THE 2003 BLACKOUT: DID THE SYSTEM OPERATOR HAVE ENOUGH POWER?

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The causes of the 2003 blackout are being investigated and it is too soon to know what went wrong. From press accounts, it appears that the problems began somewhere in Ohio at least one hour before the blackouts when some major transmission lines began tripping out of service. (It is also possible that there may have been other contributing predisposing factors, such as for example oscillations among some generators in parts of the system or some other as yet undetermined conditions.) Among the many unanswered questions, we would like to add an important one for further investigation: Were the system operator's hands (in Ohio and elsewhere) tied by rules that prevented the system operator from taking the most appropriate corrective actions?

In this short white paper, we give a brief overview of the rules followed in the Pennsylvania-Jersey-Maryland system (PJM) and elsewhere in the Northeast states and comment on the possible actions taken by a system such as PJM in response to the overloads or potential overloads. We contrast the PJM style rules with the rules prevalent in other regions of the country (e.g., Ohio). Our intent is not to place blame; indeed, if anything, our thesis is that the system operators in all regions of the country are highly skilled and extremely competent, but that these people must be entrusted with better rules, such as those followed by PJM. Incidentally the PJM rules are also market-oriented; the PJM system operation enables a well-functioning power market with real-time prices for power posted every 5 minutes, and permits generators that would rather schedule themselves to do so in response to these prices.

First, a little background. A power system is not like the interstate highway network. For example, if you decide to go to from Cleveland to New York City by road, you have a number of different combinations of highways that you can use; in other words, you have control of the route that you take. If you encounter congestion on the way, you can simply exit that highway and try to find an alternate route.

In an electrical network, if you generate power in Cleveland and someone in New York City takes out power, then the route of power flow is controlled by the laws of physics and not directly by you. The flows will go over many different lines, including, for example, around Lake Erie and through other Mid-Atlantic States. In particular, some of this flow could overload some transmission lines that could contribute to the unreliability of the power grid. In such a case, power has to be rerouted to other less loaded transmission lines, but unfortunately because of coordination and communication issues, it is not an easy task for the market players (generators and traders) to figure out how.

It is, however, a relatively easy task for the system operator to re-route transactions to prevent overloads. Moreover, the system operator has all the tools do this in the most economical way, thus saving power consumers money. For example, to relieve an overload in one transmission line, the system operator in PJM typically re-routes power by turning down generation in one location (upstream of the overload) and turning up generation at a different location (downstream of the overload) to maintain system reliability. Moreover, this is done at the most economical cost possible, and this action of the system operator sets the market prices for power everywhere in the system.

However, in other places, such as the regions neighboring PJM to the west, the system operator does not have the authority to do this (even though the system operator is plenty capable of following the PJM rules). Instead the rules call for the system operator to ignore the economics and markets altogether and to simply start curtailing many transactions to relieve a transmission line overload. Therefore to relieve a single overload the system operator may have to make possibly tens or hundreds of phone calls to other parties to stop their transactions. Apart from just bad economics --- transactions are curtailed without regard to cost, which surely results in higher prices --- the system operator wastes precious time in curtailing more transactions than necessary in a critical situation. (With PJM style rules, the operator would simply re-dispatch a handful of generators to achieve the same goals, presuming sufficient reserves were available; this is much less time-consuming and can be done through electronic signals.) In the box below, we discuss how PJM style rules might have hypothetically impacted system operations.

To summarize: without in any way intending to diminish the value of ongoing investigations about the cause of the blackout, we call on the investigators to also examine whether the inefficiencies of overload relief rules contributed to the blackout.

System operators everywhere in the US should be given all the appropriate tools and be empowered to run a reliable electricity market in the most economical way possible and should not be handicapped by rules that constrain their operation.

What could have happened had the rules been different?

To be a little more specific, we list the sequence of probable events that has been made available by the North American Electric Reliability Council (NERC) (http://www.nerc.com/pub_doc/PreliminaryDisturbanceReport.pdf). However, after each "event" in the timeline we comment as to the possible role that PJM style rules could have had; notice in particular how the market prices in the Ohio grid would have reacted to each "event". We cannot at this time be more specific than a "qualitative plausibility" analysis, because a truly correct analysis will require much more data and more time than we have at hand; such analysis may also come to very different conclusions than ours. *Note: All times given are Eastern Standard Times.*

14:06 Chamberlain – Harding 345 Kv line tripped – cause not reported

At this time the PJM rules would have recognized that this line outage would now result in either the immediate congestion or the contingency-constrained congestion of any of a number of the lines that would have been forced to carry the flow from the Chamberlain-Harding line. In all probability, this would have resulted in an increase in generation *downstream from the Hanna-Juniper line and a decrease in generation upstream to prevent the overload. (The result of this dispatch would also have been low market prices upstream of the constraint and high market prices downstream of the constraint.)*

14:32 Hanna – Juniper 345 Kv line sagged and tripped.

As in the case of the previous trip, the outage of this line would have almost immediately resulted in further generator re-dispatch with PJM style rules. (This could also have resulted in dramatic and drastic price differentials upstream and downstream of the constraint. This would have forced even those generators outside of the system operator's control to start lowering their output upstream of the constraint and increase their output downstream of the constraint, thus contributing to the reliability of the system). Thus, overload relief of the Star-S. Canton line and the Tidd-Canton line may have well occurred prior to their tripping.

14: 41 Star – S. Canton 345 Kv line tripped
14:46 Tidd - Canton Ctrl 345 Kv line tripped

If sufficient reserves were available downstream of the congestion, it is not likely that we would have reached this stage with PJM style rules. However, even after these outages, PJM style rules would likely have automatically lowered almost all possible generation upstream of the major transmission congestion constraints and increased generation downstream of these constraints. (The price differentials in the Ohio grid upstream and downstream of the congestion by now must have been dramatic.)

15:06 Sammis – Star 345 Kv line tripped and recolsed [*sic*]
(the preceding lines are located in the vicinity of Cleveland, Ohio)

If the PJM style rules had allowed us to come to this point --- something we think is highly unlikely because all the necessary generation re-dispatch prior to this would have had a significant impact on overload relief ---- then not much could be done from here on. However, properly designed and activated demand shedding that is not based on frequency drop could have still saved the day. Since this did not happen, true rapid cascading occurred and no system operator in the world could have saved the system.

15:08 Power swings noted in Canada and Eastern US.
15:10 Campbell # 3 Tripped ??
15:10 Hampton – Thetford 345 Kv line tripped
15:10 Oneida – Majestic 345 Kv line tripped
15:11 Avon Unit 9 tripped
15:11 Beaver – Davis Besse
15:11 Midway – Lemoyne – Foster 138(?) Kv line tripped
15:11 Perry Unit 1 tripped
15:15 Sammis – Star 345 Kv line tripped and reclosed
15:17 Fermi Nuclear tripped
15:17 - 15:21 Numerous lines in Michigan tripped