Old Dominion Electric Cooperative

Technical Requirements For Generation Connected to The ODEC System

March 30, 2010

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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 as an aid to those Consumers contemplating the purchase of generation equipment and interconnecting this generation equipment with the ODEC System. The information is intended only to guide the consumer 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 Consumer must first be in compliance with the tariff rules and regulations and the applicable tariff classifications and rates. The terms and conditions contained within this document are in addition to, but do not modify nor negate, the terms of the tariff.

Generator Owners are required to submit an Interconnection Request to PJM. PJM will initiate a process to study the feasibility of the generation, its impact within the PJM system and the cost to make any necessary system improvements. The extent of the studies is dependent on the size of the generation and the proposed Point of Common Coupling. The details of this process are outside the scope of this document. See the PJM website for details.

A Generator Owner must also complete an Interconnection Service Agreement with PJM if system upgrades are necessary.

III. Applicability

Unless otherwise provided, these technical requirements apply to all Consumer owned generation interconnected with and operating in parallel with the ODEC System at 69,000 volts. 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 the document with initial capitalization, the following terms have the meanings specified in this Section.

A. **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.

B. **Company** – Old Dominion Electric Cooperative, doing business as ODEC.

C. **ODEC System** – The electric transmission system of Old Dominion Electric Cooperative.

D. **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.

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

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

G. **Generator Owner** – The owner of the Facility that is interconnected to ODEC.

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

I. **Interconnection** – The physical connection of generation to the ODEC System in accordance with these technical requirements so that parallel operation can occur.

J. **Interconnection Application –** The standard form of application which must be submitted by the Generation Owner to the RTO as a request to interconnect a generating unit to the ODEC System or to increase the capacity of a generating unit already connected to the ODEC System.

K. **Interconnection Equipment** - That equipment necessary to interconnect the Facility to the ODEC System, including any and all relaying, 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.

L. **Inverter** – A static power converter with control, protection and filtering functions that converts Direct Current (DC) input to Alternating Current (AC) output. Inverters connected to the ODEC System must be of the non-islanding type.

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

O. **NERC - N**orth American **E**lectric **R**eliability **C**orporation. The purpose of NERC is to ensure the adequacy, reliability and security of the bulk electric supply systems through coordinated operations and planning of generation and transmission facilities.

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

Q. **PJM** - PJM Interconnection, L.L.C. The Independent System Operator for the **P**ennsylvania, New **J**ersey **M**aryland area of the Northeast U.S. whose members include electric utilities and independently owned generating resources. The organization is responsible for dispatching generation, operating the bulk transmission system within its service area and operating a buy/sell market for member's generation.

R. **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.

S. **Pre-Interconnection Study** – A technical study or studies which may be undertaken by either ODEC and/or PJM in response to its receipt of a completed application for Parallel Operation with the ODEC System submitted on the Interconnection Application form prescribed by these technical requirements or by PJM. Pre-Interconnection Studies may include, but are not limited to, feasibility studies, impact studies and facilities studies.

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

U. **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.

V. **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.

Stiffness Ratio = Total fault current available at PCC / Generator Fault Contribution

W. **System Control Center** – Office that monitors and has direct control over the operation of the ODEC System.

X. **System Emergency** – An imminent or occurring condition on the ODEC System, the PJM system, the system of a neighboring utility, 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.

V. Introduction and Purpose

The information contained in this document is to provide the proposed 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 complete a comprehensive interconnection feasibility study.

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 Customer 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

In the course of 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 all applicable national, state and local construction and safety codes.

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

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 or other generators on the circuit. Islanding will not be permitted.

D. The Generator Owner must equip his Facility with the necessary protective hardware and software designed to prevent sustained Parallel Operation of the generator with the ODEC System unless the system service voltage and frequency are 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 insure that his designs utilize equipment properly 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. 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 design, procurement, installation and maintenance of all equipment at the Generator Owner's Facility are the responsibility of the Generator Owner. The Generator Owner is responsible for all costs.

J. The Generator Owner will supply ODEC with the necessary technical information, one-lines, equipment data, specifications, etc. so that so that ODEC can conduct a complete review of the proposed Facility and conduct any necessary studies.

K. The Generator Owner will cover the expense of any ODEC feasibility study, coordination study or impact study, or facility study necessary to assess the impact of the interconnected generation. The scope of such Pre-Interconnection Studies will be based on the generator characteristics and the proposed point of interconnection.

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.

P. The Generator Owner must immediately cease parallel operation upon notification by ODEC that their operation 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.

VII. ODEC Obligations

A. ODEC will provide the Generator Owner 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 Generator Owner on the proposed design and protection schemes associated with the Point of Common Coupling. ODEC may also review and provide comment 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 Generation Owner 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 or reasons for denying the parallel interconnection.

F. ODEC, in the course of 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 such knowledge and information submitted by the proposed Generator Owner to offer competing services or special rate considerations. In addition, ODEC will not divulge this information to a third party, 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 interconnection of parallel Customer owned generation. The Generator Owner's design must meet or exceed the requirements outlined in these Technical Requirements and also 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 Customer's generation 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.

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 affect 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 the 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 electric problems 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 following desired 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 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 on 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.

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

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 insure 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 ODEC System has Stabilized. Automatic re-connection will be approved on a case by case basis.

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 Generation Owner's needs and other appropriate criteria.

E. System Interconnection Point Information

A Generator Owner will normally want to interconnect their generator to an ODEC System circuit or power substation that is near their site. Some details on ODEC System are noted below to assist the Generator Owner 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.

2) The ODEC System can only accept 60 Hz alternating current from parallel generators. All parallel generators must be 3-phase.

3) ODEC may limit the size of the generator that can be interconnected at any particular 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.

4) All lines have automatic line restoration following a line trip. Some faults (short circuits) are temporary in nature, such those caused by as 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 reclose could occur instantaneously, or take up to a minute or more. The net result of automatic line restoration is to restore the integrity of the ODEC System and to reduce any Customer outage time. The Generator Owner 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 remove itself from an island or de-energized circuit prior to automatic reclose. Since delaying the automatic reclose time degrades the level of service to other Customers on the circuit, ODEC may limit any delay of the automatic reclose to a few seconds or less. Alternatively, the Generator Owner may request that a direct transfer trip scheme be added to remove the interconnected generator from service 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 possible 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 here 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, thereby providing a source of ground fault current to the system, unless otherwise required by ODEC.

4) The Interface Transformer must be sized to support maximum anticipated power transfers to and from ODEC System.

5) Interface Transformers up to 10 MVA can be fuse protected on the high side. 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, Fig. 10.3, as defined in IEEE Std. 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electric 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 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. 519-1992, *Recommended Practices and Requirements for Harmonic Control in Electric Power Systems*, Table 11.1. 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 10.3 in IEEE Std. 519-1992.

4) Any DC to AC inverter should not inject DC current greater that 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 request process.

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.) so as to operate at no less a power factor (drawing VARS from the ODEC System) at the Point of Common Coupling than existed prior to the installation of the Facility. Any reactive power requirements in excess of 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.

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 inverter also prevents the Generator owner from inadvertently supplying other Company Customers in an isolated Island situation.

3) The inverter output specifications must meet the power quality requirements detailed in Section VIII - G.

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 in the course of 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 are capable of supporting sustained fault currents. As such, the protection scheme associated with the Point of Common Coupling must be designed to insure detection of fault conditions in the ODEC System.

2) Synchronous generators are capable of operating 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 paralleled 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 paralleled 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 KHW 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) 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.

7) 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.

M. Monitoring and Control Requirements

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.

1) 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.

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

3) 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.

4) For the Generator Owner's RTU communication with the Company, a dedicated communication path is necessary to provide real time data

5) If the Generator Owner's RTU is communicating with PJM, real time data communication is required with the exception of units less than 10 MW that are not being bid into the PJM market.

6) 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 required

Note: The Generator Owner shall contact PJM directly and review PJM documents to insure 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 by this event recording equipment.

3) Event information may be recorded by features internal to microprocessor type protective relays, by separate digital 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 insure 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.

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 0.1 Second for V < 50% b) Trip within 0.1 to 30 Seconds for 50% < V < 88% c) Trip within 0.1 to 30 Seconds for 106% < V < 137% d) Trip in 0.03 Second for 137% < V (Specific voltage and time delay set points will be determined for each generator installation)	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 overvoltages that occur 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.

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 Systems With Non-Islanding Inverters	Induction/Synchronous Generators Non PJM Market Up to 10 MW	Synchronous Generators In PJM Market or Greater than 10 MW
a) Trip in 0.1 Second for F < 58.5 Hz. b) Trip in 0.1 Second for F > 60.5 Hz. (Set points taken from IEEE Std. 929.)	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 insure 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) In order to avoid damaging a generator during synchronizing, 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 vs. 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, 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. ODEC will review the proposed operating time of the Facility's protection schemes and ascertain the performance requirements on a case by case basis.

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 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 its intended application and 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/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

Up to 10 MVA	10 – 50 MVA
High Side Fuse	Transformer Differential Fault Pressure 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).

Existing protection schemes for ODEC lines are:
Phase and Ground Directional Overcurrent
Phase and Ground Step Distance Backup

Future schemes capable of high speed tripping to accommodate generator additions may include Directional Comparison, Permissive Under or Overreaching Transfer Trip, and Direct Transfer Trip.

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 becomes 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, 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.

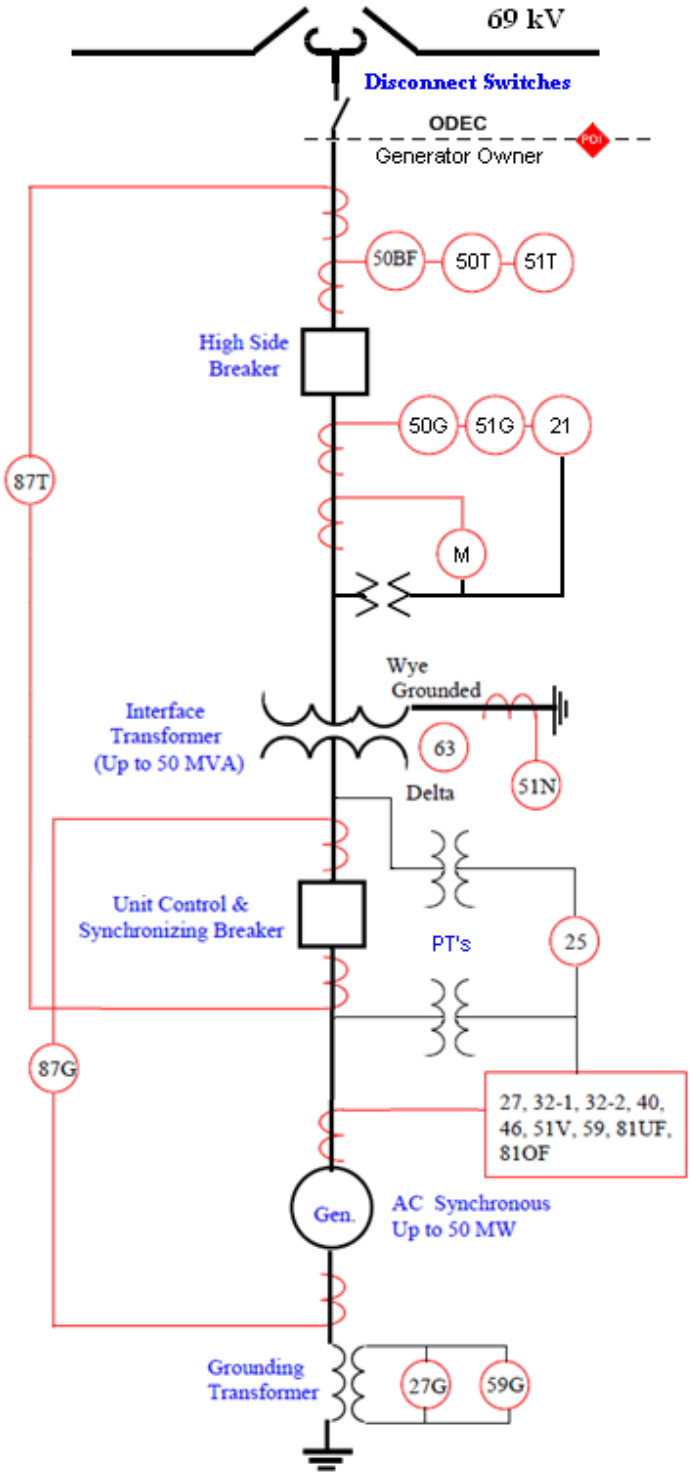
E. Generator Protection Schemes

1) The protection schemes on generators will become more complex as the size of the generator unit increases. In addition, those generators selling into the PJM marketplace will require specific protection as required by PJM.

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 off line upon a relay failure alarm and remain off line 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*.

XI. Typical One-Line Diagram



Device Designation & Function

21 - Distance Relay

25 – Synchronism Check Relay

27 - Undervoltage Protection

27G - Generator Stator Ground Fault Undervoltage Protection

32-1, 32-2 - Power Directional Relays
One protects against loss of the prime mover and the generator acting like a motor. A second 32 relay is used to limit power exported to the Grid.

40 – Generator Loss of Field Detection

46 - Negative Sequence Protection
Protects against an open phase conductor.

50BF - Breaker Failure Protection

50/51G - Overcurrent Ground Relay

50/51T - Phase Overcurrent Relay
50BF - Breaker Failure Protection

51N - Overcurrent Ground Relay to provide backup protection for system ground faults.

51V - Voltage Supervised Time Over-current Protection
Provides backup protection for phase faults in the Transformer or the Grid.

59 - Overvoltage Protection

59G - Generator Stator Ground Fault Overvoltage Protection

63 - Transformer Sudden Pressure Relay

81UF - Underfrequency Protection

81OF - Underfrequency Protection
The above protection functions monitor the output of the generator and detect when the Generating Facility has been isolated from the Grid.

87G – Generator Differential Protection

87T – Transformer Differential Protection

M - Metering

XII. Information to Be Supplied By Generator Owner

The following information must be supplied by the Generator Owner 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.

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. Type (Synchronous, Induction, Inverter, etc), and rating of proposed generator(s)

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.
2. All potential elementary diagrams associated with the protection and control schemes for the generator and interconnection equipment.
3. All current elementary diagrams associated with the protection and control schemes for the generator 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 Diagram and Three Line Diagram 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. A copy of the transformer nameplate and test report can be substituted.

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

4. Instrument Transformers – Voltage and current, phase connections.

5. Surge Arresters/Gas Tubes/Metal Oxide Varistors/Avalanche Diode/Spill Gaps/Surge Capacitors, etc. – Type and Ratings.

6. Capacitor Banks – kVAR rating.

7. Disconnect Switches – Indicate status normally open with a (N.O.) 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 shall be 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 a separate 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 the contact will be closed.

7. Explanatory notes defining switch coordination and adjustment where improper adjustment could result 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 where they are used.

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

11. Ranges of all timers and setting 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 shown as a "black box", but manufacturer's instruction book number shall be referenced and terminal connections shown.

14. Isolation points (states links, PK-2 and FT-1 blocks), etc., including terminal identification.

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

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

17. Phase sequence designation as ABC or CBA.

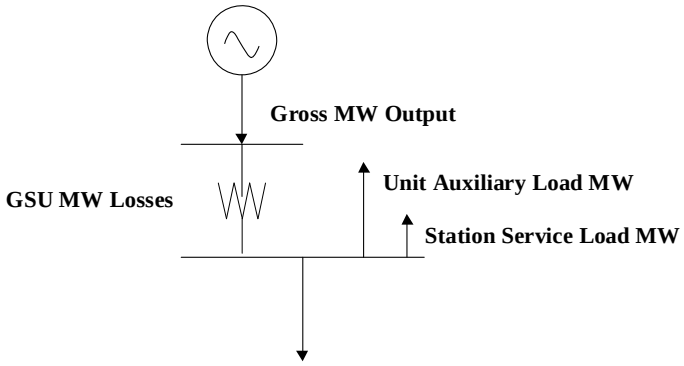
18. Potential transformers – nameplate ratio, polarity marks, rating, primary and secondary connections (see Guidelines for minimum ratings.)

19. Current transformers (including aux. CT's) – polarity marks, rating, 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.

Unit Capability Data



Net MW Capacity

Net MW Capacity = (Gross MW Output - GSU MW Losses – Unit Auxiliary Load MW - Station Service Load MW)

PJM Queue Letter/Position/Unit ID: _____

Primary Fuel Type: _____

Maximum summer (92º F ambient air temp.) net MW Output: _____

Maximum summer (92º F ambient air temp.) gross MW Output: _____

Minimum summer (92º F ambient air temp.) gross MW Output: _____

Maximum winter (30º F ambient air temp.) gross MW Output: _____

Minimum winter (30º F ambient air temp.) gross MW Output: _____

Gross Reactive Power Capability at Maximum Gross MW Output (Leading and Lagging): _____

****** Please submit Reactive Capability Curve when available***

Individual Unit Auxiliary Load at Maximum Summer MW Output (MW/MVAR): _____

Individual Unit Auxiliary Load at Minimum Summer MW Output (MW/MVAR): _____

Individual Unit Auxiliary Load at Maximum Winter MW Output (MW/MVAR): _____

Individual Unit Auxiliary Load at Minimum Winter MW Output (MW/MVAR): _____

Station Service Load (MW/MVAR): _____

Please provide any comments on the expected capability of the unit:

Unit Generator Dynamics Data

PJM Queue Letter/Position/Unit ID: _____

MVA Base (upon which all reactance, resistance and inertia are calculated): _____

Nominal Power Factor: _____

Terminal Voltage (kV): _____

Unsaturated Reactance Values (on MVA Base)

Direct Axis Synchronous Reactance, $X_{d(i)}$ _____

Direct Axis Transient Reactance, X'd(i): _____

Direct Axis Sub-transient Reactance, X"d(i): _____

Quadrature Axis Synchronous Reactance, Xq(i): _____

Quadrature Axis Transient Reactance, X'q(i): _____

Quadrature Axis Sub-transient Reactance, X"q(i): _____

Stator Leakage Reactance, Xl: _____

Negative Sequence Reactance, X2(i): _____

Zero Sequence Reactance, X0: _____

Saturated Sub-transient Reactance, X"d(v) (on MVA Base): _____

Armature Resistance, Ra (on MVA Base): _____ at ____°C

Time Constants (seconds)

Direct Axis Transient Open Circuit, T'_{do}: _____

Direct Axis Sub-transient Open Circuit, $T"_{do}$: _____

Quadrature Axis Transient Open Circuit, T'_{qo}: _____

Quadrature Axis Sub-transient Open Circuit, $T"_{qo}$: _____

Inertia, H (kW-sec/kVA, on KVA Base): _____

Speed Damping, D: _____

Saturation Values at Per-Unit Voltage [S(1.0), S(1.2)]: _____

Please submit generator certified test report information when available

IEEE dynamic model parameters:

Governor Model: _____

Exciter Model: _____

Power System Stabilizer Model: _____

Unit Transformer Data

PJM Queue Letter/Position/Unit ID:_____

Generator Step-up Transformer MVA Base:_____

Generator Step-up Transformer Impedance (R+jX, on transformer MVA Base): _____

Generator Step-up Transformer Rating (MVA):_____

Generator Step-up Transformer Low-side Voltage (kV): _____

Generator Step-up Transformer High-side Voltage (kV):_____

Generator Step-up Transformer Off-nominal Turns Ratio:_____

Generator Step-up Transformer Number of Taps and Step Size: _____

Submit transformer certified test report information when available

Indicate whether the transformer is shared with other units.