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JUPITER INTELLIGENCE SPECIAL REPORT

How Utilities Can Harness the Value of Next-Generation Climate Risk Analytics for Grid Planning

Executive summary

The electric power industry in recent years has experienced a significant shift toward higher renewable energy targets and lower carbon emissions. Many utilities, states, and communities are setting targets for nearly 100% renewable energy or (net) zero carbon. These goals require new, integrated approaches to planning that will ensure a reliable and resilient grid. Optimal solutions that balance reliability, sustainability and affordability often require comprehensive solutions across generation, transmission and distribution systems. Distributed resources and customer programs will also play a major role.

Key to the transition from a primarily fossil to a renewable based future is that grid resilience is becoming an essential goal, given recent experiences with severe natural events resulting in record fatalities, grid damage, property damage and economic setbacks. The focus of this paper is emerging approaches to incorporating resilience objectives into grid planning, including quantifiable metrics for grid performance and customer needs.

Although industry has previously dealt with the impacts of severe natural events through emergency preparedness from historical experience, grid planning looks forward 5, 10, 20 years and beyond and directly builds resilience into long-term plans (rather than reacting to events in real time). Effective grid plans that address resilience require long range data forecasting the impacts of climate change on grid and critical customer facilities. Siemens Power Technologies International and Jupiter Intelligence are collaborating in providing services to forecast the impacts to the grid and critical customers of future disasters caused by wind, flood, extreme heat, drought, wildfires and other threats, down to a granularity of three meters, and incorporating this data into grid strategies and options for increasing resilience.

This report finds that:

- While the utility industry has been using historical hazards data for grid planning, leading utilities are working with climate analytics and professional service providers to integrate forward looking dynamic risks of climate change into their grid planning regimes to prepare for low (but increasing) probability, high impact events.
- Climate change represents significant and increasing risks for utilities. The Lawrence Berkeley National Laboratory estimates $44B in business interruptions to the sector every year due to extreme weather; McKinsey estimates a typical utility in the southeastern U.S. could face costs upwards of $1.7B between now and 2050.
- The latest climate science and machine learning technologies provide quantitative measures of climate-related hazards and resolutions conducive for asset planning.
- Physical climate risk information is a critical input for constructing grid planning scenarios for utilities to evaluate system vulnerabilities, defining service priorities, and assessing options for resilience investments.

Physical climate risks present significant risk for utility grid infrastructure

Extreme weather is the most common cause of larger-scale power outages. Weather-related financial impacts on the power system have increased significantly over recent decades[1]. It is estimated that the cost to electricity customers of sustained power interruptions in the U.S. is $44 billion per year[2], with the commercial and industrial sectors representing 97%-98% of the total cost. This cost is expected to grow under rapidly evolving climate conditions, as acute hazards (e.g. heat waves, floods) increase in frequency and severity, and chronic hazards (e.g. drought, rising sea levels) intensify compared to historical trends. For one example, in the US Southeast where tropical cyclones can result in service interruptions and facility damage, it is estimated that the average utility will experience $1.7B of impacts between now and 2050 if no additional resilience investments are made[3].

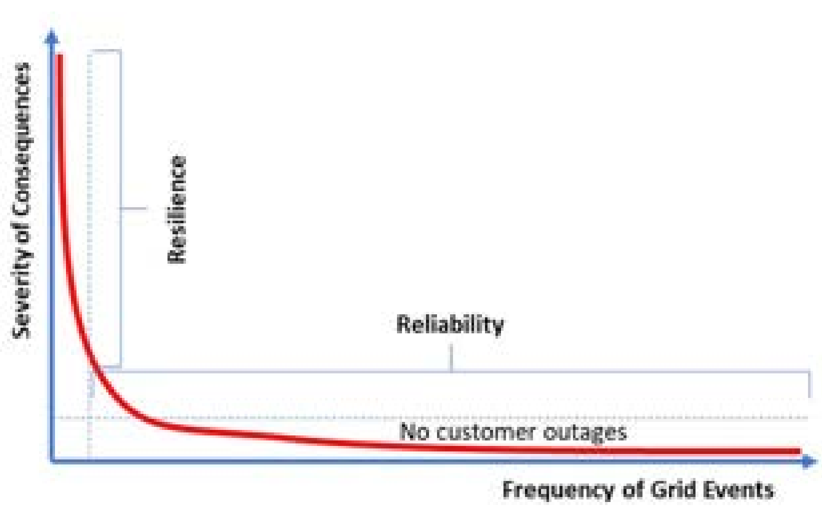

Figure 1 Comparing grid reliability versus grid resilience.

Grid resilience is different from grid reliability and is becoming a key pillar in grid planning

Grid resilience means reducing grid vulnerability and shortening the time required to recover from extreme events. Reliability, on the other hand, focuses on overall system performance (e.g. number of outages) relative to industry standards and good practice. More specifically, grid resilience is the ability to:

- Minimize consequences of severe events (that can exceed system design criteria)
- Sustain mission critical services under severe conditions
- Rapidly recover from a severe event
- Learn from severe events and continuously adapt under a changing climate

Traditional utility planning tools and methodologies were designed to optimize for cost and reliability based on historical climate patterns. With extreme events driven by climate change on the rise, utilities are increasingly requested to justify grid plans based on resilience (Figure 1).

Leading utilities are taking action with the help of advisors and data providers such as Siemens and Jupiter Intelligence

Forward-thinking utilities are already taking action to evaluate their climate vulnerabilities and incorporating physical climate risks in their long-term grid planning with the support from innovative service providers and break-through climate risk analytics companies. Jupiter Intelligence and Siemens Power Technologies International are collaborating to offer a comprehensive planning process that covers four critical steps to integrate climate resilience into grid planning (Figure 2):

- Quantify risk and construct scenarios
- Identify customer needs and priorities
- Overlay physical risk data and customer priorities to determine grid vulnerabilities
- Identify and evaluate options for resilience interventions

Figure 2 End-to-end climate resilience solution for the utility sector.

Jupiter Intelligence brings together asset-level climate risk analysis and cloud-computing to quantify current and future physical climate risks that Siemens embeds into its Integrated Grid Planning Process

This unique collaboration benefits from Jupiter's suite of hazard models that quantify future climate risks, and which serve as the foundational and critical inputs into the utility resilience planning process. Jupiter leverages dynamic downscaling, machine learning, and high-resolution digital elevation data to produce probabilistic risk analytics down to 3-meter resolution. This data quantifies the changing frequencies and severities of extreme events that are actionable by decision makers. The analysis allows the impact of future severe events to be analyzed down to the individual structure or facility.

The impact of climate change, such as sea level and changing precipitation patterns, is incorporated in the physical modeling underpinning the entire model chain. The full model chain is built on a cloud-based infrastructure to ensure global scalability, speedy deployment, and periodic updates based on new observed data and modeling methodologies. Jupiter's innovative approaches result in a material difference when compared to current practices[4] to assess climate risks. In a comparative risk assessment of flooding areas caused by Hurricane Harvey, Jupiter modeling accurately predicted 91% of flooding, compared to FEMA's 74%[5]. More than a fifth of the time, Jupiter's models were able to capture flood risk where FEMA flood maps show no flood vulnerability. These insights allow for asset owners to more accurately quantify the location and severity of extreme weather risks.

Siemens has developed an integrated (generation, transmission, and distribution) planning method to transform climate risk inputs into grid planning strategies, options, and portfolios

Starting from quantifiable climate risk inputs, Siemens has established a set of grid resilience planning frameworks that have been formalized, applied in utility, state, and community settings, and reviewed by stakeholders and publicly accepted. Siemens developed the 2018-10 PREPA Integrated Resource Plan, one of the most widely reviewed IRP plans in recent years, with the objective of developing a more resilient power grid in Puerto Rico as the result of recent hurricanes, including Hurricanes Maria and Irma in 2017.

The combination of climate risk data and grid infrastructure geo-locations informs the construction of scenarios that describe a wide spectrum of the physical risks faced by the grid. These climate risk scenarios are then mapped against utility-defined resilience objectives, such as prioritized needs of various types of electricity customers from critical service sectors to residential customers. The location of generation, transmission and grid elements is critical and must be included in the planning exercise to understand which system elements lie in areas of potential risk and which system elements service priority customers. These considerations eventually inform evaluation of the appropriate capital investments to boost grid resiliency.

Historically, system planning has been performed by different groups within a utility, using different data and tools and performing analysis over different time periods. Generation, transmission, and distribution planning have traditionally been separate activities. However, that loses the opportunity to optimize multiple objectives simultaneously, when solutions can be provided in the resource mix, transmission, or distribution system. Figure 3 highlights the diverse activities that need to come together in a true integrated planning process within an organization – and sometimes may even require organizational changes.

Figure 3 Integrated planning spans resource, transmission and distribution planning into a single planning process.

Figure 4 shows a representative approach for integrated planning. Objectives, metrics, assumptions and constraints are developed with the client across bulk power and distributed resources, transmission, and distribution systems, renewable and emissions targets, and resilience. Inputs and forecasts are then fed into a long-term capacity expansion and hourly and sub-hourly dispatch simulations to achieve an optimal resource portfolio. The resource plan is then subjected transmission and distribution system reliability and congestion analysis to identify violations and mitigation strategies. These constraints are then fed into an adjusted resource mix and the process iterated until an optimal and reliable plan is developed. Siemens is unique in having the full ranges of tools and expertise to perform all aspects of integrated planning analysis.

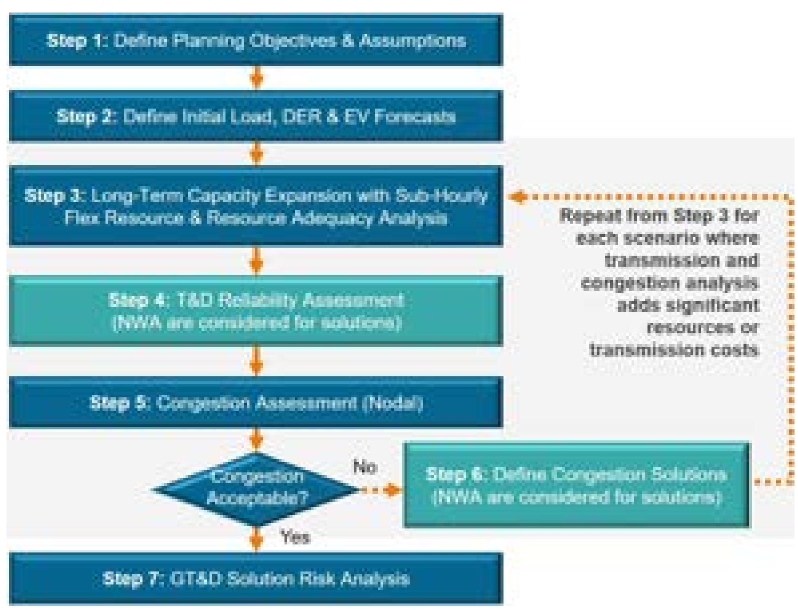

Figure 4 Sample integrated planning process for high renewable, low carbon solutions.

Figure 5 One alternative for grid resilience for Puerto Rico: eight interconnected mini-grids.

Figure 5 shows one portfolio solution for the Puerto Rico integrated plan that showed development of eight mini-grids that operate together as one grid during normal times, but can operate as islands during a severe emergency and can provide quantifiable benefits for resilience with affordable solutions.

The time for resilience planning is now

Given the evolving nature of climate change, and the increasing physical risks from resulting extreme weather events, the current approaches employed by utilities to ensure grid resilience no longer provide a complete perspective for future grid planning. Climate risk analytics backed by the latest scientific advancements and updated resilience planning frameworks exist to assist utilities with their long-term grid planning processes. Scenarios used for grid resilience planning can and should be informed by extreme weather patterns under future climate conditions. Furthermore, resilience planning should incorporate the capabilities and needs of critical infrastructure customers to ensure full and coordinated mitigation of risk and effective recovery from severe events. Leading utilities, states, and communities are already working with climate analytics and professional service providers to integrate such analysis into their periodic grid planning regimes.

About Jupiter Intelligence

Jupiter helps enterprises quantify and manage their business risks from climate change. It provides a cloud-based climate analytics platform to help asset owners and managers quantify the economic impact of physical climate risks at scale. Jupiter works with customers across the industrial, power, and financial sectors to incorporate robust climate science and customized client risk tolerance, engineering, and financial data to inform their climate resilience strategies investments.

For more information or to see a demo, please contact us at request@jupiterintel.com.

About Siemens Power Technologies International

Siemens Power Technologies International is a leading provider of resource planning and integrated grid planning, focused on renewable energy, distributed energy, and other emerging technologies and options for reducing greenhouse gas emissions. Our Energy Business Advisory team is working with major utilities and government agencies to develop cost-effective pathways for clean energy, emissions reductions, and increased grid resilience. To achieve identified objectives, Siemens builds portfolios and evaluates the performance of these portfolios to determine which perform best over a wide range of plausible future conditions. Siemens has facilitated stakeholder engagement groups in identifying resilience needs and priorities and has completed integrated plans focused on resilience to severe hazards.

Contact eba.communications.us@siemens.com to learn more.

1 *Climate Change and the U.S. Energy Sector: Regional Vulnerabilities and Resilience Solutions*. U.S. Department of Energy (2015). https://www.energy.gov/policy/downloads/climate-change-and-us-energy-sector-regional-vulnerabilities-and-resilience

2 LaCommare, K., Eto, J.H., Dunn, L.D., Sohn, M.D. *Improving the estimated cost of sustained power interruptions to electricity customers*. Energy 153 (2018). https://eta-publications.lbl.gov/sites/default/files/copi_26sept2018.pdf

3 Brody, Sarah, et al. *Why, and how, utilities should start to manage climate-change risk*. McKinsey & Company (2019). https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/why-and-how-utilities-should-start-to-manage-climate-change-risk

4 For example, Pacific Gas and Electric (PG&E) identified Bay Area substations at risk of flooding in its 2016 Climate Change Vulnerability Assessment based on FEMA's outdated 100-year flood plain.

5 *The Danger in Relying on FEMA Flood Maps for Risk Management*. Jupiter Intelligence (2020). https://jupiterintel.com/fema-special-report/