

Fuel Requirements for Black Start Questions

1. Under the current rules, are black start units allowed to rely on gas compressors that rely on the electric system as opposed to the pipeline's own gas powered compressors?
 - The majority of compressors are gas driven. In PJM, electric driven compressor stations make up about 25 percent of the installed compression. Electric driven compressors are defined as critical loads by PJM.
 - With respect to fuel source, black start units do not rely on a single compressor but rather the pipeline as a whole, which includes any local compressors, as well as the pressure that would remain in the pipe after all large industrial customers, generators and residential customers were lost as a result of the electric grid blackout.

2. How much more black start capability (by percentage) does PJM procure beyond what it needs to support black start of the grid?
 - PJM defines the Minimum Black Start Requirements in PJM Manual M36. PJM procures 110 percent of the critical load requirement. For example, if the critical load in a TO zone was 250 MW, PJM would ensure there were at least 275 MW of black start generation dedicated to the zone. Typically there will be additional black start MW above the critical load requirement for several reasons, including size of units and location/proximity of black start to critical loads.

3. How much more conservatism (by percentage) would exist on the system if the black start units designated to support offsite power to nuclear plants be utilized to start up the grid?
 - Minimal. Most black start units providing nuclear safe shutdown power are also used to provide power to other critical loads.
 - For additional consideration, NERC Standard NUC-001, Section 9.3.5 references Nuclear Plant Interface Requirements (NPIR) to have provisions to handle loss of onsite/offsite AC power. If black start units are not used to provide safe shutdown through the black start service and RFP that PJM awards, the nuclear units would need to find an alternate means to secure this service. This would result in additional costs to the nuclear plants and the potential need for additional state subsidies.

4. How many hours does a black start unit need to run to ensure that it performs its intended function, assuming 16 hours is conservative?
 - PJM has historically used 16 hours as a reasonable timeframe to ensure the black start unit can be brought online, allow time re-energize the transmission path from the black start generator to the critical load unit (which may be miles away), provide power to and start that critical load generator. There is uncertainty in how long these steps will take to complete due to the uncertainty in what the state of the transmission system will be following the catastrophic event that caused the blackout. To help validate and ensure this is a reasonable run time to use, PJM initiated outreach to our transmission owners. The consensus is that 16 hours remains a reasonable timeframe to ensure time to rebuild the cranking path and start up the critical load unit(s).

5. Is the minimum run time requirement of a black start unit reliant at all on the likelihood that other black start units are not 100% reliable? If so, what reliability level is assumed?

- No. The minimum run time requirement is not related to an assumption of the reliability of other black start units.
6. How does the black start requirement for PJM differ from its neighboring RTOs? Please discuss how these differences either provide better or worse assurance that the bulk electric system can be restarted.
- PJM included the following fuel-related requirements from other RTOs/ISOs in slides 7-11 and 28 of the 1/8/2019 [stakeholder education presentation](#):
 - PJM
 - Must be able to close to a dead bus within 180 minutes of request to start and be able to operate in isochronous mode and regulate voltage and frequency
 - Must have a successful black start test on file
 - 16 hours of fuel for restoration purposes
 - ISONE
 - Fuel supply independent of other black start resource's requirements
 - Allow unit to run at full capacity as follows:
 - 2 hours for renewables, including hydro
 - 12 hours for all other fuel types
 - NYISO
 - Requirements vary based on Transmission Owner local procedures
 - MISO
 - Must have an adequate inventory of fuel supply to accomplish the goals of the Transmission Operator's System Restoration Plan
 - CAISO
 - Each Black Start Generating Unit must be capable of sustaining its output for a minimum period of 12 hours from the time when it first starts delivering Energy
7. What zonal capabilities do existing nuclear-sited black start units have, and has this been accounted for in PJM's black start fuel assurance policy? If not, why not?
- There are no black start units that are sited at a nuclear plant. However, there are black start units that provide safe shutdown power to the nuclear units. The black start units will reside within the same TO zone as the nuclear unit. However, black start unit(s) outside the TO zone would be awarded if none exist within the zone.
8. Assuming black start units are CP resources and have a performance availability record in PJM markets, what are the causes of non-performance for those resources, including planned outages and maintenance outages? Please provide a detailed outage cause analysis for black-start units currently providing black-start service, breaking supply-related outages down by fuel type.
- When operating as PJM capacity resources and not being used to restart the grid, black start units have the same causes for non-performance (i.e., forced outages) as any other resource. There were 521 instances of lack of fuel outages from 2014 to 2019 for non-fuel assured black start resources as compared to 58 instances for fuel assured black start resources. All of these units are natural gas units.
 - There are no statistics available regarding fuel availability of PJM black start resources during a system restoration event because there has not been a restoration event.

9. What outage statistics exist for natural gas supply related outages between different levels of supply contracting?
 - PJM does not have this level of granularity for fuel contract information. In addition, the level of service can change from day to day and season to season. Please note that units connected to more than one pipeline would be considered fuel assured under PJM's proposed black start fuel assurance requirement.

10. Please provide the black start requirement, in MWs for each Transmission Operator (TO).
 - This information is CEII.

11. Please provide all PJM document references for all black start non-performance penalty provisions, including those related to testing.
 - [Manual 12](#), Section 4.6.14 Non-performance (page 64)

12. What is the current state of the problem? To what extent is the current state of black start requirements not working?
 - PJM is trying to find the best way to address the trade-off of the low probability of PJM calling on black start resources compared to the high impact of black start units unavailable to perform due to unavailability of fuel. Because there is currently no minimum requirement for fuel assurance, this requires balancing the risk of dependence on a single source of fuel (e.g., gas pipelines) without on-site storage against the cost of requiring on-site storage, or the addition of dual fuel capability.

13. Has PJM contemplated penalties for non-performance of black start units? To what degree has that worked or not worked to improve reliability?
 - Additional penalties will not incent new and/or fuel assured resources to voluntarily offer black start capability into PJM's Black Start RFP process. Increased penalties and an increased risk of losing capital cost recovery may actually reduce the number of resources that offer black start service, which is not a desirable outcome.

14. Are black start units meeting their minimum requirements? Do they have the proper contracts in place (firm or non-firm) to meet requirements? How and to what extent is PJM testing this?
 - Black start units meet the current annual testing requirements to demonstrate their ability to start from a blacked out state. If they have on-site fuel, they are required to maintain 16 hours of run time. However there is currently no requirement for black start units to have on site fuel, nor are their requirements to have firm supply and firm transport for natural gas. As a result, there is no requirement for PJM to validate/test against.

15. How does PJM distinguish between a black start unit and a regular generator on the system? Has PJM tested the performance results of the different units and what are those results?
 - A black start unit is a regular generator that has the ability to self-start without power from the grid and close to a de-energized bus within 3 hours. Black start capability is tested annually and revenues are withheld if there is no successful test on file.

16. What is the expected cost of 100 percent dual-fuel capability?

- The estimated cost for 100 percent black start fuel assurance where gas-only black start units add on-site storage or dual fuel capability is \$513 million. PJM provided cost estimates in slide 23 of the 6/11/2019 [FRBSR slides](#).

17. What would be the estimated cost of doubling the current dual-fuel capability or incrementally increasing it? At what point would there be diminishing marginal returns on the investment?

- The estimated cost for 50 percent black start fuel assurance where gas-only black start units add on-site storage or dual fuel capability is \$177 million. PJM provided cost estimates in slide 23 of the 6/11/2019 [FRBSR slides](#).

18. To what extent does DER and DR impact the assessment of fuel assurance? Does PJM have an estimate of when that impact is likely to show up?

- This is not applicable since there are currently no DER nor DR black start resources. DER resources could offer into a future RFP if they are able to meet the requirements of a black start resource.

19. Does PJM have data or information leading it to question the likelihood of black start units in certain operating status being able to meet the 16 hour run time performance standard under circumstances likely to prevail during a PJM-wide blackout?

- There is no specific data regarding performance or inability to perform that raised the initial question of black start fuel assurance requirements. The question was raised as part of PJM's resilience efforts and in the [FERC report](#) released in 2016 regarding single fuel black start resources. The question is to review and determine if the provisions in our black start RFP process to 'prefer' but not 'require' fuel assurance are sufficient.

20. Does PJM have data linking the absence of dual fuel, multiple pipeline interconnections, and firm contracts to a decreased likelihood of 16 hour black start unit performance at the time of a blackout?

- Restoration plans are designed to have the most efficient transmission paths from black start resources to critical loads. If a black start resource is unavailable due to a lack of fuel or any other reason, the only means of serving the critical load is to wait for another black start unit to start up a critical load unit and to then build a transmission path from that unit to the critical load. This could extend the system restoration time by hours or days.
- The question at hand is if PJM should implement requirements, such as dual fuel or multiple pipeline interconnects, to reduce the risk that the black start generator will not have available fuel, and will therefore not be able to start up. Without an actual system restoration event and the loss of local gas customers as a result, PJM does not have any data to indicate if gas will or will not be available. The data that PJM does have is for normal system operations (i.e., non-black out conditions) that has shown non-fuel assured resources experience a significantly higher amount of forced outages for lack of fuel than fuel assured resources (see Question 8).

21. What does "interconnected to multiple interstate pipelines" mean? Please give configuration examples of what is and is not determined to be interconnected to multiple interstate pipelines. Distinguish generator interconnections to gas distribution companies and those directly interconnected to pipelines.

- Interconnect to multiple interstate pipelines means the generator is not reliant on one source of gas and is also not served by a local distribution company (LDC). As an example, Unit A has connections to interstate pipeline X and interstate pipeline Y, with the ability to source gas from either.
- Units directly connected to an interstate pipeline are not behind an LDC and are less likely to be curtailed as they are not competing with residential heating demand during the winter.
- Black start units served by an LDC have a higher probability of being curtailed (i.e., experience lack of supply outages) during the winter when residential heating demand is high.

22. Can you provide a map of the PJM region identifying existing gas fired units that are and are not interconnected to multiple interstate pipelines?

- This information is CEII.

23. If PJM adopts any of the proposed requirements (e.g., dual fuel, multiple pipeline interconnections, and firm contracts), how would PJM measure the expected increase in black start unit performance compared to the status quo?

- The proposed fuel requirements were developed through a PJM stakeholder process that identified solution options with stakeholder feedback.
- If additional fuel source requirements were in place, PJM would require testing on both fuels and would continue to track lack of fuel outages for black start units.

24. Can PJM develop a testing regime that could accurately simulate conditions likely to prevail at the time of a PJM-wide blackout? Please describe such a testing regime. How can PJM make the testing regime more realistic to better understand expected unit performance during actual PJM-wide outage events?

- PJM's current testing regime is not a simulation, but a real world test that requires black start units to physically isolate from the grid, start the generator, then synchronize to the system. This proves their physical capability.
- PJM also performs offline, dynamic simulations as well as annual system restoration drills to prove that the black start generators are capable of meeting the needs of the system during a restoration event.
- Based on the complexity of the pipelines and uncertainties about post-blackout gas pressure, there are limited realistic tests or hydraulic simulations that PJM or the pipelines can perform to evaluate if there will be sufficient gas and gas pressure in a pipeline to ensure the generator will be able to run, or for how long it would be able to run, in a restoration scenario.
- PJM did perform an assessment of the incremental increase in restoration time (e.g., longer than what it would typically take to provide power to critical loads), to simulate the scenario where existing non-fuel assured black start resources are not available during a restoration event due to fuel unavailability.
 - Black start to critical load path analysis in a sampling of TO zones consistently showed that the required use of alternate cranking paths resulted in increased restoration complexity / time.
 - Average incremental time increase per cranking path ranged from approximately 5 hours to 11 hours; About 30 percent of sampled zones showed increases between 15 and 40 hours.
 - Applied to cranking paths across TO zones with non-fuel assured black start resources, these time ranges could be significant for black start resources to serve critical load.
 - Remainder of restoration process would follow, including restoration of high priority loads (hospitals, military installations, etc.)

25. What weight does PJM give to unit forced and planned outage data when assessing a prospective black start unit's likelihood of satisfying the 16 hour performance standard at the time of a PJM-wide blackout? Has PJM considered requiring black start units to find adequate replacement for their black start obligation for the duration of their forced or planned outage?
- PJM reviews generator forced outage rates in the evaluation of black start proposals.
 - PJM has not explored the idea of requiring existing black start units find replacement black start resources during planned or forced outages. PJM does, however, limit the number of black start resources in a TO zone that can be out of service at any given time as indicated in PJM Manual 10 Section 2.2.4.
26. Please describe the scoring protocol PJM uses to evaluate submittals from prospective black start units in PJM's procurement process. What factors does PJM weigh in the scoring and what are the weights?
- PJM evaluates the technical capabilities, level of fuel assurance, and cost/schedule during the procurement process in accordance with PJM Manual 14D Section 10.1 2, Black Start Selection Process, Subsection D.
27. In PJM's competitive window process for new transmission facilities, PJM has faced the issue of how to evaluate capped offers vs. cost estimates. Does the same issue exist in the black start procurement process? Are black start costs locked in at the time of the procurement or can they increase (or decrease) over the relevant black start commitment period?
- Black start costs are estimated by the generation owner at the time of the RFP submittal. Black Start costs may increase or decrease based on the actual project capital costs (no capped offer in place). Both PJM and Monitoring Analytics review and analyze the supporting data and documentation submitted by the generation owner to determine black start capital costs for compensation. Details of this process are included in Schedule 6A, Section 17B, Initial Review for New Black Start Units.
28. For cost allocation, Schedule 6A, paragraph 25 states, "Zonal rates will be based on Black Start Service capability or share of generation units designated by the Transmission Provider and allocated to network service customers and point-to-point reservations." Does this mean that the cost of a PJM-selected black start unit is allocated to the load in the zone where the unit is physically located? Or, is it more complicated than that?
- The cost of the black start unit is allocated to the zone(s) receiving black start service, which includes zonal load and point-to-point reservations. This is generally the most typical scenario.
 - The PJM RFP process also allows for cross zonal black start from one TO zone to an adjacent TO zone.
 - For example, if TO zone A does not have sufficient black start resources to meet its obligation, but an adjacent TO zone B does, the PJM RFP process will allow for the black start resource in TO zone B to be designated to serve the critical load in TO zone A. The load in TO zone A will pay this cost in this scenario.