What Threats Pose the Greatest Risk to the Power Sector - Understanding Regional Risks

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Outline of Presentation

- Definition of Energy Risk
- Definition of PADDs
- Natural Disasters by PADD
- Causes of disruption to Electric Transmission and Distribution
- Conclusions
**Definition of Energy Risk**

- **Risk** is the potential for an unwanted outcome resulting from an incident, event, or occurrence, as determined by its likelihood and the associated consequences:

  \[
  \text{Risk} = \text{function}(\text{threat, vulnerability, consequence})
  \]

  - **Threat** is the likelihood of a disruption or attack on the asset.
  - **Vulnerability** is a physical feature or operational attribute that renders an entity open to exploitation or susceptible to a given hazard.
  - **Consequence** is the effect of an event, incident, or occurrence.

- **Energy risk** accounts for the three interrelated energy segments: electricity, petroleum, and natural gas.
Availability of Regional Energy Risk Profiles

STATE AND REGIONAL ENERGY RISK ASSESSMENT INITIATIVE

The Office of Electricity Delivery and Energy Reliability (OE) is leading a State Energy Risk Assessment Initiative to help States better understand risks to their energy infrastructure so they can be better prepared to make informed decisions about their investments, resilience and hardening strategies, and asset management. The initiative is a collaborative effort with the National Association of State Energy Officials (NASEO), the National Association of Regulatory Utility Commissioners (NARUC), the National Conference of State Legislatures (NCSL), and the National Governors Association (NGA).

As part of this initiative, OE has developed a series of State and Regional Energy Risk Profiles that examine the relative magnitude of risks at a regional and State level highlighting energy infrastructure trends and impacts. The profiles present both natural and man-made hazards with the potential to cause disruption of the electric, petroleum, and natural gas infrastructures. In addition, OE has produced an Energy Risk Resource Library that provides information on risk and the importance of conducting energy risk assessments. The site is a library of information allowing users to explore risk resources and policy guidance.

<table>
<thead>
<tr>
<th>STATE</th>
<th>Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>State of Alabama Energy Sector Risk Profile</td>
</tr>
<tr>
<td>Alaska</td>
<td>State of Alaska Energy Sector Risk Profile</td>
</tr>
<tr>
<td>Arizona</td>
<td>State of Arizona Energy Sector Risk Profile</td>
</tr>
<tr>
<td>Arkansas</td>
<td>State of Arkansas Energy Sector Risk Profile</td>
</tr>
<tr>
<td>California</td>
<td>State of California Energy Sector Risk Profile</td>
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</tbody>
</table>

Example Energy Risk Template for East Coast

**Electric Transmission**
- According to NERC, the leading cause of electric transmission outages in the East Coast Region is ALL OTHER CAUSES.
- The region experienced the electric transmission outages from 1992 to 2009, affecting a total of 49.2 million electric customers.
- Natural Disasters - Hurricanes/Tropical Storms affected the largest number of electric customers as a result of electric transmission outages.

**Electric Distribution**
- Between 2008 and 2012, the greatest number of electric outages occurred during the month of July in the East Coast Region.
- The leading cause of electric outages during 2008 to 2012 was Weather/Falling Trees.
- On average, the number of people affected annually by electric outages during 2008 to 2012 was 9.1 million.
- The average duration of electric outages in the region during 2008 to 2012 was 72,530 minutes or 669 hours a year.

**Natural Hazards Overview**
- According to NOAA, the most common natural hazard in the East Coast is Flood, which occurs once every 5.3 years on average during the months of March to October.
- The second most common natural hazard in the region is Other, which occurs once every 1.2 years on average.

Produced by Department of Energy (DOE), Office of Electricity Delivery & Energy Reliability (OE)
Example Energy Risk Template for Alabama


State of Alabama
ENERGY SECTOR RISK PROFILE

Electric Transmission

- According to NERC, the leading cause of electric transmission outages in Alabama is Severe Weather/Thunderstorms.
- Alabama experienced 30 electric transmission outages from 1992 to 2009, affecting a total of 4,250,857 electric customers.
- Natural disasters - hurricanes/tropical storms - affected the largest number of electric customers as a result of electric transmission outages.

Electric Distribution

- Data from ERC

Electricity-Related Outages by Cause (2008-2013)

- Utilities involved in outages include:
  - Utility A: 34%
  - Utility B: 26%
  - Utility C: 18%
  - Utility D: 12%
  - Utility E: 2%

- NOTE: # of incidents - The number within each pie chart slice is the number of outages attributable to each cause.

State of Alabama
ENERGY SECTOR RISK PROFILE

- Annual Energy Production
  - Electric Power Generation: 4,035.2 TWh (4% total U.S.)
  - Transportation: 3,487.7 TWh (3% total U.S.)
  - Industrial: 944.3 TWh (1% total U.S.)
  - Commercial: 381.5 TWh (1% total U.S.)

- Natural Hazards Overview
  - Annual Frequency of Occurrence of Natural Hazards in Alabama (1950-2010)
  - Annual Property Loss due to Natural Hazards in Alabama (1990-2010)

- According to NOAA, the most common natural hazard in Alabama is Thunderstorms & Lightning, which occurs once every 1.5 days on average during the months of March to October.
- The second most common natural hazard in Alabama is Flood, which occurs once every 4.6 days on the average.
- As reported by NOAA, the natural hazard in Alabama that causes the greatest overall property loss during 1990-2010 is Flood at $50.0 million per year.
- The natural hazard with the second highest property loss in Alabama is Flood at $22.5 million per year.
PADDs

- Petroleum Administration for Defense Districts (PADDs) are geographic aggregations of the 50 States and the District of Columbia into five districts:
  - PADD 1 is the East Coast
  - PADD 2 - Midwest
  - PADD 3 - Gulf Coast
  - PADD 4 - Rocky Mountain Region
  - PADD 5 - West Coast

- Energy risk data shown in this presentation provided at the PADD-level
What Natural Disasters Cause the Most Damage?

Data from NOAA Storm Events Database analyzed for 1986 to 2014.

Above ranking reflects the significance of extreme weather events, such as:

- The Great Flood of 1993 and the 2011 Mississippi River floods (PADD 2).
- Hurricanes Ivan, Katrina, Rita, etc. in the Gulf Coast (PADD 3).
- Hail storms in Colorado and Wyoming (PADD 4).
- California wildfires of October 2007 (PADD 5).
What Hazards Posed the Greatest Threats to the Electric Transmission Grid?

<table>
<thead>
<tr>
<th>Rank by Number of Customers</th>
<th>PADD 1 (East Coast)</th>
<th>PADD 2 (Midwest)</th>
<th>PADD 3 (Gulf Coast)</th>
<th>PADD 4 (Rocky Mtns)</th>
<th>PADD 5 (West Coast)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hurricane / Tropical Storm</td>
<td>Thunderstorm</td>
<td>Hurricane / Tropical Storm</td>
<td>Transmission Line Faults and Overloads</td>
<td>Transmission Line Faults and Overloads</td>
</tr>
<tr>
<td>2</td>
<td>Complete Electrical System Failure</td>
<td>Complete Electrical System Failure</td>
<td>Thunderstorm</td>
<td>Fuel Supply Deficiency</td>
<td>High Winds</td>
</tr>
<tr>
<td>3</td>
<td>Ice Storm</td>
<td>Winter Storm</td>
<td>Faulty Equipment / Human Error</td>
<td>Faulty Equipment / Human Error</td>
<td>Thunderstorm</td>
</tr>
<tr>
<td>4</td>
<td>Thunderstorm</td>
<td>Ice Storm</td>
<td>Transmission Line Faults and Overloads</td>
<td>Unknown Cause</td>
<td>Faulty Equipment / Human Error</td>
</tr>
<tr>
<td>5</td>
<td>High Winds</td>
<td>High Winds</td>
<td>Heat Wave</td>
<td>Physical Impact / Attack</td>
<td>Heat Wave</td>
</tr>
</tbody>
</table>

- NERC “System Disturbance Report” data was analyzed to determine the most-likely causes of electric transmission – related outages.
- Total of 941 events from 1992 to 2009.
- Severe weather impacts all regions.
What are the Major Threats to Electric Distribution?

<table>
<thead>
<tr>
<th>Rank by Number of Incidents</th>
<th>PADD 1 (East Coast)</th>
<th>PADD 2 (Midwest)</th>
<th>PADD 3 (Gulf Coast)</th>
<th>PADD 4 (Rocky Mtns)</th>
<th>PADD 5 (West Coast)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Weather / Falling Trees</td>
<td>Weather / Falling Trees</td>
<td>Weather / Falling Trees</td>
<td>Weather / Falling Trees</td>
<td>Faulty Equipment / Human Error</td>
</tr>
<tr>
<td>2</td>
<td>Faulty Equipment / Human Error</td>
<td>Faulty Equipment / Human Error</td>
<td>Faulty Equipment / Human Error</td>
<td>Faulty Equipment / Human Error</td>
<td>Weather / Falling Trees</td>
</tr>
<tr>
<td>3</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
</tr>
<tr>
<td>4</td>
<td>Vehicle Accident</td>
<td>Animal</td>
<td>Vehicle Accident</td>
<td>Vehicle Accident</td>
<td>Vehicle Accident</td>
</tr>
<tr>
<td>5</td>
<td>Animal</td>
<td>Vehicle Accident</td>
<td>Animal</td>
<td>Planned Outage</td>
<td>Planned Outage</td>
</tr>
</tbody>
</table>

- Data indicates that 90% of customer outage-minutes are due to events which affect local distribution systems.
- Eaton’s “Blackout Tracker” data used to determine the most-likely causes of electric distribution – related outages.
- Top-five causes vary by PADD, with weather events predominating for PADDs 1 to 4 - *most power outages are caused by damage from trees and tree limbs falling on local electricity distribution lines and poles.*
- Faulty equipment / human error tops the list for PADD 5.
What Hazards Posed the Greatest Threats to the Overall Electric Sector?

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<tr>
<th>Rank</th>
<th>PADD 1 (East Coast)</th>
<th>PADD 2 (Midwest)</th>
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<th>PADD 5 (West Coast)</th>
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<tr>
<td>1</td>
<td>Thunderstorm</td>
<td>Thunderstorm</td>
<td>Hurricane / Tropical Storm</td>
<td>Thunderstorm</td>
<td>Balancing and Frequency Control - Shed Firm Load</td>
</tr>
<tr>
<td>2</td>
<td>Hurricane / Tropical Storm</td>
<td>Ice Storm</td>
<td>Thunderstorm</td>
<td>Balancing and Frequency Control - Shed Firm Load</td>
<td>Lightning</td>
</tr>
<tr>
<td>3</td>
<td>Winter Storm</td>
<td>High Winds</td>
<td>Under-Voltage Load Shedding</td>
<td>Winter Storm</td>
<td>Winter Storm</td>
</tr>
<tr>
<td>4</td>
<td>Under-Voltage Load Shedding</td>
<td>Winter Storm</td>
<td>Unknown Cause</td>
<td>Ice Storm</td>
<td>Thunderstorm</td>
</tr>
<tr>
<td>5</td>
<td>Unknown Cause</td>
<td>Lightning</td>
<td>Winter Storm</td>
<td>Complete Electrical System Failure</td>
<td>Faulty Equipment / Human Error</td>
</tr>
</tbody>
</table>

- DOE “Electric Disturbance Events (OE-417)” data was analyzed to determine the most-likely causes of electric sector-related outages.
- Total of 1,879 events from 2000 to 2015.
- Severe weather is the number-one cause of power outages on the nation’s electric sector → weather-related outages are estimated to have cost the U.S. economy an inflation-adjusted annual average of $18 billion to $33 billion.
As a Function of Month?

- Based on DOE “Electric Disturbance Events (OE-417)” data.
- Greatest number of affected electric customers during summer months → effect of severe weather such as thunderstorms and tropical cyclones.
- East Coast experienced greatest number of affected customers → due to Superstorm Sandy, Hurricane Irene, and other tropical cyclones.
- Impact of 2012 North American derecho seen in June → affected East Coast and Midwest regions.
What about Man-Made Threats?

- DOE “Electric Disturbance Events (OE-417)” data was analyzed to examine historic threat of man-made actions.

- Data indicates decreasing number of physical and cyber events with time:
  - Many more physical events compared to cyber-based incidents.

- Table indicates that physical and cyber attacks have not resulted in major customer impacts.

- However, prior history is not a guarantee of future events with regards to man-made threats:
  - DHS and the FBI have began a nationwide program warning of the dangers faced by U.S. utilities from damaging cyber attacks like the recent hacking against Ukraine’s power grid.
Conclusions

- Regional profiles present most common threats and outages impacting energy infrastructure:
  - Based on Energy Risk Profiles developed for 50 States and District of Columbia.

- The electric sector in the various regions of the U.S. face different threats and hazards:
  - The East and Gulf Coasts (PADDs 1 and 3) historically disrupted by hurricanes and associated severe weather conditions.
  - Hazards affecting the Midwest (PADD 2) include storms, floods, and other forms of extreme weather.
  - Thunderstorms and lightning have a major impact on the Rocky Mountain States (PADD 4) and West Coast (PADD 5).

- Information has been compiled to estimate the likelihood and impacts of disruptions to energy sector components:
  - One very useful source is the DOE-OE “Energy Risk Resources Library”.
  - Another is the DOE-OE “Energy Assurance Daily”.
Introduction

Decisions regarding how to secure and invest in our Nation’s energy infrastructure are often complex. Limited resources and investment returns, tight budgets, and lack of information can hinder the process of how to best maintain or improve existing infrastructure or build new energy facilities and systems. Threats or hazards that can impact energy infrastructure and the consequences of those impacts must be known to reduce vulnerabilities. Creating a risk assessment culture can help to inform decision making when securing and building resilient energy infrastructure.

Many approaches have been developed to analyze components of risk related to energy infrastructure. Private industry, trade and research organizations, Federal and State agencies, as well as National Laboratories have developed resources that can be used to assess risk. Risk assessment approaches range from general descriptions of state energy profiles and infrastructure (qualitative) to methods based on scoring and specific metrics that analyze risk of energy assets and systems (quantitative). There are numerous methodologies or tools that have been developed to evaluate risk or components of risk.

The purpose of this Energy Risk Resource Library is to catalogue these approaches and data to assist analysts and policy makers in making more risk informed decisions to improve energy sector resilience.

The Energy Risk Resource Library is designed to inform risk assessment practitioners on the importance of risk assessment and the methods and approaches used. It provides practitioners with an overview of risk assessment, the U.S. energy sector, and resources for monitoring energy infrastructure risks. It also provides information on advanced resources including analytical tools, methods, data, and relevant studies.

About this Website

http://energy-oe.maps.arcgis.com/apps/MapSeries/index.html?appid=ece7b1c390b24177b4361784104cab7d
Real-Time Data Source – Energy Assurance Daily

- Identifies current threats to the power system throughout this Nation
Thank you very much!

We look forward to your questions and comments!
Data on Electric Distribution Outages

According to data from the U.S. DOE and the North American Electric Reliability Corporation, the U.S. power grid has the most customer outage minutes per year for its economic size:
- Typically 2 to 3 thousand power outages annually
- Between 14 to 42 million people affected

East Coast topped the list with the most affected electric customers, followed by Midwest and West Coast:
- Apparently due to combined effects of Hurricane Irene and Superstorm Sandy.

Peak outage season for PADDs 1 to 3 occurs during the summer:
- Due to potential for severe weather during the summer
- Peak for PADDs 4 and 5 occurs during the fall-winter seasons
Data on Electric Distribution Outages by FEMA Region

Top-Ranked Hazard by FEMA Region
- Weather / Falling Trees
- Faulty Equipment / Human Error

Customers Affected (Annualized)