Assessing climate change hazards to electric power infrastructure

Dick Bratcher
National Summit on Smart Grid and Climate Change—December 2, 2014
Assessing climate change hazards to electricity infrastructure
Assessing climate change hazards to electricity infrastructure
## Responses to 2013 CDP Information Request

*Please describe your risks that are driven by change in physical climate parameters.*

<table>
<thead>
<tr>
<th>Company</th>
<th>Change in Mean Temperature</th>
<th>Change in Temperature Extremes</th>
<th>Change in Precipitation Extremes and Droughts</th>
<th>Change in Precipitation Pattern</th>
<th>Change in Mean Precipitation</th>
<th>Snow and Ice</th>
<th>Sea Level Rise</th>
<th>Tropical Cyclones (Hurricanes and Typhoons)</th>
<th>Induced Changes in Natural Resources</th>
<th>Uncertainty of Physical Risks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pepco Holdings, Inc. (PHI)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Con Edison</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Entergy</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>American Electric Power</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Exelon</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Sempra Energy</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Quantifying climate change risk

Risk = Probability of an event occurring × consequences of event

Climate Change Risk

\[
\begin{align*}
&\Pr(\text{climate change} \mid \text{GHG emission scenarios}) \\
&\times \\
&\Pr(\text{infrastructure or operational hazards occur} \mid \text{climate change}) \\
&\times \\
&\Pr(\text{impacts} \mid \text{hazards}) \\
&\times \\
&\text{Consequences (\$)}
\end{align*}
\]
Managing risks from climate change is clouded by uncertainty

- Power companies and regulatory decision makers must determine
  - How much to spend in order to create a power system that is resilient to risks resulting from climate change
  - How best to allocate financial resources among alternative measures
- Questions that must be considered include:
  - What hazards may occur, where, and how often?
  - How could the electric grid be impacted?
  - What are the consequences of those impacts?
  - What can we do to prevent damage to the grid?
  - How can we minimize the effects of grid failure?
  - What are the investments with the greatest return?
  - How will climate change affect the efficacy of investments?
DNV GL’s ADAPT risk management framework

ADAPT is a probabilistic risk analysis framework for assessing hazards and vulnerabilities, and identifying cost-effective risk management measures, explicitly accounting for uncertainties.
Long Island Case Study
Case Study Goal:
Demonstrate application of the ADAPT framework to T&D system impacts of extreme weather under a future Superstorm Sandy

Geographic coverage
- Temperature
- Precipitation
- Wind fields
- Soil moisture
- Sea level rise
- Other parameters

ADAPT
- Storms
- Flooding
- Storm surge
  - Heat waves
  - Extreme winter conditions
  - Drought
  - Wildfires

Climate Projections
- Temperature
- Precipitation
- Wind fields
- Soil moisture
- Sea level rise
- Other parameters

Hazards
- Economic impact
- Customer outage costs
- Economy-wide costs

Impacts
- Power equipment damage costs
- Electricity sales revenue loss
- Customer outage costs
- Consequential economic losses

Cost-Benefit Analysis
- Corporate P&L
- Customer outage costs
- Economy-wide costs

Risk Management Measures
- Prevention
  - Preparation
  - Response
  - Recovery

Risk
- Power equipment damage costs
- Electricity sales revenue loss
- Customer outage costs
- Consequential economic losses

Long Island case study scope

Case Study Goal:
Demonstrate application of the ADAPT framework to T&D system impacts of extreme weather under a future Superstorm Sandy
Superstorm Sandy, as it occurred and in the future

- National Center for Atmospheric Research (NCAR) collaborated with DNV GL to evaluate what Superstorm Sandy might look like in a warmer world

<table>
<thead>
<tr>
<th>Numerical experiments</th>
<th>Initial and Boundary Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Air temperature</td>
</tr>
<tr>
<td>F2020: a climate warming scenario for 2020</td>
<td>+ 1°C</td>
</tr>
<tr>
<td>F2050: three 2050 climate warming scenarios</td>
<td>A + 2°C</td>
</tr>
<tr>
<td></td>
<td>B + 2°C</td>
</tr>
<tr>
<td></td>
<td>C + 2°C</td>
</tr>
<tr>
<td>F2090: a climate warming scenario for 2090</td>
<td>+ 4°C</td>
</tr>
</tbody>
</table>
Hazard analysis

- Increasing temperatures force the future Sandy scenarios to move northward
  - Therefore the timing and location of landfall shifts

- When approaching the coast, storms produce heavier precipitation than the control simulation
  - Higher temperature increases generated significantly greater precipitation, especially in western Long Island
  - The 2090 scenario produced doubled precipitation throughout Long Island

- Before landfall, wind speeds over the ocean are substantially higher (up to ~40 m/s higher than the control simulation)
  - This and “direct hit” have important implications for storm surge
Flood extent
Impact analysis

- Probabilistic models for power system apparatus failure were developed that use wind, soil moisture, and flood level as inputs.

- Bayesian networks (graphical models for reasoning under uncertainty) were used to evaluate cause and effect relationships.
Distribution risk analysis

- The resilience of the power grid, measured as the amount of electrical load served immediately after an adverse weather event, can be improved substantially
  - In our case study, investments in additional sensors, grid communications, and automation to facilitate rescheduling of flows increased load served from 70% to 98%
In conclusion...

- The most advanced climate science can be used to create scenarios of future hazards of climate change for electricity infrastructure.

- Ensuring resilience of the grid will require not just hardening utility structures but also enabling electric facilities to continue operating despite damage and promoting a rapid return to normal operations after the event has passed.

- If we can make the electrical grid smarter and more flexible, the impact of even the worst storm can be reduced.

- ADAPT provides a proven framework for assessing natural or man-made disaster risks to electric power systems.
Thank you!

About DNV GL
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers in the maritime, oil & gas, energy and other industries to make the world safer, smarter and greener.

In the energy industry
DNV GL delivers world-renowned testing and advisory services to the energy value chain including renewables and energy efficiency. Our expertise spans onshore and offshore wind power, solar, conventional generation, transmission and distribution, smart grids, and sustainable energy use, as well as energy markets and regulations. Our 3,000 energy experts support clients around the globe in delivering a safe, reliable, efficient, and sustainable energy supply.

Dick Bratcher
dick.bratcher@dnvgl.com
+1 510 338 8062

www.dnvgl.com

SAFER, SMARTER, GREENER