

## Washington DC Reliability Requirements and the Need to Operate Mirant's Potomac River Generation Station to Support Local Area Reliability

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### Introduction

Electric power for much of downtown Washington DC is supplied

from the five unit Potomac River Generating Station and two 230kV cables from Pepco's electrical grid. Although there are other generating units in close proximity to the Potomac River substation, (e.g., Benning Road and Buzzard Point) there are no electrical paths that would allow power from these other generating stations to reach the Potomac River substation. The plant has historically operated much of the time and is a significant contributor to the reliability of the downtown DC power supply. But the plant also emits air pollutants and some feel it is desirable to limit or eliminate its operation. This paper discusses the reliability requirements of the local area and the potential impacts on reliability of changing operation of the Potomac River Generating Station.

To provide some analytical basis for the discussion, we examined one year of hourly load, generation, and transmission data; September 1, 2004 – August 24, 2005<sup>2</sup>. Results of that analysis, while no guarantee of future system performance, are presented throughout this report.

The North American Electric Reliability Council (NERC), the Mid-Atlantic Area Council (MAAC), and PJM all establish rules governing power system reliability requirements. Historically, these rules have really been voluntary guidelines. The process of converting them to comprehensive, mandatory, and legal requirements (overseen by a new electricity

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<sup>1</sup> DOE's investigation was conducted by two reliability engineers employed at DOE's Oak Ridge National Laboratory, Brendan Kirby, P.E., and John Kueck, P.E. Both have broad experience in reliability and power plant operations, including serving as investigators for the U.S. – Canada Power System Outage Task Force (2003-2004), participating in NERC/FERC Control Area and Reliability Coordinator readiness audits (2004-present), supplementing FERC's technical staff, and conducting research programs on a range of power system reliability research issues including ancillary services (reliability services), off-site power supply to nuclear units, demand response as a reliability resource, wind power integration, and distributed generation. Mr. Kirby has testified as an expert witness before the FERC and California Public Utility Commission. He has also provided consulting services on ancillary services to a number of utilities and the Electric Power Research Institute. He holds a B.S. and M.S. in Electrical Engineering. Mr. Kueck has testified as an expert witness before the FERC and was a member of the DOE's 1999 Power Outage Study Team. He holds a B.S. in Physics and an M.S. in Electrical Engineering.

<sup>2</sup> Mirant curtailed operation of the Potomac River Generating Station beginning on August 21, 2005 in response to the Virginia Department of Environmental Quality. Our analysis of Potomac River Generating Station historic operations is limited to 9/1/2004 – 8/21/2005 to avoid drawing conclusions from operations that were influenced by the August plant shutdown and later reduced operations.

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reliability organization that itself will be overseen by the Federal Energy Regulatory Commission) is only partially completed and will require implementation of the Energy Policy Act before comprehensive, mandatory reliability requirements are in place. Determining what operations are required to assure adequate reliability is presently an exercise in judgment. Accepting the absolute minimum required operations would not provide adequate reliability for a load as large and important as downtown Washington DC in the judgment of most power system engineers or perhaps the general public. The current system of rules is simply not designed as a complete reliability construct. It provides only minimum, not sufficient, guidance. Conversely, we can seldom afford the level of reliability we may want. No load is ever guaranteed complete reliability. Determining what level of reliability to operate at is always an exercise in balancing risks and costs: economic as well as environmental.

This paper attempts to outline options and expected reliability benefits of operating Potomac Generating Plant units based upon a limited analysis of past performance. NERC and MAAC/PJM reliability rules are discussed as they relate to operating requirements.

### ***Required Actual Generation***

Based upon actual performance during the study period, the 230kV transmission cable(s) were always capable of serving the entire load with no local generation. The load peaked at 552 MW and averaged [REDACTED] MW. Both 230kV cables were in service during most of the period with two 13 hour maintenance outages of one cable at a time and a single one minute unscheduled line trip. No Potomac River generation was required to serve local load during the study period. If being prepared for contingencies (sudden unexpected cable failures), an important aspect of grid reliability, were not a concern, no local generation would be required. However, cables do fail and the grid must be operated for such a contingency.

### ***Contingency Reserves***

To operate reliably and avoid blackouts, the power system must be prepared for the sudden failure of any single element. If a transmission line, cable or generator suddenly fails the load it was carrying immediately transfers to the remaining transmission lines, cables and generators. There must be sufficient local generating capacity already on line and able to pick up the load which exceeds the cable's emergency rating. This generating capacity already on line and able to quickly pick up load is called spinning reserve. If sufficient capacity is not already in service the remaining transmission lines, cables, or generators immediately overload and fail. The entire local area is blacked out. This is a physical limitation of AC power systems, which comprise all modern electric grids. The related reliability requirements established by NERC, MAAC, and PJM will be discussed below.

In the case of concern here the two 230kV cables can each carry [REDACTED] MW under normal conditions and [REDACTED] MW for [REDACTED]. If the pair of cables is carrying more than [REDACTED] MW [REDACTED] and one cable fails the second cable [REDACTED]. There must either be

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sufficient local generating capacity already on line and able to pick up the load which exceeds [REDACTED] or sufficient load must be shed immediately [REDACTED].

There were [REDACTED] hours (out of 8,520) on [REDACTED] days during the study period when there was not enough [REDACTED] emergency cable capacity to serve the entire load if [REDACTED]. This is shown in the red curve in Figure 1. Obviously, 26 of those hours and two of those days were when one cable was already out of service for scheduled maintenance and loss of the second cable would leave the area with no supply at all. Other than the 26 hours when the spinning reserve must be able to carry the entire area load (up to [REDACTED] MW during this time), the spinning reserve requirement was never greater than [REDACTED] MW and averaged [REDACTED] MW.<sup>3</sup> A single Potomac River generating unit has sufficient capacity to provide this reserve.

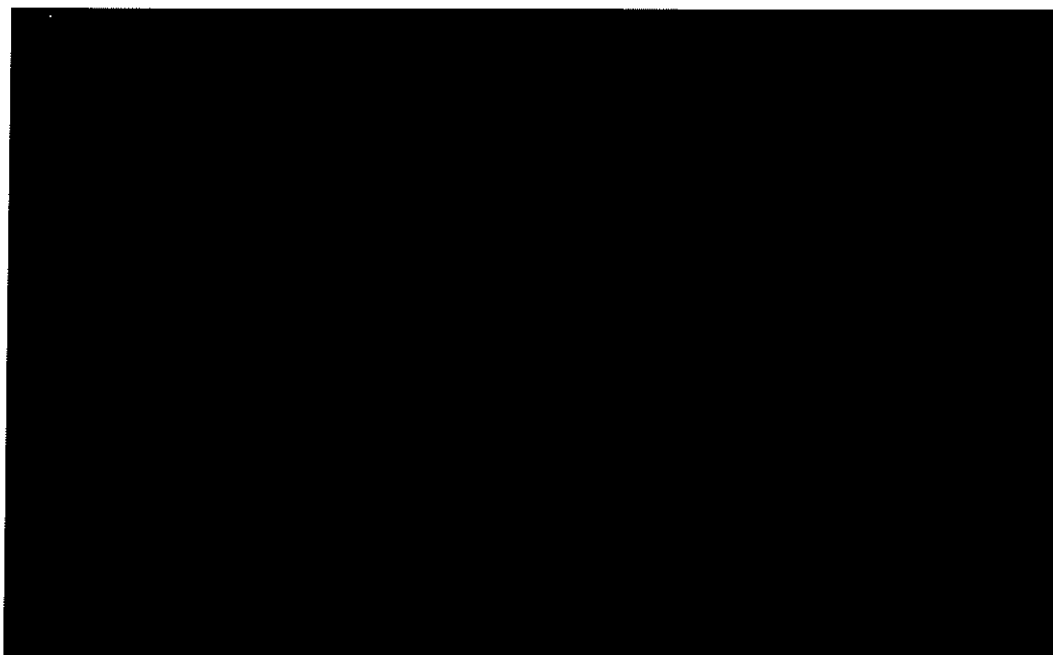


Figure 1 Reserves, rather than generation output, are required to maintain local DC area reliability.

There were [REDACTED] hours (out of 8,520) on [REDACTED] days during the study period when there was not enough [REDACTED] cable capacity to serve the entire load if one cable suddenly failed and no Potomac Generation were running. This is shown in the blue curve in Figure 1. Other than the 26 hours when the spinning reserve must be able to carry the

<sup>3</sup> It may be possible to design and install a special protection relay scheme to immediately shed (within cycles) this amount of load in the very unlikely event of a cable failure. If a special protection scheme were installed, local generation would be required only during the times of scheduled cable maintenance (26 hours on two days during the study year). However, using such a special protection relay scheme requires the utmost care as it would place the individual loads associated with the scheme in essence on a delicate "hair trigger", subject to false alarms, during the times it is armed. This analysis did not perform the detailed investigation needed of the downtown DC grid for suitability and advisability of such a scheme.

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entire area load (up to ■■■ MW during this time), the spinning reserve requirement was never greater than ■■■ MW and averaged ■■■ MW. Unscheduled cable outages are rare. If the tripped cable can not be restored within ■■■■■, load would have to be removed to avoid overloading the remaining cable. Alternatively, this much generation (one to two Potomac River Generating units) would be required to be operating within ■■■■■.

### **Generating Capacity vs Generator Output**

What the power system needs to maintain reliability in this case is generating capacity (or controlled load shedding). No generation output is actually required unless a cable actually fails. Generators like Potomac River are unable to respond instantaneously, however. Potomac River's generating units that are off line and in "cold-storage" (also known as "lay-up") require from 14 to 28 hours to come on line in order to safely heat up the boiler and turbine. Somewhat longer times are required when multiple units are brought on-line simultaneously from "cold-storage". Permanent damage, and sometimes dangerous explosions, to equipment can occur to a generating unit if proper warm-up and other related procedures are not followed. If a generator is on line, it typically has a minimum load it must operate at. Even if a generator is on line and operating, it has a limited ability to increase output rapidly (ramp rate) to meet a contingency requirement. So, even though the power system may only need generation capability and not need any actual generator output, in order to maintain reliability, generators such as Potomac River must operate to provide fast-response spinning reserve capability.

### **Reliability Requirements**

As mentioned above, reliability rules are still in the process of being converted from voluntary guidelines into mandatory standards. They are minimum, and not necessarily sufficient, operational reliability requirements. NERC reliability rules recognize the physical reality that generation and load must be continuously and essentially instantaneously balanced to prevent the power system from collapsing. The NERC standard which addresses the sudden unexpected loss of a generator or transmission line is Standard BAL-002-0 — Disturbance Control Performance.<sup>4</sup> The standard states, in part, that "each Balancing Authority shall have access to and/or operate Contingency Reserve to respond to Disturbances." The standard further states that "as a minimum, the Balancing Authority or Reserve Sharing Group shall carry at least enough Contingency Reserve to cover the most severe single contingency." In plain English, the standard requires that the system always be operated with sufficient reserves to compensate for the sudden failure of any single generator or transmission line.

BAL-002-0 does not require the system to withstand the failure of more than one element at a time:

**Simultaneous Contingencies** – Multiple Contingencies occurring within one minute or less of each other shall be treated as a single Contingency. If the combined magnitude of the multiple Contingencies exceeds the most severe

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<sup>4</sup> North American Electric Reliability Council, 2005, NERC Operating Manual, Princeton, NJ, September 14

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single Contingency, the loss shall be reported, but excluded from compliance evaluation.

**Multiple Contingencies within the Reportable Disturbance Period** – Additional Contingencies that occur after one minute of the start of a Reportable Disturbance but before the end of the Disturbance Recovery Period can be excluded from evaluation.

MAAC states that “the bulk electric supply system shall be planned and constructed in such a manner that it can be operated so the more probable contingencies can be sustained with no widespread loss of load and without impacting the overall security of the interconnected transmission systems. Less probable contingencies will be examined to determine their effect on system performance. These standards apply only to those facilities which affect reliability of the MAAC system and not to facilities affecting the reliability of supply only to local system loads.”<sup>5</sup> Note that this standard also only addresses single contingencies.

It could be argued that this standard does not actually require reserve response to avoid blacking out Washington DC since the loss of the Potomac River buss would not affect the reliability of the overall MAAC (PJM) power system. The obvious importance of the Washington DC load argues in the opposite direction. All indications from PJM, the largest and certainly one of the very best reliability organizations in North America, are that PJM applies this MAAC reliability rule to the Potomac River generating station local area power system.

### ***Restoring Reserves***

Spinning reserves deal with the immediate problem of an unexpected cable or generator failure. Reserves must be restored, however, so that the power system can withstand a subsequent failure. While the requirement to be able to withstand a single contingency is straightforward, the requirement to restore reserves within a specific time is not. The former decision is simple; either the load is important enough to warrant protecting against a single contingency or it is not. Clearly, Washington DC is. The latter decision is more difficult. Must reserves be restored within minutes? Within hours? A subsequent failure is a low-probability-high-consequence event. The more rapidly reserves are restored, the lower the probability that a second contingency will occur before the system is configured to withstand it. It would be best to restore reserves immediately but this is generally not practical.

In the event of a single contingency, reserves can be restored in two ways. In many cases (as was the case in the only unexpected cable failure during the study period) the transmission cable can be returned to service immediately and the situation is back to normal. Alternatively, local generation can supply the reserves. If fast-start combustion turbines were available these could be used. With only the slow-start Potomac River

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<sup>5</sup> Mid-Atlantic Area Council (MAAC), 2005, Document A-1 #: 192966, Reliability Principles and Standards for Planning The Bulk Electric Supply System of MAAC, January 27

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Generation available, generation may have to be on line already – but the historic record is interesting.

### **Reliability Requirements**

NERC Standard BAL-002-0 — Disturbance Control Performance, establishes minimum requirements for restoring contingency reserves:

A Balancing Authority or Reserve Sharing Group shall fully restore its Contingency Reserves within the Contingency Reserve Restoration Period for its Interconnection. The Contingency Reserve Restoration Period begins at the end of the Disturbance Recovery Period. The default Contingency Reserve Restoration Period is 90 minutes.

The Disturbance Recovery Period is 15 minutes, so reserves should be restored within 105 minutes of a contingency. Lengthening the time required to restore reserves increases the risk exposure to a second contingency and blacking out the local area. However, the risk exposure is not zero with the allowed 105 minutes for reserve restoration. Additionally, it may not be practical to restore reserves that quickly. Judgment is required to balance risks, costs and benefits.

### **Required Reserves and Historic Operation**

Were one cable to fail and be unable to be restored to service it would be necessary to operate enough local generation to be able to carry the entire local load. This is because the next worst contingency would be the loss of the second cable. Then local generation would be all there is to supply local load. The amount of generation that is required is much higher however than it was when protecting against the failure of the first cable; up to 552 MW – the local load peak.

Unlike fast-start combustion turbines, the Potomac River generating units require significant time (over a day) to be started if they have been off for a while. To have reserves restored within 105 minutes it would be necessary for the Potomac River generating units to be on line already, but this has not been done in the past. The Potomac River local area is typically not operated such that reserves can be restored within 105 minutes.

At times it is simply not possible for the Potomac River Station to carry the entire local load. Peak area load is 552 MW, 70 MW more than the 482 MW peak capacity of the Potomac River Station. Local area load exceeded Potomac River Station rated capacity ■■■ hours during the study year.

Actual operating history shows that a greater risk is normally accepted. There were ■■■ hours on ■■■ days when the load exceeded the on-line generating capacity (not just

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production but capacity) by up to ■ MW and an average of ■ MW.<sup>6</sup> Figure 2 shows the Potomac River Station output in blue, on-line capacity in red, and the local area load in dotted green. Times when local area load exceeds available on-line capacity are clearly visible as the green load curve exceeds the red capacity curve. It appears that Potomac River is dispatched largely for economic reasons rather than being constrained to provide fast restoration of reserves for reliability reasons.

While little can be done in the short range to provide capacity when local load exceeds total local installed generating capacity, this is a case where the operating decision was made to not operate available capacity simply to provide faster reserve restoration. This statement should not be misinterpreted. It is *not* a criticism of the historic operating practice. The operating decision has been made by PJM, one of the most advanced reliability organizations on the continent. The statement is an acknowledgement of what has been determined to be a good, reasonable and effective tradeoff of reliability costs and benefits. Stated differently, system operators have found that good utility practice in the Washington DC area, given the available resources, is to always cover first contingencies and to base reserve restoration times on the speed with which the Potomac River Station generators can be started.

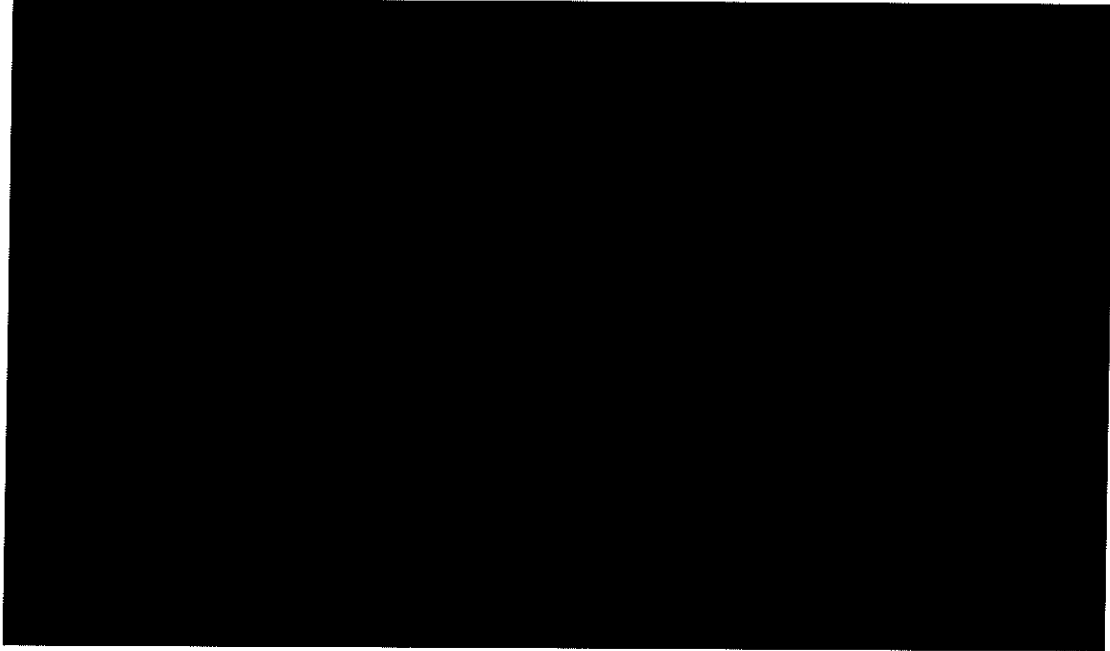


Figure 2 Load often exceeded on-line generating capacity making it impossible to restore reserves within 105 minutes of a cable failure.

***How Much Potomac River Station Generation Must Be Run?***

Table 1 summarizes the analysis results, for the study period, in terms of operating requirements for Potomac River Generation to support Washington DC power supply

<sup>6</sup> Hours after 8/21/2005 were not included in the analysis to avoid contamination from the change in operations starting on 8/25/2005 when Potomac River generation was shut down for environmental reasons.

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reliability in the absence of alternative schemes. These results are based on analysis of a single year of data. They separate generation requirements necessary to directly supply the load's immediate needs and those required to maintain adequate reliability reserves.

**Table 1 Operation of some Potomac River generation is required to support local area reliability in the absence of workable alternative schemes.**

<b>2004/2005 Historic Required Potomac River Generation</b>						
	<b>With Both 230 kV Cables in Service</b>			<b>During 230 kV Cable Maintenance</b>		
	<b>Units</b>	<b>MW</b>	<b>Hrs</b>	<b>Units</b>	<b>MW</b>	<b>Hrs<sup>1</sup></b>
To Serve Local Load Assuming No Cable Failures	0	0	0	0	0	0
Reliability Reserves Needed for Instantaneous Replacement of Lost Cable to Guard Against Loss of 2 <sup>nd</sup> Cable	1	■	■	2-4	■	26
Reserves Needed Within ■ ■ of a 230 kV Cable Failure To Prevent Exceeding Cable's Emergency Rating	1-2	■	■	2-4	■	26

Note 1: Based upon 26 hours of cable maintenance during the 2004/2005 study period. Longer maintenance outages may be required in the future.

***Alternatives to Running Local Generation***

During times of 230 kV cable maintenance (~2 days in the study period year, but in some years the requirements for more extensive preventative maintenance may be longer) there is little alternative to running Potomac River generation. If the remaining cable fails there is currently no other source of generation to serve the Washington DC load. There may be alternatives, however, for the remaining days of the year. Note that this discussion is not based on any investigation of the practicality or suitability of any of these alternatives for the electric grid area in question.

If the specific characteristics of the local grid are suitable, load shedding relaying could be installed to immediately remove up to ■ MW from service in the event of a 230 kV cable failure. This relaying could be triggered by the cable relaying itself (known as a Remedial Action Scheme, RAS), though such arming does create a "hair trigger" situation with possible false alarms and thus localized blackouts occurring. The relaying would only be armed when the local area load exceeds (or is forecast to exceed) the emergency capacity of a single 230 kV cable; ■ hours on ■ days of the study year.

This relaying would (or could) differ from normal load shedding relaying. Rather than shedding entire feeders specific loads could be selected to minimize disruption to



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customer operations. Disruptions could likely be minimal in any case. While it is not possible to predict the frequency and duration of future cable outages, at least for the study period, there was only a single one minute unplanned cable outage and it occurred at a time when the load shedding would not have been armed.

If additional interruptible load (a type of demand response which could be activated within [REDACTED] to reduce load) could be found (up to [REDACTED] MW), this could provide the remaining contingency reserve. Any interruptible load must be, however, absolutely reliable and callable to serve as a contingency reserve. While these loads would be exposed to the risk of potentially being asked to curtail during [REDACTED] hours per year on [REDACTED] days, the risk they would *actually* be called is even less than the risk that the fast responding loads would be exposed to because the probability that a cable will trip and remain out of service for longer than four hours is significantly lower. Enhancing the ability to rapidly start local generating units should a 230kV cable fail and remain out of service would also decrease the length of time this type of load would be interrupted.<sup>7</sup>

Finally, we note that the local transmission-owning utility, Pepco, has announced its intention to accelerate, subject to obtaining all the needed regulatory approvals, construction of additional transmission links to serve both the downtown DC grid and the Blue Plains sewage treatment plant. The installation and operation of these additional transmission links should remove the current reliability requirements to run the Potomac River Generating Station.

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<sup>7</sup> Measures might include increased access to personnel, added supplies on site, etc. Fast start combustion turbines would also work but only if there was a suitable location to build and install them.