



Smart Grid Testbed Vision for Electric Grid Simulation and Visualization

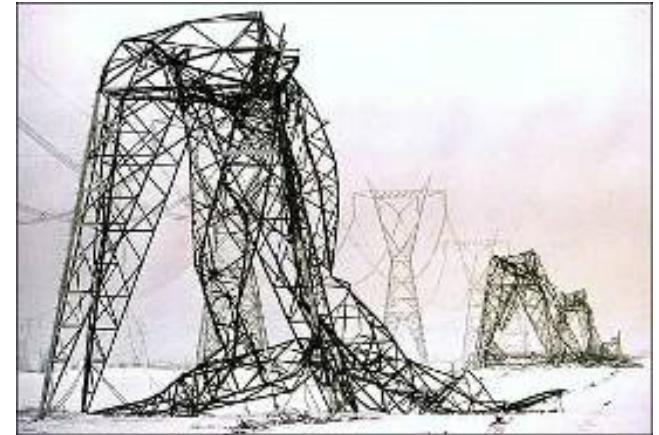
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Overview

- Our modern society depends on reliable electric grid
- Blackouts are costly, with some estimates of costs above \$100 billion/year in the US.
 - Growing risk of catastrophic, long-term blackouts
 - Blackouts cannot be completely eliminated, but improved sensing and data analytics can substantially reduce their number and/or mitigate their impact
- Risk can be mitigated through the establishment of the Smart Grid Center (SGC) Electric Grid Testbed



Blackout misery

50 million affected in Northeast and beyond as power grid fails

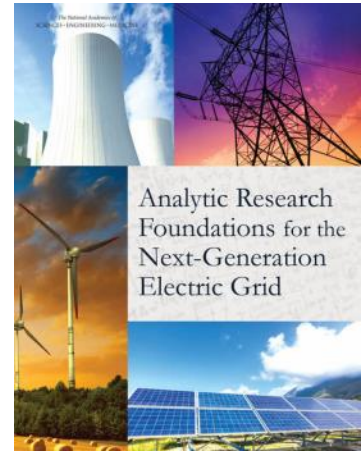
Transportation Many 'wait it out,' by air and land 4A Scenes Moms in labor, cars stuck in car washes 5A Impact Offices close, ATMs idle, cellphones jam 1B



Brooklyn Bridge: Thousands of commuters in New York took to their feet Thursday evening after a major power outage hit the city and much of the Northeast.

Three Recent IEEE and US National Academies Reports on the Grid

- IEEE Power and Energy Society (PES) Quadrennial Energy Review, 2014
- Analytic Research Foundations for the Next-Generation Electric Grid, 2016
- Enhancing the Resilience of the Nation's Electricity System, 2017
- A key recommendation was the creation of an National Electric Power Systems Research Center
 - Testbeds could play a key role in this



Working to Reduce the Potential for Long-Term, High Impact Blackouts

- There is also growing awareness of a class of events that the North American Electric Reliability Corporation (NERC) calls a severe event, defined as “an emergency situation so catastrophic that complete restoration of electric service is not possible.”
- The economic impact of such events would be extremely high!

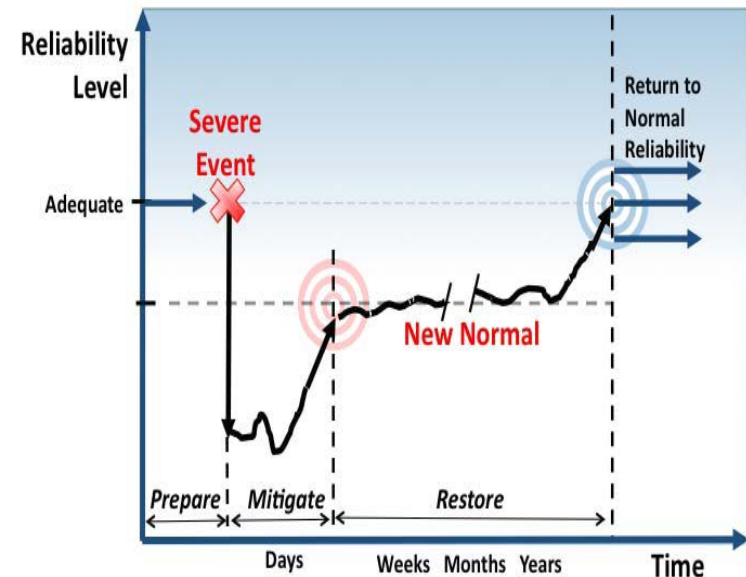
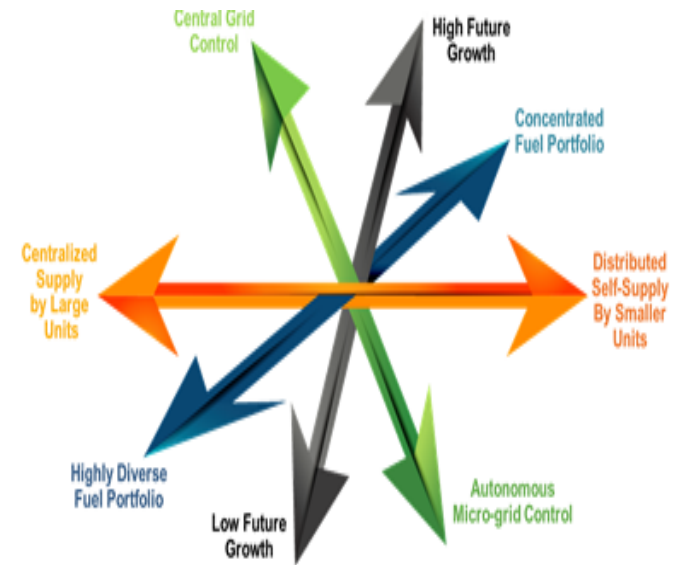


Image Source: *Severe Impact Resilience: Considerations and Recommendations*, NERC 2012

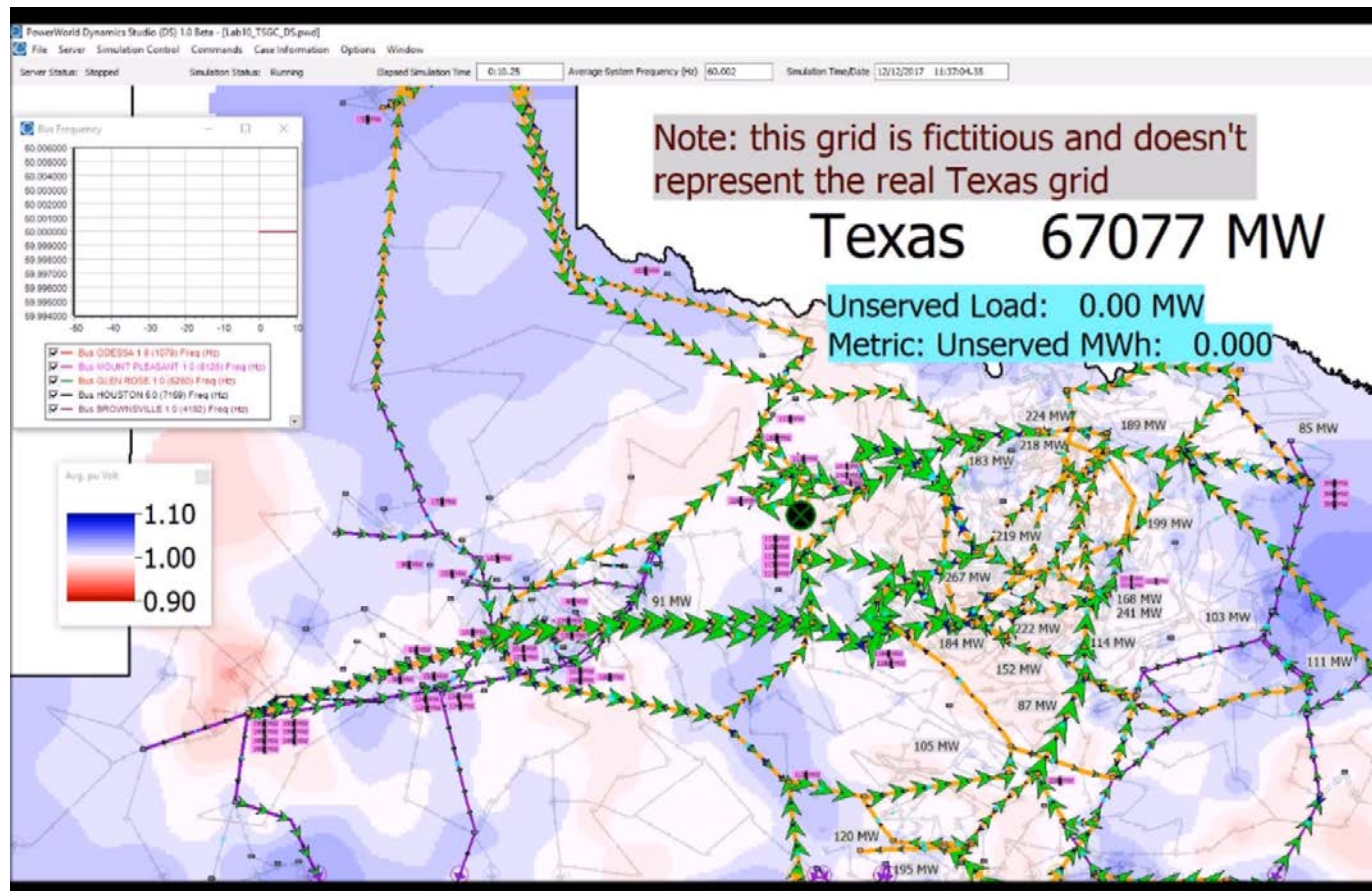
Large-Scale Testbed Simulations

- The grid is indispensable, yet also rapidly changing with the future uncertain.
- We also lack an in-depth understanding with the modeling of severe grid events, such as cyber or physical attacks, geomagnetic disturbances, EMPs and pandemics
- SGC provides location to show case state-of-art techniques and provide testing on future scenarios
 - Allowing for more rapid adoption

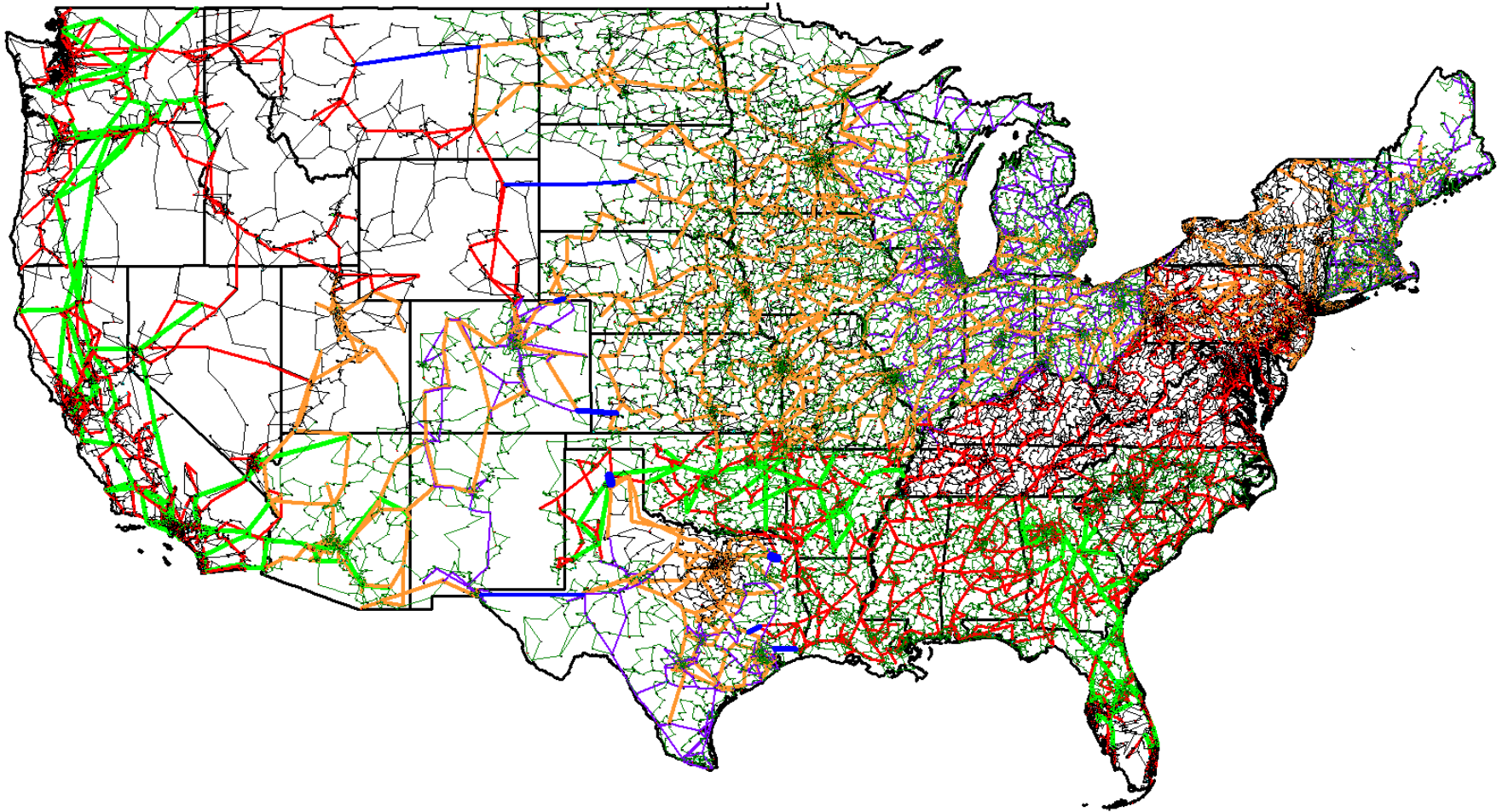


Example: Interactive Severe Disturbance Scenario Using a Synthetic Grid

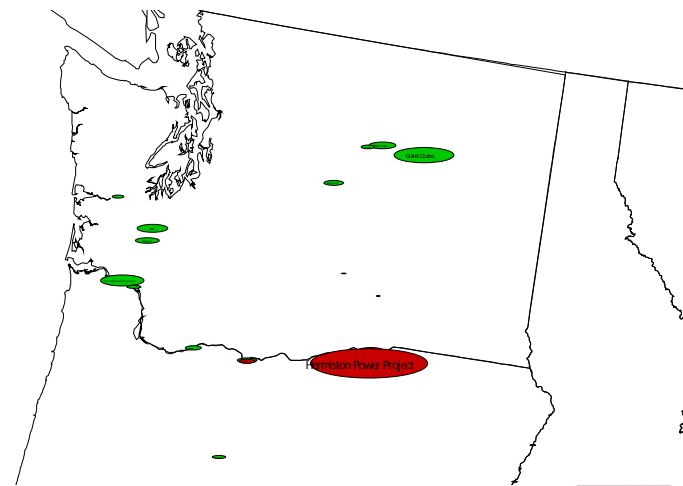
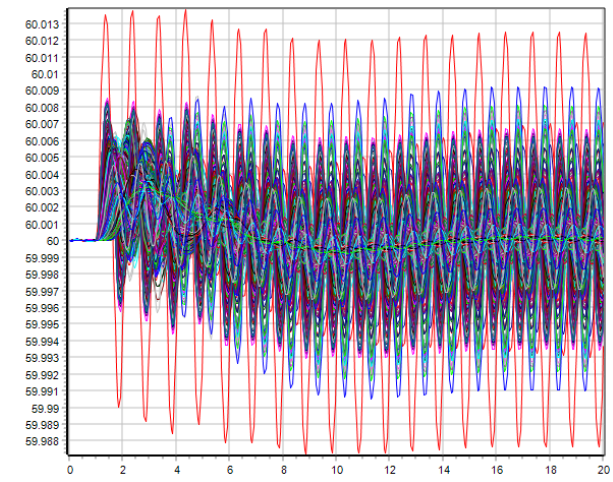
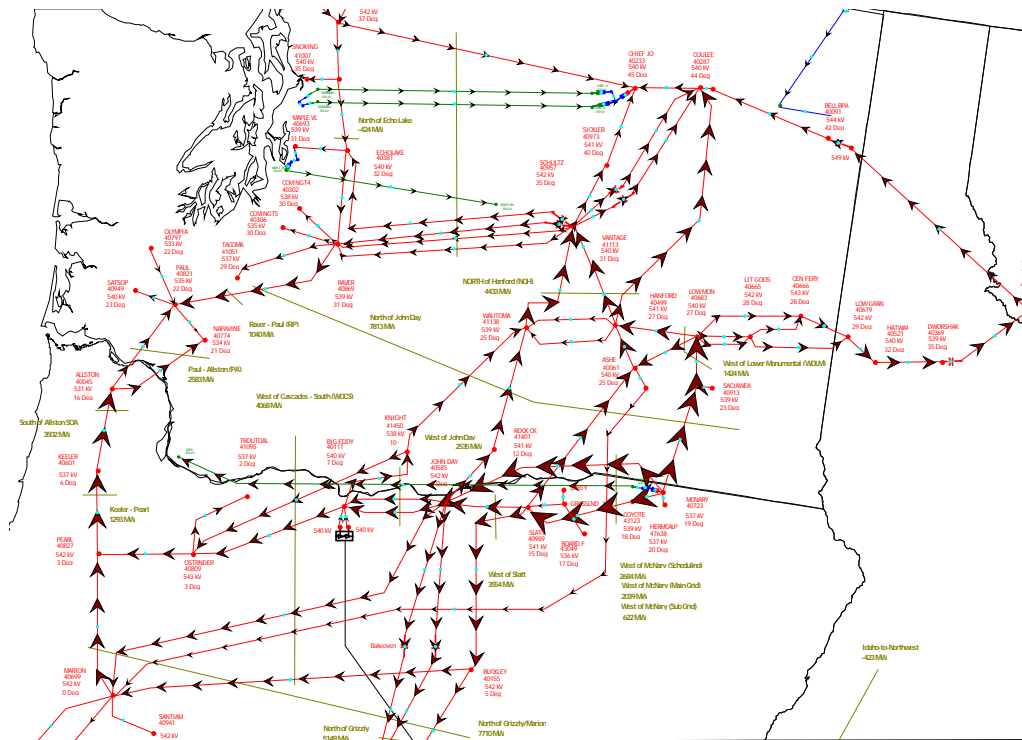
- This 2000 bus fictional Texas grid is now used for undergraduate and graduate education and research



Access to Large-Scale Electric Grids



Development of New Techniques: Location of Source of Oscillations



Thank You! Questions?



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