Understanding the National Power Grid and How it Impacts Timeframes for Power Restoration

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Presenter

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Presentation Objectives

• Basic Understanding of the Grid
• Terminology used (short list)
• Regulatory Body Hierarchy
• Limitation and Mitigation of Electric Grid
• Emergency Plans

• Priorities
• Historical Events
• System Restoration
• Electric Sector Preparations
Standard of Conduct

Standard of Conduct: Govern the relationship between;
• Transmission
• Marketing

Are intended to protect competitors from any attempt by Transmission Provider, to provide an advantage to its, or its affiliates Transactions

Standard of Conduct requires:
• Independent Functioning
• Prohibitions on sharing of Transmission Information

Transmission Information
• Information that a market participant might find useful
  • Transmission capacity and flows
  • Price and Rate design
  • TLR’s/curtailments
  • Balancing
  • Maintenance activity and outage schedules
• Information about or from 3rd-party transmission customers
Overview

Electric-power transmission is the bulk transfer of electrical energy, from generating power plants to electrical substations located near demand centers or referred to as electric power distribution.

Transmission lines, when interconnected with each other, become transmission networks.
• Typically referred to as "power grids" North America has three major grids,
  • Western Interconnection,
  • Eastern Interconnection
    • Quebec Interconnection, because of its unique status, it is often functionally considered part of the Eastern Interconnection.
  • Electric Reliability Council of Texas (ERCOT) grid,

Are often referred to as the Western System, the Eastern System and the Texas System.

Historically, transmission and distribution lines were owned by the same company, but starting in the 1990s, changes in regulation of the electricity market have led to the separation of the electricity transmission business from the distribution business.
**Terminology**

- **Independent System Operator (ISO)** coordinates, controls and monitors the operation of the electrical power system, usually within a single US State, but can encompass multiple states.
- **RTOs** typically perform the same functions as ISOs, but cover a larger geographic area.

**RC** – Reliability Coordinator

**TOP** - Transmission Operator

**TO** - Transmission Owner

**GOP** - Generator Operator

**GO** - Generator Owner

**BA** - Balancing Authority

**LSE** – Load Serving Entity

**Bulk Power System** is defined as network voltages 100kV and over. Another term used more commonly is Transmission System

**System Restoration** is the term that is used by NERC and is recognized by RFC and FERC. It is defined as being the total restoration of a partial or total collapse.

**Blackstart** is used to describe the starting of Generating Units from a energized source.

**Cranking Path** is used to describe the path from energizing source to Generating Units.
Regulatory Body Hierarchy

U.S. Congress

FERC

NERC

NERC Region

ISO/RTO

Electric Company

State Commissions

Federal Energy Regulatory Commission (FERC)

North American Electric Reliability Corporation (NERC)

Electric Reliability Organization (ERO)

ReliabilityFirst Corporation (RFC)

Regional Reliability Organization (RRO)

Regional Transmission Organization (RTO)
North American Electric Reliability Corporation (NERC) Regions

FRCC - Florida Reliability Coordinating Council
MRO - Midwest Reliability Organization
NPCC - Northeast Power Coordinating Council
RFC - Reliability First Corporation

SERC - SERC Reliability Corporation
SPP - Southwest Power Pool, RE
TRE - Texas Regional Entity
WECC - Western Electricity Coordinating Council

Note: The Alaska Systems Coordinating Council (ASCC) is an affiliate NERC member.
Electric Limitations and Mitigation

Energy cannot be stored and must be generated as needed.

Complex control system is required to ensure electric generation matches the demand.

If the demand for power exceeds the supply, in the worst case scenario,
- can lead to a major regional blackout, such as occurred in the US Northeast blackouts of 1965, 1977, 2003, and other regional blackouts in 1996 and 2011.

To reduce the risk, electric transmission networks are interconnected into regional networks providing multiple redundant alternative routes for power to flow should weather or equipment failures occur.

Analysis is done by transmission companies routinely to determine the maximum reliable capacity of each line
   To ensure spare capacity is available should there be any such failure in another part of the network the capacity less than its physical or thermal limit.
Emergency Operation Plans

Emergency Operations - Every effort is made to avoid interrupting system load. Under certain operating conditions, it is necessary to curtail or interrupt customer load if generation is not available or there are capacity limitations. Could include but not limited to public appeal, curtailment programs, voltage reduction, rotational distribution interruptions, load shed, etc.

• Coordinated by ISO/RTO
• Public Sector will be notified prior to implementing if adequate time is available
• Comply with NERC Standards

System Restoration – contains instructions and contingency plans necessary to conduct a partial or total system restoration. These plans meet or exceed ERO, RRO and RTO requirements.

An important facet of these plans is the flexibility to adapt to any condition that is encountered on the power system with respect to major disturbances that affect the system. These major disturbances may result from various elements such as storms, solar magnetic disturbances, multiple facility outages, shortage of generation, under-frequency operation, or any combination of the above.

• Each Transmission / Generation owner has an obligation to protect their own system’s equipment and reliability. Steps taken to do so are coordinated, with the ISO/RTO

Restoration - emergency response is driven by events such as customer outage(s), network facilities interruption(s), preparation for a potential event, or an event that requires an immediate response. To be in a constant preparedness state and to have the ability to respond when required, the restoration process is broken into four modes: sustained preparedness, pre-event, event and post event.
System Emergency Conditions

Emergency Operations
• Capacity - Not enough generation to meet load.
  • Solutions: find additional generation resources, or reduce load requirements
  • RTO issues Alerts, Warnings, Action

• Transmission Security
  • IROL - Interconnection Reliability Operating Limits
  • TLR - Transmission Loading Relief
  • Heavy Load, Low Voltage Condition
  • Voltage Reduction
  • Etc

• Weather/Environmental

• Sabotage/Terrorism

• Disturbance Conditions
Audience Poll Question

At this point, do you feel that a storm event (Thunderstorms, Ice, Snow, Hurricanes) could have a utility operating from all three Emergency Plans (Emergency Operations, System Restoration, and Restoration)?
Impacts Timeframes for Power Restoration

Color Key:
Black: Generation
Blue: Transmission
Green: Distribution

Emergency Operations
System Restoration
Restoration

Generating Station
Step Up Transformer

Transmission lines 765, 500, 345, 230, and 138 kV

Transmission Customer 138kV or 230kV

Substation Step Down Transformer

Subtransmission Customer 26kV and 69kV

Primary Customer 13kV and 4kV

Secondary Customer 120V and 240V
Audience Poll Question

Could you expect normal restoration priorities to change from a storm event if procedures are required to maintain a reliable grid operations?
**Power Restoration Process**

In the event a system is damaged by severe weather, we repair equipment which will restore the largest numbers of customers first, with some exceptions.

Generally, the sequence is as follows:

1. Downed live wires or potentially life-threatening situations
   - public health and safety facilities without power.
2. Transmission lines serving thousands of customers,
3. Substation equipment,
4. Main distribution lines serving large numbers of customers;
5. Secondary lines serving neighborhoods,
6. Service lines to individual homes and businesses.
Customer Restoration

1. Eliminate safety hazards
   • Fires
   • Live wire down
   • Vehicle accidents involving Electrical facilities
   • Any safety hazard involving Electrical facilities that could affect the public

2. Restore substations and main feeder lines
   • The specific order by which substations and main feeder lines are prioritized will, for the most part, be based upon the existence of critical services/customers as defined below which are served by those facilities.

3. Restore critical services
   • Hospitals
   • Emergency services (911, fire, police, etc.)
   • Communication facilities (operating as part of the Emergency Broadcast System)
   • Water/sewage facilities

4. Restore service to the largest blocks of customers
   • This should facilitate the restoration of service to most life support customers and emergency shelters possible.

5. Restore service to individual transformers and secondary
   • At this point, life support customers will be prioritized to have service restored first, when possible.
System Restoration Priorities

System Network

- Damage Assessment – Control area and bulk electric system
- Stabilize islands and reduce contingency impact by building loops
- Generating Units (ALL) on-line priority of load to stabilize unit
- Generating Units (ALL) availability and status (hot, cold, etc)
- Generating Units (ALL) implement shut-down and start-up procedures
- Cranking paths prepared to most available Power Stations by startup times
- EHV Generating Units priority
- 500Kv Backbone - Build Transmission System to re-energize 500kV System
- Synchronize islands for Parallel operation
- Prepare Stations for load pickup
- Restore and maintain communications facilities and networks
- Restoring the integrity of the Interconnection (i.e. EHV Ties)
Audience Poll Question

Could you expect issues on the grid to impact distribution restoration timeframes?
Potential Causes of a System Restoration Event

Blackouts originate from power system disturbances resulting in loss of service to all loads within an area.

• System disturbances are reported when they turn into large service interruptions.

Some of the main causes for system restoration:

• Faulty conventional protection and control equipment.

• Faulty special protection (i.e. generation rejection scheme)

• Faulty high voltage equipment

• Weather other than lightning’ (Ice, Tornados, Hurricanes, etc)

• Lightning

• Solar magnetic disturbances

• Personnel errors
## Historical Major Disturbances

<table>
<thead>
<tr>
<th>Event</th>
<th>Millions of people affected</th>
<th>Location</th>
<th>Date</th>
<th>Initiated and Partial Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>July 2012 India blackout</strong></td>
<td>670</td>
<td>India</td>
<td>July 2012</td>
<td>Load, Heat, Lack of Generation</td>
</tr>
<tr>
<td><strong>2005 Java–Bali blackout</strong></td>
<td>100</td>
<td>Indonesia</td>
<td>Aug 2005</td>
<td>Equipment Failed</td>
</tr>
<tr>
<td><strong>1999 Southern Brazil blackout</strong></td>
<td>97</td>
<td>Brazil</td>
<td>March 1999</td>
<td>Storms</td>
</tr>
<tr>
<td><strong>2009 Brazil and Paraguay blackout</strong></td>
<td>87</td>
<td>Brazil, Paraguay</td>
<td>Nov 2009</td>
<td>Storms</td>
</tr>
<tr>
<td><strong>Northeast blackout of 2003</strong></td>
<td>55</td>
<td>the United States, Canada</td>
<td>Aug 2003</td>
<td>Tree software bug</td>
</tr>
<tr>
<td><strong>2003 Italy blackout</strong></td>
<td>55</td>
<td>Italy, Switzerland, Austria, Slovenia, Croatia</td>
<td>Sep 2003</td>
<td>Storms</td>
</tr>
<tr>
<td><strong>Northeast blackout of 1965</strong></td>
<td>30</td>
<td>the United States, Canada</td>
<td>Nov 1965</td>
<td>Human Error</td>
</tr>
</tbody>
</table>
1998 Canadian Ice Storm

Between January 4th and 10th, 1998, parts of Eastern Ontario and Western Quebec were hit by 3 successive storm fronts that have been called the greatest natural disaster in Canadian history.

Close to 1.4 million people in Quebec and 230,000 in Ontario were without electricity. In some cases, people stayed without power for up to six weeks. It was the most destructive storm in Canadian history.
A sudden uptick in electricity use coupled with a sudden drop in wind power caused the unexpected dip.

At about 6:41 p.m., power grid operators ordered a shutoff of power to so-called interruptible customers, which are industrial electric users who have agreed previously to forego power in times of crisis.

The move ensured continued stability of the grid after electric reserves dropped to alarmingly low levels.

As a result, grid officials immediately went to the second stage of its emergency blackout prevention plan

This situation could of lead to regular customers being dropped through rotating outages, but that would occur only as a last resort to avoid the risk of a complete blackout
June 4, 2008 500kV Tower Collapse

On June 4, 2008 at 14:11 EST two 500kV transmission lines tripped and locked out (cause was a tornado)

Helicopter patrols located a leaning tower. The leaning tower presented a potential danger of falling into two 230kV lines.

The lines were switched off and then the tower was secured followed by the two 230kV lines being put back in service.

Erected a temporary structure and had the 500kV transmission line in-service 3 days later

- High Temperatures
- High Loads
- RS Restoration Activity
Distribution Load

Power Station

Blackstarting Unit

Transmission System (Bulk Power)

Cranking Path – line from one PS to another for blackstarting

Power Station

Blackstarting Unit

Distribution Station

Load is picked up according to Priorities Circuits (Hospitals, Water, etc)
But load is used to stabilize unit

Power Station

Blackstar t Capable Station
System Network (Grid) Preparations

- Routine Capacity Studies
- Line Patrols
- Coordinated Outages Schedules
- Real Time Scheduled and Unscheduled Outage Studies
  - N-1, N-1-1 and N-2
- Summer Readiness Reviews
- Situational Awareness Tools
  - Loads, Voltages, Frequency, Temps, SMD, etc
- RTO Exercises/Drills
  - TO’s Exercises/Drills
- System Operators Certifications and Continuing Education Hours (CEH)
- Training
  - RTO and TO’s Training
Questions

Comments

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