ANALYSIS GROUP

Electric System Reliability and EPA Regulation of GHG Emissions from Power Plants: 2023

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Acknowledgments

This is an independent study prepared by the author at the request of Environmental Defense Fund. The Report, however, reflects the analysis and judgment of the author alone.

About the Author

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About Analysis Group

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I. Executive Summary

This report is the latest in a long series of papers, comments and testimony that I have written over the past dozen years on the importance of maintaining electric system reliability as part of the development and implementation of federal regulations addressing air pollution from power plants. This report focuses on the Environmental Protection Agency's newest proposal to regulate greenhouse gas emissions from existing and new fossil generating units under Section 111 of the Clean Air Act.

A common theme in prior instances where EPA issued proposals to control power plant emissions is that industry stakeholders raise concerns that the proposal, if adopted by EPA, would jeopardize electric system reliability and thus conflict with the industry's obligation to provide around-the-clock electricity supply to consumers. Such red flags were raised in 2010 and 2011 about EPA's regulations to control mercury emissions, other hazardous air pollutants and the interstate transport of air pollution. Concerns were raised in the 2013-2015 period when EPA proposed regulations to control emissions of greenhouse gases from fossil-fueled power plants.

In each of those contexts, I authored or co-authored reports and provided testimony and commentary that acknowledged the critical importance of electric system reliability and described the various tools available to the industry to ensure the reliable supply of power even as owners of fossil-fueled generating units were required to take steps to reduce their emissions.[1] Some of these tools were written into the design of EPA's proposals themselves, because in each instance, EPA took into consideration the need to keep the lights on even as power plants complied with new regulations. Other tools are standard elements of the reliability tool kits long available to players in the electric industry.

In every instance in the past dozen years, the industry predictably stepped up to ensure that reliability was not compromised – mainly because these many tools are available and because power plant owners, reliability organizations, regulators, other public officials, and a wide range of other stakeholders took myriad actions to ensure that the grid as a whole performed its essential public service functions.

A common theme in past EPA efforts to control air pollution from existing power plants is concern that implementation of new rules will harm electric system reliability.

Yet past implementation of such power-plant emissions regulations has not led to such outcomes, in large part due to the existence and use of various tools to ensure reliable operations of the system.

In fact, in spite of early industry concerns that EPA's 2015 Clean Power Plan would introduce reliability problems if it went into effect (which it never did, after its implementation was stayed by the court and replaced by EPA in 2019), power-sector carbon dioxide emissions dropped to 34 percent below 2005 levels (thus exceeding the Clean

[1] These writings are referenced with citations in the body of this report.

Power Plan's goal of reducing such emissions by 32 percent by 2030).[2] There is no indication that such emission reductions have led to reliability events (although there is clear indication that extreme weather related to climate change has exacerbated them).

Reduction of power-sector carbon-dioxide emissions is the result of many changes in the electric industry over the past decade. The portfolio of generating resources has transitioned, with retirements of significant coal-fired generating capacity, with gas-fired power plants now providing the largest share of electricity supply and with wind and solar energy making up increasing percentages of electricity generation.[3] Electricity demand – in terms of year-long use and peak demand – has begun to grow in most parts of the country. Fundamental market forces, federal and state policies, and consumer preferences are principal drivers of such changes.[4] Extreme weather events, including frigid cold, droughts, heat waves, wildfires, torrential downpours, and flooding events, have disrupted energy infrastructure, including on the electricity grid (and notably among fossil generating units and their sources and transmitters of natural gas supply).[5]

Many stakeholders have commented that in light of these circumstances, the EPA's recent proposal errs in a number of ways, especially by not allowing more time for compliance and more expansive safety valves to provide more flexibility in the event that reliability problems arise.[6]

Many stakeholders have raised concerns that EPA's newest proposal to regulate GHG emissions from new and existing power plants could jeopardize reliability. Commenters call for longer compliance periods, greater flexibility in implementation and use of broader reliability safety valves.

The EPA regulation, however, reflects the agency's careful attention to reliability and includes many elements designed to ensure that the nation can enjoy the benefits of reduced aire pollution and operational reliability.

Although some of the particulars of the current context are different from those in the past, there are many reasons to feel reassured that this new EPA rule will not jeopardize electric system reliability.

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[2] Congressional Budget Office, "Emissions of Carbon Dioxide in the Electric Power Sector," December 2022, https://www.cbo.gov/system/files/2022-12/58419-co2-emissions-elec-power.pdf.

[3] National Academies of Sciences, Engineering and Medicine, "The Future of Electric Power in the United States," 2021 (hereafter "NASEM Future of Electric Power"), https://nap.nationalacademies.org/download/25968.

[4] Susan Tierney, "U.S. Coal-Fired Power Generation: Market Fundamentals as of 2023 and Transitions Ahead," August 8, 2023 (Corrected), https://www.analysisgroup.com/globalassets/insights/publishing/2023-tierney-coal-generation-report.pdf.

[5] Susan Tierney, Testimony before the U.S. Senate Committee on the Budget, Hearing on "Beyond the Breaking Point: The Fiscal Consequences of Climate Change on Infrastructure," July 26, 2023 (hereafter "Tierney Budget Committee Testimony 2023"), https://www.budget.senate.gov/imo/media/doc/Hon.%20Susan%20F.%20Tierney%20-%20Testimony%20-%20Senate%20Budget%20Committee.pdf.

[6] *See* for example the following sets of comments submitted to the Environmental Protection Agency in Docket EPA-HQ-OAR-2023-0072: American Public Power Association, Comments, August 9, 2023, https://www.regulations.gov/comment/EPA-HQ-OAR-2023-0072-0566; National Rural Electric Cooperative Association, Comments, August 8, 2023, https://www.electric.coop/wp-content/uploads/2023/08/111-NPRM-Comments-NRECA.pdf; Edison Electric Institute, Comments, August 8, 2023, https://www.eei.org//-/media/Project/EEI/Documents/Resources-and-Media/TFB/EEIComments_111Rules_FINAL_080823.pdf; Power Generators Air Coalition, August 8, 2023 (hereafter "PGen Comments"), https://pgen.org/wp-content/uploads/2023/08/PGen-Comments-on-EPAs-Proposed-GHG-Emission-Standards-and-Guidelines-for-Fossil-Fuel-Fired-EGUs-with-attachments.pdf; Electric Power Supply Association, "Comments", August 5, 2023. https://epsa.org/wp-content/uploads/2023/08/EPSAComments_EPA111_August2023.pdf.

First, the electricity reliability institutions, tools and processes in place today are as good as, if not better than, those in place a decade ago. In addition to its important and continually updated reliability assessments of reliability conditions and outlooks, the North American Electric Reliability Council has instituted new assessments[7] and tools to identify reliability risks and opportunities and to recommend approaches to mitigate them.

Second, significant attention is already being paid by federal and state legislators, reliability organizations, and regulators and other public officials to address confounding circumstances – including gas/electric coordination issues, cybersecurity risks, transitions in generation portfolios, need to enhance the resilience of energy infrastructure to extreme weather events, transmission expansion challenges, wholesale market rule considerations, utility forecasting and planning, equity concerns[8] – so as to assure the grid is fit for purpose in the years ahead.

Third, the EPA proposal to curb GHG emissions from new and existing electric generating units itself includes multiple features to accommodate flexibilities in implementation and compliance-related reliability concerns. These elements of the proposal include: the fact that emissions limits apply only to some subcategories of existing generating units; the long lead times for compliance (with varied deadlines for units with different "operating horizons" and capacity factors); and the ability of states to design implementation plans with a degree of allowance trading and banking; and the commitment of the Department of Energy to use its authorities in a circumstance where compliance at a particular unit might trigger a local reliability concern. There is also the agency's existing system emergency exclusion for reliability.[9]

Unquestionably, there are many other reliability risks that have been identified by NERC, FERC and other organizations.

There is significant work underway to address such risks and needs to continue in earnest, regardless of finalization of the EPA regulation and its eventual implementation in the years ahead.

Unquestionably, the important reliability risks that currently affect the electric industry must be addressed and there is significant work underway to do so.[10] Regardless of requirements that developers of new gas-fired power plants and owners of existing fossil fuel power plants comply with new GHG emission reduction requirements, the electric industry must take the steps necessary to ensure reliability given the many other changes already underway and that are affecting the nation's energy transition.

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[7] NERC, "2023 ERO Reliability Risk Priorities Report" (RISC Approved 7-24-2023; NERC Board approved 8-17-2023) (hereafter "NERC Reliability Risk Priorities Report 2023"), https://www.nerc.com/comm/RISC/Related%20Files%20DL/RISC_ERO_Priorities_Report_2023_Board_Approved_Aug_17_2023.pdf.

[8] NASEM Future of Electric Power; NASEM 2023 Decarbonization Study.

[9] https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-60/subpart-TTTT.

[10] NERC Reliability Risk Priorities Report 2023.

II. Background and Introduction

EPA's May 2023 proposal to regulate GHG emissions from existing and new fossil-fueled power plants has prompted thousands of public comments from stakeholders.[11] Among other things, various commenters from the power industry raise concerns about the implications of the proposed rule for electric system reliability, in part due to the potential for premature retirements of existing fossil-fueled electric generating units, operational constraints on some generating units, and difficulties in adding new gas-fired generating units.[12]

Some commenters point to what they view as technical flaws in the EPA's modeling of the industry's response to the proposed regulation, which in their view gives rise to reliability concerns. Other comments relate to market factors and considerations that the commenters view as inconsistent with EPA assumptions.

Comments address a wide variety of issues, only a small portion of which are addressed here in this report. This paper focuses on the following topics:

- Section III contains a high-level overview of the EPA proposal, especially as it intersects with electric-system reliability.

- Section IV provides context for considering the reliability-related comments and industry reactions to EPA's proposed regulations.

- Section V addresses my responses to thematic and technical concerns raised by stakeholders with regard to reliability issues.

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[11] As of October 24, 2023, the EPA reports that 8,034 comments have been posted to Docket EPA-HQ-OAR-2023-0072, and that the agency has received a total of 1,293,352 comments on its proposal. https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072.

[12] *See* for example the following sets of comments submitted to the Environmental Protection Agency in Docket EPA-HQ-OAR-2023-0072: American Public Power Association, Comments, August 9, 2023, https://www.regulations.gov/comment/EPA-HQ-OAR-2023-0072-0566; National Rural Electric Cooperative Association, Comments, August 8, 2023, https://www.electric.coop/wp-content/uploads/2023/08/111-NPRM-Comments-NRECA.pdf: Edison Electric Institute, Comments, August 8, 2023, https://www.eei.org//-/media/Project/EEI/Documents/Resources-and-Media/TFB/EEIComments_111Rules_FINAL_080823.pdf; Comments of the Power Generators Air Coalition on the U.S. EPA New Source Performance Standards for GHG Emissions, Docket No. EPA-HQ-OAR-2023, 0072, August 8, 2023 (hereafter "PGen Comments"), https://pgen.org/wp-content/uploads/2023/08/PGen-Comments-on-EPAs-Proposed-GHG-Emission-Standards-and-Guidelines-for-Fossil-Fuel-Fired-EGUs-with-attachments.pdf; Electric Power Supply Association, "Comments", August 5, 2023. https://epsa.org/wp-content/uploads/2023/08/EPSAComments_EPA111_August2023.pdf.

III. Overview: EPA's Proposed Regulation for GHG Emissions from Fossil Units

On May 23, 2023, the Federal Register published EPA's proposal under Section 111 of the Clean Air Act to establish new source performance standards ("NSPS") for GHG emissions from new fossil-fueled stationary combustion turbine ("CT") electric generating units ("EGUs"), existing coal-fired EGUs, and from large and frequently used existing fossil CTs.[13] (Smaller existing fossil CTs (whether frequently or infrequently used) are not covered by this proposed rule.)

The Federal Register notice (often referred to as the "Preamble") describes the proposal in detail, identifies topics for comment and is accompanied by several other documents including a Regulatory Impact Assessment.[14] EPA's May 2023 proposal anticipates that the agency will publish final emission guidelines in June 2024, with state plans due to the agency 24 months later (e.g., June 2026).[15]

EPA states that it "has designed these proposed standards and emission guidelines in a way that is compatible with the nation's overall need for a reliable supply of affordable electricity" and is "taking into account the cost of the reductions, non-air quality health and environmental impacts, and energy requirements." [16]

More specifically, EPA states that it "has carefully considered the importance of maintaining resource adequacy and grid reliability in developing these proposals and is confident that these proposed NSPS and emission guidelines – with the extensive lead time and compliance flexibilities they provide – can be successfully implemented in a manner that preserves the ability of power companies and grid operators to maintain the reliability of the nation's electric power system."[17]

In addition to its regular interactions with federal agencies involved in matters affecting the electric industry, EPA drafted its proposal after two rounds of broad stakeholder engagement, including a pre-proposal docket that solicited public input prior design of the proposed regulation.[18] EPA's interagency consultations included

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[13] This description of the EPA's proposal draws upon the Preamble published in the Federal Register 33240 Federal Register / Vol. 88, No. 99 at 33240, Tuesday, May 23, 2023, Proposed Rule (for Environmental Protection Agency, 40 CFR Part 60, [EPA–HQ–OAR–2023–0072; FRL–8536–02–OAR], RIN 2060–AV09, New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule) (hereafter referred to as the "Preamble"), https://www.govinfo.gov/content/pkg/FR-2023-05-23/pdf/2023-10141.pdf.

[14] See the "browse documents" tab at EPA's website for Docket EPA-HQ-OAR-2023-0072, https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072/document.

[15] Preamble, at 33372.

[16] Preamble, at 33243.

[17] Preamble, at 33246.

[18] Preamble, at 33276-77. "In the first round of outreach, in early 2022, the EPA sought input in a variety of formats and settings from States, Tribal nations, and a broad range of stakeholders on the state of the power sector and how the Agency's regulatory actions affect those trends. This outreach included State energy and environmental regulators; Tribal air regulators; power companies and trade associations representing investor-owned utilities, rural electric cooperatives, and municipal power agencies; environmental justice and community organizations; and labor, environmental, and public health organizations. A second round of outreach took place in August and September 2022, and focused on seeking input specific to this rulemaking. The EPA asked to hear perspectives, priorities, and feedback around five guiding questions, and encouraged public input to the nonregulatory docket (Docket ID No. EPA–HQ–OAR–2022–0723) on these questions as well."

discussions with the Department of Energy ("DOE") that covered reliability and technology issues among other things. Additionally, EPA described its resource adequacy assessment in a Resource Adequacy Technical Support Document.[19]

The proposed rule addresses emissions from certain types of fossil EGUs: new natural gas CT units (including in simple-cycle and combined-cycle configurations); existing fossil steam units (i.e., coal, natural gas, oil); and certain existing gas CTs.[20] The compliance deadlines vary for different types of units depending upon a number of factors relating to size, technology (i.e., steam unit versus combustion turbine) and operating characteristics (e.g., capacity factor, expected time period during which the unit would continue to remain in service), as explained further below.

In setting deadlines, EPA acknowledged that such factors affect the economics of recovering the costs of control technologies[21] and explained that during the early engagement process, "industry stakeholders requested that the EPA '[p]rovide approaches that allow for the retirement of units as opposed to investments in new control technologies, which could prolong the lives of higher-emitting EGUs; this will achieve maximum and durable environmental benefits.' Industry stakeholders also suggested that the EPA recognize that some units may remain operational for a several-year period but will do so at limited capacity (in part to assure reliability), and then voluntarily cease operations entirely."[22]

The proposed rule includes standards for new stationary CT units (which EPA states are likely to be fueled by natural gas) with facilities having different projected levels of output associated with "base load" operations (defined as units with a capacity factor greater than ~50 percent), "intermediate load" operations (units with a capacity factor of 20-~50 percent) and "low load" operations (units with a capacity factor less than 20 percent)).[23]

Between now and 2032, base load and intermediate units would need to meet emissions levels of highly efficient combined cycle ("CC") and CT technology, respectively. Starting in 2032, intermediate units would need to meet emissions associated co-firing with 30-percent low-GHG hydrogen ("H2"). In 2032 and beyond, base-load units would have standards consistent with two options (which EPA calls "pathways"): (a) a "Low-GHG Hydrogen Pathway" with an emissions standard based on co-firing with 30-percent low-GHG H2 starting in 2032, and with

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[19] See the EPA "TSD – Resource Adequacy," ID EPA-HQ-OAR-2023-0072-0034 (hereafter referred to as the "Resource Adequacy TSD"), at https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072/document.

[20] "The EPA is not proposing to revise the NSPS for newly constructed or reconstructed fossil fuel-fired steam generating units, which it promulgated in 2015 (80 FR 64510; October 23, 2015). This is because the EPA does not anticipate that any such units will construct or reconstruct and is unaware of plans by any companies to construct or reconstruct a new coal-fired EGU. The EPA is proposing to revise the standards of performance that it promulgated in the same 2015 action for coal-fired steam generators that undertake a large modification (*i.e.,* a modification that increases its hourly emission rate by more than 10 percent) to mirror the emissions guidelines, discussed below, for existing coal-fired steam generators. This will ensure that all existing fossil fuel-fired steam generating sources are subject to the emission controls whether they modify or not." Preamble, at 33245.

[21] Preamble, at 33245.

[22] Preamble, at 33245.

[23] EPA, "Clean Air Act Section 111 Regulation of Greenhouse Gas Emissions form Fossil Fuel-Fired Electric Generating Units," May 11, 2023, https://www.epa.gov/system/files/documents/2023-05/111%20Power%20Plants%20Stakeholder%20Presentation2_4.pdf; EPA, "Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants," Webinar for Communities with Environmental Justice Concerns and Members of Tribal Nations, June 2023, https://www.epa.gov/system/files/documents/2023-06/111%20Power%20Plants%20Stakeholder%20Presentation_Webinar%20June%202023.pdf.

emissions rates consistent with co-firing with 96-percent low-GHG H2 starting in 2038; or (b) a "CCS Pathway" tied to emissions levels of 90 percent carbon capture and storage starting in 2035. These standards are shown in Table 1, along with the timing and character of standards for existing units (explained further below).

Table 1:
EPA Proposed Emissions Guidelines and Standards for Various New and Existing Electric Generating Units

	New (or Modified) Units					Existing Units				
	New Fossil CTs (Likely natural gas units) with compliance starting on in-service date				New, Recon-structed or Modified steam units (Likely coal)	Fossil CTs >300 MW and CF>50%* (Likely gas)	Fossil Steam Units** (coal, gas, oil units)		Fossil Steam Units** (coal units)	
	CF <20%	CF 20-50%	CF >~50%				If cease operations by 2032	If cease operations by 2035	If cease operations by 2040	If operate beyond 2040
2024	Final rule (State Implementation Plans due 24 months later)									
2025	Use of low-CO_2 fuel	Use of efficient current CT technology	Use of efficient current CC technology		2015 standards remain in place***					
2026 (SIPs due)										
2027										
2028										
2029										
2030							Routine O&M (no emissions rate increase)	Routine O&M, no emissions rate increase, capacity factor <20%	Co-firing 40% natural gas (with 16% reduction in emissions rate)	CCS with 90% capture of CO_2
2031										
2032		Add co-firing with 30% low-GHG H2	Co-firing with 30% low-GHG H2	Efficient CC units		Same as New Fossil CCs with CF >50% (with two options)				
2033										
2034										
2035				CCS with 90% capture						
2036										
2037										
2038			Co-firing with 96% low-GHG H2							
2039										
2040										
2041+										

Acronyms:

CC (combined cycle); CCS (carbon capture and storage); CF (capacity factor); GHG (greenhouse gas); CO_2 (carbon dioxide); CT (combustion turbine); H2 (hydrogen); MW (megawatt); O&M (operations and maintenance); SIP (State Implementation Plan)

Notes:

Gray-shaded areas indicate years when such plants will no longer operate due to an enforceable commitment from the unit's owner.

* Existing gas-fired CTs: Smaller (<300MW) with capacity factor below 50% not covered by the current EPA GHG proposal.

** Existing gas or oil-fired boilers: routine O&M with no increase in emissions rate

*** Current standards remain in place until such time as EPA makes a new proposal

https://www.epa.gov/system/files/documents/2023-05/111%20Power%20Plants%20Stakeholder%20Presentation2_4.pdf;
https://www.epa.gov/system/files/documents/202306/111%20Power%20Plants%20Stakeholder%20Presentation_Webinar%20June%202023.pdf.

Large, frequently used existing fossil combustion turbine units would be required to follow those same emissions guidelines after 2032. For modified and reconstructed fossil steam units (which are likely to be coal-fired generating units), existing emissions standards established in 2015 remain in place.

For existing steam and combustion turbine generating units, EPA's Preamble summarizes the compliance deadlines by subcategory of generating units as follows (with emphasis and formatting adjustments added from the original text so as to focus on treatment of different categories of electric generating units):

> In response to this industry stakeholder input and recognizing that the cost effectiveness of controls depends on the unit's expected operating time horizon, which dictates the amortization period for the capital costs of the controls, **the EPA believes it is appropriate to establish subcategories of existing steam EGUs that are based on the operating horizon of the units**.
>
> The EPA is proposing that for **[existing steam] units that expect to operate in the long-term** (*i.e.,* those that plan to operate past December 31, 2039), the BSER [Best System of Emissions Reduction] is the use of CCS [carbon capture and storage] with 90 percent capture of CO_2 with an associated degree of emission limitation of an 88.4 percent reduction in emission rate (lb CO_2/MWh-gross basis). As explained in detail in this proposal, CCS with 90 percent capture of CO_2 is adequately demonstrated, cost reasonable, and achieves substantial emissions reductions from these units.
>
> The EPA is proposing to define **coal-fired steam generating units with medium-term operating horizons** as those that (1) Operate after December 31, 2031, (2) have elected to commit to permanently cease operations before January 1, 2040, (3) elect to make that commitment federally enforceable and continuing by including it in the State plan, and (4) do not meet the definition of near-term operating horizon units. **For these medium-term operating horizon units**, the EPA is proposing that the BSER is co-firing 40 percent natural gas on a heat input basis with an associated degree of emission limitation of a 16 percent reduction in emission rate (lb CO2/MWh-gross basis)….
>
> For **[existing fossil steam] units with operating horizons that are imminent-term**, *i.e.,* those that (1) Have elected to commit to permanently cease operations before January 1, 2032, and (2) elect to make that commitment federally enforceable and continuing by including it in the State plan, the EPA is proposing that the BSER is routine methods of operation and maintenance with an associated degree of emission limitation of no increase in emission rate (lb CO2/MWh-gross basis). The EPA is proposing the same BSER determination for units in the near-term operating horizon subcategory, *i.e.,* units that (1) Have elected to commit to permanently cease operations by December 31, 2034, as well as to adopt an annual capacity factor limit of 20 percent, and (2) elect to make both of these conditions federally enforceable by including them in the State plan.….
>
> The EPA is also proposing emission guidelines for **existing natural gas-fired and oil-fired steam generating units**. Recognizing that virtually all of these units have

> limited operation, the EPA is, in general, proposing that the BSER is routine methods of operation and maintenance with an associated degree of emission limitation of no increase in emission rate….[24]

Under Section 111(d) and its application to existing electric generating units, states must submit plans to EPA that provide for the establishment, implementation and enforcement of standards of performance for existing sources, with those state-specific standards being at least as stringent as EPA's final guidelines. States may take into account remaining useful life and other factors when applying standards of performance to individual existing sources. EPA is proposing that states submit their State Implementation Plans ("SIPs") within 24 months after EPA finalizes the new rule.

EPA's Preamble explains the agency's approach to considering the implications of the proposed rule for the ability of the grid to maintain resource adequacy and electric system reliability:[25]

> Finally, the EPA has carefully considered the importance of maintaining resource adequacy and grid reliability in developing these proposals and is confident that these proposed NSPS and emission guidelines – with the extensive lead time and compliance flexibilities they provide – can be successfully implemented in a manner that preserves the ability of power companies and grid operators to maintain the reliability of the nation's electric power system. The EPA has evaluated the reliability implications of the proposal in the *Resource Adequacy Analysis* TSD; conducted dispatch modeling of the proposed NSPS and proposed emission guidelines in a manner that takes into account resource adequacy needs; and consulted with the DOE and the Federal Energy Regulatory Commission (FERC) in the development of these proposals. Moreover, the EPA has included in these proposals the flexibility that power companies and grid operators need to plan for achieving feasible and necessary reductions of GHGs from these sources consistent with the EPA's statutory charge while ensuring grid reliability….[26]

EPA concluded that its proposed emissions standards for existing gas-fired and coal units and new gas-fired units would have "very little incremental impact on resource adequacy" relative to the agency's modeled baseline (without the proposed standards in place). EPA estimated, for example, that "the emission guidelines for existing gas would cover 36.8 GW of natural gas EGUs, which represents 7.7 percent of total natural gas capacity in 2035"

[24] Preamble, at 33245-46.

[25] EPA states in the Resource Adequacy Technical Support Document: "As used here, the term resource adequacy is defined as the provision of adequate generating resources to meet projected load and generating reserve requirements in each power region, while reliability includes the ability to deliver the resources to the loads, such that the overall power grid remains stable. This document is meant to serve as a resource adequacy assessment of the impacts of the final rule and how projected outcomes under the final rule compare with projected baseline outcomes in the presence of the [Inflation Reduction Act]." Resource Adequacy TSD, page 2.

[26] Preamble, at 33246.

and with "only a fraction of this amount ha[ving] a direct effect on resource adequacy" (i.e., meeting peak demand).[27]

The many provisions within EPA's proposed rule that also together address assurance of electric system resource adequacy and operational reliability include a combination of proposal elements and process attributes that provide many ways to address reliability concerns (i.e., at least a decade and in many cases longer to mitigate concerns). These elements include:

- Periods of governmental and stakeholder engagement prior to the 2023 Federal Register notice of the proposal, with discussions of potential interactions of the proposal and electric system reliability.

- Two-year lead times after EPA finalizes the rule in which states prepare their SIPs and identify potential ways (including through emissions averaging and trading) to provide compliance flexibility for affected generating units.

- Various time frames during which existing coal-fired generating units come into compliance with the emissions standards, depending on their operating horizons and output levels.

    - Coal units that commit to close by 2032 have no operating standards applied to them (except for routine operations and maintenance ("O&M")). This is nearly 10 years after notice of the proposed rule, and 8 years after the expected final rule.
    - Coal units that commit to close by 2034 and have low capacity factors (below 20 percent) have no operating standards applicable to them except for continued routine O&M. This is a decade after the expected year in which EPA finalizes the rule.
    - Coal units with longer anticipated retirement dates beyond 2034 have options for complying with the proposed standards – including through co-firing with natural gas and through eventually adding carbon capture and storage.

- Various options for gas-fired combustion turbines to comply:

    - New low load units (less than 20-percent capacity factor) are subject to standards equivalent to use of lower emitting fuels.
    - In the initial phase of compliance, new intermediate (20 to ~50 percent capacity factor) and baseload units (over ~50 percent capacity factor) are subject to GHG emissions rates tied to the most efficient CT and CC technologies, respectively, that are currently available (something that is likely to be efficient from an investor's point of view in any event).

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[27] Resource Adequacy TSD, page 7. Further, EPA explained: "The total available capacity is needed, at most, for only a fraction of the year [i.e., to meet peak demand]; most facilities can run at significantly less than full utilization throughout the year without any impact on resource adequacy or system reliability. Moreover, even those EGUs [electric generating units] that operate at 50% annual capacity factor or below, and therefore avoid any requirements under the proposed emission guidelines for existing gas, could operate at higher utilization during periods of system need without exceeding a 50% capacity factor on an annual basis. Grid planners and system operators assign high capacity accreditation values to natural gas-fired EGUs that operate at a wide range of capacity factors. Therefore, those EGUs that choose to reduce utilization to at or under 50% would receive full capacity accreditation."

- In later years, new intermediate units are subject to lower GHG emissions standards equivalent to co-firing with low-GHG-emitting hydrogen, while new baseload units are subject to standards equivalent to co-firing low-GHG hydrogen *or* use of carbon capture and storage technology.
- Existing units that are relatively large (over 300 MW) and that operate frequently (over 50-percent capacity factor) meeting similar emissions standards as new baseload units during those same post-2032 time periods.
- Existing gas-fired combustion turbines (operating as stand-alone peaking units or in combined cycle configurations) that are either smaller (which would cover most units[28]) or operate at less than 50 percent capacity factor are not covered by these proposed rules.

[28] According to the Energy Information Administration ("EIA"), most CT generating units that are in operation as of August 2023 and owned by an electric utility or an independent power product are less than 300 MW in size:

- There are approximately 1,750 gas-fired combustion turbine generating units. Only two of these units are above 300 MW in size (nameplate capacity). The total nameplate capacity of all of these units is 143,074 MW (with summer capacity rating of 120,420 MW). The average size is 81 MW (nameplate capacity), or 67 MW summer capacity rating.
- There are an additional 1540 gas-fired combined cycle generating units, of which 181 units are over 300 MW in size (nameplate capacity). The total nameplate capacity of all of these units is 291,340 MW (with summer capacity rating of 263,460 MW). The average size is 189 MW (nameplate capacity), or 171 MW summary capacity rating.

EIA, Preliminary Monthly Electric Generator Inventory, EIA 860M data for August 2023, https://www.eia.gov/electricity/data/eia860m/.

IV. Context: Reliability Concerns Raised in Prior EPA Regulatory Proposals

A predictable complement to an EPA proposal to regulate air pollutants from fossil fueled generating units is a call from various stakeholders to ensure that the new regulation would not jeopardize electric system reliability – something often accompanied by requests to modify and/or delay the proposed regulation.

This has happened on numerous occasions over the past dozen years, I have been involved in assessing reliability concerns in these instances, an experience that – along with my continued participation in a variety of fora involved with electric industry transitions – has given me a perspective on how to think about the concerns currently being raised about EPA's May 2023 proposal to regulate GHG emissions from fossil units.

Here are examples of those prior instances.

- In the early 2010s,[29] EPA published its draft Clean Air Interstate Rule ("CAIR"), which would regulate NO_x and SO_2 emissions in dozens of Eastern states and go into effect at the start of 2012. This rule was eventually replaced by the Cross-State Air Pollution Rule ("CSAPR"), issued by EPA in July 2011 for implementation starting in 2015. During the approximately same period, EPA was developing rules to regulate hazardous air pollutants and mercury emissions from power plants, which also affected emissions from fossil fueled generating units. The latter eventually took the form of the proposed Mercury and Air Toxics Standards (May 2011).[30] EPA proposed new source performance standards for new stationary sources in April 2012.[31]
- At the time, reliability concerns were raised by power plant owners, trade associations, and reliability organizations.
    - I co-authored three reports[32] aimed at assessing the implications of anticipated EPA air-emission regulations for electric-sector reliability, all of which concluded that the electric industry could comply with these EPA regulations without threatening electric system reliability. As I explained in the third of those reports:

        > The first report, published in August 2010, concluded that the electric industry is well-positioned to comply with EPA's proposed air regulations without threatening electric system reliability. The summer 2011 update, published in August,

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[29] https://www.epa.gov/sites/default/files/2016-10/documents/2013_full_report_0.pdf; https://www.epa.gov/Cross-State-Air-Pollution/overview-cross-state-air-pollution-rule-csapr#:~:text=This%20rule%20requires%20certain%20states,soot%20pollution%20in%20downwind%20state.

[30] https://www.epa.gov/mats/epa-proposes-mercury-and-air-toxics-standards-mats-power-plants.

[31] https://www.govinfo.gov/content/pkg/FR-2012-04-13/pdf/2012-7820.pdf.

[32] Michael J. Bradley, Susan Tierney, Christopher Van Atten, Paul Hibbard, Amlan Saha, and Carrie Jenks, "Ensuring a Clean, Modern Electric Generating Fleet while Maintaining Electric System Reliability," August 2010, https://www.npcc.org/content/docs/public/program-areas/rapa/government-regulatory-affairs/2010/mjbaandanalysisgroupreliabilityreportaugust2010.pdf; Michael J. Bradley, Susan Tierney, Christopher Van Atten, and Amlan Saha, "Ensuring a Clean, Modern Electric Generating Fleet while Maintaining Electric System Reliability: Summer 2011 Update," June 2011, https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/oira_2060/2060_06132011-2.pdf; Michael J. Bradley, Susan Tierney, Christopher Van Atten, and Amlan Saha, "Ensuring a Clean, Modern Electric Generating Fleet while Maintaining Electric System Reliability: Fall 2011 Update," November 2011, https://grist.org/wp-content/uploads/2011/11/reliabilityupdatenovember202011.pdf.

> supplemented the original analysis in light of new information and reaffirmed the prior report's major conclusion that the electric industry can comply with EPA's air pollution rules without threatening electric system reliability. The August report noted that proper planning and implementation can secure important public health benefits, reliable electric service, and efficient market outcomes. Th[e] "Fall 2011 Update" focuse[d] on the many tools that are available for ensuring electric reliability as companies comply with the EPA rules by installing modern pollution control systems, utilizing allowances or retiring portions of the fleet that are uneconomic to retrofit. Federal and state regulators agree that the industry has the tools to maintain electric system reliability even in the face of coal plant retirements. In testimony to Congress, FERC Commissioner John Norris stated "[i]n short, based on the information I have reviewed to date on EPA's regulations, I am sufficiently satisfied that the reliability of the electric grid can be adequately maintained as compliance with EPA's regulations is achieved.[33]

- I also wrote a "field guide" to the many industry studies assessing the impacts of EPA regulations on power supply and co-authored a peer review of an electric industry analysis of the potential impacts of environmental regulation on the U.S. generation fleet, and concluded that the report was based on "worst-case assumptions which have not materialized..."[34]

- I testified before the U.S. Senate Environment and Public Works Committee at its June 30, 2011 Oversight Hearing on Review of EPA Regulations Replacing the Clean Air Interstate Rule (CAIR) and the Clean Air Mercury Rule (CAMR), where I explained the reasons for concluding that the electric "industry will respond innovatively and effectively, and with confidence that Americans can get the benefit of clean air and reliable electricity."[35] *Because most of these reasons are still relevant today, I repeat this summary here:*

> The U.S. electric industry has a proven track record of doing what it takes to provide the nation with reliable electricity. Regulated electric utilities, competitive electric companies, grid operators, and regulators have a strong mission orientation, along

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[33] Michael J. Bradley, Susan Tierney, Christopher Van Atten, and Amlan Saha, "Ensuring a Clean, Modern Electric Generating Fleet while Maintaining Electric System Reliability: Fall 2011 Update," November 2011, https://grist.org/wp-content/uploads/2011/11/reliabilityupdatenovember202011.pdf.

[34] Susan Tierney May 17, 2011 letter to EPA Administrator Lisa Jackson, with three attachments: (a) S. Tierney and C. Cicchetti, "The Results in Context: A Peer Review of EEI's "Potential Impacts of Environmental Regulation on the U.S. Generation Fleet," May 2011; (b) S. Tierney, "Electric Reliability under New EPA Power Plant Regulations: A Field Guide," January 18, 2011; and (c) S. Tierney, "EPA Regulations, Power Generation Capacity & Reliability," MIT Center for Energy & Environmental Policy Research Workshop – May 5, 2011," https://policyintegrity.org/documents/Tierney_letter_to_EPA_Administrator_Jackson_5-17-2011_-_with_attachments.pdf.

[35] Susan F. Tierney, "Summary of Testimony Before the U.S. Senate Environment and Public Works Committee Subcommittee on Clean Air and Nuclear Safety, June 30, 2011 Oversight Hearing: Review of EPA Regulations Replacing the Clean Air Interstate Rule (CAIR) and the Clean Air Mercury Rule," https://www.epw.senate.gov/public/_cache/files/e/f/ef424b3a-c948-496d-9438-30674d9e25b3/01AFD79733D77F24A71FEF9DAFCCB056.tierneytestimonycombined.pdf.

with regulatory requirements, that together ensure that reliable electricity supply is a priority.

By 2011, it is not reasonable to suggest that EPA's CATR and Utility Toxics Rule are a surprise, or that EPA's proposed regulations will require actions that are technically and economically infeasible. These regulations have been in the works for many years. EPA's proposals allow more flexibility in compliance approaches than previously anticipated.

Many factors besides these new regulations have encouraged owners of coal-fired power plants to take steps to reduce their air emissions. Many states have already adopted regulations as strict as those proposed by EPA. Some companies with facilities affected by the CATR and Utility Toxics rules are already under court orders to achieve similar outcomes even without the new regulations. And many companies have already taken steps to install appropriate control equipment: in recent months, chief executive officers of some of the most affected utility companies in different parts of the country have told their investors that they are already or will be ready to meet the new EPA air regulations. These facts occur within a context in which low natural gas prices are putting pressure on many of the oldest, least-efficient and uncontrolled coal plants to retire for economic reasons.

Much attention has been, and will continue to be, paid to the impacts of the regulations on electric system reliability. Many assessments published in the past year have called attention to potential gaps that could arise in the absence of market, utility and regulators' responses. These studies highlight potential plant retirements under different sets of assumptions, with the more reasonable estimates indicating strongly that the impacts are manageable, as long as industry and its regulators respond in a timely fashion.

The industry has various tools to assure that reliability will not be adversely affected. Among the more important tools are: the strong system-planning processes of utility transmission companies and regional transmission organizations (grid operators); the opportunities for companies to obtain power resources through the wholesale power markets that exist in many of the affected parts of the country; the strong least-cost planning processes that exist for utilities in other affected areas; the interest and ability of developers of new power projects to bring new supplies to the market; the fact that state and federal [regulators] have a strong track record of taking the steps necessary to ensure that the companies they supervise are meeting their obligation to provide reliable electric service; the large reservoirs of untapped cost-effective energy efficiency in affected states that can be mined relatively rapidly and can help ease impacts on consumers' electricity bills; and the statutory tools available to EPA, the Federal Energy Regulatory Commission ("FERC"), the U.S. Department of Energy ("DOE"), and the President to take actions to ensure reliable system conditions when all else fails.

> Finally, recent market developments provide practical, real-world evidence that the EPA clean air regulations are manageable. Notably, the nation's largest competitive wholesale power market – PJM, serving much of the mid-Atlantic and Midwest regions affected by the EPA regulations – has recently conducted its annual auction to purchase capacity so that it will be available far in advance of need. The PJM auction elicited far more capacity offers from existing and new suppliers than is needed for reliability purposes during the period when EPA's new air rules will go into effect."

- During the mid-2010s, EPA was considering approaches to limit GHG emissions and in June 2014 proposed the Clean Power Plan, regulating carbon pollution from existing electric utility fossil generating units. There were myriad concerns raised about the direct impact of such regulations on potential retirements of fossil generating units (especially coal-fired power plants) and apparent consequential reliability concerns for the nation's electric system.

  The North American Electric Reliability Corporation ("NERC"), which is the nation's federally approved Electric Reliability Organization, had previously prepared assessments of the potential impacts of other future environmental regulations (including a November 2011 report on "Potential Impacts of Future Environmental Regulations: Extracted from the 2011 Long-Term Reliability Assessment)".[36] In November 2014, NERC issued its report on "Potential Reliability Impacts of EPA's Proposed Clean Power Plan: Initial Reliability Review."[37] These NERC reports identified retirements of fossil generating units as a major concern, noting the EPA's proposed Clean Power Plan "aims to cut CO_2 emissions from existing power plants to 30 percent below 2005 levels by 2030" and would lead to a major reduction in total generating capacity. NERC expressed its concern that, among other things, "[d]eveloping suitable replacement generation resources to maintain adequate reserve margin levels may represent a significant reliability challenge, given the constrained time period for implementation" and that "Essential Reliability Services may be strained by the proposed CPP."

  During that period, I wrote several papers[38] on reliability considerations related to potential EPA regulation of GHG emissions. Among my observations and conclusions in those reports, I note the following here because they are relevant for consideration of the May 2023 EPA proposal to regulate GHG emissions from fossil generating units:

[36] This report examined implications of several EPA regulatory activities, including the proposed Coal Combustion Residuals rule, the MATS rule, the Cooling Water Intake Structures rule, and the Cross-State Air Pollution Rule. https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/EPA%20Section.pdf.

[37] https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/Potential_Reliability_Impacts_of_EPA_Proposed_CPP_Final.pdf.

[38] Additionally, I testified before Congress on market and reliability considerations associated with EPA's regulation of GHG emissions from fossil fueled power plants: Testimony of Susan F. Tierney, Ph.D. Before the U.S. House of Representatives Committee on Energy and Commerce, Subcommittee on Energy and Power, "Hearing on EPA's Proposed GHG Standards for New Power Plants and H.R. _, Whitfield-Manchin Legislation November 14, 2013," https://docs.house.gov/meetings/IF/IF03/20131114/101482/HHRG-113-IF03-Wstate-TierneyS-20131114.pdf.

- In 2014, I wrote a white paper on EPA regulation of GHG emissions, with a focus on implications for electric system reliability.

> Historically, the reliability red flag has tended to be raised with regard to concerns that compliance with a new environmental rule would require a large portion of generating capacity to be simultaneously out of service to add control equipment, to retire permanently, or otherwise to become unavailable to produce power. To date, implementation of new environmental rules has not produced reliability problems, in large part because the industry has proven itself capable of responding effectively. A very mission-oriented industry, composed of electric utilities, other grid operators, non-utility energy companies, federal and state regulators, and others, has taken a wide variety of steps to ensure reliability."[39]
>
> Other factors also allow for cost-effective emissions reductions at Section 111(d) units in ways that do not adversely affect system reliability. A significant amount of existing generating capacity is underutilized. For example, output at natural-gas fired combined-cycle power plants averaged approximately 50 percent in 2012. There is the potential to reduce overall demand through energy efficiency, thus reducing the need to dispatch plants with relatively high emission rates. There is potential to add additional low or zero-carbon electricity supply (e.g., wind and solar; combined heat and power; nuclear uprates). Actions also can be taken to extend the life of, or increase the output from, well-performing generating units that produce no emissions at the facility (e.g., hydroelectric resources, nuclear plants).[40]

- In 2015, I participated in a FERC Technical Conference on reliability considerations relating to EPA's proposed Clean Power Plan, and then co-authored a report[41] that summarized and responded to a range of themes raised by other commenters at the series of Technical Conferences hosted by FERC in February and March 2015. Our report observed the following:

> Throughout the FERC CPP Technical Conferences, some participants questioned whether, in light of CPP-driven changes in the resource mix, the grid could continue to perform, especially through high energy demand periods or during unexpected events. These participants generally cited three main factors for these concerns: (1) closure of coal-fired power plants that provide energy, capacity, and

[39] Susan Tierney, "Greenhouse Gas Emission Reductions From Existing Power Plants: Options to Ensure Electric System Reliability," May 2014, https://www.analysisgroup.com/globalassets/content/insights/publishing/tierney_report_electric_reliability_and_ghg_emissions2.pdf.

[40] Susan Tierney, "Greenhouse Gas Emission Reductions From Existing Power Plants: Options to Ensure Electric System Reliability," May 2014, https://www.analysisgroup.com/globalassets/content/insights/publishing/tierney_report_electric_reliability_and_ghg_emissions2.pdf.

[41] Susan Tierney, Eric Svenson, and Brian Parsons, "Ensuring Electric Grid Reliability Under the Clean Power Plan: Addressing Key Themes from the FERC Technical Conferences," April 2015, https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2015/04/Ensuring-Electric-Grid-Reliability-Under-the-Clean-Power-Plan.pdf.

essential reliability services such as reactive power, inertia, and voltage control; (2) inadequate infrastructure to support increased demand for natural gas for power generation in various parts of the country, and/or inadequate natural gas supplies; and (3) higher reliance on renewable and demand-side resources.

The evidence does not support the argument that the proposed CPP will result in a general and unavoidable decline in reliability. While we do expect significant changes to the overall mix of resources under the CPP, we believe resource planners and markets will have sufficient time and resources to respond to a realistic projection of system redispatch and facility retirements. Both FERC-jurisdictional electricity markets and state-regulated resource planning processes have provided and will continue to provide timely planning, operational, and financial signals for new resources that can help maintain reliability. With clear and transparent signals, market participants can respond in different time frames and investment cycles for different types of resources, including but not limited to new gas resources, end-use energy efficiency measures and demand response, renewables, electric transmission, and natural gas pipeline infrastructure. We note that several market participants filed comments with EPA indicating their readiness to step up with solutions to these challenges.[42]

- In 2015, I co-authored several reports that addressed electric reliability issues related to the EPA's Clean Power Plan. The initial report focused on tools and practices available to electric industry and its regulators to ensure reliable electric service even as the federal government begins to regulate GHG emissions from power plants.[43] The other reports examined more specific reliability considerations in two regions – the PJM region and the MISO region – with significant existing coal-fired and other fossil generating capacity that would be affected by the CPP.[44]

Since the U.S. Environmental Protection Agency (EPA) proposed its Clean Power Plan last June, many observers have raised concerns that its implementation might jeopardize electric system reliability. Such warnings are common whenever there is major change in the industry, and play an important role in focusing the

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[42] Susan Tierney, Eric Svenson, and Brian Parsons, "Ensuring Electric Grid Reliability Under the Clean Power Plan: Addressing Key Themes from the FERC Technical Conferences," April 2015, https://blogs.edf.org/climate411/wp-content/blogs.dir/7/files/2015/04/Ensuring-Electric-Grid-Reliability-Under-the-Clean-Power-Plan.pdf.

[43] Susan Tierney, Paul Hibbard and Craig Aubuchon, "Electric System Reliability and the EPA's Clean Power Plan: Tools and Practices," February 2015 (hereafter "Tierney et al Electric Reliability Tools and Practices" and attached to this report as Attachment 1) https://hepg.hks.harvard.edu/sites/hwpi.harvard.edu/files/hepg/files/electric_system_reliability_and_epas_clean_power_plan_0215.pdf?m=1529956845.

[44] Susan Tierney, Paul Hibbard and Craig Aubuchon, "Electric System Reliability and the EPA's Clean Power Plan: The Case of PJM," March 16, 2015, https://www.analysisgroup.com/globalassets/content/insights/publishing/electric_system_reliability_and_epas_clean_power_plan_case_of_pjm2.pdf; and Susan Tierney, Paul Hibbard and Craig Aubuchon, "Electric System Reliability and the EPA's Clean Power Plan: The Case of MISO," June 8, 2015, https://www.analysisgroup.com/globalassets/content/insights/publishing/analysis_group_clean_power_plan_miso_reliability.pdf.

> attention of the industry on taking the steps necessary to ensure reliable electric service to Americans. There are, however, many reasons why carbon pollution at existing power plants can be controlled without adversely affecting electric system reliability.
>
> Given the significant shifts already underway in the electric system, the industry would need to adjust its operational and planning practices to accommodate changes even if EPA had not proposed the Clean Power Plan. In the past several years, dramatic increases in domestic energy production (stemming from the shale gas revolution), shifts in fossil fuel prices, retirements of aged infrastructure, implementation of numerous pollution-control measures, and strong growth in energy efficiency and distributed energy resources, have driven important changes in the power sector. As always, grid operators and utilities are already looking at what adjustments to long-standing planning and operational practices may be needed to stay abreast of, understand, and adapt to such changes in the industry.
>
> The standard reliability practices that the industry and its regulators have used for decades are a strong foundation from which any reliability concerns about the Clean Power Plan will be addressed. The electric industry's many players are keenly organized and strongly oriented toward safe and reliable operations. There are well-established procedures, regulations and enforceable standards in place to ensure reliable operations of the system, day in and day out…..
>
> Some of the reliability concerns raised by stakeholders about the Clean Power Plan presume inflexible implementation, are based on worst-case scenarios, and assume that policy makers, regulators, and market participants will stand on the sidelines until it is too late to act. There is no historical basis for these assumptions. Reliability issues will be solved by the dynamic interplay of actions by regulators, entities responsible for reliability, and market participants with many solutions proceeding in parallel. Some of the cautionary comments are just that: calls for timely action…
>
> In the end, because there are such fundamental shifts already underway in the electric industry, inaction is the real threat to good reliability planning. Again, there are continuously evolving ways to address electric reliability that build off of strong standard operating procedures in the industry.

In the end, there were no reliability problems that arose as a result of EPA's proposed and/or adopted regulation of air emissions from fossil-fueled power plants. This outcome occurred even as other EPA air-pollution rules (e.g., mercury controls, air transport regulations) did go into effect.

In fact, as noted previously, even though the EPA's Clean Power Plan was eventually stayed by federal courts and repealed and replaced by the EPA in 2019,[45] the CPP goal of reducing CO2 emissions from power plants by 32 percent by 2030 was reached by 2020, a decade earlier than planned by the CPP.[46] By that point, transitions in the electric industry (including retirements of significant and relatively inefficient fossil generating capacity, a shift from coal-fired generation to gas-fired power production, and the addition of significant new wind and solar capacity) had taken place more quickly than had been anticipated when the CPP was under consideration.[47]

In many ways, today's context for considering reliability issues related to EPA's new proposal to regulate power plant GHG emissions differs in a number of ways, in other regards the reliability issues, including tools and practices for ensuring reliability, are not so different than they were in the past decade, as described in the following sections of this report.

[45] https://www.epa.gov/stationary-sources-air-pollution/electric-utility-generating-units-repealing-clean-power-plan#:~:text=Additional%20Resources-,Rule%20Summary,the%20Affordable%20Clean%20Energy%20rule.

[46] CBO, "Emissions of Carbon Dioxide in the Electric Power Sector," December 2022, https://www.cbo.gov/system/files/2022-12/58419-co2-emissions-elec-power.pdf.

[47] *See*, for example, EIA, "Analysis of the Impacts of the Clean Power Plan," May 22, 2015, https://www.eia.gov/analysis/requests/powerplants/cleanplan/.

V. Concerns Raised About EPA's 2023 Proposal: Thematic and Technical Issues

A. Overview: Changing conditions in the nation's electric industry

EPA's Preamble describes the changing conditions in the U.S. electric industry, with observations that rely on and cite to many scholarly and expert analyses. As summarized in the Preamble, these power sector changes and trends include: "a prolonged period of transition and structural change. Since the generation of electricity from coal-fired power plants peaked nearly two decades ago, the power sector has changed at a rapid pace. Today, natural gas-fired power plants provide the largest share of net generation, coal-fired power plants provide a significantly smaller share than in the recent past, renewable energy provides a steadily increasing share, and as new technologies enter the marketplace, power producers continue to replace aging assets with more efficient and lower cost alternatives."[48] EPA notes that many owners of existing coal-fired power plants have either already retired them in recent years due to their no longer being economic to operate and maintain, or have announced their intention to retire specific generating units in the future.[49]

The electric-sector trends observed by EPA in detail in the Preamble are consistent with those described in detail in recent National Academies' consensus studies of which I was a co-author: *The Future of Electric Power in the U.S.* (2021),[50] *Accelerating Decarbonization in the U.S* (2021, 2023),[51] and the *Role of Net Metering in the Evolving Energy System* (2023).[52] These trends are also the subject of numerous other governmental, expert and stakeholder groups, including ones related to gas/electric coordination issues,[53] cybersecurity risks,[54] transitions in

[48] Preamble, at 33255, and 33256-33266 and 33415-33416 more generally.

[49] EPA stated that: "Industry stakeholders have requested that the EPA structure this rule to avoid imposing costly control obligations on coal-fired power plants that have announced plans to voluntarily cease operations, and the EPA proposes to accommodate those requests." Preamble, at 33255.

[50] NASEM Future of Electric Power.

[51]; NASEM 2021 Decarbonization Study; NASEM 2023 Decarbonization Study.

[52] National Academies of Sciences, Engineering and Medicine, "The Role of Net Metering in the Evolving Electricity System" (2023) (hereafter "NASEM Net Metering Study"), https://www.nationalacademies.org/our-work/the-role-of-net-metering-in-the-evolving-electricity-system.

[53] FERC, NERC, and Regional Entity Joint Staff Inquiry, "December 2022 Winter Storm Elliott Grid Operations: Key Findings and Recommendations," September 21, 2023, https://www.ferc.gov/news-events/news/presentation-ferc-nerc-regional-entity-joint-inquiry-winter-storm-elliott; FERC, NERC, and Regional Entity Joint Staff Inquiry, "December 2022 Winter Storm Elliott Grid Operations: Key Findings and Recommendations," September 21, 2023, https://www.ferc.gov/news-events/news/presentation-ferc-nerc-regional-entity-joint-inquiry-winter-storm-elliott.

[54] NASEM, Future of Electric Power.

generation portfolios,[55] need to enhance the resilience of energy infrastructure,[56] and transmission expansion challenges.[57]

The Preamble and the Technical Support Document also acknowledge the important influences and roles of other actions and developments – like the increasingly apparent impacts of a changing climate, changes in electricity demand and consumer preferences, the enactment of the 2021 Infrastructure Investment and Jobs Act and the 2022 Inflation Reduction Act, other changes in the cost and performance of electricity generation technologies and fossil fuels, trends in states' adoption of policies affecting the power sector's reliance on different resource portfolios and its emissions of GHGs, and increasing numbers of power companies with commitments to reduce GHG emissions.[58]

Perhaps with the exception of the two new federal statutes[59] which in 2021 and 2022 established extraordinary new levels of financial support and bolstered federal authority for various public and private investment in clean energy technology, these electric-industry changes have been underway for much of the past decade. As such, many of the discussions of reliability concerns and strategies described in the prior section of this report are entirely relevant today.

That said, there are heightened concerns in recent years, in part due to some recent reliability events (e.g., Winter Storm Uri in 2021 and Winter Storm Elliott in 2022[60]) that stressed electric and other energy infrastructure and in some cases produced blackouts or near blackouts with fatal consequences.[61] There is substantial attention to bulk power system reliability being paid by numerous entities, including by NERC which is capably exercising its

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[55] NASEM, Future of Electric Power; National Academies of Sciences, Engineering and Medicine, "Accelerating Decarbonization of the U.S. Energy System" (2021) (hereafter "NASEM 2021 Decarbonization Study") and "Accelerating Decarbonization in the United States: Technology, Policy and Societal Dimensions" (2023) (hereafter "NASEM 2023 Decarbonization Study"), https://www.nationalacademies.org/our-work/accelerating-decarbonization-in-the-united-states-technology-policy-and-societal-dimensions.

[56] *See* for example: U.S. Department of Energy ("DOE"), "National Transmission Needs Study," October 2023, https://www.energy.gov/sites/default/files/2023-10/National_Transmission_Needs_Study_2023.pdf; DOE, "Biden-Harris Administration Announces $13 Billion to Modernize and Expand America's Power Grid," November 18, 2022, https://www.energy.gov/articles/biden-harris-administration-announces-13-billion-modernize-and-expand-americas-power-grid.

[57] *See* for example: Joint Federal-State Task Force on Electric Transmission, https://www.ferc.gov/media/e-1-ad21-15-000; DOE, "Biden-Harris Administration Announces $3.5 Billion for Largest Ever Investment in America's Electric Grid, Deploying More Clean Energy, Lowering Costs, and Creating Union Jobs," October 18, 2023, https://www.energy.gov/articles/biden-harris-administration-announces-35-billion-largest-ever-investment-americas-electric.

[58] Preamble, at 33249-33266.

[59] The Inflation Reduction Act has been called the first and largest climate policy law enacted by Congress. *See* for example: Emma Newburger, "The U.S. passed a historic climate deal this year – here's a recap of what's in the bill," CNBC, December 30, 2022, https://www.cnbc.com/2022/12/30/2022-climate-recap-whats-in-the-historic-inflation-reduction-act.html; Josh Bivens, "The Inflation Reduction Act finally gave the U.S. a real climate change policy," August 14, 2023, https://www.epi.org/blog/the-inflation-reduction-act-finally-gave-the-u-s-a-real-climate-change-policy/.

[60] FERC – NERC – Regional Entity Staff Report, "The February 2021 Cold Weather Outages in Texas and the South Central United States," November 2021, https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and; FERC, NERC, and Regional Entity Joint Staff Inquiry, "December 2022 Winter Storm Elliott Grid Operations: Key Findings and Recommendations," September 21, 2023, https://www.ferc.gov/news-events/news/presentation-ferc-nerc-regional-entity-joint-inquiry-winter-storm-elliott.

[61] Budget Committee 2023. Tierney Budget Committee Testimony 2023; Testimony of Dr. Melissa Lott of the Columbia University Center on Global Energy Policy before the Senate Committee on Energy and Natural Resources, Hearing on Electric Reliability, June 1, 2023, https://www.energypolicy.columbia.edu/wp-content/uploads/2023/05/Lott-SENR-Testimony-with-appendix-v20230530-1.pdf.

essential role of calling attention to issues related to the adequacy, security and resilience of the power system.

For example, the most recent NERC Long-Term Reliability Assessment (December 2022)[62] identifies "government policies, regulations, consumer factors, and economic factors" as helping to shape transitions in the bulk power system. Prolonged, extreme weather events[63] and "continuing resource mix challenges"[64] are also creating new reliability challenges in recent and in upcoming years. In short: "Energy systems and the electricity grid are undergoing unprecedented change" with the need for relevant actors to take steps to ensure reliability. Such steps include "effective regional transmission and integrated resource planning processes," the adoption of policies and market mechanisms to ensure the capability of the system to maintain "essential reliability services,"[65] transmission investment,[66] "managing the pace of generator retirements until solutions are in place that can continue to meet energy needs and provide essential reliability services,"[67] and mitigating "the risks that arise from growing reliance on just-in-time fuel for electric generation and the interdependent natural gas and electric infrastructure."[68]

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[62] NERC, "Long-Term Reliability Assessment," December 2022 (hereafter "NERC Long-Term Reliability Assessment 2022"), https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2022.pdf.

[63] "Electricity supplies can decline in extreme weather for many reasons. Generators that are not designed or prepared for severe cold or heat can be forced off-line in increasing amounts. Wide area weather events can also impact multiple balancing and transmission operations simultaneously that limit the availability of transfers. Fuel production or transportation disruptions could limit the amount of natural gas or other fuels available for electric generation. Wind, solar, and other variable energy resource (VER) generators are dependent on the weather." NERC Long Term Reliability Assessment 2022.

[64] Several such challenges are called out by NERC, including: "reliable interconnection of inverter-based resources," "accommodating large amounts of distributed energy resources," "managing the pace of generation retirements," "maintaining Essential Reliability Services" (e.g., "capability to support voltage, frequency, and dispatchability," as well as reactive support, stability, and ramping/balancing). NERC Long-Term Reliability Assessment 2022.

[65] NERC states that "[v]arious technologies can contribute to essential reliability services, including variable energy resources; however, policies and market mechanisms need to reflect these requirements to ensure these services are provided and maintained. Regional transmission organizations, independent system operators, and FERC have taken steps in this direction, and these positive steps must continue." NERC Long-Term Reliability Assessment 2022.

[66] "There has been some increase in the number of miles of transmission line projects for integrating renewable generation over the next 10 years compared to the 2021 LTRA projections. Transmission investment is important for reliability and resilience as well as the integration of new generation resources." NERC Long-Term Reliability Assessment 2022.

[67] "State and provincial regulators and independent system operators (ISO)/regional transmission operators (RTO) should have mechanisms they can employ to prevent the retirement of generators that they determine are needed for reliability, including the management of energy shortfall risks. • Regulatory and policy-setting organizations should use their full suite of tools to manage the pace of retirements and ensure that replacement infrastructure can be timely developed and placed in service. If needed, the Department of Energy should use its 202(c) authority as called upon by electric system operators. • Resource planners and policymakers must pay careful attention to the pace of change in the resource mix as well as update capacity and energy risk studies (including all-hours probabilistic analysis) with accurate resource projections." NERC Long-Term Reliability Assessment 2022.

[68] "Addressing the Reliability Needs of Interdependent Electricity and Natural Gas Infrastructures. Natural gas is an essential fuel for electricity generation that bridges the reliability needs of the BPS [Bulk Power System] during this period of energy transition. As natural-gas-fired generation continues to increase, vulnerabilities associated with natural gas delivery to generators can potentially result in generator outages. Energy stakeholders must urgently act to solve reliability challenges that arise from interdependent natural gas and electricity infrastructure" including through promoting coordination of these two systems." NERC Long-Term Reliability Assessment 2022.

More recently, NERC published an update report on priority risks that need to be addressed, with identification of "strategic directions" the industry should take to understand, plan for and mitigate such risks.[69] The report highlights "five significant evolving risk profiles":

> **Energy Policy** at the federal, province, state, provincial and local levels is providing incentives and targets for resource changes and end-use applications of electricity. It is further contributing to the **Grid Transformation**, which includes the shift away from conventional synchronous central-station generators toward a new mix of resources that include natural-gas-fired generation; unprecedented proportions of non-synchronous resources, including renewables and energy storage; demand response; smart- and micro-grids; and other emerging technologies which will be more dependent on communications and advanced coordinated controls that can increase the potential **Security Risks**. Collectively, the new resource mix can be more susceptible to long-term, widespread **Extreme Events,** such as extreme temperatures or sustained loss of wind/solar, that can impact the ability to provide sufficient energy as the fuel supply is less certain. Furthermore, there is an associated increase in **Critical Infrastructure Interdependencies**. For example, for natural-gas-fired generation, there is increased interdependency on delivery of fuel from the natural gas industry that also depends on electricity to support its ability to extract and transport gas.

Although NERC does not specifically call out the risks relating to the design or implementation of EPA regulation of GHG emissions from power plants, the report includes decarbonization policy as part of the "energy policy" drivers of changes in demand and supply of electricity and other aspects of grid transformation. NERC's priority reliability risks report includes numerous recommendations to mitigate risks related to energy policy[70] (which NERC describes as including a wide range of federal, state and local policies relating to electrification of buildings and vehicles, other decarbonization policies, as well as adoption of central-station and decentralized renewable, low- and no-carbon resources, and other supply resources).

The NERC reliability risks report also includes recommendations in five other priority areas, which collectively address the complex planning, operational and other challenges that the industry must address to maintain system

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[69] NERC, "2023 ERO Reliability Risk Priorities Report" (RISC Approved 7-24-2023; NERC Board approved 8-17-2023) (hereafter "NERC Reliability Risk Priorities Report 2023"), https://www.nerc.com/comm/RISC/Related%20Files%20DL/RISC_ERO_Priorities_Report_2023_Board_Approved_Aug_17_2023.pdf. ("ERO" refers to Electric Reliability Organization.)

[70] "Increased coordination and collaboration between federal, provincial, and state policy makers, regulators, owners, and operators of the BPS as well as with the critical interdependent sectors is needed. Communication, coordination, and collaboration should be early, consistent, and clear to bridge increasingly complex jurisdictional lines. Education for policymakers and regulators to increase awareness of the reliability implications of policy decisions is a critical need. In addition, education for the industry, as the developers of reliability standards, is needed to better understand the processes and implications of policy decisions. Power system reliability requires many actively engaged, closely coordinated partners. NERC and state commissions share common goals in ensuring a reliable, resilient, safe, affordable electricity system that serves all customers. States, and the utilities they regulate, are responsible for the distribution systems, including DERs [distributed energy resources], and with some utilities responsible for resource acquisition and adequacy. As economic regulators, state commissions review and approve utility investment proposals which have long term impacts on power system reliability. State perspectives are important to NERC's success – translating BPS considerations to state-level needs, experience, and policy objectives. Concurrently, NERC's perspectives are important to the States' success..." NERC Reliability Risk Priorities Report 2023.

reliability. (I have included the full list of NERC recommendations in footnotes here to illustrate the number of actions that NERC recommends be taken in upcoming years, regardless of whether federal regulators put in place new requirements to regulate GHG emissions from fossil fuel power plants.) These other four areas are: grid transformation,[71] physical and cyber security,[72] extreme events,[73] and critical infrastructure interdependencies.[74]

[71] "Grid transformation will continue to require new and innovative approaches, tools, methods, and strategies to be used in planning and operating the BPS. To address these challenges and opportunities, [NERC] encourages the following actions in order of evaluated criticality to have the most impact and likelihood of mitigating the risk: 1. Develop and include energy sufficiency approaches in planning and operating the grid….NERC and the industry should collaborate to better understand and define energy sufficiency and develop approaches that examine the magnitude, duration, and impact across all hours and many years while also considering limitations and contributions to reliability from all resources (including load resources), neighboring grids, and transmission….2. Ensure sufficient operating flexibility during resource and grid transformation….3. Further consider the impacts and benefits of DER resources, electrification, energy storage, hybrid resources, and other emerging technologies….4. Plan for large and rapid load growth….5. Expand marketing to and development of the workforce of the future….6. Expect and be open to dramatically new grid operation approaches and platforms." NERC Reliability Risk Priorities Report 2023.

[72] "1. NERC should develop guidance for industry on the best practices to mitigate the risks from cloud adoption and the use of AI technologies. 2. NERC should continue to facilitate the development of planning approaches, models, and simulation methods that may reduce the number of critical facilities and thus mitigate the impact relative to the exposure to attack. 3. The ERO should take the lead in encouraging government partners to create a supply chain certification system….4. NERC should develop guidance to define best practices for "Secure by Design" and "Adaptive Security" principles in information technology and operational technology systems development and implementation. 5. The Electricity Information Sharing Analysis Center (E-ISAC) should continue to encourage industry efforts on workforce cyber education… 6. NERC should highlight [and provide training on] key risk areas that arise from the EPRI's EMP [electromagnetic pulse] analysis for timely industry action….7. NERC, while collaborating with industry, should continue to evaluate the need for additional assessments of the risks from attack scenarios (e.g., vulnerabilities related to drone activity, attacks on midstream or interstate natural gas pipelines or other critical infrastructure)….8. E-ISAC should continue to execute its long-term strategy to improve cyber and physical security information-sharing, protection, risk analysis, and increase engagement within the electric sector as well as potential foreign adversaries should continue to be addressed by the E-ISAC, other federal partners, and industry to continue diligently working to mitigate threats. 10. The industry must continue to focus on early detection and response to cyber attacks and adopt controls that can be executed to protect critical systems. 11.….NERC should continue to expand the scope of GridEx [exercises] to include and collaborate with cross-sector industries, such as natural gas, telecom, and water as well as state, local, and tribal authorities….12. [Other efforts relating to cybersecurity risk Information sharing should continue]." NERC Reliability Risk Priorities Report 2023.

[73] "1. Conduct special assessments of extreme event impacts, including capturing lessons learned, create simulation models, and establish protocols and procedures for system recovery and resiliency… 2. Accelerate planning and construction of strategic, resilient transmission. …. For instance, prioritize transmission installation with the explicit objective of reducing resilience risk and ensuring "hardening" for anticipated risks….3. Development of tools for BPS resiliency: DOE is performing analyses to evaluate both static, dynamic, and real-time scenarios that affect BPS reliability and resilience including transmission needs and planning studies, and evaluation of asset performance under extremes. NERC should continue to work with DOE on these efforts to ensure robust tools that can be used industry wide to evaluate potential threats to generation, transmission, and fuel supplies. 4. Regional coordination: States and any other applicable governmental authorities should meet collectively to discuss and understand impacts to ensure they are a part of the resiliency discussion….5. Workforce development: Entities should continue to focus on attracting, developing, and retaining the skilled workforce needed to plan, construct, and operate the transforming [grid]. 6. Industry forums: Forums should share and coordinate information sharing on best practices around resiliency efforts related to design considerations, supply chain deliverability issues, and identification and response to major storm events….7. Drills and emergency response: BPS operators should have formal emergency management programs that include periodic drills and exercises…8. Understanding of geomagnetic disturbance events on BPS." NERC Reliability Risk Priorities Report 2023.

[74] "1. NERC should conduct a study to determine the percent of available generation with on-site or firm fuel capacity in each Regional Entity….NERC and industry partners should continue to conduct meetings and conferences to highlight the importance of cross-sector and energy subsector interdependence and coordination, such as the NERC Reliability Summit, NATF/EPRI resiliency summits, the North American Energy Standards Board Forum, and FERC/DOE technical conferences….NERC, in collaboration with industry and industry partners, should continue to identify and prioritize limiting conditions and/or contingencies that arise from other sectors that affect the BPS. NERC and Reliability Coordinators should continue to conduct special assessments that address natural gas availability and pipeline common mode failures. NERC and industry partners should continue to increase emphasis on cross-sector coordination in industry drills ….NERC should investigate the feasibility of potential infrastructure improvements, such as feeder segmentation required to facilitate more pinpoint control of load during emergencies in order to increase the amount of load available for rotating outages. The EPRI and DOE should continue their work on communication alternatives but also the use of same or similar technologies for critical supervisory control and data acquisition data. New technologies should be explored that could assist in providing unique and hardened back-up telecommunication methods for the most critical data. The ERO Enterprise should continue to communicate to state, provincial,

These recommendations encompass a wide variety of actors in industry and government, and touch on specific areas of needed analysis, information sharing and coordination over time as conditions continue to change.

There are other discussions – e.g., in Texas, at FERC-regulated Regional Transmission Organizations ("RTOs"), and at the North American Energy Reliability Board ("NAESB")[75] – to address problems and concerns relating to preparedness and performance of electric facilities and in gas production and delivery, particularly in extreme weather situations. FERC/NERC's reports, for example, concluded that all types of generating technologies failed to adequately prepare for extreme cold weather or freezing conditions, with gas-fired units experiencing significant incremental unplanned outages, in part due to gas production, supply and delivery issues constituting the second-largest cause of unplanned outages after mechanical issues relating to cold and freezing conditions.[76] FERC/NERC's recommendations reflect the lessons learned from past events, including FERC/NERC's specific recommendations to identify critical facility components and systems that need freeze-protection measures and to prepare and execute plans to address such winterization.[77]

I note that many of these recommendations are similar – and in some cases, identical – to recommendations in reports, forums, and studies with which I have been personally involved and which focused on critical actions needed to address the complex changes already underway in the nation's electric system. For example, the National Academies' Future of Electric Power in the U.S. study identified five "major needs" for the future electric power system, including the following (and also made recommendations related to each one): (1) improving our understanding of how the system is evolving; (2) ensuring that electricity service remains clean and sustainable, and reliable and resilient; (3) improving understanding of how people use electricity and keep electricity affordable and equitable in the face of profound change; (4) facilitating innovation in technology, policy and business models relevant to the power system; and (5) accelerating innovation in technology in the face of shifting global supply chains and the influx of disruptive technologies.[78] The National Academies' Net Metering Study describes the local reliability systems that need greater visibility, operational controls and other mechanisms to be ready for increasing deployment of distributed energy resources with new power flows on the grid.[79]

Many of these broader concerns show up in comments and concerns raised in the context of EPA's proposed regulation of existing and new fossil generating units, even though EPA's proposal did not create these issues.

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and federal regulators of natural gas about the critical interdependence of this fuel source with the other infrastructure sectors. NERC and industry partners should continue to evaluate voice and data communication interdependencies and strategies for ensuring continuous communications during an emergency event, particularly as remote working arrangements grow. NERC should continue to encourage industry to consider the unavailability of other critical infrastructures, such as water, sewer, roads, rails, and communications in their emergency plans." NERC Reliability Risk Priorities Report 2023.

[75] North American Energy Standards Board, "Gas Electric Harmonization Forum Report," July 28, 2023, https://naesb.org/pdf4/geh_final_report_072823.pdf. I served as a co-chair of this Forum and co-authored the Foreword with my two co-chairs, Robert Gee and Pat Wood, III.

[76] See, for example, Section IV of the February 2021 Cold Weather Outages staff report by FERC/NERC/Regional Entities. https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and.

[77] See, for example, Section IV of the February 2021 Cold Weather Outages staff report by FERC/NERC/Regional Entities. https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and.

[78] NASEM Future of Electric Power Study.

[79] NASEM Net Metering Study, especially chapters 2, 6, and 7.

B. Reliability-related themes in comments on EPA's 2023 proposal

Several themes emerge from comments on reliability implications of EPA's proposed power plant GHG rule. These concerns include: the already-challenging operational conditions in the electric system; challenges relating to the ability of the industry to expand the transmission system; and the role of the proposal in leading to premature fossil unit retirements.

First, regarding challenging operational conditions on the electric system as a result of potential increases in demand and changes in the supply portfolio: Whether or not EPA moves forward with its proposed rule, such conditions are present and will continue to grow as operational changes and challenges, as discussed in the prior section. NERC's recommendations in its 2023 priority reliability risks report detail a broad and deep array of actions that should and can be taken to address these issues (including the impacts of any incremental changes introduced by promulgation of EPA's rule). As noted in NERC's report, these efforts are important to undertake now.

Additionally, the long list of specific recommendations that my colleagues and I previously identified as important tools and practices for assuring reliability in the context of EPA's adoption of prior regulations of GHG emissions from power plants still remain relevant here.[80] That report identified the array of key players with responsibilities that relate directly or indirectly to electric-system reliability – including FERC, other federal agencies, NERC, regional reliability organizations, system operators and balancing authorities, states, vertically integrated utilities, other power plant owners, energy efficiency program operators, and others – and potential actions that they can consider taking in the context of new EPA GHG regulations.

If the EPA's proposed rule is finalized in 2024 as anticipated by EPA, the industry will have nearly a decade to address any incremental reliability issues introduced by the rule and shaped by states' SIPs over the subsequent two years (and where the states can hear input from industry stakeholders about how to introduce greater flexibility into their plans).

Most of the nation's power plant capacity is not covered by these regulations, and includes nuclear facilities,[81] central station and distributed renewable facilities,[82] and existing combustion turbine units that are smaller than 300 MW or that operate infrequently (i.e., less that 50percent capacity factor). Notably, most existing gas-fired combustion turbines (operating as stand-alone peaking units or in combined cycle configurations) are smaller than 300 MW and therefore not covered by the proposal. According to the Energy Information Administration's current inventory of power plants, a significant share of such capacity (and associated generating units) is in this "less than 300 MW in size" category, as shown in Table 2:

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[80] See recommendation Tables 1-6 in Tierney et al. Reliability Tools and Practices (Attachment 1 to this report). https://hepg.hks.harvard.edu/sites/hwpi.harvard.edu/files/hepg/files/electric_system_reliability_and_epas_clean_power_plan_0215.pdf?m=1529956845.

[81] Nuclear generating capacity amounts to 100.5 GW. EIA Monthly Generator Inventory (existing generating units with 1 MW or greater capacity (nameplate)), August 2023 (hereafter "EIA Generator Inventory"), https://www.eia.gov/electricity/data/eia860M/.

[82] Capacity of hydro, wind, solar, and geothermal generating facilities greater than 1 MW amounts to 311 GW. EIA Generator Inventory.

Table 2: Existing Gas-Fired Combustion Turbines (Simple Cycle and Combined Cycle)

Gas-Fired CTs	Total In Operation		Total In Operation And <300 MW in Size		Total In Operation and >300 MW in Size	
	# of units	GW total	# of units	GW total	# of units	GW total
CTs (simple cycle CTs)	**1,755**	**141 GW**	**1,753**	**140.3 GW**	**2**	**0.7 GW**
CCs (combined cycle CTs)	**1,540**	**291 GW**	**1,359**	**219.0 GW**	**181**	**72.0 GW**
****All Gas-Fired CTs**	**3,295**	**432 GW**	**3,112**	**359.3 GW**	**183**	**72.7 GW**
Percentage of Currently Operating Gas-Fired CTs affected by EPA proposal			**94% not covered**	**83% not covered**	**6% covered**	**17% covered**

Source:
EIA Monthly Generator Inventory (existing generating units with 1 MW or greater capacity (nameplate)), August 2023, https://www.eia.gov/electricity/data/eia860M/.

An additional 43.7 GW of existing coal capacity[83] is currently scheduled to retire by 2032 (an amount equivalent to 24 percent of total coal-fired capacity) and needs only to perform routine O&M to comply with the EPA proposal. Also, 4.3 GW of coal-fired capacity has planned retirements in 2032 and 2033, thus similarly complying with EPA's proposal if their capacity factor is below 20 percent. This reflects another 2 percent of currently operating coal-fired steam unit capacity. Given that the EPA Section 111(d) rule is not finalized much less in effect, it is reasonable to assume that market forces and other public policies (and/or utility commitments) have led to such existing retirement announcements.

Note that current estimates of lead times for permitting and constructing new non-renewable capacity are: 24 months for battery storage; 36 months for gas-fired simple cycle CTs; and 48 months for gas-fired combined cycles.[84] Even a doubling of such time frames – such as to account quite conservatively for permitting delays or other extensions of lead times for individual projects – could allow for the economical and timely development of new facilities. Many projects are already in interconnection queues or in development, permitting, financing, and/or construction stages, and may be completed and interconnected in the years leading up to proposed implementation of the more stringent elements of EPA's proposals (e.g., post 2032). Before then, new gas-fired facilities entering service are only held to the use of efficient current CT and CC technologies. Of course, significant quantities of wind and renewable capacity are also in some stage of project development.

Second, regarding challenges in the nation's ability to expand the transmission system to support changes in the electric system: Certainly, the difficulties of adding transmission are well known and being addressed in many

[83] EIA's inventory indicates that 92 existing conventional coal units owned by utilities and independent power products and currently in operations have announced retirements by the end of 2031. EIA Generator Inventory.

[84] Paul Hibbard, Todd Schatzki, Charles Wu and Christopher Llop (Analysis Group) & Matthew Lind, Kiernan McInerney, and Stephanie Villarreal (Burns & McDonnell), "Independent Consultant Study to Establish New York ICAP Demand Curve Parameters for the 2021/2022 through 2024/2025 Capability Years – Final Report," September 9, 2020.

fora.[85] FERC has opened and received comments in a proposed rulemaking on transmission planning, cost allocation and interconnection, with final rules issued on generator interconnections in July 2022.[86]

The Infrastructure Investment and Jobs Act acknowledged such challenges in its provisions that provide expanded federal authorities to facilitate transmission expansion. The Congressional Research Service summarized these transmission-related activities as follows:

> Section 40105 of IIJA revises the process for designation of a National Interest Electric Transmission Corridor (NIETC) by the Department of Energy (DOE). A key revision allows for an NIETC designation that may lead to new interstate transmission lines specifically for intermittent (e.g., renewable) energy to connect to the electric grid. Another key change in the section enhances FERC's "backstop" siting authority for transmission lines in NIETCs. This would allow FERC to supersede traditional state permitting of transmission facilities and issue a permit for the construction and operation of certain interstate facilities under defined circumstances, including when a state has denied an applicant's request to site transmission facilities.
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> Section 40106 establishes the ''Transmission Facilitation Program,'' under which DOE can facilitate the construction of electric power transmission lines and related facilities. Under this program, DOE may potentially enter a capacity contract (for no more than 40 years or 50 percent of the total capacity) with respect to an eligible transmission project; issue a loan to an eligible entity for an eligible transmission project; or participate with an eligible entity in designing, developing, constructing, operating, maintaining, or owning an eligible transmission project. Thus, under a capacity project, DOE could be closely involved in operational support of eligible transmission-line construction. Such an arrangement could help move a transmission project from proposal to construction, as a transmission project is unlikely to be built without significant customer commitment to its use. Section 40106 also establishes a "Transmission Facilitation Fund" to help finance eligible projects deemed to be in the public interest.

The Department of Energy has established a Grid Deployment office and has already made a number of significant commitments in support of new transmission. Recently announced actions include the agency's

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[85] *See*, for example: NASEM Future of Electric Power study; NASEM Decarbonization study; Institute for Policy Integrity, "Transmission Siting Reforms in the Infrastructure and Jobs Act of 2021," December 2021, https://policyintegrity.org/files/publications/Building_a_New_Grid_Policy_Brief_v3_%281%29.pdf; Institute for Policy Integrity, Memo to DOE Grid Deployment Office on Coordination of Federal Authorizations for Electric Transmission Facilities, October 2, 2023, https://policyintegrity.org/documents/Comments_of_Institute_for_Policy_Integrity.pdf; Liza Reed et al., "How are we going to build all that clean energy infrastructure?", Niskanen Center, August, 2021, https://www.niskanencenter.org/wp-content/uploads/2021/08/CATF_Niskanen_CleanEnergyInfrastructure_Report.pdf; James Hewett, "Advancing U.S. Transmission Deployment: Navigating the Policy Landscape," Breakthrough Energy. August 7, 2023, https://breakthroughenergy.org/news/transmissiondeployment/.

[86] FERC, "Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection," 179 FERC ¶ 61,028, No. RM21-17-000, April 21, 2022, https://www.ferc.gov/media/rm21-17-000; https://www.ferc.gov/electric-transmission/generator-interconnection.

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commitment of $1.3 billion to help fund three major new transmission projects[87] and the publication of the National Transmission Needs Study.[88] Combined with the new authorities provided by Congress to DOE and FERC, and the current efforts of the DOE to use them, it is reasonable to assume that transmission bottlenecks and challenges are being addressed on a timeframe consistent with the compliance milestones anticipated by EPA in its proposed rule. Moreover, EPA's assessment of the impacts of the 2023 proposal are relatively conservative with regard to their assumptions about expansion of the interstate transmission system in support of development of renewable electricity projects.[89]

Notably, also, transmission expansion designed to support reliability outcomes tends to be approved more readily than projects aimed primarily at providing economic savings or to support public policy. To the extent that reliability challenges complicate fossil generating units' compliance strategies (e.g., including retirements, as discussed further below), there are numerous examples of successful siting approvals for such lines.[90]

Third, regarding premature retirements of fossil steam units (especially coal-fired generating units): The trends in retirements of coal-fired generation are driven principally by fundamental market economics.[91] EPA's rule allows for plants to stay in operation until the end of 2034 – a decade from now – if the unit maintains a capacity factor of no more than 20 percent (or for any level of output if a unit is retired by 2032). Already, there are dozens of coal-fired steam units with recent capacity factors below or around that levels.[92] And currently, plant owners have indicated retirement plans of approximately a quarter of total coal-fired steam capacity by those dates. Plants that commit to retire by the end of 2039 (fully 15 years from now) will need to co-fire with natural gas starting in 2030. The EPA has modeled estimated retirements of coal plants, but what will ultimately matter from a reliability point of view is the resource adequacy and other operating conditions on the grid at the time a plant is actually planning on retiring. These timelines are many years away.

To the extent that a unit has not yet announced retirement and operating conditions lead to an owner's decision to retire it (due to an uneconomic financial outlook for the facility) by any of those milestone dates, the unit's owner will need to get permission (from a reliability point of view) to retire the facility to determine whether taking the plant permanently out of service would trigger local or regional reliability issues. Most coal-fired generating capacity is either (a) owned by a vertically integrated utility with the ability to request cost recovery of a unit until alternative resources are in place to allow it to retire without adverse consequences to local reliability, or (b) not owned by a

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87 DOE, "DOE Launches New Initiative from President Biden's Bipartisan Infrastructure Law to Modernize National Grid," January 12, 2022, https://www.energy.gov/oe/articles/doe-launches-new-initiative-president-bidens-bipartisan-infrastructure-law-modernize; DOE, "Biden-Harris Administration Announces $1.3 Billion to Build Out Nation's Electric Transmission and Releases New Study Identifying Critical Grid Needs," October 30, 2023, https://www.energy.gov/articles/biden-harris-administration-announces-13-billion-build-out-nations-electric-transmission.

88 DOE, "National Transmission Needs Study," October 2023, https://www.energy.gov/sites/default/files/2023-10/National_Transmission_Needs_Study_2023.pdf.

89 See comments of Clean Air Task Force and Natural Resources Defense Council, EPA Docket No. EPA-HQ-OAR-2023-0072, August 8, 2023, pages 45-51, https://cdn.catf.us/wp-content/uploads/2023/08/09090744/CATF-and-NRDC-Comments-on-Proposed-Rule-EPA-HQ-OAR-2023-0072-1.pdf?_gl=1*1ork94d*_ga*MjEyMzQ4MDA3LjE2OTU4NzY5MzA.*_ga_88025VJ2M0*MTY5ODQzOTUyMy40LjAuMTY5ODQzOTUyNC42MC4wLjA.*_gcl_au*MTIxNTk3MjA0Ni4xNjk1ODc2OTMw.

90 NASEM, Future of Electric Power.

91 NASEM Decarbonization: Chapters 6 (The Essential Role of Clean Electricity) and Chapter 12 (The Future of Fossil Fuels).

92 SPGlobal Regional Power Summary, accessed 11-1-2023.

regulated utility but operates in an RTO region which can put in place reliability-must-run compensation arrangements to cover plant O&M costs to keep it in service until alternatives (including wires and non-wires alternatives) are in place, if needed for reliability.[93]

EPA's Resource Adequacy TSD refers to these and other options as mechanisms that help to ensure reliable system operations, which the agency has taken into account in the development of its proposal and accompanying implementation approach.

> The emission reduction requirements under this rule are based on adequately demonstrated cost-reasonable control measures that form the BSER. Some EGU owners may conclude that, all else being equal, retiring a particular EGU and replacing it with cleaner generating capacity is likely to be a more economic option from the perspective of the unit's customers and/or owners than making substantial investments in new emissions controls at the unit. However, the EPA also understands that before implementing such a retirement decision, the unit's owner will follow the processes put in place by the relevant regional transmission organization (RTO), balancing authority, or state regulator to protect electric system reliability. These processes typically include analysis of the potential impacts of the proposed EGU retirement on electrical system reliability, identification of options for mitigating any identified adverse impacts, and, in some cases, temporary provision of revenues to support the EGU's continued operation until longer-term mitigation measures can be put in place. The Agency also expects that any resulting unit retirements will be carried out through an orderly process in which RTOs, balancing authorities, and state regulators use their powers to ensure that electric system reliability is protected.[94]

[93] Tierney et al Electric Reliability Tools and Practices; Paul Hibbard, Pavel Darling and Susan Tierney, "Potomac River Generating Station: Update on Reliability and Environmental Considerations," July 19, 2011, https://www.cleanskies.org/wp-content/uploads/2011/07/PRGSReportAnalysisGroup2011.pdf.

[94] EPA, Resource Adequacy Technical Support Document, https://www.regulations.gov/document/EPA-HQ-OAR-2023-0072-0034.

More specifically, the EPA Preamble further describes the reliability options available within the proposed rule and existing in current policy, as excerpted in the text box here:

EPA Preamble
Section XIV.F: Grid Reliability Considerations (excerpts)

Preserving the ability of power companies and grid operators to maintain system reliability has been a paramount consideration in the development of these proposed actions.

Accordingly, these proposed rules include significant design elements that are intended to allow the power sector continued resource and operational flexibility, and to facilitate long-term planning during this dynamic period. Among other things, these elements include subcategories of new natural gas-fired combustion turbines that allow for the stringency of standards of performance to vary by capacity factor; subcategories for existing steam EGUs that are based on operating horizons and fuel reflecting the request of industry stakeholders; compliance deadlines for both new and existing EGUs that provide ample lead time to plan; and proposed State plan flexibilities.

In addition, this preamble discusses EPA's intention to exercise its enforcement discretion where needed to address any potential instances in which individual EGUs may need to temporarily operate for reliability reasons, and to set forth clear and transparent expectations for administrative compliance orders to ensure that compliance with these proposed rules can be achieved without impairing the ability of power companies and grid operators to maintain reliability. As such, these proposed rules provide the flexibility needed to avoid reliability concerns while still securing the pollution reductions consistent with section 111 of the CAA.

The EPA routinely consults with the DOE and FERC on electric reliability and intends to continue to do so as it develops and implements a final rule. This ongoing engagement will be strengthened with routine and comprehensive communication between the agencies under the DOE–EPA *Joint Memorandum of Understanding on Interagency Communication and Consultation on Electric Reliability* signed on March 8, 2023.716 The memorandum will provide greater interagency engagement on electric reliability issues at a time of significant dynamism in the power sector, allowing the EPA and the DOE to use their considerable expertise in various aspects of grid reliability to support the ability of Federal and State regulators, grid operators, regional reliability entities, and power companies to continue to deliver a high standard of reliable electric service….

In addition, the EPA observes that power companies, grid operators, and State public utility commissions have well-established procedures in place to preserve electric reliability in response to changes in the generating portfolio, and expects that those procedures will continue to be effective in addressing compliance decisions that power companies may make over the extended time period for implementation of these proposed rules. In response to any regulatory requirement, affected sources will have to take some type of action to reduce emissions, which will generally have costs.

Some EGU owners may conclude that, all else being equal, retiring a particular EGU is likely to be the more economic option from the perspective of the unit's customers and/or owners because there are better opportunities for using the capital than investing it in new emissions controls at the unit. Such a retirement decision will require the unit's owner to follow the processes put in place by the relevant RTO, balancing authority, or State regulator to protect electric system reliability. These processes typically include analysis of the potential impacts of the proposed EGU retirement on electrical system reliability, identification of options for mitigating any identified adverse impacts, and, in some cases, temporary provision of additional revenues to support the EGU's continued operation until longer-term mitigation measures can be put in place.

In some rare instances where the reliability of the system is jeopardized due to extreme weather events or other unforeseen emergencies, authorities can request a temporary reprieve from environmental requirements and constraints (through DOE) in order to meet electric demand and maintain reliability. These proposed actions do not interfere with these already available provisions, but rather provides a long-term pathway for sources to develop and implement a proper plan to reduce emissions while maintaining adequate supplies of electricity.

C. Other Technical Issues raised about reliability implications of EPA's 2023 Proposal

In addition to the broader, thematic issues discussed in the prior section, several other technical reliability-related issues have been raised in stakeholder comments.

For example, although critics acknowledge that EPA discusses resource adequacy issues, EPA has been criticized for not having modeled or sufficiently accounted for *operational reliability* issues in considering the feasibility of the implementation of the proposed rule.[95]

NERC defines these two major reliability concepts in the following way: Resource adequacy is "'[t]he ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.'" By contrast, operational reliability, or system security, requires "[o]perating the elements of the [Bulk-Power System] within equipment and electric system thermal, voltage, and stability limits so that instability, uncontrolled separation, or cascading failures of such system will not occur as a result of a sudden disturbance, including a cybersecurity incident, or unanticipated failure of system elements."[96]

Resource adequacy considerations indeed differ from operational reliability ones, but EPA has not erred in modeling only the former. It is not reasonable to expect that at this point in time EPA should have modeled operational-reliability outcomes for the nation – that is, prior to actual promulgation of standards that (a) require state implementation plans to be developed, (b) require compliance obligations no earlier than 2030, and (c) allow for flexibility in owners' decisions about how to comply with the eventual standards and SIPs.

It would be unrealistic to expect that EPA (or even anyone with operational responsibility for the grid) to know the specific future compliance decisions of power plant owners that would be required to conduct meaningful detailed system impact studies across all regions of the country affected by the new standards starting nearly a decade from now. Operational security studies are location specific and quite granular in form. Given the long lead times available in the proposed regulatory approach, power plant owners will need to make decisions about technology and/or fuel choices, and/or whether to retire a unit or operate it at a low capacity factor in future years and when many other changes have occurred on the grid, in electricity markets, and so forth. Moreover, EPA has provided the types of flexible compliance options and timing runways that will allow decision makers about specific power plants' compliance to explore such operational security considerations at the time and location when they are most relevant.

Other commenters have raised concerns about the performance characteristics of different types of generating resources as assumed by EPA in its analyses.[97] Certainly, different generating technologies operate in different

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[95] See, for example, PGen Comments.

[96] Paul Hibbard, Susan Tierney and Katherine Franklin, "Electricity Markets, Reliability and the Evolving Power System," June 2017, page 42, https://www.analysisgroup.com/globalassets/content/insights/publishing/ag_markets_reliability_final_june_2017.pdf, citing NERC's glossary of terms, available at http://www.nerc.com/files/glossary_of_terms.pdf.

[97] For example, a criticism is that technologies like wind or solar projects cannot be counted on to meet peak demand and thus have a lesser value from a resource adequacy point of view. PGen Comments; NRECA Comments.

modes, with combinations of characteristics – start-up and ramping speeds, fuel that is on-site (e.g., nuclear or conventional hydro) or subject to just-in-time delivery (e.g., natural gas) or tied to natural conditions (e.g., windiness or solar radiation), and so forth. Operational reliability depends on complex factors that system operators and electric companies bring to bear in real time, as my colleagues and I have previously explained:

> System operations are affected in real time by several things:
>
> - The mix of attributes of the resources on the system – their location, their fuel source, and the operating characteristics of the supply and demand resources;
> - The continuous variations in system conditions (e.g., variations in load as consumption changes; the sudden loss of a power plant or transmission line; changes in ambient conditions or sudden power outages due, e.g., to a storm); and
> - The system operator's practices and procedures for managing the changing conditions on the system at all times and in all places under that operator's responsibility, to assure that the system stays in balance.
>
> System security describes the ability of the system to meet ever changing system conditions, and to do so with enough redundancy in operational capabilities to manage and recover from a variety of potential system events – or "contingencies" – such as sudden and unexpected loss of generation, transmission, or load. System planners and operators must ensure that the technical capabilities of the mix of resources on the power system are capable of responding in real time to normal load changes and contingency events. This is needed to avoid the catastrophic wide-area failure of the bulk power system - such as a cascading outage covering one or more regions - that can come from unacceptable variations in system voltage and frequency….
>
> Importantly, system security, or operational reliability, does not result from a singular condition, such as the percentage of a system's capacity that operates in "baseload" mode. To maintain operational reliability, system operators use a combination of strategies, tools, procedures, practices, and resources to keep the entire system in balance even as conditions change on a moment to moment basis. The difficulty of this task largely results from several things, and occurs along different time frames.

In the end, on-the-ground reliability will result from a combination of technologies with different attributes (e.g., capacity, energy production, capacity factors, dispatchability, fuel delivery, ramping speed, ability to provide voltage support, and so forth). Operational reliability depends upon the attributes of thousands of physical elements of and market conditions affecting the bulk power system and local electricity distribution systems.

Some commenters[98] have argued that EPA has assumed an inappropriate "replacement rate" in modeling when renewable resources replace capacity lost when coal unit retire. While it is certainly the case that wind or solar

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[98] PGen Comments.

facilities do not replace the combination of energy and capacity of some other types of technologies, such as nuclear plants, with their typical 90-percent capacity factors, or particular coal-fired or gas-fired generating units that have similarly high current capacity factors, there are many existing fossil units where extremely low capacity factors and fuel-delivery considerations (e.g., absence of firm gas pipeline delivery arrangements) suggest that it would be reasonable to presume a priori a "standard" replacement ratio across these technologies.

The more important consideration in modeling is to identify the amount of capacity AND energy that needs to be replaced on a system when determining what is needed upon the retirement of a unit with a particular operating profile (e.g., whether it is dispatchable with around the clock output capability and without fuel delivery constraints, versus an intermittent resource available either when its wind or solar energy source is available or when its electrical output can be combined with storage to provide dispatchable service subject to the operating constraints of the storage system). The availability of wind and solar output (e.g., capacity factor; capacity reliably available at the time of system peak) will depend upon a number of factors, such as the quality of the wind or solar resource, the height of towers, the age of the facility, the tilt of solar panels, the size of the solar installation). Capacity values are under review (and will continue to need to be assessed over time), not just of intermittent resources but also for resources that depend upon just-in-time deliveries of fuel (e.g., gas-fired power plants that require deliveries during extreme weather events).

EPA's analysis has been careful to provide reasonable estimates of future system conditions, and moreover the agency's design of the proposed rule provides many options for reasonable accommodation of and support for electric reliability considerations.

Attachment 1: Tierney et al., Reliability Tools and Practices (2015)

Susan Tierney, Paul Hibbard and Craig Aubuchon,

"Electric System Reliability and the EPA's Clean Power Plan: Tools and Practices,"

February 2015

Report link:
https://www.analysisgroup.com/globalassets/content/insights/publishing/electric_system_reliability_and_epas_clean_power_plan_tools_and_practices.pdf

Electric System Reliability and EPA's Clean Power Plan: Tools and Practices

Analysis Group

Susan Tierney
Paul Hibbard
Craig Aubuchon

February 2015

Acknowledgments

This report provides a primer on various reliability issues facing the electric industry as it looks ahead to implementation of the Clean Power Plan, as proposed by the U.S. Environmental Protection Agency on June 2, 2014.

Taking into consideration the many comments of various parties filed on EPA's proposal, the report addresses issues that the nation and the electric industry need to address in order to simultaneously meet electric system reliability and carbon-emissions reduction obligations.

This is an independent report by the authors at the Analysis Group, supported by funding from the Energy Foundation.

The report, however, reflects the analysis and judgment of the authors only.

About Analysis Group

Analysis Group provides economic, financial, and business strategy consulting to leading law firms, corporations, and government agencies. The firm has more than 600 professionals, with offices in Boston, Chicago, Dallas, Denver, Los Angeles, Menlo Park, New York, San Francisco, Washington, D.C., Montreal, and Beijing.

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Executive Summary

Since the U.S. Environmental Protection Agency (EPA) proposed its Clean Power Plan last June, many observers have raised concerns that its implementation might jeopardize electric system reliability.

Such warnings are common whenever there is major change in the industry, and play an important role in focusing the attention of the industry on taking the steps necessary to ensure reliable electric service to Americans. There are, however, many reasons why carbon pollution at existing power plants can be controlled without adversely affecting electric system reliability.

Given the significant shifts already underway in the electric system, the industry would need to adjust its operational and planning practices to accommodate changes even if EPA had not proposed the Clean Power Plan.

In the past several years, dramatic increases in domestic energy production (stemming from the shale gas revolution), shifts in fossil fuel prices, retirements of aged infrastructure, implementation of numerous pollution-control measures, and strong growth in energy efficiency and distributed energy resources, have driven important changes in the power sector. As always, grid operators and utilities are already looking at what adjustments to long-standing planning and operational practices may be needed to stay abreast of, understand, and adapt to such changes in the industry.

The standard reliability practices that the industry and its regulators have used for decades are a strong foundation from which any reliability concerns about the Clean Power Plan will be addressed.

The electric industry's many players are keenly organized and strongly oriented toward safe and reliable operations. There are well-established procedures, regulations and enforceable standards in place to ensure reliable operations of the system, day in and day out.

http://imgkid.com/checklist-icon.shtml

Among other things, these "business-as-usual" procedures include:

- Assigning specific roles and responsibilities to different organizations, including regional reliability organizations, grid operators, power plant and transmission owners, regulators, and many others;
- Planning processes to look ahead at what actions and assets are needed to make sure that the overall system has the capabilities to run smoothly;
- Maintaining secure communication systems, operating protocols, and real-time monitoring processes to alert participants to any problems as they arise, and initiating corrective actions when needed; and
- Relying upon systems of reserves, asset redundancies, back-up action plans, and mutual assistance plans that kick in automatically when some part of the system has a problem.

http://www.bls.gov/ooh/installation-maintenance-and-repair/line-installers-and-repairers.htm

As proposed by EPA, the Clean Power Plan provides states and power plant owners a wide range of compliance options and operational discretion (including various market-based approaches, other means to allow emissions trading among power plants, and flexibility on deadlines to meet interim targets) that can prevent reliability issues while also reducing carbon pollution and cost.

EPA's June 2014 proposal made it clear that the agency will entertain market-based approaches and other means to allow emissions trading within and across state lines. Examples include emissions trading among plants (e.g., within a utility's fleet inside or across state lines), or within a Regional Transmission Organization (RTO) market. In this respect, the Clean Power Plan is fundamentally different from the Mercury and Air Toxics Standard (MATS) and is well-suited to utilize such flexible and market-based approaches. Experience has shown that such approaches allow for seamless, reliable implementation of emissions-reduction targets. In its final rule, EPA should clarify acceptable or standard market-based mechanisms that could be used to accomplish both cost and reliability goals.

Moreover, EPA has stated repeatedly that it will write a final rule that reflects the importance of a reliable grid and provides the appropriate flexibility.[1] We support such adjustments in EPA's final rule as needed to ensure both emissions reductions and electricity reliability.

Some of the reliability concerns raised by stakeholders about the Clean Power Plan presume inflexible implementation, are based on worst-case scenarios, and assume that policy makers, regulators, and market participants will stand on the sidelines until it is too late to act. There is no historical basis for these assumptions. Reliability issues will be solved by the dynamic interplay of actions by regulators, entities responsible for reliability, and market participants with many solutions proceeding *in parallel*.

Some of the cautionary comments are just that: calls for timely action. Many market participants have offered remedies (including readiness to bring new power plant projects, gas infrastructure, demand-side measures, and other solutions into the electric system where needed).[2] Indeed, this dynamic interplay is one reason why a recent survey of over 400 utility executives nationwide found that more than 60 percent felt optimistic about the Clean Power Plan and either supported EPA's proposed current emissions reduction targets or would make them more stringent.[3]

We note many concerns about electric system reliability can be resolved by the addition of new load-following resources, like peaking power plants and demand-side measures, which have relatively short lead times.[4] Other concerns are already being addressed by ongoing work to improve market rules, and by infrastructure planning and investment. A recent Department of Energy (DOE) report found that while a low-carbon electric

[1] See, for example, the January 6, 2015 blog post of Janet McCabe, EPA's Acting Administrator for Air and Radiation, "Time and Flexibility: Keys to Ensuring Reliable, Affordable Electricity," http://blog.epa.gov/epaconnect/2015/01/time-and-flexibility/. Also, see EPA's October 2014 Notice of Data Availability (NODA) that sought comments on, among other things, the potential to change the phase-in of emissions reductions to accommodate, for example, any constraints in natural gas distribution infrastructure, or how states could earn compliance credits for actions taken between 2012 and 2020.

[2] Although we think it is ultimately a good thing that the industry is paying close attention to reliability issues – so that any potential problems can be avoided through planning and infrastructure – we do note that serious questions have been raised about the assumptions used in recent reliability assessments performed by the North American Reliability Corporation (NERC). For example, Brattle Group's February 2015 report found that NERC failed to account for how industry is likely to respond to market and operational changes resulting from the Clean Power Plan. See Jurgen Weiss, Bruce Tsuchida, Michael Hagerty, and Will Gorman, "EPA's Clean Power Plan and Reliability: Assessing NERC's Initial Reliability Review," The Brattle Group, February 2015.

[3] The same survey found that utility executives believe that distributed energy resources offer the biggest growth opportunity over the next five years, and more than 70 percent expect to see a shift away from coal towards natural gas, wind, utility-scale solar and distributed energy. Utility Dive and Siemens, "2015 State of the Electric Utility Survey Results," January 27, 2015. The survey included 433 U.S. electric utility executives from investor-owned and municipal utilities, and electric cooperatives.

[4] Our report provides typical timelines for various types of resource additions in Section II.

system may significantly increase natural gas demand from the power sector, the projected incremental increase in natural gas pipeline capacity additions is modest (lower than historic pipeline expansion rates), and that the increasingly diverse sources of natural gas supply reduces the need for new pipeline infrastructure.[5]

Some other comments raise the reliability card as part of what is – in effect – an attempt to delay or ultimately defeat implementation of the Clean Power Plan. We encourage parties to distinguish between those who identify issues and offer solutions, and those who (incorrectly) suggest that reducing carbon pollution through the Clean Power Plan is inconsistent with electric system reliability.

In the end, because there are such fundamental shifts already underway in the electric industry, inaction is the real threat to good reliability planning. Again, there are continuously evolving ways to address electric reliability that build off of strong standard operating procedures in the industry.

Entities with roles to play as part of ensuring electric system reliability and timely compliance with EPA's Clean Power Plan	
Electric Reliability Entities	Federal Energy Regulatory Commission (FERC)
	North American Electric Reliability Corporation (NERC)
	Regional Reliability Organizations
	Electric System Operators and Balancing Authorities
Other public entities	Environmental Protection Agency (EPA)
	States (air agencies, public utility commissions, energy offices, state legislatures)
	Other federal agencies (Department of Energy, Energy Information Administration)
Entities involved with markets, resource planning, procurements	Wholesale market administrators
	Electric utilities (investor-owned, municipal utilities, cooperatives, joint action agencies
Other organizations that have a role to play	Non-utility generating companies and providers of other technologies
	Interstate natural gas pipeline companies (and storage suppliers)
	North American Energy Standards Board (NAESB)
	Energy efficiency program administrators
	Others

There are many capable entities focused on ensuring electric system reliability, and many things that states and others can do to maintain a reliable electric grid.

First and foremost, states can lean on the comprehensive planning and operational procedures that the industry has for decades successfully relied on to maintain reliability, even in the face of sudden changes in industry structure, markets and policy.

Second, states should take advantage of the vast array of tools available to them and the flexibility afforded by the Clean Power Plan to ensure compliance is obtained in the most reliable and efficient manner possible. Given the interstate nature of the electric system, we encourage states

[5] U.S DOE, "Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector," February 2015.

to rely upon mechanisms that facilitate emission trading between affected power plants in different states. Doing so will increase flexibility of the system, mitigate many electric system reliability concerns, and lower the overall cost of compliance for all.[6]

In this report we identify a number of actions that the Federal Energy Regulatory Commission (FERC), grid operators, states, and others should take to support electric system reliability as the electric industry transitions to a lower-carbon future. We summarize our recommendations for these various parties in tables at the end of our report.

In the end, the industry, its regulators and the States are responsible for ensuring electric system reliability while reducing carbon emissions from power plants as required by law. These responsibilities are compatible, and need not be in tension as long as all parties act in a timely way and use the many reliability tools at their disposal.

We observe that, too often, commenters make assertions about reliability challenges that really end up being about cost impacts. Although costs matter in this context, we think it is important to separate reliability considerations from cost issues in order to avoid distracting attention from the actions necessary (and feasible) to keep the lights on. There may be "lower cost" options that reduce emissions some part of the way toward the target reductions, but that fail to meet acceptable reliability standards. We do not view such 'solutions' as the lowest cost solution precisely because they fail to account for the cost of unacceptable system outages to electricity consumers.

Any plan that starts with consumer costs and works backward to reliability and then to emission reduction is one that fails to consider the wide availability of current tools that have served grid operators for more than a decade to meet reliability needs. There is no reason to think that cost and reliability objectives cannot be harmonized within a plan to reduce carbon pollution.

[6] As we will discuss in a series of regional reports, others have already identified that regional strategies will minimize overall compliance costs. For example, the Midcontinent Independent System Coordinator (MISO) estimated that a regional carbon constraint approach could save up to $3 billion annually relative to a sub-regional or individual state approach. MISO, "Analysis of EPA's Proposal to Reduce CO_2 Emissions from Existing Electric Generating Units," November 2014. See also, "Statement of Michael J. Kormos, Executive Vice President – Operations, PJM Interconnection, FERC Docket No. AD15-4-000, Technical Conference on Environmental Regulations and Electric Reliability, Wholesale Electricity Markets, and Energy Infrastructure," February 19, 2015.

This paper is designed to:

- Describe the changes underway in the industry which set the stage for the continued evolution of reliability tools and practices;
- Provide a "reliability 101" primer to describe what "electric reliability" means to system planners and operators, and why specific standard practices are so important to assuring electric reliability;[7]
- Summarize reliability concerns expressed by various stakeholders;
- Explain the ways that standard operating procedures can address these concerns; and,
- Recommend actions that can be taken by various actors in the electric industry to assure that the Clean Power Plan's goals do not undermine reliable power supply.

Our recommendations can be found in tables following the Executive Summary.

[7] This report also includes a glossary of acronyms used in our report.

Recommendation Tables

Table 1
Key Players in the Clean Power Plan and Available Tools

Entities	Roles and Responsibilities
Entities with direct responsibility for electric system reliability	- FERC (under the Federal Power Act (FPA)) - NERC (as the FERC-approved Electric Reliability Organization under the FPA) - Regional Reliability Organizations (RROs) - System operators and balancing authorities (including Regional Transmission Organizations (RTOs) and electric utilities) - States (for resource adequacy)

Other public agencies with direct and indirect roles in the Clean Power Plan	- U.S. Environmental Protection Agency (EPA)
	- State executive branch agencies:
	    - Air offices and other Environmental Agencies
	    - Public Utility Commissions (PUCs)
	    - Energy Offices
	    - Public authorities (e.g., state power authorities)
	- State governors and legislatures
	- U.S. Department of Energy (DOE)
	- Energy Information Administration (EIA)

Owners of existing power plants covered by 111(d) of the Clean Air Act	- Electric utilities
	    - investor-owned utilities
	    - municipal utilities
	    - electric cooperatives
	    - joint action agencies
	- Non-utility power plant owners

Markets and Resource Planning/ Procurement Organizations	- Organized markets administered by RTOs (CAISO, ERCOT, ISO-NE, MISO, NYISO, PJM, SPP).
	- Electric utilities with supply obligations & subject to least-cost planning processes:
	    - Many utilities (including joint action agencies) operate under requirements to use a combination of planning and competitive procurements (with or without self-build opportunities
	    - Transmission owners also have transmission planning requirements
	- Private investors (including non-utility companies) responding to market signals and seeking to develop/permit/construct/install/operate new resources (including new power plant projects, demand-response companies, merchant transmission companies, rooftop solar PV installation companies, etc.)

Others	- North American Energy Standards Board (NAESB) for setting electric & gas standards - Administrators/Operators of CO_2 allowance-trading systems - Administrators/Operators of energy efficiency programs - Fuel supply and delivery companies (gas pipeline and/or storage companies; gas producers; coal producers; coal transporters) - Energy marketing companies - Emerging technology providers – including, e.g., storage system providers, companies providing advanced communications and "smart" equipment, etc.

Table 2
FERC, NERC, and RROs' Potential Actions to Address Reliability Issues

Electric Reliability Entities (with some of the their Standard Tools)	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)
FERC: - Adoption of federally-enforceable reliability requirements and standards - Oversight of NERC and all bulk power system operators - Oversight of interstate natural gas pipeline owners/operators, with authority to approve interstate pipeline expansions - Authority over transmission planning, tariffs, open-access - In organized markets, authority over market rules (including capacity markets, provision of ancillary services providing various attributes to system operators) - Interagency coordination with EPA, DOE	Consider: - Requiring NERC, RROs, and system operators/balancing authorities to periodically assess potential reliability impacts of CPP with geographic scope appropriate to the reliability entity. The assessments could identify specific concerns, and develop backstop solutions – Preliminary assessments starting at end of 2015/early 2016, to inform state action taking into account known policy, practices, resources in the relevant area – Reliability assessments at the time of proposed state plans – Reliability assessments annually up through early 2020s - Continuing to evaluate the adequacy of current FERC gas/electric coordination policies in light of *incremental* changes resulting from CPP relative to trends already underway in the industry - Eliciting filings from RTOs and other transmission companies about any new planning tools, notice provisions for potential retirements, information reporting, new products, minimum levels of capability with various attributes - Inquiring into new natural gas policies to support wider interdependence with electric system reliability (e.g., incentives for development of gas delivery/storage infrastructure) - Working with states to consider mechanisms to afford bulk-power system grid operators' greater visibility into generating and demand-side resources on the distribution system - Providing guidance outlining compliance strategies that would require approvals of the FERC under the FPA (versus approaches that might not require such)
NERC – Reliability Standards, compliance assessment, and enforcement – Annual & seasonal reliability assessments – Special reliability assessments	Consider: – Continuing to conduct special assessments of impact of CPP on reliability (as it periodically does for other developments in the industry) – Preliminary assessments in parallel with final rule development,(in 2015) and development of State Plans (2015/2016) – Final assessments upon finalization of State Plans (2016+) – Assess whether any new standards relating to Essential Reliability Services need to be modified in light of electric system changes occurring as part of the industry's response(s) to CPP
Regional Reliability Organizations – Annual & seasonal reliability assessments – Special reliability assessments – Coordination with neighboring RROs	Consider: – Conducting special assessments of impact of CPP on reliability – Preliminary assessments in parallel with final rule development,(in 2015) and development of State Plans (2015/2016) – Final assessments upon finalization of State Plans (2016+)

Table 3
Grid Operators' Potential Actions to Address Reliability Issues

Electric Reliability Entities (with some of the their Standard Tools)	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)

System Operators and Balancing Authorities
– On-going annual & seasonal reliability assessments, including transmission planning
– Special reliability assessments
– Coordination with neighboring systems
 	
Note: Some of these entities also fulfill market, resource planning and procurement functions (described further below)
	Consider
	– Conducting special assessments of impact of CPP on system reliability
	  – Preliminary assessments in parallel with final rule development (in 2015) and development of State Plans (2015/2016)
	  – Final assessments upon finalization of State Plans (2016+)
	– Identifying specific areas of concern (e.g., notice period for potential unit retirements; need for more routine anticipatory analyses in transmission planning to explore "what if" changes occur on the system; identification of zones with violations of reliability requirements and any specific units needed for reliability pending resolution of the violation)
	– Working with stakeholders (including environmental agencies in relevant states) to develop proposals for reliability safety value to ensure mechanism to fully offset CO_2 emission impacts when use of a safety valve is triggered
	– Working with counterparts in natural gas industry to harmonize business practices, develop improved inter-industry forecasting tools, coordinate operating days/market timing, share information, identify specific natural gas infrastructure needs
	– Refreshing policies and practices to assure technology-neutral and competitively neutral means for providing reliability services (both resource adequacy and system operations)
	  - Technology neutrality should recognize the different attributes needed for essential reliability services, but be supportive of generation, transmission and demand-side solutions for providing such attributes
	– Working with state officials and distribution utilities within their relevant geographies to explore ways to expand the visibility (e.g., through communications and information systems) of the system operator into distribution system resource operations (i.e., distributed variable resources such as solar PV); incorporate into planning activities
	– Continuing to improve meteorological forecasting capabilities

Table 4
Other Federal Agencies' Potential Actions to Address Reliability Issues

Other Public Entities (with some of the their Standard Tools)	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)

EPA
- **Issuing the final Clean Power Plan regulation**
- **Responsibility for finalizing standards for new power plants (Section 111(b))**
- **Responsibility for administering federal air, water, and waste pollution standards**
	Consider:
	- Clarifying acceptable standard market mechanisms that could be used to accomplish emission-reduction and reliability goals in economically efficient ways
	- Providing guidance on allowing one or more forms of a reliability safety valve, *with the condition* that overall emissions over the interim period (e.g., 2020-2029) are equal to or better than the plan without a triggering of the reliability safety valve. Examples might include:
	  - Allowing the reliability safety valve as proposed by the RTO/ISO Council (with the noted CO_2 emissions offset condition)
	  - Requiring/allowing temporary exemptions/modifications of timing/quantity requirements in State Plans
	  - Providing guidance about how states may propose to alter compliance deadlines/requirements where needed for reliability, should such issues arise over time
	- Requiring States to include reliability assessments in final State Plans (not for EPA to review/approve, but rather to ensure that such studies are conducted)

Other federal agencies - **DOE** - **EIA**	Consider: - Investigating additional reporting requirements by members of the industry - Conducting studies and analyses that examine physical capabilities of more integrated gas and electric system - Identifying CPP compliance issues as qualifying for DOE Critical Congestion Areas and Congestion Areas of Concern, and/or "national interest electric transmission corridors" under the Energy Policy Act of 2005

Table 5
States' Potential Actions to Address Reliability Issues

Other Public Entities (with some of the their Standard Tools)	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)

States
– Air agency:
  – obligation to submit State Plans to EPA
  – reviewing/approving any modification to air permits of affected generating units
– Executive and legislative responsibility for energy, environmental laws and regulations
– Oversight over regulated electric and natural gas utilities (public utility commissions) – including ratemaking, programs (e.g., energy efficiency), planning and resource procurement
– Coordination with neighboring states
– Engagement in regional planning, operational, and market rules and procedures
– Siting/permitting of electric energy infrastructure and local gas distribution facilities
	Consider:
	– Proactively (i.e., now) engaging with state utilities and state/regional system operators in evaluation of potential CPP reliability impacts, and identification of reliability solutions (including supporting preliminary assessments in parallel with development of State Plans (2015/2016), and final assessments upon finalization of State Plans (2016+))
	– Establishing as part of the State Plan an annual state reliability evaluation, and identification of/commitment to take steps and measures in the future in response to any identified reliability concerns. This could include a framework for allowing compliance waivers and extensions in the early years in the event that reliability issues arise circa 2020, combined with requirements on state and/or compliance entities for provisional CO_2 reductions over transition period to make up for waivers/extensions in early years (e.g., to arrive at same cumulative emissions over the period)
	- Incorporating conditions in air permits to reflect operating limits (e.g., total emissions within an annual period)
	- Creating flexible implementation plans (e.g., mass-based models) and multi-state programs (e.g., regional cap/trade) to mitigate potential reliability impacts and operational flexibility across regions that reflect the normal operations of interconnected electric system
	  - State or regional cap and trade programs
	  - "Bubbling" of requirements across units owned by common owner (e.g., within one state or across states through bilateral state agreements/MOUs)
	– Developing statewide policies and measures for compliance that support reliability (energy-efficiency/renewable energy programs, including measures beyond Investor Owned Utility funded programs), for example:
	  – Clean energy standards
	  – Investment in emerging or early-stage technologies (*e.g.*, storage), public-private partnerships, tax and investment credits
	  – Protocols for counting Energy Performance Savings Contracts in State Plans
	– Reviewing need to modify permitting/siting regulations to accommodate dual-fuel capability of gas-fired power plants
	– Reviewing need to modify administrative or procedural measures to expedite siting, zoning, permitting of needed energy infrastructure (renewables, other power plants, transmission, LNG storage)
	– Instituting new entities (e.g., natural-gas buying authorities) to serve as contracting entity to support long-term commitments that may be necessary for gas system expansion
	– Requiring longer advance notice of power plant retirements

Table 6
Organized Markets' & Electric Utilities Potential Actions to Address Reliability Issues

Entities Involved with Markets, Resource Planning, and Procurements	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)

Wholesale Market Administrators (Generally, Bulk Power System (BPS) Operators in Competitive Market Regions)
– **Markets designed and administered to minimize costs *subject to the constraint* that all reliability requirements of the system are met**
	Consider:
	– Adding technology-neutral and competitively neutral market rules/products to add incentives for new reliability attributes.
	    – Local (zonal/load pocket) capacity and energy market pricing; changes to scarcity pricing
	    – Reliability attributes for system security (greater quantities of spinning or non-spinning reserves; AGC; ramping/load-following; reactive power; on-site fuel; frequency response; black start capability)
	– Establishing or clarifying, where necessary, expectations around unit performance during shortage or scarcity conditions
	– Clarifying how normal dispatch processes incorporate current restrictions on unit operations (including emissions limits, ramping periods, etc.), and how similar operational restrictions (if any) resulting from Clean Power Plan compliance would be incorporated in system operations
	– Establishing or clarifying, where needed, provisions for the creation of reliability must run (RMR) contracts for generators needed for reliability that would otherwise retire – conditioned upon permit restrictions that account for CO_2 emissions offsets
	– Establishing or clarifying, where needed, procedures to minimize duration of RMR contracts through development of utility or market responses (generation, transmission)
	– Identifying any changes in forward capacity markets for the period starting in 2020

Vertically-Integrated Utilities, Cooperatives, Municipal Light Companies
– **Long-term resource planning**
– **Obligation and opportunity to develop and obtain cost recovery for necessary demand, supply, and transmission investments and expenses**
– **Obligation to maintain power system reliability**
– **In some states, integrated resource planning and/or resource need/procurement processes**
– **Coordinated operation of systems with neighboring utilities**
	Consider:
	– Conducting forward-looking assessments of potential impacts on system reliability of CPP implementation
	    – Preliminary assessments prior to and during final rule development and SIP implementation
	    – Final assessments upon finalization of SIP
	– Developing or expanding long-term integrated resource planning processes for timely and practical incorporation of CPP compliance requirements
	– Incorporating all potential short- and long-term measures (supply and demand; generation and transmission) to address significant changes during CPP transition period
	– Engaging in coordination with neighboring utilities around local reliability concerns tied to CPP implementation

Table 7
Other Organizations' Potential Actions to Address Reliability Issues

Other Organizations that have a Role To Play in Assisting in Reliable and Effective Industry Compliance	Potential Additional Actions to Address Reliability Issues Relating Directly or Indirectly to Clean Power Plan (CPP)
Non-Utility Generating Companies	Consider: - Responding to signals in organized wholesale markets and in response to competitive solicitations by electric utilities
Interstate Natural Gas Pipeline Owners/Operators – Coordination among NGP owners/operators – Coordination with BPS operators – Development of new pipeline capacity	Consider: – Improving coordination with system operators – e.g., harmonize standards and practices, coordinate operating days/market timing, share information, etc.
NAESB - Working with industry stakeholders to develop standards for operations in electric and gas industry	Consider: – Periodically convening industry sector discussions about continuing need to harmonize standards in the electric and gas industries
Administrators of Allowance Trading Programs (e.g, RGGI, California, new ones)	Consider: - Establishing new "plug and play" programs that allow states to join with relatively administrative ease
Administrators of Energy Efficiency Programs	Consider: - Establishing products to offer to generating companies to 'purchase' program credits to offset emissions, subject to strict measurement and verification
Energy Service Companies (ESCos)	Consider: - Working with State agencies to develop mechanisms to incorporate energy-savings-performance contracts into State Plans

I. Context

In June 2014, the U.S. Environmental Protection Agency (EPA) issued its proposed Clean Power Plan, designed to reduce carbon dioxide (CO_2) emissions from existing fossil-fuel power plants in the United States. The final rule, which is now anticipated to come out in mid-2015, will require each of the 49 states with covered power plants to prepare and submit plans for how they propose to reduce emissions from the plants in their state. Although the features of the final regulation will undoubtedly change in light of the many comments filed, EPA's current proposal requires states and affected electric generating units (EGUs) to demonstrate progress to reduce emissions starting in 2020, with subsequent reductions thereafter. This new policy will eventually affect over half of the nation's generating capacity and all but the smallest fossil fuel generating units.[8]

In light of the broad scope of the regulation, many stakeholders have raised concerns about whether EPA's proposal will jeopardize the reliability of the electric system. In Washington, in state capitols, in media alerts, in comments filed at the EPA, and elsewhere, many public officials, electric utilities, industry reliability organizations, and others have been demanding

[8] An affected electric generating unit (EGU) is defined broadly, as any boiler, integrated gasification combined cycle (IGCC), or combustion turbine (in either simple cycle or combined cycle configuration) that (1) is capable of combusting at least 250 million Btu per hour; (2) combusts fossil fuel for more than 10 percent of its total annual heat input and (3) sells the greater of 219,000 MWh per year and one-third of its potential electrical output to a utility distribution system (Proposed Rule, Federal Register, Vol. 79, No. 117, June 18, 2014, page 34854). Generating units estimated to be subject to EPA's Clean Power Plan:

SNL Financial (as of 2-2015)	Generating Units Likely to be Directly Covered by Section 111(d)*		Total Grid-Connected Generating Capacity in the U.S. (GW)	111(d) Capacity as Share of Total Capacity (%)
	(# Units)	Summer Capacity (GW)	Summer Capacity (GW)	Summer Capacity (GW)
Coal	922	300	303	99%
Gas	2,137	334	464	72%
Oil	62	17	39	44%
Total Fossil	3,121	651	806	81%
All Capacity			1,151	57%

* Includes all existing or under development steam turbines and combined cycle units greater than 25 MW, and any natural gas combustion turbines with generation greater than 219,000 MWh.
Source: SNL Financial, Power Plant Unit Database.

that the changes introduced by the Clean Power Plan not come at the expense of electric reliability.[9]

For many decades, such cautions have appeared whenever major events – such as major new environmental regulations affecting power plants or structural changes to introduce competition in the electric industry – occur that could affect electric system reliability.[10]

Indeed, well before the EPA issued its proposal, various reliability organizations had already begun to anticipate how changes underway in the electric industry would necessitate modifications in traditional ways to plan for and operate the electric system. For example, the North American Electric Reliability Corporation (NERC) – the nation's electric reliability standards organization – issued a "concept paper" in October 2014, in which NERC describes the many ways that today's reliability procedures will need to evolve to keep ahead of the changing character of the electric "resources" that connect with the grid.[11]

NERC's paper, which was in development well before the EPA issued its Clean Power Plan (and is different from NERC's November 2014 assessment relating to the EPA proposal), begins by recognizing that the

> North American BPS [bulk power system] is experiencing a transformation that could result in significant changes to the way the power grid is planned and operated. These changes include retirements of baseload generating units; increases in natural gas generation; rapid expansion of wind, solar, and commercial solar photovoltaic (PV) integration; and more prominent uses of Demand Response (DR) and distributed generation…. As the overall resource mix changes, all the aspects of the ERSs [Electric Reliability Services] still need to

[9] See discussion in Section III and the Appendix to this paper. Note that even the leadership of the EPA and the President of the United States have insisted upon design and implementation of the Clean Power Plan in ways consistent with electric system reliability. See, for example: President Obama's Presidential Memorandum ("Power Sector Carbon Pollution Standards," June 25, 2013), in which the President directed the EPA to issue regulations to control CO_2 emissions from the power sector, and included the following instructions: "In developing standards, regulations, or guidelines … [EPA] shall ensure, to the greatest extent possible, that you: …(v) ensure that the standards are developed and implemented in a manner consistent with the continued provision of reliable and affordable electric power for consumers and businesses…" Available at: http://www.whitehouse.gov/the-press-office/2013/06/25/presidential-memorandum-power-sector-carbon-pollution-standards

Also, see: Statement of Gina McCarthy, Nominee for the Position of Administrator of the EPA, Before the Environment and Public Works Committee, U.S. Senate, April 11, 2013; and the January 6, 2015 blog post of Janet McCabe, EPA's Acting Assistant Administrator for Air and Radiation, "Time and Flexibility: Keys to Ensuring Reliable, Affordable Electricity," http://blog.epa.gov/epaconnect/2015/01/time-and-flexibility/.

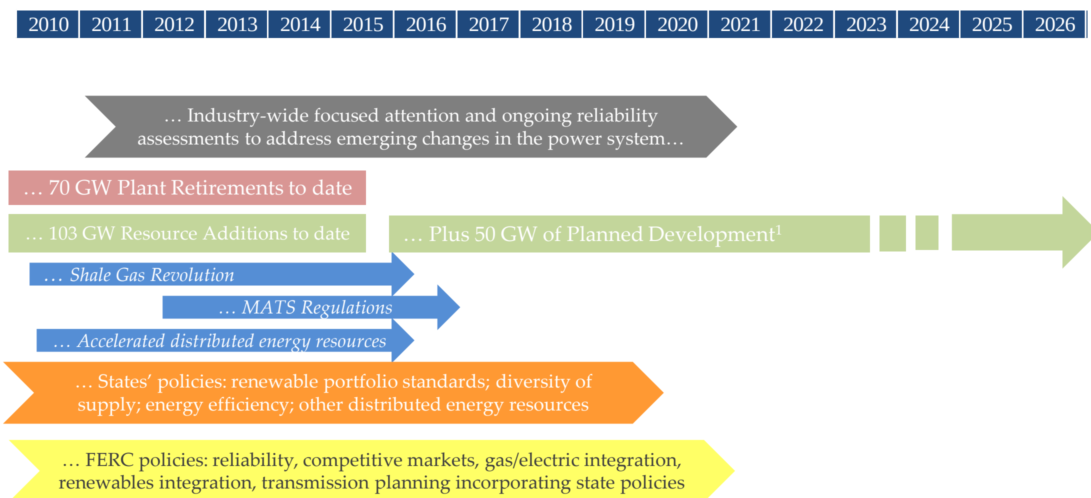
[10] Notably, this has occurred in conjunction with: the EPA "NO_x SIP call" which affected 23 states in the 1990s; state and federal policies related to electric industry restructuring in the 1990s: the Cross-State Air Pollution Rule (CSAPR) and MATS rule; and with on-going increases in the amount of distributed energy resources and intermittent/non-dispatchable resources on the grid.

[11] NERC, "Essential Reliability Services Task Force: A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability," October 2014. Hereinafter referred to as "NERC Essential Reliability Services Report".

be provided to support reliable operation. ERSs are technology neutral and must be available regardless of the resource mix composition.[12]

Those transformations have been in the works for years – in part as a result of the shale gas revolution, changes in the relative prices of fossil fuels, state policies and federal laws encouraging greater use of renewable energy and energy efficiency, declines in wind and solar technology costs, retirements of old and highly polluting coal plants, retirements of a handful of nuclear plants (in some cases for safety reasons, and others for economic reasons), and strong interest by many customers in exploring ways to better manage their own energy use.[13] We depict these changes occurring in parallel in Figure 1, below.

Figure 1
Timeline of Changes Underway in the Electric Industry



[1] Includes retirements/additions announced for 2015 and units that are mothballed or out of service. Planned units include those under construction or in advanced development. Source for MW of retirements and planned additions: SN Financial, Accessed February 2015

As always, grid operators and utilities have implemented and adjusted long-standing planning and operational practices to stay abreast of, understand, and adapt practices to address reliability issues related to such changes in the industry. Given the multiple pressures on the electric power sector, such actions would be needed today even if EPA had not proposed to control carbon pollution in the Clean Power Plan.

[12] NERC Essential Reliability Services Report, page iii. The scope of work for this report was adopted by NERC in March of 2014, before the EPA Clean Power Plan was issued in proposed form in June, 2014.

[13] See, for example: Susan Tierney, "Greenhouse Gas Emission Reductions From Existing Power Plants Under Section 111(d) of the Clean Air Act: Options to Ensure Electric System Reliability," May 8, 2014, pages 23-46.

Indeed, many organizations besides NERC have also been flagging the need to address reliability issues as the industry undergoes significant change. For example:

- The Federal Energy Regulatory Commission's (FERC) attention to gas-electric coordination as the two industries become increasingly dependent on each other,[14] and transmission companies and Regional Transmission Organizations (RTOs) plan for integration of variable generating resources and transmission requirements driven by public policies of state and local governments;[15]
- Studies by the Midcontinent ISO (MISO) of gas infrastructure,[16] and MISO's support for policies addressing transmission implications of the region's growing quantities of wind and other renewable resources;[17]
- ISO-New England's (ISO-NE) continuing analysis of that region's deepening reliance on gas-fired generating facilities, near-term generator retirements, and need to integrate deepening amounts of renewable resources;[18]

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[14] FERC Commissioner Philip Moeller first requested comments on gas-electric coordination in February 2012. Since that time, the FERC has held nine regional conferences to address the issue. See FERC "Natural Gas – Electric Coordination." Available: http://www.ferc.gov/industries/electric/indus-act/electric-coord.asp for additional detail. In 2013, FERC Chairman Cheryl LaFleur and Commissioner Moeller testified before Congress on "The Role of Regulators and Grid Operators in Meeting Natural Gas and Electric Coordination Challenges". The Commissioners noted that gas-electric coordination was and is a growing and important trend due to falling natural gas prices and substantial domestic supplies. FERC receives quarterly updates from its staff on the status of developments in the industry regarding gas/electric coordination issues. http://www.ferc.gov/industries/electric/indus-act/electric-coord.asp. Note too that in response to a directive from FERC, the North American Energy Standards Board (NAESB) undertook a process to develop some new standards for both electric and natural gas industries, which were described in a report submitted to FERC on September 29, 2014.

[15] On July 21, 2011, FERC issued Order 1000 (Docket No. RM10-23-000), in which the agency required, among other things, that each public utility transmission provider: (1) participate in a regional transmission planning process that produces a regional transmission plan; and (2) consider transmission needs driven by public policy requirements established by state or federal laws or regulations. Each public utility transmission provider must establish procedures to identify transmission needs driven by public policy requirements and evaluate proposed solutions to those transmission needs. FERC Fact Sheet, Order 1000, http://www.ferc.gov/media/news-releases/2011/2011-3/07-21-11-E-6-factsheet.pdf. On June 22, 2012, FERC issued the final rule in its docket (RM10-11-000) on Integration of Variable Energy Resources, in which it ordered a number of changes in interconnection agreements, transmission tariffs and cost recovery for regulation reserves to better accommodate renewables reliably and efficiently. 139 FERC ¶ 61,246, FERC Order No. 764.

[16] MISO released its first gas-electric interdependence study in February 2012; it reviewed existing gas pipeline capacity to serve existing electric generation and additional capacity that could be added in the future, and signaled to the MISO and stakeholders that an increase in gas-fired generation will require an "improved collaborative process between pipelines, power generators, and regulators to coordinate natural gas infrastructure projects." Gregory L. Peters, "Gas and Electric Infrastructure Interdependency Analysis," Prepared for the Midwest Independent Transmission System Operator, February 22, 2012, page. 12.

[17] MISO's "Multi-Value Project Portfolio Analysis" of transmission projects will support delivery of up to 41 million MWh of wind energy. Available: https://www.misoenergy.org/PLANNING/TRANSMISSIONEXPANSIONPLANNING/Pages/MVPAnalysis.aspx

[18] ISO-NE first identified these issues in 2010. In 2013, ISO-NE's Chief Executive Officer, Gordon van Welie, stated: "It is clear that resolving these challenges will not be simple, and it will take several years to realize the benefits of the solutions… It is important to remember that, often, the best ideas are born out of necessity. Today the power system faces significant and formidable obstacles. But tomorrow, it will be smarter, stronger, and more environmentally sound because of our collective efforts." ISO-NE, "2013 Regional Electricity Outlook," January 31, 2013, page 8.

- Starting in 2010, calls by the American Public Power Association (APPA) to pay greater attention to the impacts of distributed generation and increased natural gas demand for power generation;[19]
- The Electric Reliability Council of Texas' (ERCOT) ongoing analysis of wind integration as part of its bi-annual Long Term System Assessment;[20]
- The review by the five major electric utilities in California of the implications of a potential significant increase in the state's renewable portfolio standard,[21] and the California ISO's (CAISO) solicitation of more flexible resources to support integration of renewables;[22]
- PJM Interconnection's (PJM) recent capacity performance proposal, in response to concerns raised by unavailable conventional generation capacity during the 2013-2014 polar vortex;[23] and
- New York ISO's (NYISO) ongoing evaluation of reliability needs, including scenarios that account for environmental regulations, increasing penetration of renewable resources, and natural gas fuel availability.[24]

These studies and activities – and others like them – illustrate that our electric system operators, planners, regulators, and others are stepping up to the plate (as they typically do) to grapple with ways to make sure that the future electric system is as reliable as the one we count on today. And their analyses reflect the reality that these trends are occurring as a result of economic, policy and regulatory forces that are independent of EPA's Clean Power Plan.

The value of such "reliability alerts" is that they identify ways in which changes in policy, economics, technology, and law affecting the electric industry intersect with the physics and engineering of interconnected electric systems. All parts of the system must pay attention to certain imperatives of the others.

[19] See, for example, Aspen Environmental Group, "Implications of Greater Reliance on Natural Gas for Electricity Generation," prepared for American Public Power Association, July 2010.; and American Public Power Association, "Distributed Generation: An Overview of Recent Policy and Market Developments", November 2013.

[20] See, for example, ERCOT, "Long-Term System Assessment for the ERCOT Region," December 2012, which examined the implications of introducing significant wind generation and new gas-fired power plants on to the ERCOT Texas system.

[21] Energy+Environmental Economics, "Investigating a Higher Renewables Portfolio Standard in California," January 2014.

[22] California Independent System Operator Corporation Reply Comments on Workshop issues, before the Public Utilities Commission of the State of California, In the Matter of "Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Refinements, and Establish Annual Local Procurement Obligations." Rulemaking 11-10-023, April 5, 2013.

[23] PJM Staff Proposal, "PJM Capacity Performance Proposal", August 20, 2014.

[24] NYISO conducts a detailed "Reliability Needs Assessment" every two years. See, for example, NYISO, "2014 Reliability Needs Assessment," Final Report, September 16, 2014.

Certainly, the shale gas 'revolution' has introduced significant quantities of domestically supplied natural gas at prices which compete with coal, the historically dominant domestic fossil fuel for power generation. This new reality presents economic opportunities to the power system, with cost and environmental benefits for households and businesses. At the same time, however, lower-cost natural gas introduces new issues that must be addressed in the standards, business practices and regulation of both the electric and gas industries: for example, there are new issues surrounding ensuring adequate fuel-transportation and storage arrangements. States' policies to rely more heavily on domestic wind and solar generation also introduce new challenges: grid operators must plan to operate their systems reliably with greater reliance on less dispatchable resources (or in some cases resources that cannot be 'seen' on the system by grid operators, when the resources are behind the meters of customers).

Reliability organizations and grid operators (including NERC, Regional Transmission Organizations (RTOs), electric utilities, and others) are already facing the implications of these trends. They are doing what we count on them to do: looking ahead to see what's on the horizon and identifying reliability-related issues that require adjustments to planning, markets, or operations. They are identifying issues that arise from economic, technological, legal or policy changes. They are developing new analytic tools to better understand how factors like the weather (or wind or sun/cloud-cover conditions) affect power system operations. They are identifying possible, if not likely, changes in power supplies, and indicating where and when new resources might be needed in the years ahead. They are working with transmission owners, power plant companies, government regulators, reliability coordination organizations, consumer representatives, and others to identify changes that may be required in operating standards, market products, and practices.

This is standard operating procedure in an industry with a history with strong legal, cultural, and organizational incentives to do what it takes to make sure that a world-class reliable electric system remains a bedrock of the American economy and society. Recent calls for action to ensure that the Clean Power Plan does not jeopardize electric system reliability should be viewed in that context: people are doing their jobs, not necessarily trying to impede the Clean Power Plan.

II. What Do We Mean by "Electric System Reliability"?

What is reliability, and why does it matter?

http://www.dailymail.co.uk/news/article-2226399/Sandy-Vast-majority-ConEd-wont-power-10-days--Manhattan-hopes-lit-Saturday.html

Most electricity users think of reliability in terms of how often their power shuts off and how long it takes to get it back on. These familiar reliability annoyances typically result from events affecting the local distribution system, such as a snowstorm or hurricane knocking out power lines or a car hitting a power pole.

While critically important to electricity users,[25] such events are not the main concern of observers considering the implications of EPA's Clean Power Plan. What they worry about is whether the overall electric system can do its job, day in and day out, even if one neighborhood or another loses its power.

This other kind of reliability is known as "bulk power system"[26] reliability (and what we call "system reliability" and what insiders sometimes call "BPS" reliability). Outages due to system failures differ from local outages in fundamental ways: in how they can arise; in the geographic scope of power interruptions; in the process and timing of power restoration; in the magnitude of adverse consequences; and, in terms of the parties responsible to fix the problems. The sheer scale of potential human health, safety, and economic impacts is what separates system reliability from local reliability, and dictates a high degree of vigilance on the part of regulators and the industry to avoid system-reliability failures.[27]

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[25] Electricity consumers are acutely aware of how inconvenient and costly outages can become, and of course may not care whether an outage is local or system-wide, in terms of the disruptive impacts on their lives. At the state level, maintaining reliable service is a fundamental obligation of every local utility, and state public utility commissions (PUCs) measure the performance of local utilities in maintaining local reliability over time through measurements that track the frequency and duration of outages. In many states, utilities can be fined heavily for poor reliability performance tied to local distribution-system outages. In contrast, system power failures – which are far less common – generally involve events affecting power plants and transmission lines and a wider geographic area of the grid, with reliability enforcement subject to the jurisdiction of FERC under then Federal Power Act (FPA).

[26] A Bulk Power System (BPS) generally covers a wide geographic region, and includes the generating resources, transmission lines, and associated equipment and systems used to operate the integrated electric system within the region. BPSs generally do not include the lower-voltage distribution systems of local utilities, which deliver power from the BPS to end-use customers.

[27] This is not to say that local distribution system circumstances can never create system reliability challenges. Given that the electric system has to maintain customer demand (load) and supply in balance at all times, a major storm that causes local lines to

For this reason, multiple entities (including those in Table 8) constantly monitor conditions on the overall power system to assure that the overall system operates with a high degree of reliability. System planners, reliability organizations, power companies and regulators look many years ahead, to analyze changing conditions and flag issues on the horizon that need attention. From one season to the next, they review whether there will be enough resources to meet peak demand. Closer to real time, system operators monitor whether power plants are out for maintenance, whether temperature conditions will produce higher than expected demand, and myriad other conditions so that they can get ready for the next day's operations. And in real time, on a second-by-second basis, grid operators have to monitor, and manage the "balance" of the system so that supply equals demand within tolerable operating limits (i.e., "frequency"). Thus, across very different time frames, many actors in the industry work to assure that the system performs with impeccable reliability levels.

Table 8
Entities Responsible for Electric System Reliability

Organization	Roles and Responsibilities
Federal Energy Regulatory Commission (FERC)	- Federal agency responsible for enforcement of electric sector reliability requirements, including oversight of the ERO (NERC)
North American Electric Reliability Corporation (NERC)	- Designated as the Electric Reliability Organization (ERO) by FERC; responsible for developing, assessing and enforcing reliability standards
Regional Reliability Organizations (RROs)	- Members of the NERC that ensure regional operations are reliable, adequate and secure. Includes: Florida Reliability Coordinating Council (FRCC), Midwest Reliability Organization (MRO), Northeast Power Coordinating Council (NPCC), Reliability First (RF), SERC, Southwest Power Pool (SPP), Texas Reliability Entity (TRE), and Western Electric Coordinating Council (WECC)
Grid and System Operators, and Balancing Authorities	- Responsible for the reliability functions in specific geographic areas. In addition to many electric utilities, there are other organizations serving this function in wide geographic areas, including Regional Transmission Organizations (the New York System Operator (NYISO), PJM Interconnection, New England Independent System Operator (ISONE), Midcontinent Independent System Operator (MISO), California Independent System Operator (CAISO), and Electric Reliability Council of Texas (ERCOT)

Those responsible range from: the federal regulators at the FERC, which has statutory authority relating to system reliability; to NERC, the nation's "Electric Reliability Organization" (ERO), authorized by FERC to set reliability standards for grid operators, utilities and other power companies; to Regional Reliability Organizations (RRO) which ensure that the system is reliable, adequate and secure within the geographic footprint for which they're responsible; to grid operators (also known as "balancing authorities" or "system operators") with the operational responsibility in smaller areas.[28] Each

go down can cause a rapid loss of demand with the immediate need to address that big imbalance on the overall system in order to avoid a bigger problem affecting many other areas of the grid. Similarly, high penetrations of distributed resources (e.g., rooftop solar panels on customers' premises) connected to the local distribution system are emerging as a reason to increase the BPS grid operator's "visibility" into what is happening at the distribution system level because of the interrelationships between the two systems. In fact, several areas with significant current or expected installation of distributed resources (e.g., Hawaii, California) have begun to evaluate potential system-wide challenges associated with such developments.

[28] NERC's Glossary of Terms formally defines the various entities, along with various terminologies that described their responsibilities. NERC, "Glossary of Terms Used in NERC Reliability Standards," January 29, 2015, available: http://www.nerc.com/pa/stand/glossary%20of%20terms/glossary_of_terms.pdf

one has different responsibilities, as shown in Table 8.

These entities monitor system reliability using time-tested, well-developed industry analytic tools. For longer-term assessments, the standard methods take into consideration a vast array of potential future infrastructure scenarios and system operational contingencies (e.g., sudden loss of generation, transmission or load). Annually and seasonally, system operators and reliability planners conduct reliability assessments to evaluate system changes, flag areas of concern that need to be addressed within different time frames, and identify plans to address any reliability concerns that may arise over the planning period. In addition, special assessments are periodically carried out in response to any industry or policy changes that have the potential to affect system reliability.

Thus it should not be surprising that EPA's proposed Clean Power Plan is being (and will continue to be) evaluated for potential reliability impacts in future years. We have seen such reliability evaluations exercised regularly over decades in the face of other major industry changes, as noted previously.[29] In every case, the prospect of change has led to reliability assessments and the waving of cautionary flags to call attention to the new challenges ahead.

How could electric system reliability be affected by the Clean Power Plan?

The Clean Power Plan will not lead to more cars hitting distribution poles, nor will it affect the frequency, location, or severity of storms that lead to local outages. The more relevant questions are how controls on power plant CO_2 emissions will affect power system components and operations. As highlighted in Section III (which summarizes stakeholder concerns around the Clean Power Plan's potential impacts on system reliability), concerns primarily relate to impacts these pollution controls will have on availability of existing power plants. Will plants

[29] There are many examples where changes in conditions have led to questions about whether the electric industry (and its supply chains) could respond in a sufficiently timely and effective way to avoid reliability problems. This occurred, for example, with: (1) prior EPA and state regulations governing human health and environmental impacts, including the CAA Title IV sulfur dioxide cap-and-trade program contained in the 1990s; the changes in National Ambient Air Quality Standards (NAAQS) and Clean Water Act (CWA) requirements; the more recent CSAPR and MATS regulations; and the proposals under 316(b) of the CWA. (2) Changes to the structure of the electric industry over the past several decades, involving major changes in the regulation of and the incentives for investment and operation; transfers of ownership and management of existing generation and transmission system elements; and the formation of RTOs and associated wholesale markets for energy, capacity and ancillary services. (3) Fundamental shifts in the economics of generating power from coal or from natural gas, driven initially by changes in technology costs (e.g., large-scale steam generators versus combined-cycle technologies) and more recently by the emergence of low-priced domestic shale gas resources; the growing strain in some regions on the capacity of interstate natural gas delivery and storage systems to meet combined demand from heating and electricity generation uses during peak winter conditions; and different business practices, and operational protocols and standards in two industries (the natural gas industry and the electric industry) that might need to be better aligned as the two industries become more interdependent. (4) The ongoing displacement of traditional generation resources by grid-connected and customer-sited variable renewable resources, in some cases dramatically changing the shape of net load that must be followed by system operators. (5) Questions about the ability of some wholesale electricity markets to provide sufficient financial incentives for suppliers to continue to operate and/or to enter the market.

retire and, if so, which ones and when? Which new ones will be added, over what time period? Will gas pipelines and other fuel-delivery infrastructure be in place in time to fuel a power system that depends more upon natural gas? Will the electric transmission system be capable of moving power generated in new locations relative to customer demand?

Insights and answers to these various questions fall into two basic categories, differentiated by time scales. One focuses on long-term planning considerations, and is called "resource adequacy": Will there be enough (adequate) resources in place when system operators need to manage the system to meet demand in the future? The other focuses on short-term operations, and is called "system security": Will the operators be able to run the system in real time in a secure way to keep the system in balance, with all that that entails technically?[30]

Resource Adequacy

First, the interconnected electric grid must have resource adequacy – that is, there must be sufficient electric supply to meet electric demand at the time of annual peak consumption, taking into account the expectation that some parts of the system will not be able to operate for one reason or another. The system must have some additional quantity of capacity above the annual peak load value (the reserve margin) to cover the possibility that in highest-demand hours some resources may be out of service due to planned or unplanned outages.[31] In some regions and sub-regions (or "zones"), constraints on the ability of the transmission system to move power from one location to another mean that some portion of the demand within the zone must be met by generating resources within that same zone.

Ensuring resource adequacy is generally accomplished through two steps. First, the expected system peak demand and energy requirements over a long-term period (e.g., ten years) are established through a comprehensive forecasting effort. Forecasting processes for this purpose use well-established economic and industry modeling tools and data, are conducted frequently, and typically involve input by utilities, grid operators, public officials, consumer advocates, and

[30] The U.S. Energy Information Administration (EIA) defines electric system reliability as the "degree to which the performance of the elements of the electrical system results in power being delivered to consumers within accepted standards and in the amount desired. Reliability encompasses two concepts, adequacy and security. Adequacy implies that there are sufficient generation and transmission resources installed and available to meet projected electrical demand plus reserves for contingencies. Security implies that the system will remain intact operationally (i.e., will have sufficient available operating capacity) even after outages or other equipment failure. The degree of reliability may be measured by the frequency, duration, and magnitude of adverse effects on consumer service." U.S. EIA, "Glossary," available at http://www.eia.gov/tools/glossary/index.cfm?id=E.

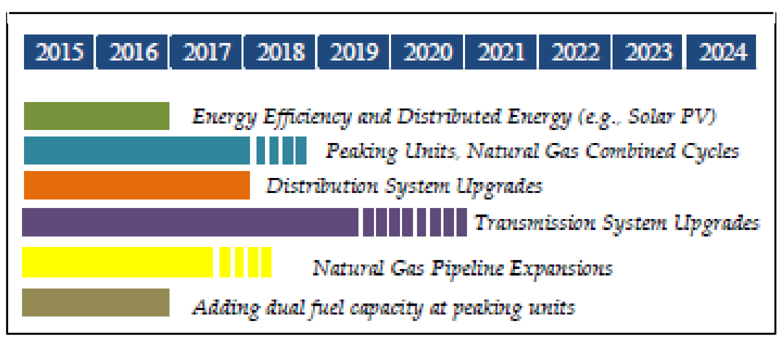
[31] Reserve margins are generally in the range of 10 to 20 percent of system peak load. The actual reserve margin varies from region to region as a function of many factors (e.g., the mix and expected performance of assets on the system, operational and emergency procedures, the availability of demand response/load curtailment, and contributions that may come from neighboring regions).

many other market participants and stakeholders. This step occurs in both wholesale energy markets and through integrated resource planning conducted by electric utilities.

Second, to the extent that identified long-term needs exceed resources expected to be on the system (due, for example, to growth in demand over time, and/or the retirement of existing resources), the deficit is met through the addition of new infrastructure (power plants or transmission lines) and/or demand resources (such as energy efficiency or demand-response measures). The ways in which new resources are added varies around the country, depending on the structure of the electric industry and the regulatory approach in place in a given state, along with other aspects of the market (including FERC-regulated RTOs in many regions). In wholesale market regions like PJM and NYISO, identified needs are met through market structures designed to provide financial incentives for investment in new capacity. In other regions (like most of the West), vertically integrated utilities, cooperatives and municipal electric companies add needed capacity by proposing and building their own project and/or through soliciting offers from other competitive suppliers. In any event, the overall resource need is forecasted (and, if relevant, a local/zonal requirement is further identified), and some combination of regulated and/or market process brings forth proposals to satisfy the need.

These processes are designed to accommodate the lead times necessary to bring a new project or resource into operation. They typically involve sufficient advance notification of need to allow for: (1) initial development stages and associated studies around project feasibility, interconnection, etc.; (2) administration of the markets or competitive procurement processes (and regulatory approvals of them); (3) zoning, permitting, and siting approvals for specific facility projects; (4) construction of the power plant and associated infrastructure (e.g., transmission interconnection/upgrades and – if needed – fuel delivery such as natural gas pipeline connections). Lead times for implementing peaking generating units and demand-side actions (e.g., programs leading to installation of energy efficiency measures; equipping buildings with automated capability to control demand when signaled to do so by the system operator; adding solar PV panels) are much shorter than those for large power plants and transmission upgrades. Figure 2 provides a conceptual depiction of lead times for planning, developing and installing

Figure 2
Typical Lead Times for Different Electric Resources



Source: Analysis Group

different types of infrastructure to support electric resource options.

The processes outlined above rarely occur in a sequential fashion.[32] Ten-year assessments take into account time periods that extend well beyond the number of years it typically takes to develop, permit, finance, and construct a new power plant.[33] As one developer is starting to scope out where to site a new power plant in anticipation of hoping to get approvals and enter the market four years in the future, another already has its approvals and has commenced construction. Installation of demand-response measures take much shorter time periods altogether. Many steps occur concurrently across many different types of resources that are being planned and put in place to meet resource adequacy requirements.

In practice, there are exceptionally few instances where industry has failed to provide for resource adequacy, where – due to a lack of installed capacity – the grid operator had to implement emergency protocols (such as lowering voltage (sometimes known as rolling brownouts) or curtailing service to customers (sometimes known as rolling blackouts)).[34] Although there have been rare occasions where a relatively near-term resource adequacy problem has been identified, regulators, market participants, grid operators, customers and reliability organizations have taken the steps needed to assure that the lights stayed on. There are well-known examples from around the country where the industry (including its regulators) did what was necessary to keep power flowing to consumers.[35] In large part, this track record

[32] For example, often initial market development of a new generating resource – e.g., site identification and control, technology selection, fuel and transmission infrastructure studies, fatal flaw analyses, even some initial siting and permitting efforts – happen in advance of or concurrent with resource need specification or market/utility procurement. Similarly, engineering, construction, and fuel contracts may be established (on a contingent basis) prior to final resource selection or final regulatory approval. Successful resource development teams effectively manage the flow of steps needed to take a new power plant from concept to operation so as to balance the stages of investment risk against the process of procurement and approval.

[33] Typically, lead times for a new natural gas power plant involve 2 years for development and permitting and another 2 years for construction. A peaking unit typically takes less time: from 2 to 3 years. Demand-response and other distributed energy resources can be brought to market in 1 to 2 years. Some generating additions may further require transmission or distribution system upgrades. These can range in time from as little as 2 to 3 years for local distribution upgrades to 5 to 6 years or longer for more extensive transmission system upgrades, but such permitting and construction activities are carried out coincident with power plant permitting and construction. Lead and development times are in part, flexible, depending on the system need and critically, it is possible to move faster when needed. For example, following the California Energy Crisis in the early 2000's, the state added thousands of MWs of new generation using a set of emergency 21-day, 4-month, and 6-month citing procedures. These emergency responses helped establish a set of best practice siting procedures that can be used by other states in similar situations. Susan F. Tierney and Paul J. Hibbard, "Siting Power Plants: Recent Experience in California and Best Practices in Other States," Hewlett Foundation Energy Series, February 2002.

[34] A notable exception is the well-known California electricity crisis of 2000-2001, which resulted from a combination of actions (including market manipulation through actions in the electric and natural gas markets, as well as caps on retail electricity prices). To our knowledge, there has never been a resource adequacy event (e.g., a brownout or blackout) due to implementation of an environmental regulation.

[35] Examples include:

- ERCOT's slim reserve margins in recent summers, including for example, in 2012, when nearly 2,000 MW of mothballed capacity was returned to service. Commissioner Anderson Jr., Public Utilities Commission of Texas, "Resource Adequacy in reflects the existence of the many resource-adequacy processes outlined above, the presence of multiple early warning systems, the ability of policy makers to take action to address challenges when urgent action is needed,[36] and a strong mission orientation of the industry and its regulators.[37]

System Security

Even assuming that these resource adequacy processes end up ensuring there are enough megawatts of capacity in place when needed to meet aggregate load requirements, actual

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ERCOT," Update #4, January 30, 2013. Available: https://www.puc.texas.gov/agency/about/commissioners/anderson/pp/analysis_ercot_capacity_reserve_margin_013013.pdf.

- Reliability must run (RMR) contracts to keep plants operating, for example:
    - The retention of operations of the Potomac Generating Station until completion of the Pepco transmission lines; see, Paul J. Hibbard, Pavel G. Darling, and Susan F. Tierney, "Potomac River Generating Station: Update on Reliability and Environmental Considerations," July 19, 2011);
    - A delay in Exelon's proposed retirement of the Eddystone and Cromby generating stations in Pennsylvania after PJM determined that in the absence of transmission upgrades, retirements of those units would lead to violations of security standards, with a reliability must run agreement between PJM and Exelon and state air regulators so that the plant could remain on line pending those transmission upgrades, but with limits on the units' dispatch to only those times when the units were needed for operational reliability purposes. Prepared Testimony of Kathleen L. Barrón, Vice President of Federal Regulatory Affairs and Policy, Exelon Corporation, before the FERC, Reliability Technical Conference Docket No. AD12-1-000 (etc.), November 11, 2011.
- Construction of peaking units on a fast-track basis by the New York Power Authority: "We increased our generating capacity by about 450 megawatts during summer 2001 when we began operating small, clean natural gas-powered generating plants at six sites in New York City and one on Long Island. We had launched a crash program in late August 2000 to install these PowerNow! plants in response to warnings from officials in the public and private sectors that the New York City metropolitan area could face power shortages in the summer of 2001. Similar warnings were repeated throughout the 10 months it took to obtain, site, design and install the units—a process that normally would require more than two years." New York Power Authority, "Small Clean Power Plants," Available: http://www.nypa.gov/facilities/powernow.htm.
- Requests by ISO-NE for demand-response resources in Connecticut on a fast-track basis: "On December 1, 2003, ISO New England Inc. (ISO-NE) issued a Request for Proposals (RFP) soliciting up to 300 MW of temporary supply and demand resources for Southwest Connecticut (SWCT) for the period 2004 to 2008. The purpose for acquiring these resources was to improve the electric system reliability in SWCT through the summer of 2007, when the 345 kV transmission loop is planned for completion." J.E. Platts, ISO-NE, "Final Report on Evaluation and Selection of Resources in SWCT RFP for Emergency Capability, 2004-2008," October 4, 2004, page iii.
- New York State's contingency planning efforts (including consideration of new transmission projects) to prepare for a possible shutdown of the Indian Point nuclear plant, shutdown as early as 2018, depending on the outcome of its re-licensing with NRC. See the New York Department of Public Service Commission Case No. 12-E-0503, "Proceeding on Motion to Review Generation Retirement Contingency Plans." Available: http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterCaseNo=12-e-0503&submit=Search+by+Case+Number

[36] Susan F. Tierney, and Paul J. Hibbard, "Siting Power Plants: Recent Experience in California and Best Practices in Other States," Hewlett Foundation Energy Series, February 2002.

[37] For example, FERC/EPA processes under the MATS regulation introduced a Reliability Safety Valve and related procedures to ensure that identified reliability challenges could be addressed, while allowing some flexibility with the eventual MATS timeline. As discussed below, the ISO/RTO council has proposed a similar reliability safety valve for the Clean Power Plan and the EPA has also acknowledged potential reliability concerns in its most recent Notice of Data Availability memorandum.

'delivered' reliability also depends on making sure that the system operates in real time with high technical integrity.

System reliability is affected in real time by several things:

- The mix of attributes of the resources on the system – their location, their fuel source, and the operating characteristics of the supply and demand resources;
- The variations in system conditions (e.g., building lights turned on, or a power plant tripping off line unexpectedly, or sudden storm-related outages, or shifts in windiness) that change on a second-to-second, minute-to-minute, hour-to-hour, and day-to-day basis; and
- The system operator's practices and procedures for managing the changing conditions on the system at all times and in all places under that operator's responsibility, to assure that the system stays in balance.

System security describes the ability of the system to meet ever changing system conditions, and to do so with enough redundancy in operational capabilities to manage and recover from a variety of potential system events – or "contingencies" – such as sudden and unexpected loss of generation, transmission, or load.[38] System planners and operator must ensure that the mix of resources on the system is capable of responding in real time to normal load changes and contingency events. This is needed to avoid the catastrophic wide-area failure of the bulk power system – such as a cascading outage covering one or more regions – that can come from unacceptable variations in system voltage and frequency. Blackouts can damage electrical equipment on the grid and on customers' premises, and create wide-ranging safety and health impacts.

To assure system security, the system as a whole must have certain attributes allowing it to provide "essential reliability services," as summarized in Table 9. These include two functional categories:

- *Voltage support*, meaning the ability of system resources to maintain real power across the transmission grid, through the use of reactive power sources such as generators connected to the system, capacitors, reactors, etc. Voltage on the system must be

[38] NERC describes certain features of the bulk power system needed to meet system security requirements – e.g., voltage control, frequency control – as Essential Reliability Services, or ERS. NERC Essential Reliability Services Report.

maintained within an acceptable voltage bandwidth in normal operations and following a contingency on the system.[39]

- *Frequency Management*, meaning the ability of the system to maintain a system frequency within a technical tolerance at all times.[40] Frequency is a function of the match between generation output and load on the system, and requires constant balancing, or following of load by resources that can increase and decrease output instantaneously.

Importantly, system security, or operational reliability, is not a "yes" or "no" condition. To maintain it, system operators use a combination of strategies, tools, procedures, practices, and resources to keep the entire system in balance even as conditions change on a moment to moment basis.[41] The difficulty of this task largely results from several things. First, the

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[39] Voltage support is local in nature, can change rapidly, and depends in part on the type and location of generators connected to the transmission system. Typically, voltage control is maintained by system planners and operators. Acceptable power factors for voltage support are maintained, in part, through the use of reactive power devices (or power factor control) that inject or absorb reactive power from the bulk power system. Reactive power can be provided by synchronous thermal generators and through capacitors and other devices, as well as by 'adequately designed' variable energy resources (including wind and solar) and storage technology. Voltage disturbance performance is the ability to maintain voltage support and voltage control after a disturbance event. NERC Essential Reliability Services Report, pages 1, 10-11.

[40] Frequency must typically be maintained within tens of mHz of a 60 Hz target. Higher frequencies indicate greater supply, while lower frequencies typically indicate greater demand. Frequency management includes: (1) Operating reserves, which are used to balance minute to minute differences in load and demand, load following capabilities to respond to intra- and inter-hour changes in load fluctuations, and reserves, which are used to restore system synchronization following generator or transmission outages; (2) Active Power Control, including ramping capability to quickly bring generators online in response to operator needs, often in ten minutes or less; (3) Inertia, or stored rotating energy that is used to arrest declines in frequency following unexpected losses. Historically, inertia has been supplied by large coal-fired generators, although NERC notes that new 'synthetic' inertia is available through the operation of variable energy resources supported by energy storage devices; and (4) Frequency Distribution Performance, which similar to voltage distribution performance, is the ability to maintain operations during and after an unplanned disturbance. NERC Essential Reliability Services Report, pages 3-5, 8-9.

[41] System operators manage voltage and frequency as load changes over time, and in response to contingency events, through the posturing and management of the resources on the system across several time scales:

- On a second-by-second basis through automatic generation control (AGC) systems on resources that will automatically adjust generation up or down in response to system frequency signals.
- On the time scale of minutes through tens of minutes through accessing "spinning reserves," including operating resources with the ability to ramp output up or down quickly, and resources that can connect to the system within several minutes.
- On the timescale of tens of minutes through accessing longer-term reserve resources that can turn on and connect to the system in less than an hour (typically on the order of 15 to 30 minutes).
- On the time scale of hours or days by committing sufficient operating and reserve resources to manage *expected* swings in net system load (that is, system load net of variable resource output). Note that load varies in relatively 'normal' ways over the course of the days, weeks, and months, and is predictable with a relatively high degree of accuracy by system operators. This allows for the commitment and availability of enough system resources to meet reliability objectives. However, the proliferation of distribution-level, behind-the-meter (BTM) generation with variable output (e.g., distributed wind and solar PV) complicates the forecasting of "net load" visible to system operators – that is, the normal variation in load net of variable BTM output that comes and goes with the sun and wind.
- On an as-needed basis for voltage control by adjusting reactive power injected into or absorbed from the system by on-line generators, capacitors, reactors, and system var compensators.

Source: NERC Essential Reliability Services Report, generally.

operator has, in effect, a particular set of assets on the system at any time, which reflects the operational attributes of the various resources on the system at that time. These include things like: power plants with different operating profiles (e.g., start-up time, limits on output under different temperature conditions, availability to fuel supply); transmission systems that allow or limit power flows in various directions; 'smart' controls and communications devices that allow (or not) visibility into and/or management of power flows; demand response; storage systems; and so forth.

Table 9

System Security Needs and "Essential Reliability Services"

Services	Components		Description	Consequences of Failure
Voltage Support	*Voltage Control*		Support system load; maintain transmission system in a secure and stable range	· Loss of Load · Equipment Failure · Cascading Losses
	Voltage Disturbance Performance		Ability to maintain voltage support after a disturbance	
Frequency Management	*Operating Reserves*	Regulation	Minute-to-minute differences between load and resources	· Loss of Generation · Load Shedding · Interconnection Islanding · Overload Transmission Facilities · Damage Equipment and lead to Power System Collapse
		Load Following	Intra- and inter-hour load fluctuations	
		Reserves	Includes Spinning, Non-Spinning, and Supplemental; Used for synchronization and respond to generator or transmission outages in 10 min or greater time frames	
	Inertia		Stored rotating energy; Used to arrest decline in frequency following unexpected losses	
	Frequency Distribution Performance		Ability of a plant to stay operational during disturbances and restore frequency to BPS	
	Active Power Control	Frequency Control	Real-time balance between supply and demand	
		Ramping (Curtailment) Capability	Ability to increase/decrease active power, in response to operator needs. Measured in MW/min basis	

__Notes and Sources:__

[1] Adapted from NERC (2014) "Essential Reliability Services Task Force: A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability".

[2] NERC (2014) notes that these Essential Reliability Services are functionally equivalent to the Interconnected Operations Service (IOS) definitions, with Voltage Support covering Reactive Power Supply from Generation Sources and Frequency Support covering Frequency Response, Regulation, Load Following, and Contingency Reserves.

[3] NERC notes that many of these ESRs are already defined as ancillary services in the OATT of many system operators. Ancillary services are "those services necessary to support the transmission of electric power form seller to purchaser", considering reliabilty needs. Therefore, NERC considers ancillary services to be a subset of ESRs.

Second, the operator must maintain frequency and voltage on the system at all times. This means, for example, starting up plants as backup resources ("reserves") to quickly replace another plant that trips off line or dips in its output (e.g., due to changes in wind conditions or power plant failure), or adjusting power output up and down with little notice to meet swings in load.

Third, the operator maintains and draws on a diverse set of operational procedures to manage system performance – such as committing or "posturing" resources that may be needed, allowing minor variations in system voltage, calling on resources from neighboring regions, disconnecting variable generation, signaling to 'demand-response' providers to curtail their loads within short periods of time, and other procedures (including, as a last resort, isolated involuntary disconnection of load – or "rolling blackouts").

Reliability is by nature a technology-neutral concept. That said, not all of a system's resources are equal when it comes to the attributes they provide to system operators to manage system security. Historically, power systems' needs for voltage support, inertia, frequency control, and contingency-response capability have been met through operator actions in conjunction with their commitment of the types of technologies on the system: traditional thermal steam units (e.g., coal, nuclear, oil plants, natural gas and combined heat and power units) providing baseload service around the clock; cycling and load-following technologies (e.g., combined cycle plants operating on natural gas); quick-start fossil-fired peaking plants; and dispatchable hydro power supplies.

As the technologies on the system change – which is happening to different extents in different regions as a result of various forces, with or without the Clean Power Plan (as described above in Section I) – steps are being taken to ensure that the suite of essential reliability services is available to supply the frequency/voltage control and contingency-reserve needs of the system. NERC has characterized the challenge as one of filling gaps in services as they arise or widen over time.

Notably, system planners across the country are dealing constantly – and so far successfully – with the new and emerging reliability challenges from changing technology mixes. For example, the CAISO and California electric utilities have identified the need to add greater ramping capability to handle an increased variability in intra-day loads introduced from increasing amounts of 'variable energy resources' (VERs) necessary to meet increasingly higher renewable portfolio standards.[42] In general, load following is typically accomplished through the dispatch of fast-ramping combustion turbines and natural gas combined cycle (NGCC), although load following can also be met through well-designed and cost-effective storage, optimized energy efficiency programs, demand response, and devices (such as smart inverters) being added to wind farms.

[42] California is on track to meet its renewables portfolio standard target, such that by 2020, 33 percent of its total energy comes from renewable resources. The state is considering whether to adopt a 50-percent goal by 2030. Behind-the-meter solar and wind supplies are projected to significantly decrease net load during the middle of the day, while leaving significant shoulder peaks in the morning and evening, resulting in what is commonly called the "duck curve." A recent analysis found that this will require a significant increase in fast ramping, flexible dispatchable generation resources (along with other technologies, including storage). See Energy+Environmental Economics (E3), "Investigating a Higher Renewables Portfolio Standard in California," January 2014.

III. What Concerns are Commenters Raising About Reliability Issues Associated with EPA's Clean Power Plan?

Summary of comments

To date, the EPA has received more than 3 million comments on the proposed Clean Power Plan. Many comments have raised concerns about electric system reliability. These comments have come from a wide range of stakeholders, including: owners of affected power plants (including vertically integrated utilities, merchant generators, municipal electric utilities, cooperatives); state officials, including public utility commissions, air pollution regulators, energy offices, as well as governors, attorneys general, and consumer advocate offices, and associations representing these various groups of public officials; system operators, regional reliability organizations; trade associations with business, public health, environmental, fossil-fuel supply and delivery organizations; members of the public; and others.[43]

The many comments received on reliability issues reflect the importance of thinking clearly about the potential impacts of the Clean Power Plan on system reliability. We summarize the types of reliability-related comments in Table 10, below, and provide more information about these public comments in the Appendix. Notably, EPA has made it clear that system reliability needs to be maintained as the Clean Power Plan is finalized and implemented.[44]

[43] Among the latter include various electric industry organizations (e.g., the Edison Electric Institute; the APPA; the National Rule Electric Cooperative Association; the Electric Power Supply Organization; the Clean Energy Group); business associations (e.g., the Chamber of Commerce); gas industry organizations (e.g., the Interstate Natural Gas Association (INGAA)); coal-industry groups (e.g., the Coal Utilization Research Council); non-energy trade groups (e.g., Water Associations such as the American Water Works Association, National Association of Water Companies and the National Association of Clean Water Agencies), and environmental organizations (e.g. Natural Resources Defense Council and Environmental Defense Fund); NERC; various individual RTOs (MISO, PJM, NYISO); FERC Commissioner Philip Moeller; Senator Dan Coats and 22 other senators. This is not intended to be a comprehensive or exhaustive list of comments or commenters, but rather represent the broad cross-section of types of organizations with an interest in Clean Power Plan reliability issues. Regulations.gov Docket Folder Summary, Docket No. EPA-HQ-OAR-2013-0602, "Standards of Performance for Greenhouse Gas Emissions from Existing Sources: Electric Utility Generating Units," available at http://www.regulations.gov/#!docketDetail;rpp=100;so=DESC;sb=docId;po=0;D=EPA-HQ-OAR-2013-0602.

[44] For example, see both the Proposed Rule, Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, Federal Register, Vol. 79, No. 117, June 18, 2014. Available at: http://www.gpo.gov/fdsys/pkg/FR-2014-06-18/pdf/2014-13726.pdf, and the Technical Support Document: Resource Adequacy and Reliability Analysis. Available at: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-resource-adequacy-and-reliability-analysis

Table 10
Summary of Reliability Concerns Raised in Public Comments and Which Need to be Addressed as the EPA's Proposed Clean Power Plan is Implemented

Summary of Comments Submitted on Reliability Issues Related to the EPA Clean Power Plan		
Category	**Description**	**Potential Reliability Considerations – Which Need to be Addressed**
Resource Adequacy	Retirements of baseload power plants are presenting on-going challenges in some regions	May tighten planning reserve margins in some regions and require timely replacement of capacity on a 1-to-1 basis
		Requires additional transmission planning and analyses, with transmission solutions typically having longer lead times (~10 years) than generation additions
Resource Mix and Operational Security	Retirement of coal-fired capacity and restrictions on output at coal plants, combined with greater use of gas-fired capacity, will result in less fuel diversity in various regions	Some coal units will/may be cycled more frequently, ending up with lower overall capacity factors and adversely impacting relevant heat rates (and emissions per MWh)
		Operating gas plants at higher output will depend upon having adequate gas delivery capability, including firm supply and delivery contracts
		Increased reliance on variable and non-dispatchable resources (like wind and solar) will mean the need for greater quantities of operating reserves and ramping capability
		Loss of baseload generation requires additional voltage and frequency Support, including Inertia
Planning and Regulatory Coordination	The interim goals established in the Clean Power Plan do not provide adequate time for planning and development of adequate resources, for state and regional coordination, or for market solutions	Lead times for new transmission and power plants (including planning, siting, permitting, and construction time lines) extend beyond 2020 and the interim deadlines)
		Successful resolution of various gas-electric coordination issues will be needed to support greater reliance on natural gas in many regions
		RTO/ISO rules and practices regarding security-constrained economic dispatch may need to be reviewed and/or updated, depending upon how states design their plans to incorporate emissions controls
		Greater reliance on demand response and energy efficiency may require new rules and forecasting capabilities in wholesale energy and capacity markets
		Allocation (or reassignment) of transmission rights may be needed to accommodate changing power flows following power plant retirements or to accommodate greater reliance on underutilized gas-fired capacity and/or renewable resources.
Market Impacts and Market Responses	Uncertainty surrounding final regulations and state plans make it hard for markets to respond with concrete proposals in timely fashion	Uncertainty surrounding the regulatory treatment of new gas-fired combined cycles (under 111(b)) may chill development.
		Increased reliance on gas-fired power plants may depend upon new investment in pipeline capacity, with need for new mechanisms to support long-term commitments in some regions (e.g., organized markets)
		Increased reliance on natural gas may accelerate retirements of nuclear units prior to the end of their operating licenses.
		Reliability must-run contracts may be needed to retain some units needed for reliability, but with potential adverse impacts on wholesale market efficiency
		Uncertainty surrounding how states will plan for ensuring new capacity additions in regional organized markets, in light of buyer-side mitigation and other federal wholesale market rules

Many observers' concerns that the Clean Power Plan could jeopardize *resource adequacy* are tied primarily to questions around timing: Does the sequence of steps implied by EPA's proposal – starting with the June 2014 proposal, then taking into account the timing of EPA's final rule, the development of State Plans, the approval of plans by the EPA, and then through compliance decisions and actions by owners of affected power plants – allow sufficient time for everything that needs to be done by states, reliability planners, grid operators, planning and procurement processes, market responses, and so forth to ensure resource adequacy? Or, where that is not assured, do the final EPA and state compliance provisions and administrative procedures allow sufficient flexibility to ensure proper administration of Clean Power Plan without jeopardizing resource adequacy?

Concerns voiced about whether Clean Power Plan implementation could jeopardize *system security* are tied primarily to anxiety over how and when state compliance activity will alter the diversity of resources on the system, and thus the mix of resource capabilities needed to meet system security requirements. In particular, will the economic signals and compliance obligations provided through state implementation of the Clean Power Plan cause the retirement of resources that are needed for system security, and/or will replacement capacity provide the needed operational capabilities? If a significant portion of existing coal-fired capacity retires and is replaced (in part) by gas-fired capacity, will regional interstate pipeline systems be robust enough to ensure reliable delivery of fuel in all hours of the year? If state compliance activities significantly increase the proliferation of grid- and distribution-level variable resources, how much more difficult will it be for system operators to manage the variability in net load on a real-time basis? Or, where this is not assured, do the final EPA and state compliance provisions and administrative procedures allow sufficient flexibility to ensure proper administration of Clean Power Plan without jeopardizing system security concerns?

Other commenters portray the readiness of the industry to step up with solutions to these reliability issues. For example, INGAA described the capability of the natural gas pipeline industry to add new infrastructure.[45] Calpine stated its readiness (along with other market participants) to add new gas-fired generation (and to offer under-utilized capacity already existing on the system).[46] The Clean Energy Group provided suggestions about how the design of policies supporting flexibility and market-based approaches can substantially mitigate reliability concerns.[47] State energy offices (through their national association (NASEO)) noted the ability of a wide variety of well-tested energy efficiency measures (beyond utility-provided programs) to avoid CO_2 emissions from power plant operations.[48] The National Association of Regulatory Commissioners (NARUC) pointed to the ability to reap cost-effective savings in the

[45] Comments of INGAA, filed December 1, 2014.

[46] Comments of Calpine Corporation, filed November 26, 2014.

[47] Comments of the Clean Energy Group (CEG), filed December 1, 2014.

[48] Comments of the National Association of State Energy Officials (NASEO), filed December 1, 2014.

electricity used for water treatment and delivery by introducing measures on the water utility system – thus affording water savings and avoiding CO_2 emissions on the power system.[49]

We also point out many ways to address the reliability issues raised in comments in Section IV of our report, with our suggestions organized around the different entities with some direct or indirect role to play in system reliability.

Reliability safety value concept

The ISO/RTO Council (IRC) has proposed that EPA include a "Reliability Safety Valve" provision as part of the final rule, to help with resolve multi-state issues that may arise due to the Proposed Rule and impact grid reliability.[50] In the view of the IRC, a Reliability Safety Value would provide a regulated and reviewed backstop solution with a defined process for modifying State Plans to ensure reliability against unforeseen issues. As part of this process, the IRC has recommended that the EPA include a specific requirement in the final rule that State Plans must include a detailed reliability assessment. By requiring reliability assessments ahead of final plans, according to the IRC, the Reliability Safety Valve would only be used in situations that could not be addressed ahead of time and that arise solely from dynamic, unplanned changes in the grid. As proposed by the IRC, a Reliability Safety Value would allow relief from compliance schedules if specific units are deemed necessary for reliability considerations.[51] The Reliability Safety Value has been supported by numerous organizations and RTOs, who point out that the concept has been successfully implemented as part of the MATS compliance policy.

We note – as an important element in considering the particular Reliability Safety Valve proposed by the IRC – that there are key differences between the regulatory frameworks of Clean Power Plan and the MATS rule. In particular, the latter assigns emissions-reductions targets on each affected fossil-fuel generating unit, and does not allow any emission averaging across generating stations or across time. As we noted previously in this report, there is much more flexibility in the design of the Clean Power Plan.[52] In particular, the opportunity for states

[49] Comments of the National Association of Regulatory Utility Commissioners (NARUC), filed November 19, 2014.

[50] For example, see comments filed by the ISO/RTO Council (IRC), December 1, 2014.

[51] This process is analogous to RMR contracts that are often available in organized ISO/RTO markets. These contracts provide for time-limited, out-of-market payments to generators that have provided notification of retirement but are necessary for reliability reasons (e.g., local voltage support). Once alternative resources (transmission or generation) solving the reliability need are in place, the RMR contracts cease and the units may retire. By way of example, the IRC suggests that the Reliability Safety Value and a mandatory reliability assessment could help identify reliability issues arising from an individual State Plan, such as a state requirement for reduced utilization at a fossil unit needed for transmission security and voltage support on a transmission network that crosses a state line. ISO/RTC Comments, filed December 1, 2014.

[52] EPA is relying on a portion of the Clean Air Act– Section 111(d) – in its Clean Power Plan. "Section 111(d)'s regulatory framework creates an entirely different and potentially much wider set of compliance and implementation options compared to

to rely upon market-based mechanisms that allow emission trading across power plants within states and across wide regions is a compelling basis for thinking differently about the need for a reliability safety value in this instance. The wider the region in which emission trading might occur, the less likely that reliability issues will be introduced by the Clean Power Plan.

NERC's initial reliability assessment of the Clean Power Plan

NERC published its own "Initial Reliability Review" of the Proposed Rule in November 2014.[53] NERC flagged a number of "significant reliability challenge[s], given the constrained time period for implementation" and that "Essential Reliability Services may be strained by the proposed [Clean Power Plan]."[54] NERC notes that the primary purpose of the paper was to "provide the foundation for the range of reliability analyses" that will be required for stakeholders to work together. Notably, NERC recommended that coordinated regional and multi-regional planning and analysis should start immediately to identify specific areas of concern and that the EPA should consider a more timely approach to resolving any known reliability concerns.

NERC noted that the accelerated retirement of fossil units will stress already declining reserve margins, and that time will be a major constraint, particularly for facility planning, permitting, and construction. NERC identifies transmission upgrades as potentially being needed to successfully integrate variable energy resources anticipated as part of various states' plans, as well as to support reliability concerns regarding voltage and frequency support associated with extensive re-dispatch of NGCC. NERC also suggested that pipeline capacity constraints will

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other recent federal regulatory initiatives applicable to the electric industry.… In the recent MATS rule, for example, EPA set uniform national standards to reduce emissions from different categories of existing coal- and oil-fired power plants. No trading or averaging is allowed across different generating stations. There is no possibility of purchasing credits resulting from over-compliance at other sources, or to credit emissions reductions resulting from end-use efficiency or zero-carbon energy sources. By contrast with MATS, Section 111(d) inherently allows greater opportunities for different pathways to compliance… And in its [State Plan], each state will have flexibility to propose its own preferred actions to accomplish the targeted reductions, as long as the plan provides reductions across the facilities in the state that are at least as effective as EPA's approach. This language "supports the use of market-based mechanisms" and other alternatives in ways that are not possible under the statutory language governing MATs, which required each affected generating station to have emissions at or below the allowed emissions rates. If a state has concerns about the reliability implications of compliance with EPA guidance, the state can take that fact into account as it designs its SIP and its schedule/timetable for individual units' compliance so long as the overall emission reduction required by the guideline has a firm deadline and is achieved. For example, a state could propose plan elements that enable early action/compliance at some Section 111(d) generating units in exchange for allowing more time for others, or that allow for deeper reductions at one unit in exchange for lighter reductions at another." Source: Susan F. Tierney, "Greenhouse Gas Emission Reductions From Existing Power Plants Under Section 111(d) of the Clean Air Act: Options to Ensure Electric System Reliability," May 2014, pages 3-4.

[53] NERC has stated that its November report, "Potential Reliability Impacts of EPA's Proposed Clean Power Plan: Initial Reliability Review," November 2014 (Hereinafter referred to as "NERC CPP IRR") is the first in a series of reliability assessments that NERC plans to conduct. NERC says it plans to release two additional studies in 2015 that will include a detailed evaluation of generation and transmission adequacy and a preliminary assessment of state SIPs.

[54] NERC CPP IRR, page 2.

exacerbate the strain on essential reliability services from relying more heavily on gas. While a full review of the NERC study is beyond the scope of this paper, we note again that these issues have been emerging in markets for a number of years, well before the introduction of the Clean Power Plan. Indeed, NERC covered these "emerging trends" in California, Hawaii, ERCOT, and other regions in its October primer on "Essential Reliability Services."

Many comments in turn, have cited and expanded on the NERC Review. While reliability has been a common theme of these comments, for the most part the NERC report and the public's comments on the Clean Power Plan do not point to specific, modeled reliability problems that have been identified at known points on the bulk power system. Rather, both the report and the comments focus on generalized concerns about potential reliability issues that may arise due to the operational challenge of meeting both the interim and final-goal targets, generally assuming little in the way of the compliance flexibility built into the proposed rule and available to states. While these are valid concerns, it is critical to recognize the numerous strategies, policies, markets and organizations in place that have successfully dealt with these similar operational challenges in the past, and will going forward, as we discuss further below.

Moreover, the Clean Power Plan proposed rule, like all proposed EPA rules, is a "first draft" that is designed to elicit data and comments. EPA has already signaled that it is evaluating stakeholder concerns about the timing and glide path for meeting interim and final targets, and will evaluate this information as it writes the final rule.

Although we think it is ultimately a good thing that the industry is paying close attention to reliability issues – so that any potential problems can be avoided and addressed in time through planning and infrastructure – we do note recent critiques (e.g., Brattle Group's February 2015 report) of the assumptions used in NERC's recent reliability assessments, which do not take into consideration industry responses to market and reliability signals. This is a significant reason to view the NERC as only having set the table with respect to potential reliability concerns, and to recognize that NERC and many other parties will step up with their important contributions to implementation of the CPP within the electric system reliability context.

IV. Options for Assuring Electric System Reliability in Conjunction with Implementing the Clean Power Plan

The reliability check list

The many comments on the proposed Clean Power Plan submitted to EPA serve as a reminder of the broadly-understood condition that pursuing CO_2 emission reductions in the power sector has to occur in an environment that respects the reliability rules of the game. Like the check list at the start of any endeavor, the comments point out a number of potential items to consider adding to the "to do" list that the electric industry routinely uses to ready itself for reliable system operations.

http://imgkid.com/checklist-icon.shtml

Fortunately, that check list is already robust. There are well-established procedures, regulations and enforceable standards in place to ensure reliable operations, placing the country in a good starting position as of the start of 2015. Many of the reliability issues identified in public comments are not new – the industry has responded successfully and effectively to similar challenges in the past. And for several years, some of the trends that commenters note must now be addressed in response to the Clean Power Plan are actually developments that have been underway for many years – and that are currently being addressed. Examples include the FERC's policies addressing: transmission planning taking into account infrastructure needs arising from state-policy (such as renewable portfolio standards); integration of variable electric resources; market designs to assure efficient entry of capacity with attributes needed for reliable system operations; and directives to modify standards and policies so as to better harmonize operations of the electric and gas markets. Other examples include the many studies conducted by RTOs, electric utilities, national laboratories (like the National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory), research institutions (such as the Electric Power Research Institute, university research centers, and think tanks) , and the Department of Energy.

These many studies are already pointing out that some of the tools and checklists needed for reliability may need to be enhanced as a result of the many changes underway in the industry. In many respects, the shift towards natural gas-fired generation (driven in large part by fundamental economic forces), the proliferation of variable resources due to economic and policy factors, and the growth in distributed resources in some regions will drive changes in industry planning and operations over a schedule largely coincident with implementation of the Clean Power Plan.

In the end, we think that even if sometimes exaggerated, the reliability "alerts" are actually a good thing: It is appropriate that people are paying attention to reliability issues, so that potential problems can be avoided – and they can be addressed in time through proper planning and appropriate responses. Even if some of the existing tools need to be sharpened or even new ones added, past experience, the capabilities of the industry, the attention of regulators, and the inherent flexibility of Clean Power Plan implementation strongly suggest that the task is manageable. As always, careful planning and advance work is necessary to make sure that there are not inefficient trade-offs between the two core objectives.

The Reliability Toolkit: Which ones to use here?

The U.S. electric system performs so reliably because it includes both clearly defined and clearly assigned roles and responsibilities to particular actors, and also relies upon markets and regulated planning processes to provide an array of workable solutions. This is a very sturdy toolkit to build upon. Our suggestions aim to make it even better by pointing out some extra steps that responsible parties might take to make the toolkit as strong as possible for supporting the changes underway in the industry, including Clean Power Plan implementation.

For this reason, we organize our discussion of tools by identifying those in the hands of "reliability organizations" (like grid operators, FERC, NERC, the states, and others) and those in others' hands (including power plant owners, the markets, and many additional players, including the EPA itself). While the latter may not be "reliability organizations" in the same ways that the institutions in the first group are, they still have significant opportunities (if not genuine responsibility) to take actions to help ensure reliable pathways to compliance with CO_2 emission reductions required from the power sector.

In Table 1 at the beginning of our report, we categorize parties into the following groupings:

- Entities with direct responsibility for critical reliability functions;
- Other public agencies with direct or indirect roles in the Clean Power Plan;
- Owners of existing power plants covered by Section 111(d) of the CAA;
- "Markets" and resource planning/procurement organizations; and
- Other entities with inevitable roles to play in ensuring a reliable system in conjunction with enabling effective and timely compliance with the Clean Power Plan.

Note that in some cases, some parties (e.g., a vertically integrated utility which is a balancing authority and also conducts resource/planning and procurements) may fall into one or more categories.

Then we use those groupings not only to identify the normal, business-as-usual responsibilities of those parties, but also to make a number of suggestions for things that those different players might do in anticipation of heading off potential reliability problems before they arise, or in mitigating impacts if they do. Table 2 makes suggestions for what FERC, NERC, the Regional Reliability Organizations, with Table 3 providing suggestions for System Operators/Balancing Authorities might do, in terms of institutionalizing new studies, reporting requirements, and so forth. Table 4 then focuses on things that other federal agencies can do, with Table 5 suggesting actions by state government entities. Table 6 identifies potential actions that might be considered/adopted as part of organized markets to send appropriate and timely signals for investment, and in parallel, what electric utilities might do within their own resource planning/procurement processes to accomplish reliable outcomes in their geographic footprint. Finally, Table 7 provides a number of suggestions about things that other players might do in their own zones of influence.

In the end, the industry, its reliability regulators and the States have a wide variety of existing and modified tools at their disposal to help as they develop, formalize, and implement their respective State Plans. These two responsibilities – assuring electric system reliability while taking the actions required under law to reduce CO_2 emissions from existing power plants – are compatible, and need not be in tension with each other as long as parties act in timely ways.

This is not to suggest that electricity costs to consumers do not also matter in this context; of course they do. But we observe that too often, commenters make assertions about reliability challenges that really end up being about cost impacts. We think that separating reliability considerations from cost consideration is important so as to avoid distracting attention from the actions necessary (and possible) in order to keep the lights on. There may be "lower cost" options that reduce emissions some part of the way toward the target reductions, but that fail to meet acceptable reliability standards. We do not view such 'solutions' as the lowest cost solution, precisely because they fail to account for the cost of unacceptable system outages to electricity consumers. Any plan that starts with consumer costs and works backward to reliability and then to emission reduction is one that fails to consider the wide availability of current tools that have served grid operators for more than a decade to meet reliability needs.

This array of tools is of course subject to important and beneficial social constraints and must be exercised to serve the interests of ratepayers. There is no reason to think that these dual objectives cannot be harmonized within a plan to reduce carbon pollution.

V. Conclusion

In this report we identify the many rules, regulations, institutions, and organizations – in effect, the industry's *standard operating procedures* – for ensuring that EPA's design and administration of the Clean Power Plan in no way jeopardizes or compromises the high level of power system reliability we are used to. Such reliability is essential for the strength of our economy and the public health and safety of our citizens.

In the end, of course, it is a good thing that the industry is paying close attention to reliability issues, so that any potential problems can be avoided – and can be addressed in time through planning and appropriate responses. This is do-able, based on past experience and the capabilities of the industry. As always, careful planning and advance work is necessary to make sure that there are not trade-offs between the two.

Having reviewed the broad range of comments received by EPA with a focus on power system reliability, and the potential reliability challenges posed by Clean Power Plan administration, we find that many of these comments tend to assume inflexible implementation and present worst case scenarios, with an exaggerated cause-and-effect relationship. Moreover, many comments (including those from NERC itself) tend to assume that policy makers, regulators, and market participants will stand on the sidelines until it is too late to act. The history of the electric system and its ability to respond to previous challenges including industry deregulation and previous Clean Air Act regulations such as the NO_x SIP call, SO_2 rule, CSAPR, and MATS prove that this is highly unlikely. These challenges will be solved by the dynamic interplay of regulators and market forces with many solutions proceeding *in parallel*.

Indeed, this dynamic interplay is one reason why a recent survey of more than 400 utility executives nationwide found that more than 60 percent felt optimistic about the Clean Power Plan and felt that EPA should either hold to its current emissions reduction targets or make them more aggressive.[55] Similarly, other market participants announced a willingness and ability to help meet system demand for new natural gas supplies[56] and gas-fired generation, in

[55] The same survey found that those utility executives believed that distributed energy resources offered the biggest growth opportunity over the next five years, and more than 70 percent expect to see a shift away from coal towards natural gas, wind, utility-scale solar and distributed energy. Utility Dive and Siemens, 2015 State of the Electric Utility Survey Results, January 27, 2015. The survey included 433 U.S. electric utility executives from investor-owned, municipal, and electric cooperatives.

[56] See, for example, comments filed by INGAA, December 1, 2014. ("INGAA is confident that … the natural gas pipeline industry can respond to demand for the natural gas pipeline capacity that may be necessary to enable compliance with the Clean Power Plan."). INGAA noted that the existing natural gas pipeline system is already supporting national gas-fired combined-cycle utilization rates of 60 percent during peak periods, which are the same periods when distribution constraints are most likely.

support of the Clean Power Plan.[57] This is in addition to the expanded and innovative solutions and strategies for incremental energy efficiency and distributed energy resources identified by State Regulators and Energy Officials.

There are a number of things states and others can (and, in our view, should) do as part of developing their State Plans to further ensure reliability. First and foremost, states can lean on the comprehensive planning and operational procedures that the industry has relied on to maintain reliability for decades – in the face of both normal operations and sudden changes in markets and policy. These procedures flow from a comprehensive set of laws, rules, protocols, organizations, and industry structures that focus continuously on what is needed to maintain electric reliability.

Second, states should give due consideration to the vast array of tools available to them and the flexibility afforded by the Clean Power Plan in order to ensure compliance is obtained in the most reliable and efficient manner possible. In particular, given the interstate nature of the electric system, we encourage states to enter into agreements with other states or add provisions to state plans that facilitate emission trading between affected power plants in different states; doing so will increase flexibility of the system, mitigate electric system reliability concerns, and lower the overall cost of compliance for all.

[57] See, for example, the comments of Calpine Corporation, filed November 26, 2014. ("With our modern, flexible, and efficient generating fleet, Calpine is prepared to facilitate the successful implementation of the Proposed Clean Power Plan. We are confident that by working constructively with the states and EPA as we have always done, the Clean Power Plan can be a success.")

APPENDIX:
Public Comments on EPA's Proposed Clean Power Plan: Summary of Concerns Relating to Electric System Reliability Issues

As of February 8, 2015, 3.83 million comments have been filed on the EPA's proposed Clean Power Plan.[58] Many organizations have compiled lists and summaries of comments filed by various parties.[59] Most of the comments focus on stringency of the proposed emissions reductions targets, the reasonableness of (and legal bases for) the "building block" methodology used by EPA is setting state targets, the timing of emissions reductions in two periods (interim: 2020-2029); and final (2030 and beyond); the ability of states to develop their State Plans with enough time; and other comments.[60],[61]

[58] Regulations.gov Docket Folder Summary, Docket No. EPA-HQ-OAR-2013-0602, "Standards of Performance for Greenhouse Gas Emissions from Existing Sources: Electric Utility Generating Units," available at http://www.regulations.gov/#!docketDetail;rpp=100;so=DESC;sb=docId;po=0;D=EPA-HQ-OAR-2013-0602.

[59] See, for example: Bipartisan Policy Center (http://bipartisanpolicy.org/wp-content/uploads/2015/02/Comments_Map_Static.pdf); National Association of State Energy Offices (http://111d.naseo.org/); Advanced Energy Economy (http://blog.aee.net/epa-ghg-regs-we-read-the-comments-so-you-dont-have-to-part-1-state-federal-regulator-association); Institute for 21st Century Energy (U.S. Chamber of Commerce); (http://www.energyxxi.org/eparule-stateanalysis; http://www.energyxxi.org/eparule-stateanalysis).

[60] See, for example, comments filed by APPA, December 1, 2014; Business Roundtable, December 1, 2014; Class of '85 Regulatory Response Group, December 1, 2014; CEG, December 1, 2014; CURC, December 1, 2014; Coalition for Innovative Climate Solutions, December 1, 2014; Edison Electric Institute (EEI), December 1, 2014; Electric Power Supply Institute, December 1, 2014; ERCOT, November 17, 2014; Environmental Defense Fund, December 1, 2014; Georgetown Climate Center (with state officials from California, Connecticut, Delaware, Illinois, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New York, Oregon, Rhode Island, Vermont, and Washington), December 1, 2014; INGAA, December 1, 2014; NARUC, November 19, 2014; NASEO, December 1, 2014; NRDC, December 1, 2014; National Rural Electric Cooperative Association, July 29, 2014; Nuclear Energy Institute (NEI), December 1, 2014; NYISO, November 17, 2014; PJM Interconnection, December 1, 2014; RTO/ISO Council, December 1, 2014; Sierra Club, December 1, 2014; Southern States Energy Council, September 29, 2014; and Western Electricity Coordinating Council (WECC), November 25, 2014.

[61] Even before the final December 1st, 2014 deadline for filing comments, the EPA and other regulators had acknowledged these many public statements and the comments that had been submitted in advance of the deadline. Specifically, in October of 2014, EPA issued a Notice of Data Availability (NODA) that sought comments on three core issues, which we summarize below:

- *Compliance trajectory of emissions reductions from 2020 to 2029*, and in particular, if or how reductions related to building block 2 could be phased in over time (for example, to accommodate constraints in natural gas distribution infrastructure, or how the book life of existing assets could be used to define an alternative glide path) or how states could earn compliance credits for actions taken between 2012 and 2020;
- *Technical assumptions in the building block methodologies for 2 and 3*, including how to consider new gas-fired combined cycle (NGCC) units in state goals, the role of natural gas co-firing at coal plants as a compliance strategy, and if states with little to no existing NGCC capacity should achieve a minimum target of new NGCC generation; and with respect to renewable energy, how or if the EPA could consider alternative goal setting strategies that account for state or regional economic potential of renewables as opposed to relying on existing RPS; and the role of nuclear units in building block 3; and
- *Methodologies for setting State-specific goals*, including the feasibility of using a multi-year baseline (2010-2012) for goal setting, to what extent renewable and energy efficiency goals should be assumed to displace existing fossil generation – as opposed to displacing or avoiding future fossil generation.

The formal NODA is available through Regulations.Gov in Docket No. EPA-HQ-OAR-2013-0602 and informally, through the EPA, here: http://www2.epa.gov/carbon-pollution-standards/clean-power-plan-proposed-rule-notice-data-availability.

Our own review of submissions from the public and various organizations has focused on issues related to system reliability. These commentaries include concerns raised about one or another aspect of the proposal's impact on the power system's performance. Many comments make suggestions for changes in EPA's proposal, and steps that other entities might take to address reliability issues in the context of compliance with the Clean Power Plan.

A common reliability-related comment is that the EPA did not consider – or seek out the expertise – for how the assumptions it used in setting states' emission reduction targets (i.e., the four "building blocks") may change the operations of the electric grid and how those changes in turn can affect the ability to meet state targets.[62] A similar theme is that the individual state targets do not account for the regional nature of electric grid reliability. Finally, a common concern is that the proposed timeframes for compliance, combined with the interim targets for emissions reductions commencing in 2020, do not provide adequate time for states to develop regional compliance plans or for RTOs to incorporate State Plan provisions into the regional long-term planning frameworks or existing market rules for economic dispatch.

That said, a wide range of regulators and other organizations have committed to working with the EPA and the states to manage these challenges, and in turn, leverage their detailed knowledge of the electric system. As discussed later in this report, many regional coordinators and state regulators already have planning policies and procedures in place that can proceed in parallel with the development of SIPs to ensure the timely development of generation, transmission, and distribution infrastructure needs.[63]

Although the comments do not point to specific known, localized reliability problems identified by a specific commenter, many observers caution that if a state elects not to (or cannot, for one reason or another) accomplish the depth of emission reductions assumed by EPA in state

[62] For example, the EEI noted that "a significant portion of [it's] comments is devoted to explaining how the system operates and how electric utilities, states and system operators engage in complex planning to maintain the reliability of the interconnected power system." Comments filed December 1, 2014, at 12. Similarly, on December 22, 2014, Senator Murkowski (ranking member, Committee on Energy & Natural Resources), Representative Upton (Chairman, Committee on Energy & Commerce), and Representative Whitfield (Chairman, Subcommittee on Energy & Power) requested comment from the FERC Commissioners on their level of involvement and interaction with EPA staff when developing the Clean Power Plan and understanding reliability implications. Letter to FERC from Senator Murkowski, Representative Upton, and Representative Whitfield, December 22, 2014.

[63] Note for example, recent activities among the PJM states: the recent comments submitted to the FERC (Docket No. AD15-4-000: Technical Conference on Environmental Regulations and Electric Reliability, Wholesale Electricity Markets, and Energy Infrastructure, February 19, 2015) by Michael Kormos, Executive Vice President for Operations, PJM: "PJM has begun this coordination process by engaging state commissions, state environmental regulators responsible for implementing the Clean Power Plan, and EPA starting last year. Recently, PJM has undertaken detailed analyses of scenarios and alternatives that were provided to us by OPSI. Those results have been reviewed with our members and with the states and are posted on our website at http://www.pjm.com/~/media/committeesgroups/committees/mc/20150120-webinar/20150120-item-05-carbon-rule-analysis.ashx.

targets, then the state will inevitably need to make additional cuts from other blocks which will increase the stress on remaining assets and strategies.

Comments on reliability issues thus tend to focus on challenges in system operation that may lead to reliability failures. The commentaries do, however, provide suggestions for how to mitigate the challenges for system reliability failures by building into State Plans alternative strategies for meeting those same targets beyond those incorporated into EPA's target-setting assumptions. For example, comments by both NARUC and NASEO discuss the extensive potential for additional CO_2 savings from energy efficiency projects at the interface of the energy-water nexus and other energy-efficiency initiatives outside of conventional programs administered by electric utilities. Additional guidance or clarification from the EPA on how to account for these programs in State Plans could unleash and incentivize a broad swath of carbon reduction strategies beyond the narrow four building blocks.

Many comments focused on the implications of greater utilization of natural gas-fired power plants on changes in system dispatch and the interdependence of interim and final state goals.[64] Achieving a system-wide 70-percent capacity factor for existing natural-gas combined cycle (NGCC) units, for example, would transition a set of power plants now used largely as intermediate and load-following resources to become base-load capacity resources. Baseload coal-fired generators in place at the end of the 2010s would feel the effects, through either greater cycling of these units, or retention of the units to operate only occasionally if needed to remain on the system for resource adequacy purposes, or retirements. Observers note that cycling such coal-fired units more frequently will decrease their efficiency (i.e., increase their heat rates), as plants use additional energy to overcome the inertia inherent in these units. Commenters' cautions that such impacts will increase the overall fleet average emission profile. The observation is that such interactions will mean that states will need to find additional carbon reductions elsewhere. To the extent that the shift includes greater reliance on renewable energy penetration, then the system operators will need to adjust how they operate the resources on their system to maintain reliability. These variable energy resources do not offer system operators the same level of control (e.g., some may be behind the meter and therefore not even "visible" to operator) for frequency or voltage support nor can they be relied upon to meet load in all hours of the day. In the absence of significant new storage capability on the system, this will increase the need for load-following, fast-ramping resources to respond to

[64] The U.S. Chamber of Commerce Institute for 21st Century Energy reviewed and summarized State comments and found that 35 states raised issue with Building Block 2. This was more than any other category identified by the report. Institute for 21st Century Energy, U.S. Chamber of Commerce. "In Their Own Words: A Guide to States' Concerns Regarding the Environmental Protection Agency's Proposed Greenhouse Gas Regulations for Existing Power Plants", January 22, 2015, page 14.

sudden drops in renewable generation. Traditionally, gas-fired combined cycles or natural gas combustion turbines have met this need. But gas-fired plants that begin to operate more in baseload mode may not be able to perform that load-following function. As described in Section II, Figure 2 above, lead times for implementing peaking generating units and demand-side actions (e.g., programs leading to installation of energy efficiency measures; equipping buildings with automated capability to control demand when signaled to do so by the system operator; adding solar PV panels) are much shorter than those for large power plants and transmission upgrades.

These changes are already underway in part due to the shale gas revolution, state and federal policies supporting renewable energy, other environmental policies. According to some observers, the Clean Power Plan will accelerate such trends. Either way, grid operators will need to address the potential diminishing reservoir of voltage support and inertia that has historically been supplied by coal-fired thermal units with their rotating mass of equipment.

Also, the successful operation of natural gas combustion turbines to balance and integrate intermittent and variable renewable supplies will depend, in turn, on the availability and access to fuel when needed for dispatch. Commenters have suggested, and rightly so, that a significant increase in gas-fired generation will require new gas delivery infrastructure. (We note the recent report published by the U.S. DOE that found, among other things, that the amount of incremental gas infrastructure needed is less than what has been put in place by the industry in the recent past.[65]

> Diverse sources of natural gas supply and demand will reduce the need for additional interstate natural gas pipeline infrastructure. The combination of a geographic shift in regional natural gas production—largely due to the expanded production of natural gas from shale formations—and growth in natural gas demand is projected to require expanded natural gas pipeline capacity. However, the rate of pipeline capacity expansion in the scenarios considered by this analysis is lower than the historical rate of natural gas pipeline capacity expansion. …
>
> (2) Higher utilization of existing interstate natural gas pipeline infrastructure will reduce the need for new pipelines. The U.S. pipeline system is not fully utilized because flow patterns have evolved with changes in supply and demand. …
>
> (3) Incremental interstate natural gas pipeline infrastructure needs in a future with an illustrative national carbon policy are projected to be modest relative to the Reference Case. While a future carbon policy may significantly increase natural gas demand from

[65] U.S. DOE, "Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector, February 2015, http://energy.gov/sites/prod/files/2015/02/f19/DOE%20Report%20Natural%20Gas%20Infrastructure%20V_02-02.pdf. After modeling interactions between the gas and electric industries, the report's key findings (at iv-v).

> the electric power sector, the projected incremental increase in natural gas pipeline capacity additions is modest relative to the Reference Case.
>
> (4) While there are constraints to siting new interstate natural gas pipeline infrastructure, the projected pipeline capacity additions in this study are lower than past additions that have accommodated such constraints."

It will take time – in some cases several years – to build this infrastructure, and unlike transmission planning that is coordinated by a central planning authority, expansion of the gas delivery and storage system is driven by market economics. But significant amount of pipeline expansion is already in advanced planning and permitting. Thus, while typically, gas pipeline companies require long-term commitments from 'anchor' gas shippers before receiving permitting approval and proceeding to break ground, there is no reason to believe that the system will be short of capacity as a result of the Clean Power Plan. Indeed, such commitments have and can be made in many regions (notably, in Colorado, as part of the state's approval of Xcel's decision to replace parts of its coal fleet with gas-fired plants, or in the Midwest, where DTE Energy has committed to support pipeline expansion to access gas supplies in the Marcellus). In some organized wholesale electric markets, however, there may need to be changes in some market rules and/or new institutional commitments to induce new investment in firm pipeline expansion to make gas available to non-utility generators.

Another issue raised in many comments relates to the current uncertainty that exists with regard to how states may/should/will count *new* gas-fired combined cycle power plants in their overall planning. Because such new plants fall under a different part of the Clean Air Act (i.e., Section 111(b)) than existing power plants (i.e., Section 111(d)), EPA has suggested that states will have the option to determine whether to fold in new plants into their overall framework for controlling emissions of then-existing power plants, or to keep those new plants regulated under a separate regime. What states will do remains a critical unknown, and could affect the operations of the overall power system, as well as emissions from the plants now covered under the Clean Power Plan.[66]

Beyond regional concerns and detailed technical criticisms, the most frequent reliability-related comments focus on the implications of the interim targets and the timelines for compliance.[67]

[66] For example, states with an emission rate goal less than 1,000 lbs/MWh may meet such a target through extensive renewable resources. The use and reliance on new NGCC units (with an emission rate equal to 1,000 lbs/MWh) to provide significant quantities of energy when renewables are off-line may actually increase net total emissions.

[67] The current rule includes two compliance options: a 2030 final goal with an interim compliance goal for average emissions between 2020 and 2029, and a second option, with lower total goals and no interim goals, to be achieved by 2025. Under option 1, States are required to file their SIP by June 30, 2016, with one year extensions available for single states and two years for multi-state plans. EPA has committed to reviewing and approving all SIPs within one year of receipt. Therefore, final SIPs will take effect

Commenters point out that the compliance timeline presents at least two challenges. The first is the added pressure on resource adequacy in light of pending retirements, particularly of economically marginal coal units facing difficult retrofit decisions for compliance with ongoing air regulations such as the MATS.[68] The second is the asserted lack of time for states to develop regional plans for compliance, which could easily require multi-year time frames to coordinate necessary staff in legislative departments, PUCs, and state energy and air offices.

Others have raised the issue that the timelines will result in significant stranded costs for ratepayers.[69] While not a reliability issue per-se, these stranded costs carry a true economic cost in that those monies may have been better spent on other programs in support of the Clean Power Plan project. However, as we discussed we observe that too often, commenters make assertions about reliability challenges that really end up being about cost impacts. We think that separating reliability considerations from cost consideration is important so as to avoid distracting attention from the actions necessary (and possible) in order to keep the lights on. There may be "lower cost" options that reduce emissions some part of the way toward the target reductions, but that fail to meet acceptable reliability standards. We do not view such 'solutions' as the lowest cost solution precisely because they fail to account for the cost of unacceptable system outages to electricity consumers. Any plan that starts with consumer costs and works backward to reliability and then to emission reduction is one that fails to consider the wide availability of current tools that have served grid operators for more than a decade to meet reliability needs.

between June 30, 2017 and June 30, 2019. Interim compliance goals for each state are set for the 2020 to 2029 period, in what is commonly referred to as the "glide path" of emission reductions to the 2030 target. The interim compliance goals assume that states can achieve the full quantity of reductions equal to estimates from Building Block 1 and Building Block 2. The "glide" in the interim targets, then, is due to the steady increase in carbon reductions from avoided fossil fuel generation in the 2020-2029 period from increasing levels of renewable energy and energy efficiency deployment.

[68] For example, MISO estimated that between 10 -12 gigawatts of coal-fired capacity will retire by 2016 to meet the MATS rule. An additional 14 gigawatts of coal-fired generation (25 percent of the remaining supply) is further at risk of retirement by 2020. MISO conservatively estimates that it will take a minimum of six years for the necessary generation and transmission infrastructure to replace these retirements. Assuming that all state plans are finalized and approved by 2018, necessary infrastructure would not be in place until 2024 – leaving a four year gap of increased reliability risk. MISO, "Analysis of EPA's Proposal to Reduce CO_2 Emissions from Existing Electric Generating Units," November 2014.

[69] For example, Ameren estimated that the 2020-2029 interim timelines could cost Missouri ratepayers an additional $4 billion compared to its existing Integrated Resource Plan (IRP). Ameren noted that its existing IRP assumes the full retirement of coal units at the end of their useful lives by 2034. The early retirements would move forward the in-service date for proposed NGCC and require additional capacity than would otherwise be needed by 2034. See Comments of Ameren, filed December 1, 2014, at 3.

Acronyms

Acronym	Definition
APPA	American Public Power Association
BPS	Bulk Power System
BTM	Behind the Meter
CAA	Clean Air Act
CAISO	California Independent System Operator
CPP	Clean Power Plan
CO_2	Carbon Dioxide
CSAPR	Cross State Air Pollution Rule
CURC	Coal Utilization Research Council
CWA	Clean Water Act
EEI	Edison Electric Institute
EGU	Electric Generating Unit
EPA	Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ERO	Electric Reliability Organization
ERSs	Essential Reliability Services
FERC	Federal Energy Regulatory Commission
FPA	Federal Power Act
IRP	Integrated Resource Plan
ISO	Independent System Operator
ISO-NE	Independent System Operator – New England
MATS	Mercury and Air Toxics Standard
MISO	Midcontinent Independent System Operator
NAAQS	National Ambient Air Quality Standards
NASEO	National Association of State Energy Officials
NARUC	National Association of Utility Regulatory Commissioners
NEI	Nuclear Energy Institute
NERC	North American Electric Reliability Corporation
NGCC	Natural Gas Combined Cycle
NODA	Notice of Data Availability
NYISO	New York Independent System Operator
OATT	Open Access Transmission Tariff
PJM	PJM Interconnection
PUC	Public Utility Commission
RPS	Renewable Portfolio Standard
RSV	Reliability Safety Valve
RRO	Regional Reliability Organization
RTO	Regional Transmission Organization
SIPs	State Implementation Plans
SPP	Southwest Power Pool
VER	Variable Energy Resources (e.g., wind and solar)
WECC	Western Electric Coordination Council