

# *City of Independence*

**INDEPENDENCE POWER & LIGHT**



**TRANSMISSION FACILITY**

**CONNECTION REQUIREMENTS**

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## **I. Introduction**

Independence Power & Light Department (INDN) is a non-profit, municipally owned electric utility serving the needs of more than 50,000 customers in Independence, Missouri. INDN was formed in 1901. A seven Member City Council, including the Mayor, governs INDN.

INDN currently owns and operates transmission facilities within the city limits of Independence and outer counties.

INDN's transmission network involves facilities energized at 69 kV and 161 kV and operated as an interconnected electrical system. The INDN transmission system is operated as a part of the Eastern Interconnected electrical network. The Eastern Interconnection spans a large portion of the Midwest and the entire eastern portions of the United States and is the largest interconnected grid in North America. INDN is a member of the Southwest Power Pool Reliability Organization (SPP). The SPP region encompasses all of Oklahoma, Kansas, and parts of Missouri, Arkansas, Louisiana, Texas, and New Mexico.

## **II. Purpose**

This document was developed to describe the general requirements for interconnection with the INDN transmission system. This document provides an overview of the technical and reliability requirements to address interconnection requests. The interconnections include facility additions and modifications to accommodate generation, transmission and end-user load facilities that are being connected to or are planned for connection to the INDN transmission system. These requirements were established to promote safe operation, system integrity, reliability and compliance with NERC and regional Reliability Standards. These requirements are considered a minimum to be used as a guide toward processing of interconnection requests by INDN. There may be additional requirements which will be determined on a case-by-case basis.

INDN shall maintain and update its facility connection requirements as required. This document shall be posted on the INDN section of the City of Independence Web site for review by the Reliability Coordinators, Transmission Operators, Transmission Planners and Planning Authorities that have responsibilities within the INDN BES area.

The web address for the site is <http://www.ci.independence.mo.us/PL/TransFacConnReqs.aspx>.

Upon written request, INDN will make this information available within 5 business days of receipt of a request.

## **III. General Interconnection Requirements**

All requests for interconnection to the INDN transmission system must be consistent with regional reliability requirements and standard utility practices. A proposed interconnection must not degrade the reliability or operating flexibility of the existing transmission system. INDN assumes responsibility to operate and maintain its interconnected facilities in accordance with regional planning and operating standards. Transmission interconnection studies will be required to evaluate the impact of the requested interconnection and alternative plans to meet established reliability criteria.

All arrangements for transmission studies, engineering design, construction, ownership, operations, maintenance, replacement equipment, metering, facility controls and telecommunications must be set forth in written contracts between INDN and the requesting party. If additional equipment or replacement equipment is required to accommodate the facility interconnection, INDN will retain equivalent transmission capacity and operational control as previously existed. The cost associated with equipment modifications is the responsibility of the requesting party. INDN reserves the right to participate in the costs of proposed projects that may be accommodated through mutually advantageous alternatives which provide substantial benefits to regional reliability or transmission transfer capability.

The requesting party will generally be responsible for obtaining any necessary right-of-way or easements from landowners. All costs associated with environmental activities for the new facility will be the responsibility of the requesting party. Advance funds or deposits will be required by INDN prior to any work being performed.

## **IV. Reliability Requirements**

### **A. Transmission Planning**

The transmission planning process is an important first step in the determination of interconnection feasibility. The transmission planning studies will identify impacts, deficiencies, operational problems or interconnection facility concerns and evaluate potential solutions. A proposed interconnection must not degrade the reliability or operating flexibility of the existing power system. The proposed interconnection must comply with all North American Electric Reliability Council (NERC) Reliability Standards. The proposed interconnection must also comply with all SPP criteria.

INDN will conduct or review studies required to evaluate the system impact of a proposed interconnection on the reliability and capability of the transmission system. Any costs to conduct or review these studies are the responsibility of the requesting party. The studies will include, but are not limited to, power flow, dynamic stability, short circuit studies, and Electro-magnetic Transients Program (EMTP) studies if deemed necessary. Evaluation of alternatives to the proposed interconnection, such as lower voltage construction, alternative interconnection points, reactive support facilities, or upgraded facilities, may be requested. Powerflow analysis will require 10-year load and resource growth projections and the planned facilities needed to satisfy all long-term transmission service requirements. If the studies indicate that additions or upgrades to the existing transmission system are necessary, INDN will conduct or review facilities studies, at the expense of the requesting entity, to determine the cost of additions or upgrades and the time frame for implementing system additions or upgrades. (R2.1.1)

The transmission planning process for the proposed new interconnection facility must also accommodate coordinated joint studies with other affected interconnected transmission system owners. Once a new facility is considered feasible for interconnection, the requestor shall notify the SPP Transmission Working Group (TWG). (R2.1.2)

The SPP TWG provides an appropriate technical forum of regional transmission providers who can review proposed facility plans and readily identify concerns, issues, and impacts. The regional transmission providers and requestors can work together to develop the most efficient transmission plan that will accommodate the proposed project and meet NERC reliability

criteria. Any transmission planning studies performed by either INDN or others will need to be review and coordinated with the appropriate impacted parties.

The requestor shall provide to the INDN Engineering Department the following detailed information for use in the transmission planning studies:

- Facility one-line diagram depicting detailed proposed interconnection points, voltage levels, equipment data, breaker/switch configurations and protective relay zones.
- Transformer impedance data, winding configurations, voltage levels, thermal ratings and available tap ranges
- Generator nameplate data and machine constants, generator voltage rating, step-up and auxiliary transformer data, impedance data and ratings
- Generator rotor, governor, exciter, power system stabilizer and any other generator auxiliary data
- Generator MW/MVAR levels, reactive capability curves, operational power factors and proposed load factors.
- Transmission line configuration, impedance and thermal ratings.

Attachment 1 of this document provides a detailed listing of all of the data requirements associated with a Generator interconnection request. The data request form shall be mailed to the following address for consideration:

Independence Power & Light  
Engineering Department  
21500 E. Truman Road  
Independence, MO 64056  
Attn. Engineering Supervisor

The requestor for a proposed facility shall specify the requested voltage level and MW/MVAR capacity and/or demand at the point of connection. (R2.1.3) For Generator Interconnection studies, the full nameplate capacity will be studied for injection at the requested location. All powerflow and stability studies will evaluate the impacts of the maximum capability of the requesting interconnection facility. Also, the full approved capacity of other existing generators in the impacted region will be studied and maintained. Any special operational considerations or limitations associated with the interconnection facility shall be specified by the requestor. This information will be utilized to develop computer models of the requested facility for input into the transmission planning studies. Any specialized modeling development requirements are the responsibility of the requestor. (R2.1.14)

The System Impact and Facilities Studies will typically be performed in multiple sequential stages. Phase 1 of the System Impact Study (Feasibility Study) will address a first level powerflow screening analysis of the proposed interconnection facility. Phase 2 of the System Impact Study will address a much more detailed powerflow analysis, dynamic stability analysis, short circuit analysis and any other required study work. Phase 3 (Facilities Study) will detail the final interconnection facilities design, direct assignment facilities, costs and construction schedule estimates. The Facility Study will merge the results of the System Impact studies into a final Planning/Design study which will be formatted for submittal to the regional approval authority. The Interconnection Agreement not be executed until all of these steps have been successfully completed. An Interconnection Agreement will be under the SPP Large Generator

Interconnection Agreement (LGIA) process. The SPP LGIA process and standard interconnection agreement can be found at [www.spp.org](http://www.spp.org). The Requestor will have the option to rescind the interconnection request following the completion of any of the study phases. (R2.1.2)

## B. Generation Facilities

When INDN considers integrating a generation facility interconnection into the INDN transmission system, additional special studies are required. There are stability limitations in the regional area that will require transient stability analysis for any proposed generation additions that could affect this area. Operational studies may also be required to evaluate impacts on present generation operations in the INDN Control Area. Operational problems on INDN's system, either during normal or emergency conditions, may affect INDN's control performance. Under certain conditions, the requesting generator interconnection may have to relinquish unit load and voltage control to INDN's Control Center. The power factor for both the generating units and loads shall be measured at the interconnection point. Special region-specific operational studies will evaluate the transmission system and reliability considerations. Should replacement of existing equipment be required as a result of the interconnection, INDN will retain equivalent transmission capacity and operational control as previously existed.

Automatic synchronization shall be supervised by a synchronizing check relay IEEE Device 25. This assures that no synchronous generator is connected to the power system out of synchronization. Generators must meet all applicable American National Standards Institute (ANSI) and IEEE standards. The prime mover and the generator should also be able to operate within the full range of voltage and frequency excursions that may exist on the INDN system without damage. (R2.1.12)

System voltage regulation is necessary for efficient and reliable electrical power transmission and for adequate service to loads. All interconnected synchronous generators are required to participate in voltage regulation by meeting voltage requirements. INDN may require additional reactive capability or voltage regulations on some parts of its system to integrate the generation. It is the generator owner's responsibility to mitigate any unacceptable reactive or voltage regulation problems created due to the integration of the generator. If INDN requires additional reactive or voltage regulation to solve other problems in an area, INDN will negotiate with the generator owner for any additional capability beyond the minimum requirements stated above.

Synchronous generators are required to produce or absorb reactive power between .95 leading and .95 lagging power factors for steady state conditions to meet voltage requirements. Interconnected generators are also required to produce or absorb reactive power up to the thermal capability of the generator during transmission system disturbances. The voltage regulator must be capable of maintaining the voltage at the generator terminal, without hunting, within 0.5 percent of any set point. The operating range of the regulator shall be at least plus or minus 5 percent of the rated voltage of the generator. (R2.1.9)

Voltage regulators are required for all synchronous generators larger than 100 kW. All synchronous generators connected to INDN's transmission system shall operate the units using the voltage regulators for voltage control. INDN will specify the required voltage schedule. Generators connected to the distribution system in most cases will also require a power factor controller. Generators connected to the transmission system that have both voltage and power

factor modes available on the controller system, shall be set on voltage control mode. In rare exceptions, INDN may direct a specific generator(s) to operate on power factor control mode.

The excitation system of synchronous generators is required to be of a fast-response or High Initial Response type (the voltage response time is 0.5 seconds or less). A Power System Stabilizer (PSS) uses auxiliary stabilizing signals to control the excitation system to improve power system dynamic performance. A PSS is required with the excitation system for all interconnected synchronous generators 75 MVA and larger. However, it may be necessary to use a PSS on a smaller generator, depending on where the generator is interconnected to INDN's system and how this machine participates in critical damping modes within the SPP region. A Small Signal Stability analysis may be required to determine the applicability of a PSS to any proposed interconnected synchronous generator.

A speed governor system is required on all synchronous generators. The governor regulates the output of the generator as a function of the system frequency. That function (called the governor's "droop" characteristic) must be coordinated with the governors of other generating units located within the INDN control area to assure proper system response to frequency variations. The speed governor system shall have an adjustable droop characteristic setting typically set to 5 percent.

INDN's system protection requirements are designed and intended to protect the INDN transmission system. Additional protective relays will be required to protect an interconnected generator. It is the generation owner's responsibility to install the proper protective relaying needed to protect the generation in coordination with INDN system protection. The owner of the generator is solely responsible for protecting interconnected equipment in such a manner that faults, imbalances, or other disturbances on the INDN system do not cause damage to the interconnected generation facilities.

Wind turbines or other induction type generators without VAR control capability will absorb VAR's from the transmission system and therefore require reactive power support from INDN's system. For proposed wind induction type generator interconnections, INDN will require power factor correction at a minimum. Power factor correction capacitors must be installed either by the owner of the generation or by INDN at the owner's expense. Switched capacitor banks supplied by the generation owner shall be coordinated with INDN voltage control requirements and switched at the request of INDN. Owners of interconnected induction generators shall provide, at a minimum, sufficient reactive power capability to deliver the generator output at unity power factor at the point of interconnection. Dynamic reactive compensation through turbine based or substation based systems are also acceptable methods to provide voltage control at the point of interconnection. Dynamic reactive power compensation may also be required in addition to static reactive compensation required for the wind turbine generator interconnection. Wind generator interconnections are also required to meet the current technical standards for Low Voltage Ride Through capability and Power Factor Design Criteria (Reactive Power) as specified in FERC Order 661 and SPP Appendix G to the LGIA.

Power system disturbances initiated by faults and forced equipment outages expose connected generators to voltage and frequency oscillations. It is important that generators remain in service to help ensure that any dynamic or transient oscillations are stable and well damped. Therefore, each generator must be capable of continuous operation at 0.95 to 1.05 per unit voltage and 58.0 to 61.8 Hertz (per NERC PRC-024 frequency curves). Even larger voltage and frequency

deviations may be experienced for short periods of time and interconnected generators must have capability for off-nominal operation. Over/under voltage and over/under frequency relays are normally installed to protect the generators from extended off-nominal voltage/frequency operations. To ensure that the interconnected generators do not trip prematurely, the time delays for these relays must be coordinated with INDN's system protection schemes and NERC requirements.

Generation integration may substantially increase fault current levels at nearby substations. Increased fault currents may exceed existing equipment ratings, interrupting ratings and/or through fault ratings. Any existing equipment replacements required due to new fault current requirements associated with new generation is the responsibility of the requesting party. Modifications to the ground grids of existing substations may also be necessary to keep grid voltage rises within safe levels. The ground grid should be designed to ANSI/IEEE Standard 80-2000, IEEE Guide for Safety in AC Substation Grounding. (R2.1.7)

Power system equipment is designed to withstand voltage stresses associated with expected operation. Interconnecting new generation resources can change equipment duty, and may require that equipment be replaced or switchgear, communications, shielding, grounding and/or surge protection added to restrict voltage stress to acceptable levels. System impact and/or Facilities studies will need to include the evaluation of the impact of the interconnected generator on equipment insulation coordination. INDN will review breaker duty and surge protection to identify any additions required to maintain an acceptable level of INDN system availability, reliability, equipment insulation margins and safety. (R2.1.4)

All generation equipment ratings shall be submitted to INDN and the regional RTO and RE in accordance with their data submittal requirements. Attached INDN Generator Interconnection Data Request Form provides a detailed listing of all of the data requirements associated with a Generator interconnection request. (R2.1.11)

### C. Transmission Facilities

Any proposed transmission facility interconnecting into INDN's high voltage transmission system shall be coordinated and reviewed through the Transmission Planning process described in this section. The transmission facility addition shall maintain or improve the level of system reliability that existed prior to the interconnection. Power flows as a result of the transmission interconnection shall not overload or adversely affect the INDN Transmission System. Voltage levels shall be coordinated with INDN's existing transmission system and substation operational voltage levels. Currently, INDN's existing transmission system voltage levels are 161 kV and 69 kV. The transmission line design and construction shall be in accordance with INDN's transmission line design and construction standards.

A transmission line switching study may be required to evaluate transient over-voltages caused by switching operations involving the proposed new transmission line. This study will be required for proposed 161 kV transmission facilities to address insulation coordination requirements due to potential switching surges. Also, proposed lower voltage transmission lines which are electrically close to existing 161 kV facilities may require a switching surge study in order to determine the Basic Insulation Level (BIL) requirements and/or breaker closing resistor requirements for the proposed new facilities. The requestor is responsible for all required approvals, environmental requirements, protection coordination, interconnection metering,

maintenance, and control coordination. The thermal ratings for the proposed transmission facilities shall also be provided to INDN and subsequently submitted to the regional reliability council. The thermal ratings shall be coordinated with industry standards and INDN's thermal rating assumptions contained in INDN's Rating Methodologies for System Facilities. (R2.1.8)

#### D. End-User Facilities

Typical end-user facilities considered for interconnection would encompass load (dynamic and static) and reactive devices (capacitors and reactors). The impacts on the transmission system must be studied to address any special operational limitations or facility requirements.

All end-use load connected directly to the INDN system are to maintain a power factor between 0.95 lag and 0.95 lead as measured at the point where the load interconnects with INDN-owned facilities. If this power factor requirement is not met, INDN may install power factor correction equipment at the load owner's expense.

INDN maintains transmission voltages at levels required for the reliable delivery of electricity. Regulation to keep voltage variations within limits acceptable to end-use customers is typically provided on distribution. Voltage regulation at transmission voltage levels is different from distribution voltage levels. INDN typically maintains transmission voltage levels between 0.95 – 1.05 Per Unit during normal conditions and between 0.92 – 1.08 Per Unit during emergency conditions. During system restoration, system voltage should be maintained between 0.90 – 1.10 Per Unit. Load owners are strongly urged to install their own voltage regulation equipment and coordinate any voltage set points or time delays with the normal transmission voltage bandwidths.

All end-user facilities connected to the INDN system must meet the power quality standards set forth in Section V – Technical Requirements. The requestor is responsible for any mitigation efforts necessary to meet those standards.

INDN's system protection requirements are designed and intended to protect the INDN system. Additional protective relays are required to protect an interconnected end-user facility. It is the requestor's responsibility to install the proper protective relaying needed to protect the end-user facilities. INDN does not assume responsibility for protection of the interconnected end-user facilities. The requestor is solely responsible for protecting interconnected equipment so that faults, imbalances or other disturbances on the INDN system do not cause damage to the end-user facilities.

To meet the reliability requirements of SPP, under frequency and/or under voltage load shedding schemes may be required. Any load or reactive device connected to the INDN system will be expected to participate in under frequency or under voltage load shedding if INDN determines such action is necessary to maintain system reliability. If INDN requires load-shedding participation for a particular end-user facility, the requestor shall be responsible for all related costs. (R2.1.9)

## V. Technical Requirements

### A. Power Quality

Unbalanced phase voltages and currents can affect protective relay coordination and cause high neutral currents and thermal overloading of transformers. To protect INDN and customer equipment, the interconnected facility contribution at the point of interconnection shall not cause a voltage unbalance greater than 1 percent or a current unbalance greater than 5 percent. Phase unbalance is the percent deviation of one phase from the average of all three phases.

Harmonics can cause telecommunication interference, thermal heating in transformers, disruptions to solid-state equipment and resonant over voltages. To protect equipment from damage, harmonics must be managed and mitigated. The interconnected generator/load shall not cause voltage and current harmonics on the INDN system that exceed the limits specified in Institute of Electrical and Electronics Engineers (IEEE) Standard 519. Harmonic distortion is defined as the ratio of the root mean square (rms) value of the harmonic to the rms value of the fundamental voltage or current. Single frequency and total harmonic distortion measurements may be conducted at the point of interconnection, generation/load site or other locations on INDN's system to determine whether the project is the source of excessive harmonics.

Many methods may be used to restrict harmonics. The preferred method is to install a transformer with at least one delta connection between the generator/load and the INDN system. This method significantly limits the amount of voltage and current harmonics entering the INDN system.

Voltage fluctuations may be noticeable as visual lighting variations (flicker) and can damage or disrupt the operation of electronic equipment. IEEE Standard 519 provides definitions and limits on acceptable levels of voltage fluctuation. All generators/loads connecting to the INDN system shall comply with the limits set by this Standard.

Electro-magnetic Transients Program (EMTP) studies may be required to analyze the power quality impacts of a proposed facility. [\(R2.1.10\)](#)

## B. Engineering

INDN will provide for engineering design, specification and construction of the proposed interconnection to INDN owned, operated and maintained facilities. Non-INDN engineering design may be allowed provided it receives initial approval and subsequent review by INDN. All engineering costs and engineering review costs are the responsibility of the requesting party. For transmission line taps owned by others, prints of applicable facility drawings will be furnished by INDN upon request. All work performed by INDN will include revisions to existing INDN drawings at the expense of the requesting entity.

If the interconnected facilities are to be owned by INDN, then any new land rights necessary for the interconnection may be acquired by INDN from the affected landowners, at the expense of the requesting entity. In certain circumstances, the requesting entity may acquire these additional land rights, provided they coordinate with INDN as to what rights are necessary.

Drawings for facility additions must conform to INDN's drafting standards and be approved by INDN. The requesting entity will supply drawings on a magnetic medium or electronic file, compatible with INDN's computer-aided design system, AutoCAD. The requesting entity will reimburse INDN for drawing costs. INDN's drafting standards will be furnished to the entity requesting the interconnection if the design is not produced by INDN. "As-built" drawings must

be provided prior to final approval by INDN. Three complete sets of accurate substation drawings shall be provided to INDN for non-INDN-owned substations. These drawings shall include, but not be limited to, station plot plans, equipment layouts, single-line diagrams, control circuit schematics and wiring diagrams. Updated copies of these drawings shall be furnished to INDN within 60 days of any modification to non-INDN owned equipment or substations on INDN's system.

Breakers and switches installed in INDN substations shall adhere to INDN numbering schemes. Breaker and switch operation numbers will be assigned by INDN. All switches to be operated by INDN will be locked with locks furnished by INDN. All switches to be operated by INDN shall be designed in accordance with INDN's design criteria.

### C. Substations

Generally, power circuit breakers must be installed at all interconnections with INDN's system. Typical specifications covering circuit breaker requirements are available from INDN upon request. A review of the surrounding area power system characteristics, including system stability studies, will be made for a final determination when the need for out-of-step switching capability is questionable.

Installation of equipment in substations must conform to INDN's requirements and must be approved by INDN. All oil-filled equipment, including bushings, shall not contain polychlorinated biphenyls (PCB's). In addition, the manufacturer shall permanently label oil-filled equipment as non-PCB. Certification shall be provided to INDN at or before the time of installation. Oil-filled equipment may require an oil spill containment system to comply with U.S. Environmental Protection Agency or state regulations. Any increased equipment costs due to these requirements will be borne by the entity requesting the equipment.

The owner of installed equipment will be responsible for its proper operation and maintenance. Equipment must be operated and maintained in accordance with manufacturer's recommendations, prudent utility practices and applicable environmental and safety standards. INDN may require additional equipment to assure a reliable interconnection and to safeguard the proper operating conditions of its power system. INDN prefers, in many cases, to provide required O&M services provided funds have been advanced to cover these costs. Costs may include training on maintenance procedures for unfamiliar equipment.

The interconnection substation must have a ground grid that solidly grounds all metallic structures and other non-energized metallic equipment. This grid shall limit the ground potential gradients to such voltage and current levels that will not endanger the safety of people or damage equipment located in, or immediately adjacent to, the station under normal and fault conditions.

INDN personnel will conduct an inspection of the new substation interconnection facilities prior to the energization of these facilities. The inspection requirements will be consistent with the inspection requirements of existing substation facilities. Only after a satisfactory inspection is completed will the new substation interconnection facilities be authorized for energization and synchronization. (R2.1.15)

#### D. Transmission Line Taps

Proposed taps to INDN's transmission system are subject to approval on a case-by-case basis. Additional taps can be placed on existing lines as long as Single Contingency outage criteria is not violated and as long as all loads can be fed radially from either terminal, system intact. Single Contingency outage criteria means the interconnected power system shall be operated at all times so that general system instability, uncontrolled separation, cascading outages and/or voltage collapse will not occur as a result of the loss of a single system element.

Taps to lines of 161 kV and 69 kV must meet the following minimum criteria:

1. A line section protected by circuit breakers may have a mileage maximum for tap lines that are not protected by circuit breakers, determined on a case-by-case basis.
2. A proposed interconnection to a transmission line, whenever possible, will be connected to the line at an existing tap.
3. No more than one connection, without line sectionalizing capability, will be permitted between 69 kV and 161 kV transmission line breakers.
4. New lines of 69 kV and above will have overhead ground wire (OHGW) shielding over the entire length of the tap-line. A breaker may be required for the tap line due to relaying or specific reliability criteria.
5. SCADA-controlled interrupter switches (or equivalent) capable of interrupting load and charging current shall be installed in the line sectionalizing positions for all tap substations. These interrupters will be used to de-energize line sections without interruption of the tapped loads, if necessary. Line sectionalizing switches installed in transmission lines shall be furnished with grounding blades, and must have a visible air gap. Normally, INDN assumes ownership of the sectionalizing switches. If INDN does not assume ownership, however, INDN will still maintain operational control.
6. An ungrounded high voltage winding is the preferred transformer connection on the tapped line, however, no more than one grounded transformer will be permitted to tap a 161 kV or 69 kV line.

Entities requesting non-INDN designed transmission line taps shall submit designs, calculations and drawings demonstrating that the structures and foundations have been designed in accordance with INDN's design criteria. Taps to transmission lines with insulated OHGW's shall not degrade the capability of the existing OHGW.

#### E. System Protection

Protective relaying requirements for each interconnection and relay scheme coordination will be determined by INDN after review of existing interconnection protection schemes and short circuit study work. INDN requires receipt of a preliminary single-line drawing of the proposed interconnection and a single-line drawing and maps of the requesting entity's system in the area. The requestor will be required to provide all positive, negative and zero sequence impedance data necessary to adequately model the proposed interconnection facility in a short circuit analysis. The requestor should also provide re-closer and fuse ratings, and relaying data

necessary to address protective relaying coordination. Specialized relaying may be required to provide automatic load, generation shedding or interconnected system separation.

Protective relays and control systems must be inspected and tested by functional trip checking prior to putting any interconnected facility in service. INDN personnel will need to be involved with procedures prior to and during any future maintenance and testing of protective relaying devices. The requesting entity is responsible for the costs associated with the ongoing testing and maintenance of the protective relaying and control equipment. (R2.1.5)

## F. System Operations

Following the execution of an Interconnection and Operating agreement and the successful completion of all construction, inspection and facility checkout procedures, the interconnected facility will be released for energization. The initial synchronization will be supervised and coordinated with INDN personnel. INDN personnel will control future synchronization and will either be automatic or manual per the direction of INDN.

Requests from the interconnected facility for outages associated with maintenance operations shall be posted on the SPP Outage Scheduler “CROW”. The INDN system operator shall also be notified of the maintenance operation request. SPP will issue final approval of the requested maintenance outage through the CROW system. (R2.1.13)

All communications and operating procedures during normal and emergency operating conditions that affect INDN assets and facilities shall be coordinated through INDN System Operations personnel. (R2.1.16) Known or suspected impacts to any neighboring utility facilities will be communicated to the affected utility and the SPP Reliability Coordinator by INDN System Operations personnel. Any requests from the interconnected facility for any special operating considerations related to an emergency will be submitted to INDN for review and approval prior to execution. Emergency operating conditions will be handled in accordance with NERC Reliability Standards and good utility practice. The interconnection facility must recognize the dynamic nature of an interconnected transmission system and the reliability and safety priorities of INDN. INDN personnel may not be available immediately during all emergency conditions and INDN will communicate the system status and any special operating restrictions to the interconnected facility as soon as feasible.

Circuit breakers, disconnects, interrupters and motor-operated disconnect switches that are an integral part of INDN’s transmission system shall be operated and dispatched by INDN. The INDN Operations and Dispatch Center will direct switching and issue all clearances, hot-line orders and general switching on the transmission portion of the interconnection or substation. This will involve use of approved INDN switching and clearance procedures, including use of INDN locks and tags.

The requesting entity making the interconnection will write Standard Operating Procedures in coordination with INDN for the interconnected facility. Three sets of instructions and manufacturer’s drawings shall be furnished to INDN for each piece of equipment that INDN operates.

If construction activities are performed by other entities, INDN may require at least one INDN representative be present to coordinate and provide for switching, clearances, special work

permits and inspections during construction work on INDN's right-of-way. The INDN representative will also conduct operability checkout on equipment, including metering, relay settings and tests and protective device operation (circuit breakers, motor-operated disconnects, etc.). Final electrical connections to INDN's system will be made by INDN or under INDN's supervision.

Maintenance will normally be performed by and at the expense of the entity that owns the equipment or facility when the proposed interconnection involves a tap or substation sectionalizing one of INDN's transmission lines. INDN shall be notified and have the right to witness settings and testing of relays, meters and controls that could affect the integrity and security of INDN's transmission system. INDN shall also have the right to enter interconnected facilities for emergency operation and maintenance of equipment or structures INDN deem necessary to maintain a reliable power system.

### G. System Control

Supervisory control by INDN of circuit breakers, interrupters or motor-operated disconnects will be required on all interconnections that directly affect the security of INDN's transmission system. The Remote Terminal Units (RTU's) for supervisory control shall be compatible with the Energy Management System (EMS)/SCADA system used within the INDN system. The cost of providing and installing the RTU at a new location or proportionate cost of modifying an RTU at an existing facility will be at the expense of the requesting entity. INDN will perform the necessary expansion, including hardware and software changes, to the EMS/SCADA master station equipment at the requesting entity's expense for that portion attributed to the new interconnection. Transducers, interface hardware and appropriate communication channels compatible with existing EMS/SCADA system requirements shall be furnished by the requesting entity. The requesting entity shall provide necessary auxiliary and control relays, hot-line indication, supervisory local / remote switches, and all other equipment necessary to interface with INDN's supervisory control equipment.

Interconnections that establish additional or new control area boundaries require the requesting entity to furnish all necessary control area metering equipment. (R2.1.6) These requirements may include, but are not limited to:

1. Analog and/or digital telemetering at the point of interconnection
2. Analog to digital conversion equipment as required, at both the point of interconnection and INDN's Operations and Dispatch Center
3. Totalizing equipment at the point of interconnection or some intermediate point on the communications link. A multiport RTU may be substituted in some cases. If a multiport RTU is used, a points list identifying alarms, events, and telemetered quantities will be jointly developed between the requesting entity and INDN. The service agreement implementing the multiport RTU will include operating/dispatch jurisdiction, primary and backup service control protocol, SCADA tagging and control design, switching procedures and definitions of terms used by the system operators.

4. Automatic Generation Control (AGC) hardware and software modifications INDN's Operations and Dispatch Center and other organization's power system control centers (if required).

INDN's telemetering, scheduling and interconnection metering are performed on a megawatt or whole megawatt hour basis, therefore, interconnection metering and totalizing equipment shall meet this criterion. Dynamic schedules to the appropriate automatic generation controller may be a consideration for radial tap lines to the INDN system whenever the load is supplied from a source outside the INDN control area. Similarly, internal generating resources supplying loads outside INDN's load control area may require special equipment at INDN's and other power system control centers.

The tap should not adversely affect the protection scheme or outage frequency on the present tap(s). Additional taps can be placed on existing lines where delta-wye transformers are used. Autotransformers or three-winding transformers are sources of zero sequence current and can make both directional ground over current and ground distance relaying complicated. It is best to sectionalize whenever auto or three-winding transformers are utilized. The proximity of the tap to either line terminal may affect the protective relaying scheme on the transmission line. The tap transformer impedance and relative location on the tap on the transmission line may necessitate pilot relaying be installed on the transmission line in order to prevent tripping of the transmission line for faults in the low voltage tap system.

INDN reserves the right to maintain backup control on all facilities that interconnect with INDN's transmission system and that may be vital to system stability and telemetry values.

#### H. Telecommunications (R2.1.6)

The requesting entity shall provide telecommunications facilities sufficient to meet INDN's telephone, radio, system protection, remote meter reading and EMS/SCADA requirements. The communication channel and channel hardware will be provided by the requesting entity. INDN will specify the type, speed and characteristics of the communication channel equipment so that compatibility with existing communications, supervisory control, relaying and telemetering equipment is maintained. The specific type of communication equipment to be furnished by the requesting entity will be reviewed and approved by INDN. The requesting entity will reimburse INDN for the costs of any additional facilities provided by INDN.

Fiber optic additions to new or existing INDN transmission lines will be considered on a case-by-case basis. Technical analysis of clearances, structural loads and electrical field effects may limit applications. Outage restrictions and maintenance responsibilities may also impact potential paths. INDN reserves the right to charge a fee for ROW, pole attachments and/or acquire individual optical fibers on the circuit, per agreement between the interconnecting entity and INDN.

#### I. Metering (R2.1.6)

Current transformers used for revenue metering circuits must meet the accuracy standards, as specified under ANSI C57.13, for an accuracy class of 0.3 percent at all burdens. The thermal current rating of current transformers shall exceed the maximum current capacity of the circuit involved by a factor of 1.5 to 2.0.

Voltage transformers used for revenue metering circuits must meet the accuracy standards, as specified under ANSI C57.13, of 0.3 percent accuracy with the following burdens:

1. “W” through “Y” burden for 25-kV and below
2. “W” through “ZZ” burden for above 25-kV.

Revenue metering with mass memory storage shall be used if the estimated maximum demand is 500 KVA or greater, or if maximum simultaneous demand billing is contractually required. Such revenue metering shall be compatible with the metering policy established by INDN.

# INDN Generator Interconnection Data Request Form

## A. Requestor

Organization: \_\_\_\_\_

Contact: \_\_\_\_\_

Address: \_\_\_\_\_

Phone: \_\_\_\_\_

E-Mail: \_\_\_\_\_

## B. Interconnection Site Information

Proposed New Generation Facility

Increased Capacity at an Existing Generation Site

Physical Location Site Description (Address):

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Electrical Location Site Description (Point of Interconnection):

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Attached One-Line Diagram?       Yes       No

## C. Generator General Information

Fuel Type (Coal, Diesel, Wind, etc.): \_\_\_\_\_

Maximum Total Generation Capacity (MW): \_\_\_\_\_

Number of Generating Units: \_\_\_\_\_

Generator Type (Synchronous/Induction): \_\_\_\_\_

Expected Commercial In-Service Date: \_\_\_\_\_

Expected Initial Synchronization Date: \_\_\_\_\_

## D. Generator Nameplate Ratings

Machine MVA: \_\_\_\_\_      Power Factor: \_\_\_\_\_

Terminal Voltage (kV): \_\_\_\_\_      Frequency (Hz): \_\_\_\_\_

Machine Speed (RPM): \_\_\_\_\_      Short Circuit Ratio: \_\_\_\_\_

**E. Generator Modeling Data**

**Reactance Data (Per-Unit Machine MVA Base)**

	<u>Direct Axis</u>	<u>Quadrature Axis</u>
Synchronous – saturated	$X_{dv}$ _____	$X_{qv}$ _____
Synchronous – unsaturated	$X_{di}$ _____	$X_{qi}$ _____
Transient – saturated	$X'_{dv}$ _____	$X'_{qv}$ _____
Transient – unsaturated	$X'_{di}$ _____	$X'_{qi}$ _____
Subtransient – saturated	$X''_{dv}$ _____	$X''_{qv}$ _____
Subtransient – unsaturated	$X''_{di}$ _____	$X''_{qi}$ _____
Negative Sequence – saturated	$X_{2v}$ _____	
Negative Sequence – unsaturated	$X_{2i}$ _____	
Zero Sequence – saturated	$X_{0v}$ _____	
Zero Sequence – unsaturated	$X_{0i}$ _____	
Leakage Reactance	$X_{lm}$	

**Time Constant Data (Sec)**

Open Circuit Subtransient	$T''_{do}$ _____	$T''_{qo}$ _____
3-Ph Short Circuit Armature	$T_a$ _____	

**Armature Winding Resistance**

Positive  $R_1$  \_\_\_\_\_ Negative  $R_2$  \_\_\_\_\_ Zero  $R_0$  \_\_\_\_\_

**Total Inertia (Generator + Turbine)**

Inertia Constant  $H$  \_\_\_\_\_ MW-sec/MVA (On Machine MVA Base)

**Generator Characteristic Curves**

- Generator Reactive Capability Curves Attached?     Yes     No
- Generator Vee Curves Attached?     Yes     No
- Generator Saturation Curves Attached?     Yes     No

**Excitation System Data**

Identify appropriate IEEE model block diagram or PTI Power System Simulator Model of the excitation control system and power system stabilizer. The corresponding constant data is required for computer representation in power system stability simulations.

**Governor System Data**

Identify appropriate IEEE model block diagram or PTI Power System Simulator Model of the governor system. The corresponding governor system constant data is required for computer representation in power system stability simulations.

Note: If actual generator data is not available, INDN will work with the customer to develop representative modeling data for use in the transmission studies. Once the facility is constructed and tested, the models must be updated with actual data and the complete data and test results must be provided to INDN.

**Wind Generator Data**

Number of Wind Turbines to be connected at the Point of Interconnection: \_\_\_\_\_

Type of Induction Generating Unit: \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Nameplate Rated MVA: \_\_\_\_\_

Unit Maximum Output (MW): \_\_\_\_\_

Power Factor Control Characteristics: \_\_\_\_\_

Voltage Control Characteristics: \_\_\_\_\_

Note: Detailed dynamic modeling data for the specified wind turbines is required for computer representation in power system stability simulations. This includes data required to develop a detailed generator/converter model, electrical control model, turbine and turbine control model. The data is required in compatible IEEE or PTI PSS/E format.

**Generator Step-up (GSU) Transformer Data**

Generator Step-up Transformer MVA Base: \_\_\_\_\_

Generator Step-up Transformer Rating(s) (MVA): \_\_\_\_\_

GSU Transformer Voltage Ratings: H \_\_\_\_\_ L \_\_\_\_\_ T \_\_\_\_\_

GSU Winding Connection (Wye/Delta): H \_\_\_\_\_ L \_\_\_\_\_ T \_\_\_\_\_

Available Fixed Taps: \_\_\_\_\_

Present Fixed Tap Setting: \_\_\_\_\_

Generator Step-up Transformer Impedance: (R+jX or % R & % X on transformer MVA Base)

**Positive Sequence**

	<u>R</u>	<u>X</u>	<u>MVA Base</u>
H-L	_____	_____	_____
H-T	_____	_____	_____
L-T	_____	_____	_____

**Zero Sequence T-Model**

Note: Following construction and testing, transformer test reports must be provided to INDN.