System Restoration Strategy Senior Task Force (SRSTF)
Final Proposal Report on System Restoration Strategy Changes

2/22/13

System Restoration Strategy

Due to industry developments such as new environmental regulations, NERC CIP standards and increasing cost of Black Start generation, PJM foresees a potential future reliability issue with the current method of System Restoration Planning. The System Restoration Strategy Senior Task Force was chartered on January 26, 2012 by the Markets and Reliability Committee to address these issues.

Specifically, the Task Force examined the current System Restoration Planning process to determine its viability and efficiency moving forward and recommended changes to the System Restoration Strategy.

As background education, the Task Force reviewed current System Restoration planning processes, Minimum Critical Black Start Requirements (as defined in M-36, Attachment A), applicable NERC Standards relating to System Restoration, targets and goals or restoration, System Restoration target times and requirements for evaluation of new generation for Black Start capability.

1. Recommended Proposal

The SRSTF developed and support the proposal below. This proposal achieved majority support (50.89%) at the System Restoration Strategy Task Force.

Design Component #1 – Restoration Time (Target)

PJM has shown analysis that indicates the current 24 hour restoration target time is not achievable given the assumptions of a complete blackout with no outside assistance. Further analysis indicates that even in an optimal hypothetical situation in which all units are Black Start capable; a 24 hour system restoration is unlikely. Transmission Owners may elect to include System Restoration time estimates for their zone in their individual restoration plans, if desired.

For these reasons, **PJM has eliminated the time targets from Manual M-36** (Section 3.1, Attachment A) and M-12 (Section 4.6.6). PJM has replaced the time references with the following statement:

A system assessment following a blackout is a critical first step in identifying an overall system restoration time. While PJM and its Members work to restore the integrity to the interconnection as quickly as possible, there are a wide variety of factors that can influence a system restoration. Once the system conditions following a blackout are known, estimates of restoration times of the Bulk Electric System (BES) transmission and customer load restoration estimates can more accurately be made.

Design Component #2 – Redundancy

The SRSTF recognizes the need for some redundancy in Black Start generation. Redundancy allows for system restoration even if some Black Start resources are unavailable, potential system damage precludes use of certain Black Start resources and also allows for variance between Critical Load calculations and actual needs. This redundancy can be accomplished in different ways including adding margin to the Critical Load calculation (which in turn should result in a higher amount of Black Start capability than should be required for Critical Load) and requiring a minimum number of Black Start resources within a defined restoration area.

The SRSTF recommends the following actions to achieve redundancy:

1) **Add a 10% margin of Critical load to the Black Start requirement**. This will account for an average forced outage rate (5%) plus an allowance for additional, unexpected Critical Load (5%).
2) **Ensure a minimum of two Black Start resources are "allocated" to each transmission zone with a Critical Load requirement**. Note that the Black Start resources are not required to be physically located within the zone to which they are allocated. However, each zone must be able to identify within their System Restoration plan the two resources allocated to them during a System Restoration. Exceptions to this "two resource rule" will be allowed with PJM and System Operation Subcommittee-Transmission (SOS-T) endorsement.

In some cases, the same Black Start resource may be used to serve critical load in multiple TO zones if it has the capacity available to do so. Upon full aggregation of TO Restoration Plans into new Restoration "zone", redundancy will be measured based on the redefined area (see Cross Zonal coordination section below)

Design Component #3 – Cross Zonal Coordination

The SRSTF recommends a proactive approach to identifying areas of the system where it would be beneficial to coordinate Transmission Owner (TO) Restoration plans. PJM would work with the TOs to identify areas in the RTO where it would be beneficial to coordinate System Restoration plans based on:

- Reliability requirements including:
  - Procuring sufficient Black Start resources to meet crticial load requirements
  - Meeting critical load restoration timing requirements
  - Meeting redundancy requirements
- Technical feasibility requirements including:
  - Maintaining voltages within limits
  - Maintaining MW flows within thermal limits
  - Maintaining dynamic stability of generation
  - Timing requirements of serving critical load
  - Test history and performance history of Black Start resource
- Complexity considerations
  - Amount of switching to establish cranking path(s)

        - Characteristics of cranking path (length, geography, travel time, number of substations, voltage level, etc)
        - Staffing availability (field/control room) to support building cranking path to neighboring area
            - SCADA versus Manual control
    - Logistical coordination
        - Adjacent TO zones only (do not cross 3 or more zones)
        - Type of load restored in each TO zone
        - Potential additional TO costs incurred to enable cross zonal coordination
        - Number of TO zones in coordination with a single TO zone
- TO/State Relationship considerations
    - States may want priority of restoration to remain local
- Cost Savings
    - PJM will work with the TOs on a cost/benefit analysis for decisions on utilizing cross zonal coordination. The cost/benefit analysis will require a savings ratio of 1.2 (benefit to cost) threshold for consideration. Cost benefit ratio will evaluate:
        - Black Start unit cost differences (savings)
        - Potential additional TO costs including coordination costs, CIP related costs and other costs the TO might incur (such as increased training, increased analysis of the restoration plan, increased compliance cost, etc)
- Increased efficiency
- Increase in speed of restoration

There are three possible levels of Cross Zonal Coordination:

Level 1 – Supply Black Start from outside TO zone to meet TO critical load requirements

- This would be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- Restoration Plans would be on a TO basis, but coordinated between TOs.
- PJM would work with TO to identify these situations
- Redundancy on a TO zonal basis (2 BS units allocated to each TO zone, though physically may be outside zone)
- The TO may acquire additional Black Start above the PJM requirements outside of the PJM OATT through bilateral contracts, if desired.

Level 2 – In collaboration with TOs, identify opportunities to supply critical load and/or customer load pockets across TO zones

- This could be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability

requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- A single Black Start unit may serve critical load in multiple TO zones
- Restoration Plans would be on a TO basis, but coordinated between TOs.
- Redundancy would be on a TO basis (2 BS units allocated to each zone, though physically may be outside zone)

Level 3 – In collaboration with TOs, Identify opportunities to fully aggregate TO Restoration Plans
- This could be done to eliminate a Black Start shortage in a zone (reliability requirement), meet critical load restoration timing requirements (reliability requirement), improve restoration speed or efficiency (efficiency opportunity) or significantly reduce Black Start cost (efficiency opportunity).
- This could be merging of 2 or more existing TO zones or creating new Restoration Regions (new boundaries).
- Restoration plan would be for aggregated area(s).
- Redundancy would be evaluated on a Restoration region basis

Design Component #4 – Entity responsible for Black Start selection

PJM, in its role as Transmission Operator (TOP), is responsible for selecting the Black Start resources for a System Restoration plan. PJM would work closely with the TOs to identify these units based on:
- Critical Load requirements
- Available Black Start resources
- Minimum number of Black Start resources allocated to a zone
- Possible cross zonal coordination opportunities

. The TO will adjust its System Restoration plan based on the Black Start units allocated to it from this selection process. The TO has the option of procuring additional Black Start resources (if not already procured by PJM), but the costs of these resources will be recovered, if necessary, outside of the PJM Open Access Transmission Tariff (OATT).

Should there be a disagreement about the location, amount or number of Black Start resources, or disagreement between the supplying TO, receiving TO or PJM about cross zonal coordination, the following process will be followed:
- The parties involved would bring the issue to the SOS-T for consultation
- If the parties continue to disagree, the issue would be referred to the Dispute Resolution Process
    - General notification of initiation and result of Dispute Resolution process will be given to the Operating Committee

Design Component #4 and #5 – Tiered approach to Black Start

The SRSTF recommends revising the current requirement of 90 minute start time for Black Start resources to a three hour or less start time requirement.

This change would recognize the changing generation landscape and allow for the potential for more Black Start resources to be recognized in System Restoration planning. This simple change could allow up to an additional 64,000 MW of resources to potentially supply Black Start. It is estimated that about 2,000 MW of this could supply Black Start with no plant modifications. PJM would allow exceptions to this three hour criteria on a selected basis if it benefits the System Restoration plan.

PJM will utilize the start time parameters and test data to evaluate the Black Start resources and whether these resources will meet the requirements of the restoration plans. PJM may require some Black Start resources to adhere to less than a 3 hour start time given critical load restoration timing requirements. These units will be notified of this timing requirement and tested to it during annual Black Start testing. PJM recognizes that Black Start resources with three hour start times may not be appropriate to meet nuclear power off-site safe-shutdown load restoration requirements. PJM will retain the 4 hour time target for restoration of off-site power to nuclear stations.

Design Component #8 – Amount of Black Start MW required

The SRSTF proposes redefining the existing definition of Critical Load to the following:

Critical Load is the sum of the following components:

a) **Cranking power to all units with a hot start time four hours or less***
b) **Off-site Nuclear Station Light and Power**
c) **Critical Gas Infrastructure**
d) **Exceptions or additions to the criteria shown above will be allowed with PJM approval**
    1. **SOS endorsement will be sought for these exceptions and additions and the nature of the exception will be discussed at the Operating Committee.**
    2. **One such example could be to address coping power needs for steam units that cannot be supplied by resources other than Black Start.**

The prominent change from the existing Critical Load definition is in component (a). The current definition is “cranking power to critical steam units with a hot start time of 8 hours or less”. *The change was to include the cranking power for ALL units (not just steam) and change the start time to a hot start time of four hours or less.*

The justification for this change is to target the use of the cranking power to *any* unit that can start in four hours or less. PJM estimates that this is about 70,000 MW of capacity. This will provide significant generation capacity that could be utilized in the early stages of a System Restoration. Once this “four hour” generation is online, it can be used to supply the cranking power to units with longer than a four hour start time.

*Note: For generating stations with multiple units (0-4 hour start), consider the impact on restoration time if only enough critical load was carried to start one of the units at the station. This unit could then supply the other units at the station with auxiliary power. If doing this would increase restoration time significantly, critical load will be identified for all units at the station. Consideration will also be given to whether plant personnel can start all units at the plant in parallel given physical plant or resource constraints.

Required Black Start = 110% (Critical Load requirement) on a locational basis

This requirement reflects the redundancy proposed in Design Component #2. It is recognized that while this requirement is specified on a TO zonal basis, that zones may be aggregated, as described in Design Component #3, such that the Black Start resources may physically lie in adjacent zones.

Design Component – Procurement Option

The SRSTF recommends a 5 year Selection Process for Black Start Generation procurement. Every 5 years, PJM issues an RFP for Black Start generation. This RPF would be open to all existing and potential new Black Start units on a voluntary basis. Existing compensated BS units do not need to respond to RFP (assumption is they will continue to offer to provide BS at current rate, but not guaranteed to be selected to provide BS going forward). If existing units are not interested in supplying BS going forward, they would need to send PJM a termination notice per current process. If existing units want to change their rate utilized for cost recovery, they would need to terminate current agreement and resubmit.

PJM will work with TOs to select units on the basis of Critical Load requirements, location, cost and operational considerations (amount, start time, etc). Units on cost recovery rate would be automatically selected for the length of the cost recovery. Units on bilateral contracts with TO would be automatically selected for use in those zones.

Length of commitment would remain a minimum of 2 years (or longer based on capital recovery time). Compensation for units not electing to recover black start capital costs is based on the PJM OATT Schedule 6A formula rate. Compensation for units electing to recover black start capital costs would be based on the PJM OATT Schedule 6A Capital Recovery Rate based on age of the unit.

Design Component – Incremental Procurement

The SRSTF recommends retention of the existing RFP process with added flexibility. Upon Black Start resource notice of termination (requiring a one year notice); PJM will work with the TOs to identify if replacement Black Start is required. PJM will evaluate if existing Black Start from outside the zone or refurbishment of existing units within the zone may be utilized to meet the requirement. If required, PJM will issue an RFP to procure this Black Start. If no resources or not enough resources are procured, PJM will expand the

geographic scope or MW amounts of the RFP and re-issue. If still no resources are procured, PJM will utilize the Reliability Backstop option, if required.

Design Component – Reliability Backstop

The SRSTF recommends a Reliability Backstop option.

Triggers for the Reliability Backstop:

- 2 failed incremental RFPs – no technical solution available even after consideration of cross zonal coordination options
- Technically feasible solution available, but not economically feasible (not in accordance with OATT rate or FERC rate is rejected)
- Reliability criteria not met in 5 year Selection process in one or more areas

Allow Reliability criteria exceptions for the following situations:

- Black Start capacity less than Critical Load Requirement
- Less than 2 Black Start units per zone (or Restoration region if aggregated)
- Critical Gas Infrastructure load restoration longer than 4 hours
- Nuclear safe shutdown load restoration longer than 4 hours

These exceptions would request (but not require) SOS-T endorsement.

If the following Reliability criteria is violated, other options would be pursued:

- NPIR requirements violated
- No Black Start generation allocated to a zone that has a critical load requirement

Other options that will be pursued:

- RTEP Transmission only solution such as new transmission line for cranking path, reactor, SVC, etc
- Work with generators in Interconnection queue to install Black Start capability
- Work with TO to contract for Black Start

If all methods fail:

- Deficient zone will receive cranking power from neighboring zones
    - This cranking power will NOT be from a Black Start unit and will likely not be available for many hours
    - Based on M-36, Section 8.1.9, cranking power must be supplied to neighboring areas as a priority to restoring internal load

Design Component #9 – Initial Restoration Plan Assumptions

The SRSTF recommends retaining the existing restoration plan assumption of a complete blackout with no outside assistance available (i.e. bottom up restoration).

Design Component #10 – Initial Restoration Assumptions (Weather/Load)

The SRSTF recommends retaining existing restoration plan assumptions. These assumptions include:

- Normal weather pattern
- Intermediate to Peak load levels
- Minimal equipment damage
- Adequate staffing available

Design Component #16 – Scenarios in Restoration Drills

The SRSTF recommends planning for worst case scenario (Design Component #9), but focus training and analysis on a variety of scenarios.

Design Component #12 – Area for Restoration Assumption

The SRSTF recommends M-36 continue to define common elements and guideline for TO restoration plans. TO restoration plans will be coordinated or aggregated based on results of analysis of benefits of aggregation as described above in Design Component #3.

Design Component #13 – Responsibility for Restoration and Coordination

The SRSTF recommends retaining the existing paradigm; Implementation of a System Restoration is performed at a TO zonal level with PJM coordination of area interconnection and restoration of the EHV system restoration.

Design Component #14 – Maximum Number of Black Start Units at one site.

The SRSTF recommends removal of this business rule. This would allow more than three Black Start units at a generating plant to provide Black Start.

Design Component #15 – Cross-zonal Black Start Addressed

The SRSTF recommends that System Restoration plans remain TO-based except in cases where plans have been aggregated into regions. In these cases, plans must reflect responsibility of each TO operator in the aggregated plans, or at a minimum, coordinate the TO-based System Restoration plans to reflect the larger, regional approach.

Design Component #17 – Units Eligible to be Black Start

The SRSTF recommends that any unit capable of meeting the requirements of a Black Start unit should be eligible for consideration in System Restoration planning. This would include the revision of Black Start start-up time to three hours. It would also not preclude new technologies (renewable, mobile Black Start) from participating as Black Start generators if these resources can meet the established criteria.

Design Component #18 – TOs may optionally procure additional BS through bilateral contracts outside PJM OATT.

The SRSTF recommends inclusion of the option for TOs to optionally procure additional Black Start capability (above PJM procurement). This additional Black Start would not be compensated through the PJM OATT. Terms of these procurements would be between the TO and Black Start resource owner.

Design Component #19 – Reactive and Voltage Concerns addressed

PJM will ensure reactive and voltage concerns were addressed based on testing and simulations. This is required at least every 5 years in accordance with NERC Standard EOP-005-2 R6.

Design Component #20 - Cranking Path Issues Addressed

PJM will ensure cranking path viability based on studies and simulations. This is required at least every 5 years in accordance with NERC Standard EOP-005-2 R6.

Design Component #21 – Fuel Reliability/Fuel Diversity Addressed

The SRSTF recommends an analysis to ensure fuel and gas pipeline diversity is considered during Black Start unit selection.

2. Appendix I: Supplemental Documents

[Replace with a bulleted list of hyperlinks to key stakeholder process documents posted on the PJM website. Ex.: Options and Solutions Matrix, Governing Document Revisions (OA, Tariff, RAA draft language), etc.]

Black start generation procurement: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/black-start-generation-procurement.ashx

Charter: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/charter.ashx

Cross-zonal coordination issue: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/srstf-cross-zonal-coordination-issue.ashx

EOP-005 Simulation Requirements: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/eop-005-simulation-requirements.ashx

FAQ Document: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/faq-document.ashx

OPSI State Outreach: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/opsi-presentation.ashx

PJM Manual 36: http://www.pjm.com/~/media/documents/manuals/m36.ashx

Preliminary Interests: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/interests.ashx

SRSTF Solutions Matrix: http://www.pjm.com/~/media/committees-groups/task-forces/srstf/postings/srstf-matrix.ashx

3. Appendix II: Stakeholder Participation

Last Name	First Name	Company	Sector
Anders	David	PJM Interconnection	Not Applicable
Balma	Peter	PSEG Energy Resources and Trade LLC	Generation Owner
Baznik	Ed	FirstEnergy Solutions Corp.	Transmission Owner
Boltz	Jeff	FirstEnergy Solutions Corp.	Transmission Owner
Boyle	Glen	PJM Interconnection	Not Applicable
Brodbeck	John	Potomac Electric Power Company	Electric Distributor
Bryson	Mike	PJM Interconnection	Not Applicable
Burner	Bob	Duke Energy Business Services LLC	Generation Owner
Calore	James	Public Service Electric & Gas Company	Transmission Owner
Cannon	Ralph	FirstEnergy Solutions Corp.	Transmission Owner
Carmean	Gregory	OPSI	Not Applicable
Carretta	Ken	PSEG Energy Resources and Trade LLC	Transmission Owner
Casablanca	Carlos	American Electric Power	Transmission Owner

Chu	Ron	PECO Energy Company	Transmission Owner
Citrolo	John	PSEG Energy Resources and Trade LLC	Transmission Owner
Cumpton	Frank	Baltimore Gas and Electric Company	Transmission Owner
Daniels	Jeff	PPL Electric Utilities Corporation d/b/a PPL Utilities	Transmission Owner
DeGeeter	Ralph	Maryland Public Service Commission	Not Applicable
Dugan	Bill	Monitoring Analytics, LLC	Not Applicable
Egan	Amanda	PJM Interconnection	Not Applicable
Fabiano	Janell	PJM Interconnection	Not Applicable
Fecho	Thomas	Indiana Michigan Power Company	Transmission Owner
Feliks	Kent	Appalachian Power Company	Transmission Owner
Filomena	Guy	Customized Energy Solutions, Inc.	Not Applicable
Fitch	Neal	GenOn Energy Management, LLC	Generation Owner
Forcum	David	Duke Energy Ohio, Inc.	Other Supplier
Freeman	Al	Michigan Public Service Commission	Not Applicable
Garbini	Marj	Potomac Electric Power Company	Electric Distributor
Glazer	Craig	PJM Interconnection	Not Applicable
Gooden	Mark	AEP Energy Partners, Inc.	Transmission Owner
Gyrath	John	Exelon Generation Co., LLC	Transmission Owner
Hauske	Thomas	PJM Interconnection	Not Applicable
Hendrzak	Chantal	PJM Interconnection	Not Applicable
Hoatson	Tom	Riverside Generating, LLC	Other Supplier
Horstmann	John	Dayton Power & Light Company (The)	Transmission Owner
Hunt	Randy	Dominion Energy Marketing, Inc.	Generation Owner
Issermoyer	John	PPL Electric Utilities Corporation d/b/a PPL Utilities	Transmission Owner
Jennings	Ken	Duke Energy Business Services LLC	Generation Owner
Johnson	Carl	Long Island Lighting Company d/b/a LIPA	Other Supplier
Jones	Kim	North Carolina Utilities Commission	Not Applicable
Karcher	James	Duquesne Light Company	Transmission Owner
Keech	Adam	PJM Interconnection	Not Applicable
Kerr	Jack	Virginia Electric & Power Company	Transmission Owner
Kimmish	Steven	PSEG Energy Resources and Trade LLC	Generation Owner
Kormos	Mike	PJM Interconnection	Not Applicable
Kuras	Mark	PJM Interconnection	Not Applicable
LaRocque	Matthew	PJM Interconnection	Not Applicable
Lavan	Ron	PJM Interconnection	Not Applicable
Libertz	John	PJM Interconnection	Not Applicable
Lieberman	Steven	Old Dominion Electric Cooperative	Electric Distributor
Lindeman	Tony	FirstEnergy Solutions Corp.	Transmission Owner
Lowe	Connie	Dominion Virginia Power	Not Applicable
Mabry	David	McNees Wallace & Nurick LLC	Not Applicable
Martin	Beth	Wisconsin Electric Power Company	Generation Owner
Martinez	John	FirstEnergy Solutions Corp.	Transmission Owner
Marton	David	FirstEnergy Solutions Corp.	Transmission Owner

Maucher	Andrea	Division of the Public Advocate of State of Delaware	End Use Customer
McDonald	Steve	Customized Energy Solutions, Inc.	Not Applicable
Miller	Don	FirstEnergy Solutions Corp.	Transmission Owner
Nobile	Joe	Richland-Stryker Generation LLC	Generation Owner
Norton	Chris	American Municipal Power, Inc.	Electric Distributor
Ondayko	Brock	Appalachian Power Company	Transmission Owner
Palcic	Ronald	FirstEnergy Solutions Corp.	Transmission Owner
Patten	Kevin	Appalachian Power Company	Transmission Owner
Pleiss	Robert	Constellation Energy Commodities Group, Inc.	Other Supplier
Pratzon	David	GT Power Group	Not Applicable
Quinlan	Pamela	Rockland Electric Company	Transmission Owner
Richardson	Mike	AEP	Transmission Owner
Riley	Tunisia	Commonwealth Edison Company	Transmission Owner
Sanicky	Jerry	FirstEnergy Solutions Corp.	Transmission Owner
Scarpignato	Dave	Direct Energy Business, LLC	Other Supplier
Schofield	William	Customized Energy Solutions, Inc.	Not Applicable
Schweizer	Dave	PJM Interconnection	Not Applicable
Schweizer	David	PJM Interconnection	Not Applicable
Scurria	Nicholas	Exelon Energy Company	Transmission Owner
Sechrist	Erin	PJM Interconnection	Not Applicable
Sem	Nitin	Baltimore Gas and Electric Company	Transmission Owner
Siegrist	Hal	GenOn Energy Management, LLC	Generation Owner
Slade	Louis	Virginia Electric and Power Company	Transmission Owner
Snow	Robert	Federal Energy Regulatory Commission	Not Applicable
Souder	David	PJM Interconnection	Not Applicable
Spidle	William	American Transmission Systems, Inc.	Transmission Owner
Stadelmeyer	Rebecca	Exelon Business Services Company, LLC	Transmission Owner
Steinbacher	Rich	Rockland Electric Company	Transmission Owner
Sudhakara	Raghu	Rockland Electric Company	Transmission Owner
Summers	Theodore	PSEG Energy Resources and Trade LLC	Transmission Owner
Taylor	Robert	Exelon Business Services Company, LLC	Transmission Owner
Tong	Dr.	PJM Interconnection	Not Applicable
Walter	Laura	PJM Interconnection	Not Applicable
Walter	Laura	PJM Interconnection	Not Applicable
Weghorst	Bradley	PPL Energy Plus, LLC	Transmission Owner
Winter	Nicholas	PJM Interconnection	Not Applicable

4. Standing Committee Results

[Replace with voting results for all options at standing committee or senior task force.]

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