The Frequency of Large Blackouts in the United States

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Motivation

- Industry, Government, and Academia have invested heavily to improve grid reliability in the United States.
- Has this effort significantly affected reliability of the bulk electricity system in the United States?

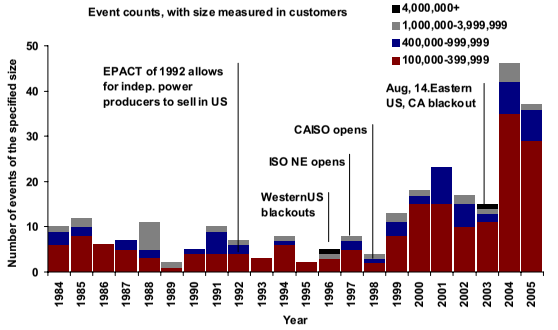
Research hypothesis

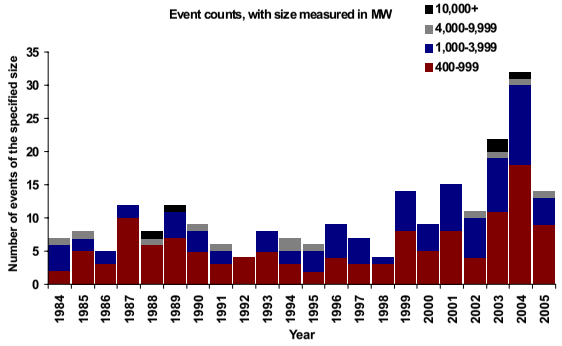
- Controlling for demand growth, the frequency of large blackouts in the United States has decreased between 1984 and the present.

Data source

- NERC Disturbance Analysis Working Group (DAWG) event records for 1984—2002.
- 2003 NERC DAWG data available from a committee report on the NERC web site.
- Supplementary data for 2004, 2005 from the DoE Energy Information Agency (EIA) form 417 fillings.
- 879 events total.

Raw data

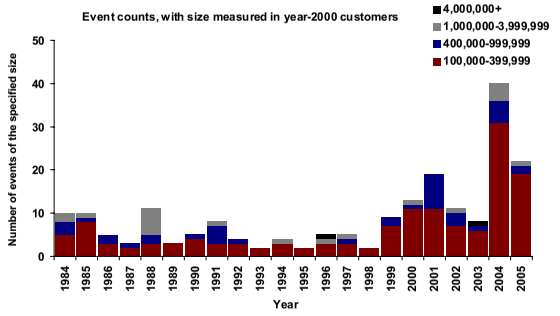


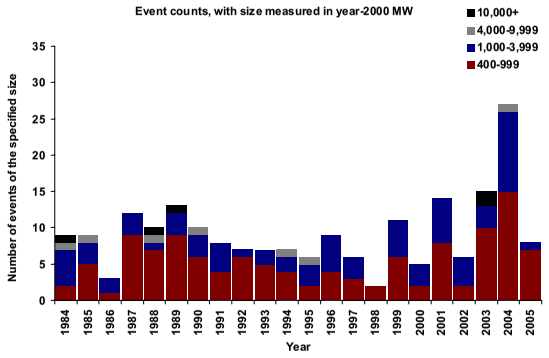


Data filtering procedure

- Removed extreme events from the database to isolate events that were potentially preventable, particularly cascading failures. Specifically:
  - hurricanes
  - earthquakes
  - ice storms
  - tornados
- In order to control for population/demand growth, we normalize each event size (MW or customers) by yearly nation-wide net generation or yearly population. Thus, all blackout sizes are scaled to year-2000 MW, or year-2000 customers.
- Eliminated events smaller than 400 MW or 100,000 customers, since only events larger than 400 MW must be reported to the Dept. of Energy.
- Removed data for years 1998, 2004, 2005 for statistical accuracy. The NERC DAWG data shows no events between 3/31/1998 and 12/08/1998, indicating a data collection/ reporting error. The years 2004, and 2005 come from the EIA, not NERC, and are potentially biased.
- 167 events with size ≥ 400 year-2000 MW.
- 137 events with size ≥ 100,000 year-2000 customers.

Filtered results





Statistical tests

- Used two statistical tests to evaluate our research hypothesis.
  - Correlation test:
    - evaluate the hypothesis that there is a significant positive relationship between blackout frequency and time;
  - Kruskall-Wallis (K-W) T-test
    - tests the hypothesis that the median blackout frequency has changed over time.
    - We divide the data at 1998 for this test. 1998 is 2 years after the 1996 blackouts, allowing for changes to take effect. In 1998 both the CAISO and ISONE are open, indicative of significant industry changes.

Results for events with size ≥ 100,000 year-2000 customers

Statistic	*Value*
Mean frequency (size ≥ 100k Y2k customers) for years 1984-1997	5.50
Mean frequency (size ≥ 100k Y2k customers) for years 1998-2005	15.50
Mean frequency (size ≥ 100k Y2k customers) for years 1999-2003	12.00
Significance (P-Value) for the K-W t-test testing the difference between the years (84-97) and (99-03).	0.009
Correlation between year and frequency	0.33 (P=0.16)

The K-W test shows a statistically significant increase in the frequency of large blackouts for the most recent years. The correlation test shows a weak (not statistically significant) correlation between years and frequency. Certainly the frequency is not decreasing.

Results for events with size ≥ 400 year-2000 MW

Statistic	*Value*
Mean frequency (size ≥ 400 Y2k MW) for years 1984-1997	8.29
Mean frequency (size ≥ 400 Y2k MW) for years 1998-2005	11.00
Mean frequency (size ≥ 400 Y2k MW) for years 1999-2003	10.20
Significance (P-Value) for the K-W t-test testing the difference between the years (84-97) and (99-03).	0.4563
Correlation between year and frequency	0.12 (P=0.62)

No statistically significant increase or decrease is observable.

Potential explanations for the lack of improvement

- An increase in stress on the transmission system due to industry restructuring
- Insufficient investment in transmission infrastructure
- Inherent complexity of the transmission system
- A lack of coordinated, system-wide solutions to the blackout problem
- Failure of the protection system to control cascading failures

Conclusions

- The frequency of large blackouts in the United States is not decreasing, and may in fact be increasing.
- More must be done if we are to actually increase the reliability of the bulk electricity system.

Acknowledgements

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