Old Dominion Electric Cooperative

Facility Interconnection Requirements

January 1, 2025

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I. Disclaimer

This document and all the material contained herein are designed for informational and illustrative purposes only. It is produced to aid those Consumers, Generator Owners and Project Developers contemplating the addition of new load or the purchase of generation equipment and interconnecting this load or this generation equipment with the Old Dominion Electric Cooperative (ODEC) System. For the purposes of this document, both Generator Owners and Project Developers are considered interchangeable. The information is intended only to guide the Project Developer in making a decision on whether to proceed with a more detailed engineering study.

All the information in this document is intended to be typical and of a general nature for information purposes. It is not intended to be site or facility specific. Requirements and practices are also subject to change, and it must be recognized that any given item may become obsolete in the future.

ODEC makes no warranty of any nature whatsoever concerning the information contained in this document.

II. Prerequisites

To interconnect with the ODEC System, the Project Developer must first be in compliance with the tariff rules and regulations and the applicable tariff classifications and rates. The terms and conditions contained within thisdocument are in addition to, but do not modify nor negate, the terms of the tariff. For any new load, the Project Developer must make an application to ODEC.

Project Developers are required to submit a New Service Request to PJM if the generator owner intends to sell the energy into PJM markets. PJM will initiate a process to study the feasibility of the generation, its impact within the PJM system and the cost of interconnection facilities and network upgrades. The extent of the studies is dependent on the size of the generation and the proposed Point of Common Coupling and/or Point of Change of Ownership. The details of this process are outside the scope of this document. Please refer to PJM Manual 14H for details.

A Project Developer must also complete a Generator Interconnection Agreement with PJM if network upgrades are necessary either on the ODEC System or on Affected Transmission Owner systems.

III. Applicability

Unless otherwise provided, these technical requirements apply to all new load and Generator Owners interconnected with and operating in parallel with the ODEC System at 69,000 volts (69kV). Where multiple generators are connected to the system through a single Point of Common Coupling, the sum of the generator ratings will be used to determine the applicability of these Technical Requirements.

IV. Definitions

Various terms as utilized in this document are defined below. Whenever used in this document with initial capitalization, the following terms have the meanings specified in this Section.

Account - An account is one metered or un-metered rate or service classification which normally has one electric delivery point of service. Each account shall have only one electric service supplier providing full electric supply requirements for that account. Premises may have more than one account.

Affected Transmission Owner - the transmission system that is electrically adjacent to, or impacted by, any change to the ODEC System. The Affected Transmission Owner most immediate to ODEC is Delmarva Power and Light, an operating company of Exelon Corporation.

BESS – Battery Energy Storage System.

Company - Old Dominion Electric Cooperative, doing business as ODEC.

Consumer - Any adult person, partnership, association, corporation, or other entity: (i) in whose name a service account is listed, (ii) who occupies or is the ratepayer for a premises, building, structure, etc., and (iii)who is primarily responsible for payment of bills. A Consumer includes anyone taking Delivery Service or combined Electric Supply & Delivery Service from ODEC under one service classification for one account, premises or site. Multiple premises or sites under the same name are considered multiple Consumers.

DER - Distributed Energy Resources - A source of electric power that is not directly connected to the ODEC System.

DTT - Direct Transfer Trip. - A trip operation (i.e., opening a Circuit breaker etc.) initiated on a communication channel locally or from a remote station under abnormal conditions.

Facility (or **Facilities**) - The equipment and all associated or ancillary equipment, including Interconnection Equipment, on the Consumer or Generator Owner's side of the Point of Common Coupling.

Generator Owner - The owner of the Facility that is interconnected to ODEC.

Harmonic distortion - defined as continuous distortion of the normal 60 Hz sine wave typically caused by non-linear loads or by inverters, measured in total harmonic distortion, THD.

Interconnection - The physical connection of new load or generation to the ODEC System in accordance with these technical requirements so that parallel operation can occur.

Interconnection Equipment - That equipment necessary to interconnect the Facility to the ODEC System, including any and all relaying, switching, fault interrupting, metering or communication equipment needed to protect the Facility and the ODEC System and to control and safely operate the Facility in parallel with the ODEC System.

Interface Transformer - A transformer which interconnects a privately owned load or generation source with the ODEC System voltage.

Inverter - A static power converter with control, protection and filtering functions that converts Direct Current (DC) input to Alternating Current (AC) output. Note: Inverters connected to the ODEC System must be of the non-islanding type; the use of grid-forming inverters will be evaluated by ODEC on a case-by-case basis.

Island - An operating condition whereby an isolated generator is serving load without being connected to the remainder of the system.

NERC - **N**orth American **E**lectric **R**eliability **C**orporation. The mission of NERC is to assure the effective and efficient reduction of risks to the reliability and security of the transmission grid in North America.

New Service Request - as that term, and its associated processes, are defined in PJM Manual 14H.

NIST - National Institute of Standards and Technology.

ODEC System - The electric transmission system of Old Dominion Electric Cooperative.

Parallel Operation - Any electrical connection between the ODEC System and the Generator Owner's generation source.

Phase I, Phase II and Phase III System Impact Studies - as those terms, and their associated processes, are defined and described in PJM Manual 14H.

PJM - PJM Interconnection, L.L.C. A regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia, whose members include electric utilities, independently owned generating resources, and other stakeholders.

Point of Change of Ownership (or **POCOO**) as that term is defined in PJM Manual 14H.

Point of Common Coupling (or **PCC**) - The point where the electrical conductors of the ODEC System are connected to the Generator Owner's conductors and where any transfer of electric power between the two entities takes place.

Pre-Interconnection Study - A technical study or studies which may be undertaken by ODEC and/or PJM in response to its receipt of a completed application for Parallel Operation with the ODEC System submitted on the Customer Request form prescribed by these technical requirements or by PJM. Pre-Interconnection Studies may include, but are not limited to, Phase I, Phase II and Phase III System Impact studies as more fully described in PJM Manual 14H.

Project Developer - the entity that develops the Facility that will be interconnected to ODEC.

RFC - Reliability First Corporation, the NERC Regional Entity in which the ODEC system operates.

RTU - **R**emote **T**erminal **U**nit. The remote unit of a supervisory control system used to telemeter analog or digital operating data, provide device status/alarms and to provide remote control of equipment at a substation or generator site. The RTU communicates with a master unit at the System Control Center.

Stabilized - The state of ODEC's system following a disturbance which returns to the normal range of voltage and frequency for at least 5 minutes or longer. ODEC may require a longer time period upon a reasonable showing that reconnection after only 5 minutes will adversely impact the safety and reliability of the ODEC System.

Stiffness Ratio - A measure of how strong a generator's fault current contribution is in comparison to the total fault current available at the Point of Common Coupling (PCC). Stiffness Ratio = Total fault current available at PCC / Generator Fault Contribution.

System - The interconnected arrangement of lines, transformers and generators that make up the electric power system.

System Control Center – The office that monitors and has direct control over the operation of the ODECSystem.

System Emergency - An imminent or occurring condition on the ODEC System, the PJM system, the system of an Affected Transmission Owner, or in the Facility, that is likely to impair system reliability, quality of service, or result in significant disruption of service, or damage, to any of the foregoing, or is likely to endanger life, property or the environment.

Voltage flicker - voltage defined as variations in system voltage magnitude and duration sufficient to allow visual observation of a change in electric light source intensity.

V. Introduction and Purpose

The information contained in this document is intended to provide the Project Developer or Generation Owner with Company and Generator Owner obligations, technical and safety requirements and the need for adequate protective equipment to be designed and installed by the Generator Owner, in order to operate one or more generator units in Parallel Operation with the ODEC System, without adversely impacting the reliability of electric service to ODEC Consumers, or the safety of the general public and Company employees. As such, the emphasis of this document deals with the protection of the generator equipment and the utility system. The information should be useful in understanding the need for a proper design and the analysis needed to completea comprehensive suite of interconnection studies.

Some aspects of interconnected parallel generation are not fully addressed in this document. Metering and remote monitor/control requirements are covered only at a high level, with detailed requirements beyond the intended scope of this document. Detailed metering and remote monitor/control requirements will have to be reviewed on a case-by-case basis.

No one document can provide all the details needed to cover every conceivable generator installation. Consequently, this document is provided only as a starting point and a source of preliminary information. Any Project Developer or Generator Owner considering the installation of interconnected generation will have to consult all available resources, design standards and professionals necessary to develop a feasible design and installation.

VI. Generator Owner Obligations

While owning, interconnecting and operating a generator in parallel with the ODEC System, the Generator Owner is responsible for the following obligations:

A. The Generator Owner must design and construct his Facility to meet the latest versions of all applicable national, state and local construction and safety codes. Please refer to Section XIV.

B. The Generator Owner must design his Facility with protective hardware and software to prevent the generator from energizing any de-energized circuit(s).

C. The Generator Owner must design his Facility with protective hardware and software to automatically disconnect from ODEC System if the source from the ODEC System is lost, irrespective of connected loads orother generators on the circuit. Islanding will not be permitted.

D. The Generator Owner's Facility must equip necessary protective hardware and software designed to prevent sustained Parallel Operation of the generator with the ODEC System. Under all operations, the system service voltage and frequency must be within acceptable magnitudes as defined in Sections IX - B and C.

E. The Generator Owner is responsible for protecting his own Facility in such a matter that ODEC System outages, short circuits, single phasing conditions or other disturbances including zero sequence currents and ferroresonant overvoltages do not damage the Generator Owner's equipment.

F. The Generator Owner is responsible for protecting his generator and equipment from the effects of switching and automatic reclosing on the ODEC System circuit(s) supplying the Generator Owner's Facility.

G. The Generator Owner shall ensure that his designs utilize equipment adequately sized to meet the operating voltage, current rating, fault duty etc. necessary for the site.

H. The Generator Owner is responsible for protecting its own generator and all interconnection / ancillary equipment(s) including any line extensions. The Generator Owner must supply the required protection schemes along with the necessary metering and monitor/control requirements specified either by ODEC or by PJM.

I. The Generator Owner is responsible for the design, procurement, installation, and maintenance of all equipment at the Generator Owner's Facility including all associated costs. .

J. As part of the PJM New Service Request, the Project Developer will supply PJM and ODEC with the necessary technical information, models, one-lines, equipment data, specifications, etc. so that ODEC can conduct a complete review of the proposed facility and conduct any required studies. A list of the required data will be included in the aforementioned New Service Request and PJM Dynamic Modeling Guidelines. This data will be used for temporary overvoltage, harmonics and protection scheme evaluation studies as required by ODEC. Applicable standards include but not limited to ODEC's Planning Criteria, IEEE 1547-2018, IEEE 2800 -2022, IEEE 519-2014, IEEE 1453-2015, and NERC PRC-024.

K. The Project Developer will cover the expense of any additional ODEC feasibility study, impact study, protection and coordination studies, or facility study (as distinguished from PJM Phase I, Phase II and Phase III System Impact Studies) necessary to assess the generator's impact on the ODEC system. The interconnection studies will be based on the generator characteristics and the proposed point of interconnection (POI).

L. Any necessary enhancements or improvements needed within the ODEC System and/or at Consumer sites to accommodate the Parallel Operation of the Generator Owner's generator will be at the Generation Owner's cost unless otherwise allocated in accordance with PJM Transmission Tariff or PJM Operating Agreement.

M. The Generator Owner has full responsibility and liability for the safe and proper operation and control of their equipment and for the power originating from their generator.

N. The Generator Owner is responsible for synchronizing their generator to the ODEC System and maintaining a synchronous condition.

O. The Generator Owner shall maintain their Facility in good working order, consistent with industry standards, manufacturer recommendations, and in compliance with all applicable rules, codes and regulations. The Generation Owner shall have maintenance and testing programs that ensure all protective schemes and equipment are periodically calibrated and functionally tested. *PJM Relay Testing and Maintenance Practices* shall be followed for all facilities participating in the PJM marketplace. The relay testing and maintenance logs shall be available to ODEC upon request and shall be maintained by the generator owner at their Facility.

P. The Generator Owner must immediately cease parallel operation upon notification by ODEC that theiroperation is unsafe, interferes with the quality of supply to Consumers or interferes with ODEC's system maintenance or operation.

Q. The Generator Owner will connect and disconnect their generator to/from the ODEC System only under the direction and approval of the **System Control Center**.

R. The Generator Owner will obtain and cover the cost of any required communication circuits to their site for protective relaying, generator monitoring/control, metering, and equipment remote access.

S. The generator must not be connected in parallel with the ODEC System until ODEC has granted approval to interconnect and the Generator Owner has received notification.

T. The Generator Owner must notify ODEC in writing if it intends to add or modify any equipment at its Facility that impacts the protection associated with the Point of Common Coupling. The Generator Owner must also give ODEC reasonable advance notice if it intends to permanently shut down their generation.

U. The Generator Owner shall maintain an operating log at their Facility which details all changes in operating status, trip occurrences, maintenance outages or other unusual conditions found upon inspection. ODEC may require other information to be logged. The Generator Owner and ODEC will generally negotiate the specific information that must be logged at each site. The operating log shall be available to ODEC upon request and shall be maintained by the Generator Owner at their Facility.

V. The Generator Owner must accept the fact all Consumers and Generator Owners may be switched temporarily or permanently from one ODEC circuit to another in response to such causes as load growth, equipment failure, maintenance outages etc. The Generator Owner is responsible for any redesign or setting adjustments in their Facility that are necessary to accommodate their transfer to another Company circuit.

W. The Generator Owner will apply a warning label provided by the Company in a conspicuous place on or near their meter, meter box, breaker or Point of Common Coupling to notify Company personnel that there is a generator source at the site.

VII. ODEC Obligations

A. ODEC will provide the Project Developer with the ODEC System available fault current, system impedance and protection system details at the proposed Point of Common Coupling. This data will be updated, as required, when significant system changes occur.

B. ODEC will review the proposed Facility and make all necessary Pre-Interconnection Studies to evaluate the impact of the generator on the ODEC System and identify any system enhancements necessary. ODEC should complete this review in a timely manner.

C. ODEC will review and provide feedback to the Project Developer on the proposed design and protection schemes associated with the Point of Common Coupling. ODEC may also review and provide comment(s) on the generator protection and protective relay settings. However, any review by ODEC does not relieve the Generation Owner of full responsibility for the protection of their generator and equipment.

D. ODEC may provide the Project Developer with the technical details and requirements necessary to satisfy the generator metering and RTU monitoring/control needs for each specific generator installation site.

E. ODEC will provide written approval or enter into an appropriate agreement for the interconnection of the Generator Owner's Facility as soon as all requirements are satisfied. Such approval does not, however, supersede the Generator Owner's obligations or imply that the Facility meets all federal, state and local standards. If not approved, ODEC will provide details on the reason for denying the parallel interconnection.

F. ODEC, while reviewing applications for interconnected parallel generators and making any necessary Pre-Interconnection Studies, has the need for detailed information on the proposed Generator Owner's Facility. ODEC or any of its affiliates shall not use Facility knowledge and information submitted by the Project Developer to offer competing services or special rate considerations. In addition, ODEC will not divulge this information to a third party without the Project Developer / Generator Owner's consent, unless required to do so by law.

G. ODEC may disconnect and isolate the Generator Owner's Facility from the ODEC System for routine maintenance and repairs on ODEC's system consistent with applicable tariffs and agreements. ODEC will make reasonable efforts to provide advance notice to the Generator Owner of service interruptions resulting from routine maintenance. ODEC will reconnect the Generator Owner's Facility as quickly as possible following any such service interruption.

H. ODEC reserves the right to disconnect and isolate the Generator Owner's Facility from the ODEC System for System Emergencies or unsafe conditions without notice. ODEC will use reasonable efforts to notify the Generator Owner prior to disconnecting.

I. ODEC will advise the Generator Owner if the Generator Owner's Facility must be transferred from one ODEC circuit to another circuit. ODEC will also provide the Generator Owner with data about ODEC circuits needed by the Generator Owner to re-design or reset equipment at their Facility.

VIII. Technical Design Requirements

A. General

1) This Technical Requirements Document describes the minimum design requirements and operating procedures necessary for the safe and effective parallel generators. The Generator Owner's design must meet or exceed the requirements outlined in these Technical Requirements and meet any applicable Tariff requirements. Some aspects of the Generator Owner's design and operation must also meet PJM, RFC and NERC requirements.

2) The Generator Owner's Facility must meet all applicable national, state and local municipal construction, safety and electrical codes. Company approval to interconnect indicates only that the minimum requirements for parallel operation outlined in this document have been satisfied. Such approval does not imply that the Generator Owner 's Facility meets all federal, state and local standards and regulations (please refer to Section XIV).

3) All equipment, circuit breakers and other current interrupting devices at the Generator Owner's Facility must be capable of interrupting the maximum available fault current at the site including any contribution from the Facility's generator.

4) The Generator Owner must furnish and install a manual disconnect device which, when opened, will have the effect of isolating the generator from the ODEC System. This disconnect device shall have a visual break such as a disconnect switch or draw-out breaker as appropriate to the voltage level. The disconnect device will, at all times, be accessible to Company personnel and be capable of being locked in an open position via a Company padlock. (ODEC will use reasonable efforts to utilize padlocks of a size consistent with typical manufacturer's specifications.)

B. Background Information and Need for Protection

1) The ODEC System is subject to a variety of natural and man-made hazards. Among these are lightning, wind, snow, animals, vehicular-pole accidents, vandalism and human error. These same hazards are present in residential and commercial electric systems but to a lesser degree due to the smaller size and protected environment of these systems.

2) The fault condition that can result from the preceding hazards are principally short circuits, grounded conductors and broken or open conductors. All of these problems require that the affected equipment be de-energized as quickly as possible to minimize equipment damage, to protect system security, to lessen the adverse impact on Customers and to remove any hazard to the public and Company personnel.

3) The Generator Owner has the responsibility to protect both his own Facility and the impact of his Facility on the ODEC System.

C. Basic Protection Goals

The protection system at the Point of Common Coupling should be designed and operated with the followingdesired goals in mind:

1) Protect the ODEC System from the adverse impacts of the parallel generator.

2) Protect the parallel generator from faults or other disturbances in the ODEC System.

3) Disconnect the parallel generator from the ODEC System for abnormal operating conditions.

4) Permit the desired range of power transfer without false operation.

D. Protection General Requirements

1) The generator and Point of Common Coupling protection schemes shall be continuously monitored and in a functional state. The generator shall immediately be disconnected from the ODEC System for any condition that would make the protection scheme inoperable.

2) The operating power for the generator and Point of Common Coupling protection schemes and the control power used to disconnect the generator from ODEC System must not be dependent on ODEC System power.

3) The generator protection shall be designed to automatically and immediately disconnect the generator from the ODEC System if the source circuit from ODEC is lost, irrespective of connected loads or other generators on the circuit.

4) The generator shall be equipped with protective equipment (hardware or software) to prevent the generator from energizing a de-energized ODEC circuit.

5) Parallel operation must cease immediately and automatically for abnormal operating voltage, frequency, harmonic content or power flow. Parallel operation must also cease for loss of a phase or improper phase sequence. Voltage sensing shall be performed at all three phases.

6) Protection at the Point of Common Coupling must detect and isolate the Facility from the ODEC System for a fault condition in the Generation Owner's Facility. In case of breaker failure at the Point of Common Coupling, a Direct Transfer Trip (DTT) from the protection at the Point of Common Coupling must be transmitted to ODEC protection system for fault isolation purpose.

7) Protection at the Point of Common Coupling must detect and isolate the Generation Owner's Facility from ODEC System for a fault condition on the ODEC System circuit that supplies the generator site.

Note: Distributed Energy Resources (DER) can desensitize detection of faults that can be detected by the ODEC protection system prior to the interconnection of the generator. Adjustment to the settings of the ODEC protection systems or changes to the generator interconnection parameters, which can compensate for the generator's fault current contribution, may be needed to maintain proper fault detection time and protective relaying coordination intervals acceptable to the ODEC system. Please refer to Section XI for more requirements related to DER.

8) The protection scheme should permit the desired range of power transfer without false operation. The protection scheme should also prevent excessive or unnecessary tripping that would adversely affect ODEC's service reliability to Consumers or other Generator Owners.

9) The generator protection or protection at the Point of Common Coupling must ensure that the generator is disconnected from ODEC System before any automatic re-energizing of the ODEC System supply circuit.

10) The protection at the Point of Common Coupling must recognize and disconnect the Generator from ODEC System if the generator becomes an Island with Consumer load. Exceptions are those generators with specific contractual obligations to supply Consumer load and who have installed necessary equipment to control and stabilize voltage and frequency within normal range within the Island.

11) Any automatic re-connection of the generator to the ODEC System following a loss and subsequent restoration of the ODEC System source must occur only after the ODEC System has stabilized. Automatic re-connection will be reviewed and if acceptable to ODEC, approved on a case-by-case basis.

12) All new generation facilities will require high speed current differential protection on the generator tie line to the point of common coupling (PCC) and the communication medium shall be a fiber optic system utilizing OPGW or ADSS under build. Generator will not be allowed to parallel and feed into ODEC's system when the fiber optic communication is out of service for any reason.

Note: This preceding list of design requirements is not intended to be all-inclusive. Other hazards and conditions may need to be taken into consideration by the design engineer based upon the circumstances, the specific site, the Generator Owner's needs and other appropriate criteria.

E. System Interconnection Point Information

A Project Developer will normally want to interconnect their generator to an ODEC System circuit or substation that is near their site. Some details about the ODEC System are provided below to assist the Project Developer in the design of their Facility.

1) The ODEC transmission system consists of 69kV transmission circuits. All circuits are effectively grounded. The configuration may be radial or networked. New interconnections shall be on a ring or a breaker and half station. Addition of a facility that would result in more than 6 terminals to the ring bus shall require the station be upgraded to breaker and a half design. New generation projects requiring conductor upgrades on the ODEC system shall also include replacing the existing static conductor with OPGW, if OPGW does not already exist at the location and typically will require terminal to terminal upgrades. Specifics will be detailed in the Phase III System Impact Study.

2) The ODEC System can only accept 60 Hz alternating current from parallel generators. All parallel generators must be 3-phase. The maximum size of the generator that can be interconnected is determined on case-by-case basis following the interconnection studies.

3) ODEC may limit the size of the generator that can be interconnected at any location due to the existing infrastructure and loading of the system surrounding the proposed generator site. Any Company system upgrades or new construction necessary to interconnect a generator larger than the existing ODEC System will support will be done at the Generator Owner's cost, unless otherwise allocated in accordance with PJM Tariff or PJM Operating Agreement or State regulation.

4) All circuits have automatic line restoration following a line trip. Some faults (short circuits) are temporary in nature, such as those caused by a flashed insulator or a tree limb that brushed against a line. Once the fault has been detected and the affected circuit de-energized, the circuit can often be successfully re-energized. This re-energizing or automatic reclosing could occur instantaneously or take up to a minute or more. The purpose of automatic line restoration is to i) restore the integrity of the ODEC System and ii) reduce any Customer outage time. The Project Developer will have to take into account the impact of automatic circuit restoration in the design and operation of their Facility.

The Generator Owner may request ODEC to delay any high-speed reclosing on the ODEC System supply circuit to allow the Parallel Operation generator sufficient time to isolate itself from an island or de-energized circuit prior to ODEC automatic reclosing. Since delaying the automatic reclosing time degrades the level of service to other Customers on the circuit, ODEC may limit any delay of the automatic reclosing to a few seconds or less. Alternatively, the Generator Owner may request that a direct transfer trip scheme be added to isolate the interconnected generator from ODEC system prior to automatic reclosing by using communication equipment between the Generator Owner's site and ODEC. Similarly, the Generator Owner may request that a synchronizing check or reclose-blocking scheme be installed on ODEC's source circuit to prevent out of phase reclosing. The Generator owner is responsible for all costs associated with the installation and maintenance of these requested modifications.

F. Interface Transformer

1) In most cases, an Interface Transformer will be required to interconnect the Generator Owner's Facility to the ODEC System voltage. This Interface Transformer will decrease voltage variations seen by Consumers, help to attenuate harmonics and reduce the effects of fault currents.

2) ODEC reserves the right to specify the type of Interface Transformer connection (e.g., delta-delta, wye-delta, wye-wye) that should be utilized, consistent, where reasonable, with the needs of the Generator Owner's Facility. The intent is to best integrate the transformer with the circuit grounding and area ground fault detection schemes.

3) The Interface Transformer shall have a grounded wye connection to ODEC System, and have a delta winding, thereby providing a source of ground fault current to the system, unless otherwise required by ODEC. Special protection scheme must be developed to resolve or reduce the impact of overvoltage when the interface transformer to ODEC system is ungrounded connection (delta or ungrounded wye).

4) The Interface Transformer must be sized to support maximum anticipated power transfers to and from the ODEC System. Transformer impedances and neutral-to-ground impedance shall be selected to provide an effectively grounded source to the ODEC system.

5) Interface Transformers protection will be finalized during the ODEC impact and facility study (or, as applicable, the PJM Phase III System Impact Study). Transformers larger than 10 MVA require a high side circuit breaker or circuit switcher along with appropriate protective relaying, as described in section X-B.

G. Power Quality Requirements

1) The Generator Owner's Facility shall be designed and operated in such a manner that there are no noticeable adverse impacts to ODEC System voltage, frequency, harmonics etc.

2) The parallel generator shall not cause voltage flicker on the ODEC System. (Voltage flicker is defined as variations in system voltage magnitude and duration sufficient to allow visual observation of a change in electric light source intensity.) Any flicker shall not exceed the "Borderline of Irritation" Curve, as defined in IEEE Std. 519, IEEE 141, IEEE 1453-2015*, IEEE Recommended Practice for the analysis of*

Fluctuating Installations on Power Systems. ODEC reserves the right to require tighter flicker control in situations where other Customer's equipment or operations (computers, instrumentation, process controls, etc.) are impacted.

3) The parallel generator shall not cause rapid voltage change (RVC) at the PCC. Depending on the PCC voltage level, the generator shall not cause step or ramp change in the RMS voltage at the PCC exceeding some fraction of nominal or averaged value over the period of one second; the details of the limitations are defined in IEEE Std. 1547-2018.

4) A parallel generator could introduce harmonic distortion into the ODEC System if equipment such as DC to AC inverters are used in the Facility (Harmonic distortion is defined as continuous distortion of the normal 60 Hz sine wave typically caused by non-linear loads or by inverters, measured in total harmonic distortion, THD.). Any voltage harmonic distortion shall not exceed the limitation as defined in IEEE Std. 519-2014, *Recommended Practices and Requirements for Harmonic Control in Electric Power Systems*, Table 1. The limits vary dependent on the voltage. In addition, the level of harmonic current that the Generator Owner shall inject into ODEC System should not exceed the level specified in Table 1 and in IEEE Std. 519-2014.

5) Any DC to AC inverter should not inject DC current greater than 0.5% of the rated inverter capacity into the Point of Common Coupling during both normal and abnormal operation.

H. Power Factor Requirements

1) A parallel generator shall not adversely impact the power factor of the ODEC System at or near the Point of Common Coupling. The generator type impacts the power factor. The inverters of most DC generators are designed to operate close to unity power factor. Induction generators absorb VARS from the ODEC System. Synchronous generators can either absorb or produce VARS thus having a varying power factor depending upon excitation control. VAR requirements for generators will be determined through the PJM interconnection study process. For Customer owned generators seeking parallel operation through an New Service Request directly to PJM, the generator(s) must adhere to the power factor requirements as detailed in PJM Manual 14H, New Service Requests Cycle Process, Section 9.2: Generator Power Factor Requirements. Otherwise, the power factor requirements listed below apply, unless otherwise stated in the Generator Interconnection Agreement.

2) The System Control Center can request that the generator's real and reactive power output be adjusted to best meet the needs of the overall system.

3) Depending on the Point of Common Coupling location, the ODEC System can be limited in the amount of reactive power capacity available to the Generator Owner. The Generator Owner must provide for his own reactive power requirements (via generator control, capacitors, etc.) to operate with a power factor (drawing VARS from the ODEC System) at the Point of Common Coupling of no less than existed prior to the installation of the Facility. Any reactive power requirements of more than this limit may require upgrades and/or the installation of capacitor units on the ODEC System. The costs for any such upgrades will be charged to the Generator Owner. Specific purchase power arrangements, including power factor requirements, are defined in appropriate tariffs and interconnection agreements.

4) It is the Generator Owner's responsibility to provide adequate mitigation equipment or controls to ensure that any variation in voltage at the Point of Common Coupling does not exceed the limits defined in the tariff and by the local regulatory jurisdiction.

5) Generator Owner will be required to maintain the voltage per the schedule provided by PJM and ODEC. The voltage schedule will be updated annually or as needed by the Transmission Operator.

6) For intermittent type generators such as wind and solar (photovoltaic) the generator may be required to operate in a fixed absorbing vars power factor schedule to mitigate voltage impacts caused by power output fluctuations. If the generating facility is capable and obtains permission from ODEC, it may operate in a dynamic mode to mitigate voltage impacts by dynamically controlling VARs.

I. Inverter Requirements

1) The Generator Owner must use a non-islanding type inverter as defined in IEEE 929 2000, *IEEE Recommended Practices for Utility Interface of Photovoltaic (PV) Systems* and UL Subject 1741, May 1999,*Standard for Static Inverters and Charge Controllers for use in Photovoltaic Power Systems*.

2) Non-islanding type inverters are inherently designed to automatically disconnect from the ODEC System if the Generator Owner's site becomes isolated from the ODEC System. This type of inverter also prevents the Generator Owner from inadvertently supplying other Company Customers in an isolated Island situation.

3) The default requirement for all BESS IBRs connected to ODEC's 69kV system is to have Grid-Forming (GFM) capability.

4) Non-islanding type inverters are manufactured with built-in protection; however, Generator Owner shall provide additional or redundant protection functions by using utility grade protective relays.

5) The inverter output specifications must meet the power quality requirements detailed in Section VIII - G. Inverters used in utility-scale solar installations may need to include dynamic var compensation or use other mitigating means to maintain voltage regulation at the Point of Common Coupling. Non-islanding dynamic inverters shall meet the provisions of IEEE 1547 and UL 1741.

J. Induction Generator Requirements

1) The reactive supply for induction generators may impose some design and generator size constraints as these generators obtain their excitation from the ODEC System. Capacitors may have to be added either at the Generator Owner's site or on the ODEC System (see Section VIII-H). The addition of capacitors may also cause undesirable ferro-resonance.

2) Any flicker produced while starting an induction generator and bringing it up to synchronous speed (as an induction motor) must not exceed the flicker limit detailed in Section VIII-G. 2.

3) The installation of capacitors for reactive supply at or near an induction generator site greatly increases the risk that the induction machine may become self-excited if somehow isolated from the ODEC System. A self-excited induction generator can rapidly produce abnormally high voltages which can damage equipment on the ODEC System and at other Customer sites. Self-excitation is more likely where the ODEC System capacity and the circuit load density are both low.

4) The Generator Owner with an induction generator must include protection at their facility to detect self-excitation operation and disconnect the generator from the ODEC System.

5) By their design, induction generators can only supply fault current for a short period of time as the field flux decays rapidly on removal or decay of the source voltage.

K. Synchronous Generator Requirements

1) By their design and generally larger size, synchronous generators can support sustained fault currents. As such, the protection scheme associated with the Point of Common Coupling must be designed to ensure detection of fault conditions in the ODEC System.

2) Synchronous generators can operate independently irrespective of the system source. They can continue to operate after being isolated from the system providing the load is within the generator's capacity. Consequently, a more robust protection scheme is generally needed to detect isolation from the system, such as transfer trip from ODEC source.

3) Sufficient generator reactive power capability shall be provided to withstand normal voltage changes on the ODEC System.

L. Kilowatt-Hour Metering Requirements

Detailed kilowatt-hour metering requirements are outside of the scope of this document. The requirements for each parallel generator installation will be reviewed and determined on a case-by-case basis. However, some basic assumptions can be made.

1) All parallel generator Facilities shall be metered in accordance with applicable tariffs and specifications provided in approved Company publications.

2) ODEC reserves the right to specify the required KWH metering equipment for each parallel generator site.

3) Unless otherwise mutually agreed upon by ODEC and the Generator Owner, ODEC shall have ownership of the equipment and supply all inspection, reading, maintenance and testing of KWH metering for the Generator Owner's Facility, at the Generator Owner's cost. ODEC may elect to have the Generator Owner install the metering PTs (potential transformers) and CTs (current transformers) within the Generator Owner's switchgear equipment.

4) ODEC shall require KWH metering of the generator output to the extent reasonably necessary to provide ODEC with the data needed to administer its tariffs and to operate and plan the ODEC System.

5) The Point of Common Coupling KWH metering shall be bi-directional so that power deliveries to and from the Generator Owner's site can be separately recorded. The Point of Common Coupling metering shall be equipped with detents to prevent reverse registration.

6) All metering shall comply with ANSI and Company technical requirements (including meter model, options & programming). For power quality purpose, IEEE 1547 Std. can be followed for minimum measurement and calculation accuracy requirements.

7) Metering devices shall have communication capabilities to provide metering data to SCADA.

8) A suitably located and adequately protected meter location shall be provided to ensure meter accuracy, and to facilitate meter access, reading, and testing, without undue inconvenience.

9) The Generator Owner may, at its sole option and cost, install or have ODEC install additional metering equipment to meet any special needs that the Generator Owner may have.

10) PJM may have additional metering requirements for those Generators Owners under contract for PJM energy or capacity purchases. The Generator Owner will have to contact PJM and review PJM publications for metering details.

11) The metering devices should have harmonic monitoring based on standard IEEE 519 and IEEE 1547.

M. Monitoring and Control Requirements

1) For customer owned generators seeking parallel operation through an Interconnection Request directly to ODEC, the generator(s) must adhere to the monitoring, control and remote telecommunication requirements as outlined in PJM Manual 01, *Control Center and Data Exchange Requirements* and PJM Manual 14D, *Generator Operational Requirements.*

2) Since parallel generators, particularly the larger units, have a direct impact on the overall operation and performance of the ODEC System, it is important that ODEC monitor and, in some cases, have control access to generator synchronizing and interface breakers. In addition, monitoring and certain control functions are needed for those parallel generators that are dispatched either by ODEC or via PJM. The requirements for each parallel generator installation will be reviewed on a case-by-case basis. However, some basic assumptions can be made.

3) The Generator Owner shall purchase and install a Remote Terminal Unit (RTU) of a suitable vendor to enable ODEC and, if required, PJM to monitor the status of the data points listed in item 6) below at the Generator Owner's site and to control certain breakers, if required. This RTU shall utilize DNP 3.0 protocol, or other such protocol compatible with the existing Supervisory Control System at ODEC and PJM.

4) The Generator Owner shall provide a communication link between ODEC, PJM (if required), and the Generator Owner's on-site RTU.

5) The generator size and operating requirements will determine whether the RTU at the Generator Owner's Facility is to communicate with only ODEC or also with PJM. Certain cases are outlined in item 6) below.

6) For the Generator Owner's RTU communication with the Company, a dedicated communication path is necessary to provide real time data. The Generator System shall not be allowed to operate in parallel if the RTU or its associated communication is out of service.

7) If the Generator Owner's RTU is communicating with PJM, real time data communication is required except for units less than 10 MW that are not being offered into the PJM market.

8) RTU requirements will vary based on the size of installed generation. Analog telemetry and status indication points are listed below. In addition, certain control functions may be required to allow remote dispatch of generation or isolation of the generator from the ODEC System in the event of System Emergencies. Specific requirements will be determined on a case-by-case basis.

a) Telemeter MW and MVAR Output for each generator
b) Telemeter MW, MVAR, Amp Flow on each Point of Common Coupling
c) Telemeter generation and Point of Common Coupling Bus Voltages
d) Telemeter frequency at the Point of Common Coupling
e) Status indication of generator breakers and Point of Common Coupling breakers
f) RTU interconnection to Company and PJM
g) Alarms such as loss of communication, loss of DTT for each direction, and critical device failure (not limited to relay, battery, and generator control etc.)
h) Primary equipment failure alarms such as breaker failure, low SF6 Gas, blown PT fuses, trip coil failure, transformer critical alarms (low pressure, winding temperature, etc.)

Note: The Generator Owner shall contact PJM directly and review PJM documents to ensure compliance with all the PJM RTU monitoring/control requirements for their proposed site.

N. Event Recording Requirements

1) The Generator Owner shall purchase and install recording equipment to monitor the performance of their protection and control equipment for those parallel generator sites interconnected with the ODEC System at voltages 69kV and above.

2) ODEC reserves the right to specify the voltages, currents, device status, etc. to be monitored and recorded bythis event recording equipment. Additionally, ODEC may install additional event recording equipment on its side of the interconnection.

3) Event information may be recorded by features internal to microprocessor type protective relays, by separatedigital fault/event recorders or by a combination of these two methods.

4) When a digital fault/event recorder is installed, ODEC will specify a manufacturer and type to ensure compatibility with other digital fault/event recorders in the ODEC System.

5) The Generator Owner shall supply event data as requested by ODEC.

6) Digital fault recorders should be time synchronized to a reference traceable to the National Institute of Standards and Technology (NIST).

It is the Generator Owner's responsibility to meet any and all PJM/NERC event recording requirements. ODEC reserves the right to isolate the Generator due to the failure of collecting data, failure of data available upon request, and potential hazards to ODEC system or general public.

O. Cyber Security Requirements

The interoperability and communications cyber security requirements of specific generator deployments may be based on mutual agreement between the generator owner and the ODEC based on the risk profile. It may also be subject to regulatory requirements.

IX. Performance Requirements

A. General

1) The interconnection of parallel generation with the ODEC System is permissible only if the system voltage, frequency and current flow at the Point of Common Coupling are within normal limits. Parallel operation must cease immediately and automatically for abnormal voltage, frequency, or current flow as defined below.

2) Parallel operation must also cease automatically for operation outside the power quality limitations detailed in Technical Design Requirements, Section VIII - G.

B. Voltage Limits

1) The Generator Owner's equipment shall be operated in such a manner that the voltage levels on ODEC's system remain within the operating limits defined by ANSI C84.1.

2) The generator must immediately and automatically cease parallel operation and disconnect from the ODEC System if the voltage (V) at the Point of Common Coupling exceeds the limits defined below:

Table 2

DC Generating Systems with Non-Islanding Inverters	Induction and Synchronous Generators All Sizes
a) Trip in 0.16 Second for V < 50% b) Trip within 3 Seconds for 50% < V < 70% c) Trip within 6 Seconds for 70% < V < 88% d) Trip within 2 Seconds for 107% < V < 120% e) Trip in 0.16 Second for V > 120% Specific voltage and time delay set pointswill be determined for each generator installation. **Note**: Voltage and time delay set points taken from IEEE 2800 2022, IEEE Std. 1547-2018 & UL 1741	a) Trip in 0.1 Second for V > 115% b) Trip within 0.1 to 30 Seconds for V > 110% or V < 90% Specific voltage and time delay set points will be determined for each generator installation. **Note:** Exceptions to these limits are those bulk generators with a contractual obligation and authority to supply other Customer load in an island mode arrangement, and which have installed appropriate equipment to control and stabilize voltage within the island.

Notes:

i. Trip time refers to the time between when the abnormal voltage condition occurs and the generator being disconnected from ODEC System.
ii. Three-phase voltage sensing shall be used.
iii. The voltages must be sensed on the high side of any Interface Transformer if the high voltage winding is ungrounded. Such a scheme is necessary to rapidly detect severe overvoltage that occurs for a grounded high side conductor being energized from an ungrounded generation source. These high voltages can quickly cause catastrophic failure of lightning arresters and lead to other equipment insulation failures.
iv. The generators shall be able to provide the voltage disturbance ride-through capability specified in Table 14-16 of IEEE 1547-2018 Std. without exceeding generator capabilities unless the frequency is outside of the ride through range specified in Table 19 of the same standard.
v. All voltage protection used within the plant shall use filtered quantities to reduce the possibility of mis-operation while providing protection to system equipment. Voltage protection shall meet the ride through requirements listed above, coordinate with transient overvoltage capability of the Generator and other surge protection within the Generator facility.

3) The Generator Owner may reconnect to the ODEC System when the system voltage returns to normal range and the system is stabilized. Reconnection approval shall be requested from the ODEC System **Control Center**.

C. Frequency Limits

1) The generator must immediately and automatically cease parallel operation and disconnect from the ODEC System if the operating frequency exceeds the limits defined below:

Table 3

DC Generating SystemsWith Non-Islanding Inverters	Induction/Synchronous Generators Non-PJM Market Up to 10 MW	Synchronous Generators in PJM Market or Greater than 10MW
a) Trip in 300 Seconds for F < 58.5 Hz. b) Trip in 300 Seconds for F > 61.2 Hz. c) Trip in 0.16 Second for F < 57 Hz. d) Trip in 0.16 Second for F > 62 Hz. Set points taken from IEEE 1547-2018 and UL 1741.	a) Trip in 0.1 Second for F < 58.5 Hz. b) Trip in 0.1 Second for F > 60.5 Hz. Other frequency and time delay set points may be necessary for a specific installation.	a) Trip in 5.0 Seconds for F < 57.5 Hz. b) Trip within 1.0 Second for F > 61.0 Hz.

Notes:

i. Trip time refers to the time between when the abnormal frequency condition occurs and the generator being disconnected from the ODEC System.
ii. Synchronous Generators less than 10 MW whose output is netted with peak load (net system load reducer) to calculate PJM underfrequency load shedding needs, will also have to meet frequency requirements for PJM Market generators.
iii. PJM Frequency requirements are to provide uniformity across the entire system and to ensure that all generator units will remain online until the frequency limits are reached.

2) The Generator Owner may reconnect to the ODEC System when the system frequency returns to normal range and the system is stabilized. Reconnection approval shall be requested from ODEC System **Control Center**.

D. Synchronization

1) To avoid damaging a generator during synchronization, the generator manufacturer will generally provide synchronizing limits in terms of breaker closing angle, slip frequency and voltage matching. Those manufacturer limits should be followed but in no case should they exceed the limits listed below.

Table 4

Frequency Difference (Slip)	Voltage Difference	Phase Angle Difference
0.2 Hz.	10%	10 Degrees

2) Generators with a Stiffness Ratio of 20 or less, or those units where a stability study has indicated possible unstable operation shall be equipped with a protective functions suitable for detecting loss of synchronism (out of step or pole slipping).

3) Induction generators that are started across the line shall not cause voltage flicker to exceed the limitation defined in Technical Design Requirements, Section VIII - G 2. If these flicker limits are exceeded, the induction generator shall be accelerated to synchronous speed by the prime mover prior to paralleling with ODEC System.

4) The inverters of DC generating systems shall obtain their commutation reference from the ODEC System and thus synchronization will not be an issue.

E. Island Operation

1) The generator must automatically and immediately disconnect from the ODEC System if the source from the system is lost. This separation must occur irrespective of connected load or other generators on the circuit. An Island of generation with Consumers will be permitted only if specific contractual arrangements have been made and necessary equipment has been installed by the Generator Owner to control and stabilize the island voltage and frequency within the limitations defined in Sections IX - B and C. In general, this will require the Interface Transformer to provide a grounded source to the Island and a generator capable of isochronous operation.

2) The generator must be disconnected from ODEC System before any automatic reclose or re-energizing of the ODEC source.

F. Fault Detection and Isolation

1) For a fault condition on an ODEC source circuit that interconnects with the Generator Owner's Facility, the Generator Owner must have protective relaying to detect this condition and disconnect the generator from the system. The required operating time of the protection scheme is dependent on many variables including voltage class, generator stability concerns, primary versus backup relaying, and coordination requirements with Company relaying scheme. The Company will work with the Generator Owner and ascertain the performance requirements on a case-by-case basis.

2) In cases where clearing time from the Generator Site is critical and/or when high speed auto reclose is needed on the source circuit, transfer trip from the Company end of the circuit to the Generator Owner's site may be required.

3) For a fault condition within the Generator Owner's Facility, the Generator Owner must have protective relaying to detect and isolate the fault from the ODEC System. The required clearing time of the Facility's protection schemes is dependent on many variables such as voltage class and the operating time of any Company protection schemes that reach into the Facility. In case of an Interface Transformer high side breaker failure, DTT from relays in Facility's protection to ODEC relaying protection system shall be implemented. ODEC will review the proposed operating time of the Facility's protection schemes and ascertain the performance requirements on a case-by-case basis.

4) DTT, breaker statuses, and protection variables are acceptable to be transmitted between relays in ODEC system and generator's relays. ODEC will review the transmitted data.

Any protection relays that can impact ODEC's system must be coordinated.

G. Closed Transition Switching Installations

Some privately owned generation may be paralleled only momentarily with the ODEC System during part of a source or load transfer sequence.

1) At the time of momentary parallel operation, these installations must meet the voltage, frequency and synchronization requirements outlined in preceding Sections IX - B, C, and D. The synchronizing may be manual for generators up to 10 MW if the closed transition is manually initiated. Otherwise, the synchronizing should be automatic.

2) The transition scheme must have an additional safeguard to limit the amount of time the generator is paralleled with the system. The scheme shall trip the generator if the closed transition mode remains in effect longer than some predetermined time, usually 0.1 second.

X. Protection Scheme Details

A. General

1) The protection schemes described in this section are intended to be typical for illustration purposes and not specific design requirements for any particular site. They are intended to guide the proposed Generator Owner as to the type of protection schemes necessary for Parallel Operation of generation.

2) Protective relays, wherever possible, shall be microprocessor type with integral trip record and fault recording, self-checking and remote communications. Remote communications should be provided through a digital switching device to allow a single communication line to service multiple protective relays.

3) All protective relays must have the desired sensitivity and speed for their intended application and must be of utility grade.

4) All equipment, lines and busses operating at 69kV and above shall be protected by two independent protective schemes.

5) Primary and backup protection schemes shall be supplied via independent current and potential circuits and independently protected DC control circuits.

6) DC circuits supplying protective relaying schemes shall be continuously monitored and fused separately from any other DC control circuits. Loss of any control power bus including DC trip and close busses of each breaker shall also be monitored and alarmed to a manned location so that corrective action can be taken. Relay failure alarms shall be handled in a similar manner.

7) All protective relay systems, equipment, design, operation and maintenance shall be in accordance with all applicable Federal, State and Local requirements, National and Regional Reliability Criteria and Industry Recognized Standards and Guidelines. References to such requirements may be found in Section XIII of this document. The listing is not intended to be all-inclusive.

B. Interface Transformer Protection

Based on Interface Transformer size, various elements to be included in the scheme are listed below.

Table 5

Less Than 10 MVA	10 – 50 MVA
Protection to be confirmed during the Phase II and Phase III System Impact Studies as described in PJM Manual 14H.	Transformer Primary and Secondary Differential REF Differential Fault Pressure Phase and Neutral Time/Inst. Overcurrent

Notes:

i. The location of the transformer overcurrent relaying may be dependent on the transformer connections.
ii. Generators with a fuse protected Interface Transformer must include protection to detect an open fuse condition.

C. Interconnection Line Protection

The protection applied to a line terminal at the Generator Owner's site that interconnects the privately owned generator with the ODEC System will vary depending on the voltage class and existing line relaying scheme at ODEC end(s). All new generation interconnection lines will require high-speed protection schemes, one of which shall be fiber current differential scheme with DTT.

D. Generator Isolation Detection Schemes

1) Under/over frequency and under/over voltage schemes can be used to detect the fact that the generator is Islanded with load (and possibly other generation) and needs to be disconnected from ODEC System. These schemes are effective where there is a significant mismatch between load and generator rating (See Performance Requirements, Sections IX - B3 and C1).

2) Under/over frequency and under/over voltage detection become less reliable when the Islanded load is closely matched to the generator capacity so that the resulting voltage and frequency is at or very near normal. In these cases, a direct transfer trip from the ODEC System end of the interconnection circuit will be necessary.

3) Generators selling into the PJM marketplace that have their under-frequency trip point set to 57.5 Hz for 5 seconds essentially removes under-frequency sensing as

a sensitive means to detect isolation. In this event, other protective measures may be required.

4) Generally, combinations of different protection schemes are necessary to be 100% effective and to provide a level of redundancy.

5) For cases where a transfer tripping scheme is needed to guarantee isolation detection, the failure of the transfer trip scheme or communication channel will require that the generator automatically disconnects from the Company until the transfer trip scheme is restored.

6) Transfer trip schemes shall only utilize a fiber path as a communication medium.

E. Generator Protection Schemes

1) The protection schemes on generators will become more complex as the size of the generator unit increases. In addition, those generators offering their output into the PJM marketplace will require specific protection as required by PJM. The *PJM Relay Subcommittee Protective Relaying Philosophy and Design Standards* should be consulted.

2) Multi-function microprocessor relays can be used to provide several generator protection functions. However, a second multi-function relay (preferably from another manufacturer to avoid a common failure mode or defective algorithm) is necessary to provide for a relay failure. Alternatively, the generator could be immediately and automatically tripped offline upon a relay failure alarm and remain offline until the relay is repaired.

3) The Generator Owner should consult the generator manufacturer and national standards to develop the appropriate protection for each generator installation. National standards include C37.102-2006, *IEEE Guide for AC Generator Protection* and C37.101-2006, *IEEE Guide for Generator Ground Protection*.

Notes:

i. On generators with primary and backup differentials, one differential may also cover the unit step up transformer.
ii. Loss of synchronism (out-of-step) protection is necessary where stability studies have shown this type of protection to be needed.
iii. Ancillary protection schemes such as breaker failure are also required.

XI. Distributed Energy Resources (DER)

A. General

1) For these specifications, DER is defined as resources interconnected with ANEC facilities rather than ODEC facilities of no less than 2 MW.

2) DER may be classified by those that have a Wholesale Market Participation Agreement (WMPA), and those which do not. They may be further classified by those that will normally inject current into the transmission system (specifically, the injected power is greater than the lightest loads on the ANEC distribution circuit) and those that will not (injected power is less than the lightest loads on the ANEC distribution circuit). These possibilities can be categorized as follows:

   a) Class I: DER with WMPA and will inject power onto the transmission system under normal conditions.
   b) Class II: DER with WMPA and will not inject power onto the transmission system under normal conditions.
   c) Class III: DER without WMPA and will not inject power onto the transmission system under normal conditions.
   d) Class IV: DER without WMPA and will inject power onto the transmission system under normal conditions. [Class IV is not allowed.]

3) ODEC requires an impact study be performed for any DER greater than 2 MW that may connect to the system under any circumstances.

4) Notes:

   a) Normal Conditions: All distribution circuits from the substation are energized and all field tie switches between circuits of different substation are open. Load may take on any value from lightest (historical or predicted) to heaviest (historical or predicted).
   b) Class I and Class II DER will have a queue number assigned to each project by PJM.
   c) To prevent unintentional islanding, grid forming operation of inverters on the ANEC and ODEC system is prohibited until the anti-islanding scheme is constructed and made operational.

B. Transfer Trip

1) For Class I DER, evaluation will be made according to PJM new service queue process requirements. Transfer trip from the 69kV island detection scheme (to be implemented) to prevent islanding will be required.

2) For Class II DER, when the total of all DERs and renewable generation on the ANEC and ODEC systems are generating less than 30% of historic ODEC system light load, reverse power relaying (set to prevent zero flow into the ODEC system) along with passive island detection (81o/u, 59, 27) shall be installed at the POI between ANEC and ODEC and shall trip the DER. Under and over voltage relaying will be set to NERC minimum ride-through requirements. For DERs resulting in generation totaling more than 30% of load in any area that could become islanded, transfer trip from the 69kV island detection scheme is required. ODEC cannot approve DER interconnections until the fiber optic and island detection systems are installed. Anti-islanding schemes are implemented to prevent individual generators from energizing transmission elements within the island and to also prevent unsynchronized reclosing on the generator.

3) For Class III DER, the requirements are the same as Class II.

4) All DER shall be studied for infeed to faults on the transmission system and shall require transfer trip from the remote terminals of the transmission line or line differential relaying if deemed necessary by ODEC.

C. Harmonics

"Before and after" current harmonics readings shall be taken at the POI between ODEC and ANEC at the delivery point serving the DER. The DER owner shall install filtering should any current or voltage harmonic exceed the values given in Table 17 and Table 18 of IEEE 2800-2022 (Section 8.2.1) found to exist after installation of the DER that were not previously existing before the installation.

D. Metering

1) Class I and Class II DER shall be metered according to the criteria given in this document, the PJM OATT and the requirements stated by ODEC during the interconnection study process.

2) Class III DER shall be metered according to the information given in the interconnection study process. Any Class III DER purchased by ODEC shall be subject to additional requirements given by ODEC to the developer before or at the time of sale, e.g. remote reading capability by ODEC and compatibility with ODEC's meter data system.

E. Other

1) Flicker: Impact studies for DER will include a test for flicker.

2) Facilities Study results must satisfy ODEC planning criteria as well as all sections of this document

3) ODEC breakers shall not be used to synchronize DER generation to the transmission system. These breakers shall also remain under control at all time by ODEC's transmission operator. DER must provide their own synchronizing equipment. ODEC breakers will not reclose on energized member or DER facilities and therefore all DER power facilities need to be de-energized before power can be restored.

XII. Typical One-Line Diagram

Only Ring or Breaker and Half Configuration Allowed for new IPPs.

XIII. Information to Be Supplied by Generator Owner

The following information must be supplied by the Generator Owner with the submittal of the PJM New Service Request to allow ODEC to conduct necessary studies and reviews to assess the impact of the proposed Facility on the ODEC System, and to quantify what, if any, upgrades are required to accommodate the proposed generation addition at the specified Point of Common Coupling. **PLEASE REFER ATTACHED CUSTOMER REQUEST FORM.**

It is recognized that some information will not be available at the time of initial application submission. However, the Generator Owner should supply as much information and detail as possible and forward other necessary information as soon as it becomes available.

At the very least, data requested in Sections A through G, H1 and L should accompany the initial application submission.

A. Name of Generator Owner.

B. Name, address, telephone number, and E-mail address of individual able to answer technical questions relating to the design and operation of the proposed Facility.

C. Exact location of proposed Point of Common Coupling.

D. Energy Source, Generator Manufacturer, Type and Model Name, (Synchronous, Induction, Inverter, etc.), Quantity of Generators, Generator Compliances, Generator Technical Information/Datasheet, Generator Simulation Model (if available), and rating of proposed generator(s).

   1. For Synchronous Generator: rated power factor leading/lagging, generator nameplate, grounding methodology (if applicable).

   2. For Solar or DC sources: inverter model name/number, panel manufacturer, quantity of panels, and panel size.

   3. For Wind Turbines: inverter model name/number, equipment nameplates, height to tip, blade diameter, quantity of turbines, turbine size.

E. Estimated maximum and minimum Facility load at Point of Common Coupling with generation in service.

F. Estimated maximum and minimum Facility load at Point of Common Coupling without generation in service.

G. Estimated maximum power anticipated to be exported into the ODEC System.

H. The Generator Owner shall provide copies of the following drawings to ODEC for their review:

1. A one-line diagram of Facility with specified GSU interconnect transformer(s).

2. All potential elementary diagrams associated with the protection and control schemes for thegenerator and interconnection equipment.

3. All current elementary diagrams associated with the protection and control schemes for thegenerator and interconnection equipment.

4. A control elementary of the generator breaker and the interconnection breaker.

5. A three-line diagram of generation system.

I. The One-Line and Three-Line Diagrams shall include the following information:

1. Equipment names and/or numerical designations for all circuit breakers, contactors, air switches,transformers, generators, etc. associated with the generation as required by ODEC to facilitate switching.

2. Power Transformers - name or designation, nominal kVA, nominal primary, secondary, tertiary voltages, vector diagram showing winding connections, tap setting and transformer impedance. Acopy of the transformer nameplate and test report can be substituted.

3. Station Service Transformers - Nameplate, Designate phase(s) of connection and estimate kVA load.

4. Instrument Transformers - Voltage and current, test report, phase connections.

5. Surge Arresters, etc. - Type and Ratings.

6. Capacitor Banks - kVAR rating, manufacturer datasheets.

7. Disconnect Switches - Indicate status normally open with a (N.O.), remote control capability, and whether manual or motor operated. Include switch voltage, continuous and interrupting ratings.

8. Circuit Breakers and/or Contactors - Interrupting rating, continuous rating, operating times.

9. Generators(s) - Include nameplate, test report, type, connection, kVA, voltage, current, PF,impedances, time constants, etc.

10. Point of Interconnection to ODEC System and phase identification.

11. Fuses - Manufacturer, type, size, speed, and location.

J. Elementary Diagrams shall include the following information:

1. Terminal designation of all devices - relay coils and contacts, switches, transducers, etc.

2. Relay functional designation - per latest ANSI Standard. The same functional designation shallbe used on all drawings showing the relay.

3. Complete relay type (such as CV-2, SEL321-1, REL-301, IJS51A, etc.).

4. Switch contact shall be referenced to the switch development if development is shown on aseparate drawing.

5. Switch developments and escutcheons shall be shown on the drawing where the majority of contacts are used. Where contacts of a switch appear on a separate drawing, that drawing should be referenced adjacent to the contacts in the switch development. Any contacts not used should be referenced as spare.

6. All switch contacts are to be shown open with each labeled to indicate the positions in which thecontact will be closed.

7. Explanatory notes defining switch coordination and adjustment where improper adjustment couldresult in equipment failure or safety hazard.

8. Auxiliary relay contacts shall be referenced to the coil location drawing if coil is shown on a separate drawing. All contacts of auxiliary relays should be shown and the appropriate drawing referenced adjacent to the respective contacts.

9. Device auxiliary switches (circuit breakers, contactor) should be referenced to the drawing wherethey are used.

10. Any interlocks electromechanical, key, etc., associated with the generation or interconnection substation.

11. Ranges of all timers and settings if dictated by control logic.

12. All target ratings on dual ratings note the appropriate target tap setting.

13. Complete internal for electromechanical protective relays. Microprocessor relays may be shownas a “black box”, but manufacturer’s instruction book number shall be referenced and terminal connections shown, including power supply voltage, digital inputs, digital outputs, polarity marks, voltage/current inputs, and communication ports.

14. Isolation points (States links, PK-2 and FT-1 blocks), etc., including terminal identification, shorting test switches, shorting terminal blocks.

15. All circuit elements and components, with device designation, rating and setting whereapplicable. Coil voltage is shown only if it is different from nominal control voltage.

16. Size, type, rating and designation of all fuses.

17. Phase sequence designation as ABC or CBA.

18. Potential transformers - nameplate ratio, tap ratio, polarity marks, rating, primary and secondary connections (see Guidelines for minimum ratings.)

19. Current transformers (including auxiliary CT's) - polarity marks, rating, nameplate ratio, tap ratio and connection.

K. Documentation of all protective device settings shall be provided. The setting documentation shall also include relay type, model/catalog number and setting range. If automatic transfer schemes or unique or special protective schemes are used, a description of their operation should be included. ODEC must review and approve the settings of all protective devices and automatic control equipment which: (1) serve to protect the ODEC System from hazardous currents and voltages originating from the Facility or (2) must coordinate with protective devices or control equipment located on the ODEC System.

L. The following modeling data must be supplied to ODEC and/or PJM to allow necessary interconnection studies to be performed. It is recognized that some of this data may initially be preliminary in nature. Interconnection studies will be based on data submitted. Any changes, or modifications, to this data after the interconnection study has been completed may render the analysis invalid and require re-opening of the interconnection study. It is the Generator Owners responsibility to make ODEC and / or PJM aware of any changes to this data, and to provide final certified test reports and modeling data as soon as it is available.

Data Required from Interconnection Customer

Description	Data Needed
Harmonics Study	
Generation Single-Line Diagram	Detailed layout of plant and interconnection; indicating number of generation units, connection plan, auxiliary loads, and system configuration; Stamped as Issued for Permit (i.e., 60% design).
Substation / GSU Transformer	Specification Sheet including at a minimum: Type, Base Rating, and cooling (kVA and Temperature), % Impedance, Primary and Secondary Winding Ratings and Configurations, Tap Setting, Transformer Test Report, saturation data.
Inverters	Manufacturer Specs (block diagram, parameters, capability curve, ratings) and Harmonic data sheet. Control replica in DLL format, filter RLC values and configuration.
AC cables	Type, Size, Lengths, Geometry, and installation method for all phase and ground conductors.
Skid/Collector Transformers	Specification Sheet including at a minimum: Type, Ratings (kVA/MVA and Temperature), % Impedance, Primary and Secondary Winding Ratings and Configurations, and Tap Setting, saturation data.
Capacitor Banks (if any)	Location, size, and configuration (Delta or Wye).
TOV Screening Study (In addition to above information required for Harmonic study)	
Inverters - dynamic model	Control replica in DLL format. EMTP® or PSS®E file, operating mode settings, for import into EMTP®. *Should dynamic model not be available, ODEC may utilize a Generic EMTP inverter dynamic model upon Developer acceptance.*
TOV Detailed Study (In addition to above information required for Harmonic and TOV Screening study)	
Substation Bus Information	Bus type and lengths. Lengths of all conductors in substation from POI to collector circuits.
Circuit Breaker Information	Nameplate Information including at a minimum: Impulse Withstand Voltage, Rated Voltage and Current, Switching Current Ratings. Circuit Breaker Interrupting Time.

XIV. Standards & References

The references and standards listed below can provide technical requirements, support and insight into the safe, reliable interconnection of parallel generation with the ODEC System. It is suggested that those individuals and firms contemplating operation of parallel generation with the Company review these references for applicability to their installation. This listing is not intended to be all-inclusive. In cases where a reference document has been updated, the most recent version of the document should be used.

Industry Standards

- IEEE C2, National Electric Safety Code (NESC)
- NFPA 70, National Electric Code (NEC)
- IEEE Std. 493-2007, IEEE Recommended Practice for Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book)
- IEEE Std. 519-2014, Second Printing 2004 IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
- IEEE Std. 242-2001, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book)
- ANSI Std. C84.1-2011, Electric Power Systems and Equipment – Voltage Ratings
- IEEE Std. 1159-2009 , IEEE Recommended Practice for Monitoring Power Quality
- ANSI/IEEE Std. C37.1-2007, IEEE Standard for SCADA and Automation Systems
- IEEE Std. C37.2-2008, IEEE Standard for Electric Power System Device Function Numbers, Acronyms and Contact Designations
- IEEE Std. C37.90-2005, Standard for Relays and Relay Systems Associated with Electric Power Apparatus
- IEEE Std. C37.90.1-2012, Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems Associated with Electric Power Apparatus.
- IEEE Std. C37.91-2008, IEEE Guide for Protecting Power Transformers
- IEEE Std. C37.93-2004, IEEE Guide for Power System Protective Relay Applications of Audio Tones over Voice Grade Channels
- IEEE Std. C37.95-2014, IEEE Guide for Protective Relaying of Utility Consumer Interconnections
- IEEE Std. C37.101-2006, Guide for Generator Ground Protection
- IEEE C37.102-2006, Guide for AC Generator Protection
- IEEE C37.103-2015, Guide for Differential and Polarizing Relay Circuit Testing
- IEEE C37.104-2012, IEEE Guide for Automatic Reclosing of Line Circuit Breakers for AC Distribution and Transmission Lines
- IEEE C37.106-2003 (Reaff. 2009), Guide for Abnormal Frequency Protection of Power Generating Plants

- IEEE Std. C37.110-2007, Guide for the Application of Current Transformers Used for Protective Relaying Purposes
- IEEE Std. C37.113-2015 (Reaff. 2004), Guide for Protective Relaying Applications to Transmission Lines
- IEEE C37.230-2007, IEEE Guide for Protective Relaying Applications to Distribution Lines
- IEEE C37.234-2009, IEEE Guide for Protective Relay Applications for Power System Busses
- IEEE Std. C57.13.1-2006, Guide to Field Testing of Relaying Current Transformers
- IEEE Std. C57.13.2-2005, Standard Conformance Test Procedures for Instrument Transformers
- IEEE Std. C57.13.3-2014, Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases
- IEEE Std. 141-1993, Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book)
- IEEE Std. 1453-2015, IEEE Recommended Practice for the Analysis of Fluctuating Installations of Power Systems
- IEEE Std. 1547-2018, Standard for Distributed Resources Interconnected with Electric Power Systems
- IEEE Std. 1547.1-2020, IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems
- IEEE Std. 1547.2-2008, IEEE Application Guide for IEEE 1547
- IEEE Std. 1547.3-2007, IEEE Guide for Monitoring, Information Exchange and Control of Distributed Resources Interconnected with Electric Power Systems.
- IEEE Std. P1547.4-2011 Guide for Design, Operation and Integration of Distributed Resource Island Systems with Electric Power Systems
- UL Subject 1741, 2010, Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

PJM Documents

- PJM Manual 7
- PJM Relay Testing and Maintenance Practices
- PJM Transmission Substation and Line Design, Application and Maintenance Guidelines
- NERC & RFC Planning Standards
- PJM Manual 03 - Transmission Operations
- PJM Manual 14A - New Services Request Process
- PJM Manual 14B - PJM Region Transmission Planning Process
- PJM Manual 14C - Generation and Transmission Interconnection Facility Construction
- PJM Manual 14D - Generator Operational Requirements
- PJM Manual 14E - Additional Information for Upgrade & Transmission Interconnection Projects
- PJM Manual 14H - New Service Requests Cycle Process

- PJM Manual 14G - Generator Interconnection Requests
- PJM Manual 21 - Rules and Procedures for Determination of Generating Capacity
- Transmission Owner Facility Connection Requirements

Revision History		
Date	**Revision No.**	**Notes**
January 1, 2025	0	Document Creation: Revises, Reformats and Replaces Prior Versions

Old Dominion Electric Cooperative

Facility Interconnection Requirements

CUSTOMER REQUEST FORM

January 1, 2025

Customer Interconnection Requests That Impact Old Dominion Electric Cooperative Facilities

For all requests that may impact any Old Dominion Electric Cooperative ("ODEC") facilities, customers shall electronically submit the information requested in this form ("Request Form"), in addition to any other information requested by ODEC and/or A&N Electric Cooperative (ANEC). A customer shall submit this Request Form for any proposed interconnection that may result in:

- the installation, modification, or removal of any of ODEC's facilities;
- an increase in, decrease in, or discontinuation of an existing load of 2 MW or more being served either directly from the ODEC 69kV transmission system or the ANEC distribution system;
- a new load of 2 MW or more being served either directly from the ODEC 69 kV transmission system or the ANEC distribution system; and
- the generation of 2 MVA or more (in the aggregate) that would utilize any of ODEC's facilities for the transmission of same.

In addition, a customer shall submit this Request Form when its proposed new interconnection, or any proposed change to an existing interconnection, is reasonably expected to impact the operation of ODEC's facilities. ODEC, together with ANEC, reserves the right to determine whether an existing delivery point or a new delivery point will be used for any new loads or generation, as well as the best location and path for interconnection of the same.

Customer Request Forms shall be submitted as soon as useful information is available. As the project matures, and additional or updated information becomes available, it is the responsibility of the customer to revise the original Request Form appropriately. Each time a customer submits a revised Request Form it will supersede the earlier Request Form(s).

Customer Request Special Instructions:

1. When a Request Form is submitted with an estimated timeline, the customer, ODEC, and ANEC, (collectively, the "Parties"), shall determine a schedule for the customer's submission of a final timeline.
   1.1. If the customer provides an estimated date for the "Requested Date to Energize," the final "Requested Date to Energize" shall not be before the estimated date provided, unless ODEC and the customer mutually agree on an earlier "Requested Date to Energize" prior to submission of a revised Request Form.
2. A customer may enter "N/A" if a particular field is not applicable to the Customer's interconnection project.
3. ODEC understands that not all equipment information may not be known during the early stages of the project. If equipment details are not known, enter "TBD" with the date that the information is expected to be available (TBD by [date]) in either the applicable field or in the section comments field. Enter as much information as is available at the time of the request. Missing information may delay ODEC's ability to perform the requisite interconnection studies.
4. A customer shall include in its submission of the Request Form each Required Attachment (listed below). If a customer does not have the information to fully complete the attachment, it shall include any available information on the attachment page, or if none, list the date by which the customer will provide the completed attachment.
5. Upon receiving a Request Form, ODEC shall evaluate the request consistent with PJM requirements. The evaluation may include investigation of alternative solutions and estimates for ODEC's portion of the project. Customers shall provide reasonable assistance during the evaluation should ODEC asks for additional information. ODEC shall complete its evaluation in a reasonable time (per PJM requirements) after the customer has supplied all required information as firm or final information.
6. Upon concluding its evaluation, ODEC shall provide customer with a written response documenting (i) request approval, (ii) request approval with modifications, or (iii) request denial. Upon approval of a request, or approval with modifications, ODEC will describe any required modifications and provide an estimate for project costs, cost responsibilities between the Parties, and any other actions that the Parties must take to implement the request in its approved form. Should a request be denied, ODEC will provide an explanation for the denial. If the customer chooses to continue to pursue such project, the customer shall submit a new Request Form that addresses the issues described in the explanation of the denial.

PART 1: Load Delivery Point/DER Interconnection Submittal Information

Customer Submittal Information

Customer Company Name:		Request Date:	
Customer Address:			
Name of Contact Person:			
Contact Phone Number:		Alternate Phone Number:	
Contact Fax Number:		Contact Email Address:	
Is this a revision to an existing request? *If so, please provide the delivery point name, location, or request number.*			
List any previous, relevant New Service Requests			

Request Information

Requested Delivery/Interconnection Point:	
Description of Request: *(Attach Detail)*	
Reason for Request: *(Attach Detail)*	

Customer Timing

*Requested Date to Energize:	
Expected Date Customer's Construction to Commence:	
Expected Completion Date of Customer Work:	
Date Requested ODEC Construction to Commence:	
Requested Completion Date of ODEC Work (De- energized):	
Other Key Milestones:	
Required Attachments:	1. Construction One-line Diagram 2. Site Plan showing substation notable characteristics (pad size allocated and access road plans). 3. Geospatial Coordinates

* *The required Customer Equipment Information included in Part 2 of this Request Form must be submitted at least 180 days prior to the energization date determined during ODEC's review of project feasibility*

Select the type of request

Then, provide the information requested below for the selected request type.

☐ **Large Load** Interconnection ☐ **DER** Interconnection

Request for Large Load Interconnection Delivery Point

Delivery Point Location: *(Attach Detail)*	
Description of Delivery Point Facilities Route:	
New Delivery Point Voltage (kV):	
New Peak kVA Capacity of Delivery Point Facilities:	
New Peak kVA Demand of Delivery Point Facilities:	
Noteworthy Load Characteristics:	Complete the ***Noteworthy Load Characteristics*** form attached and include with Request Form submission.
Additional Comments:	

Provide anticipated peak seasonal demand (kW/KVAR) for the years and seasons below:

	Applicable Year	**Summer Peak Demand (kW)**	**Summer Peak Demand (kVAR)**	**Winter Peak Demand (kW)**	**Winter Peak Demand (kVAR)**
Year 1					
Year 2					
Year 3					
Year 4					
Year 5					
Year 6					
Year 7					
Year 8					
Year 9					
Highest peak in first 10 years					
Year 15					

Request for DER Interconnection Delivery Point

Interconnection Point Location (*Attach Detail):*			
Description of Delivery Point Facilities Route:			
New Delivery Point Voltage (kV):			
Is the DER exporting power back to the ODEC or ANEC system?	☐ YES ☐ NO	If yes, please supply the PJM queue number (if applicable):	
What measures will be taken to control/meter reverse power flow?			
Inverter Based Resource?	☐ YES ☐ NO		
Inverter Manufacturer/Model Number:			
Grid Forming Inverter Based Resource? (*Describe how islanding will be avoided*)	☐ YES ☐ NO		
Capacity of Inverter based resources (kVA):			
Synchronous Generation?	☐ YES ☐ NO		
Generator Manufacturer/Model Number:			
Capacity of Synchronous generation resources (MVA):			
Maximum Storage Capacity of Delivery Point (MVA):			
Maximum Expected Site Load (MVA):			
Additional Comments:			

Provide breakdown of generation resources below:

	Peak Real Power Capacity (kW)	Peak Reactive Power Capacity (KVAR)	Total Capacity (MVA)
Synchronous Generation			
Solar			
Wind			
Geothermal			
Battery Energy Storage			
Other (*describe*)			

Requirement of Authorization

The signature below authorizes Old Dominion Electric Cooperative ("ODEC") to proceed with design, engineering, and estimation of project cost as appropriate for ODEC to evaluate and respond to this request. This authorization is pursuant and subject to all terms and conditions of the New Service Request of which this Customer Request Form is a part.

Authorizing Signature: _____ Authorization Date: _____
Printed Name: _____ Phone: _____
Title: _____ Email: _____

PART 2: Customer Equipment *

Transformer Voltage (kV):	Primary (HV)_____ Secondary (XV)_____ Tertiary (YV)_____	Transformer Nameplate Capacity at Maximum Nameplate Rating (including kVA or MVA units):
Transformer Impedances	HV-XV _____% @ _____ kVA HV-YV _____% @ _____ kVA XV-YV _____% @ _____ kVA	
Transformer Taps (De-energized, and tap changing under load as appropriate)		Transformer Temperature Rise (ºC):
Connection (e.g. Wye or -Delta):	HV _____ (XV)_____ (YV)_____	
Isolation Device Type and Rating:		
Protection Device Type and Rating:		

** Customer Equipment information must be submitted at least 180 days prior to the energization date determined during ODEC's review of project feasibility.*

Required Attachments

Studies Phase	• Generator/DER details
	• Operating One-Line Diagram
	• Power flow model of entire facility
	• Inverter manufacturer specifications (if included)
	• Load/Generation Single-Line Diagram
	• AC Cable Schedule including Electrical Characteristics
	• Skid/Collector Transformer Specifications
	• Reactive power compensation (if applicable)
	• Inverter control replica in DLL format
	  ○ EMTP or PSSE File
	  ○ Operating mode settings (for import into EMTP)
	• Bus types and lengths
	• Length and characteristics of all conductors in substation from POI to collector circuits
	• Energy storage devices description

Detailed Engineering Phase	• Transformer test reports
	• Operating procedures description
	• Protection Scheme functional diagram
	• Protection device information - Include:
	  ○ Device Types
	  ○ Serial and Model numbers
	  ○ Relay settings

Noteworthy Load Characteristics Form

Load Composition *

Motor A The percentage of load consisting of 3-phase induction motors with low inertia (H = 0.1 sec) driving constant torque loads. These motors are found in commercial/industrial air conditioning compressors and refrigeration systems (not NEMA B). • Smaller 5-15 HP compressor motors typical of rooftop air conditioning units commonly found at grocery stores, consumer products stores, and malls. • Larger 200-500 HP compressor motors typical of large commercial buildings' central cooling systems.	_____ %
Motor B The percentage of load consisting of 3-phase induction motors with high inertia (H=0.25-0.1 sec) driving loads whose torque is proportional to speed squared. These motors are found in commercial ventilation fans and air-handling systems. • 5-25 hp fan motors which are normally NEMA B motors.	_____ %
Motor C The percentage of load consisting of 3-phase induction motors with low inertia (H = 0.1-0.2 sec). This represents motors commonly found in commercial water circulation pumps in central cooling systems. • 5-25 HP pump motors which are usually NEMA B motors.	_____ %
Motor D The percentage of load consisting of 1-phase air conditioners. This represents commonly found residential single phase air conditioners.	_____ %
Electronic The percentage of load consisting of power electronic converters. These are constant active and reactive power loads that include consumer electronics (Plasma and LED televisions, cell phones and tablets, clocks, radios, etc.), appliances (High efficiency appliances such as refrigerators, washing machines, etc.) and office equipment (Printers, copy machines, servers, etc.).	_____ %
Static The percentage of load that will be static. This represents electric ovens, water heaters, incandescent lighting, and all other loads whose behavior changes with voltage magnitude.	_____ %
Total Load Percent =	**100 %**

** The listed load characteristics are parameters needed to perform simulations using the composite load model referenced in, "NERC Technical Reference Document for Dynamics Load Modeling, December 2016".*

Data Center Voltage Performance

Voltage sag level/duration at which the computer/server load disconnects from the utility system (these may transfer to a local UPS):	____ V	____ sec
Voltage sag level/duration at which the cooling load disconnects from the system (these may transfer to an emergency generator or local power source):	____ V	____ sec
How are the voltage sag levels measured for the disconnecting action?	☐ Per phase ☐ 3-phase RMS	
Voltage swell level/duration at which the computer/server load disconnects from the utility system (these may transfer to a local UPS):	____ V	____ sec
Voltage swell level/duration at which the cooling load disconnects from the system (these may transfer to an emergency generator or local power source):	____ V	____ sec
How are the voltage swells measured for the disconnecting action?	☐ Per phase ☐ 3-phase RMS	

Data Center Frequency Performance

The **lowest** frequency at which the data center will disconnect from the system:	_____ Hz
The **highest** frequency at which the data center will disconnect from the system:	_____ Hz

Data Center Reconnection Method
After Automatic Disconnect from Service Provider System

Manual	☐ YES ☐ NO		
Immediate Reconnect *(No Deliberate Time Delay)*	☐ YES ☐ NO	If **YES**, provide the information below:	
Vhigh: reconnect when voltage is below:	_____ V	_____ V deadband	_____ msec
Vlow: reconnect with voltage is above:	_____ V	_____ V deadband	_____ msec
fhigh: reconnect when frequency below:	_____ Hz	_____ Hz deadband	_____ msec
flow: reconnect when frequency above:	_____ Hz	_____ Hz deadband	_____ msec

Delayed Reconnection	☐ YES ☐ NO	If **YES**, provide the information below:	
Time delay after voltage is within acceptable limits to reconnect:	_____ sec		
Vhigh: reconnect when voltage is below:	_____ V	_____ V deadband	_____ msec
Vlow: reconnect with voltage is above:	_____ V	_____ V deadband	_____ msec
Time delay after frequency is within acceptable limits to reconnect:	_____ sec		
fhigh: reconnect when frequency below:	_____ Hz	_____ Hz deadband	_____ msec
flow: reconnect when frequency above:	_____ Hz	_____ Hz deadband	_____ msec

Reconnect Loading Process

Is all load reconnected at once?	☐ YES ☐ NO
Continuous ramp rate for ramping to reconnect:	_____ kW/sec
Number of steps for stepwise ramping to reconnect:	_____ Step(s)
Load increase per step for stepwise ramping to reconnect:	_____ kW/step

Data Center Emergency Backup Power System Details

Emergency Generator (EG) capacity:	_____ kW
Duration of EG based on available fuel:	_____ hours
Battery Energy Storage (BESS) discharging capacity:	_____ kW
Duration of BESS discharge based on fully charged battery capacity:	_____ hours
Percent of Data Center Load which can be carried by EG and/or BESS:	_____ %
Will the Data Center Backup Power System participate in demand side management in a grid emergency or as an ancillary service?	☐ YES ☐ NO
In the event of a planned or unplanned disconnection from the grid, will the Data Center be Islanded and operate with the EG and/or BESS?	☐ YES ☐ NO
What percentage of the server farm load could be redistributed to redundant server sites across the world?	_____ %
If the data center trips offline, what percent of the load will be transferred to other server farms?	_____ %
How fast will load transfers be completed?	_____ sec

Reviewed By	Reviewer Entity	Review Date