UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Grid Reliability and Resiliency Pricing	))))	**Docket No. RM18-1-000**

REPLY COMMENTS OF MICHAEL MILLIGAN, Ph.D.

Introduction

On October 23, 2017, the North American Reliability Corporation (NERC) provided comments to FERC in response to the Notice of Proposed Rulemaking on Grid Reliability and Resilience Pricing (NOPR)**.** I hereby provide comments on NERC's submittal (the "NERC Comments").

For more than 25 years I have developed a deep expertise on the topic of maintaining a reliable and resilient North American power system in light of the changes in the generation mix and the electricity power markets. Until my recent retirement, I was Principal Researcher for Transmission and Grid Integration at the Department of Energy's (DOE) National Renewable Energy Laboratory (NREL). During my service at NREL I led and participated in numerous task forces for the NERC (including most recently the NERC Essential Reliability Services Task Force, ERSTF), the Institute of Electrical and Electronics Engineers (IEEE) Power and Energy Society, and the Western Electricity Coordinating Council (WECC). I have authored or coauthored more than 225 journal articles, conference papers, technical reports, and book chapters related to the power system.[1]

[1] My professional profile can be found on LinkedIn at www.linkedin.com/in/michael-milligan-11999234, and most publications are available at http://tinyurl.com/y8kollw9.

I am providing these Reply Comments primarily to explain that the NERC Comments overlooked or misconstrued NERC's own very significant body of work to ensure reliability as the resource mix changes in the Bulk Power System (BPS). While I have deep respect for NERC's mission and work, NERC's Comments in this docket conflict with the rich and nuanced findings of NERC technical studies and reliability assessments, which do not support a conclusion that any single class of generator must be retained in order to ensure the reliability of the BPS.

NERC President and CEO Gerry Cauley's recent testimony before Congress provided broader and more accurate context for the issues posed by the NOPR. For example, he stated:

- "Even with all the changes underway, the BPS remains highly reliable and resilient, showing improved reliable performance year over year. This record demonstrates the strong commitment to reliability by industry and all stakeholders, and the effectiveness of the model adopted by this committee in the Energy Policy Act of 2005."[2]

- "With a focus on these challenges, the grid can become even more reliable and resilient. Throughout this transition, NERC plays a critical role in identifying, assessing, and addressing risks to help navigate the transition reliably."[3]

Nowhere in his testimony did he suggest that out-of-market or other payments to a particular power source was necessary, or even advisable, as a solution to meet these challenges. The NOPR, however, would introduce a potential out-of-market payment structure that is discriminatory and does not reflect good market design principles. No demonstration has been made that shows fuel storage will (a) solve the problems of High Impact Low Probability (HILP) events or (b) that it is the most effective option, both from economic and reliability points of

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[2] Testimony of Gerry W. Cauley Before the Subcommittee on Energy, House Committee on Energy and Commerce, at 1 (Sept. 14, 2017), *available at* http://docs.house.gov/meetings/IF/IF03/20170914/106383/HHRG-115-IF03-Wstate-CauleyG-20170914-U1.pdf).

[3] Ibid. at 8.

view. In fact, data from the recent Polar Vortex identifies many contributing factors to the challenges to keeping the lights on during a difficult time. Among the many recommendations produced by a NERC/industry-wide working group, onsite fuel storage did not appear.[4]

The DOE NOPR does not appear to grasp the large and ongoing efforts by NERC, working collaboratively with the electric power industry, that have resulted in a consistently reliable bulk power system. The NERC Comments to the DOE NOPR, surprisingly, largely ignore much the good work that has been carried out by NERC and the various RTO/ISO market design processes that have worked successfully for many years and, importantly, are ongoing. Specifically:

- The DOE NOPR suggests that there has been some failure to properly address aspects of reliability and resilience of the BPS. This is directly at odds with NERC's diligent assessments of BPS reliability, and recent increases in reliability cited in NERC's Comments.[5]
- BPS reliability and resilience are inseparable and both are already included in NERC assessments and standards. NERC reliability metrics have long emphasized generators' ability to ride through all types of disturbances and automatically recover from events and attacks. Therefore, the capabilities required for resilience are already a core part of the NERC mandate for ensuring BPS reliability.
- NERC, with its broad participation of industry experts, has made significant progress in identifying the attributes of reliability and resilience, and is working toward explicit quantifications of how much is needed of each attribute to ensure reliability and resilience. This work will allow NERC to track trends with respect to these attributes so that entities responsible for operating the system reliability can procure needed services

[4] NERC: Polar Vortex Review, September 2014. Available at http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

[5] Comments of the North American Electric Reliability Corporation in Response to Notice of Proposed Rulemaking. FERC Docket No. RM18-1-000. P5. Available at http://www.nerc.com/FilingsOrders/us/NERC%20Filings%20to%20FERC%20DL/Comments%20of%20NERC%20re%20Proposed%20Grid%20Reliability%20and%20Resilience%20Pricing.pdf

well in advance of when they are actually needed. If FERC believes that there is some shortfall in the existing work at NERC related to BPS resilience, then it should suggest that NERC expand its current efforts. This could be done through a working group effort similar to the Integrating Variable Generation Task Force (IVGTF) and the Essential Reliability Services Working Group (ERSWG), which are discussed in more detail below. NERC's objective is to ensure reliability and security of the BPS, and as such, NERC is the appropriate home for such work.[6]

- To be consistent with NERC's responsibilities, existing body of work and technology-neutral mandate, it would have been appropriate for the NERC Comments to clearly explain the following points: (i) NERC is already assessing grid needs due to changes in the resource mix, (ii) any assessment of resilience must be based on a methodical definition and a methodical process based on data and engineering principles, and (iii) the principles of reliability and resilience must be based on technology-neutral attributes.

1. NERC's Role in the Bulk Power System

NERC sets the reliability rules for the bulk power system in the U.S. The interconnected portions of North America, including the Provinces of Canada and portions of Mexico, also follow NERC rules and standards. NERC staff convene many working groups, task forces, and committees, each of which focuses on one or more aspects of BPS reliability. Groups are comprised of power system experts, and are collaborative and data-based. In some cases, new metrics/measurements are developed so that particular aspects of reliability can be quantified. If data trends indicate a potential reliability issue, then rules, standards, or recommended practices, as appropriate, may be adopted through a collaborative process. This process is open and

[6] From the NERC web site www.nerc.com: "The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to assure the reliability and security of the bulk power system in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long- term reliability; monitors the bulk power system through system awareness; and educates, trains, and certifies industry personnel."

transparent; interested parties are able to review and comment upon proposed products of NERC groups, and voting establishes best practice and reliability standards/rules.

NERC standards are performance-based. For example, the new reliability standard BAL-002-2, which will become effective 1/1/2018, will require that area control error (ACE, a measure of imbalance) of a Balancing Authority (BA) must return to zero or pre-disturbance levels within 15 minutes.[7] As is typical for reliability standards, this new BAL standard will be agnostic to the resource mix available to the BA, as it will be agnostic to the transmission configuration. It specifies a performance standard and the metrics for meeting the standard; it does not constrain a BA's tools and options for meeting the standard.

2. NERC's Ongoing Efforts to Ensure Reliability with a Changing Resource Mix

The BPS is changing rapidly. A combination of technology, relative cost, and public preferences have instigated a transition to using more natural gas generation, more renewable energy sources such as wind and solar (variable generation, or VG), a declining amount of nuclear generation, and less coal generation. Although the type of technology shift changes many aspects of the power system, NERC has long been aware of this shift and has studied it thoroughly. Key considerations of this transition in the generation mix are (a) more variability and uncertainty in supply, (b) additional variability in demand caused by more impact of weather patterns on loads, generation, and distributed energy resources (DER) that are behind the meter,[8]

[7] BAL-002-2 – Disturbance Control Standard – Contingency Reserve for Recovery from a Balancing Contingency Event available at http://www.nerc.com/pa/Stand/Reliability%20Standards/BAL-002-2.pdf

[8] Although DER variability and uncertainty are referred to as "demand" because they are generally not visible to the power system operator and thus presents as if related to demand, the primary source of DER today is solar PV, which reduces demand for electricity from the BPS.

(c) requirements for more rigorous resource adequacy assessments, and (d) a gradual move toward a "lighter" system with less synchronous inertial response. NERC has been proactive in addressing these issues and continues to do so. DOE's NREL also is very involved in studying the changing energy mix. It has done numerous studies (including, for example, the Western Wind and Solar Integration Study[9] and the Renewable Electricity Futures Study[10]) that model how reliability can be maintained with much higher levels of variable generation than are on the system today.

The efforts of NERC, NREL and others on the careful understanding and planning of the BPS in light of the changing generation mix have been a long source of collaboration, as highlighted by the examples that follow.

a. Integrating Variable Generation Task Force (IVGTF)

This task force was formed in 2008 with an objective of investigating the issues that result from more VG on the power system. Because this was a NERC-led effort, the focus was on BPS reliability and the implications of high levels of VG. The IVGTF published a report[11] that identified a dozen issues that warranted more attention. The IVGTF then moved to a second

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[9] The National Renewable Energy Laboratory undertook a multi-year, in-depth evaluation of the Western power system in the U.S. that address most of these issues. See https://www.nrel.gov/grid/wwsis.html for the project web page and publications.

[10] The National Renewable Energy Laboratory undertook a multi-year, in-depth evaluation of the U.S. power system with very high levels of VG. See https://www.nrel.gov/analysis/re-futures.html for the project web page and publications.

[11] Special Report: Accommodating High Levels of Variable Generation, 2009. http://www.nerc.com/files/ivgtf_report_041609.pdf

phase of work, forming one working group per issue, and published a series of reports to assist system operators and planners with incorporating the characteristics of VG into their work.[12]

IVGTF Task 1.2 focused on calculating the capacity contribution of VG.[13] The report included several key observations:

- Probabilistic approaches to calculate capacity value are well-grounded in reliability theory and practice and should be continued, perhaps using additional related metrics.
- Because transmission can have an impact on BPS reliability,[14] the report recommends the development of additional methods and increased transparency in transmission assumptions for reliability studies. (Subsequent work[15] has shown the impact of additional transmission capability in reducing the need for planning reserves; this finding also is informative in cases of a HILP event such as a Polar Vortex).

b. Essential Reliability Services Task Force/Working Group

In 2014, NERC established the Essential Reliability Services Task Force (ERSTF)[16], which was subsequently changed to a working group (ERSWG) that continues to this day. This group has focused on the concerns that the ongoing retirement of large conventional base-load power

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[12] Links to the IVGTF and Task Forces can be found at http://www.nerc.com/comm/PC/Pages/Integration%20of%20Variable%20Generation%20Task%20Force%20(IVGTF)/Sub%20Teams/Interconnection.aspx

[13] Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning, available at http://www.nerc.com/files/ivgtf1-2.pdf

[14] See Ibanez, E.; Milligan, M. (2012). Probabilistic Approach to Quantifying the Contribution of Variable Generation and Transmission to System Reliability: Preprint. Prepared for the 11th Annual International Workshop on Large-Scale Integration of Wind Power into Power Systems as Well as on Transmission Networks for Offshore Wind Power Plants Conference, November 13-15, Lisbon, Portugal; 7 pp.; NREL Report No. CP-5500-56219. Available at http://www.nrel.gov/docs/fy12osti/56219.pdf

[15] ibid

[16] The Task Force/Work Group web page is located at http://www.nerc.com/comm/Other/Pages/Essential-Reliability-Services-Task-Force-(ERSTF).aspx

plants and the use of more natural gas plants, more demand response, and more non-synchronous resources using power electronics (largely VG) could potentially compromise reliability. A group of experts have met regularly and developed materials and processes for measuring how the system responds today, and to track trends so that mitigating measures can be taken in advance of any reliability concerns.

The ERSTF/WG effort has produced a significant increase in understanding of power systems and the transition of the resource mix. Significantly, an early recommendation of the ERSTF was that it would be prudent to ensure that all new resources have the capability of supporting voltage and frequency, regardless of fuel type and technology, and this early recommendation provided support for FERC's subsequent Order 827, Order 828, and the FERC NOPR on "Essential Reliability Services and the Evolving Bulk-Power System—Primary Frequency Response" (Docket No. RM16-6-000).

The ERSTF/WG effort has focused heavily on studying frequency support. To gain a technical understanding of the relationships between the inertial response from large rotating machines and the fast frequency response that is becoming available from both loads and non-synchronous resources, the ERSWG defined a series of frequency support metrics.[17] It is now working with the NERC Planning Committee and Operating Committee to collect measurement data from the BPS to establish valid baseline values and ensure the ongoing trending and monitoring of all aspects of frequency support, system balancing, and other attributes of reliability. As more conventional units retire and are replace with newer technologies, this

[17] Essential Reliability Services Task Force Measures Framework Report http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSTF%20Framework%20Report%20-%20Final.pdf

provides a way to track the attributes so that system operators and planners can be aware of emerging trends and prepare the system accordingly.[18,19]

In addition to inclusion of these trends in NERC's major annual assessment reports, industry practices will help ensure that any emerging concerns are addressed, and the sharing of experiences and lessons learned will increase our understanding and ability to manage the system for reliability. "The reliability of the system can be maintained or improved as the resource mix evolves, provided that sufficient amounts of essential reliability services are available." [20]

Technology is also evolving to support reliability, as new variable generators (wind, solar and storage) can provide essential reliability services (ERS) including voltage support, fast frequency response, and dynamic reactive power. **In at least some cases, BPS fault recovery performance is faster with high levels of VG and low levels of large thermal plants as compared to today's system.** VG can be called upon to respond to automatic frequency regulation, automatic frequency response, and economic dispatch when it is economic to do so, or if reliability requires it.[21] Modern wind and solar generation can therefore provide the key essential reliability services: voltage support, frequency response, simulated inertial response, ramping, frequency and voltage ride through, and more.

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[18] NERC ERS Sufficiency Guidelines Paper, Dec 2016, available at http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERSWG_Sufficiency_Guideline_Report.pdf

[19] NERC: Essential Reliability Services: Transformation of the Power System. Available at http://www.nerc.com/comm/Other/essntlrlbltysrvcstskfrcDL/ERS%20Abstract%20Report%20Final.pdf

[20] Id.

[21] Michael Milligan, et al., IEEE Power & Energy Magazine, *Alternative No More,* (Nov./Dec 2015) *available at* http://iiesi.org/assets/pdfs/ieee-power-energy-mag-2015.pdf provide examples of each of these.

c. Polar Vortex Review

To better prepare the power system industry for potential future extreme cold weather episodes,[22] NERC performed an analysis of the extreme cold weather event that occurred in early 2014. A large number of contributing factors were found that resulted in some combination of loss of generation, longer time to bring a resource online, or reduced output from a resource. The extreme cold weather had a major impact on generator equipment. Of the approximately 19,500 MW of capacity lost due to cold weather conditions, over 17,700 MW was due to frozen equipment.[23] Many outages, including a number of those in the southeastern United States, were the result of temperatures that fell below the plant's design basis for cold weather. In approximately 60 instances, this resulted in plant outages or delayed the units' ability to come online.[24]

The NERC report made several recommendations to help prepare for future, similar events, including the following:[25]

- Review natural gas supply and transportation issues and work with gas suppliers, markets, and regulators to develop appropriate actions.
- Review and update power plant weatherization programs, including procedures and staff training.
- Continue or consider implementing a program for winter preparation site reviews at generation facilities.
- Review internal processes to ensure they account for the ability to secure necessary waivers of environmental and/or fuel restrictions.

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[22] This extreme weather event is a good example of a "high impact, low probability" event (HILP).

[23] P. 2

[24] P. 14

[25] NERC: Polar Vortex Review, September 2014. Available at http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

- Continue to improve operational awareness of the fuel status and pipeline system conditions for all generators.
- Include in winter assessments reasonable losses of gas-fired generation and considerations of oil burn rates relative to oil replenishment rates to determine fuel needs for continuous operation.
- Ensure that on-site fuel and fuel ordered for winter is adequately protected from the effects of cold weather.
- Consider (where appropriate) the temperature design basis for generation plants to determine if improvements are needed for the plants to withstand lower winter temperatures without compromising their ability to withstand summer temperatures.
- Review the basis for reporting forced and planned outages to ensure appropriate data for unit outages and de-ratings.

d. Significance of the IVGTF, ESRWG, and Polar Vortex efforts

These efforts demonstrate that NERC staff, working with power system experts, have performed "due diligence" in evaluating potential reliability risks *and* in proposing mitigation methods. Because NERC's Comments to the DOE NOPR largely omitted its own *modus operandi* and recent good work that is relevant here, the record may not reflect the fact that the concerns that underlay the NOPR have been, and continue to be, high on the collective radar screen of NERC and the power system industry.

Notably, the solution posed by the DOE NOPR has *not* been identified as a significant contributor to reliability by NERC analyses, nor is the solution currently being contemplated by the various market design committees at the RTOs. This is not due to any omission on the part of NERC or the RTOs, but rather because the concern raised by the NOPR is not supported by the careful analysis and considerable experience of NERC, the RTOs and the industry.

3. Ambiguity and Omissions in NERC's Comments

Regrettably, the NERC Comments uses several terms that are not generally accepted, nor are they defined. NERC does not adequately discuss the issue of flexibility[26], and does not make it clear that most coal and all nuclear power plants in the U.S. provide limited, if any, ramping services. The flexibility of these plants is further reduced because of the lengthy minimum up- and down-times of these plants, which may be as long as 24 hours or more in some cases. This means these plants are significantly constrained from providing the flexibility that may be needed in response to large, unforeseen events.

a. Using terms that are not well-defined

The NERC Comments state that "Reliable operation of the BPS requires dependable capacity."[27] Dependable capacity does not have a uniform, universal definition: it generally refers to the maximum capacity that a unit can produce during a given time period, absent a forced outage or other issues. Power system reliability calculations have been well-established for many decades and utilize unit capacity and forced outage rates, mathematically convolved together with demand, to produce a family of reliability metrics. From these calculations, one

[26] There is a general agreement that the future power system must be more flexible. See Cochran, J.; Miller, M.; Zinaman, O.; Milligan, M.; Arent, D.; Palmintier, B.; O'Malley, M.; Mueller, S.; Lannoye, E.; Tuohy, A.; Kujala, B.; Sommer, M.; Holttinen, H.; Kiviluoma, J.; Soonee, S. K. (2014). **Flexibility in 21st Century Power Systems**. 21st Century Power Partnership. 14 pp.; NREL Report No. TP-6A20-61721. http://www.nrel.gov/docs/fy14osti/61721.pdf. See also the NERC IVGTF report North American Electric Reliability Corporation. Integrating Variable Generation Task Force on Probabilistic Methods Team. M. Milligan and M. O'Malley, leads. (2010). Special Report: Flexibility Requirements and Metrics for Variable Generation: Implications for System Planning Studies. Available at http://www.nerc.com/docs/pc/ivgtf/IVGTF_Task_1_4_Final.pdf

[27] P. 6

can extract the capacity value (or capacity credit, or reliable capacity) of a generator or group of generators, along with an estimate of the reliability of the entire power supply.

NERC's statement about dependable capacity misses an important point: *what is required for reliable operation is a reliable supply, and individual plants are not as reliable as the aggregate supply.* This can be easily seen by noting that individual plant forced outage rates are higher than system outage rates on the bulk system.[28] **Although individually-reliable units are certainly desirable, a reliable supply of power can be provided by a portfolio of plants that are less reliable than the system itself**. Milligan and Porter demonstrated this using a rigorous loss-of-load probability model, showing that a system-wide 1 day/10 years reliability target can be met with a large fleet of unreliable generators with forced outage rates exceeding 50%.[29] This means that system reliability can be met with a large portfolio of plants even though individual plant reliability may not be "dependable." Thus, in at least some cases generation diversity can overcome some notion of "dependability" and deliver high reliability for the BPS.

The DOE NOPR appears to have introduced a new term, "secure capacity," giving it a vague definition that cannot be meaningfully used in practice without further refinement. The NERC Comments also use this term, and while no one would conceptually object to having capacity

[28] For example, the effective forced outage rates of coal plants between 2011-2015, according to NERC data, is 8.58%. A common overall BPS reliability target is 1 day/10 years, roughly equivalent to a system EFOR of about 0.027%. See http://www.nerc.com/pa/RAPA/gads/_layouts/xlviewer.aspx?id=/pa/RAPA/gads/Reports/Generating%20Unit%20Statistical%20Brochure%204%202011-2015%20-%20All%20Units%20Reporting.xlsx&Source=http%3A%2F%2Fwww%2Enerc%2Ecom%2Fpa%2FRAPA%2Fgads%2FPages%2FReports%2Easpx&DefaultItemOpen=1

[29] The Capacity Value of Wind in the United States: Methods and Implementation, Electricity Journal, March 2006, Vol 19 #2, and also in NREL conference paper https://www.nrel.gov/docs/fy05osti/38062.pdf.

that is "secure," it is suggested in both the NOPR and the NERC Comments that this type of capacity is directly related to having on-site fuel storage, a need which has yet to be demonstrated. This need was **not** recognized in the NERC Polar Vortex report.[30] In fact, as was recognized very clearly in NERC's report, issues such as frozen coal piles or mechanical failures associated with cold temperatures suggest that on-site storage is simply not an attribute that would have any significant reliability/resilience value. Therefore, payments to encourage such fuel storage would have little, if any, impact on BPS overall reliability and would needlessly increase the cost of electricity.

The extensive literature and methods for assessing various types of risk in power system operations have not generally been rigorously applied to issues such as extreme weather events. These methods, coupled with scenario analysis and historical evidence from past extreme weather events, could shed light on potential vulnerabilities for extreme weather events, and also for other HILP events.[31]

b. Flexibility and Replacement of Capacity

The NERC Comments state that "Non-synchronous generation and natural gas-fired facilities do not currently replace the secure capacity provided by coal and nuclear generation."[32] It is not at all clear what this means because "secure capacity" is not defined. However, in the context of a large body of literature and power system practice, reliable capacity, as defined by capacity

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[30] North American Electric Reliability Corporation, "Polar Vortex Review," 2014. Available at http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

[31] Some of this is discussed in the IVGTF 1.6 Report: Probabilistic Methods, available at http://www.nerc.com/comm/PC/Integration%20of%20Variable%20Generation%20Task%20Force%20I1/IVGTF%20Task%201-6_09182014.pdf

[32] p 7

credit (effective load carrying capability, or ELCC) can be used to find the combination of gas/VG plants can replace the capacity of a coal/nuclear plant. Plants that are able to provide energy during critical times, whether peak demand periods or extreme weather events, will have higher ELCC, while plants unable to provide energy during these times will have lower ELCC. Coupled with scenario analysis, probabilistic methods based on loss-of-load probability (LOLP), expected unserved energy (EUE), and other methods can capture plant performance and contributions to reliability, and can account for fuel delivery disruptions. These methods can be used for any type of resource, and have been recommended for all types of generation (including gas, wind and solar plants) by the IEEE Power and Energy Society[33] and by NERC itself.[34]

In addition, nuclear and coal plants are not flexible: Nuclear plants in the U.S. don't ramp, turn down, or provide regulation or frequency response support[35], and coal plants have limited turn-down levels and ramping ability. Coal plants can provide frequency support but are generally relatively slow to respond (and may not be very accurate[36]). Both types of plants have

[33] Keane, A.; Milligan, M.; D'Annunzio, C.; Dent, C.; Dragoon, K.; Hasche, B.; Holttinen, H.; Samaan, N.; Söder, L.; O'Malley, M. (2011). Capacity Value of Wind Power. IEEE Transactions on Power Systems, Vol 26, No. 2, May. (IEEE Wind Capacity Value Task Force paper.)

[34] North American Electric Reliability Corporation. Integrating Variable Generation Task Force on Probabilistic Methods Team. M. Milligan and M. O'Malley, leads. (2011). Methods to Model and Calculate Capacity Contributions of Variable Generation for Resource Adequacy Planning. Available at http://www.nerc.com/docs/pc/ivgtf/IVGTF1-2.pdf

[35] See Kirby et al (2007), Nuclear Generating Stations and Transmission Grid Reliability, 2007 39th North American Power Symposium. IEEE Power and Energy Society. Available at http://www.consultkirby.com/files/NAPS_Sept_07.pdf

[36] Milligan et al (2011) show an example of a particularly inaccurate coal plant that, instead of providing frequency regulation, imposed an additional frequency regulation burden on the BPS. See NREL Technical Report Milligan, M.; Ela, E.; Hodge, B. M.; Kirby, B.; Lew, D.; Clark, C.; DeCesaro, J.; Lynn, K. (2011). Cost-Causation and Integration Cost Analysis for Variable Generation. 37 pp.; NREL Report No. TP-5500-51860. Available at

long start-up and shut-down times, further limiting their flexibility. Natural gas and VG plants provide these services much faster and more accurately.[37]

c. System Support Resources

It is not uncommon to have resources that are designated as "must-run" for reliability reasons, so that local constraints can be mitigated. These are generally "out of market" but are a result of insufficient transmission, and are thus used as an expedient but non-preferred solution until transmission upgrades or other mitigations can be made. There is no need to develop a full market for these products because they are limited in number and are local issues. (Similarly, voltage support is local and has no centralized market). However, these reliability-based, out-of-market payments are motivated because of temporary local constraints, and are made only after rigorous analysis shows that the resource is needed to provide a specific service—usually voltage support on a weak portion of the grid. These are usually temporary, and are maintained only until the binding system constraint can be removed through transmission or other system upgrades.

4. Unsubstantiated or Poorly-Described Claims

The NERC Comments claim that "Reliable operation of the BPS requires a generation resource mix that includes resources with fuel assurance and low sensitivity to disruptions of the fuel supply."[38] This statement is vague and does not provide useful information about the *level* of fuel assurance, either in the form of a probabilistic metric or fuel level. Similarly, a "low sensitivity" is not well defined. While it is reasonable to agree with the sentiment of the

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http://www.nrel.gov/docs/fy11osti/51860.pdf, also published in the Electricity Journal http://www.consultkirby.com/files/EJ_Article_Cost_Causation_Nov_2011.pdf

[37] Michael Milligan, et al., IEEE Power & Energy Magazine, *Alternative No More,* (Nov./Dec 2015) *available at* http://iiesi.org/assets/pdfs/ieee-power-energy-mag-2015.pdf

[38] P 9

statement, the NERC Comments could have gone further to say that existing power system computational tools can be used to help quantify questions such as "how much, how often, and when" might fuel supplies be disrupted, and whether that would have any impact on power system reliability. The answers likely depend upon specific transmission system characteristics, including the network topography but also the generation mix, and could allow for proactive operator response to emergency situations. As pointed out in the NERC Polar Vortex Review, fuel contracts can be a source of limitation, and this can occur even if there is sufficient physical gas fuel and pipeline capability. As in all markets, efficiency depends in part upon ensuring that institutional mechanisms such as contracting, scheduling, and operational practice do not serve as impediments to physical deliveries and reliable performance.

As NERC correctly states, diversity is helpful and mechanisms can enhance system performance under HILP events. There are many potential approaches, each of which has merits and demerits, and all should be evaluated for their efficacy and efficiency: revision of gas contracts to increase flexibility in delivery; reserve capacity; enhanced gas networks to enable diverse gas supply lines; enhanced electricity grid to enable diverse generation response to outages; there may be many more options and some are complementary.[39]

NERC Comments (and the NOPR) have assumed a single solution (which may not in fact be effective in the first place) to the resilience question, and have not fully examined the issue with the usual rigor of NERC working groups and task forces. This severely undermines the credibility of both the NOPR and the NERC Comments.

[39] The NERC Polar Vortex Review has a large number of additional recommendations.

Summary and Conclusions

NERC is the designated entity to ensure bulk system reliability in the United States. NERC's process is inclusive, collaborative, and based on extensive data and engineering analysis so that rules and processes are fact-based. For example, NERC has investigated gas supply issues and found room for improvement. NERC, along with its extensive network of power system experts, are now working on solutions. NERC's long and successful history of maintaining and improving BPS reliability confirms it has been successful in its mandate, and therefore NERC should continue to be the primary entity charged with identifying system reliability needs and solutions.

The NERC Comments miss the opportunity to describe a large, critical, and broadly collaborative set of work effort that has been addressing reliability and resiliency issues for the current and future evolution of the BPS. **Remarkably, onsite fuel storage (with its own attendant problems) has not emerged as a significant contributor to enhanced BPS reliability or resilience**. Finally, the NERC Comments fall short of recommending that the existing NERC processes, based on best engineering data and analysis, are indeed the most appropriate processes to stay abreast of the reliability implications of the many changes in the bulk power system.

Any initiative seeking to address reliability and resiliency should first define and then recognize the reliability attributes provide by *all* resources (including generators, storage, and responsive demand), not just coal and nuclear. The NERC Comments[40] and the NOPR both acknowledge that all resources have some reliability contributions. FERC's nondiscriminatory

[40] NERC Comments P.6: "The Commission should continue to pursue policies that recognize the reliability attributes of all resources…"

approach to market design does not allow for the discriminatory approach described in the NOPR. Market products should be performance-based, and not based on the type of fuel or technology used. This focus on performance-based market design is consistent with FERC policy, does not discriminate, rewards entities that can provide the service, does not reward entities that cannot provide the service, encourages the development of resources that can provide the service, and encourages the development of new technologies that could provide the service more economically. Grid reliability and resilience is maintained when the services that provably and directly contribute to reliability and resilience.

Document Content(s)