NEW STANDARDS NEEDED FOR SYSTEM BLACKSTART IN COMPETITIVE BULK-POWER MARKETS

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November 1998

INTRODUCTION

Restructuring the electric-power industry may present new challenges for bulk-power reliability. The incentives to maintain and properly deploy system blackstart services that worked for vertically integrated utilities may not work when the system operator, the transmission system, and individual generators are in separate commercial organizations.

The four North American power system interconnections are designed to be in continuous *synchronized* operation. Individual pieces of equipment are taken out of service for maintenance, but each interconnection as a whole is designed to run without interruption.

Nevertheless, the power system must be prepared for the rare occasions when all or a major portion of the system is forced out of service. This might be the result of a particularly severe disturbance resulting in the loss of stability and the need for many generators to shut down. If this occurs, the system must be able to be restored to normal operations as quickly as possible. This is called system-blackstart capability. It requires four sets of resources (Hirst and Kirby 1998):

- Blackstart-generating units that can start themselves without an external electricity source and can then energize transmission lines, restart other generating units, and ultimately restore service to customers;
- Nonblack start generating units that can quickly return to service after offsite power has been restored to the station and can then participate in further restoration efforts;
- Transmission-system equipment, controls, and communications (including ones that can operate without grid power), and field personnel to monitor and rebuild the electrical system after a widespread blackout; and

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- System-control equipment and communications (including ones that can operate without grid power), and people to plan for and direct the restoration operations after such a blackout.

For system restoration to be effective there must be a well thought out restoration plan, training exercises, and verification testing. Because the exact condition of the system at the time of failure will not be known ahead of time, the plan must be flexible.

CURRENT STANDARDS

The North American Electric Reliability Council (NERC 1997b) delineates required actions in various policies. System restoration from a blackout condition is addressed in Policy 5E: Emergency Operations – System Restoration and in Policy 6D: Operations Planning – System Restoration. Policy 5E specifies the following:

> After a system collapse, restoration shall begin when it can proceed in an orderly and secure manner. Systems and control areas shall coordinate their restoration actions. Restoration priority shall be given to the station supply of power plants and the transmission system. Even though the restoration is to be expeditious, system operators shall avoid premature action to prevent a re-collapse of the system. Customer load shall be restored as generation and transmission equipment becomes available, recognizing that load and generation must remain in balance at normal frequency as the system is restored.

Policy 6D requires "each system [to] develop and periodically update a logical plan to reestablish its electric system ... . A reliable and adequate source of startup power for generating units shall be provided. ... Generation restoration steps shall be verified by actual testing whenever possible. ... System restoration procedures shall be verified by actual testing or by simulation."

NERC's (1997a) Planning Standards also address system blackstart (Section IVA) by, again, requiring "a coordinated system blackstart capability plan" and requiring that blackstart generators demonstrate their capability once every five years "through simulation or testing."

NERC's (1998) proposed Policy 10 improves upon the existing NERC guidance by including requirements for certifying and testing blackstart units themselves. Unfortunately, the policy does not address any system control, transmission system, or nonblackstart unit requirements. Nor does it address training, simulation, or exercises.

While the guidance currently offered by NERC is helpful, it may not be enough for a restructured industry where competitive entities must be organized and act cooperatively to address a system emergency. NERC offers little detail concerning either the required response that the service is supposed to deliver or the resources that should be dedicated to service provision. NERC provides no specifics on the number of generating units that should be blackstart equipped, how to determine this, or how quickly blackstart units should respond. It says nothing about often the system restoration plan should be tested or what should be included in such tests.

STANDARDS UNDER RESTRUCTURING

In a restructured electricity industry, it may be appropriate to have separate standards for each of the four components of system blackstart.

System Operator: The system operator will, at least once a year, simulate system restoration using information on blackstart generation, transmission, nonblackstart generation, load, and the restoration plan. The regional security coordinator will certify the restoration plan only if the simulation demonstrates a high probability that restoration will be successful. Simulations and training exercises will include operating personnel from system operations, transmission operations, blackstart generators, and nonblackstart generators. The exercise will be conducted in the facilities the personnel will be working in during a restoration using the communications equipment that will be available during such a restoration. The entire restoration plan will be simulated with each party reporting on actions they would take in a restoration. A computer simulator will be used to determine the expected response from the power system to each action taken.

Transmission System: The system operator will certify the transmission provider's capability (personnel and equipment) to support the blackstart plan. The transmission provider will supply the system operator with detailed information concerning the transmission blackstart capabilities and requirements of all equipment on the transmission system. This information shall include: charging current, control capability without support from the grid under manual and automatic control, communications capability with and without grid support, personnel available for emergency response, and availability of synchronization and other special equipment to restore the system. Communications, metering, and control systems must be capable of operating without support from the power system with sufficient capability to support the system blackstart restoration plan.

Blackstart Generators: In addition to metering and communications requirements, each blackstart generator will undergo separate starting tests, line-energizing tests, and load-carrying tests. The blackstart test, conducted at least twice a year, involves isolating the generator from the power system, having the unit start itself within the agreed upon time of being directed to do so by the system operator, and then remaining stable (both voltage and frequency) for at least 30 minutes. The line-energizing test, conducted at least every three years, will demonstrate the ability of the generator to energize a previously de-energized transmission line and to remain stable for at least 30 minutes. The load-carrying test, conducted at least every six years, will demonstrate the ability of the generator to pick up sufficient load at the remote end of the isolated transmission system to demonstrate its capability to supply this load for at least 30 minutes.

Nonblackstart Generators: Each nonblackstart generating unit must submit to the system operator its restoration plan. The restoration plan will assume that the system failure was not the result of physical damage to or failure of this generator. The plan must specify the amount of time the generator requires, after the restoration of off-site power, before it is capable of synchronizing and picking up load. The plan must specify the amount of off-site real and reactive power required by each unit during the time it is preparing to return to service. The plan must specify the capabilities and requirements of the nonblackstart generator once it synchronizes to the grid including minimum load, maximum load, ramp rate, and reactive capability range at minimum and maximum load.

SYSTEM BLACKSTART AND RESTRUCTURING

The lack of specificity in blackstart requirements presents a fundamental problem under restructuring. This lack of specificity, coupled with the need for multiple independent parties (generators, transmission owners, and the system operator) to work cooperatively makes it difficult to assign responsibility for failure of the final result (rapid system restoration). Hence, the current system of indirect regulatory pressure is likely to be ineffective.

In April 1996, the U.S. Federal Energy Regulatory Commission (FERC 1996) issued its landmark Order No. 888. As part of its program to unbundle generation from transmission, FERC required transmission providers to offer six ancillary services to transmission customers. FERC did not impose any requirements with respect to blackstart, perhaps assuming that the cost to provide system-blackstart capability would be incorporated in the basic transmission tariff. So little help is provided here.

The system operator could likely procure blackstart capability competitively from generators. Technical restrictions concerning unit capabilities (e.g., speed of response, control capability, and voltage control) may limit the number of suitable generators. Locational restrictions may further reduce the number of units that can provide this service. But enough units meet (or could meet) the technical requirements to allow formation of a competitive market. Within reason, restoration plans could be adjusted to accommodate changes in the location of blackstart units.

System-operator and transmission-system costs related to system blackstart, on the other hand, should be dealt with as are other system-operator and transmission-system costs. They will likely require FERC review to assure that they are prudent and can be recovered in regulated rates.

Individual nonblackstart generators may affect the cost of blackstart in two ways. First, the amount of offsite power required to restart units and the speed with which that power must be restored may differ. Second, generators may differ in the time it takes to return to service and begin supporting the power system once offsite power is restored. These differences can be a result of the generating technology employed as well as commercial considerations. Larger units, for example, require more power to restart. Consequently, blackstart units have to be larger. Other generating units may impose additional system-blackstart requirements. The location and controllability of nonblackstart units affect their value when restoring the system. How quickly off-site power has to be restored to other generators to avoid damaging the unit and greatly delaying the its ability to restart may also differ. Compensating nonblackstart units for their costs to support restoration could be difficult. Alternatively, provision of blackstart capability could be a requirement for connecting to the grid.

Volkmann (1998) recognized this problem. He recommends that nonblackstart generators be required to return to service within a specific time after the system restores offsite power to them. This amount of time would depend on how long it takes the system to restore offsite power, recognizing that a generator will be in progressively worse condition the longer it remains without offsite power to operate auxiliaries and/or as the unit cools. Additional time may be required to restart each subsequent unit at a generating plant.

CONCLUSIONS

While system blackstart is conceptually well understood and universally acknowledged to be important, its detailed requirements are difficult to pin down. For the system to require blackstart, something went badly wrong. It is difficult to quantify expected results from the blackstart service without prior knowledge of what will go wrong. Still, this does not explain the diversity among utility blackstart plans. The current system of indirect regulatory pressure on vertically integrated utilities will not work in a restructured environment.

FERC views system blackstart narrowly, focusing on the ability of some generating units to self start. FERC apparently did not consider the transmission-system and system-control activities associated with this service. More important, FERC imposed no requirement on transmission providers to offer the service or on transmission customers to pay for it. And NERC’s standards for this service lack specificity; they do not address the need for nonblackstart generators to aggressively support system restoration.

Possible ways to ensure continued provision of this essential service in a restructured electricity industry include (1) NERC developing more specific planning, testing, and operating standards for this service; (2) FERC recognizing system-blackstart as distinct from generator-blackstart capability; (3) FERC requiring transmission providers to offer and transmission customers to purchase this service; and (4) Providing the system operator with the authority to ensure that blackstart and nonblackstart generators, transmission owners, and the system operator itself provide and coordinate this service, which will require both technical requirements and economic incentives for generators and transmission providers.

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