

BEDFORD ELECTRIC DEPARTMENT

**INTERCONNECTION REQUIREMENTS FOR NEW DISTRIBUTED
GENERATORS, CONNECTED IN PARALLEL WITH PRIMARY DISTRIBUTION
CIRCUITS AND CUSTOMER SECONDARY SERVICES**

**ANY FORM OF CUSTOMER OWNED GENERATION
INTERCONNECTED WITH THE BEDFORD ELECTRIC
DEPARTMENT (BED) MUST COMPLY WITH THE APPLICATION
PROCESS HEREIN, BE REVIEWED BY, BED AND RECEIVE THE
EXPRESSED CONSENT OF BED IN WRITING WITH AN
APPROVED APPLICATION BEFORE ANY INTERCONNECTION
AND PARALLEL OPERATION BEGINS**

DECEMBER 1, 2017

**Generation that cannot operate in parallel with BED
is not subject to these requirements but requires a site specific
interconnection agreement.**



Table of Contents

1. General
2. Scope
3. Application Process
4. Standardized Interconnection Requirements (SIR)
 - 4.1. Design Requirements
 - 4.1.1. Common
 - 4.1.2. Synchronous Generators
 - 4.1.3. Induction Generators
 - 4.1.4. DC Inverters
 - 4.1.5. Inductive Generators
 - 4.1.6. DC to AC Inversion Systems
 - 4.3. Grounding
 - 4.4. Operating Requirements
 - 4.5. Dedicated Transformer
 - 4.6. Disconnect Switch or Device
 - 4.7. Power Quality
 - 4.8. Power Factor Correction
 - 4.9. Stand Alone Islanding
 - 4.10. Required Testing of Distributed Generation Systems
 - 4.10.1. Type Testing
 - 4.10.2. Verification Testing
 - 4.11. BED Back-up or Stand-by Power and Capacity
 - 4.12. Interconnection to Primary and Secondary Network Distribution System
5. Insurance Requirements

Appendix A - Glossary of Terms

Appendix B - Application Form for Wind / Photovoltaic 5 kW or Less

Appendix C - Application Form for all other Installations

Appendix D - Examples of Disconnect Switch Warning Tags

Appendix E – Reference & Construction Standards

Authorized by:

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1.0 General

This document standardizes the technical requirements for interconnection of Distributed Generation (DG) equipment to the Bedford Electric Department (BED) Distribution facilities in all sizes to a maximum of 50 kW. After BED reaches 500 kW of distributed generation connected to its electric system, additional distributed generation will no longer be accepted. Customer Net Metering is available in the BED service territory. Bedford does not bank or buy excess energy. See the metering section for more detail.

Generation not operating in parallel, i.e. isolated from BED grid, does not qualify for interconnection under these terms.

2.0 Scope

This set of interconnection requirements defines the application process, technical interconnection requirements and agreement elements for interconnecting new distributed generation facilities to **Sub-transmission Circuits, Primary Distribution Circuits and to Customer Secondary Services**.¹ This document addresses only those points in which the customer, developer, operator, equipment manufacturer and the utilities have a mutual interest and is primarily directed toward the safety aspects of the interconnected distributed generator.

The Distributed Generator may also need to get approval from other entities, including but not limited to Bedford County, Town of Bedford, PJM Interconnection, American Electric Power (AEP), Virginia Department of Environmental Quality (VADEQ), and the Federal Energy Regulatory Commission (FERC) depending on size and power export plan. This document does not address the policies and procedures of any organization outside of BED.

¹ See Glossary for definition.

3.0 Application Process

Key Steps in the Application Process for the Interconnection of New Distributed Generation Connected to Primary Distribution Circuits and to Customer Secondary Services Operating in Parallel with the BED Grid. (General Guidelines)

Application Process

STEP 1 - Initial Communication from the Applicant.

Communication will range from a general inquiry to a completed application. The applicant should supply as much technical information as possible.

Applications for small residential, commercial or industrial distributed generation systems less than 5 kW shall strictly adhere to the requirements outlined in the National Electrical Code NFPA-70-1999 and list all proposed equipment .

Applications for all commercial or industrial distributed generation systems greater than 5 kW shall strictly adhere to the requirements outlined in the National Electrical Code NFPA-70-2017 where applicable, the National Electrical Safety Code IEEE C2-2017, include a listing of all proposed equipment and include a one line control /interconnection diagram signed and sealed by a licensed Virginia Professional Engineer.

STEP 1A Expedited Application Process for Installations 5 kW or Less.

- 1) Prior to installation the system (5 kW or less), applicants must submit a fully completed first page of the Application (see Appendix B) to BED,
- 2) After BED receives the completed application and conducts the appropriate review, it will inform the applicant if it can proceed with the interconnection, or if a more detailed interconnection study is required (see Step 4 below).
- 3) After the applicant has received permission to interconnect from BED, has completed the installation and has received the appropriate municipal inspection, the applicant must submit a fully completed and signed application (all pages) to BED. This application must include the signature of the local inspection official, or a copy of the approved municipal inspection certificate.
- 4) The following sections apply to 5 kW or less installations:
 - a. **4.2 Metering**
 - b. **4.3 Grounding**
 - c. **4.6 Disconnect switch or device**
 - d. **4.7 Power Quality**
 - e. **4.10.1 A Compliance with IEEE 929-2000**
 - f. **4.10.2 Verification Testing**
 - g. **4.12 Connections to Network Systems**

STEP 2 - The Inquiry is reviewed by BED to Determine the Nature of the Project.

A BED representative shall discuss the scope of the project with the potential applicant (either by phone or in person) to determine what specific information and documents (such as an application, agreement, technical requirements, specifications, listing of qualified Type tested equipment/systems, application fee information, applicable rate schedules and metering requirements) will be required by the applicant. The preliminary technical feasibility of the project at the proposed location may also be discussed at this time. All such information, and a copy of this application, will be sent to the applicant in no more than twenty (20) business days following the initial communication from the applicant. A BED representative will serve as the single point of contact for the applicant in coordinating the project.

STEP 3 - Filing an Application

Applicants for wind or solar photovoltaic installations of 5 kW and less must file an application in the form of **Appendix B** as described in Step 1A. Applicants for wind or solar photovoltaic installations greater than 5 kW, and all other proposed installations, shall file an application in the form of **Appendix C**. The filing must include a completed application form and/or other information as indicated in **STEP 2**. Within thirty (30) business days of receiving the application, BED will notify the applicant of receipt and whether the application has been completed adequately. Several exchanges of information between BED and applicant might occur until the application has been completed according to BED's technical requirements for interconnection. BED will review all applications over 5 kW and may restrict systems sized over 5 kW due to available distribution feeder capacity. BED feeder sizing prohibits installations above 50 kW or those installations that represent, along with all distributed generation on the circuit where the applicant proposes to install the distributed generation that have a capacity rating of greater than 1/4 of the circuit load. The total system wide amount of distributed generation BED will accept is 500 kW.

STEP 4 . Preliminary Coordinated Interconnection Review and Cost Estimate Development

Upon completion of the application, BED will conduct a preliminary Coordinated Interconnection Review³ and will inform the applicant of any necessary BED system additions/modifications, and of any agreement requirements which BED may require for interconnection. Applicant will be provided with an assessment of the technical feasibility of the proposed interconnection, a preliminary schedule, and a good faith, detailed estimate of the interconnection costs, if applicable agreement elements might include a parallel interconnection agreement, coverage of interconnection costs, agreement to tariff conditions, requirements for design, and O&M specifications.

³See Glossary for definition

Depending on unit size, export capability, and or circuit characteristics, a full Coordinated Interconnection Review may need to be performed by BED to determine if the new generation on the circuit results in any relay coordination, fault current, and/or voltage regulation problems.

A full Coordinated Interconnection Review may not be needed if:

- The aggregate generation is less than 5 kW on a single-phase branch of a distribution circuit; or
- The proposed installation is not interconnected to a Network System; or
- The proposed generator has no power export capability.

Note: Units without export capability must either be sized for 50% or less of peak facility demand (or average energy consumption) or be equipped with Reverse Power Relays to prevent power export into the BED System.

Framework for Standardized Interconnection Study Costs for systems that do not meet the criteria outlined above:

The following are "standardized" study costs for customers seeking to interconnect systems to BED's Electric Distribution System, when such Distributed Generation systems (individually or in aggregate) meet the criteria specified below. These charges would be in addition to any application fee.

1) For requests to interconnect (i) single phase systems on single phase branches where the total aggregate generation is greater than 5 kW, or (ii) single phase and 3 phase systems on 3 phase feeders where the total aggregate generation is greater than 50 kW but less than or equal to 100 kW, the study cost may be up to, but not exceed, the cost of 3 man-days of study labor at the current BED loaded labor rate.

As an example, for BED this cost would not exceed \$2,880 (based on the current loaded labor rate). These charges will be based on actual time incurred up to the maximum cost.

2) Requests to interconnect any generation over 100 kW will be individual quoted.

STEP 5 - Applicant Commits to BED's Coordinated Interconnection Review of the Project Design.

If discussions with the applicant, review of the application or review of the proposed design indicate a major impact on the interconnected BED facilities.

The applicant will be required to:

- Provide BED with a cost-based advance payment for the BED review of the proposed generator.
- Submit a detailed design package.
- Confirm with BED a mutually agreeable schedule for the project based on the applicant's work plans and the discussions held in **STEP 4**.

Additional exchanges of information between BED and the applicant may be

required to complete the design package according to BED's technical requirements for interconnection.

STEP 6 – BED Review of Applicant's Design Package

BED will:

Conduct a review of the design package to ensure that the plans / design satisfy the technical requirements for interconnection.

Upon completion of the review, notify the applicant of its final acceptance of the applicant's design **or** an explanation of the technical requirements the design fails to meet. In addition, this notice will include any site-specific test requirements applicable to **STEP 9**.

For Type tested systems, BED will complete its review in ninety (90) days.

STEP 7 - Applicant Commits to BED Construction of BED's System Modifications

The applicant will:

- Execute a standardized interconnection agreement or commit in writing to the applicable tariff requirements; and
- Provide BED with an advance payment for BED's estimated costs associated with system modifications, metering, and on site verification. (Estimated costs will be reconciled with actual costs in **Step 11**.)

STEP 8 - Project Construction

The Applicant's facility will be constructed in accordance with BED accepted design. BED will commence construction/installation of system modifications and metering requirements.

BED system modifications will vary in construction time depending on the extent of work and equipment required. The schedule for this work is to be discussed with the applicant in **STEP 5**.

STEP 9 - The Testing of the Applicant's Facility in Accordance With BED's Technical Requirements.

The applicant will develop a written testing plan to be submitted to BED for review and acceptance. This testing plan will be designed to verify compliance of the facility with the applicant's BED accepted drawings and details of the interconnection. The final testing will include testing in accordance with the SIR and the site-specific requirements identified by BED in **STEP 6**. The final testing will be conducted at a mutually agreeable time, and BED shall be given the opportunity to witness the tests.

STEP 10 - Interconnection

The applicant's facility will be allowed to commence parallel operation upon satisfactory completion of the tests in **STEP 9**. In addition, the applicant must have complied with BED's contractual, tariff, and/or technical requirements.

STEP 11 - Final Acceptance and BED Cost Reconciliation

Within 30 days after interconnection, BED will review the results of its on-site verification and issue to the applicant a formal letter of acceptance for interconnection. BED will also reconcile its actual costs related to the applicant's project against the application fee and advance payments made by the applicant. The applicant will receive either a bill for any balance due or a reimbursement for overpayment as determined by BED's reconciliation.

Commercial operation of the customer's generator will begin after balance due is paid to BED or overpayment is refunded to applicant. Failure of the customer to begin construction within one (1) year of receiving BED letter of acceptance will cause interconnection approval to be revoked and queue position to be forfeited.

4.0 Standardized Interconnection Requirements (SIR)

4.1.1 Common

The generator-owner shall provide appropriate protection and control equipment, including **an interrupting device, that will disconnect**⁴ the generator in the event that the portion of BED system that serves the generator is de-energized for any reason or for a fault in the generator-owner's system. The generator owner's protection and control equipment shall be capable of disconnecting the generation upon detection of an **Islanding**⁵ condition and upon detection of a BED system fault.

Note: For certain generators without export capability, Reverse Power Relays must be used to prevent export. These Reverse Power Relays will also effectively prevent any possibility of **Islanding**.

The generator-owner's protection and control scheme shall be designed to allow the generation, at steady state, to operate only within the limits specified in this proposal for frequency and voltage. Upon request from BED, the generator-owner shall provide documentation detailing compliance with the requirements set forth in this proposal.

The specific design of the protection, control and grounding schemes will depend on the size and characteristics of the generator. In addition the facility load level and the characteristics of the particular portion of BED's system where the generator-owner is interconnected must also be considered.

Note: Additional Islanding protection or Interrupting devices are NOT required for installation of <5 kW units that are compliant to IEEE 929-2000.

4.1.2 Single Phase and Three Phase Generators and Inverters with an aggregate capacity of 100 kW and Less

The generator-owner shall have, as a minimum, an interrupting device(s) sized to meet all applicable local, state and federal codes and operated by over and under voltage protection (installed in each phase and wired phase to ground), as well as additional loss of phase protection. The interrupting device(s) shall also be operated by over and under frequency protection.

- The interrupting device shall automatically initiate a disconnect sequence from BED system within six (6) cycles if the voltage falls below 60 V RMS phase to ground (nominal 120 V RMS base) on any phase.

⁴See Glossary for definition

⁵See Glossary for definition

- The interrupting device shall automatically initiate a disconnect sequence from BED system within two (2) seconds if the voltage rises above 132 V RMS phase to ground or falls below 104 V RMS phase to ground (nominal 120 V RMS base) on any phase.
- The interrupting device shall automatically initiate a disconnect sequence from BED system within two (2) cycles if the voltage rises above 165 V RMS phase to ground (nominal 120V RMS base) on any phase.
- The interrupting device shall automatically initiate a disconnect sequence from BED system within six (6) cycles if the frequency rises above 60.3 Hz or falls below 59.3 Hz.

4.1.3 Three-Phase Inverters and Generators with an Aggregate Capacity of 100 kW and Greater

Distributed Generators with an aggregate capacity greater than 100 kW shall utilize special voltage and frequency settings to adhere to Pennsylvania, New Jersey, Maryland (PJM) interconnection requirements and BED system requirements. The use of Multi-Function Micro-processor based protective relays will require utilization of a second unit for back-up. Further, these distributed generators shall limit operation to 98.5% leading or lagging power factor (pf) or better.

Voltage sensing shall be three phase line to line with a protective relay or internal element on each line to line voltage. The secondary line to line voltage maybe either 120 Volts or 208 Volts, the Distributed Generator shall utilize appropriate relays whose range shall match that of the secondary line to line voltage.

- **Undervoltage** - 3 phase line to line. Pick-up at 90% nominal with a 5second trip at 0% nominal.
- **Oversupply** - 3 phase line to line. Pick-up at 110% nominal with a 10cycle trip at 120% nominal.
- **Under Frequency** * - 5 second delayed trip if frequency is less than 57.5Hz. (PJM requirement) It may be necessary to use an external time delay relay to achieve the desired 5 second delay.
- **Over Frequency** - 10 cycle delayed trip if frequency exceeds 60.5 Hz.
- **Directional Power** * - If the Applicants installation will not export power into the BED system, it shall be equipped with a Directional power relay. In order to avoid unnecessary operations during faults on the Distribution system the Directional power relay should be equipped with a 5 second time delay relay.

* Note: BED operational and maintenance procedures may require the ability to by-pass and physically block the time delays associated with Under Frequency and Directional Power during "Live Line" maintenance. BED personnel shall have reasonable access to the DG facility to by-pass and block the time delays and temporarily place these devices on instantaneous operation.

The need for additional protection equipment shall be determined by BED on a

case-by-case basis. BED shall specify and provide settings for those relays that BED designates as being required to satisfy protection practices. Any protective equipment or setting specified by BED shall not be changed or modified at any time by the generator-owner without written consent from BED.

To avoid out-of-phase reclosing, the design of the generator-owner's protection and control scheme shall take into account the BED practice of automatically reclosing the feeder without synchronism check after being tripped. Before the distributed Generation device is re-connected to the system after a Trip, the control system shall wait five (5) minutes after normal system conditions are re-established.

The generator-owner shall be responsible for ongoing compliance with all applicable local, state and federal codes and BED system design and operating changes as they pertain to the interconnection of the generating equipment.

Protection circuitry, potential and current sensing shall not be connected with BED revenue metering.

A failure of the generator-owner's interconnection protection equipment, including loss of control power, shall open the interrupting device, thus disconnecting the generation from BED system. A generator-owner's protection equipment shall utilize a non-volatile memory design such that a loss of internal or external control power, including batteries, will not cause a loss of interconnection protection functions including all pickup set points.

All interface protection and control equipment shall operate as specified independent of the calendar date.

4.1.4 Synchronous Generators

Synchronous generators shall require synchronizing facilities. These shall include automatic synchronizing equipment or manual synchronizing with relay supervision, voltage regulator and power factor control. Synchronous generators shall normally require the below listed minimum protective equipment:

- 1) Directional Power Relay . ANSI device # 32**, Single phase sensing .Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover. **Note:** The directional power relay is used in those systems without export capability.
- 2) Reverse VAR Relay . ANSI device # 40**, Acts as a loss of excitation relay, single phase sensing. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.
- 3) Current Balance Relay . ANSI device # 46**, three phase sensing. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.
- 4) Over Voltage Relay . ANSI device # 59**, single phase sensing. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.
- 5) Phase Sequence / Under Voltage Relay . ANSI device # 47 / 27**, three

phase sensing. This relay protects both the Distributed Generator and the BED circuit from either loss of BED power and or fault during parallel operation.

Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.

6) Over / Under Frequency Relay . ANSI device # 81 O/U, single phase sensing, with settings for over and under frequency the time delays adjustable in cycles. This relay protects both the Distributed Generator and the BED circuit from either loss of BED power and or fault during parallel operation. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.

7) Generator Overcurrent, time and instantaneous . ANSI device # 50 / 51, 3 phase sensing. This relay protects both the Distributed Generator and the BED circuit from either loss of BED power and or fault during parallel operation. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.

8) Ground Overcurrent - ANSI device 51G, includes a grounding and current sensing system mounted in the generator neutral / ground lead. Activation of this relay causes immediate tripping of the generator breaker and immediate shutdown of the engine / prime mover.

9) Automatic Lock Out Relay w/ manual reset . ANSI device # 86, all generator electrical protective devices shall actuate an electrically operated / manual reset lock out relay. This lockout relay shall be a high speed tripping grade device that trips and blocks closing of the generator circuit breaker. Manual reset can be accomplished only after all protective trips have been cleared.

10) Auxiliary Trip Input . The Distributed Generator shall be equipped with an auxiliary trip input to be used by BED, if required, to initiate a **Direct Transfer Trip (DTT)**⁶ (See last paragraph of Section 4.2).

11) Surge Arrestors . All three phases of the load side of the Distributed Generator circuit breaker shall be equipped with metal oxide type surge arrestors. These arrestors shall be sized in accordance with accepted standards to the appropriate maximum BED interconnection circuit voltage.

Note: Protective functions 1 through 8 may be accomplished with either discrete devices or with a multifunction device. Depending on the size of the Distributed Generator and / or types of protective devices used, the Applicant may be required to provide a level of redundancy for safety. Also the Applicant should be aware that the listed minimum protective functions are designed to primarily protect BED personnel and circuits, and that total protection of the applicants' equipment may require additional protective functionality.

4.1.5 Induction Generators

Induction Generation may be connected and brought up to synchronous speed (as an induction motor) if it can be demonstrated that the initial voltage drop measured at the point of common coupling is acceptable based on current inrush

⁶ See Glossary for definition

limits. Generally, Induction Generators greater than 100 kW shall not be allowed to be brought up to speed as an Induction Motor, without specific BED review and approval. The same requirements also apply to Induction Generation connected at or near synchronous speed because a similar voltage dip is present due to an inrush magnetizing current. The generator-owner shall submit number of starts per specific time period and maximum starting KVA draw data for BED to verify that the voltage dip due to starting is within the visible flicker limits as defined by IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems (IEEE519)".

Starting or rapid load fluctuations on Induction Generators can adversely impact BED's system voltage. Corrective step-switched capacitors or other techniques may be necessary. These measures can, in turn, cause ferro-resonance. If these measures (additional capacitors) are installed on the customer's side of the **Point of Common Coupling**⁷, BED will review these measures and may require the customer to install additional switching equipment. In all cases where Induction Generators are deployed it shall be the owners' responsibility to supply the necessary VAR requirements of the Induction Generator so that the total Power Factor as seen by BED at the Point of Common Coupling is better than .85 lagging with the customer importing power from BED. If a "Purchased Electric Power" agreement (See the BED Tariff for Electric Service) is in effect, during those periods that the customer is exporting excess power into the BED system, the Power Factor as seen by BED at the Point of Common Coupling shall be Unity or up to .9 Leading. **Also see Section 4.8**

4.1.6 DC to AC Inversion Systems

Direct current generation (Fuel Cells, Photovoltaics and even high frequency Permanent Magnet Generators) can only be installed in parallel with BED's distribution system using a synchronous inverter for power conversion and conditioning. The design of the inverter shall be such as to disconnect this synchronous inverter from the BED distribution system upon a BED system interruption. Line-commutated inverters do not require synchronizing equipment if the voltage drop is determined to be acceptable, as defined in Section 4.5, Power Quality, of this document. Self-commutated inverters with external frequency sensing can be used to synchronize to BED. Stand-alone, self-commutated inverters with internal frequency references shall not be used for parallel operation with the BED system.

4.2 Metering

The need for additional metering or modifications to existing metering will be reviewed on a case-by-case basis and shall be consistent with BED metering requirements. Customer is responsible for any incremental metering costs. Bedford does not buy or bank excess energy. Customer's production may offset usage only.

⁷See Glossary for definition.

4.3 Grounding, Neutrals, & Service Compatibility

All Distributed Generation connected to the BED Distribution and Sub-Transmission System shall meet the grounding requirements and the physical electrical characteristics of the system to which the DG is connected. Direct Physical connections of shall meet the criteria listed below Qualified units 5 kW or less do not need to meet the physical interconnection criteria outlined below. In many cases especially at the Primary and Sub-Transmission level, due to either limitations in generator single phase to ground short circuit duty (impedance grounding) and or generator terminal voltage, a two winding interface transformer will be required. Before proceeding with equipment purchase the DG applicant must have the proposed system reviewed by BED for physical interconnection suitability.

Also see Section 4.5 - Dedicated Transformer.

- **SECONDARY SERVICE INTERCONNECTIONS**
- Single Phase 120 VAC devices shall have one leg solidly connected to the system neutral which is solidly grounded.
- Single Phase 240 VAC devices shall have center point neutral solidly ground referenced. If the device generates at 240 VAC and does not have a ground referenced center point neutral, the device will be connected to the grounded system through a 2 winding transformer whose Primary (generator side) is 2 wire 240 VAC and whose Secondary (BED System side) is 240 VAC 3 wire with a grounded center point Neutral. Exception will be made for units 5 kW or less that generate at 240 VAC 2 wire and do not have a grounded neutral reference.

3 Phase . 120 / 208 VAC & 277 /480 VAC, WYE connected, neutral solidly connected to ground with balanced electrical output. DELTA connected induction generators directly interconnected to 4 wire WYE services shall require a DELTA /WYE transformer. DELTA connected induction generators directly connected to 240 VAC open or closed DELTA services may be connected without the use of an interface transformer. One or more single phase inverters producing a total output of 5 kW or less may be interconnected as a single phase device to a 3 phase system or in a 3 phase open DELTA configuration. If the total output of any qualified system interconnected to a 4 wire, 3 phase service exceeds 5

kW, that system shall be connected as a 4 wire, 3 phase balanced system.

PRIMARY SERVICE INTERCONNECTIONS

- 3 Phase - 2,400 / 4,160 VAC & 7,620/13,200 VAC, WYE connected, neutral solidly connected to ground. This application may require a dedicated interface transformer. Impedance grounded generators cannot be directly connected to these systems without an interface transformer.
- All interconnections at 69,000 VAC and above, are major complex applications that will require a full BED, AEP interconnection / PJM coordination study.

4.4 Operating Requirements (Does not apply to Qualified units that are 5 kW or less)

The generator-owner shall provide a 24-hour telephone contact(s). This contact will be used by BED to arrange access for repairs, inspection or emergencies. BED will make such arrangements (except for emergencies) during normal business hours. The generator-owner shall not be connected or export power to the BED system during any outages of the feed that serves the Point of Common Coupling. The applicant's generation may be operated during such outages only with an open tie to BED. Islanding will not be permitted under any circumstance.

The generator must be equipped with an automatic, electrically operated interrupting device that will disconnect the generator from the BED system if system voltage parameters fall out of the ranges described in Section 4.1.1. That interrupting device may be the Disconnect Switch described in Section 4.4, if it is capable of both automatic and manual operation, or other BED approved device. This generator disconnect shall utilize potential monitoring of the incoming BED feed and interlock the generator circuitry to prevent the generator from being connected to the BED feeder if the system parameters are out of the ranges described in Section 4.1.1.

Certain protective functions that are equipped with time delays may be required to have a provision to allow instantaneous operation when BED Line Crews are performing "Live Line" maintenance. In these cases BED shall be provided reasonable access to the DG facility to by-pass and physically block time delays during "Live Line" maintenance.

A Generator that cannot operate in parallel with the BED's system is not subject to these requirements but requires a site specific interconnection agreement.

The generator-owner shall not energize a de-energized BED's circuit for any reason.

The **Disconnect Switch**⁸ specified in Section 4.4 of this document may be opened by BED at any time for any of the following reasons:

- To eliminate conditions that constitutes a potential hazard to BED personnel or the general public.
- Pre-emergency or emergency conditions on the BED system.
- A hazardous condition is revealed by a BED inspection.
- Protective device tampering.

The Disconnect Switch may be opened by BED for the following reasons, after notice to the responsible party has been delivered and a reasonable time to correct (consistent with the conditions) has elapsed:

- A generator-owner has failed to make available records of Verification tests and maintenance of its protective devices.
- A generator-owner's system interferes with BED equipment or equipment belonging to other BED customers.
- A generator owner's system is found to affect quality of service of adjoining customers.

The customer shall be allowed to disconnect from BED without prior notice in order to self-generate.

Following a generation facility disconnect as a result of a voltage or frequency excursion (parameters are described in Section 4.1.1), the generation facility shall remain disconnected until the service voltage and frequency has recovered to BED's acceptable voltage and frequency limits for a minimum of five (5) minutes.

BED may require **Direct Transfer Trip (DTT)**⁹ whenever:

1. the minimum load to generation ratio on a circuit is such that a ferro-resonance condition could occur;
2. it is determined that the customer's protective relaying may not operate for certain conditions or faults and/or
3. the installation could increase the length of outages on a distribution circuit or jeopardize the reliability of the circuit. The Distributed Generator shall be responsible for all costs required to deploy a DTT protective scheme

⁸See Glossary for definition ⁹ See Glossary for definition.

4.5 Dedicated Transformer¹⁰

BED reserves the right to require a generation facility to connect to BED system through a dedicated transformer. The transformer shall either be provided by BED at the generator-owner's expense, purchased from BED, or conforms to BED's specifications. The transformer may be necessary to ensure conformance with BED safe work practices, to enhance service restoration operations or to prevent detrimental effects to other BED customers. The dedicated transformer that is part of the normal electrical service connection of a generator-owner's facility may meet this requirement if there are no other customers supplied from it. A dedicated transformer is not required if the installation is sized, designed and coordinated with BED to protect BED system and its customers adequately from potential detrimental net effects caused by the operation of the generator. **Also see Section 4.3 Grounding.** If BED determines a need for a dedicated transformer, it shall notify the generator-owner in writing of the requirements.

4.6 Disconnect Switch or Device

All generating equipment shall be capable of being isolated from BED system by means of an external, manual, visible, gang-operated, load break disconnecting switch or circuit breaker. The disconnect device shall be installed, owned and maintained by the generator-owner and located between the power producing equipment and its interconnection point with BED system. The Disconnect Switch or Device must be rated for the voltage and current requirements of the installation. The Basic Insulation Level (BIL) of the disconnect device shall be such that it will coordinate with that of BED's equipment. Disconnect devices shall meet applicable UL, ANSI and IEEE standards, and shall be installed to meet all applicable local, state and federal codes. The Disconnect Switch or Device shall be clearly marked, "Generator Disconnect", with permanent 1 inch letters or larger. Whenever possible, the disconnect device shall be located within 10 feet of BED's external electric service meter, or the location and nature of the distributed power disconnection switches shall be indicated in the immediate¹⁰ proximity of the electric service entrance.

The Disconnect Switch shall be readily accessible for operation / locking and or disabling by BED personnel in accordance with Section 4.2 of this proposal.

The Disconnect Switch or device shall be lockable in the open position with a standard BED padlock with a 3/8-inch shank. If the disconnect device cannot be physically locked in the open position, it must be able to made in operative and the operating mechanism locked, blocked or drawn out. BED shall review and assist the generator owner design an acceptable disconnect device.

¹⁰ See Appendix D and Glossary for definition.

4.7 Power Quality The maximum harmonic limits for electrical equipment shall be in accordance with IEEE 519 - 1992. The objective of IEEE 519 - 1992 is to limit the maximum individual frequency voltage harmonic to 3% of the fundamental frequency and the voltage Total Harmonic Distortion (THD) to 5% on BED side of the point of common coupling. In addition per IEEE 1453-2004, any voltage flicker resulting from the connection of the customer's energy producing equipment to BED system must not exceed the maximum short term (Pst) flicker of 0.8 and maximum long term (Plt) flicker 0.6 as defined by the maximum permissible voltage fluctuations border line of visibility curve, Figure 10.3 identified in IEEE 519 -1992. This requirement is necessary to minimize the adverse voltage effect upon other customers on BED system.

4.8 Power Factor Correction (Does not apply to units that are 50 kW or less)
No Distributed Generation Installation shall degrade the Reactive performance of the BED system. All facilities, utilizing Distributed Generation resources providing 90% or less of the required electrical load of a given facility, shall have a Power Factor at the Point of Common Coupling of 98.5% lagging or 98.5% leading or better. If the Distributed Generation Resource can at times provide more than 90% of the facilities electrical power or is designed for export, the Power Factor shall range from unity to .9 leading.

In all cases where Induction Generators are deployed, it shall be the owners' responsibility to supply the necessary VAR requirements of the Induction Generator so that the total Power Factor as seen by BED at the Point of Common Coupling is in accordance with the criteria described above. The method of power factor correction necessitated by the installation of the generator will be negotiated with BED as a commercial item.

Induction power generators may be provided VAR capacity from BED system at the generator-owner's expense. The BED Tariff for Electric Service, Standard Terms and Conditions, makes provision for Special Facilities Charges. If it is necessary for BED to provide the necessary reactive compensation to correct the generator-owner's facility's Power Factor at the PCC to unity, the generator-owner shall be charged on an ongoing monthly basis, 1.66% per month of the capital costs of a capacitor bank, switching devices and controls to supply the required reactive correction. Capitals costs are dependent on the amount of reactive power required; BED shall give the generator-owner an estimated cost before installing said reactive compensation. The installation of VAR correction equipment by the generator-owner on the generator-owner's side of the point of common coupling must be reviewed and approved by BED prior to installation.

4.9 Stand Alone Islanding

Interconnected Distributed Generation systems must be designed and operated so that stand alone islanding is not sustained on any distribution circuit. The requirements listed in this document are designed and intended to prevent

islanding. See the first paragraph of Section 4.1.1 for more information.

4.10 Required Testing of Distributed Generation Systems

This section is divided into Type testing and Verification testing. Type testing is performed once by an independent testing laboratory for a specific equipment /protection package. Once a package meets the basic type-test criteria defined by UL 1741-2005 the design is accepted by BED. If any changes are made to the hardware, software, firmware, or verification test procedures, the manufacturer must notify the independent testing laboratory to determine what, if any, parts of the type testing must be repeated. Failure of the manufacturer to notify the independent test laboratory of changes may result in withdrawal of approval and disconnection of units installed since the change was made. The equipment in the field must have a nameplate that clearly shows the model number, firmware version (if applicable) and that it meets the requirements of UL1741-2005. The manufacturer shall certify in their literature and technical brochures that a unit meets the requirements of UL1741-2005.

This certification applies only to devices and packages associated with protection of the interface between the generating system and BED. Interface protection is usually limited to voltage relays, frequency relays, synchronizing relays, reverse current or power relays, and anti-islanding schemes. Testing of relays or devices associated specifically with protection or control of generating equipment is recommended, but not required unless they impact the interface protection. At the time of production, all interconnecting equipment including inverters and discrete relays must meet or exceed the requirements of ANSI/IEEE Standards C37.90.1-1989, IEEE Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems, or the most current version or one year after the issuance of the revised standard, but not earlier than one year after the commercial availability of test equipment required to demonstrate conformance.

Verification testing is site-specific, periodic testing to assure continued safe acceptable performance.

4.10.1 Type Testing

All interface protective equipment must meet the Utility Compatibility criteria as defined in 5 Section 46. Type testing shall be utilized by the manufacturer to determine if the protection system and settings meet these requirements.

Underwriters Laboratory or other qualified independent testing laboratory shall conduct the tests prescribed by UL 1741-2005 to determine and certify performance consistent with UL 1741-2005.

Prior to testing, all batteries shall be disconnected or removed for a minimum of ten (10) minutes. This test is to verify the system has a non-volatile memory and that protection settings are not lost. A test shall also be performed to determine that failure of any battery not used to supply trip power will result in an automatic shutdown.

Single-Phase Generators and Inverters equal to or less than 10 kW and Three-Phase Inverters 50 kW or Less

All generators and inverters shall be designed as non-islanding systems as defined by IEEE 929 - 2000. Small generators and inverters 10 kW and below shall at the time of production meet or exceed the requirements of IEEE 929 - 2000 and UL 1741- 2005. Specifically, the generator or inverter shall automatically disconnect for an islanding condition with a Load Quality Factor of 2.5 or worse within two (2) seconds. All inverters and equipment protected by voltage / frequency relay systems shall initiate a Trip from the Utility system for Voltage and Frequency variations as shown in UL 1741-2005.

4.10.2 Verification Testing

Upon initial parallel operation of a generating system, or any time interface hardware or software is changed, a verification test must be performed. A Virginia Licensed Professional Engineer or qualified individual working under the direction of a Virginia Licensed Professional Engineer must perform verification testing in accordance with the manufacturer's published test procedure. Qualified individuals include factory trained and certified technicians, and licensed electricians with experience in testing protective equipment. BED reserves the right to witness verification testing or require written certification that the testing was performed.

Verification testing shall be performed every four years. All verification tests prescribed by the manufacturer shall be performed. If wires must be removed to perform certain tests, each wire and each terminal must be clearly and permanently marked. The generator-owner shall maintain verification test reports for inspection by the connecting BED.

Single-phase inverters rated 10 kW and below may be verified once per year as follows: once per year, the owner or his agent shall operate the load break Disconnect Switch and verify the power producing facility automatically shuts down and does not restart for five minutes after the switch is closed.

Any system that depends upon a battery for trip power shall be checked and logged once per month for proper voltage. Once every four (4) years the battery must be either replaced or a discharge test performed.

4.11 BED Back-up or Stand-by Power and Capacity

The BED Tariff for Electric Service makes provision for the costs associated with BED providing Back-up and Stand-by service for Distributed Generators under certain rate schedules. Stand-by Service agreements are contractual vehicles committing both the Applicant and BED for a minimum 12-month period.

4.12 Interconnections to Primary and Secondary Network Distribution System¹¹

Distributed Generators including Photovoltaic or wind systems that can export power beyond the common network bus will **not** be permitted to be

interconnected into BED's distribution system in primary and secondary

¹¹See Glossary for Definition

Network areas. Further, all such systems, even those proposed as non-export, must be reviewed and approved by BED prior to installation to ensure that network system safety and integrity will not be affected by the installation. For those systems proposed to be installed in a network area, the maximum size of the units must be 50 kW or less, or represent 33 % of the minimum load on the network bus to which the Distributed Generator is connected, whichever is

5.0 Insurance Requirements

5.1 Units of 10 kW or Less:

No additional insurance is required.

5.4 Units Greater Than 10 kW:

If the Distributed Generator has a nameplate rating greater than 10 kW, the owner shall demonstrate prior to the date on which the Unit is first placed into operation, and continuing all the while the generator is interconnected with the BED system, at its cost and expense, shall maintain and keep in full force and effect, for the term of this Agreement the following insurance coverage by an insurer licensed to do business in the State of Virginia

- A. Comprehensive General Liability Insurance (occurrence form) including premises, contractual liability, products liability, completed operations, independent contractors, broad form property damage and coverage for explosion, with the following minimum limits of liability: bodily injury \$2,000,000 each occurrence; property damage - \$2,000,000 each occurrence.
- B. All risk Property Insurance to cover the replacement cost of owners facilities where the Distributed Generator is installed. This coverage shall contain a waiver of subrogation against BED.
- C. All Liability coverage shall name BED as an additional insured to support the obligations assumed by the owner as described in this Section 5 and provide that this coverage is primary and without right of contribution from insurance carried by BED.
- D. The completed operations coverage shall be provided and remain in effect for a period of at least two (2) years after the owner disconnects and removes the Distributed Generator.
- E. Prior to the start of interconnected Distributed Generation under this agreement, the owner will deliver Certificates of Insurance to BED evidencing this coverage is in effect and providing at least thirty (30) days notice to BED of any cancellation, termination or material alteration of required insurance. The

owner shall be obligated to furnish these Certificates on an annual basis as long as the Distributed Generator is interconnected with the BED system, to show evidence of continuing insurance protection

F. The owner shall notify the BED Electric Department immediately by telephoning 540-587-6071 after the occurrence of any accident as a result of the owner's Distributed Generation activities.

G. The insurance requirements as described are to protect BED from claims by third parties including, but not limited to, employees of the owner or its agents, subcontractors and invitees. Required insurance is not to relieve or release the owner, its agents, subcontractors and invitees from, or to limit their liability as to any and all obligations that result from Distributed Generator operation. The owner shall carry insurance naming BED as an additional insured so that this coverage is primary and without right of contribution from insurance carried by BED.

APPENDIX B

Glossary of Terms

Automatic Disconnect Device – An electronic, electro-mechanical or mechanical switch used to isolate a circuit or piece of equipment from a source of power without the need for human intervention.

Alternating current (AC) the movement of electric charge periodically reverses direction. It is the usable form of energy which may be produced by an inverter and necessary to interconnect with BED.

Coordinated Interconnection Review - Any studies performed by BED to ensure that the safety and reliability of the Electric Distribution System with respect to the interconnection of Distributed Generation as discussed in this document.

Dedicated Service Transformer or Dedicated Transformer – A transformer with a secondary winding that serves only the Applicant/generator owner.

Direct current (DC) is the unidirectional flow of electric charge which may be converted to AC by an inverter

Direct Transfer Trip (DTT) - Remote operation of the Distributed Generator Automatic Disconnect Device by means of a communication channel by BED.

Disconnect (verb) - To isolate a circuit or equipment from a source of power.

Disconnect Switch– A mechanical device used for isolating a circuit or equipment from a source of power. In some applications the Automatic Disconnect Device and the Disconnect Switch maybe the same device.

Energy Conversion Device – A machine or solid state circuit for changing direct current to alternating current or a machine that changes shaft horsepower to electrical power.

Islanding – A condition in which a portion of BED system that contains both load and distributed generation is isolated from the remainder of BED system.

[Adopted from IEEE 929 - 2000].

Point of Common Coupling (PCC) – The point at which the BED and the Grantee electric interface occurs. Typically, this is the Grantee side of BED revenue meter. [Adopted from IEEE 929 – 2000].

Primary Distribution Circuit – Refers to the circuit that originates from a BED substation and distributes 3 phase power at a primary level voltage of 4 kV or 13 kV.

Grantee Secondary Services - Refers to the Grantee service connection at voltage levels of: 120 V / 240 V single phase, 120V/208V 3 phase, or 277V/480V3 phase.

Sub-transmission Circuit . Refers to a circuit supplying 3 phase power at a primary level voltage of 69 kV.

Type tested - A protection device or system that has been certified by a qualified independent testing laboratory as to meeting the requirements listed in the testing section of this proposal is considered “Type tested”. It is expected by BED, that equipment manufacturers will sponsor Type testing.

Network Distribution System – means an electric delivery system characterized by multiple uni-directional sub-transmission or primary level voltage feeders that are transformed and converge to a secondary voltage level,

where secondary conductors are commonly interconnected via automated secondary switches.

BED . Bedford Electric Department a department of the Town of Bedford

APPENDIX B

BED INTERCONNECTION APPLICATION FOR 10 kW OR SMALLER

A. Applicant Information

Name: _____
Mailing Address: _____
City: _____ State: _____ Zip Code: _____
Street Address (if different from above): _____
City: _____ State: _____ Zip Code: _____
Daytime Phone: _____ Fax: _____ Email: _____
Electric Utility Name (from utility Bill): _____
Electric Utility Account Number: Customer ID _____ ; Location ID: _____
Electric Energy Third Party Supplier _____
Electric Energy Third Party Supplier Account No.: _____

B. System Information

Manufacturer Name Plate AC Power Rating (for the entire installation) : _____ kW
System Type: Solar Wind Other (circle one)
System Location: _____
Inverter Manufacturer: _____
Inverter Model No: _____ Inverter Serial No: _____
Inverter Location: (Indoor) (Outdoor) (Self Contained) Location: _____
Outdoor Manual AC Disconnect Switch -Location: _____

C. Installation Contractor Information/Hardware and Installation Compliance Installation Contractor (Company Name) _____
Contractor's License No.: _____ Proposed Installation Date: _____
Mailing Address: _____ City: _____
State: _____ Zip Code: _____ Daytime Phone: _____
Fax: _____ Email: _____
If PV, the proposed System hardware is in compliance with *Underwriters Laboratories (UL) 1741, Standard for Static Inverters and Charge Controllers for Use in Photovoltaic Systems; UL 1703, Standard for Safety: Flat-Plate Photovoltaic Modules and Panels; and IEEE 1262-1995, IEEE Recommended Practice for Qualification of Photovoltaic (PV) Modules*. If PV, System must be installed in compliance with *IEEE Standard 929-2000, Recommended Practice for Utility Interface of Photovoltaic Systems*. All System types must be installed in compliance with applicable requirements of local electrical codes, the Electric Utility and the *National Electrical Code® (NEC)* and must use a non-islanding inverter as defined under *IEEE Standard 929-2000 (section 3.2 to 3.4)*. The System must have a lockable, visible disconnect device, accessible at all times to Electric Distribution Company personnel. If the System is designed to provide uninterruptible power to critical loads, either through energy storage, back-up generator, or the generation source, the System will include a parallel blocking scheme for this backup source. This function may be integral to the inverter manufacturer's packaged system.

Signed _____ Date:
(Contractor)

Contractor Name (Print): _____

D. Additional Terms and Conditions

a) Operation/Disconnection If it appears to the Electric Distribution Company, at any time, in the reasonable exercise of its judgment, that operation of the System is adversely affecting or may adversely affect the Electric Distribution Company's electrical system, the Electric Distribution Company may immediately take any and all steps it reasonably believes necessary to mitigate or cure the conditions including, without limitation, disconnecting the System from the Electric Distribution Company's electrical system. Applicant/Owner shall at all times permit Electric Distribution Company employees and inspectors reasonable access to inspect, test, or examine the System or metering equipment after notice by the Electric Distribution Company. Applicant/Owner may be liable for the costs and expenses incurred by the Electric Distribution Company related to disconnection and reconnection of the System by the Electric Distribution Company when disconnection is permitted under this paragraph D.

b) Liability/Indemnity Applicant/Owner hereby covenants and agrees to assume all risk of and liability for personal injuries (including death) and damage to property arising out of or caused by the operation of the System. Applicant/owner hereby covenants and agrees to indemnify, protect, defend and save harmless the Electric Distribution Company, its affiliates, officers, directors, employees and agents from and against any and all claims and demands for damages to property and injury or death to persons which may arise out of, or be related to, or caused by, the operation of the System or its interconnection to the Electric Distribution Company's electrical system, except if caused solely by the gross negligence or willful misconduct of the Electric Distribution Company as determined by Virginia court of law.

E. Electrical Code Inspection

The System referenced above satisfies applicable electrical code requirements.

Inspector Name (Print):

Signed: _____ Date: _____
(Inspector)

(In lieu of the signature of the Inspector, a copy of the final Inspection Certificate may be attached)

Date: _____

Municipality: _____

F. Customer Acknowledgment

The System has been installed to my satisfaction and I have been given System warranty information, and an operation manual. I have also been instructed in the operation of the System by the manufacturer and/or the installer of the System. I agree to abide by the terms of this Application /Agreement and I agree to operate and maintain the System in accordance with manufacturer's recommended practices as well as the Electric Distribution Company's interconnection standards. Further, I agree to notify the Electric Distribution Company 30 days prior to modification or replacement of the System's components or design. Any such modification or replacement may require submission of a new Application to the Electric Distribution Company. I agree not to operate the System in parallel with the Electric Distribution Company until this Application/Agreement is accepted by the Electric Distribution Company. I also agree to install a warning label provided by the Electric Distribution Company on or near my service meter location.

Signed (Owner): _____ Date: _____

Name (Print):

**INTERCONNECTION APPLICATION
FOR SYSTEMS 10 kW OR SMALLER (Continued)**

G. Utility Application Acceptance

The Bedford Electric Utility does not, by acceptance of this Application/Agreement, assume any responsibility or liability for damage to property or physical injury to persons. Further, this Application/Agreement does not constitute a dedication of the customer's System to BED's electrical system equipment or facilities. This Application is accepted by BED on this

_____ day of _____, 20____

Bedford Electric Utility Signed BED Representative):

Date:

Name (Print):

Please send completed applications to:

Bedford Electric Department

877 Monroe St

Bedford, VA 24523

Att: Scott Salmon

Phone: 840-587-6076

E-mail: ssalmon@bedfordva.gov

**Application for Connection of Distributed Generation to the BED
Distribution System Wind or Photovoltaic
Greater than 10 kW and all other Proposed Installations**

Applicant Information

Company: _____

Name: _____

Address: _____

City: _____, State: _____ Zip: _____

Tel: _____ Fax: _____ E-mail: _____

Existing BED Account Number: Customer ID: _____ Location ID: _____

Location of proposed Distributed Generation Equipment: _____

Estimated Service Date: _____ Size in KW: _____

Application Fee: All

**units up to and including 10 kW - \$100 All units greater than
10 kW - \$500**

Size of unit as % of facility normal load: _____

Size of unit as % of facility peak load: _____

If unit size is greater than 100% of facility peak load, state intended use of
excess capacity:

If the Applicant does not plan to export excess power, explain the mechanism to
be used to prevent export:

If the Applicant intends to export excess power outside of the Local Distribution
Circuit, explain intended Grantees and location:

Note: If the Applicant intends to export and sell excess Distributed Generation
capacity outside of the Local Distribution Circuit utilizing the Pennsylvania-New
Jersey-Maryland (PJM) Interconnection High Voltage Transmission System and
the American Electric Power (AEP) Transmission System, it will be necessary to
file an application and secure permission from PJM and AEP before any such
exports are made.

PJM can be reached on the Internet at www.pjm.org

Will BED be expected to supply Back-up power to support the facility in case the Distributed Generator is unavailable? Yes No (circle one)

Terminal Voltage: _____

Generator or Inverter: _____

Single or 3 Phase: _____

Inverter Type: Line commutated or Line Synchronized

Generator type: Induction or Synchronous

Method of Neutral Point Grounding: _____

If Induction, list full load VAR requirement: _____

Source of Capacitive VARs: _____

Proposed point of connection: _____

Prime

Mover: Reciprocating Engine, Combustion Turbine, Fuel Cell, Photo-Voltaic or other (circle one or describe other)

Other: _____

Manufacturer: _____

Fuel Type: _____

If Natural Gas _____ SCFM and Pressure @ Full load

Utility Application Acceptance Bedford Electric does not, by acceptance of this Application/Agreement, assume any responsibility or liability for damage to property or physical injury to persons. Further, this Application/Agreement does not constitute a dedication of the owner's System to the Electric Distribution Company's electrical system equipment or facilities. This Application is accepted by the Bedford Electric on this _____

day of _____, 20____

Signed: _____ Date: _____

(Electric Distribution Company Representative)

Name (Print):

Please send completed applications to:

Bedford Electric Department 877

Monroe St

Bedford, VA 24523

Att: Scott Salmon

Phone: 840-587-6076

E-mail: ssalmon@bedfordva.gov

Appendix D

Example of Safety Disconnect Tag (Reference Section 4.6)

The Tag should be either glued with Silicone adhesive or mechanically attached. Size of the Tag should be as large as practical to fit on or near the disconnect switch. In any case it should not be less than 4 inches by 6 inches. The Tag shall be made of yellow laminated engraving stock with at least 5/16 inch high black letters.

Customer Owned Parallel Generation BED Safety Disconnect Switch

If the disconnect switch is not located at the meter, than another Tag must be made that will be placed at the meter and direct BED personnel to the Disconnect location. The following tag shall be placed at the meter, on the meter pan or on the CT cabinet.

Customer Owned Parallel Generation Safety Disconnect Switch is located at rear of building

If the Disconnect Switch is located at the side of the building it should say so. It should be specific enough so that BED personnel can easily find the disconnect switch.

APPENDIX E

Construction should adhere to the following industry standards:

- ANSI C84.1-1995: Electric Power Systems and Equipment – Voltage Ratings (60 Hertz)
- EN 50524-2009: Data Sheet and Name Plate for Photovoltaic (PV) Inverters
- EN 50530-2010: Overall Efficiency of Grid Connected Photovoltaic (PV) Inverters
- IEC 61683-1999: Photovoltaic Systems – Power Conditioners – Procedure for Measuring Efficiency
- IEC 62109-1: Standard for Safety of Power Converters for Use in Photovoltaic Power Systems – Part 1 – General Requirements
- IEC 62109-2: Standard for Safety of Power Converters for Use in Photovoltaic Power Systems – Part 2 – Particular Requirements for Inverters
- IEEE 1547A: Standard for Interconnecting Distributed Resources with Electric Power Systems (including use of IEEE 1547.1 testing protocols to establish conformity)
- IEEE 100-2000: Standard Dictionary of Electrical and Electronic Terms
- IEEE 519-1992: Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
- IEEE C37.108-1989 (R2002): Guide for the Protection of Network Transformers
- IEEE C37.90.1-1989 (R1994): Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems
- IEEE C37.90.2 (1995): Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers
- IEEE C57.12.44-2000: Standard Requirements for Secondary Network Protectors
- IEEE C62.41.2-2002: Recommended Practice on Characterization of Surges in Low Voltage (1000V and Less) AC Power Circuits
- IEEE C62.45-1992 (R2002): Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits
- IEEE 929-2000: Recommended Practice for Utility Interface of Photovoltaic (PV) Systems
- IEEE 1262-1995: Recommended Practice for Qualification of Photovoltaic (PV) Modules
- IEEE 1453-2004: Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems
- NEMA MG 1-1998: Motors and Small Resources, Revision 3
- UL 1741-2005: Standard for Inverters, Converters, Controllers and Interconnectoin Systems Equipment for Use With Distributed Energy Resources
- UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels