Indianapolis Power & Light Company d/b/a AES Indiana

Facilities Connection Requirements

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AES Indiana Interconnections

AES Indiana Transmission Planning

Contents

1) Acronyms

- AES Indiana – Indianapolis Power & Light Company d/b/a AES Indiana "AES Indiana"
- BIL – Basic Impulse Level
- BES – Bulk Electric System
- DPP – Definitive Planning Phase
- EMT – Electromagnetic Transient
- FERC – Federal Energy Regulatory Commission
- GIA – Generator Interconnection Agreement
- GO – Generator Owner
- IBR -Inverter-Based Resources
- IC – Interconnection Customer
- IEEE – Institute of Electrical and Electronics Engineers
- IURC – State of Indiana Utility Regulatory Commission
- MISO – Midcontinent Independent System Operator
- MMWG – Model Manager Working Group
- MTEP – MISO Transmission Expansion Planning
- NEC – National Electric Code
- NEMA – National Electrical Manufactures Association
- NERC – North American Electric Reliability Council
- NESC – National Electric Safety Code

- OSHA – Occupational Safety and Health Administration
- PC – Planning Coordinator
- POI – Point of Interconnection
- POM – Point of Measurement
- RF – Reliability First Corporation
- STATCOM – Static Synchronous Compensator
- SVC – Static VAR Compensator
- TO – Transmission Owner
- TOCC – Transmissions Operations Control Center
- TP – Transmission Planner
- UTC – Universal Time Coordinated

2) Introduction

AES Indiana has prepared this Facilities Connection Requirements document to ensure compliance with NERC Reliability Standards and applicable Regional Reliability Organization, subregional, Power Pool, and individual TO and GO planning criteria and Facility connection requirements in compliance to NERC Standard FAC-001-4. The purpose of NERC Standard FAC-001-4 is to require TOs and GOs to establish Facility connection and performance requirements to avoid adverse impacts on reliability for additions to the transmission system. These connection requirements apply to all generation Facilities, transmission Facilities, and end-user Facilities connecting to the AES Indiana transmission system.

AES Indiana Transmission as the TO and acting on behalf of the AES Indiana Generation as the GO has prepared this connection requirements document to address the various requirements and coordinated joint studies for planning, designing, maintaining, and operating a new or materially modified existing interconnections of generation, transmission, or electricity end-user Facilities. Parallel operation must be both safe and reliable for AES Indiana customers and personnel; and, parallel operation shall not adversely affect existing generation, transmission, or end-user Facilities. The interconnecting Facility is allowed to operate in parallel with AES Indiana only if it complies and continues to comply with the AES Indiana Facility Connection Requirements; AES Indiana Rates, Rules, and Regulations; and all applicable Federal (including FERC), State (including IURC), and local Laws and Codes; and the MISO Interconnection

Requirements as applicable. Additionally, compliance with the NEC and industry-wide standards such as NEMA, IEEE, etc. shall be required. AES Indiana has developed a review process to assure compliance with all requirements.

For any generating Facility that desires to participate in the MISO market, they must adhere to MISO's DPP process by submitting an application and entering the Generator Interconnection Queue. Throughout the study process, MISO will coordinate with AES Indiana, affected TOs, and stakeholders to conduct any coordinated joint studies.

3) FAC-001-4 Facility Interconnection Requirements

FAC – R1.

Each Transmission Owner shall document Facility interconnection requirements, update them as needed, and make them available upon request. Each Transmission Owner's Facility interconnection requirements shall address interconnection requirements for: [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]

The impact of the IC's Facilities on the reliability of the transmission system shall be evaluated through MISO process(es) as applicable for the type of Facilities. Studies are performed by MISO in conjunction with AES Indiana and in accordance with established NERC, RF, MISO and AES Indiana Transmission Planning Criteria to ensure continued compliance to the established criteria throughout the planning horizon.

FAC - R1.1.

Generation Facilities

The studies performed by MISO and AES Indiana as part of the DPP process will determine the impact of the interconnection request on the reliability of the transmission system. These studies also identify any transmission system upgrades required to ensure the system continues to operate in accordance with the established criteria. The results of these studies are posted on the MISO website. DPP projects that receive GIAs shall be submitted into the MTEP study cycle.

FAC - R1.2.

Transmission Facilities

New or materially modified transmission Facilities are studied through the MTEP process. The studies performed by MISO along with TOs determine if there are needs for transmission upgrades across multiple TO systems to ensure continued compliance to the established planning criteria. Any upgrades identified become part of the current MTEP cycle, which is documented on the MISO website.

FAC - R1.3.

End-User Facilities

Under the guidance of NERC FAC-002, the system impacts of end-user requests are evaluated by AES Indiana internally to determine any necessary system modifications and estimated project costs. Any identified system upgrades and estimated Facility costs are coordinated with the end-user to determine feasibility and project viability. The new or modified end-user Facility and any system-upgrades will be studied under the MTEP process to maintain compliance.

FAC – R2.

Each applicable Generator Owner shall document Facility interconnection requirements and make them available upon request within 45 calendar days of full execution of an Agreement to conduct a study on the reliability impact of interconnecting a third party Facility to the Generator Owner's existing Facility that is used to interconnect to the Transmission system. [Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]

AES Indiana Transmission as the TO and acting on behalf of the AES Indiana Generation as the GO has prepared this connection requirements document to address the various requirements for ICs desiring to connect as a third party to an AES Indiana GO Facility.

FAC – R3.

Each Transmission Owner shall address the following items in its Facility interconnection requirements: [Violation Risk Factor: Lower] [Time Horizon: Long-Term Planning]

FAC – R3.1.

Procedures for coordinated studies for new interconnections or existing interconnections seeking to make a qualified change as defined by the Planning Coordinator and their impacts on affected systems.

AES Indiana Transmission as the TO has documented procedures under the guidance of NERC FAC-002. AES Indiana's PC is MISO.

FAC – R3.2.

Procedures for notifying those responsible for the reliability of affected system(s) of new interconnections or existing interconnections seeking to make a qualified change.

Under the MISO MTEP and DPP processes, MISO as the PC is wholly responsible for the coordination of affected systems(s) from new or materially modified existing interconnections. AES Indiana Transmission as the TO participates in the coordination process.

FAC – R3.3.

Procedures for confirming with those responsible for the reliability of affected systems that new Facilities or existing Facilities seeking to make a qualified change are within a Balancing Authority Area.

MISO is the Balancing Authority for AES Indiana.

FAC – R4.

Each applicable Generator Owner shall address the following items in its Facility interconnection requirements: [Violation Risk Factor: Lower] [Time Horizon: Long-Term Planning]

FAC – R4.1.

Procedures for coordinated studies of new interconnections and their impacts on affected system(s).

AES Indiana Generation as the GO defers to MISO's MTEP and DPP process(es) and procedures.

FAC – R4.2.

Procedures for notifying those responsible for the reliability of affected system(s) of new interconnections.

Under the MISO MTEP and DPP processes, MISO as the PC is wholly responsible for the coordination of affected systems(s) from new or materially modified existing interconnections. AES Indiana Transmission as the TO participates in the coordination process.

FAC – R4.3.

Procedures for confirming with those responsible for the reliability of affected systems that new Facilities or existing Facilities seeking to make a qualified change as defined by the Planning Coordinator are within a Balancing Authority Area.

MISO is the Balancing Authority for AES Indiana.

4) Performance Requirements

4.1 Voltage Level and MW and MVAR Capacity or Demand at POI

The normal voltage operating range on the transmission system is from 95% to 105% of the nominal transmission voltages, which are 345 kV and 138 kV. Generation Facilities and transmission Facilities must be capable of continuous non-interrupted operation within the normal voltage range during normal state (P0 of NERC TPL-001-5) and N-1 contingent state (P1, P2 of NERC TPL-001-5). For more severe system conditions such as N-1-1 contingency (P3-P7 of NERC TPL-001-5), an emergency voltage operating range of 90% to 105% may be used. In transient conditions immediately following a contingent event, voltages may temporarily be outside the identified operating voltage range. Throughout contingent events, all reasonable measures should be taken to avoid tripping of the generation and/or transmission Facilities due to high or low voltage. End-users are responsible for installing their own voltage regulating equipment to restrict the voltage range to protect their equipment. End-users are responsible for installing any voltage sensing equipment required to protect their equipment during abnormal voltage operations.

Generation Facilities desiring to connect to the transmission system must follow the process(es) and procedures documented in MISO's BPM-015 – Generator Interconnection.

Parties desiring to connect their transmission system with AES Indiana's transmission system should be able to supply their own reactive power requirements unless mutually agreed to other arrangements. Transmission interconnections must be sized to handle the potential MW and MVAR flow under contingent conditions considered in the prevailing planning criteria.

End-users desiring to interconnect to AES Indiana's transmission system must supply information on characteristics of load, such as initial and near future expected load (MW and MVAR), power factor of such load, voltage level at POI, and dynamic (flicker, harmonics, etc.) load characteristics.

4.2 Breaker Duty and Surge Protection

The IC must provide a three-phase interrupting device(s) with appropriate relays and/or other protective equipment to isolate their Facility from the AES Indiana system for any faults, loss of supply from AES Indiana or abnormal operating conditions, whether or not their Facility is operating. This device shall fully comply with the latest ANSI/IEEE C37 collection of standards and be capable of interrupting the maximum available fault current at that location. The device shall interrupt all three phases simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility source to permit operation upon loss of the AES Indiana transmission system connection. Automatic reclosing of the IC's Facilities is not permitted unless a special agreement is worked out with AES Indiana. All gas insulated protective devices within the IC's Facility having a direct connection to an AES Indiana transmission line shall be equipped with a low gas pressure alarming/tripping/lockout scheme as appropriate for the device.

Lightning arresters protecting transformers are generally mounted on the transformer. However, since lightning arresters can adequately protect equipment some distance from the arresters, the overall number of lightning arresters required in each design can be reduced. Allowable lightning arrester separation distance from the equipment being protected shall be determined by the latest edition of IEEE Std. C62.22 IEEE Guide for the Application of Metal-Oxide Surge Arresters for Alternating–Current Systems. The IC should consult the manufacturer's catalog for details concerning arrester protective characteristics, ratings, and application.

The minimum substation Basic Impulse Levels (BIL) and arrester ratings for AES Indiana are shown below:

Nominal System Voltage (kV)	Substation Bus BIL (kV)	Bank Arrester (kV)	Line Arrester (kV)	Switch Rating (kV)	Transformer BIL Internal/Bushing (kV)
138	650	120	120	138	650/650
345	1300	276	276	345	1050/1300

4.3 System Protection and Coordination

Generation Facilities, transmission Facilities, and end-user Facilities connecting to the AES Indiana transmission system are responsible for determining that the proper protective equipment meets all applicable standards, is properly installed and coordinates with AES Indiana relaying. Protective relaying systems and associated communications systems for all Facility interconnections shall be planned, designed, constructed, and maintained in accordance with applicable NERC, RF, and MISO standards. Utility grade protective relays and fault clearing systems are to be utilized on the interconnected power system. Utility grade relays are defined as follows:

a) Meet ANSI/IEEE Standard C37.90, Relays and Relay Systems Associated with Electric Power Apparatus.
b) Have relay test facilities to allow testing without unwiring or disassembling the relay.
c) Have appropriate test plugs/switches for testing the operation of the relay.
d) Have targets to indicate relay operation.

The IC is responsible for providing adequate system protection to its Facilities and to AES Indiana Facilities under any transmission operating condition, whether their Facilities are in operation. Conditions may include but are not limited to:

a) Single phasing of supply System faults.
b) Equipment failures.
c) Abnormal voltage or frequency.
d) Lightning and switching surges.
e) Excessive harmonic voltages and/or currents.
f) Excessive negative/zero sequence voltages and/or currents.
g) Separation from the AES Indiana system.
h) Synchronizing of generation to the AES Indiana system.

AES Indiana reserves the right to specify functional specifications and relay settings deemed necessary to avoid safety hazards or to prevent any disturbance, impairment or interference with AES Indiana's ability to serve other customers. The criteria for these functional specifications and settings will be based on existing AES Indiana protection practices. AES Indiana reserves the right to specify the type and manufacturer for these protective relays to ensure compatibility with existing relays. AES Indiana will make specific recommendations and requirements for protection based on the individual substation location, voltage, and configuration.

For generation Facilities, the relay protection system may be part of a self-contained generation control package. Additional relay protection may be required if testing or operational problems are encountered with this self-contained generation control package. AES Indiana shall review the interface protection and/or the self-contained protection schemes included with the generation before the unit will be permitted to interconnect to the AES Indiana system. The following relay functions are required by the IC for protection of the AES Indiana system.

Relay	Purpose
Under/Over Frequency	To detect under and over frequency operation and separate the customer's parallel generation.
Under/Over Voltage	To detect under and over voltage operation and separate the customer's parallel generation.
Transfer Trip Receiver	To receive a trip signal from an AES Indiana transfer trip transmitter and separate the customer's parallel generation.
Ground Detector	To detect a ground fault on the AES Indiana or customer system and separate the customer's parallel generation.
Directional Power	To detect a reverse power flow condition and separate the customer's parallel generation.

The purpose of these relays is to detect the above conditions and to separate the GO's generation from the AES Indiana system. Output contacts of these relays shall directly energize the trip coil(s) of the generation breaker or an intermediate auxiliary tripping relay that directly energizes the breaker trip coil(s). The relaying system shall have a power source independent from the utility source (e.g., dc battery and charger) to assure proper operation of the protection scheme. Loss of the independent source shall cause removal of the generation from the AES Indiana system.

It is the GO's responsibility to ensure that their internal protective equipment coordinates with the required AES Indiana protective equipment and is adequate to meet all applicable standards. AES Indiana reserves the right to modify all protection settings when deemed necessary.

A transfer trip relaying system (or other not specified above) must be installed at the GO's expense if AES Indiana determines it is necessary to protect the transmission system. The transfer trip relaying system shall consist of all transfer trip transmitters located at AES Indiana Facilities, transfer trip receivers at the generation Facility and the communication channels between the AES Indiana location(s) and the generation Facility.

4.4 Metering and Telecommunications

Metering

At the IC's expense, AES Indiana will install, own, operate, and maintain the metering equipment at the delivery point. The IC must provide the necessary space for this metering equipment. The metering equipment will include potential and current transformers, meters, and test switches. The accuracy of the instrument transformers and meters will be 0.3 percent or better. The secondary wiring and burdens of the instrument transformers will be configured so that they do not degrade the accuracy of the metering equipment to less than 0.3 percent. The metering equipment shall be tested periodically as defined in the connection or service agreement and the test results will be available to all involved parties. The meters, test switches and wiring termination equipment will be sealed and the seal may be broken only when the meters are to be tested, adjusted, or repaired. Proper authorities in both parties will be notified when seals are broken. At least N-1 metering elements will be used to measure all real and reactive power crossing the metering point, where N is the number of wires in service including the ground wire. Bi-directional energy flows including watt-hour and var-hour will be separately measured on an hourly basis. Depending on the tariffs to be applied, appropriate demand quantities will be metered in terms of kilowatts, kilovars or kilovolt-amperes. The meters will have a separate register for loss compensation.

Revenue Metering

AES Indiana approved revenue class metering equipment shall be installed at the delivery point to meter the aggregated load of the connected Facility consisting of instantaneous bi-directional real and reactive power and integrated hourly real and reactive energy metering. The instrument transformers used for revenue metering shall be installed on the high voltage side of the connecting party's step-down transformer. Under special circumstances and with written approval granted by AES Indiana, revenue metering may be performed on the low voltage side of the step-down transformer. Written approval shall only be given if the connecting party can demonstrate that accurate transformer loss compensation will be programmed into the revenue metering when instrument transformers are installed on the low voltage side of the step-down transformer or accepts a 1% differential between the low side and high side.

Telecommunications

If, at the discretion of AES Indiana, the interconnection necessitates real-time telemetry to the MISO and/or AES Indiana TOCC, AES Indiana will install, own, operate, and maintain, at the IC's expense, the communication channel, telemetry equipment and associated devices. Suitable telemetry equipment shall be installed at the metering point to provide real-time telemetry data to AES Indiana and to all other participating parties. Telemetry equipment will include transducers, remote terminal units, modems, telecommunication lines, and any other equipment of the same or better function. The remote terminal unit, or equivalent device, must have multiple communication ports to allow simultaneous communications with all participating parties. That device will accommodate data communication requirements specified by each participating parties' TOCC, including communication protocol, rate and mode (either synchronous or asynchronous). All metered values provided to the telemetry equipment will originate from common metering equipment. All transducers used for telemetry will have at least 0.2 percent accuracy. As part of real-time data to be provided, AES Indiana has the right to require the status and remote control of switching devices at the receipt and/or delivery points. A continuous, accumulating record of megawatt-hours and megavar-hours will be provided by means of the registers on the meter. Freezing accumulation data for transmission will be taken every clock hour. The freezing signals synchronized to within 2 seconds of UTC must be provided by only one of the agreed-upon participating parties. If the freeze signal is not received within a predefined time window, the remote terminal unit, or equivalent device, will be capable of freezing data with its own internal clock. The metering, if external power supply is required, and telemetry equipment will be powered from a reliable power source, such as a station control battery, to allow the equipment to be continuously operational under any power outage situations. Proper surge protection will be provided for each communication link to protect communication hardware from ground-potential-rise due to any fault conditions. A separate communication media shall be provided to allow AES Indiana to remotely retrieve billing quantities from the meters. When real-time telemetry is required, a back-up data link must be provided in case of the outage of the primary telemetry line. The back-up link can be a data communication link between involved control centers; the party requesting service is responsible for furnishing the back-up link. At the discretion of AES Indiana, generation control Facilities and supervisory control and data acquisition of specific electrical devices from the MISO and/or AES Indiana TOCC may be necessary to integrate the generation into MISO's control area. Such additional Facilities, including the required communication channels, should, if required, be furnished and installed at the GO's expense. The requirement for data acquisition and control will depend on the generation capacity, system location and voltage, and the net generation input into AES Indiana System. Data acquisition and control information will typically include, but not be limited to:

a) desired generation MW set point,
b) automatic generation control status (on, off),

c) generator availability,
d) generation MW, MVAR output,
e) generator minimum and base MW capability,
f) generator MW AGC high limit and low limit,
g) connection Facilities' breaker status/control/alarms,
h) connection Facilities' MW and MVAR line values and bus voltage, and
i) generator and substation metering (MWh) data.

4.5 Grounding and Safety Issues

Safety is of utmost importance. Strict adherence to established switching, Lock Out/Tag Out procedures, and grounding procedures are required at all times for the safety of personnel. Any work carried out within a Facility shall be performed in accordance with all applicable laws, rules, and regulations in compliance with OSHA, NESC, and good utility practice. Automatic and manual disconnect devices are to be provided as a means of removing all sources of current to any particular element of a power system. AES Indiana personnel must be granted 24x7 access for emergency patrol or tagging purposes. Only trained operators are to perform switching functions within a Facility under the direction of the responsible dispatcher or designated person as outlined in the NESC.

A safe grounding design must accomplish two basic functions:

a) Ensure that personnel in the vicinity of grounded structures and Facilities are not exposed to critical levels of step or touch potential.
b) Provide a path for electric currents into the earth under all possible system conditions without exceeding any operating and equipment limits or adversely affecting the continuity of service.

IC's equipment ground sources can contribute significant fault current. These ground sources should be considered in the design of the grounding system. The grounding system should be designed to provide a solid ground for all metallic structures and equipment in accordance with the latest edition of IEEE 80 – IEEE Guide for Safety in AC Substation Grounding. The fence safety clearances in the IC's Facility shall comply with Section 11 of the latest edition of ANSI C2, National Electrical Safety Code. Testing must be performed to ensure safe step and touch potential parameters have been met in accordance with IEEE 80.

When various switching devices are opened on an energized circuit, its ground reference may be lost if all sources are not effectively grounded. This situation may cause over voltages that can affect personnel safety and damage equipment. This is especially true when one phase becomes short-circuited to ground. Therefore, the interconnected transmission power system is to be effectively grounded from all sources. Interconnection generators should provide for effective system grounding of the high-side transmission equipment by means of a grounded high-voltage generation step-up transformer.

4.6 Insulation and Insulation Coordination

Insulation coordination is the selection of insulation strength. Insulation coordination must be done properly to ensure electric system reliability and personnel safety. Basic switching surge levels, surge arrester, conductor spacing and gap application, substation and transmission line insulation strength, protection, and shielding shall be documented and submitted for evaluation as part of the interconnection plan. Equipment BIL shielding and surge protection shall be designed to meet the latest IEEE C62 standards, along with AES Indiana standards. The minimum substation basic impulse levels for AES Indiana are shown in section 4.2. Facilities in areas with significant air pollution may require a higher insulation level. Higher strength insulators are available and should be used if needed to meet bus momentary fault circuit withstand values.

4.7 Voltage, Reactive Power, and Power Factor Control

MISO is responsible for the stability and reliable operation of the electric transmission system. An essential part of the transmission system reliability is the coordination of real and reactive power sources to maintain an adequate voltage profile both for normal and contingent conditions. Reactive sources must be distributed throughout the electric systems due to large voltage drops associated with transmission of reactive power.

Operators of transmission systems follow voltage control strategies to minimize the risk of exceeding equipment voltage limitations and the grid’s voltage stability limitations.

Generation Facilities

All generation customers interconnected to the AES Indiana transmission system are responsible for operating their units in a stable manner.

Generation excitation and prime mover controls are key elements in ensuring electric system stability and reliability. Reasonable measures should be taken to avoid tripping of the generation Facilities due to high or low voltage excursions. MISO must have the ability to establish voltage and governor control requirements for all generators connected to the system. These requirements may vary depending on location, size, and type of generation installed. Generation customers are required with oversight by MISO to follow the current NERC and RF standards and guides for generation operation, protection, and control. Power factor requirements for new generation interconnection requests and increases to existing generators are documented in MISO BPM-015 – Generator Interconnection. Specific requirements for voltage regulators, power system stabilizers, governor controls, and remote control and telemetry of such devices will be determined during the System Impact Study. The specific requirements for a generator will become part of the GIA.

Transmission Facilities

The transmission system must be capable of moving electric power under a wide variety of expected system conditions. Reasonable measures should be taken to avoid tripping of transmission Facilities due to high or low voltage excursions. Transmission Facilities must be designed to minimize excessively high voltages during light transmission loading conditions yet have adequate reactive supplies to support system voltage during heavy transmission loading conditions.

End-User Facilities

End-Users connected directly to the AES Indiana transmission system should plan and design their systems to operate at close to unity power factor to minimize the reactive power burden on the transmission system.

4.8 Power Quality Impacts

The IC shall take responsibility for limiting harmonic voltage and current distortion and/or voltage flicker caused by their equipment. Limits for harmonic distortion are consistent with those published in the latest IEEE 519, Standard for Harmonic Control in Electric Power Systems. AES Indiana criteria requires that flicker occurring at the POI shall be compatible with the levels specified in IEC 61000-3-7, Assessment of emissions limits for fluctuating loads in MV and HV power systems. Compatibility levels are shown below.

Voltage Levels	Pst (Perception, Short Term)	Plt (Perception, Long Term)
≤ 1 kV	1.0	0.8
1kV < V ≤ 35kV	0.9	0.7
> 35kV	0.8	0.6

Depending upon the nature of the equipment and its location, AES Indiana may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria. The monitoring system, if required, will be installed at the IC's expense.

Certain electrical equipment in the IC's Facility may be sensitive to normally occurring electric interference from nearby connected loads within the Facility, other end-users connected to the system, natural causes, system switching, etc. If sensitive electrical equipment is to be supplied directly from the electric power system, it is recommended that the equipment grounding requirements and power supply requirements be examined by the end-user's consultant prior to installation. Attention should be given to equipment tolerance to various forms of electric interference, including voltage sags and surges, momentary outages, transients, current and voltage harmonic distortion, or other electrical and electromechanical noise. When electrical disturbances to sensitive electrical equipment such as computers, electronics, controls, and communication equipment cannot be tolerated, the end-user shall install additional equipment as necessary to prevent equipment malfunctions and protect against equipment failure. The end-user should consult the supplier of such sensitive electrical equipment regarding the power supply requirements or the remedial measures to be taken to alleviate potential operational problems or failure of the equipment. The end-user may need to hire a power quality consultant to perform a site survey of the electric power supply environment and furnish recommendations to provide acceptable levels of reliability and quality of service.

4.9 Equipment Ratings

All circuit breakers and other fault-interrupting devices shall be capable of safely interrupting fault currents for any fault they may be required to interrupt. Application of circuit breakers shall be in accordance with the ANSI/IEEE C37 collection of standards.

All current carrying equipment and devices shall be designed to not limit the rating of the transmission line to less than the rating of the transmission conductor without the interconnection. All current carrying equipment and devices at 138 kV shall be rated for at least 3000 amperes. All current carrying equipment and devices at 345 kV shall be rated for at least 4000 amperes.

Equipment BILs, shielding, and surge protective device application must meet requirements as determined by the latest IEEE C62 standards. AES Indiana will provide the BIL for the system in the interconnection area. Equipment must meet all applicable ANSI/IEEE standards and specifications communicated by MISO and AES Indiana.

4.10 Synchronization of Facilities

Synchronizing equipment consisting of potential transformers and associated protective relaying/controls is required on Facilities where energy can be sourced on both sides of an interconnection breaker. This equipment serves the following purposes:

a) Verifies the voltages on both sides of a circuit breaker fall within certain tolerances of magnitude and phase angle as established by system conditions.
b) Supervises the closing and automatic reclosing of the circuit breaker.
c) Prevents the closing of the circuit breaker when the two systems are out of sync.

Generation Facility and transmission Facility customers shall install sync check breakers and relaying on the interconnection breakers with AES Indiana's transmission system. end-users do not require sync check breakers if they do not have generation on their side of the interconnection. The IC assumes all responsibility for properly synchronizing their generation or transmission Facilities with the AES Indiana transmission system. Upon loss of the AES Indiana source, the IC shall immediately cause the generation and transmission Facilities to be separated from the AES Indiana system. Synchronizing and connection to the AES Indiana Transmission System must be performed under the direction of the MISO TOCC with coordination by the AES Indiana TOCC.

4.11 Maintenance Coordination

The maintenance of Facilities is the responsibility of the owner of those Facilities. Adjoining Facilities on the interconnected power system are to be maintained in accordance with accepted industry practices and procedures to ensure proper operation of equipment. Each party is to have a documented maintenance program ensuring compliance to NERC, RF, and MISO standards. AES Indiana will have the right to review maintenance reports and calibration records of equipment that could impact the AES Indiana system. Planned maintenance and testing of the Facilities must be scheduled and coordinated through MISO to ensure the reliability and capability of the AES Indiana transmission system is maintained.

4.12 Operational Issues (Abnormal Frequency and Voltages)

The interconnection operation will be consistent with NERC, RF, and MISO requirements. All switching that could impact the transmission system must be coordinated through MISO.

The AES Indiana system typically operates at a nominal 60.0 Hz with a variation of +0.05 Hz to –0.05 Hz (59.95 to 60.05 Hz). Under certain emergency conditions, the transmission system may operate transiently outside of this range. Under the guidance of NERC PRC-006, TOs have been given frequency bands to enact an under-frequency load shedding scheme. AES Indiana has been instructed to follow MISO, as an RTO, under-frequency load shedding program. Additionally, under the guidance of NERC PRC-024, applicable generating Facilities must set frequency-sensitive protection equipment to support the system and mitigate adverse system conditions without damaging Facility equipment. Therefore, the IC is responsible for providing any frequency sensing equipment.

The AES Indiana system voltages can range on the AES Indiana transmission system from 95% to 105% of the nominal transmission voltages, which are 345kV and 138kV. Generating Facilities operating in conjunction with AES Indiana Transmission Operations must comply with NERC VAR-002 as applicable. AES Indiana does not have a NERC PRC-010 under-voltage load shedding program. Additionally, under the guidance of NERC PRC-024, applicable generating Facilities must set voltage-sensitive protection equipment to support the system and mitigate adverse system conditions without damaging Facility equipment. Therefore, the IC is responsible for providing any voltage sensing equipment.

4.13 Inspection Requirements for Existing or New Facilities

Each party to the interconnection agreement shall perform routine inspections and testing of its Facilities and equipment in accordance with good utility practice and regulatory requirements to ensure the continued interconnection of the Facilities with the AES Indiana transmission system.

Each party shall notify the other party in advance of Facility and equipment testing, and the other party may have a representative attend and be present during such testing. If a party observes any deficiencies or defects on or become aware of a lack of scheduled maintenance and testing with respect to the other party's Facilities and equipment that might reasonably be expected to adversely affect the observing party's Facilities and equipment, the observing party shall provide notice to the other party that is prompt under the circumstances, and the other party shall make any corrections required in accordance with good utility practice and as required by regulatory agencies. Where deficiencies or defects are not resolved in a reasonable manner, decisions will be made on a case-by-case basis whether the Facility may remain in operation. Decisions will consider severity of the deficiency or defect and the resulting impact to reliability.

MISO and AES Indiana shall receive final documentation of the Facility once the Facility is ready for operation. Prior to operation of a Facility, the IC shall supply to AES Indiana three copies of all as-built one-lines, equipment data, and schematic diagrams. Subsequent revisions affecting the Facility shall be documented with three electronic copies of the revised one-line and schematic diagrams.

The construction, testing, and maintenance of the protective relaying equipment provided by the IC for protection of the transmission system shall be subject to review and approval by AES Indiana. Prior to the connection, energizing of, or operation of the Facility, the IC shall obtain approval from AES Indiana for the Facility, electrical equipment specifications, and operating procedures. MISO and AES Indiana will issue final approval for operation of an IC's Facilities. For generators and transmission interconnections, a signed Interconnection Agreement with AES Indiana is required for final approval of the interconnection and before connection of the Facility to the transmission system. Failure to meet any of the requirements stated herein to the satisfaction of AES Indiana may result in a refusal to permit operation of the generation Facility. Review and approval by AES Indiana of the proposed generation Facility specifications and plans shall not be construed as confirming or endorsing the design or warranting the safety, durability, reliability, adequacy, or otherwise of the IC's Facility.

4.14 Communications and Procedures during Normal and Emergency Operating Conditions

Complete, precise, and timely communication is an essential element for maintaining reliability and security of a power system. Under normal operating conditions, the major link of communication with various interconnects shall be by telephone lines. AES Indiana and the IC shall maintain communications which shall include, but not limited to:

a) System paralleling or separation
b) Scheduled or unscheduled shutdowns
c) Equipment clearances
d) Periodic load reports
e) Maintenance schedules
f) Tagging of interconnection interrupting devices
g) Meter tests
h) Relay tests
i) Billing
j) Other routine communication

In case of emergency or abnormal operating conditions, various communication channels may be used depending on the interconnection category. Emergency telephone numbers should be agreed upon by both parties prior to the actual connection date. The IC shall install and maintain satisfactory operating communications with MISO's system dispatcher and with AES Indiana's transmission system dispatcher. The IC shall provide standard voice line, dedicated voice line and facsimile communications at its Customer Facility control room. The IC also shall provide and maintain backup communication links with both MISO and AES Indiana for use during abnormal conditions as specified by MISO and AES Indiana. The IC further shall provide the dedicated data circuits necessary to provide IC data to MISO and AES Indiana as necessary to conform with applicable technical requirements and standards.

The IC is required to notify MISO and AES Indiana of their intention to perform any operational step(s) that could have an influence on the transmission system. Planned outages of Facilities that impact the transmission system must be scheduled and coordinated through AES Indiana TOCC and/or MISO TOCC.

Each party shall notify the other parties promptly when it becomes aware of an emergency condition that may reasonably be expected to affect operation of the IC Facility or AES Indiana Facilities. The IC is required to follow MISO and AES Indiana instructions during emergency conditions. Specific instructions may also be given regarding the operation of the IC's Facilities depending on the nature of the emergency. These instructions may consist of voltage schedule changes, real and/or reactive dispatch changes, or instructions to shut down or start-up the IC's generation. It is the IC's responsibility to ensure that the unit operators follow all instructions given by MISO or AES Indiana during system emergencies. Participation in drills conducted by MISO or AES Indiana is required upon request. AES Indiana personnel must be granted 24x7 access for emergency patrol or tagging purposes.

End-user customers will provide communication to AES Indiana through their AES Indiana Account Managers.

5) Inverter-based Resources - Interconnection Requirements

In addition to the Facility requirements listed above for generation interconnection customers, the following capabilities and control settings are desired for IBRs connecting to the AES Indiana system.

5.1 Active Power – Frequency Control

IBRs interconnecting to the AES Indiana system require active power frequency control in accordance with the FERC Order No. 842 to provide primary frequency response capability. It must install, maintain, and operate equivalent controls capable of primary frequency response.

The primary frequency response of a generating Facility shall follow a maximum 5% droop curve for any frequency deviations greater than a ± 0.036 Hz deadband. Each individual inverter in said generating Facility shall also have a response following a maximum 5% droop curve, rather than a step change response for any frequency deviations greater than a ± 0.036 Hz deadband.

A response at a different droop rate or an asymmetrical droop curve might be required by AES Indiana as needed based on the studies performed at the POI.

To meet this requirement, the IBR is expected to be capable of reducing its output to respond to an over-frequency event and be capable to increasing the active power output to the maximum rated output during an under-frequency event. For any sudden changes in frequency the dynamic performance should meet or exceed the criteria listed in Table 1 and is also illustrated in Figure 1.

Table 1. Dynamic Active Power-Frequency Performance

Parameter	Description	Performance Target
For a step change in frequency at the POM of the IBR		
Reaction Time	Time between the step change in frequency and the time when the resource active power output begins responding to the change	< 500 ms
Rise Time	Time in which the resource has reached 90% of the new steady-state (target) active output command	< 4 sec
Settling Time	Time in which the resource has entered, and remains within, the settling band of the new steady-state active power output command	< 10 sec
Overshoot	Percentage of rated active power output that the resource can exceed while reaching the settling band	< 5%
Settling Band	Percentage of rated active power output that the resource should settle to within the settling time	< 2.5%

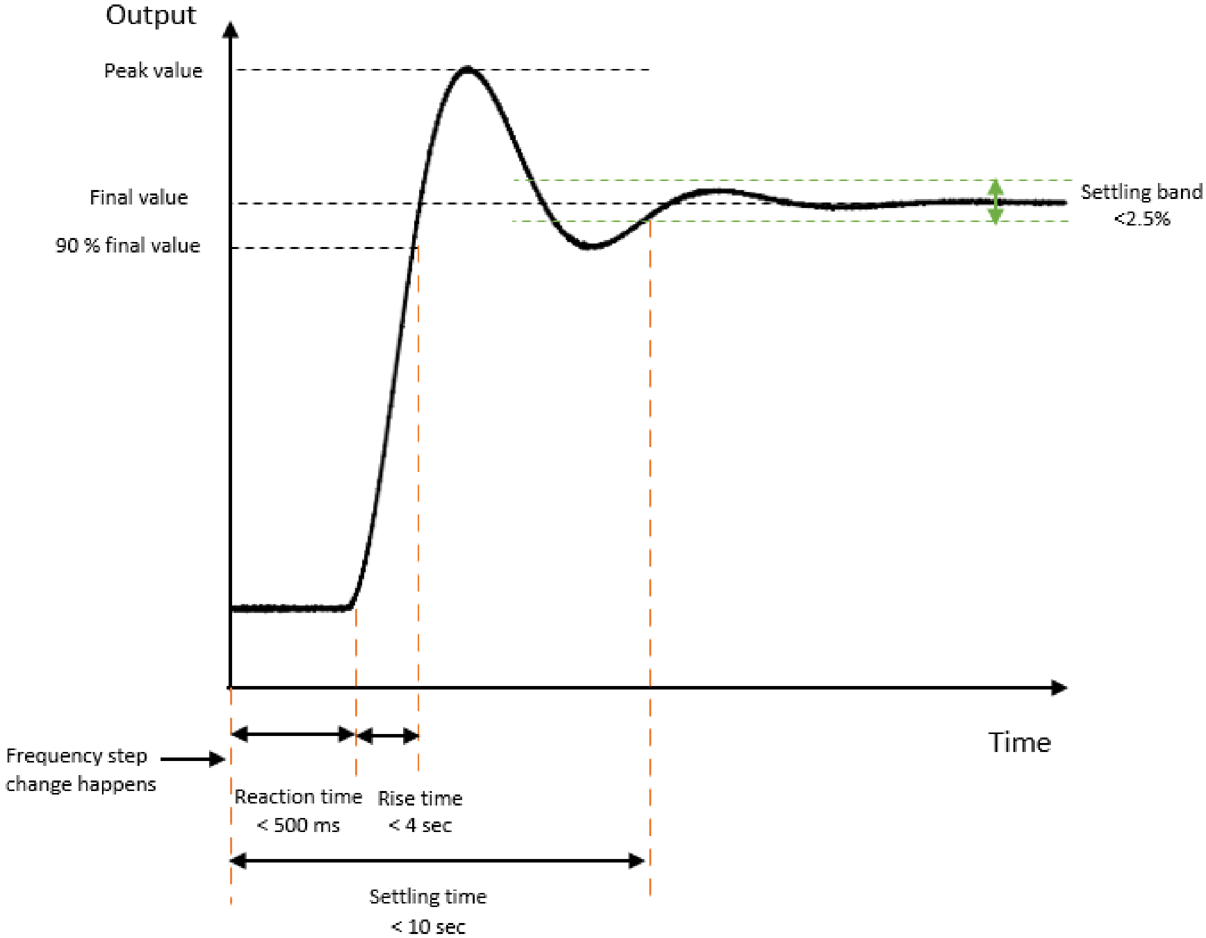


Figure 1. Dynamic Active Power-Frequency Performance

The GO should either verify the performance of the resource at a curtailed output during commissioning or provide EMT study results based on a tuned model that utilizes the actual algorithm to be implemented on site. Any changes to the control logic and the operation of the resource should be communicated to AES Indiana and the EMT model must be updated and tuned as implemented on site.

5.2 Reactive Power – Voltage Control

Per NERC VAR-002, new IBRs interconnecting to the AES Indiana system are required to be able to control voltage at the POM with a closed-loop, automatic voltage control mode to maintain the scheduled voltage in the AES Indiana transmission system within ±2%.

The IBR shall be designed to exchange reactive power with the transmission system for voltage control when no active power is generated. IBRs should meet small disturbance and large disturbance performance requirements in voltage control. Generally, small disturbance behavior is where voltage stays within the continuous operating range and is dominated by plant-level controls. Large disturbance behavior is where voltage falls outside this range (i.e., "ride-through mode") and is typically dominated by individual inverter controls. The typical boundary of continuous operating range is ±2% around nominal operating voltage determined by AES Indiana.

For small disturbance, IBRs shall have the capability to meet or exceed the performance characteristics shown in Table 2 and Figure 2.

Table 2. Small Disturbance Reactive Power-Voltage Performance

Parameter	Description	Performance Target
For a step change in frequency at the POM of the inverter-based resource…		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change	< 500 ms
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90% of its final value	1-30 sec
Overshoot	Percentage of rated reactive power output that the resource can exceed while reaching the settling band	< 5%

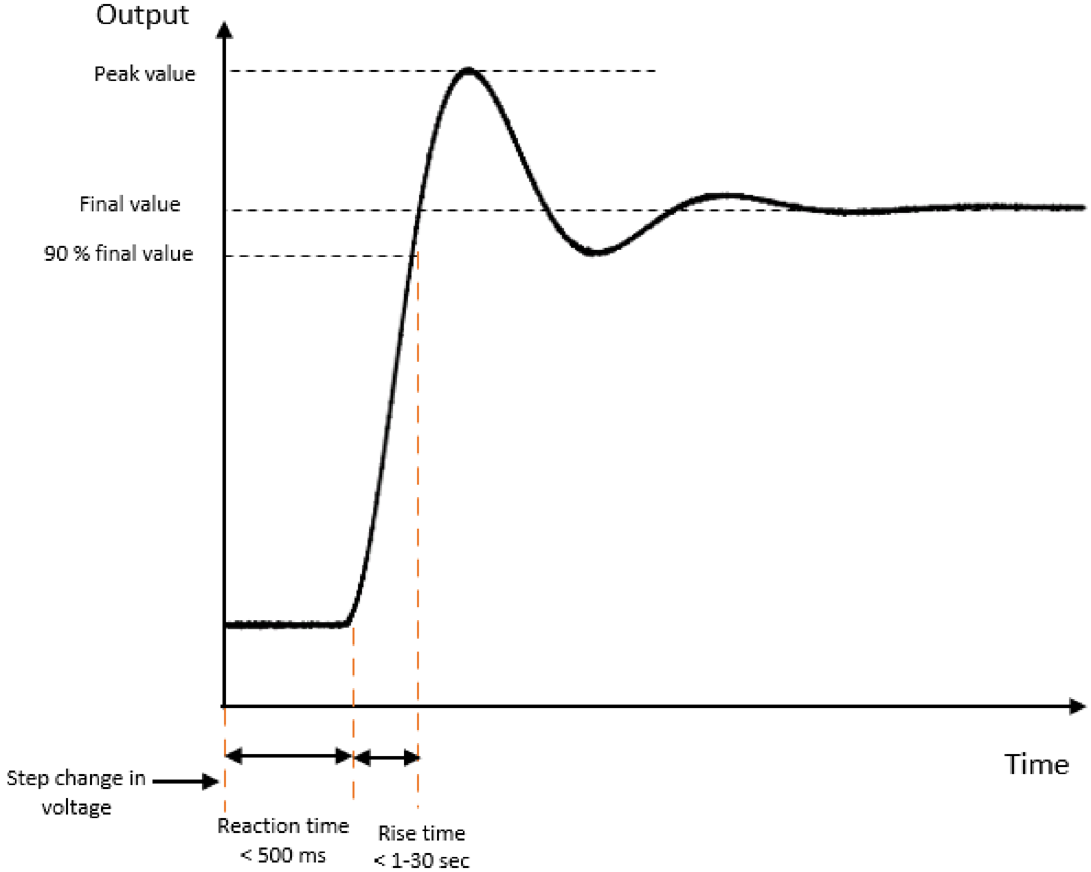


Figure 2. Large Disturbance Reactive Power-Voltage Performance

For large disturbance, IBRs should have the capability to meet or exceed the performance characteristics shown in Table 3 and Figure 3.

Table 3. Large Disturbance Reactive Current-Voltage Performance

Parameter	Description	Performance Target
For a large disturbance step change in voltage, measured at the inverter terminals, where voltage falls outside the continuous operating range, the positive sequence component of the inverter reactive current response should meet the following performance specifications		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change	< 16 ms
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90% of its final value	< 100 ms

Overshoot	Percentage of rated reactive current output that the resource can exceed while reaching the settling band.	Determined by AES Indiana*

*AES Indiana will indicate the reactive power overshoot limit based on the POI and the local voltage profile.

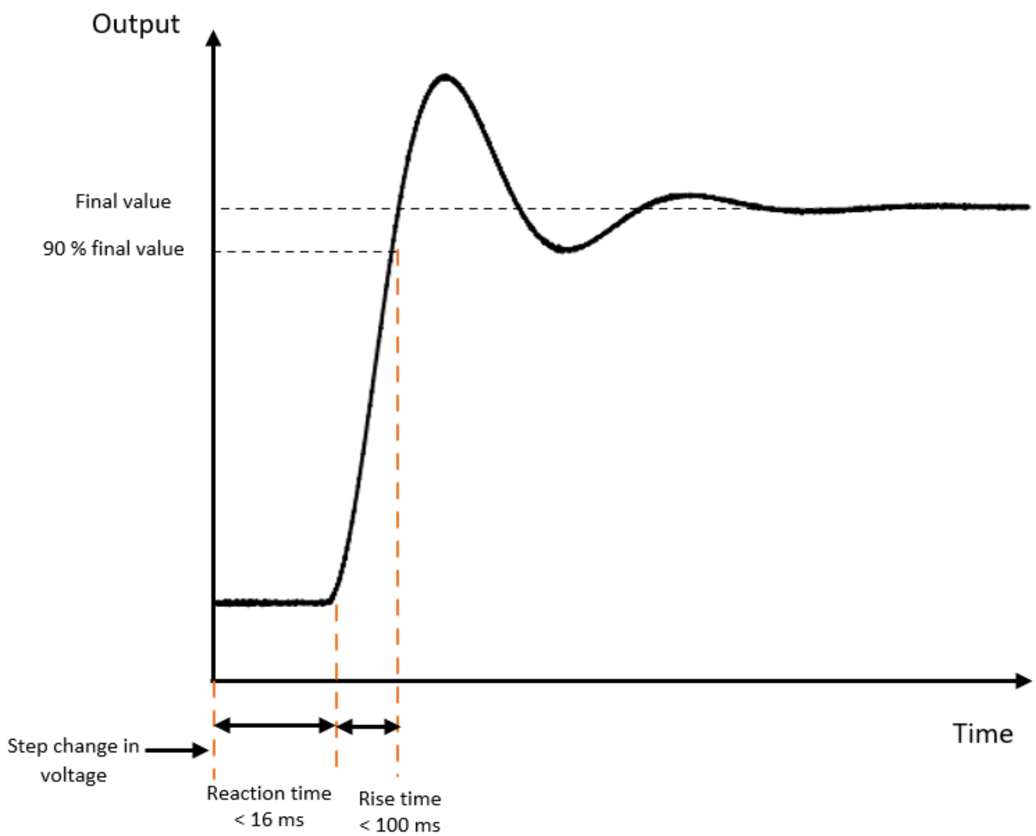


Figure 3. Large Disturbance Reactive Current-Voltage Performance

To maintain the scheduled voltage at the POI, the IBR under voltage control will respond to a voltage range or setpoint to determine the amount of reactive power compensation required. If there are existing resources regulating the same bus or located in close proximity, the interconnecting resource is required to utilize a reactive droop for the voltage outside the pre-determined deadband to coordinate voltage control with the nearby resources.

The selection of the reactive droop and voltage control should be coordinated with AES Indiana and based on the AES Indiana's operating voltage range. An illustration of the Reactive Power – Voltage Control characteristic based on the NERC Reliability Guideline for BPS-Connected Inverter-Based Resource Performance is included in Figure 4.

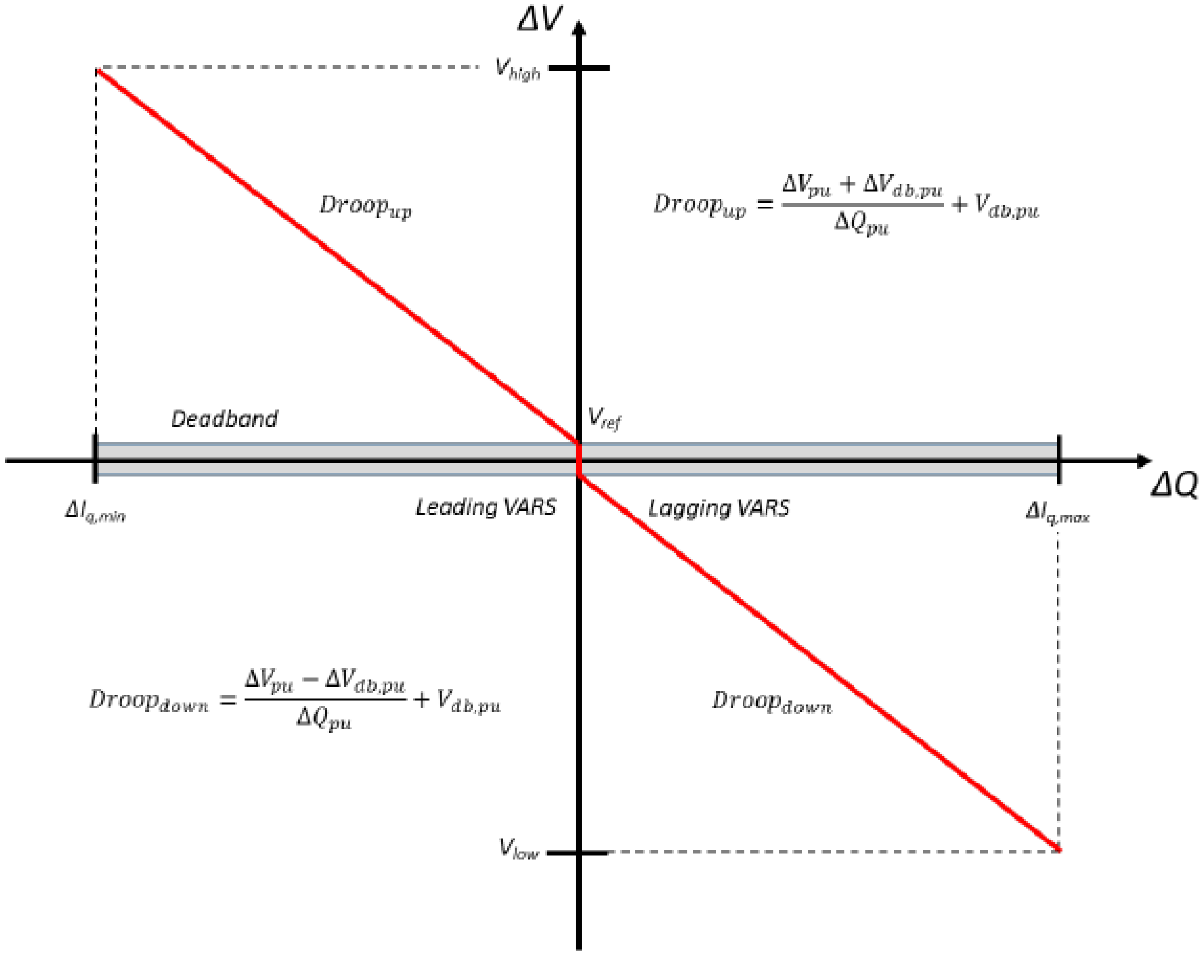


Figure 4. Reactive Power – Voltage Control Characteristic

5.3 Power Factor

In accordance with FERC Order No. 827, all newly interconnecting inverter-based resources are required to provide dynamic reactive power support within the power factor range of 0.95 leading to 0.95 lagging measured from the POM at the rated active power output. Similar to synchronous machines, it is recommended that, if additional reactive power capability is available from the IBRs for a specific active power output, that capability should not be artificially limited.

Static reactive power devices can only be used to make up for reactive losses that occur between the inverters and the transmission voltage side of the generator step-up transformer. Any shortfall in dynamic reactive power should be compensated by installing a dynamic reactive power device such as a STATCOM or SVC.

For each inverter model installed at the project site, a P-Q curve, also known as the capability curve, must be provided to AES Indiana by the IC. The curve should include the active and reactive power injection capability at nominal voltage, and across the voltage range of 95% to 105% of the nominal voltage at the POM. A "composite capability curve" which includes the overall active and reactive power output capability of the resource at the (POM) shall also be provided by the IC if available.

5.4 Power Quality

Power quality meters and meter accuracy instrument transformers should be installed at the POI of the IBRs. The following requirements must be met for all IBRs.

Voltage Flicker

IBRs may become a source for voltage flicker under abnormal system configurations (i.e., major outage conditions). Therefore, the IC shall make provisions to install power quality monitoring devices to ensure that the IEEE 1453 requirement is met at the POI with the inverter-based resource. The required planning levels for voltage flicker are shown in Table 4, where LP_{st} and LP_{lt} are the short-term and long-term planning levels.

Table 4. Required planning levels for voltage flicker

Voltage Level	LP_{st}	LP_{lt}
1kV < V ≤ 35 kV	0.9	0.7
> 35 kV	0.8	0.6

Harmonic Distortion

Harmonic injection into the transmission system is another power quality concern for IBRs. Therefore, the IC shall make provisions to install power quality monitoring devices to ensure that the IEEE 519 requirement is met at the POI. The IC may request AES Indiana to provide frequency-dependent system (source) impedances, including the effects of nearby reactive compensation Facilities (e.g., switching shunt capacitor banks on-line and off-line), so that information can be provided to the inverter manufacturer during the study process.

The following requirement should be met for voltage distortion:

- Daily 99th percentile very short time (3 s) values should be less than 1.5 times the values given in Table 5.

- Weekly 95th percentile short time (10 min) values should be less than the values given in Table 5.

All values should be in percent of the rated power frequency voltage at the POI. Table 5 applies to voltage harmonics whose frequencies are integer multiples of the power frequency.

Table 5. Voltage distortion requirement

Voltage Level	Individual Harmonic (%)	Total Harmonic Distortion THD (%)
V ≤ 1 kV	5.0	8.0
1kV < V ≤ 69 kV	3.0	5.0
69 kV < V ≤ 161 kV	1.5	2.5
161 kV < V	1.0	1.5

For systems with different voltage levels, the following requirement should be met for current distortion:

- Daily 99th percentile very short time (3 s) harmonic currents should be less than 2.0 times the corresponding values given in Table 6 through Table 8.
- Weekly 99th percentile short time (10 min) harmonic currents should be less than 1.5 times the corresponding values given in Table 6-Table 8.
- Weekly 95th percentile short time (10 min) harmonic currents should be less than the corresponding values given in Table 6-Table 8.

Table 6. Current distortion requirement for system rated 120V through 69 kV

Individual harmonic order (odd harmonics) *						
I_{SC}/I_L	3 ≤ h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h < 50	Total demand distortion (TDD)
< 20	4.0	2.0	1.5	0.6	0.3	5.0
20 < 50	7.0	3.5	2.5	1.0	0.5	8.0
50 < 100	10.0	4.5	4.0	1.5	0.7	12.0
100 < 1000	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

Table 7. Current distortion requirement for system rated 69 kV through 161 kV

Individual harmonic order (odd harmonics) *						
I_{SC}/I_L	3 ≤ h < 11	11 ≤ h < 17	17 ≤ h < 23	23 ≤ h < 35	35 ≤ h < 50	Total demand distortion (TDD)
< 20	2.0	1.0	0.75	0.3	0.15	2.5
20 < 50	3.5	1.75	1.25	0.5	0.25	4.0

50 < 100	5.0	2.25	2.0	0.75	0.35	6.0
100 < 1000	6.0	2.75	2.5	1.0	0.5	7.5
> 1000	7.5	3.5	3.0	1.25	0.7	10.0

Table 8. Current distortion requirement for system rated above 161 kV

Individual harmonic order (odd harmonics) *						
I_{SC}/I_L	**3 ≤ h < 11**	**11 ≤ h < 17**	**17 ≤ h < 23**	**23 ≤ h < 35**	**35 ≤ h < 50**	**Total demand distortion (TDD)**
< 25	1.0	0.5	0.38	0.15	0.1	1.5
25 < 50	2.0	1.0	0.75	0.3	0.15	2.5
≥ 50	3.0	1.5	1.15	0.45	0.22	3.75

* Even harmonics are limited to 25% of the odd harmonic limits above. Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

I_{SC} = maximum short-circuit current at POI

I_L = maximum demand load current (fundamental frequency component) at the POI under normal load operating conditions

5.5 Fault Ride Through Capability

In accordance with NERC PRC-024 and NERC Reliability Guideline for BPS-Connected Inverter-Based Resource Performance, all new IBRs interconnecting to the AES Indiana transmission system are required to have the voltage ride-through and frequency ride-through capability. Inverters must continue current injection during disturbances with the ride-through duration. The NERC PRC-024 voltage and frequency ride-through curves specify a "No Trip Zone". Operations outside of the "No Trip Zone" shall not be interpreted as a "Must Trip Zone" but rather a "May Trip Zone". Tripping should be based on physical equipment limitations and protection should be set to the widest range of voltage and frequency deviations possible while still ensuring equipment safety and reliability.

The frequency and voltage ride-through curves described in NERC Reliability Standard PRC-024-2 apply to the POI and not the inverter terminals themselves.

Voltage Ride-Through

This voltage ride-through is separated into two aspects: fundamental frequency voltage ride-through and sub-cycle transient overvoltage ride-through.

The fundamental frequency voltage ride-through requirement is shown in Table 9. In a disturbance, the IBR must remain interconnected within the "No Trip Zone" described in Table 9. In Table 9, voltages are the filtered fundamental frequency RMS value at POI.

Table 9. Fundamental Frequency Voltage ride-through requirement

High Voltage Ride Through Duration		Low Voltage Ride Through Duration	
Voltage (pu)	**Time (s)**	**Voltage (pu)**	**Time (s)**
≥1.200	Instantaneous trip	<0.45	0.15
≥1.175	0.20	<0.65	0.30
≥1.15	0.50	<0.75	2.00
≥1.10	1.00	<0.90	3.00

The sub-cycle transient overvoltage ride-through requirement is shown in Table 10. In Table 10, voltage values are instantaneous inverter terminal voltage.

Table 10. sub-cycle transient overvoltage ride-through requirement

Voltage (pu)	Time (s)
≥2.000	Instantaneous trip
≥1.700	0.0016
≥1.400	0.003

Frequency Ride-Through

The frequency ride-through requirement is shown in Table 11. In a disturbance, the IBR must remain interconnected within the "No Trip Zone" described in Table 11. In Table 11, the specified frequency ride-through requirement is not based on instantaneously calculated frequency. The frequency requirement is based on an accurately calculated and filtered frequency measurement over a time window (e.g., six cycles). The phase jumps during ride-through event should not result in inverter tripping.

Table 11. Frequency ride-through requirement

High Frequency Ride Through Duration		Low Frequency Ride Through Duration	
Frequency (Hz)	**Time (s)**	**Frequency (Hz)**	**Time (s)**
≥ 61.8	Instantaneous trip	≤ 57.8	Instantaneous trip
≥ 60.5	$10^{(90.935-1.45713*f)}$	≤ 59.5	$10^{(1.7373*f-100.116)}$
< 60.5	Continuous operation	> 59.5	Continuous operation

5.6 Momentary Cessation

All the IBRs should be able to continuously inject current within the "No Trip Zone" of the PRC-024 frequency and voltage ride-through curves. Therefore, newly interconnecting IBRs in the AES Indiana system should eliminate the use of momentary cessation (ceases firing of power electronics commands such that the inverter does not produce active or reactive current) inside the "No Trip zone" unless a reliability study identifies the need to cease injecting current. If the momentary cessation is approved by AES Indiana and utilized by the interconnecting generator, the following information shall be provided by the GO:

- Low voltage magnitude threshold (pu) for momentary cessation
  - The low voltage at which the inverter enters momentary cessation. If the limit is based on a time duration (i.e., different levels for different times), then a curve should be provided.
- High voltage magnitude threshold (pu) for momentary cessation
  - The high voltage at which the inverter enters momentary cessation. If the limit is based on a time duration (i.e., different levels for different times), then a curve should be provided.
- Time delay before recovery begins after voltage recovers (sec)
- Active current ramp rate back to pre-contingency current after voltage recovery (pu/sec)
  - The ramp rate (expressed in terms of percent of rated current per second) of recovery in active current injection following momentary cessation.
- IBRs should be designed and configured to use momentary cessation only outside the "No Trip Zone" if this helps mitigate potential tripping conditions based on the interconnection studies.
- GOs should ensure that the dynamic models, both generic and vendor-specific, used to represent their IBR(s) capture momentary cessation. Any updates to the model shall be coordinated with the inverter manufacturer and provided to the AES Indiana Transmission Planning team.

5.7 Grid Forming Capability

If the IBR can form the grid by providing the voltage and frequency reference independent of the existing utility system, the IBRs should not attempt to automatically reconnect to the grid, unless directed by the grid operator, to not interfere with the existing black start procedures.

After the system impact studies, AES Indiana shall decide if the IBR will be required to participate in the black start process, and if so, the resource must satisfy the requirements in the NERC Standard EOP-005-2 and MISO BPM-022 Blackstart Service. The resource should be capable of self-starting and can be required to operate in the grid forming mode (ISO-mode) by providing the voltage and frequency reference required to pick up critical load or assist in start-up of other generation resources.

5.8 Operational and Maintenance Requirements

Monitoring Events Data

Data related to the inverter to effectively monitor resource performance and perform event analysis must be provided within 30 calendar days of the request from AES Indiana by the GO. All data on an IBR shall be synchronized to a common reference time. An overview of the data points and the corresponding resolution and retention requirements are shown in Table 12.

Table 12. Measurement Data and Retention Requirements

Data Type	Measurement Data Points	Resolution	Retention
Plant Control Settings	The plant settings, set points, and other static information must be captured at a suitable resolution to identify changes. Data points include, but not limited to – • Active power/frequency control mode of operation. • Reactive power/voltage mode of operation • Individual inverter mode of operation • Digital control system gains, time constants, limiters	Static, as changed	1 year
Plant SCADA Data	The SCADA system should include, at a minimum, the following data points: • All breaker statuses • Shunt (dynamic or static) reactive compensation statuses • Shunt (dynamic or static) reactive power output • Substation transformer status • Substation transformer tap position • Time synchronization	1-2 seconds	1 year

	• Medium voltage collector system statuses • Individual inverter statuses • External control signals • External automatic generation control signals • Active and reactive power commands sent to individual inverters • Active and reactive power output of individual inverters • Overall plant active and reactive power output Point of Measurement voltage and medium voltage collector system voltages		
Sequence of Events Recording (SER) Data	SER devices must capture event records and logs, triggered by different reasons including: • Event date/time stamp, synchronized to common reference • Event type such as status changes, synchronization • status, configuration change. • Description of action Sequence number (for potential overwriting)	≤ 1 millisecond	90 days
Digital Fault Recording (DFR) Data	Typically, high resolution point-on-wave data triggered based on configuration settings must be captured at the POM for BES events. The data points include – • Bus voltage phase quantities • Bus frequency • Current phase quantities • Calculated active and reactive power output Dynamic reactive element voltage, frequency, current, and power output	> 960 samples per second, triggered	90 days
Dynamic Disturbance Recorder (DDR) Data	A DDR must capture continuously at the Point of Measurement, plant-level response during normal and disturbance events. The data points that can be used	> 30 samples per second, continuous	1 year

	for event analysis and disturbance-based model verification include – Bus voltage phasor (phase quantities and positive		

Power Quality Data

The data retention period for the power quality meter shall be at least 30 days. Background measurements for harmonics, flicker, and voltage imbalance shall be supplied to AES Indiana upon request. If power quality issues are observed at the POI in excess of the criteria specified in IEEE 519-2014 for harmonic distortion and IEEE 1453-2015 for voltage flicker, or AES Indiana experiences power quality related performance issues, the restrictions will be placed on the operation of the IBR.

If the power quality meter at the POI identifies any power quality issues in excess of the power quality criteria, and either complaints related to power quality are received from other customers on the system in the vicinity of the IBR, or AES Indiana experiences equipment performance issues that is due to power quality issues then operating restrictions will be placed on the IBR plant by AES Indiana until it has been adequately demonstrated that the power quality issues have been resolved.

6) Inverter-based Resources - Modeling Requirements

As a part of the MISO DPP process, generating facility must submit the modeling data according to the Attachment X and MISO MOD-032 data requirements & reporting procedures.

6.1. Harmonics Modeling Data

The IC shall provide harmonics modeling data for the inverters to be installed including, but not limit to harmonic current spectrum information for modeling of the IBR to analyze power quality performance at the POI.

7) Configuration and Arrangements of Facility Connections

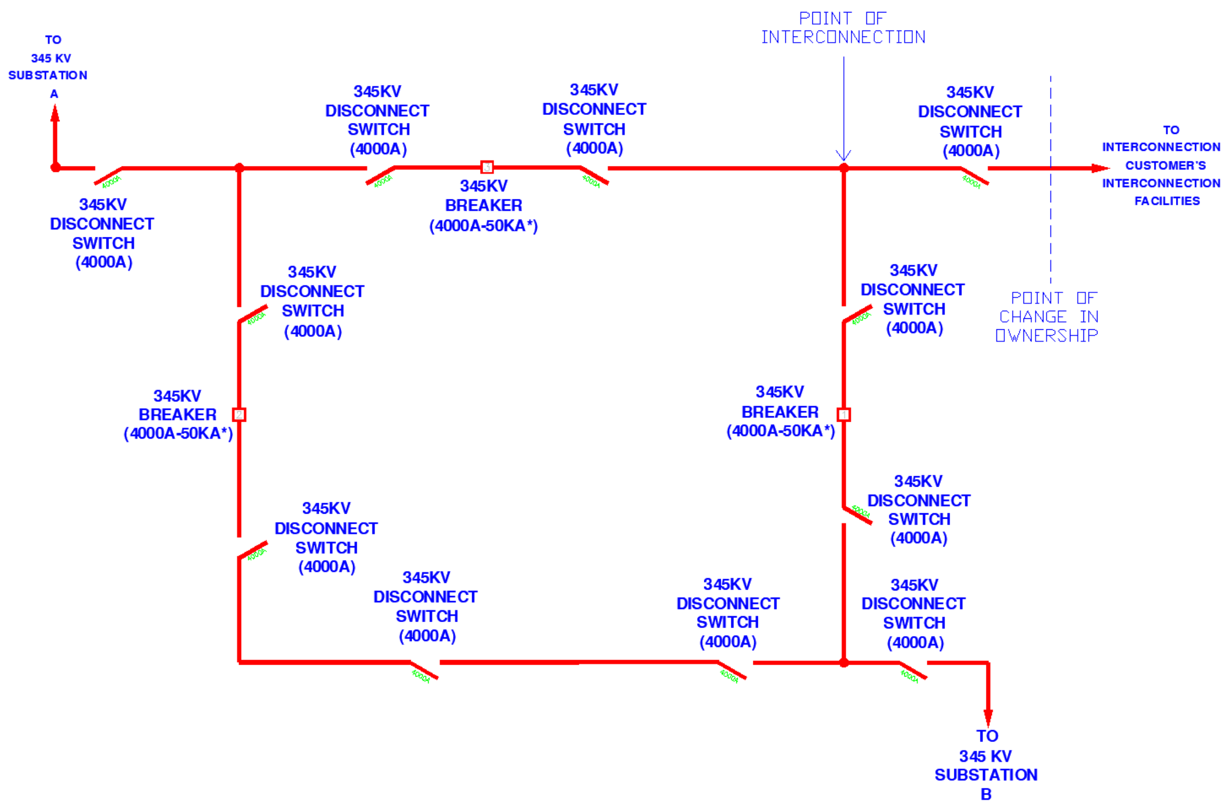
7.1. Interface of Transmission Owner and Generation Entity

In order to improve the operability between the Transmission Owner substation and Generation Entity's facility, the coordinated Facility is expected to be a transmission line terminated with a line or bus breaker(s) at the Generation Entity's Facility.

7.2. Transmission Owner Substation Configuration

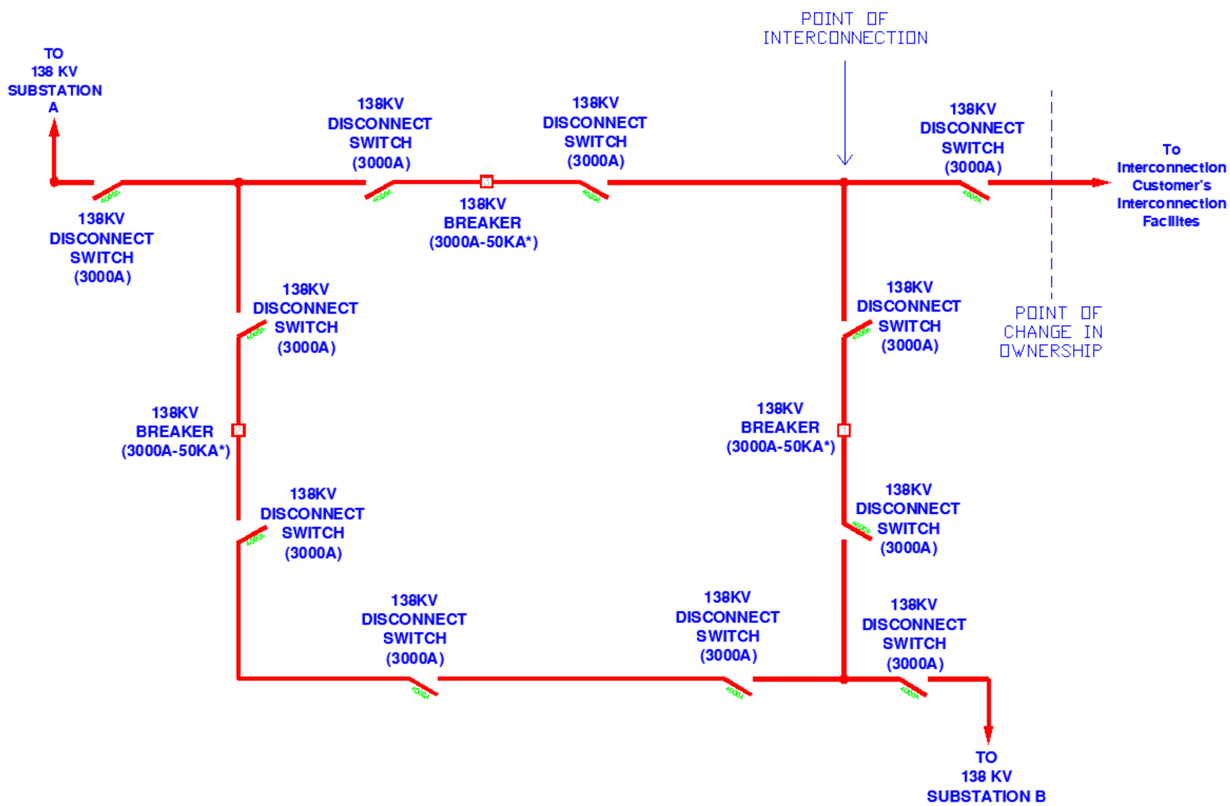
For new load and generation connecting to the AES Indiana transmission system, exhibits A and B below have been provided as standards for an interconnection at the voltage class of 345 kV and 138 kV. The Interconnection Customer Interconnection Facilities ("ICIF") Facility Study will provide any additional details and requirements specific to the interconnection site based on typical configurations used by AES Indiana. For cost estimates, AES Indiana participates in the MISO Planning Subcommittee to develop the Transmission Cost Estimation Guide (MISO Planning Subcommittee's April 12, 2022 meeting has the guide located here). The Interconnection Customer Interconnection Facilities ("ICIF") Facility Study will detail specific cost estimates.

Exhibit A: 345 kV Ring Bus



*Equipment rating with an asterisk are subject to engineering review.

Exhibit B: 138 kV Ring Bus



*Equipment rating with an asterisk are subject to engineering review.

Notes:

1. A circuit breaker configuration shall be required for all new interconnections to maintain reliable operation throughout the AES Indiana system.
2. Communication-assisted trip scheme on the line, either DCB over power line carrier or POTT/differential over fiber/OPGW, is required.
3. Ring bus configurations may be converted to a breaker and a half design at 5 elements and beyond or earlier depending on the size of the generator/load.
4. New generation substations located less than 5 miles from an existing substation may be required to expand an existing substation.
5. Generator/Load Connections into existing substations will require circuit breaker installations. The final breaker configuration will be determined by AES Indiana based on site specific engineering layouts, future site plans, configurations, and customer requirements.

The final breaker configuration will be determined by AES Indiana based on site specific engineering layouts, future site plans, configurations, and customer requirements.

7.3. Substation Land Requirements

Standard and non-standard substation layouts for AES Indiana are shown in the exhibits above. Please refer to Table 1, which shows fence dimensions and land dimensions based upon the substation layouts. Note that the land requirements shown in table 1 does not include any additional land requirements to safely accommodate separation from including but not limited to adjacent electrical facilities (substations and electrical lines), roadways, buildings, railways, and/or geographical features, etc. The land requirements shown in Table 2 also do not include any spacing requirement for stormwater detention basins, access roads, overhead/underground electrical circuits, public or private right-of-way/easements, or government mandated setbacks that may be required as this varies from site to site. New substations must have an AES Indiana owned access road 24 feet wide with direct and unimpeded access to a public roadway. AES Indiana reserves the right to modify these requirements ad hoc for each individual project. AES Indiana also reserves the right to request the Interconnection Customer's proposed site plan to review the aforementioned requirements.

Table 1. Substation Land Requirements

Substation Type	Fence Dimensions	Fence Acreage	Estimated Land Dimensions	Estimated Land Acreage
138 kV 4 Element Ring	250' X 250'	2 acres	450' X 350'	4 acres
138 kV 2 Bay Breaker & a half	450' X 185'	2 acres	650' X 385'	6 acres
138 kV 4 Bay Breaker & a half	450' X 305'	4 acres	650' X 385'	6 acres

345 kV 4 Element Ring	375' X 340'	3 acres	575' X 500'	7 acres
345 kV 2 Bay Breaker & a half	508' X 270'	4 acres	708' X 470'	8 acres
345 kV 4 Bay Breaker & a half	508' X 460'	6 acres	708' X 660'	11 acres