



Big Rivers
Electric Corporation

Procedure Documentation

TRANSMISSION PLANNING CRITERIA AND GUIDELINES

PL-FAC-1

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1. GENERAL SYSTEM PLANNING REQUIREMENTS

The Big Rivers transmission system consists of the physical equipment necessary to transmit power from its generating plants and interconnection points to all substations from which customers of its three member distribution cooperatives are served. Transmission planning embodies making investment decisions required to maintain this system so that it can reliably meet the power needs of the customers served. Transmission planning also includes the evaluation of transmission service requests, internal and external generator interconnection requests, internal and external transmission interconnection requests, and end-user connection requests. Justifications used in any transmission study are based on technical and economic evaluations of opinions that may be implemented to meet the specific need. The planning criteria described in this document are consistently utilized for all transmission studies.

The technical studies performed by the system planning section require the use of several software packages. The software package PSLF (Positive Sequence Load Flow) is a comprehensive set of transmission system planning programs supported by the General Electric Company. PSSE is a similar program supported by Siemens. Both software programs are used to complete AC and DC power flow studies, to create power flow equivalents, to prepare stability studies, and to complete other studies.

A software package for short-circuit calculations and relay coordination is also used. This package is known as CAPE (The Computer-Aided Power Engineering System) and is supported by Electrocon International Inc.

The above-described software programs are used in the preparation of seasonal assessments (for internal use and to meet NERC and/or SERC requirements) as well as short-term and long-term construction plans (as defined and required by RUS). Power flow studies for specific operating conditions are also performed to support system operations. Special power flow studies, generator, transmission, and end-user interconnection studies, and transfer capability studies are performed as needed.

2. POWER FLOW STUDIES

The most widely used software program for transmission system planning is the power flow program. In order to get consistent and meaningful results from power flow studies, specific criteria and procedures have been established and are followed. Succeeding sections of the document describe the contingency criteria, voltage criteria, line and transformer loading criteria, and modeling procedures established and consistently applied by Big Rivers for all transmission system planning study efforts.

Contingency Criteria

Big Rivers follows two RUS recommended criteria for analyzing the adequacy of its transmission system. The first criteria defines single contingency outages to be used in all system planning studies. This criteria serves as the basis for planning and justifying system improvements.

The second criteria outlines double contingency outages that can be analyzed to determine the extent of problems encountered on the system under extreme outage or emergency situations.

In most double contingency cases, system improvements would not be considered justifiable. However, the type and severity of the system problems encountered is useful information in planning those system improvements that are justifiable.

Single Contingency Criteria:

1. Outage of two generation units (any combination).
2. Outage of one generation unit and one transmission line.
3. Outage of one generating unit and one transformer.
4. Outage of one transmission line.

Double Contingency Criteria:

1. Outage of two transmission lines on the same right-of-way.
2. Outage of transmission lines due to outage of one bus.
3. Outage of three generation units.

In addition to the above-described criteria, Big Rivers also analyzes its transmission system to ensure compliance with NERC Planning Standards. When referring to Big Rivers, Henderson Municipal Power & Light (HMP&L) is generally included. Since HMP&L is within the Big Rivers Balancing Area, Big Rivers' studies include the HMP&L 161 kV system for outages and monitoring. The following describes the outages studied to ensure compliance with the NERC TPL standards:

NERC Category A (no contingencies)

As with all studies, base case conditions (no outages) are evaluated to ensure compliance with all planning criteria and standards. Base case models used for all studies should include appropriate loads that are consistent with the corporate load forecast; firm transactions, realistic generator dispatch based on historic data, and should include existing and planned facilities.

With the described conditions, all facilities shall be within their facility ratings (thermal and voltage) and stability shall be maintained.

NERC Category B

1. Individual outage of all single elements in Big Rivers (including 3-terminal circuits), Hoosier Energy (HE), KU and LG&E (LGEE), Southern Illinois Power Cooperative (SIPC), TVA, and Vectren.
2. Single generating unit outages.

Seasonal assessments and other bulk system assessments performed by Big Rivers include the outage of each single element above 100 kV in the systems listed above with the bulk facilities in each of the above listed systems monitored.

With the described conditions, all facilities shall be within their facility ratings (thermal and voltage), stability shall be maintained, and no cascading outages or uncontrollable separation shall occur. Interruption of radial load is acceptable.

NERC Category C (including NERC Category B with Generating Unit outage)

1. Single transmission element outage with simultaneous generating unit outage (including each of the following: Wilson, Green, Coleman, and Paradise).
2. Double transmission element outages including two circuits on a common tower (global Big Rivers outages and select external).
3. Substation bus or bus section outage.

Seasonal assessments include every combination of double contingencies in the Big Rivers system (above 100 kV). In addition, each Big Rivers single contingency is performed with the simultaneous outage of select individual generating units (listed above). Select bus section outages in Big Rivers are studied. While performing these outages, all bulk facilities (Big Rivers, HE, LGEE, SIPC, TVA, and Vectren) are monitored. However, the external facilities are monitored only for the potential to cascade (130% overload). Other transmission assessment studies may include only a subset of the above described outages.

As with Category B outages, all facilities shall be within their facility ratings with stability maintained and no cascading or uncontrolled separation. However, manual system adjustments (system reconfiguration, load shedding, re-dispatch, etc.) are allowed after the first outage and prior to the outage of a second independent facility.

NERC Category D

1. Coleman generating plant outaged
2. Wilson generating plant outaged
3. Green generating plant outaged
4. Century Aluminum load outaged
5. Alcan load outaged
6. Outage of Reid 161 kV switchyard
7. Outage of Coleman 161 kV switchyard
8. Outage of all Green and HMP&L generating units

Seasonal assessments include the above described Category D outages. While performing these outages, all bulk facilities (Big Rivers, HE, LGEE, SIPC, TVA, and Vectren) are monitored. However, the external facilities are monitored only for the potential to cascade (130% overload).

Other transmission assessment studies may include only a subset of the above described outages.

When completing all bulk transmission studies, all internal facilities are monitored for voltage and loading violations.

Either select external facilities or the complete list of external system previously described are also monitored. When completing seasonal assessments, the neighboring systems may only be monitored for the potential to cascade.

When completing expansion studies or connection studies, any neighboring system violation will be compared against the base model to determine the impact of the proposed projects. Any violation made worse by the proposed system improvement will be investigated with the facility owner.

Voltage Criteria

As indicated in the following table, Big Rivers has adopted a voltage criteria for planning and assessing its transmission system. This criteria defines acceptable minimum and maximum voltage levels for the high-side buses. The criteria include a range of acceptable voltages for normal system conditions (all facilities in service) and during single contingency conditions. A more detailed description of the voltage criteria is included as Appendix A.

Transmission System Conditions	69 kV Bus Voltage		> 69 kV Bus Voltage	
	Minimum	Maximum	Minimum	Maximum
Range A: Normal System Operations	95.0%	105.0%	95.0%	105.0%
Range B: Single Contingency Conditions	91.7%	105.8%	92.0%	105.0%

Facility Rating Criteria

Big Rivers' transmission lines are rated according to limits determined by the most restrictive of either the conductor thermal ratings, the NESC minimum line to ground clearances, or the terminal equipment ratings with relay loadability considered. Big Rivers' transformer ratings are established according to their thermal design ratings as specified by the manufacturer. For normal and single contingency situations, all lines are to be loaded at or below their ratings and all transformers are to be loaded at or below their maximum 65° C ratings. Substation equipment ratings are based on manufacturer recommendations. Big Rivers does not derate high voltage air switches, line traps, or power circuit breakers based on weather conditions or previous loading conditions. Shunt capacitors are designed for a minimum of 1.05 p.u. voltage. Jumpers connecting these substation components to other elements of the transmission system are sized with current carrying capacity greater than the component itself. Additional rating details can be found later in this report.

Modeling Procedures

In order to perform a power flow study, a model of the electrical system is required. The power flow model requires line and transformer impedances, transformer tap settings, generation levels, load levels (MW and MVAR), scheduled voltages, line and transformer ratings, and interchange schedules for Big Rivers' facilities as well as for other utilities.

To start the model development process, an MMWG power flow case for a desired year is obtained. This model includes all Big Rivers bulk system facilities and information for neighboring utilities within SERC as well as other reliability areas. Neighboring utilities may be contacted directly in order to obtain more detailed system information. After the MMWG case is obtained, the Big Rivers model and any desired neighboring utility representations are removed and more detailed models are merged into the case.

After all detailed representations are merged into the MMWG case, fine-tuning of the case begins. The first step is to make sure Big Rivers' interchange is correct. The modeled interchange should typically reflect firm contract sales for the desired time period. Transactions that are consistent with firm transmission reservations confirmed on the OASIS may also be modeled as part of Big Rivers' scheduled interchange. Close attention is paid to HMP&L's allocation from Station 2 generation and HMP&L's loads (in the MMWG case, the HMP&L take is modeled as Big Rivers load. HMP&L load is modeled in a separate HMP&L area in the detailed case). After the interchange is modeled, the loads in Big Rivers' area are reviewed and revised. The distributed loads will match the forecast numbers found in the latest available Big Rivers load forecast for the desired year. Regression techniques or averages based on historical data are used to distribute the total rural load. The large industrial loads modeled in the power flow case will match the values given in the Big Rivers load forecast. Each distribution cooperative is consulted during this load distribution process. Additional details regarding this process are included in Appendix B. In most cases, the generation at Reid 1 and at the Reid CT is modeled off-line. All transmission or generation construction scheduled to be completed before the time period to be studied is added into the model. A final check of line and transformer impedances and ratings is performed prior to starting the desired power flow studies.

Model Validation

Model validation is completed by making a comparison of the power flow model to a state estimator snapshot. The comparison is completed on a regular basis at a minimum of once every five years.

To start the process, a state estimator snapshot is taken as close to system peak as possible. The snapshot includes all line flows, voltages, generator outputs, and transformer tap settings. The majority of this information is based on real-time measurements gathered by the SCADA system.

The current year summer peak power flow model from the NERC/MMWG series is used in the comparison. The model includes a detailed representation of the Big Rivers system. Large industrial loads tied directly to the 161 kV system are adjusted to be consistent with the snapshot data.

Rural loads may also be scaled to ensure that the total system load from the base case closely matches that of the snapshot. Load scaling is done so as to not alter the load distribution or the power factors included in the model. Any large discrepancies in load values are evaluated to determine the reason. Once loads are adjusted, generator outputs and tie line flows are adjusted to match the snapshot as closely as possible. Transformer taps are also set to match the settings in the snapshot.

Several aspects of the two models are then compared with any large or unexplained discrepancies documented. Although the impedances that are used in the models are derived from same source, they are compared to ensure accuracy in the values. System MVar load and load power factors are compared. Voltages at major buses and flows on major transmission elements are also reviewed.

The results of the comparison are used as a reference when making adjustments to the current model and when developing the next years' power flow model.

3. SHORT CIRCUIT STUDIES

System planning utilizes short circuit study results to evaluate the adequacy of the short time current or interrupting ratings of existing equipment, to determine the ratings of new equipment to be purchased, and to provide short circuit source data to its member cooperatives, their industrial customers, or for Big Rivers' own protection coordination studies. System planning currently performs these short circuit studies. Short circuit studies are performed using the CAPE software package.

In order to perform these short circuit studies, a database model including the positive and zero sequence impedances of each line, transformer, and generator is prepared for Big Rivers' system. Equivalent system impedances for each of Big Rivers' interconnections are also determined and modeled. Short circuit studies are then run to determine the magnitude of single phase to ground and three phase faults at each station or bus in Big Rivers' system. These fault levels are compared to the existing power circuit breaker ratings to determine if any equipment ratings are exceeded. If equipment ratings are exceeded, then upgrades in equipment are recommended.

4. STABILITY STUDIES

Another concern for the system planning section is system stability. Stability refers to the ability of a generator to remain in synchronism with all other generators after a disturbance or fault. On an annual basis, seasonal assessments performed by Big Rivers will be reviewed to determine significant NERC Category B, C, and D outages that warrant near-term dynamic simulations. In general, any Category B, C, or D outage that has the potential to result in significant facility overloads, widespread low voltages, or cascading outages without operator action will be considered for inclusion in a dynamic analysis. Particular attention should be given to facilities or geographic areas that appear particularly vulnerable to frequent overloading or low voltage conditions (during various independent single or multiple contingencies).

If no new significant facilities, outages, or areas of concerns are identified, previously prepared dynamic simulations may be sufficient. However, dynamic simulations should be performed if any of the following conditions or situations occurs:

- Significant system changes have occurred since the last dynamic simulations were completed. This includes internal and nearby external exchanges (EHV additions, generator additions or retirements, interconnection additions, load loss or addition, etc.).
- Additional significant facilities or outages are identified through the seasonal assessment study process.
- The most recent dynamic simulations are found to be over 5 years old.

The criteria followed stability studies follows:

- With one transmission element out-of-service, all generating units must remain stable with a subsequent single phase-to-ground fault.
- Under normal system peak load conditions with full generation output, all generating units must remain stable with a three phase-to-ground fault or single phase-to-ground fault at the most critical location.
- Under normal system peak load conditions with full generation output, all generating units must remain stable with a three phase-to-ground fault at the most critical location followed by a breaker failure.
- All circuit breakers should be capable of interrupting the maximum fault current duty imposed on the circuit breaker.
- All NERC standards and SERC Supplement requirements must be met.

5. CONSTRUCTION WORK PLANS

RUS requires that borrowers maintain an up-to-date short range construction work plan (CWP). The CWP consists of a series of system studies, which covers a period of 2 to 3 years in the future and identifies required transmission facility improvements. The CWP is consistent with the long-range engineering plan. The CWP studies use the system load estimates found in the borrower's approved load forecast.

A CWP, according to RUS, shall normally include studies of power flows, voltage regulation, and stability characteristics to demonstrate system performance and needs. These requirements, as well as additional requirements, are described in the Federal Register in 7 CFR Part 1710.

A CWP, as prepared by Big Rivers, covers a three year period beyond the year in which the study is being performed. For example, a CWP prepared in the summer of 1995 would cover the time frame from 1996 to 1998. New CWP's are typically prepared during the last year covered by an existing CWP.

Power flow studies make up the majority of a CWP as prepared by Big Rivers. A power flow database is prepared as previously described. Load levels that are consistent with the most current load forecast are modeled. Typically, the interchange is modeled according to firm contract sales and purchases. However, transactions that are consistent with firm transmission reservations that are confirmed on the OASIS may also be modeled as part of Big Rivers' scheduled interchange. Single contingency outages of each line of Big Rivers' system (excluding radial lines) are studied. Single contingencies, which yield unacceptable system results, are identified. Alternated systems switching arrangements or changes in transformer tap settings are evaluated as the first solution option. If operational changes will not correct the problem, ten system improvement alternatives are defined, modeled, and studied to determine their merits in correcting the system problem. The system improvements that prove to be successful solutions for the system problem are then evaluated based on economics, reliability, practicality, possible system benefits, and consistency with long range engineering plans to determine their inclusion in the CWP recommendation. Both external and internal improvement options are considered. When external options are considered (or internal options that may impact external facilities), coordination with all neighboring systems (including MISO, SPP, and TVA RC) is necessary and will be initiated as soon as possible. Final construction plans should be provided to interested and potentially impacted entities for comment as soon as possible. Power flow studies are typically completed for summer and winter peak conditions. Power flow studies with extreme conditions (peak load forecast with extreme weather) are also performed and may be used to evaluate construction alternatives.

Maximum transfer capability studies may be included as a part of the CWP. A maximum transfer capability study typically includes multiple scenarios to evaluate potential transfers. Maximum power transfer studies from Big Rivers to TVA and MISO would be evaluated. The intent of these studies is to identify any system problems that may occur because of off-system sales or purchases.

Short circuit studies to evaluate the adequacy of system equipment ratings are also performed and their results analyzed. Stability studies accompany any study in which additional generation is being recommended or evaluated.

6. LONG-RANGE ENGINEERING PLANS

RUS also requires that borrowers maintain up-to-date long-range engineering plans. These long-range engineering plans are prepared in a manner similar to the process of preparing a CWP. A long-range engineering plan is prepared immediately following each CWP. This allows the CWP to be reviewed in light of long-range plans. Reviewing and revising a long-range engineering plan is acceptable in place of preparing an entirely new study if system changes and load forecast changes have been minimal. Engineering judgment is used to decide if simply reviewing and revising the study is appropriate.

As with a CWP, the long-range engineering plan is predominately driven by the results of system power flow studies. The power flow studies are again prepared with an MMWG database. This database represents all systems ten years in the future. A detailed representation of Big Rivers, and any desired neighbor, is merged into the MMWG database. The load level modeled for Big Rivers are consistent with the approved load forecast for the desired year.

The power flow cases are modeled with summer peak and off-peak loads. The modeled interchange reflects what Big Rivers management believes is most probable for the study period. This interchange level may be equivalent to firm contract sales and purchases or may include transactions that are consistent with firm transmission reservations that are confirmed on the OASIS. Single contingency outages of each Big Rivers' line (excluding radial lines) are studied. These single contingency studies identify cases that yield unacceptable voltages or line loading conditions. Studies are then run to evaluate possible solutions for the problems identified. Operational changes such as switching or transformer tap changes are the first solution options studied. If operational changes proved to be unsuccessful, then various system improvement options are studied. All system improvements that are found to be successful solutions for the system problems are then evaluated based on economics, reliability, practicality, and other system benefits to determine the best solution. Additional system studies are run to evaluate the cumulative effects of multiple system improvements. The result is a transmission system that will allow Big Rivers to provide reliable and cost-effective electric service to its member cooperatives.

In addition to the ten-year study, a fifteen or twenty year study is performed. A procedure, similar to the ten-year study procedure, would be followed with a fifteen or twenty year power flow database. Any final conclusion is made using the results from both the ten-year study and the fifteen or twenty year study.

Maximum power transfer capability studies are also prepared as part of a long-range engineering plan. These studies will help to identify any problems that may occur in the long run as a result of off-system transactions. Possible solutions to correct the deficiencies are identified and evaluated following normal power flow study procedures.

Short circuit studies are also performed as previously described. These studies help identify long-term problems associated with increasing fault duties. Stability studies accompany any study in which additional generation is being recommended or evaluated.

It should be noted that not every system addition or upgrade identified or proposed in the long-range engineering is implemented. As Big Rivers' system actually grows, it may become obvious that the problems identified in the long-range study may not develop or that problems may develop in other areas. The actual system development is continually reviewed and monitored to determine when a new long-range engineering plan is necessary. The long-range plan, when reviewed with the CWP, helps to identify any proposed short run solutions that may just be "band aid" solutions for a major long-range problem. In some of these cases, investing in a facility that may only be a temporary solution may not be advisable. Instead, other alternatives may be more economical when the long-term system needs are considered.

7. SHORT-TERM/OPERATIONAL PLANNING

Technical studies are performed by the system planning department to support near-term and real-time reliability efforts. These studies utilize both the OSI OpenNet application that provides a real-time state estimator and contingency analysis tool (EMS application) and the off-line power flow study tool (PSLF).

Planned System Outages

Both the on-line and off-line power flow programs are used to study planned outages and system events as necessary. The TVA RC studies all outages entered into the NERC SDX and coordinates this information with other reliability coordinators.

Any action plans involving Henderson Municipal Power and Light (HMP&L), our member cooperatives, or any impacted customer are coordinated through Big Rivers' System Supervisors with engineering support provided as needed. Action plans involving adjacent reliability coordinators are coordinated through TVA.

Real-Time Contingency Analysis

The real-time contingency analysis tool is used on a continuous basis (once every two minutes) to study all bulk system single contingencies (single line, transformer, and generator outages). Also, all single line/transformer contingencies are run with simultaneous generator outages on a regular basis (generally on a daily basis). Several external outages that have a known impact on the Big Rivers' system are also run on a daily basis.

In addition, the TVA RC uses the AREVA state estimator/contingency analysis program to monitor and study the Big Rivers system as well as the regional transmission network.

Real-Time Contingency Analysis Alarming

As previously discussed, the real-time contingency analysis tool is part of the EMS and the results can be viewed by the System Supervisors. The thermal and voltage results can be viewed on two separate displays. Any line or transformer with normal or N-1 loadings at 90% or greater of its seasonal thermal rating are alarmed and displayed. Normal and N-1 system voltages outside of the range from 95% to 105% of nominal are also alarmed and displayed.

Off-Line Model

MMWG power flow models for the desired years are used as the basis for developing the power flow model for use in reliability and planning studies. Detailed models for Big Rivers and any desired neighboring utility are merged into the case. This model is then updated to reflect the system conditions that are to be studied. Actual system data from the EMS is used in the update process.

Real-Time Model

The real-time model was also created from a MMWG power flow model with the detailed Big Rivers model merged in. The model is updated manually with support from the engineering department and neighboring utilities as needed. Real-time data is brought into the model every time the state estimator executes (once per minute) through the Big Rivers SCADA system and the ICCP connection with the TVA.

8. TRANSFER CAPABILITY

Transfer capabilities are calculated, coordinated, and communicated to others through various means. The criteria described in this document are consistently applied in all transfer capability studies (near-term operating horizon and longer-term planning horizon). In all study processes, Big Rivers will respect all system operating limits (internal and external). Any variations from the criteria will be documented in the appropriate study report.

Big Rivers participates in SERC near-term, long-term, and OASIS study groups. These studies include all existing and planned facilities in the Big Rivers system. The Big Rivers loads will be consistent with the Big Rivers corporate load forecast for the study period. Only those transactions with a firm contract will be included in the model (after proper coordination with the other entity). Generation dispatch is based on known merit orders and should reflect past experience. Reliability margins (CBM, TRM, etc.) are not included in these models. However, generator outages scheduled to last longer than one month are included in the quarterly BASIS studies. Various import and export scenarios are studied. Currently, Big Rivers imports and exports with LGEE, SIPC, and TVA are studied. Additional transfers will be added as necessary. Study results are available to all SERC members and other appropriate entities.

Internal studies also consider transfer capabilities. Internal seasonal assessments generally begin with all generation except Reid 1 and Reid CT dispatched. This net export base model gives an indication of expected system performance with most generation dispatched. Generation outages (single and multiple units) provide an indication of performance under import conditions. Summer assessments generally include a study of north to south transfers. The seasonal assessment study reports are provided internally to system operations and are also made available to the reliability coordinator. Additionally, the report will also be made available to neighboring utilities and other interested parties.

Big Rivers TTC, AFC, and ATC calculations are performed by TVA. These calculations are described in the Big Rivers document PL-MOD-1 *AFC/ATC Calculation Procedures*. This document and resulting ATC values are available through the Big Rivers OASIS.

9. MISCELLANEOUS PLANNING STUDIES

Other studies performed by Big Rivers include operational studies, system impact studies to evaluate transmission service requests, generator interconnection studies, transmission interconnection studies, end-user connection studies, and various other special studies. The study process and format will vary according to need. However, all studies should follow the same voltage and facility loading criteria and should be consistent with the procedures and methodologies outlined in this report (the alternative selection process is consistent with the process described in Section V). As with all studies, compliance with NERC standards is necessary.

In addition, transmission studies should be properly coordinated with neighboring transmission systems and reliability organizations. Specifically, all potentially impacted neighbors (E.ON. U.S., Hoosier Energy, MISO, SIPC, SPP, TVA, and Vectren) should be invited to participate in all generator interconnection studies and significant transmission interconnection or modification studies.

Modeling information, study results, and proposed transmission plans should be communicated to these entities and any other interested transmission planning entity or transmission owner/provider. After all internal and external approvals (including regulatory approvals) are obtained, the proposed facilities will be included in the MMWG model building process and communicated to the TVA Reliability Coordinator. A log of communication (email history is acceptable) should be maintained as part of the study process.

On an annual basis, studies are prepared to evaluate all annual firm transmission requests (new or renewals). Other studies are performed to support the calculation of the ATC values that are posted on the OASIS. Details concerning these studies are included in a separate document.

Seasonal system assessments are also prepared on an annual basis. These seasonal assessments include (at a minimum) summer peak studies, winter peak studies, stress cases (heavy transfers or extreme loads), and long-range studies.

Single, double, and extreme contingencies should be studied with the results compared against NERC planning standard requirements. Stability studies should also be reviewed as necessary.

Big Rivers also participates in SERC near-term and long-term assessments. In addition, Big Rivers participates in the quarterly OASIS studies prepared by SERC companies.

10. RATING METHODOLOGIES

All transmission facility ratings are based on the most limiting element included in any circuit (switches, breakers, buses, traps, protective relaying systems and their trip settings, transformers, CTs, transmission lines, etc.). Unless otherwise stated, summer and winter ratings are based on the same methodology.

All transmission system ratings have been provided to the TVA Reliability Coordinator. Any rating changes are communicated to the TVA Reliability Coordinator and interested neighboring systems as the changes occur. In addition, up-to-date ratings are included in the MMWG models available to most interested parties. Additional rating details will be made available to neighboring utilities and other interested parties as needed (within 15 business days of a request). If the reliability coordinator or neighboring system provides comments on its review of the facility ratings, then a response addressing those comments will be provided within 45 calendar days.

Interconnection ratings are coordinated once per year as part of the MMWG model building process. Additional coordination is completed via email as necessary.

Conductors

The calculations of transmission line ratings are consistent with IEEE Standard 738-1993 "IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors". The following assumptions are utilized in the calculations:

1. Minimum ground clearances (as defined by NESC) will be maintained during operations at the conductor's maximum operating temperature (typically 212° F).

2. Summer Normal and Summer Emergency ratings are calculated with 2 foot per second wind speed, full sun, and an ambient temperature of 100° F.
3. Winter Normal and Winter Emergency ratings are calculated with 2 foot per second wind speed, full sun, and an ambient temperature of 32° F.
4. In addition to the above ratings, temperature dependent ratings are used by system operations (actual temperatures are used in place of the assumed temperature when calculating the ratings).

Generators

Manufacturer's nameplate information (including reactive capability curves) is used to determine unit ratings when actual test data is unavailable. At this time, each generating unit is scheduled to be field tested. The test will determine actual real and reactive capabilities and other data necessary to properly model the generating units for steady-state and dynamic analyses.

High Voltage Air Switches

Big Rivers purchases, operates, and maintains transmission voltage (100 kV and above) High Voltage Air Switches in accordance with ANSI C37.32 *HV Air Switches – Preferred Ratings, Specifications and Application Guide*. Table 1 of C37.32 lists *Preferred Ratings for Outdoor Air Switches*. Big Rivers does not derate High Voltage Air Switches based on weather conditions or previous loading conditions. Jumpers connecting switches to other elements of the transmission facility are sized with current carrying capacity greater than the switch itself.

Shunt Capacitors

Big Rivers purchases, operates and maintains transmission voltage (100 kV and above) Shunt Capacitors in accordance with NEMA CP1 – Shunt Capacitors, and ANSI/IEEE C37.99 – Guide for Protection of Shunt Capacitor Banks, and IEEE 1036 Guide for the Application of Shunt Power Capacitors. These capacitor banks are composed of capacitor can groups in series and connected in a grounded wye configuration. Since substation bus voltages run higher than 1.0 p.u., banks are designed for a minimum of 1.05 p.u. Jumpers connecting capacitor banks to other elements of the transmission system are sized with current carrying capacity greater than the capacitor bank itself.

Line Traps

Big Rivers purchases, operates and maintains transmission voltage (100 kV and above) Line Traps in accordance with ANSI C93.3 – *Requirements for Power-Line Carrier Line Traps*. Table 5 of C93.3 lists *Current Ratings*. Big Rivers does not derate Line Traps based on weather conditions or previous loading conditions. Jumpers connecting Line Traps to other elements of the transmission facility are sized with current carrying capacity greater than the Line Trap itself.

Transformers

Big Rivers purchases, operates and maintains transmission voltage (100 kV and above) Transformers in accordance with ANSI/IEEE C57.12.00 – 1987 *General Requirements for Liquid Immersed Power Transformers* and ANSI/IEEE C57.92 – 1981 *Loading Mineral Oil Immersed Power Transformers*. Big Rivers plans and operates power transformers on its system whose voltage ratings fall within the bulk transmission level (100 kV and above high side). Big Rivers has established that the normal and emergency rating for power transformers shall be the highest nameplate rating with all cooling equipment operating. In the absence of any or all stages of cooling equipment, the rating is the maximum nameplate rating associated with that level of cooling. For the six 345/161 kV power transformers the rating is 420 MVA (a significant increase above the nameplate value as determined by the manufacturer, General Electric Company). However, if these units are operated in a step-up mode (direction of flow from 161 kV to 345 kV system), either the high side voltage must be limited to 345 kV (1.0 per unit) or the unit rating reverts back to the 336 MVA nameplate value.

High Voltage Bus

Big Rivers purchases, operates and maintains transmission voltage (100 kV and above) High Voltage Bus in accordance with ANSI/IEEE Standard 605 – 1987 *Guide for Design of Substation Rigid-Bus Structures*. Table B3 of Standard 605 Appendix B lists *Bus Conductor Ampacity – Aluminum Tubular Bus – Schedule 40 AC Ampacity (53% Conductivity)*. Big Rivers utilizes this table assuming a normal oxidized surface with emissivity of 0.50, with sun, in still but unconfined air, with a 30 degree C temperature rise over 40 degree C ambient.

Power Circuit Breakers

Big Rivers purchases, operates and maintains transmission voltage (100 kV and above) Power Circuit Breakers in accordance with ANSI C37.06 *AC HV Circuit Breakers – Preferred Ratings and Related Required Capabilities*. Table 3 of C37.06 lists *Preferred Ratings for Outdoor Circuit Breakers 121 kV and Above*. Big Rivers does not derate PCBs based on weather conditions or previous loading conditions. PCBs on the Big Rivers transmission system are equipped with Bushing Current Transformers (BCTs). These BCTs are usually Multi-ratio and sometimes tapped at less than the full continuous current rating of the PCB. In these situations, the PCB is derated to the Multi-Ratio BCT tap value. The Thermal Rating Factor of the BCT is used where applicable. Jumpers connecting PCBs to other elements of the transmission facility are sized with current carrying capacity greater than the PCB itself.

Protective Relaying

Big Rivers purchases, operates and maintains transmission facilities protective relays in accordance with IEEE C37 Guides and Standards for Protective Relaying Systems. The protective relaying schemes are specified and their settings are calculated such that neither limits the capacity of the transmission facility. For impedance relays of networked transmission facilities, 0.85 p.u. voltage is utilized in the rating calculation.

Current Transformers

Big Rivers purchases, operates and maintains current transformers in accordance with ANSI/IEEE C57.13 – Standard Requirements for Instrument Transformers. Current transformers are operated up-to a maximum current level equal to the nameplate rating multiplied by any continuous-thermal-current rating factor (RF).

11. LINE SWITCH CRITERIA

The following documents the criteria applied in the planning, design, construction, and operation of line switches on Big Rivers' transmission system. The focus here is on the 69 kV system serving all of the rural and many of the dedicated (customer) delivery point substations of our three member cooperatives. The following functional objectives and standards define the 69 kV transmission line switching practices currently in effect.

For loop or dual feed line sections:

1. Line sectionalizing switches shall be employed at both ends of every line section
2. Full load interrupting capability shall exist at a minimum on one end of every line section
3. Load interrupting capability shall exist on the other end line sectionalizing switch of sufficient rating to safely de-energize the line (i.e. break the line charging current).
4. Remote control operational equipment shall be added to full load interrupting switches to solve service reliability problems and typically shall be applied at three-way junction points to provide alternate power supply switching arrangements for a number of distribution stations.

For radial line sections:

1. Line sectionalizing switches shall be applied for tap lines greater than 4.0 miles in length or where continuous service is essential to other stations supplied off the radial line section being tapped.
2. Line sectionalizing switches shall have sufficient load interrupting capability to safely de-energize the line (i.e. minimum capability equal to or greater than line charging current).

12. SYSTEM OPERATING LIMITS METHODOLOGY

The Big Rivers System Operating Limits (SOLs) used in the planning and operation of the Bulk Electric System (BES) are based on the following established methodology. This methodology will be reviewed/updated annually as part of the overall review of the Transmission Planning Criteria and Guideline document. The review shall ensure that the Big Rivers SOL and IROL methodologies are consistent with NERC Standards and methodologies established by the TVA RC. All versions of this document and related communications will be maintained for a minimum of three years.

Definitions

SOL is defined as follows:

The value (such as MW, MVAR, Amperes, Frequency, or Volts) that satisfies the most limiting of the prescribed operating criteria for a specified system configuration to ensure operation with acceptable reliability criteria. System Operating Limits are based upon certain criteria. These include but are not limited to:

- Facility Ratings
- Transient Stability Ratings
- Voltage Stability Ratings
- System Voltage Limits

An Interconnection Reliability Operating Limit (IROL) for the planning and operating horizons shall be defined as a System Operating Limit which, if violated, could lead to instability, uncontrolled separation, or cascading outages that adversely impact the reliability of the BES.

SOL Methodology – Planning Horizon

The SOLs shall not exceed the associated Facility Ratings as documented in section 10 of this report. SOLs equal the Facility Ratings unless stability studies or other analyses establish a lower value.

If an SOL is violated and uncontrollable separation, instability, or cascading outages occur, then this SOL will be defined as an IROL. Big Rivers studies used to ensure compliance with NERC TPL Standards will be used for this identification. In addition, studies performed by the TVA RC, SERC study groups, or others will also be used to identify IROLs. At this time, no IROLs have been identified. The contingencies studied and areas monitored are those described in Section 2. Near-term and long-term MMWG models are used as part of this study process. Each model must include an accurate representation of both Big Rivers and HMP&L's 138 kV and up system. At this time, Big Rives has no SPSs and does not rely on any external SPS. The use of SPSs will be evaluated on a case-by-case basis in the future. The system modeling practices should be consistent with this report. This generally includes realistic generation dispatch based on known merit orders, load levels consistent with the Big Rivers corporate load forecast, only known planned outages modeled, and firm transactions with executed contracts included in the models.

Pre-contingency State: All Facilities in Service for the Planning Horizon:

Big Rivers develops SOLs for the pre-contingency state with all facilities in-service when performing the assessment required with planning standard TPL-001. Any known or planned outages and other system changes will be modeled.

With a pre-contingency state, transient, dynamic, and voltage stability shall be maintained; all facilities shall be within their facility ratings and within thermal, voltage, and stability limits. Any potential SOL violations shall be documented and reported to the TVA RC.

Single Contingency Outages for the Planning Horizon:

Big Rivers develops SOLs for the single contingency state outages when performing the assessment required with planning standard TPL-002. Following a single contingency (as defined in sections 2 and 4 of this report), transient, dynamic, and voltage stability shall be maintained; all facilities shall be within their facility ratings and within thermal, voltage, and stability limits; and cascading outages or uncontrolled separation shall not occur. Consistent with FAC-010-1, planned or controlled interruption of radial and some local loads, and manual or automatic system reconfiguration. Other system adjustments such as re-dispatch are allowed to prepare for the next possible contingency. Any potential SOL violations shall be documented and reported to the TVA RC.

Less Probable Contingency Outages for the Planning Horizon:

Big Rivers develops SOLs for the less probable contingency outages when performing the assessment required with planning standard TPL-003. Following a multiple facility outage (as defined in TPL-003), transient, dynamic, and voltage stability shall be maintained; all facilities shall be within their facility ratings and within thermal, voltage, and stability limits; and cascading outages or uncontrolled separation shall not occur. Consistent with FAC-010-1, planned or controlled interruption of local loads, manual or automatic system reconfiguration, the curtailment of firm transactions, and other system adjustments such as re-dispatch are allowed. Any potential SOL violations shall be documented and reported to the TVA RC.

Study Model

MMWG study models are used for the TPL assessments and the determination of SOLs. The model detail generally includes facilities of 69 kV and up. However, only 100 kV and up facilities are considered during TPL related studies. The models shall reflect any known system changes such as facility outages.

The selection of contingencies is described in the assessments for TPL standards. This generally includes outages of all 100 kV and up facilities in the Big Rivers Balancing Area. Big Rivers does not use Special Protection Systems and any remedial actions relied upon are described in the assessments for TPL standards.

Document Communication and Maintenance

Big Rivers shall post this methodology on the public OASIS. In addition, the methodology will be provided to the TVA RC.

Big Rivers shall maintain and update these requirements as necessary. The requirements will be provided to transmission users, SERC, and NERC within 5 business days upon request.

If a recipient of this SOL methodology provides written technical comments, Big Rivers shall provide a written response within 45 calendar days after receiving the comments. The response shall include whether a change will be made to this methodology and, if no change the reason why.

SOL Methodology – Operating Horizon

Big Rivers recognizes the IROL and SOL definitions and processes as documented in *System Operating Limits Methodology for Operations Horizon* (attached as Appendix F).

Critical Facilities

At this time, no critical facilities have been identified. Big Rivers has internal flowgates that can limit the ability to import and export power. No SOLs have been identified that if exceeded in the planning or operating horizon could lead to instability, uncontrolled separation, or cascading outages. In addition, no multiple contingency related stability limits (TPL-003) have been identified. Therefore, no IROLs have been identified and no such limits need to be reported to the TVA RC.

The state estimator/on-line power flow model is used to monitor and study each flowgate as well as other bulk system facilities.

13. COORDINATION/COMMUNICATION

As stated previously, transmission studies should be properly coordinated with neighboring transmission systems and reliability organizations. Specifically, all potentially impacted neighbors (E.ON. U.S., Hoosier Energy, MISO, SIPC, SPP, TVA RC, and Vectren) should be invited to participate (or allowed to review and provide input regarding planned improvements) in all generator interconnection studies and significant transmission interconnection or modification studies. Modeling information, study assumptions, alternatives considered, study results, and proposed transmission plans should be communicated to these entities and any other interested transmission planning entity or transmission owner/provider.

After all internal and external approvals (including regulatory approvals) are obtained, the proposed facilities will be included in the MMWG model building process and communicated to the TVA Reliability Coordinator. A log of communication (email history is acceptable) should be maintained as part of the study process. All documentation will be maintained for a minimum of five years.

As part of this communication/coordination effort, Big Rivers participates in near-term and long-term SERC study groups. Internal seasonal assessments will be made available to the reliability coordinator and others as requested.

In addition to study coordination and communication, facility ratings and methodologies must be properly coordinated and communicated. As previously stated, all transmission system ratings have been provided to the TVA Reliability Coordinator.

Any rating changes are communicated to the TVA Reliability Coordinator and interested neighboring systems as the changes occur. In addition, up-to-date ratings are included in the MMWG models available to most interested parties. Additional rating details will be made available to neighboring utilities and other interested parties as needed or requested. If a request is received (from the reliability coordinator or neighboring systems) concerning the identification of the most limiting element and the impact of that element on the facility rating, then the requested information will be provided within 30 calendar days if the facility rating meets the criteria in NERC Standard FAC-008-2, Requirements 7.1-7.3.

Interconnection ratings are coordinated once per year as part of the MMWG model building process. Additional coordination is completed via email as necessary.

As an additional communication and coordination effort, this document and Big Rivers documents relating to TTC/ATC/TRM/CBM will be provided to the reliability coordinator when any update is made (prior to effective date or implementation of any significant change). Upon request, or as appropriate, these documents will also be made available to neighboring utilities and other interested parties. Any comments or concerns received will be addressed in a written response within 45 calendar days of receipt.