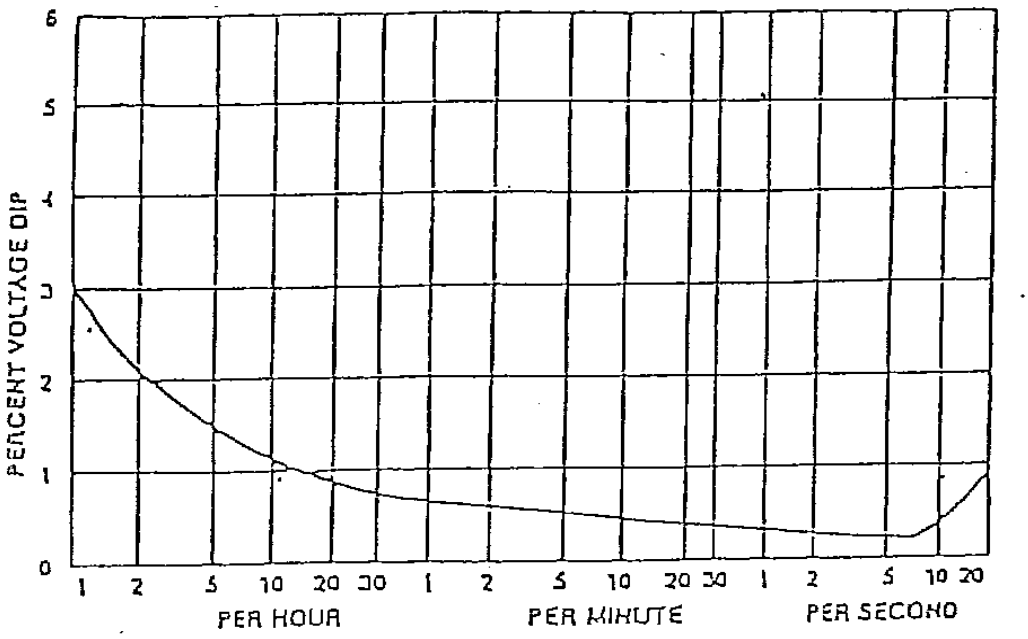
Voltage Range (% of base voltage[a])	Clearing Time(s)[b]
V< 50	0.16
50 ≤ V <88	2.00
110 < V < 120	1.00
V ≥ 120	0.16

a) Base voltages are the nominal system voltages stated in ANSI C84.1-1995, Table 1.
b) Generator ≤ 30 KW, maximum clearing times; Generator > 30 KW, default clearing time.

After a voltage disturbance, no reconnection of the Facility shall take place until the voltage at the Point of Common Coupling is within Range B of ANSI C84.1-1995, Table 1. The interconnection system shall include a fixed delay of 5 minutes for generator ≤ 30 KW and an adjustable delay up to 5 minutes for generator > 30 KW that delay reconnection up to 5 minutes after the steady state voltage and frequency are restored to the ranges identified in Table 1 and Table 2.

3. Voltage Flicker

BED has adopted a "point of irritation" for flicker which is dependent upon both the frequency and magnitude of the flicker. A graphic representation of this standard is shown in the following figure:



Frequency of Occurrence

Any voltage flicker at the Point of Common Coupling caused by the generating facility shall not exceed the limits defined by the "point of irritation" curve shown above identified in IEEE Std 519-1992 (IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems). Compliance with the "point of irritation" does not absolve the generation interconnection applicant from the burden of modifying the installation should the installation be identified as the source of voltage flicker. Speed matching of induction generators (within 1%), proper synchronization/voltage matching of synchronous generators (within 10 electrical degree and a few percent voltage magnitude) and soft-start of inverters are means to help reduce voltage flicker impacts on distribution circuits at the moment of interconnection and should be employed to reduce flicker impacts.

C1. Generation Disconnection Voltage Flicker: A distributed resource shall not cause more than a 3% change in the primary voltage at the Point of Common Coupling (PCC) for a 100% loss of its rated output.

C2. Single Phase Generator Voltage Imbalance: Single phase generators shall not cause a voltage unbalance exceeding 3% on BED's three phase interconnecting circuit (ANSI C84.1).

4. Power Factor

Generating systems shall be designed to be capable of operating with power factor between 0.95 lagging and 0.95 leading. Generators shall normally be operated near unity power factor (+/- 0.98) or as mutually agreed upon between BED and Applicant.

5. Frequency

All DG facilities are to operate at a nominal frequency of 60Hz. All DG Facilities are also responsible to comply with IEEE 1547 and provide two levels of underfrequency protection and one or more levels of overfrequency protection. Underfrequency set point and clearing times are not permitted above the curve in Figure 1 in order to comply with PRC-006-NPCC-1 Requirement 13 on generator underfrequency settings. The Facility interconnection protection shall disconnect the Facility from the distribution system should the frequency fall outside the range with clearing time given in Table 2 below (IEEE Std 1547-2003):

Figure 1
Standards for setting underfrequency trip protection for generators

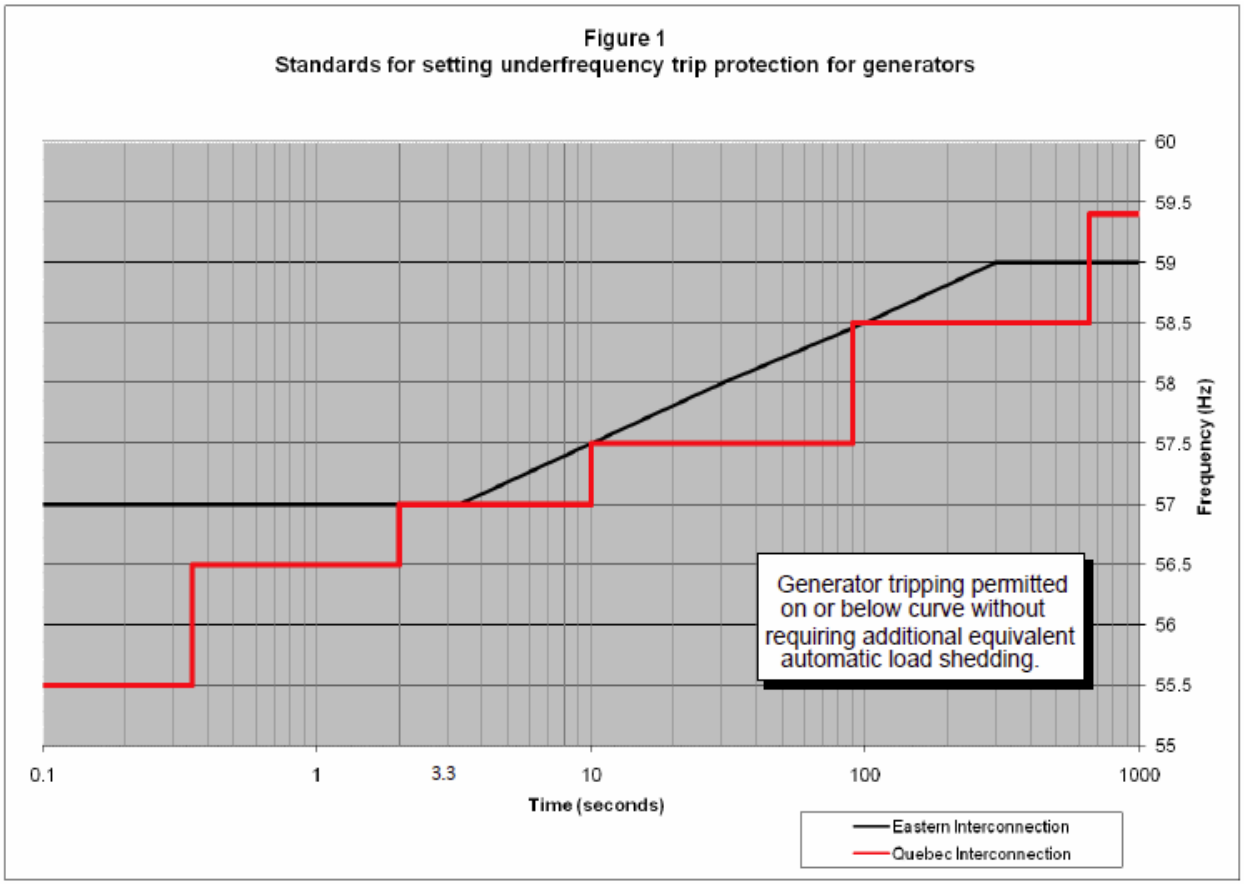


Table 2- Interconnection system response to abnormal frequencies (IEEE Std 1547-2003)

Generator Size	Frequency range (Hz)	Clearing time(s)[a]
≤ 30kW	>60.5	0.16
	<59.3	0.16
>30kW	>60.5	0.16
	<{59.8 – 57.0} (adjustable set point)	Adjustable 0.16 to 300
	<57	0.16

[a]Generator ≤ 30 KW, maximum clearing times; Generator > 30 KW, default clearing times.

Clearing time is the time between the start of the abnormal condition and the Facility ceasing to energize BED's electrical system. For a Facility greater than 30 KW, the frequency set points shall be field adjustable. Adjustable under-frequency trip settings shall be coordinated with BED. The disconnection shall take place within a time interval which will be specified by BED after completion of engineering studies. After a frequency disturbance, no reconnection of the Facility shall take place until the voltage is within Range B of ANSI C84.1-1995 Table 1 and frequency range of 59.3 Hz to 60.5 Hz for generator ≤ 30 KW and frequency range of 59.8 Hz to 60.5 Hz for generator > 30 KW. The interconnection system shall include an adjustable delay (or a fixed delay of five minutes) to delay reconnection after the steady state frequency is restored to the ranges identified Table 1 and Table 2. Larger sized generators will include adjustable delay.

6. Harmonics

Per IEEE Std 1547-2003, harmonic current injection into the BED system at the Point of Interconnection between BED and the Facility shall not exceed the limits stated below in Table 3. The harmonic current injections shall be exclusive of any harmonic currents due to harmonic voltage distortion present in the BED system without the generator(s) connected.

Table 3 – Maximum harmonic current distortion in percent of current (I)[a]

Individual harmonic order h (odd harmonics)[b]	h<11	11≤ h <17	17≤h<23	23≤h<35	35≤h	Total demand distortion (TDD)
Percent (%)	4.0	2.0	1.5	0.6	0.3	5.0

[a]I = the greater of the BED system maximum load current integrated demand (15 or 30 minutes) without the generator unit, or the generator (s) unit rated current capacity (transformed to the PCC when a transformer exists between the generator unit and the PCC (IEEE Std 1547-2003).

[b]Even harmonics are limited to 25% of the odd harmonic limits above (IEEE Std 1547-2004).

7. Transformer & Grounding

BED's distribution system is a four wire multi-grounded system. BED's nominal primary distribution system voltage is 13.8/7.967 KV. The Facility shall be effectively grounded where the positive sequence reactance is greater than the zero sequence resistance (X1 > R0) and the zero sequence reactance is less than three times the positive sequence reactance (3 X1 > X0). For a three phase Facility connected to BED's system, the transformer should be grounded Y-Y.

8. Dedicated Transformer

A dedicated transformer shall be required for all facilities larger than 150kW. A dedicated transformer shall also be required where the Facility is served from the same transformer as another customer with sensitive load. In addition, a dedicated transformer or other current-limiting device shall be installed for any type of Facility installation where the increase in available short circuit current could adversely impact other customers on the same secondary circuit.

9. Underwriters Laboratories (UL) & National Electric Code (NEC) requirements

Generation installations using Inverters for interconnection with BED's electrical system must use UL listed non-islanding type inverters. The installation of the generator and its facilities shall be in accordance with applicable NEC requirements.

10. Disconnect Switch

The Facility shall provide an approved, visible, lockable, load break disconnect switch adequate to provide safe working clearance for BED personnel. It shall be accessible to and available for control by BED personnel at all times. When BED has operated the disconnect device, the FACILITY SHALL NOT OPERATE the device without prior approval from the BED representative designated on the tag attached to the disconnect device. For a facility larger than 150 KW, loadbreak switch capable of responding to an external trip signal to disconnect the generation equipment from the BED's electrical system is required.

11. Circuit Breaker

The Facility shall provide a circuit breaker that is capable of interrupting the maximum fault current available at the breaker's location from BED's electrical system and from the Facility. The circuit breaker shall be equipped with an approved stored-energy tripping device. For a facility larger than 500 KW, circuit breaker or recloser capable of responding to an external trip signal to disconnect the generation equipment from the BED's electrical system is required.

12. SCADA Control/Indication

For a Facility larger than 150 KW, a SCADA remote terminal unit shall be supplied by BED. However, the applicant shall bear the cost of the unit and the installation cost. The remote terminal unit shall monitor the output of the generator and status points which indicate the condition of the generator breaker. The unit shall also provide remote tripping control to BED's dispatcher.

13. Direct Transfer Trip (DTT)

For a large sized Facility, BED may require the installation of a direct transfer trip. The Applicant shall bear the cost of installing a communication channel between the generator and a BED substation. This channel will allow remote direct transfer trip by BED. The communication channel will be detailed by BED after completion of system studies.

14. Fault Clearing

Protection equipment shall be provided to clear all faults. The equipment shall conform to BED supplied current settings, time-current curves and instantaneous trip settings. Protection equipment shall meet ANSI C37.90 requirements.

15. Protective Relays

Imbedded electronic controls or microprocessor-based relays are suitable in lieu of utility grade relays for the functions below as long as they satisfy IEEE P929 and UL1741 requirements.

1. Over/Under Voltage Relays: The Facility shall provide utility grade, over voltage (59) and under voltage (27) relays. These relays shall cover all three phases in a three phase installation and capable of tripping the circuit breaker when the voltage is not within the specifications in section 1, above.

2. Over/Under Frequency: The Facility shall provide utility grade, over frequency (81/O) and under frequency (81/U) relays capable of tripping the circuit breaker when the frequency is not within the specifications in section 4, above.

3. Unbalanced Fault Protection (Three Phase Generation): The Facility shall provide a means of detecting an unbalanced fault condition on BED's electric system using utility grade relay and associated equipment, and the ability for tripping the generation circuit breaker when such a fault occurs. The relay should be capable of detecting one of the following:

    a) Magnitude difference between the three phase currents.
    b) The presence of negative sequence current.
    c) The presence of negative sequence voltage.
    d) Overcurrent Relays (50, 51, & 51G)
    e) Synchronization Relays
    f) Additional Required Relays

16. Anti-Islanding

A Facility shall not be allowed to island with a portion of BED's distribution system. The facility anti-islanding protection shall detect the island and cease to energize BED's distribution system within two seconds of the formation of an island (IEEE Std 1547). For a large Facility where the impact of islanding could affect a large number of customers, the application of transfer trip operation over a communication medium is recommended.

17. Automatic Reclosing

The Facility shall be responsible for protecting his/her equipment from the effect of switching or automatic reclosing of BED's circuits. BED has at least one aerial microprocessor recloser on each circuit.

18. Protection for Faults on Generator Facilities

The Facility shall be responsible for providing protection for faults on its generating and interconnection equipment.

19. Other Protection Requirement

The Facility shall be responsible for protecting its generating and interconnection equipment in such a manner that BED system outages, short circuits, single phasing conditions, or other disturbances including zero sequence currents and Ferro-resonant over-voltage do not damage the Facility's generating and interconnection equipment.

20. Metering

BED shall install, at the Facility's expense, bi-directional metering equipment adequate to accurately measure and record energy received and/or delivered by the Facility to BED's electric system. The installed metering arrangement, including telephone line connection to be supplied by the Facility, must comply with all communication requirements as specified in the Interconnection Agreement and allow the remote interrogation of the meter by BED.