



Big Rivers
Electric Corporation

Procedure Documentation

GENERATOR CONNECTION REQUIREMENTS

PL-FAC-3

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1.0 Introduction

Big Rivers Electric Corporation (Big Rivers) has prepared this document which outlines the minimum requirements for all generation facilities connecting to the Transmission System. These requirements, as well as the planning procedures and criteria described in Big Rivers document PL-FAC-1, are consistent in content and application to those requirements used by Big Rivers when connecting its own new or modified generation, transmission, or end-user facilities. In addition to the specifics in this document, all facilities shall comply with applicable codes, standards (including NERC, SERC, and SERC supplements), federal and state regulations, environmental regulations, siting requirements, contracts, operating agreements, and NERC/SERC reporting requirements. Additional details can be found in Big Rivers document PL-FAC-4: *Procedures and Requirements for Adding Generation to Big Rivers' Transmission System* and PL-FAC-5: *Interconnection and Operating Agreement Template*, PL-FAC-1: *Transmission Planning Criteria and Guidelines*. In addition, requirements specified in PL-FAC-2: *Transmission End-User Connection Requirements* may apply. This document and all referenced Big Rivers documents are available upon request (within 5 business days) and are available on the Big Rivers OASIS.

Background

In the present electric utility environment characterized by deregulation, open access to the transmission network, wholesale and retail competition, etc., there is wide recognition that electric system reliability, safety and quality of service are to be maintained. Maintaining reliability, safety and quality of service in this changing environment places additional challenges in the planning and operation of electric systems.

Each request to connect to the Big Rivers Transmission System will be reviewed to identify the facility impacts and necessary system improvements on the system. These reviews ensure that comparable treatment is given to all users, and that reliability, safety, and quality of service is maintained.

Scope

The scope of this document satisfies the NERC Planning Standards by identifying requirements for connections to the bulk transmission system at voltages generally 100 kV and above. This document also applies to connections to those systems designated as subtransmission facilities that are rated at lower voltages, which include 69 kV. Requirements applicable for all types of generation facilities, regardless of generation capacity, are covered. The minimum requirements pertaining to connected facilities are contained herein.

The requirements for initial facility connection apply equally to continued operation of existing connected facilities. Therefore, any upgrades, additions, enhancements, or changes of any kind to an existing connected facility are subject to Big Rivers review to ensure continued compliance with these requirements.

The scope of these documents is limited to the technical requirements for connected facility design and operation. Customers interested in the terms of transmission service should refer to the Big Rivers Open Access Transmission Tariff.

Objectives

Big Rivers, in its role as a transmission provider, has prepared this document based on the following objectives:

- a) Maintain system reliability, personnel and equipment safety, and quality of service as new facilities are added to the transmission network and existing facilities are modified to meet customer load demands.
- b) Ensure comparability in the requirements imposed upon the various entities seeking to connect facilities to the transmission network.
- c) Satisfy compliance with NERC Planning Standard FAC-001 the SERC Supplement *titled Facility Connection Requirements* pertaining to documentation of facility connection requirements by those entities responsible for system reliability.
- d) Inform those entities that seek facility connections to the Big Rivers Transmission System of the various requirements for system reliability, safety of personnel and equipment, and quality of service.
- e) Facilitate uniform and compatible equipment specification, design, engineering, and installation practices to promote safety and uniformity of service.

2.0 DESIGN REQUIREMENTS FOR CONNECTION

The **Customer** is responsible for installing appropriate equipment and facilities so that the generation is compatible with the Big Rivers Transmission System. The **Customer** is also responsible for meeting any applicable federal, state, and local codes. The minimum Big Rivers Transmission System connection requirements for generation are as follows.

Generator Frequency

The **Customer's** generating facility will provide a balanced, symmetrical, three phase interchange of electrical power with the Big Rivers Transmission System at a nominal frequency of 60 Hz.

System Protection

The **Customer** is responsible for providing adequate protection to Big Rivers facilities for conditions arising from the operation of generation under all Big Rivers transmission system operating conditions. The **Customer** is also responsible for providing adequate protection to their facility under any Big Rivers transmission system operating condition whether or not their generation is in operation. Conditions may include but are not limited to:

1. single phasing of supply,
2. transmission system faults,
3. equipment failures,
4. abnormal failures,
5. lightning and switching surges,
6. excessive harmonic voltages,
7. excessive negative sequence voltages,
8. separation from supply,
9. synchronizing generation,
10. re-synchronizing the Owner's generation after electric restoration of the supply.

More complete relaying system requirements are identified in Section 4.0.

Interrupting Device

All **Customers** shall provide three-phase circuit interrupting device with appropriate relaying systems (as stated in Section 4.0) to isolate the generation facilities from the Big Rivers supply for all faults, loss of Big Rivers supply, or abnormal operating conditions regardless of whether or not the **Customer's** generation is in operation.

This device shall be capable of interrupting the maximum available fault current at that location. The three-phase device shall interrupt all three phases simultaneously. The tripping control of the circuit interrupting device shall be powered independently of the utility AC source in order to permit operation upon loss of the Big Rivers transmission system connection.

The specific reclosing times for the **Customer's** circuit interrupting device will be provided by Big Rivers. It is the **Customer's** responsibility to design and maintain their interrupting device(s) to properly isolate generation upon loss of the Big Rivers connection until the appropriate Big Rivers facilities are returned to service.

System Grounding

The grounding of the **Customer's** system at the transmission voltage level will be considered on a case-by-case basis.

Voice Communication Circuit

The **Customer** will be required to establish a dedicated voice communication circuit to the Big Rivers Control Center to permit coordination of the synchronization and operation of the generation.

Disconnecting Devices

A three phase air break switch or a three-pole single-throw disconnect switch shall be installed on each transmission line supply entrance to the **Customer's** facility and be accessible at all times. The disconnecting device shall be mechanically lockable in the open position with a Big Rivers padlock in order to provide for a visible electric isolation of the **Customer's** facility and shall be identified with a Big Rivers designated equipment number.

Disturbance Monitoring

The **Customer's** facility must have disturbance monitoring equipment per applicable NERC standards and SERC Supplements.

Excitation Control

In addition to the normal excitation system and automatic voltage regulation equipment, the following controls are also required for each synchronous generator.

Reactive Compensation

A circuit should be provided in the automatic voltage regulator (AVR) to permit the control of voltage beyond the generator terminals. This is known as reactive line drop compensation. The point of control is to be adjustable over a range covering 0 to 15% reactance (on the generator base) beyond the generator terminals.

Big Rivers' general practice is to regulate voltage at 6% back from the station bus (toward the generator).

Overcurrent Limiter

The excitation system is to be provided with a current limiting device which will supercede or act in conjunction with the AVR to automatically reduce excitation so that generator field current is maintained at the allowable limit in the event of sustained under-voltages on the transmission system. This device must not prevent the exciter from going to and remaining at the positive ceiling for 0.1 seconds following the inception of a fault on the power system.

Underexcitation Limiter

A limiter to prevent instability resulting from generator underexcitation is required.

Power System Stabilizer

Studies may identify the need for the use of power system stabilizers, depending on the plant size, excitation system type and settings, facility location, area transmission system configuration and other factors.

Speed Governing

All synchronous generators shall be equipped with speed governing capability.

This governing capability shall be unhindered in its operation consistent with overall economic operation of the generation facility. Overspeed protection in the event of load rejection is the responsibility of the **Customer**.

Automatic Generation Control (AGC)

Provision for dispatch control of the generation facility by Big Rivers Control Center AGC system may be required. This will be considered on a case-by-case basis and any provision for control by AGC should be included in an Interconnection Agreement between the **Customer** and Big Rivers.

Black Start Capability

The provision of blackstart capability may be required or desirable. A blackstart capable generation facility is one that can be started without the aid of off-site power supplied from the Transmission System.

Sub-Synchronous Torsional Interactions or Resonances

The provision of high speed reclosing following transmission line faults may result in excessive torsional duties. The **Customer** must provide Big Rivers with immunity from damaging torsional oscillations resulting from all Big Rivers Transmission System operations, and insure the turbine-generator is not excited into resonance by normal system operations.

Unbalanced Electric Conditions

Voltage Balance

All three-phase generation shall produce balanced 60 Hz voltages. Voltage unbalance attributable to the **Customer** combined generation and load shall not exceed 1.0% measured at the point-of-service. Voltage unbalance is defined as the maximum phase deviation from average as specified in ANSI C84-1, "American National Standard for Electric Power Systems and Equipment – Voltage Ratings, 60 Hertz."

Current Balance

Phase current unbalance attributable to the **Customer** combined generation and load shall not exceed that which would exist with balanced equipment in service, measured at the point-of-interconnection.

Harmonics

The **Customer** shall take responsibility for limiting harmonic voltage and current distortion caused by their generation equipment. Limits for harmonic distortion (including inductive telephone influence factors) are consistent with those published in the latest issues of ANSI/IEEE 519, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems." Big Rivers may require the installation of a monitoring system to permit ongoing assessment of compliance with these criteria.

3.0 REQUIREMENTS FOR OPERATION

The **Customer** is responsible for operating its generation with full regard for the safe practices of, and with full cooperation under the supervision of the Big Rivers Control Center. Big Rivers maintains the right to inspect all customer facilities prior to synchronizing with the Big Rivers transmission system. This includes generator plant facilities and switchyard facilities. The inspections will focus on ensuring all technical and safety requirements have been met.

Under no circumstances shall a **Customer** energize Big Rivers transmission facilities which have been de-energized. Circuits which are electrically disconnected from the Big Rivers transmission system and are energized by a **Customer** constitute a potential safety hazard for both Big Rivers transmission personnel and the general public. Also, the energizing of such circuits at abnormal voltage or frequency could cause damage to electrical equipment of both the Big Rivers Transmission System and the generation.

The minimum requirements for operation of generation on the Big Rivers Transmission System are contained herein.

Synchronization

The **Customer** shall assume all responsibility for properly synchronizing their generation for operation with the Big Rivers Transmission System. Upon loss of the Big Rivers supply, the **Customer** shall immediately and positively cause the generation to be separated from the Big Rivers system. Synchronizing of generation to the Big Rivers Transmission System may be, at Big Rivers' discretion, performed under the direction of the Big Rivers Control Center.

Voltage Schedule

Specification of the generator voltage schedule will be determined under the direction of the Big Rivers Control Center. A steady-state deviation from this schedule between +0.5% to -0.5% of the nominal voltage will be permissible.

Voltage Range

The generation facility must be capable of continuous non-interrupted operation within a steady-state voltage range during system normal and single facility outage conditions. This range is from 91.7% to 105.8% range. All reasonable measures should be taken to avoid tripping of the generation facility due to high or low voltage.

Frequency Range

The generation facility must be capable of continuous, non-interrupted operation in the frequency range of 59.5 to 60.5 Hz. Limited time, non-interrupted operation is also expected outside this frequency range in accordance with the generator manufacturer's recommendation.

Net Demonstrated Real and Reactive Capabilities

The Net Demonstrated real capability in accordance with NERC standards and SERC Supplements, must be provided to Big Rivers annually. Big Rivers reserves the right to witness these tests.

In addition, individual generators in the generation facility must make available the full steady-state over- and under-excited reactive capability given by the manufacturer's generator capability curve at any MW dispatch level. Tests which demonstrate this capability must be conducted in a manner and frequency that is in accordance with NERC standards and SERC Supplements. Such documentation shall be provided to Big Rivers. Big Rivers reserves the right to witness these tests.

Other Applicable Operating Requirements

In order to assure the continued reliability of the Big Rivers Transmission System, the **Customer** may be requested to adhere to other operating requirements and/or encouraged to adopt common operating practices. These include the coordination of maintenance scheduling, performance not to exceed a specified forced outage rate, operations procedures during system emergencies, participation in control area operating reserves, provisions for backup fuel supply or storage, and provisions for emergency availability identified by the North American Electric Reliability Council. Big Rivers, as the Transmission Provider, may require the **Customer** to provide generation based ancillary services per the Big Rivers Open Access Transmission Tariff.

Conformance with applicable requirements in NERC Standards and SERC Supplements is required. All data reportable to SERC and/or NERC shall also be made available to Big Rivers.

Make-Before-Break Transfer

Make-before-break transfer is only permitted between two live sources, which are in, or close to, synchronism. A transfer switch designed for automatic make-before-break transition shall be equipped with logic to prevent a transfer if the specifications for either the **Customer** or the Big Rivers transmission system source fall outside of the synchronizing requirements recommended by the generator equipment manufacturer. Switch transfers made when the synchronizing requirements cannot be met shall be of the break-before-make type of transfer. The time that the **Customer's** generation is permitted to operate in parallel with the Big Rivers Transmission System during a make-before-break transfer shall be no greater than 100 milliseconds (6 cycles).

4.0 PROTECTIVE RELAYING

Customer relay requirements are summarized in Section 2.2. Specific requirements are noted below.

Parallel Generation Facility

The following utility-grade relays shall be provided by the **Customer** for protection of the Big Rivers system.

Use of the transfer trip receiver is conditional as set forth in Section 4.2, Big Rivers Facilities. All relays specified for the protection of the Big Rivers system, including time delay and auxiliary relays, shall be approved by Big Rivers. Relay operation for any of the listed functions shall initiate immediate separation of the **Customer's** generation from the Big Rivers Transmission System.

<u>Relay</u>	<u>Function</u>
Frequency	To detect under frequency and over frequency operation.
Overvoltage	To detect overvoltage operation.
Undervoltage	To detect undervoltage operation.
Ground Detector	To detect a circuit ground on the Big Rivers system (applicable to three-phase circuits only).
Directional Overcurrent	To detect the directional flow of current in excess of a desired limit.
Transfer Trip Receiver	To provide tripping logic to the generation for isolation of the generation upon opening of the Big Rivers supply circuits.
Directional Power	To detect under all system conditions, a loss of Big Rivers primary source. The relay shall be sensitive enough to detect transformer magnetizing current supplied by the generation.

The purpose of these relays is to detect the **Customer's** energization of a Big Rivers circuit that has been disconnected from the Big Rivers system, to detect the generation operating at an abnormal voltage or frequency, or to detect a fault or abnormal condition on the Big Rivers system for which the **Customer** shall separate their generation.

Output contacts of these relays shall directly energize the trip coil(s) of the generator breaker or an intermediate auxiliary tripping relay which directly energizes the breaker trip coil(s). The relaying system shall have a source of power independent from the AC system or immune to AC system loss or disturbances (e.g., DC battery and charger) to assure proper operation of the protection scheme. Loss of this source shall cause removal of the generation from the Big Rivers system.

The protective relays required by Big Rivers and any auxiliary tripping relay associated with those relays shall be utility-grade devices.

Utility grade relays are defined as follows:

1. Meet ANSI/IEEE Standard C37.90, "Relays and Relay Systems Associated with Electric Power Apparatus."

2. Have relay test facilities to allow testing without unwiring or disassembling the relay.
3. Have appropriate test plugs/switches for testing the operation of the relay.
4. Have targets to indicate relay operation.

Big Rivers will specify settings for the Big Rivers-required relays to assure coordination between the generation protective equipment and the Big Rivers system relays. It is the **Customer's** responsibility to determine that their internal protective equipment coordinates with the required Big Rivers protective equipment and is adequate to meet all applicable standards to which the generation is subject. Big Rivers further reserves the right to modify relay settings when deemed necessary to avoid safety hazards to utility personnel or the public and to prevent any disturbance, impairment, or interference with Big Rivers' ability to serve other customers.

Big Rivers Facilities

If at any time it is determined that the use of the above relay systems cannot provide adequate protection to the Big Rivers system, the **Customer** shall furnish and install upon the request of Big Rivers, a transfer trip receiver(s) at its facility to receive tripping signals originating from a Big Rivers location(s). This additional protection would also necessitate the purchase and installation of transfer trip equipment at the Big Rivers' location(s) and a communication channel between the Big Rivers location(s) and the generation facility.

Other Protection Requirements

The following items should be coordinated with each other.

- Volts/Hz and overexcitation protection/limiting.
- Loss-of- excitation and underexcitation limiting.

5.0 SUPERVISORY CONTROL AND DATA ACQUISITION

At the discretion of Big Rivers, generation control facilities and supervisory control and data acquisition of specific electrical devices from the Big Rivers Control Center may be necessary to integrate the generation into Big Rivers' control area. Such additional facilities, including required communication channels, shall, if required, be furnished and installed by the **Customer**.

The requirement for data acquisition and control will depend on the generation capacity, system location and voltage, and the net generation input into Big Rivers System. In all cases, the equipment shall allow Big Rivers to meet all industry standards that apply to Big Rivers as a balancing authority, planning authority, transmission owner and operator and any other applicable classification.

Data acquisition and control information will typically include, but not be limited to:

1. desired generation MW set point,

2. automatic generation control status (on,off),
3. generator availability,
4. generation MW, Mvar output,
5. generator minimum and base MW capability,
6. generator MW AGC high limit and low limit,
7. connection facilities' breaker status/control/alarms,
8. connection facilities' MW and Mvar line values and bus voltage, and
9. generator and substation metering (MWh) data.

6.0 COMMUNICATIONS

Voice Communications

- A. **Normal** – At Big Rivers' request, the **Customer** shall provide a dedicated voice communication circuit to the Big Rivers Control Center. Such a dedicated voice communication circuit would originate from the **Customer's** office staffed 24 hours a day and would be typically required for generation facility synchronization and operation within Big Rivers' Control Area.

All other normal voice communication concerning facility operations shall be conducted through the public telephone network to the Control Center phone number(s) issued by Big Rivers.

- B. **Emergency** – Voice communication in the event of a transmission system or energy emergency shall use the dedicated voice circuits, or public telephone network and phone number(s) designated for emergency use.

In the event of a transmission system or energy emergency, the **Customer** may be notified by the Big Rivers Control Center. Specific instructions may also be given regarding the operation of the **Customer's** unit(s) 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 **Owner's** unit(s). It is the **Owner's** responsibility to ensure that the unit operators follow all instructions given by the Big Rivers Control Center during system emergencies.