

System Restoration after Blackout

Introduction

In case of system restoration after a blackout situation, a reliability coordinator who is responsible for maintaining a reliability of the electrical power system have to determine a regulation for taking the system back to the normal situation. Each transmission operator has to coordinate with the reliability coordinator and balancing authority in the area to prepare the system blackout restoration plan in the same standard. The transmission operator who has the black start power plant in their area has to determine the process to start up those power plants to expand their system. In the other area, the transmission operators do not be the owner of a black start power plant. They have to depend on the generation to expand their system from neighboring areas. They have to set the order for coordinating with the reliability coordinator and the nearby transmission operators to restore their system.

Definition

Transmission Operator	means	Regional Control Center
Reliability Coordinator	means	National Control Center (or an assigned group / organization after the interconnection set up in the future)
Balancing Authority	means	National Control Center (or an assigned group / organization after the interconnection set up in the future)
Reliability Improvement Committee	means	A group / organization is responsible for improving the reliability of the electrical power system
Compliance Monitoring Sub-committee	means	A group / organization is responsible for monitoring the standard of the power system control

Objective

To prepare a process of a restoration, including an available of generations and equipment, in order to bring the electrical power system back after a blackout situation.

Requirement

- Reliability Coordinator

- R-1. The reliability coordinator shall have a restoration plan that provides coordination between individual transmission operators.
- R-2. The reliability coordinator must have a coordinating role in system restoration to ensure that the reliability of the system is maintained during restoration and priority is placed on restoring the interconnection.
- R-3. The reliability coordinator shall serve as the primary contact for disseminating restoration information to transmission operators or balancing authorities and neighboring system not immediately involved in restoration.
- R-4. Reliability coordinator shall approve a coordinating and a communication between transmission operators and reliability coordinators nearby in correctly among a restoration time frame. (Pending)
- R-5. Reliability coordinator shall review the instruction, coordination and implementation during the restoration is in process in order to use for improving the plan to be a more effective.
- R-6. Reliability coordinator has to train operators to simulate different operational scenarios in emergency situations and to correctly implement emergency procedures.

- Transmission Operator and Balancing Authority

- R-1. Each transmission operator shall have a restoration plan to reestablish its electrical power system in a stable and orderly manner in the event of a partial or total blackout, including necessary operating instructions and procedures to cover emergency conditions or the loss of vital telecommunications channels.
- R-2. Each transmission operator shall document the cranking paths, including initial switching requirements, between each black start generating unit and the units to be started and it shall provide this documentation for reviewing by the regional reliability organization upon request.
- R-3. Each transmission operator shall review and update its restoration plan at least one time per year or whenever it makes changes in the power system network and it shall correct deficiencies found during the simulated restoration exercises.
- R-4. Restoration has to be carried out by the affected transmission operator with its own available procedures for implementing solving actions. Interconnection is

used in a coordinated way with neighboring transmission operators that can provide as following :-

- R-4.1 Support through active and reactive power.
 - R-4.2 Prepare and agree in advance the common actions to be taken in case of system restoration.
 - R-4.3 Coordinate the restoration action especially in case when a blackout affects neighboring system.
 - R-4.4 Exchange information to identify isolated areas and networks out of voltage.
 - R-4.5 Communicate the blackout state to other neighboring system.
 - R-4.6 Develop proper re-energization procedures allowing the progressive restoration of normal operating conditions of the system in the shortest possible timeframe.
- R-5. Each transmission operator and balancing authority shall periodically test its telecommunication facilities needed to implement the restoration plan.
- R-6. Each transmission operator and balancing authority shall train its operating personnel in the implementation of the restoration plan and they shall verify the restoration procedure by actual testing or by simulation.
- R-7. Each transmission operator shall verify that the number, size, availability and location of system black start generating units are sufficient to meet regional requirements in restoration plan.
- R-8. Transmission operators shall implement restoration procedures to re-create as soon as possible an energized main grid, to which load and generation should be re-connected step by step and considering with :-
- R-10.1 The affected transmission operator has to know as quick as possible the state of any component of its power system after a blackout, i.e.; black start capabilities, power plants in island operation and ready to re-energize, power plants in urgent need for an external source of voltage and the state of the network.
 - R-10.2 The affected transmission operator and balancing authority shall work together with their reliability coordinator to determine the extent and condition of the isolated area.
 - R-10.3 The affected transmission operator and balancing authority shall take the necessary actions to restore bulk electrical system frequency to normal state, including adjusting generation, placing additional generators on line or load shedding.

- R-10.4 Each transmission operator shall work with its reliability coordinator for immediately reviewing the interchange areas.
- R-10.5 Each transmission operator shall develop restoration plan with a priority of restoring the integrity of the interconnection.
- R-10.6 The affected transmission operator shall consider supplying generations to a highest priority loads before, i.e.; to power plants separated from the network but not secured, remote control centers, telecommunication center, etc.
- R-10.7 The affected transmission operators may re-synchronize the isolated area with the neighboring area when the following conditions are met :-
 - R-10.7.1 Voltage, frequency and phase angle permit.
 - R-10.7.2 The size of the area being reconnected, the capacity of the interchange transmission lines effecting and the number of synchronizing points across the system are considered.
 - R-10.7.3 Reliability coordinator and neighboring areas are notified and reliability coordinator approval is given.
 - R-10.7.4 Load is shed in both affected and neighboring areas, if required, to permit successful synchronizing system in restoration process.
- R-10.8 Transmission operators and Balancing authorities have to assure, during the restoration, full functionality and reliability of :-
 - R-10.8.1 SCADA System
 - R-10.8.2 Remote Control System
 - R-10.8.3 Communication system for dispatching centers

Procedure

- P-1. For setting up restoring procedures, the following aspects should be taken into account :-
 - P-1.1 Saving the integrity of the network elements and more generally of the whole power system.
 - P-1.2 Restoring generating units able to re-energize the system.
 - P-1.3 Supplying the highest priority sites before, in sequences.
- P-2. In the process of re-energizing the network, the power plants previously supplying their in-house load should gradually increase their production and proper block loads should be progressively connected.

P-3. Prefixed switching sequences for restoration are carried out under certain conditions to the purpose of saving time and reducing errors in performing switching sequences as well as to face potential communication problems.

Prefixed switching sequences may be used for preparing :-

P-3.1 Restoration paths

P-3.2 Suitable arrangements on the generation units

P-3.3 Block loads of appropriate size

Guideline

G-1. In case of a large disruption, predetermined plans on the separation of networks, e.g.; after a loss of synchronism, should be implemented with related protection devices.

G-2. In case of a large scale collapse involving several transmission operators, each transmission operator is entitled to give priority to restore its internal system prior to re-establish the interconnections.

G-3. The restoration plan should describe all the actions necessary to restore normal conditions of supply in a timely and reliable manner.

G-4. Transmission operations should define several scenarios in a restoration plan by using situations with the highest probability of occurrence and with general validity. Restoration plans are based on the identification of proper restoration paths or to keep the system out of the voltage control problem.

G-5. After a blackout, a quick system operation analysis should be possible for operators to arrive at a hypothesis about the contingency sequences that produced the blackout. As a result, operators should be possible to establish the right order to start the proper restoration paths.

G-6. The reliability of restoration paths should be periodically studied and practically tested, if possible. Tests should refer in particular to :-

G-6.1 Black start capability

G-6.2 Load rejection efficiency

G-6.3 Times required for predetermining the restoration paths

G-6.4 Efficiency check of involved protections and automatic devices

G-7. Transmission operators and balancing authorities shall assure that the communication system is always ready for the process.

- G-8. The training of operators or the simulation is recommended to indicate and improve the operators' ability in responding to emergencies and unusual scenarios which rarely occur in practice on the electric system.
- G-9. Transmission operators should hold periodical meetings with other interested operational units in order to illustrate the application of the restoration plans and to study more accurately the problems concerned.
- G-10. Due to economic and social effects of a blackout, it is necessary to establish an internal and external communication plan. Transmission operators should communicate to the main stakeholders involved to inform them about the operational situation of the system. Further communication should help transmission operators to avoid interference with the operational activities of the control centers during a restoration procedure.

Measure

- M-1. The transmission operator must have the restoration plan to reestablish its electric system, black start testing, block loads and cranking paths to supply power for power plants' station services available for reviewing by the regional reliability organization at all times.

Compliance

- Compliance Monitoring by Sub-committee

- C-1. Compliance Monitoring

- C-1.1 Compliance Monitoring Responsibility

- Reliability Improvement Committee is responsible for setting up the Compliance Monitoring Sub-committee

- C-1.2 Compliance Monitoring Period and Reset Timeframe

- One or more of the following methods will be used to assess compliance :-

- C-1.2.1 Conducted annually with submission according to schedule.
(Self Certification)

- C-1.2.2 Conducted anytime with up to 30 days notice given to prepare.
(Spot Check Audits)

- C-1.2.3 Conducted once every three years according to schedule.
(Periodic Audit)

C-1.2.4 Notification of an investigation must be made within 60 days of an event or complaint of noncompliance. The entity will have up to 30 days to prepare for the investigation. An entity may request an extension of the preparation period and the extension will be considered by the compliance monitor on a case-by-case basis. (Triggered Investigations)

C-1.3 Compliance Information

C-1.3.1 Each reliability coordinator shall have the current version of its restoration plan and the plans of its transmission operators and the adjacent reliability coordinators.

C-1.3.2 Each reliability coordinator shall keep historical data gathered during the restoration period until normal system operation resumed for three years.

C-1.3.3 Each reliability coordinator shall keep the reports of restoration training for the operators.

- Compliance Monitoring by Self-certify

C-2. Compliance Monitoring

C-2.1 Compliance Monitoring Period and Reset Timeframe

Each transmission operator shall annually self-certify to the regional reliability organization that the following criteria have been met :-

C-2.2 Compliance Information

C-2.2.1 The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements, a set of procedures for annual review for simulating and actual testing in practical and a verification of the restoration plan.

C-2.2.2 Any significant changes to the restoration plan have to be reported to the regional reliability organization.

C-2.2.3 Annually documentation records of operating personnel training to implement a restoration plan in practical.

C-2.2.4 A blackout restoration plan in up-to-date version.

C-2.2.5 The number, size, availability and location of system black start generating units including in transmission operators'

restoration plan are sufficient to meet regional reliability organization's requirements.

C-2.2.6 The cranking or switching paths between each black start generating unit and units depended on the others have been documented in order to reviewing by the regional reliability organization.

C-2.2.7 Annual reports of power plants' black start testing

Level of Non-Compliance

- Level 1 : Plan exists but it is not reviewed annually.
- Level 2 : Plan exists but it does not addressed one of the requirements in Attachment 1.
- Level 3 : Plan exists but documentations showing the number, size and location of system black start generating units and the associated cranking paths are not made available.
- Level 4 : Plan exists but if does not addressed two or more of the element lists in Attachment 1 or No restoration plan in place.

Attachment 1

The restoration plan has to be considered with the following requirements :-

1. Procedures outlining the relationships and responsibilities of the personnel necessary to implement system restoration.
2. The provision for a reliable black start capability plan, including fuel resources for black start power for generating units, available cranking paths, communication adequacy, communication protocol and power supplies for communication system.
3. The plan has to account for the possibility that restoration cannot be completed as expected.
4. The necessary operating instructions and procedures for synchronizing areas of the separated system.
5. The necessary operating instructions and procedures for restoring loads, including identification of critical load requirements.
6. A set of procedures for simulating, actual testing in practical and a verifying of plan resources and procedures.
7. Annually documentation records of operating personnel training to implement a restoration plan in practical.
8. The coordination procedures with reliability coordinators and neighboring transmission operators. (The plan should include references to coordination of actions among neighboring transmission operators and reliability coordinators when the plans are implemented.)
9. Notification shall be made to other operating entities as the steps of the restoration plan are implemented.