Editorial

The Energy Transition: Advanced Nuclear Needed but Address Climate Change Vulnerabilities Now[1]

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Abstract

The term "Energy Transition" is an attempt to capture an elaborate set of activities related to the modernization and decarbonization of energy grids. Performed concurrently and often in an ad hoc manner across local, state, regional and national boundaries, it is bringing chaos to what should arguably be one of the most conservatively managed of all critical infrastructure sectors. What's more, with climate change producing an increasing tempo of extreme events, confidence in the intended resilient and redundant structure of the electric grids is likely to ebb. Even without these climate induced stressors, the nation's electric grid was built for an earlier century.

In addition to a drive towards greater efficiency via digitization and a continuing price decline in distributed energy resources (DERs), one could argue that climate change concerns are the primary driver of the energy transition. Non-CO2 emitting generation sources like wind and solar have become an important part of the overall generation fleet, albeit ones that cannot be counted upon to provide dispatchable power. Current projections indicate deployment of even larger percentages of DERs in coming years. Until far better storage capabilities arrive, the variability of wind and solar, inconsistent performance of traditional thermal generation plants, and energy delivery failures associated with natural gas pipelines will reinforce mounting reliability concerns. This pertains to both electric transmission and distribution.

The recent shuttering of nuclear power plants in Germany, Japan, the US and elsewhere are also putting more downward pressure on dispatchable generation. Russia's attack on Ukraine has roiled

1 As an Editorial, views expressed herein are those of the author do not necessarily reflect those of the *Journal of Critical Infrastructure Policy* or the Idaho National Laboratory

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energy markets worldwide and forced some countries to return to coal as a primary fuel.

In view circumstances such as these, it is essential that significant changes be made to policies and planning criteria, and to the standards and code on which they are based. Given the accelerating pace of extreme weather events, this needs to occur as soon as possible.

Keywords: grid reliability, extreme weather, decarbonization, resilience, regulation

Introduction

Calling what the US grid is going through "The Energy Transition" is like calling the migration that accompanied the great midwestern dustbowl a population transition. What may sound smooth as modern, cleaner forms of energy generation and delivery replace higher carbon emitting approaches, is proving anything but smooth. This is accentuated by the fact that alternative generation sources fluctuate with the rising and setting of the sun and with other far less predictable natural phenomena. What's more, with the exception of hydropower, thermal plants being shuttered have formed a stable foundation for grid planners to count on to deliver baseload. In other words, these have been the primary, predictable sources of reliable electricity on which nations depend. The North American Electric Reliability Corporation (NERC) calls them "firm" resources.

"Transition" also invites conjuring winners and losers. Some may imagine new clean energy millionaires being minted while coal barons and oil sheiks are forced to trim their profligate spending. The trajectory appears to be that as industries like solar, wind, and energy storage proliferate, stakeholders in fossil fuel extraction, processing, delivery or utilization will likely eventually decline, though that decline will be many years off.

Governance Snapshot

The interstate high voltage Bulk Power System (BPS) is under Federal jurisdiction while lower voltage assets and the utilities who own and manage them are supervised at the state level by public utility commissions (PUCs). Some federal regulations for transmission, large generation and important control centers are mandatory and are enforced with stiff penalties administered by FERC and the national Electric Reliability Organization (ERO), NERC. Distribution level matters are handled somewhat more gently by the PUCs. Trade groups play an important part in this ecosystem, rallying the collective needs and visions of their members.

These include:

- The Edison Electric Institute (EEI) for the Investor-Owned Utilities (IOUs)
- The American Public Power Association (APPA) represents the Municipal Utilities
- The North American Rural Electric Cooperative Association (NRECA) works with Electric Cooperatives

These organizations as well as executives from the larger IOUs are regularly convened by the US Department of Energy's Electricity Subsector Coordinating Council (ESCC) to discuss security and reliability challenges. Another important role is served by the National Association of Regulatory Utility Commissioners (NARUC) which convenes the PUCs in annual meetings and conveys their concerns in Washington DC and state capitals.

In addition to regulatory forces, electric utilities, whether regulated with guaranteed rates set by their PUCs, or de-regulated and operating in competitive markets, have financial incentives to be as reliable as possible. They earn revenue by delivering kilowatt-hours to their customers, so when electricity isn't flowing, funding is reduced.

To date, regulation and market drivers have tended to ensure that reliable electric service is provided nearly everywhere when weather conditions were optimal or near optimal. However, when extreme weather in the form of record-breaking heat or cold, floods and fires, and storms of increasing ferocity arrive, as they do now with increasing frequency, the grid can buckle, as it did during the recent cold snap enveloping large swaths of the nation in December 2022.

The ERO Energy Transition Warning

The "warning" took the form of a response to capacity shortfalls due to heat and cold in summer and winter of the past year. Specifically, in 2022, NERC issued two reliability assessments, one in the spring with cautions about summer, and one in the fall ahead of winter.

The summer reliability assessment[2] (Figure 1) painted the entire western half of the United States and the Canadian province of Saskatchewan orange indicating elevated risk of electric service interruptions due to high heat, drought and wildfire concerns. And in the middle of the US, the Midcontinent Independent System Operator (MISO) region was warned about high risk due to capacity shortfalls, largely due to the closing of baseload coal generation plants without making up the difference.

And, of course, there's Texas, which chooses to remain an island, largely separate from the rest of the US grid. In so doing, the State limits its ability to im-

2 https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_SRA_2022.pdf

port electricity from other regions during extreme weather events like the deadly freeze experienced during February 2021.

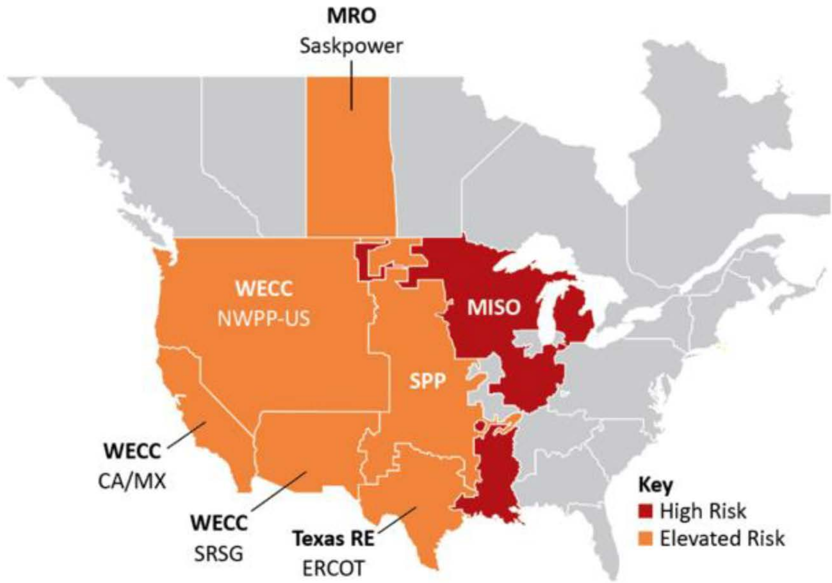

Figure 1: Summer Reliability Risk Area Summary

Seasonal Risk Assessment Summary	
High	Potential for insufficient operating reserves in normal peak conditions
Elevated	Potential for insufficient operating reserves in above-normal conditions
Low	Sufficient operating reserves expected

Figure 1: NERC Summer Reliability Risk Area Summary

The winter reliability report[3] colored the map differently, with the MISO region still in trouble for similar capacity adequacy reasons, and Texas for its inability to import electricity when needed, across state lines. Similar to Texas, but for different reasons, New England was also assessed as risky. Among other factors, the lack of adequate natural gas pipelines to the region makes it an island of sorts as well. When sustained cold weather arrives each winter, hard choices between using gas for electricity generation or for heating homes or businesses have to be made.

December's Winter Storm Elliott arrived just in time to cause catastrophic flight disruptions before, during and after Christmas. It once again helped illustrate how the electric and natural gas infrastructures are not up to the challenges of increasing extreme weather events.

> "High winds along with the cold temperatures from the arctic blast across much of the country created equipment problems at TVA's biggest coal plant and limited power from some natural gas-pow-

3 https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_WRA_2022.pdf

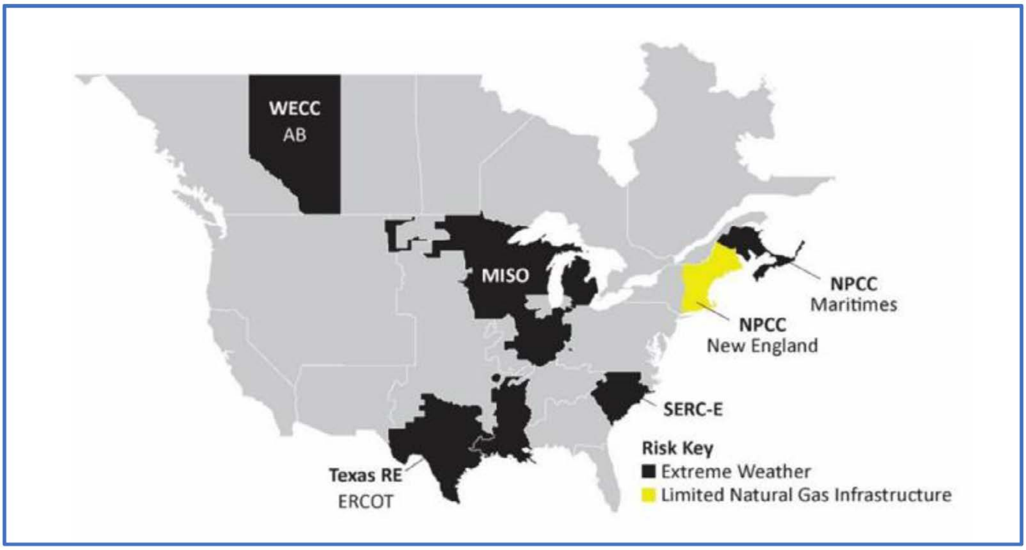

Figure 2: NERC Winter Reliability Risk Area Summary

> ered combustion turbines. At one point Friday, TVA lost more than 6,000 megawatts of power generation or nearly 20% of its load at the time, with both units at TVA's Cumberland Fossil Plant offline and other problems at some gas generating units."[4]

Just before year's end 2022, FERC and NERC filed to open an investigation on what went wrong and to possibly generate proposals for better performance in the face of future extreme winter weather events.[5] It should be noted that after every extreme heat, extreme cold or extreme storm event, utility representatives seem to suggest that they were unforeseeable.

NERC's Longer Look

Looking further out, NERC issues ten-year lookaheads intended to inform the next round of planning cycles. The most recent Long Term Reliability Assessment (LTRA) cites five trends that NERC perceives as having likely impact on grid performance on both good and more challenging days:

- Integration of inverter-based resources
- Growth in distributed energy resources
- Generation retirements
- Flat transmission growth
- Increased demand growth

4 https://www.timesfreepress.com/news/2022/dec/24/power-outages-tfp/

5 https://www.tdworld.com/overhead-distribution/article/21257108/ferc-nerc-to-open-joint-inquiry-into-winter-storm-elliott

Any one of these factors, if not monitored closely and adapted, could mean a North American grid that is less reliable than we expect it to be—and that we ought to we require it to be.

Add other eventualities that even the most prescient grid regulators and planners cannot foresee are events such as major war breaking out among countries with substantial energy market roles, or a global pandemic. Another contingency, however, is the future deployment of new forms of nuclear power generation that might meet both the demand for clean power with the urgent need for a firm baseload.

Is Help on the Way?

After stagnating for decades, enthusiasm for nuclear energy is rapidly growing. According to a mid-2022 report from the Pew Research Center:

> Despite longstanding safety concerns, many state leaders and some environmental groups say climate change poses a greater risk than reactors.[6]

According to former NERC Chief Security Officer Tim Roxey, there are two factors that should guide decision-makers and planners when it comes to developing new generation resources in 2023 and beyond: capacity factor and carbon footprint. "Taken together these two knowable factors can help policymakers sort through the societal demands for clean, available energy that is climate sensitive."[7]

While these factors can prompt significant debate among various renewable energy and thermal energy stakeholders, the Department of Energy's (DOE's) Office of Nuclear Energy claims that "nuclear has the highest capacity factor of any other energy source—producing reliable, carbon-free power more than 92% of the time in 2021. That's nearly twice as reliable as a coal (49.3%) or natural gas (54.4%) plant and almost 3 times more often than wind (34.6%) and solar (24.6%) plants."[8]

At Idaho National Laboratory and many other research facilities in the US and globally, new nuclear power plant designs are being developed and tested at a pace not seen until very recently.[9] Many of advanced designs use physics-based passive safety strategies to ensure that even when electric power is lost, nuclear fuel will remain cool. Such was the case in 2011 when a tidal wave hit Japan's Fukushima plant, swamping backup generators leading to a partial meltdown. With truck-transportable small modular reactors (SMRs) ranging from 50 Mega-

6 https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2022/06/15/climate-change-is-shifting-state-views-on-nuclear-power

7 Via personal communications

8 https://www.energy.gov/ne/articles/what-generation-capacity

9 https://inl.gov/trending-topic/small-modular-reactors/

watts to 800 Megawatts, and microreactors from 1 to 50 Megawatts, we may find ourselves in approximately a decade having the ability to build out a low-to-no carbon, load-following baseload that can then support larger amounts of wind and solar generation than is currently deployed.

Climate Change and Energy Transition Risks

The simplest way to frame this is that with weather increasingly getting more extreme, instead of reinforcing the North American grid to be able to handle it with confidence, we are inadvertently weakening it due to an overriding desire to decarbonize. Decarbonize, since emissions are what scientists agree are making the weather more extreme.[10]

One multi-state Southern utility, now fully aware of this situation, is poised to act:

> "Entergy Louisiana … filed its proposed Phase I Entergy Future Ready resilience plan with the Louisiana Public Service Commission. Phase I seeks approval of the first five years of a 10-year resilience plan that would aim to accelerate the restoration of power and reduce the costs associated with doing so following major storms … Although the company has successfully invested in its electric system for years, it is important to review the pace at which these efforts occur because the threat of weather events has increased at a time when the demand for power is expected to grow significantly to decarbonize the local economy and create a more sustainable future."[11]

While there are varying degrees of confidence and skepticism about the accuracy and precision of the perils global climate models show are coming, one need only turn to the international news. Or better yet, in one's own backyard to see that, depending on geography, significant changes to seasonal and other weather patterns are well underway. These conditions portend profound changes in both generation capacity and load, all which must be managed by utility operators and reliability coordinators.

Physical Risk Vulnerability Assessments Getting Underway

In January 2020 the Biden administration set the wheels in motion for the US Federal government to begin taking stock of climate change-borne risks to its own

10 From a technical and multi-disciplinary standpoint, Chris Nelder's "Energy Transition Show" is a dynamic information source for readers: https://xenetwork.org/ets/about/

11 https://www.tdworld.com/overhead-distribution/article/21256752/entergy-louisiana-files-proposed-10year-entergy-future-ready-resilience-plan

missions with the issuance of Executive Order 14008. Section 211 includes requirements for all US agencies and departments to:

> "Submit a draft action plan to the Federal Chief Sustainability Officer … that describes steps the agency can take to bolster adaptation and increase resilience of its facilities and operations to the impacts of climate change."[12] It continues, "Action plans should, among other things, describe the agency's climate vulnerabilities." And, "after submitting an initial action plan, the head of each agency shall submit to the Task Force and Federal Chief Sustainability Officer progress reports annually on the status of implementation efforts."

Two years later, DOE, for example, received the first round of reports in from its national laboratories and other sites in response to the Department's Vulnerability Assessment and Planning (VARP) guide.[13] Beginning in 2021 and over the next several years, the VARP requires each DOE entity to:

- Identify Critical Assets and Infrastructure
- Characterize Climate Trends and Events
- Characterize the Likelihood of Climate Change Hazards
- Characterize Current and Projected Impacts of Climate Change Hazards on Assets and Infrastructure Systems
- Characterize Vulnerabilities with a Risk Matrix
- Identify and Assess Resilience Solutions
- Develop and Implement a Portfolio of Resilience Solutions
- Monitor, Evaluate, and Reassess the Resilience Plan

At approximately the same time, FERC[14] and the SEC[15] have begun promulgating similar reporting requirements to the large number of energy and other organizations over which they have governance authority. Most of the corporate and governmental climate change activity to date has focused on emissions reductions. However, by the mid-2020s we should anticipate that every organization of consequence will examine climate change risks to both its mission and key assets. Furthermore, these organizations will update their resilience, business continuity

12 https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

13 Vulnerability Assessment and Resilience Plan Guidance v1.2 (Updated)

14 https://www.federalregister.gov/documents/2022/06/27/2022-13471/transmission-system-planning-performance-requirements-for-extreme-weather

15 https://www.sec.gov/news/press-release/2022-46

and adaptation plan accordingly. In truth, many have already begun this process, such as AT&T.[16]

Conclusions

Throughout history, there have been storms and floods, freezes and fires. Some arrive slowly, like drought and sea level rise, while others appear suddenly. Despite having experienced a similar if less intense weather system ten years prior, in February 2021, Texas was impacted by a wave of cold weather for which it was not prepared. Many died, and $100 billion dollars of physical and financial damage resulted. Amidst a tremendous amount of finger pointing, prominent US utility CEO Tom Fanning of Southern Company summarized the peril that befell Texas and that, without swift action, awaits utilities worldwide when he said:

> "This weather system in Texas greatly exceeded the planning criteria in which they operate ERCOT (Electric Reliability Council of Texas)."

What does it mean when for infrastructure as essential to economic security and public health as the power grid, utility planners misunderstand risks to reliable operations that their stakeholders expect? What are the criteria used based upon? Perhaps one aspect of this is undue reliance on historic conditions to project dynamic future circumstances. In the case of climate change, that may no longer be a responsible approach. Making the best use of downscaled appropriately calibrated global climate modeling data is the soundest approach from this point on.

Though its projections typically lag observed reality due to a conservative, consensus-driven approach, the Intergovernmental Panel on Climate Change (IPCC), in its sixth round of reports published in 2021 and 2022, largely removed qualifying language about what the world can expect to experience in the coming years.[17] A few takeaways:

- The world will probably reach or exceed 1.5 degrees C (2.7 degrees F) of warming above the industrial baseline within the next two decades.
- No region will be left untouched by the impacts of climate change, with enormous human and economic costs that far outweigh the costs of action. Southern Africa, the Mediterranean, the Amazon, the western United States and Australia will see increased droughts and fires, which will continue to affect livelihoods, agriculture, water systems and ecosystems.

16 https://www.forbes.com/sites/esri/2020/10/19/four-lessons-from-att-on-climate-resilience-and-business-continuity/?sh=6133f9523f94

17 Intergovernmental Panel on Climate Change, AR6 WG1. "Climate change widespread, rapid, and intensifying. 2021. https://www.ipcc.ch/2021/08/09/ar6-wg1-20210809-pr/

- Changes in snow, ice and river flooding are projected to impact infrastructure, transport, energy production and tourism in North America, the Arctic, Europe, the Andes and more.
- Many consequences of climate change will become irreversible over time, most notably melting ice sheets, rising seas, species loss and more acidic oceans.

In many ways, a dawning national recognition of the urgent need to address climate threats to critical infrastructure mirrors how cyber threats to these essential national assets were slowly recognized and then acted upon. Major climate change impacts on critical infrastructure are now drawing increased attention. It is arguable that far less time will be required to respond to this threat than the approximately two decades that it took for the full scope of cyber infrastructure threats to fully register. In short, the longer government regulators, reliability coordinators and utilities take to adjust their "planning criteria" and to update their adaptation and resiliency measures, the more we can expect grid reliability and performance metrics in both the energy and related critical infrastructure sectors to decline.

Author Capsule Bio

Andrew Bochman is Senior Grid Strategist for Idaho National Laboratory's National and Homeland Security directorate. Mr. Bochman provides strategic guidance on topics at the intersection of grid security, the Energy Transition, and infrastructure climate resilience and adaption to senior U.S. and international government and industry leaders. A Non-Resident Senior Fellow at the Atlantic Council's Global Energy Center, in 2021 he published *Countering Cyber Sabotage: Introducing Consequence-based Cyber-Informed Engineering*. He began his career as a communications officer in the US Air Force, and prior to joining INL, was a Senior Advisor at the Chertoff Group and the Energy Security Lead at IBM. Mr. Bochman received a BS from the U.S. Air Force Academy and an MA from Harvard University. With national laboratory colleagues, he is developing a decision support tool for government and industry planners and regulators. You can read more about its prioritization, data and workflow model here.[18]

18 https://resilience.inl.gov/icar/