On the Relationship Between Weather and Widespread Power Outages in the United States

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Introduction

Disruptions to electric power grids have far-reaching consequences for society, impacting transportation, communication, running water, and the heating and cooling of homes. In the United States, the two most common causes for power outages are equipment failure and weather, but only weather related incidents are strongly associated with wide-scale long duration outages (Siminoff, et al, 2007). Weather can cause outages in a variety of ways. Wind, lightning, or loose soil due to abundant rainfall can cause trees to fall on local distribution lines, or the lines themselves can be directly damaged as a result of high winds, heavy snowfall accumulations, or ice accretions (Haibin et al., 2005). Power outages in the United States are becoming increasingly more frequent, with a reported 7.2% annual increase since 1990, and weather related incidents are also becoming more common (Siminoff et al., 2007). With a projected increase in the frequency of heavy precipitation events as well as the likelihood of more intense tropical cyclones affecting the United States due to climate change, it is especially important to better understand the nature of these weather related outages (IPCC Report, 2007). In our research, we looked to relate different storm types and weather variables to power outages as a way to determine trends and characteristics related to these weather events.

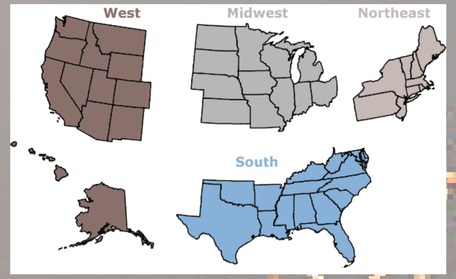

Figure 1:Regions of the United States, as categorized in our study and as used by the U.S. Census Bureau

Methods

An electric power outage database, which included information on the start and end date, customers affected, and location of each outage event, was taken from the U.S. Department of Energy, spanning the years 2002-2008. The data was separated into weather and non-weather related events and a comparative analysis was done between them to determine their relative impacts on customers. A more robust data set was then created with the weather related outages, as we gathered weather and storm data available from the National Climatic Data Center (NCDC) to compare with the corresponding weather related events. From the data, we extracted the following weather parameters for each event: **maximum total rainfall** from the affected region, **maximum wind speed**, **largest hail size**, **maximum snowfall**, **maximum ice accretion**, and **estimated property damage**. We then categorized all events by region (**Notheast**, **South**, **Midwest**, and **West**), storm type (**wind**, **snow**, **ice**, **tropical**, **thunderstorms with hail**, and **thunderstorms without hail**) and severity of each type (i.e. increasing wind speed, rainfall accumulation, ice accretion, etc.) to derive different measures of relation between weather and impact, and conducted descriptive statistics on all the data.

Results

Weather related power outages are more frequent than non-weather related outages and have a bigger impact on customers…

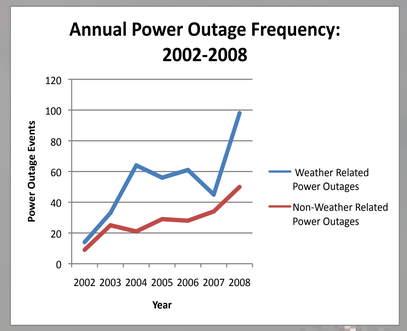

Figure 2: Annual Power Outage Frequency, 2002-2008

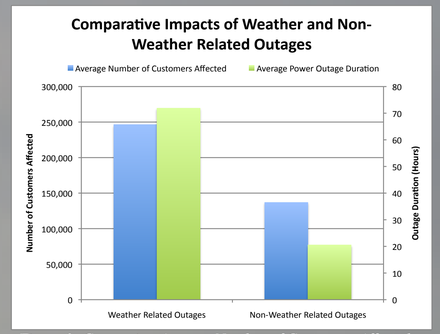

Figure 3: Comparing Average Number of Customers Affected and Average Power Outage Duration in Weather and Non-Weather Related Outages

…the South experiences the most power outages, and it also incurs the highest average property damage…

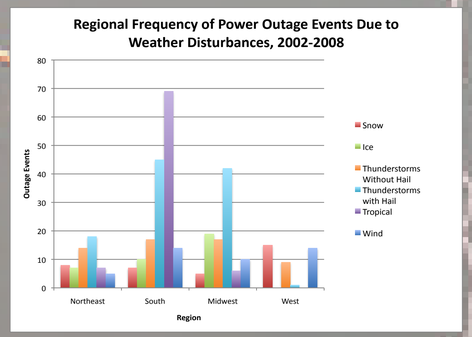

Figure 4: Regional Frequency of Power Outages Dur to Weather Disturbances, 2002-2008

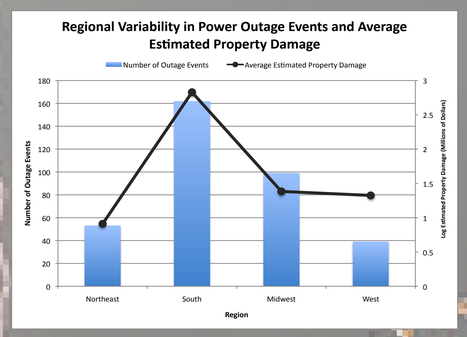

Figure 5: Regional Variability in Frequency of Power Outage Events and Average Estimated Property Damage

…tropical systems cause the most property damage and affect the most customers, yet ice storms tend to have the longest power outages…

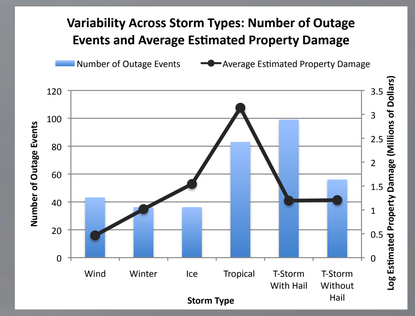

Figure 6: Variability Across Storm Types: Frequency of Power Outages and Average Estimated Property Damage

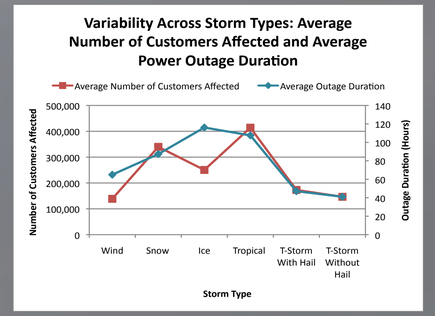

Figure 7: Variability Across Storm Types: Average Number of Customers Affected and Average Power Outage Duration

…tropical systems cause significantly more damage and affect more customers with increasing wind speeds, as do ice storms with increasing ice accretion

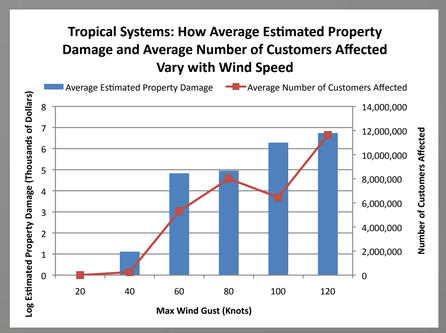

Figure 8: Impacts of Greater Wind Gusts in Tropical Systems

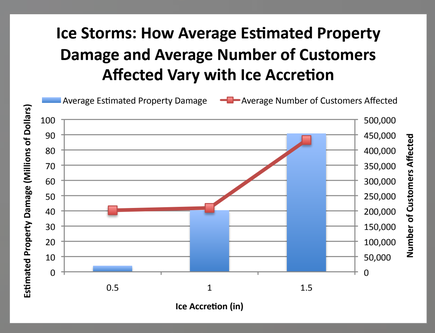

Figure 9: Impacts of Higher Ice Accretion in Ice Storms

Conclusions

Our research confirmed previous studies that weather related incidents are far more frequent than non-weather related outages and are more likely to impact customers, as they are of longer duration and affect more customers. A regional analysis of the weather related outages showed that the South receives the most frequent and damaging power outages, and this is largely attributed to tropical systems and thunderstorms containing hail. An analysis by weather type showed that tropical systems cause the most property damage and affect the most customers, and that ice storms tend to have the longest power outages. While thunderstorms are the most frequent cause of power outages, they are also among the least disruptive of storm types. Our research also showed that increasing severity in wind gusts in tropical systems and in ice accretion in ice storms lead to greater power outage impacts. Future work will focus on expanding the data set to include more years of data, determining a more statistically rigorous method of relating the weather and outage data, and on better relating the weather variables to power outage impacts on a spatial scale.

References

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