
Blackstart and System Restoration Simulations using PowerWorld Simulator

PowerWorld Users Group

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Planning vs Operations

- In Planning, one identifies foreseen contingencies (causes) and designs a system to avoid overloads and low voltages
- In Operations, the Operator responds to system conditions, initially without concern for cause
- Operators must quickly assess the state of the system and initiate switching or redispatch to relieve overloads and low voltage conditions in real time

Operations Applications

- Blackstart and Restoration Procedure assessment and review
- System Operator Response Training
- These are two very distinct applications even though both are related to system restoration

Islanding

- Non-trivial restoration involves re-energizing an “island” and resynchronizing with the network
- If parts or all of a system are disconnected from the “Interconnection”, what actions are to be taken?

NERC System Restoration Guidelines

- Disassemble the transmission system
- Establish off-site power for nuclear units, both those that had been operating and those already off line. This is required without regard to using these units for restoring load.
- Units with blackstart capability should begin the restart process for use in supplying start-up power to other units.
- Priority access to start-up power should be given to hot units that can be returned to service immediately.
- Priority access to start-up power also should be given to other units that can be started within a few hours.

NERC System Restoration Guidelines

- Consideration should be given to connecting shunt reactor devices to help stabilize generating units being brought on line.
- Transmission corridors for supplying start-up power should be identified and switching procedures determined, taking extra care to isolate damaged facilities.
- Units without blackstart capability should be prepared to begin the start-up process when start-up power becomes available.
- Transmission system corridors to support the start-up process should be established but not energized until needed.
- As units with blackstart capability come on line, *energize* appropriate transmission system corridors supplying start-up power for units that are ready to return to service.

Load Flow

- 7000 bus model with breaker orientation
- Specific breakers are identified and breaker numbers are shown
- One line is configured to match the Operators' mapboard

PowerWorld Simulator

- Simulator is run in the “Simulation” mode providing for chronological progression of load flows as actions are taken on the system
- Lines are monitored for overloads
- Contouring is used to monitor voltage levels

Scenarios

- Saved cases are developed with specific scenarios in mind
- Islanding of a portion of the system is typical
- In an island, the largest unit becomes the default swing bus until reconnected to the larger network

System Reconstruction

- As the system is reconstructed, the island swing bus will pick up load.
- Other generation must be dispatched to keep the swing bus from exceeding its capacity.
- Load must be added in small steps to prevent collapse of the system

Restoration Procedure Assessment and Review

- Typically, Restoration Procedures prescribe very specific switching for foreseen system conditions.
- An example would be switching to restore off-site power to a nuclear plant.

Objective

- The objective is to allow operators and engineers the opportunity to test their procedure for weaknesses by watching the power system respond to the step by step implementation of the restoration procedure
- Missed steps are easily visualized by watching the re-energization take place graphically bus by bus.

Objective

- Operator review of the procedures is much more effective than a classroom review of a written document.
- When the procedure is reviewed by “doing” and the results are seen graphically, the procedure is better assimilated

System Operator Response Training

- Scenarios are created for which no specific restoration procedure exists.
- There are typically several right and wrong ways to restore the system
- Operators use NERC and company guidelines to re-establish load and generation and re-synchronize where necessary
- Additional system events are thrown at the operators in the course of re-establishing the system

Objective

- The objective is to train the operators to apply NERC and company guidelines in a variety of situations.
- Operators can experiment to develop better understanding of the guidelines
- Guidelines are better understood when operators can experience visual feedback to their implementation.

PowerWorld Simulations

PowerWorld Simulator as a Power System Simulator

- The applications described are similar to those of an EMS simulator
- For those systems that do not have an EMS simulator, this application of PowerWorld is very eye opening
- For those systems that do have an EMS simulator, PowerWorld offers the opportunity to make Power System simulation more portable.
- Operators can do simulation runs at their consoles in the control room and without the need for a simulator operator

PowerWorld Simulator as a Power System Simulator

- EMS simulators can be in high demand. PowerWorld Simulator can serve as a second simulator for certain scenarios.
- As the use of Retriever in the control room becomes more widespread, Simulator becomes more valuable in training operators and engineers in the use of PowerWorld graphics in real time. Simulator can be used to develop displays, voltage contouring and line monitoring for Retriever.
- Simulator can be used to identify early warning graphical “signatures” for potentially damaging events so that these events can be avoided.

NERC Certified Training

- Powersmiths International, Inc. has developed two NERC certified courses in Blackstart and System Restoration using computer simulation
- Attendees are awarded 4 Continuing Education Hours upon the successful completion of each course