System Restoration Developments at ISO New England

March 8, 2012 meeting with PJM and members
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Presentation Objectives

• Define a Top Down System Restoration plan and understand differences from the Bottom Up System Restoration approach

• Introduce system restoration developments during 2008 – 2011

• Identify (7) new electrical islands of interest in New England

• Introduce generator conversion requirements

• Identify next steps in the black start program
Top Down System Restoration

• **Current Approach**
  - Bottom Up System Restoration uses small black start resources far from 345kV lines and nuclear units

• **What is Top Down System Restoration?**
  - Re-energizes transmission system using large black start resources at or near 345kV system and nuclear units
Top down – energize 345 kV before load

Bottom up – energize local 115 kV circuits & load before 345 kV
Current Challenges

- The current restoration plan requires significant coordination because:

  - 22 separate islands throughout New England
  - 67 black start generators (over half <20MW)
  - Island synchronization coordination
Current Challenges

- time consuming

  - Black start resources are located near cranked units that do not run frequently
  - Time to restore power to nuclear units 2-3 times as reported by other areas
  - Aging units may retire
    - Compliance requirements and costs
NERC Standard Requirements

- Plan accounts for outages, damage, etc
- Black start units must be right size, location and number
- Black start units must have enough real and reactive power
Regulatory Requirements

- NERC Reliability Standards (New)

  • EOP-006-2,– System Restoration Coordination
    • “Each Reliability Coordinator shall have a Reliability Coordinator Area restoration plan…The scope of the plan ends when all of its TOPs are interconnected and its RCA is connected to **ALL** of its neighboring RCAs”
Regulatory Requirements, *cont.*

- NPCC Directory 8, System Restoration
  - Identify the Basic Minimum Power System(s) (BMPS).
  - Prioritize restoring off-site power to nukes.
  - Identify interconnection points.
  - Identify synchronization parameters.
  - Coordination of restoration with neighbor RCA.
  - Cranking paths to major generators and inter-tie points.
  - Island stabilization.
  - Identify adequate on-site fuel resources for supplemental generators to supply station service for key facilities.
ISO New England 2008-2012 Efforts

• Technically driven by New England’s System Restoration Working Group with compliance focus (SRWG members = ISO, LCCs and TOs)

• Proactive effort to address plan and compliance

• Reassessed approach to restoration (Bottom Up versus Top Down)

• Focused on size and location of black start resources – 22 candidate black start resources identified by SRWG in 2008-2009

• Final study report developed and validated by independent consultant to enhance the black start fleet – 2010

• Stakeholder technical presentations held in 2011 (Reliability, Transmission Committees)
Final Study Report Recommendations

• Changing plan to:
  – Restore off-site power to nuclear units faster
  – Provide a quicker and more efficient system restoration time.
  – Establish inter-area tie connectivity with our neighbors more effectively.

• Identifies approximately 1500MW of additional black start resources needed
  – Conversion to black start required for most or all
New Regional Top Down System Restoration Plan

- Seven new islands of interest in New England
  - South of Boston
  - Rhode Island
  - Connecticut
  - Central MA
  - Boston
  - New Hampshire
  - Maine
System Restoration Regional Goals

1. Decreasing time to provide off-site AC power sources to nuclear stations

2. Establish 345kV New England backbone

3. Interconnect with the New York and Eastern Interconnection

4. Interconnect with New Brunswick
System Studies Performed

- Identified and verified cranking paths
  - Start from black start units
  - Provide cranking power to major generating stations, including nuclear stations
  - Enable interconnection of local islands
  - Restore ties to external areas

- Load Flow, Stability and Transients Analysis
Steady-State Analysis

• Leading and Lagging Power Factor requirements

• Selection of transformer tap positions

• Voltage Control and balancing of transmission system charging capacitance
Dynamic Analysis

- Excitation system dynamic response
- Frequency stability and governing response
- Dynamic voltage response to starting of large motors
- Self-excitation and fundamental frequency temporary over-voltages (TOV)
- BSR dynamic response to load rejection, over-frequency, over-flux and fundamental frequency TOV
Switching Transients

- Simulate switching transient over-voltages
- Key restoration switching transient issues:
  - Ring buses with 345 kV cables
  - Switching Surges from energizing 345 kV circuits
  - Temporary Over-voltages (TOV) from energizing large transformers

PSCAD Graphs

System Restoration Developments ISO New England 2012
Conclusions of System Studies

• Viable Concept
• Can meet the restoration goals
• Improvement to the existing plan
• Candidate black start units identified and ranked
• Initial plans tested and found to be sound
• Ongoing process
Study Conclusions

- Black start resources capable of quickly energizing 345kV

- Add Large Frame Combustion Turbines
  - 150+ MW Range

- Focus on existing Combined Cycle installations
  - Previously these units have had limited application in Black Start Plans
Unit Conversion

• Black Start Diesels or Small Gas Turbine Start Source
• Station Service Switchgear Lineup Breaker Position
• Dead Bus Closing Logic
• Synchronizing scheme to synchronize large generator to cranking source supplying station service
• Isochronous Control Logic
• HMI Control Interfaces
On Site Start Up Power
Option #1 - Diesel Generators

• Advantage over a small Gas Turbine is lower cost

• Advantage - can use “1 out” redundancy e.g. 1 of 2 or 5 of 6 to start

• Disadvantage is larger footprint (real estate)

• Starting diesels need not be dedicated to a particular Gas Turbine in the plant
On Site Start Up Power
Option #2 Small Gas Turbine

• Higher Cost/Smaller Footprint
• Could be considered where large MW starting requirement needed or real estate is limited
• Cranking source ability to black start any Gas Turbine in the plant, like the diesels
Station Service Switchgear Addition

- Facility needs to have room and electrical capacity for addition of a new breaker position for the black start source (or possible addition to existing emergency diesel tie).
- The Black Start source can be used to supply emergency backup power with fewer limitations
Static Start

- Special Considerations for Static Start (LCI).
- Cranking power sources with high short circuit capability may be required due to harmonics.
Generator Controls
Modifications

• Generators should be fitted with isochronous controls.

• Generators need to be modified for “dead-bus” closing schemes.

• Synchronizing scheme development to synchronize large GTs with diesel or small GT supplied station service.
Combined Cycle
Steam Cycle Bypass Option

Bypasses High Temperature Exhaust from Gas Turbine to Atmosphere

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Disadvantages</th>
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<tr>
<td>Allows more flexible operation by allowing full Gas Turbine output without waiting for gradual heating required for the Steam Cycle Equipment.</td>
<td>Less efficient operation because of leaks in the bypass damper system. Heat that would otherwise be used to make power is wasted. Cost of damper equipment.</td>
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Industry Advisory
Turbine Combustor Lean Blowout
Issued June 26, 2008

• February 26th, 2008, the FRCC Bulk Power System experienced a system disturbance, **frequency off-nominal**. Loss of approximately 2,300 MW of load along with the loss of approximately 4,300 MW of generation.

• Indications are that six combustion turbine (CT) generators within the Region that were operating in a lean-burn mode (“Dry Low NOx or DLN” used for low emissions) tripped offline as result of a phenomenon known as “turbine combustor lean blowout.”
Industry Advisory
Turbine Combustor Lean Blowout
Issued June 26, 2008

- The Alert recommends specific coordination between the generator manufacturers and bulk power system analysts to ensure that machine performance is appropriately modeled in specific dynamics analysis studies.

- ISO New England had detailed discussions with manufacturers to address this issue with regard to black start. Manufacturers documented that these types of units are suitable for black start.

- Manufacturers want to review loading interaction with DLN – may not just use a 5% step.
Procedure Revisions in Future

• ISO New England OP-11, *Black Start Testing*
  – Details to come including CIP recovery before 2013

• ISO New England OP-6, *System Restoration*
  – This will be an evolutionary revision as new assets become available and old assets are released.
  – Managed by the System Restoration Working Group. Revisions are underway as some black start resources will be terminated due to lack of effectiveness.

• Various System Operating Procedures (SOPs)
Where we are now

• Concluding a site-by-site assessment with independent consultant to identify preliminary plant black start conversion requirements.

• Reports will be shared with owners to complement black start conversion decision between ISO and generator owners.

• Effective date for the new black start rate is January 1, 2013

• Plants can begin to enter program

• May take years until sufficient resources for full top-down plan
Review

- Top Down seeks to black start large units at or near 345kV
- The result is fewer islands
- Faster to nuclear units
- Faster to interconnections
- System restoration time reduced
Additional Detailed Information

- Plenty of materials from fall 2011 available at:
  

- Contact information

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