Analysis of the Negative Effects and Possible Contingencies Of the Northeastern Blackout in 2003

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https://wiki.ornl.gov/sites/rams/b_davis/Pages/default.aspx

Abstract

The Northeastern black out of 2003 demonstrates what will keep occurring in the future, if the electrical grid is not understood in more detail. In order to address this issue, the physics limitations as a result of infrastructure failures must be understood and automatic settings continuously updated. We intend to understand parameters of the dynamics of the grid and explore numerical understanding and bases determining the effectiveness of grid command and control. The study was completed using the North American Electrical Reliability Corporation Technical Report (NERC) as the basis, to gain understanding pertaining to the events leading to and causing the black out. An analysis of the report, formal texts on electricity flow in the United States and other resource tools to see at what key points the electrical grid began to fail and then to understand interactive effects of those failures. The analysis of the NERC report with information from different sources such as: text books, internet sources, and research reports allowed for a better understanding of the systems involved with the eventual cascade. Furthermore, this allowed for different conclusions to be drawn. After assessing the report, key events leading to the black out were narrowed down to the critical few of several different events. These few events should or could have been prevented, but there appears to be a lack of understanding of the affected infrastructure and its limits in Ohio and by the Independent Systems Operators and the NERC region personnel. Supervisory Control and Data Acquisition (SCADA) systems were not collecting the right information often enough, or the events were either ignored, not known to operators, or not understood to the point where mistakes were made. Thus, it can be hypothesized that an important key problem is that there is an inherent misunderstanding of how the physics of the electrical grid operates in different instances, which lead to black outs and may be regulated improperly and operated through poor standards and procedures.

Background

- Voltage 'instability' due to power demand
- Not direct cause ('limited to Cleveland Akron Area')
- Area systems 'Fragile' beginning ~0800 hrs
- The Eastern Interconnect of the United States was vulnerable to a failure no later than 1303 hrs

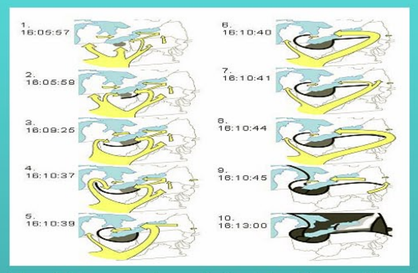


Fig. 1 Progression of electrical flow of the black out over the course of the blackout

- Area remains functional but at Emergency Level of operations: Cannot accommodate any subsequent forced contingency, regardless of loss of situational awareness experienced

Objectives

- Empirically understanding of the electrical grid
- Understand the physics that dictate the flow of electricity
- Compare what the NERC report said was done to was is actually the correct method

Methods

- Reference the electrical distribution flow principles
- Review Literature after action report for the blackout including: reports, text books principles, continuation
- Understand system efficiencies system and inefficiencies
- Mathematical and empirical relationships among parameters
- Reanalysis of consequences preceding and following blackout

Analysis of Events

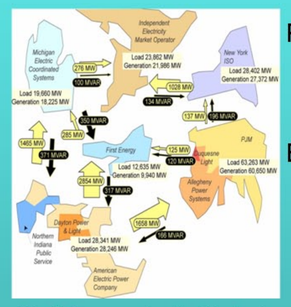


Fig. 2. 'Power wheeling' indicates lack of technical & operational understanding.

P=EI
E= IR

P= power (watt) (Generation)
E= (volt)
I=Current (ampere)
Mvar=reactive power

R=Resistance (ohm)
High Load, Low or Constant Generation Ξ Reduced Voltage

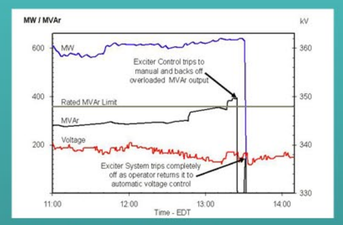


Fig. 3. East Lake Unit 5* goes Offline, 1331 hrs EDT3

Operators addressed low voltage situation by trying to increase voltage (E). Normal response is to decreased current (I).

(Cleveland-Akron) *612 MW and 400Mvar

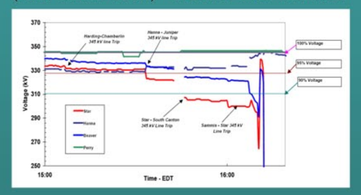
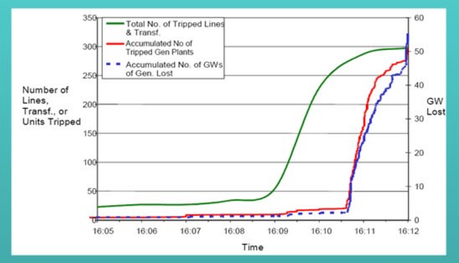


Fig. 4. Graph of subsequent overload failures of four 345kV lines (with one recovery at a non-FE control area @1427 hrs) 1505-1542 hrs

- Reactive power held a>100% for 3-4 minutes before failure.

Results

- Proper methodology to empirically address (in real time) reliability issues within the electrical power system is needed
- Analysis showed missing data on key parameters representing Mvar and its control
- Loop effects evident in cascade of Ohio control area (effects of this nature are notoriously uncontrollable in present SCADA-based environments)
- Empirical representation of fundamental electrical power concepts incomplete and not verifiable



Sammis-Star outage is determined by NERC to be the precipitating event of the New York Blackout of 2003. It is similar in cause and consequence to the Eastlake Unit 5 outage. The difference between the two are only the scale of the consequences. The first incidence affected the Ohio Reliability Control Areas, the latter affected the entire Eastern Interconnect of the U.S.

Conclusions

- Parallelization, which occurred after 16:05:57 hrs has escaped attention. The northern Ohio outages effectively blocked all effective routes for electricity to flow into the 'area'
- If major disturbances in the grid are to be prevented in the future, the measures of performance and conditions must be empirically understood, in detail and monitored continuously
- Anecdotal (post event) After Action Reporting of chronology of events or by summary description such as 'voltage was degraded' or ' system was unstable' is insufficient
- Electric potential overloads the system when a generator suddenly goes off line

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Data and illustrations are from Technical Analysis of the August 14, 2003 Blackout, North American Electric Reliability Council, ,Princeton NJ, 13 July 2004.

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