COMMONWEALTH OF VIRGINIA
CLEAN POWER PLAN FOR GREENHOUSE GASES

STAKEHOLDER GROUP MEETING

SECOND FLOOR CONFERENCE ROOM
629 EAST MAIN STREET, RICHMOND, VIRGINIA
FEBRUARY 12, 2016

Members Present:

Malcolm Woolf, Advanced Energy Economy
John Hendricks, AEP
Walton Shepherd, NRDC
Will Poleway, Birchwood
Kris Gaus, Power Plant Management Services
Lenny Dupuis, Dominion
Irene Kowalczyk, WestRock/VMA
Laura Rose, ODEC
Greg Kunkel, Tenaska
John Morrill, VACO
Michael Van Brunt, Covanta

Members Absent:

Scott Carver, Doswell/LS Power
Donald Ratliff, Alpha Natural Resources

Department of Environmental Quality:

David K. Paylor, Director
Ann M. Regn, Office of Public Information
Michael G. Dowd, Air Division
Karen Sabasteanski, Regulatory Affairs
Mary E, Major, Regulatory Affairs

The meeting began at approximately 9:40 a.m.

Meeting Purpose: This stakeholders group has been established to advise and assist the Commonwealth on elements that could be included in the state compliance plan to meet the final U.S. Environmental Protection Agency (EPA) Clean Power Plan (CPP) rule for the control of greenhouse gases. The purpose of this meeting is for DEQ to coordinate and facilitate discussions of this group in an effort to find common ground and elements that could be recommended to the Administration for consideration in the state compliance plan for the Commonwealth.

Welcome and Introductions: Mr. Paylor welcomed the group and made a number of introductory remarks. Although the Supreme Court has stayed the federal emissions guidelines on which the plan will be based, the guidelines have not been struck, so the group will continue to consider the pros and cons of elements of a potential plan, and determine what would be the best plan for Virginia.

Ms. Regn welcomed the group. Members introduced themselves individually. Ms. Regn then reviewed the agenda, provided a brief summary of the previous meeting, the questions for group discussion, general guidelines for discussions, and the main factors to be considered. She also reviewed the discussion and consensus process (see

Attachment A). The focus of today's meeting was Question 2: What general mechanism should be used to implement the preferred compliance plan?

Members were then asked to individually state the pros and cons of the two primary compliance options: (i) a mass-based program (either limited to existing sources, or including existing and new sources), and (ii) a rate-based program. Although the group did not reach consensus of any specific recommendations, the following general areas of agreement were put forth as important factors in any plan regardless of what compliance option is chosen:

- Regulatory certainty
- A well-functioning market (transparency/liquidity/efficiency)
- Minimize impacts/costs to consumers
- Encourage diverse power sources
- Avoid impeding economic development
- Consider a low-carbon future
- Use all available tools to get to low cost
- Level the playing field among like units
- Use performance to assess technologies
- Avoid creating market distortions

Mr. Woolf provided the group with a copy of *Modeling a low-cost approach to Clean Power Plan Compliance for Virginia*, and Mr. Shepherd provided a copy of a white paper on *Guidance Principles for Clean Power Plan Modeling* (see Attachment B). The group also discussed several modeling options previously sent to the group by Ms. Kowalczyk.

Ms. Regn polled the group and found the members supported compliance approaches as follows:

option	support	oppose	neutral/unsure
rate	4 members	4 members	3 members
mass - existing only	2 members	3 members	6 members
mass with new source component	3 members	6 members	2 members

In advance of the next meeting, the group was asked to consider the following elements, assuming a neutral stance on which approach to take, but providing detail on what each type of approach should contain:

- What are the important operational details for each plan type
- How to handle allocation of allowances
- Steps that could be taken beyond the EPA plan

The meeting adjourned at approximately 2:15 p.m.

ATTACHMENT A

COMMONWEALTH OF VIRGINIA
CLEAN POWER PLAN
STAKEHOLDER GROUP MEETING #3
FEBRUARY 12, 2016

AGENDA

9:00 – 9:10 a.m.	WELCOME David Paylor
9:10 – 9:25 a.m.	MEETING 2 RECAP Ann Regn
9:25 – 11:30 a.m.	FACILITATED GROUP DISCUSSION: ADDRESS PROS AND CONS OF MASS-BASED COMPLIANCE APPROACHES Ann Regn
11:30 a.m. – 12:30 p.m.	LUNCH BREAK (on your own)
12:30 – 2:00p.m.	FACILITATED GROUP DISCUSSION: ADDRESS PROS AND CONS OF RATE-BASED COMPLIANCE APPROACHES Ann Regn
2: 15 – 2:30 P.M.	SOURCE SPECIFIC ISSUES WITH RESPECT TO LOCAL IMPACTS Tom Ballou
2:30 – 3:00 p.m.	WRAP-UP Ann Regn
3:00 p.m.	ADJOURN

RECAP OF STAKEHOLDER MEETING 2

- Stakeholder group report
- CPP state CO2 emission goals/EGU 2012 baseline data/2000-2014 emission and rate trends for CO2 and criteria pollutants
- Consensus reached that emission performance standard approach was preferred
- Facilitated discussion on the pros and cons of a mass- and a rate-based emission standards compliance approach
- No formal consensus on rate- vs. mass-based emission standards compliance approach
- No formal consensus on mass-based existing EGUs only vs. Mass-based for existing EGUs + New Source Compliment
- Stakeholder group discussed Virginia's participation in EPA's proposed Clean Energy Incentive Program (CEIP)

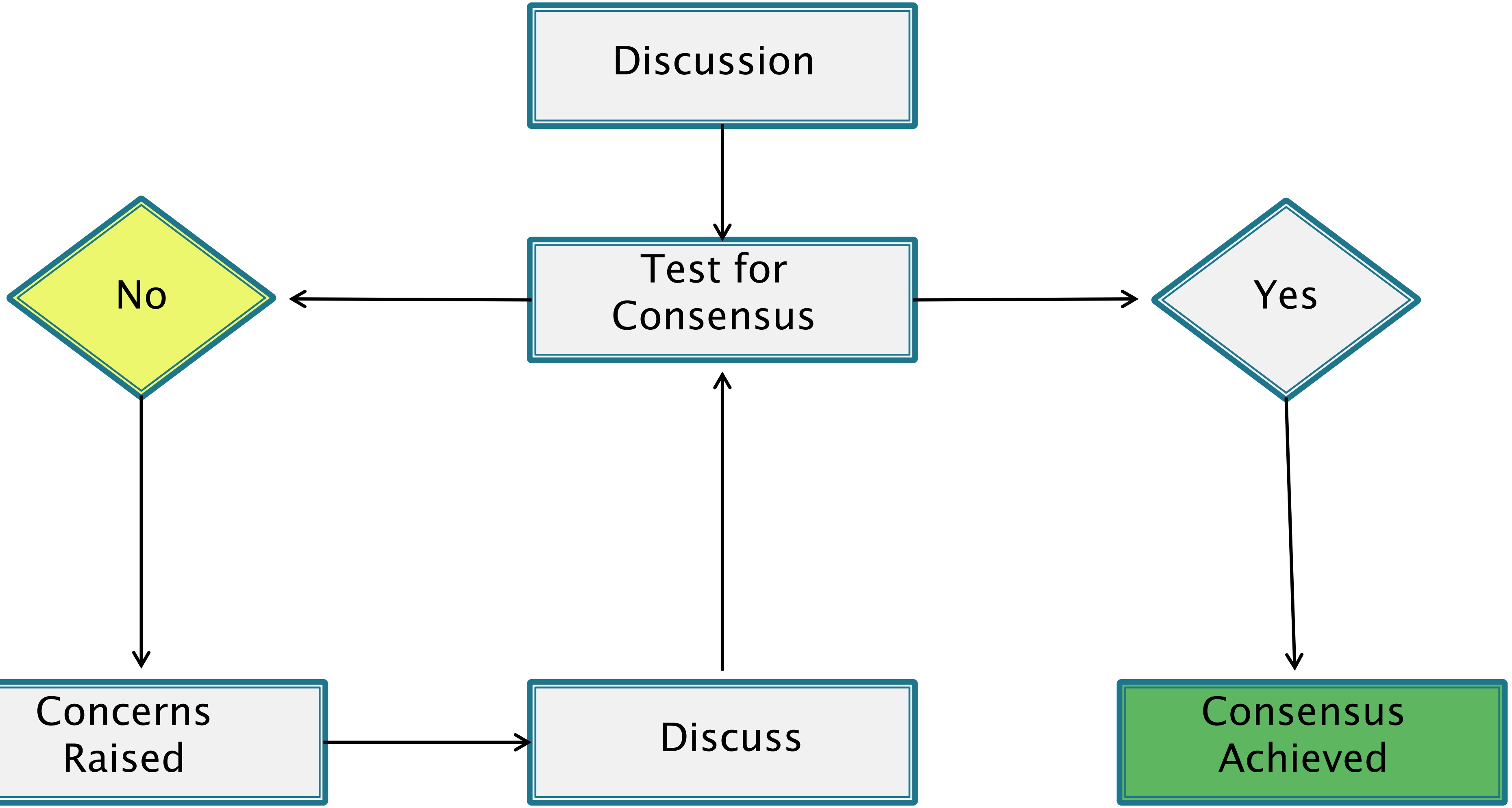
QUESTIONS FOR GROUP DISCUSSION

- Two general approaches are provided in the rule for compliance
  - Source performance standards plan, or
  - State measures plan
- Question 1 - What are the benefits and issues of each approach and what is the preferred path?
- **<u>Question 2 </u>– What general mechanism should be used to implement the preferred compliance plan?**
- Question 3 – What specific mechanisms should be included in the compliance plan?
- Question 4 – What other issues should be addressed and how?

FACTORS TO CONSIDER DURING GROUP DISCUSSIONS:

- Compliance deadlines
- Compliance flexibility
- Compliance with federal requirements
- Cost effectiveness
- Electric rate impacts
- Environmental benefits/impacts
- Low income and vulnerable communities impacts
- Plan implementation and administration
- Reliability and asset impacts
- State and regional interactions

DISCUSSION AND CONSENSUS PROCESS



WHAT ARE THE PROS AND CONS OF MASS- BASED COMPLIANCE APPROACHES?

		MASS Goal for Existing EGUs Only		MASS Goal for Existing EGUs + New Source Complement	
		PRO	CON	PRO	CON
Compliance					
Costs					
Benefits					

LUNCH BREAK

WHAT ARE THE PROS AND CONS OF RATE- BASED COMPLIANCE APPROACHES?

	Subcategorized (DUAL) RATE-based Emission Standard		**State (BLENDED) RATE-based CO2 Goal**	
	PRO	CON	PRO	CON
Compliance				
Costs				
Benefits				

MEETING WRAP-UP

- Next Steps/Future Meetings
  - February 19, 2016
  - March 11, 2016

- Homework – to be determined

MODELING A LOW-COST APPROACH TO CLEAN POWER PLAN COMPLIANCE FOR VIRGINIA

Insights from the State Tool for Electricity Emissions Reduction

ABOUT AEE INSTITUTE

The Advanced Energy Economy Institute (AEE Institute) is a 501(c)(3) charitable organization whose mission is to raise awareness of the public benefits and opportunities of advanced energy. AEE Institute provides critical data to drive the policy discussion on key issues through commissioned research and reports, data aggregation, and analytic tools. AEE Institute also provides a forum where leaders can address energy challenges and opportunities facing the United States. AEE Institute is affiliated with Advanced Energy Economy (AEE), a 501(c)(6) business association, whose purpose is to advance and promote the common business interests of its members and the advanced energy industry as a whole.

ABOUT 5 LAKES ENERGY

5 Lakes Energy is an expert-model energy consultancy based in Michigan. The principals and consultants of 5 Lakes Energy have the expertise and experience to help clients operationalize their ideas and goals. Working with the private sector, foundations and nonprofits, government and academia, 5 Lakes Energy offers a portfolio of services that enable and accelerate innovation. Recent projects have included modeling and analytics to aid states in planning for compliance with the Clean Power Plan; outreach and stakeholder engagement to advance industrial energy efficiency; and facilitation of the groundbreaking Michigan Sustainable Wine Feasibility Study.

Advanced Energy Economy Institute would like to acknowledge the contributions of the Energy Foundation to the development of the STEER modeling framework. In addition, we would like to acknowledge the work of Professor Jeremiah Johnson and his graduate students of the University of Michigan for their work on the core model development.

STEER VIRGINIA: MODELING A LOW-COST APPROACH TO CLEAN POWER PLAN COMPLIANCE

Introduction

On August 3, 2015, the U.S. Environmental Protection Agency (EPA) released the final rule for carbon emissions from existing power plants, called the Clean Power Plan (CPP). To implement the Clean Power Plan, states have the authority to develop their own compliance plan, using strategies that best fit within the context of each state's unique energy portfolio and policy priorities. The State Tool for Electricity Emissions Reduction (STEER) is a resource for regulators and stakeholders to help them better assess a wide variety of technology and service options available to states for carbon emission reduction.

STEER was developed by the University of Michigan and 5 Lakes Energy for the Advanced Energy Economy Institute. STEER is being delivered to a number of states as a free, open-access tool so that anyone with an interest in thinking about how to implement the Clean Power Plan will have access to the necessary data and calculations for an informed analysis. It is delivered as an Excel spreadsheet with a user manual. After downloading the tool, evaluating each scenario that a user might consider takes only a few minutes, enabling the user to develop a deeper understanding of the tradeoffs and considerations in implementing the Clean Power Plan. STEER is unique in that it considers economic impacts, including rate impacts to multiple customer classes, for any compliance scenarios. The model has a default set of data, which is composed of publicly available data for Virginia; however, a user can incorporate more granular data if available.

STEER Virginia can be downloaded from info.AEE.net/steer.

Summary Findings

This paper presents the results of two specific scenarios that are representative of multiple runs of STEER conducted utilizing a wide range of assumptions. These assumptions include projected prices for a variety of power sources, as well as other costs associated with Clean Power Plan compliance, such as carbon allowances. For each scenario, STEER identifies the combination of generation sources, efficiency improvements, and other mitigation measures that represents the lowest cost means of compliance with Clean Power Plan standards for Virginia in 2030.

In this paper, we examine how Virginia is able to reach compliance with the Clean Power Plan in 2030 under two scenarios: (a) with PJM sales growth projections and Dominion Virginia Power's 2015 energy efficiency potential study extrapolated to the entire state; and (b) with PJM sales growth projections and the State Corporation Commission (SCC)'s 2008 energy efficiency potential study. Under neither scenario is any existing generating plant expected to close beyond those already announced for retirement. Certain components of a mitigation plan, such as energy efficiency improvements in both the distribution network and end-use of electricity by customers, are present in both scenarios as they are cost-saving measures, even outside of the Clean Power Plan.

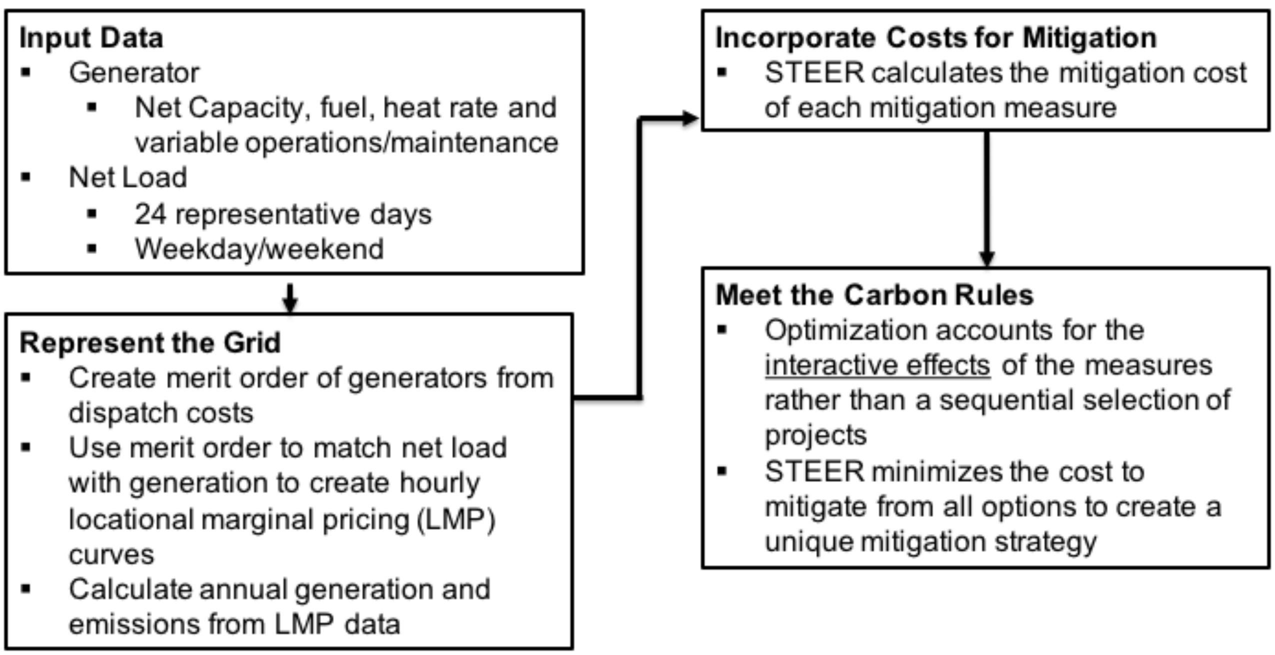
In Scenario A there is a minor rate increase seen, less than a half of a penny per kilowatt hour, compared with a business-as-usual projection. In Scenario B, the scenario using the SCC's efficiency potential study, we see a decrease in electric rates compared with business-as-usual. In neither scenario do we see significant costs imposed on Virginia ratepayers as a result of Clean Power Plan compliance. The result is likely due to the substantial contribution to compliance made by low-cost resources such as energy efficiency and renewable energy. The scenarios shown here demonstrate that Virginia can achieve its required carbon reduction targets without imposing significant costs on ratepayers compared with business as usual.

How STEER Works

STEER is an integrated resource planning tool tailored specifically to find the least-cost way for a state to implement the Clean Power Plan. Integrated resource planning is a mathematical method used by utilities and utility regulators to find the best plan for a utility to meet its obligations. It assures adequate power generation by modeling the use of power plants as needed to meet peak load with a reserve margin. It finds the lowest cost to supply needed power by "dispatching" the plants with lowest operating cost to satisfy load in each hour and by "building" new power plants (or alternative technology that provides megawatt-hours generation or "negawatt-hours" of demand reduction) of the kind and location that minimize the state's total utility bill.

STEER can be run for each individual Clean Power Plan compliance year from 2022 through 2030. Since STEER is run for a single compliance year, any "build," be it a generation facility or energy efficiency deployment, is assumed to occur before the analysis year and is available for use in the analysis year. STEER is able to optimize for lowest cost of power supply while making sure that total carbon emissions from the power sector are below Virginia's target under the Clean Power Plan. The logical flow of STEER is illustrated in the following diagram.

Figure 1. STEER Operational Flow Chart



STEER incorporates a wide variety of measures that are available to mitigate carbon emissions from Virginia's power system. These measures include the following:

- Improving the fuel efficiency of existing power plants, based on either generic assumptions or plant-specific engineering studies, as available
- Changing the dispatch order of power plants to preferentially run those that produce fewer carbon emissions per unit of electricity produced
- Implementing more energy-efficient commercial and residential building codes
- Implementing more demand response resources to lower demand peaks
- Implementing more energy performance contracting to reduce electricity consumption in buildings and campuses

- Implementing utility energy efficiency programs beyond what is currently required by the state
- Using smart grid technologies, including Volt-VAR optimization, to improve efficiency in electricity distribution networks
- Promoting distributed renewable generation through net metering and similar practices
- Reducing use of coal plants by substituting new, less carbon-intensive generation resources, such as:
    - Industrial cogeneration of heat and electricity using natural gas
    - Utility-scale natural gas combined cycle plants
    - New nuclear plants
    - On-shore and off-shore wind farms
    - Utility-scale solar installations
    - Hydropower generators both at dams and in-stream at locations without impoundments and tubine retrofits to existing impoundments
    - Generators fueled by landfill gas or gas produced from anaerobic digesters
    - Municipal solid waste plants
    - Power plants fueled by biomass such as mill wastes, urban wood waste, agricultural residue
    - Blending biomass with coal to fuel existing coal plants
    - Natural gas fuel cells
- Using pumped storage or battery systems to make excess low-carbon power available at other times
- Changes in the amount of power exported by Virginia to other states

STEER models the interactions of carbon mitigation measures by recomputing the effects of measures not yet chosen in light of measures already chosen. For example, heat rate improvements performed at an existing coal plant will affect the results of redispatch to natural gas generation elsewhere in the state.

In addition, STEER allows the user to choose different plan types as laid out in the final Clean Power Plan issued by EPA. The model allows the user to choose a mass-based target or a rate-based target for the state. Under the mass-based target, users can choose to apply the new source complement and allow new gas plants to be built, or the user can use existing power plant emissions only without the new natural gas plant option.

Uses and Limitations of STEER

STEER can serve as a fast, straightforward model for regulators and stakeholders to use in the early stages of compliance planning. While utilities have proprietary software to analyze the ultimate state plan, STEER can help stakeholders cross-check various proposals and assumptions on their own.

Although the STEER Model is a comprehensive modeling tool that uses the same underlying decision framework of proprietary modeling software packages used by utilities and grid operators, there are important limitations to note. The model does not consider transmission constraints when calculating the least-cost mitigation options. In addition, the model calculates the least-cost plan for the single year chosen by the user (which is typically 2030), and the model does not aggregate year-by-year results over a period of time. Also, STEER is designed for individual states, not regions or regional transmission operator territories, although STEER does allow for the accounting of electricity imports and exports. Finally, as described above, STEER considers the full range of carbon mitigation technologies and services, but in a given state, some technologies or services might be technically available yet inaccessible due to existing policies. For example, demand response is a cost effective mitigation option in many states, yet the policy suite in some states does not allow for demand response. The user should be mindful of these limitations when considering the results of STEER.

Energy efficiency measures are incorporated into STEER based on the energy efficiency potential study prepared for Dominion Virginia Power in 2015 or a similar statewide study prepared for the State Corporation

Commission in 2008.[1] Energy efficiency programs typically try to influence purchase decisions when equipment is to be replaced, so energy efficiency potential studies typically report the savings that can be achieved in the 10th year through continuous application of the program for 10 years. STEER treats energy efficiency potential in this way, and so will overstate energy efficiency potential if the programs are not operated continuously for the 10 years prior to the modeled year.

STEER was not developed with the intention of weighing the differences between mass-based and rate-based implementation plans. However, as the choice of plan type does not prohibit any mitigation options, the specifics of the actual plan implementation, not the type, will dictate the outcomes. Note that STEER does not examine how a state might allocate or trade credits within the state, although it does allow the user to determine how many allowances would be required to meet the overall state carbon emissions target for the given year.

Virginia's Options for Clean Power Plan Compliance

How Virginia should implement the Clean Power Plan needs to be determined with full engagement of stakeholders representing the diverse interests of the people and businesses in Virginia. Issues such as future generation mix and rate impacts are of major concern to regulators, businesses, and ratepayers alike, and need to be taken into consideration. STEER is a flexible tool that stakeholders can use to help with those deliberations.

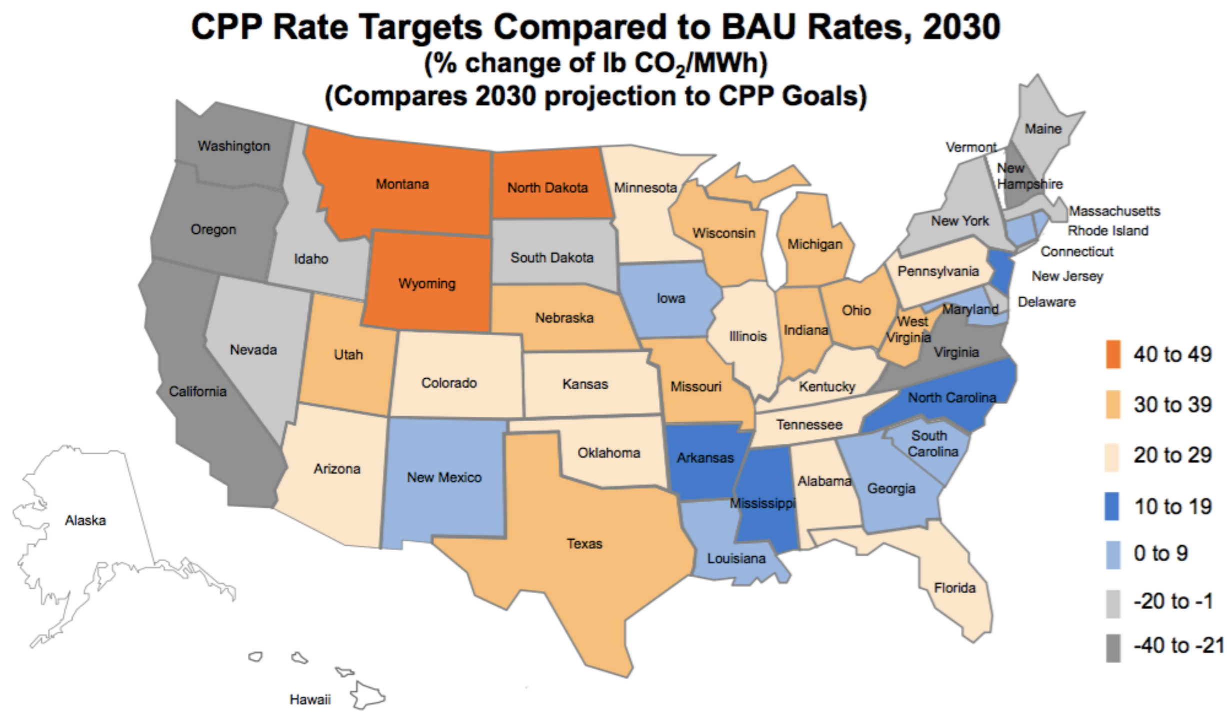
Taking into account Virginia's carbon emissions goal as established in the final rule and the scope of mitigation measures that can be used for compliance, STEER provides certain insights into how Virginia can reach its emissions goal at low cost. STEER users will be able to run a variety of scenarios to test different assumptions and outcomes, but through our initial examination, we have noticed some important themes.

Virginia Is Well Positioned to Comply with the Clean Power Plan

With the release of the Clean Power Plan final rule in August 2015, Virginia saw a significant reduction in the stringency of its interim and final targets as compared to the proposed rule. The 2030 final goal is set at an achievable 934 lb/MWh, in the middle of the pack. Based on EPA's projections, Virginia is set to hit a rate of 959 lb/MWh by 2020, even without the Clean Power Plan, so the state's 2030 targets are certainly achievable (see Figure 2).

[1] "ENERGIZING VIRGINIA: EFFICIENCY FIRST," American Council for an Energy-Efficient Economy, Summit Blue Consulting, ICF International, Synapse Energy Economics; September 2008. https://dmme.virginia.gov/DE/LinkDocuments/GEC/Energizing_VA_EfficiencyFirst_ACEEE_September2008.pdf

Figure 2. Clean Power Plan Targets Compared to Business-as-Usual in 2030



Source: https://blog.epa.gov/blog/wp-content/uploads/2015/08/State-tables-tab-2.pdf
Analysis by Advanced Energy Economy

Virginia has many different options for securing the remaining emission reductions required by the Clean Power Plan. Over several runs of the STEER model, energy efficiency and renewable energy are consistently the lowest cost mitigation options for the state. With significant energy efficiency potential, the state has an untapped resource in utility energy efficiency and network efficiency improvements. Network efficiency technologies include dynamic volt-VAR control and conservation voltage reduction.

Least-Cost Compliance Scenarios Include Renewables and Energy Efficiency

In each of the following scenarios, both energy efficiency (utility, non-utility, and network efficiency efforts) and renewable energy contribute a significant amount to Virginia's least-cost compliance. More importantly, the scenarios demonstrate that compliance with the Clean Power Plan does not have to significantly increase costs for Virginia's electricity customers. In fact, the STEER model shows that, under certain scenarios, the actions taken under Clean Power Plan implementation may marginally lower the cost of electric power.

The graphs below illustrate potential low-cost mitigation options for the year 2030 specifically for Virginia, under a rate-based plan, for which the state's major utility has expressed preference.[2] These are merely a few of the hundreds of scenarios that a user could run to examine projected outcomes. The particular scenarios shown here do not consider changes in the price of natural gas or the use of carbon trading credits, at various prices, as mitigation options, though such scenarios could be run through STEER to project outcomes. Since Virginia can go well beyond the EPA established target, it would appear that the state could generate additional credits, either emission rate credits or allowances, depending on its plan choice, for sale to other states.

[2] E&E News, "Dominion Airs Hopes for VA State Compliance Plan," (19 Nov. 2015), available at http://www.eenews.net/climatewire/2015/11/19/stories/1060028289

In Scenario A, the model uses Dominion Virginia Power's 2015 estimates for energy efficiency potential. Since Dominion Virginia's study only covers its service territory (approximately 60% of the state), the model has extrapolated the efficiency potential to the rest of the state. In this scenario, retail sales are anticipated to increase 0.9% annually between 2015 and 2025 in the Mid-Atlantic region as is projected by PJM. This growth is accounted for in this scenario, with a 113.5% retail sales increase over today's sales in 2030.

The rate impact of 2030 compliance under Scenario A is $0.004/kWh, or less than one-half of a penny per kilowatt-hour over business-as-usual.

In Scenario B, the model uses the same assumptions as Scenario A except for energy efficiency potential. In the first scenario (Scenario A), the model uses Dominion Virginia Power's estimates for potential, extrapolating from the utility's service territory to the rest of the state. In the second scenario (Scenario B), the model uses the Virginia SCC's energy efficiency potential estimates from a statewide anlysis performed in 2008. While the two efficiency potential estimates used in Scenarios A and B yield notably different results due to differences in assumptions, both exhibit singificant contributions from energy efficiency and renewable energy, and both have minimal impacts on rates over business-as-usual

Both Scenario A and Scenario B allow for heat rate improvements up to 4.3% – the heat rate improvement deemed feasible by EPA for the Eastern Interconnection – at those existing coal-fired power plants for which the investment makes economic sense. Additionally, the cost of natural gas in 2030 is assumed to be $6.22/MMBtu, the U.S. Energy Information Administration (EIA)'s forecasted price for natural gas in 2030.[3]

The rate impact of 2030 compliance under Scenario B is negative; ratepayers can anticipate a rate decrease of $0.002 per kilowatt-hour less than business-as-usual.

Figures 3 and 4 show the changes in capacity needed to achieve the CPP targets in each scenario, while Figures 5 and 6 show the change in generation associated with each scenario. Under Scenario A, coal and gas capacity remain relatively unchanged while renewable capacity, in particular solar capacity, expands substantially (Figure 3). Scenario B also maintains relatively unchaged coal and gas capacity but significantly less additional renewable capacity. In Figures 5 and 6, there is an overall decrease in generation with fossil generation decreasing while renewable generation increases, despite the assumption (based on PJM's demand forecast) of additional load growth. The primary difference between Figures 5 and 6 is the size of the role played by energy efficiency in least-cost compliance. The major difference between the two scenarios is the stronger role for energy efficiency in Scenario B, as shown in Figures 7 and 8.

[3] 2015 Annual Energy Outlook, Energy Information Administration. http://www.eia.gov/forecasts/aeo/

Figure 3. Scenario A: Capacity Under Least-Cost 2030 CPP Compliance

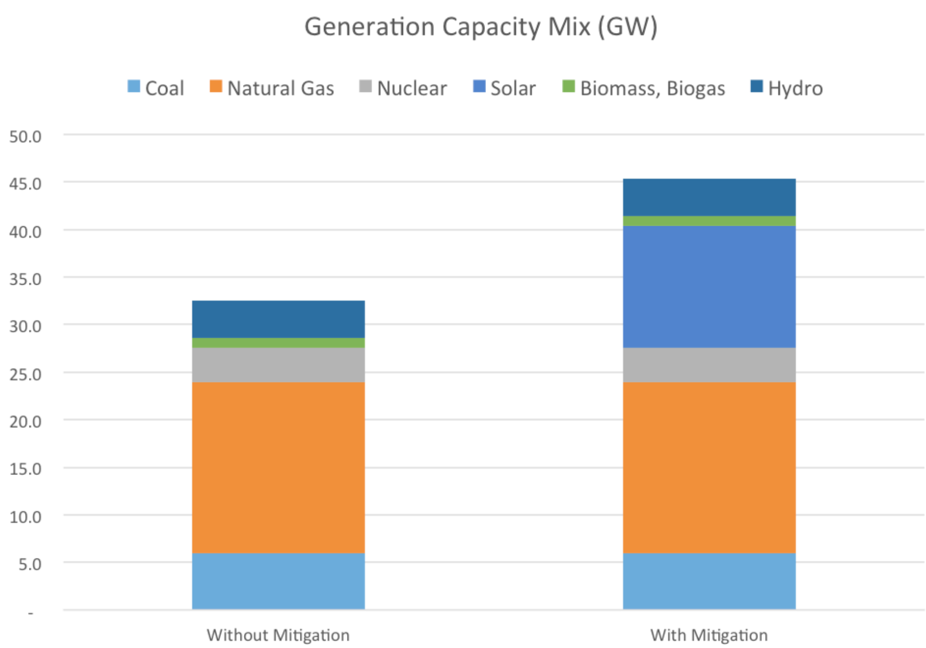


Figure 4. Scenario B: Capacity Under Least-Cost 2030 CPP Compliance

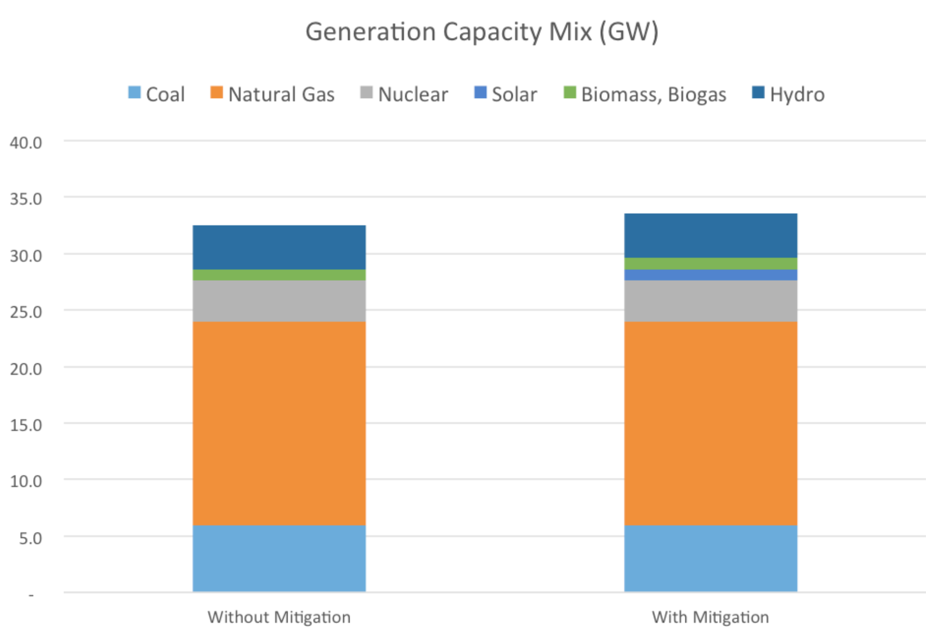


Figure 5. Scenario A: Statewide Generation Under Least-Cost 2030 CPP Compliance

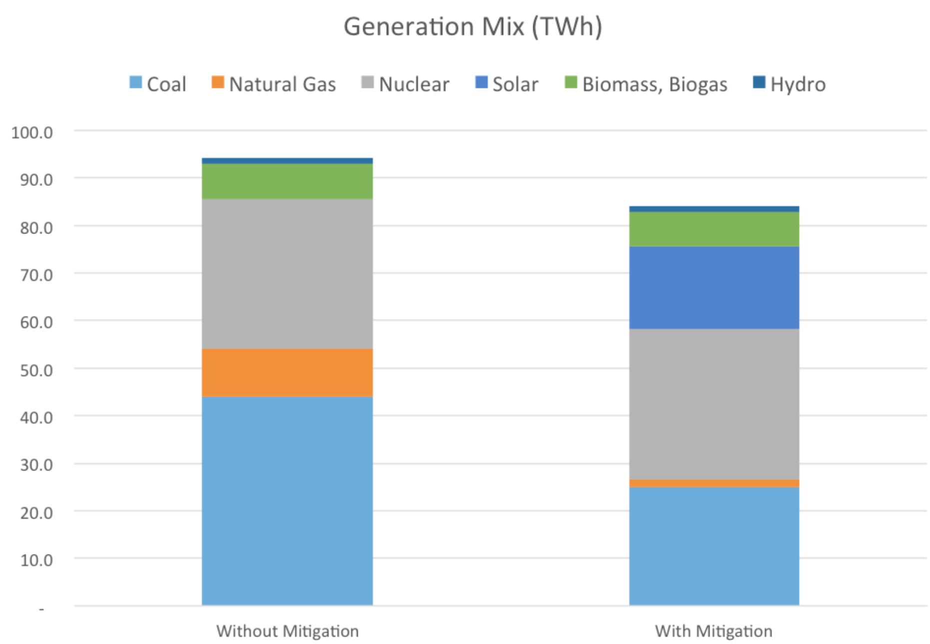


Figure 6. Scenario B: Statewide Generation Under Least-Cost 2030 CPP Compliance

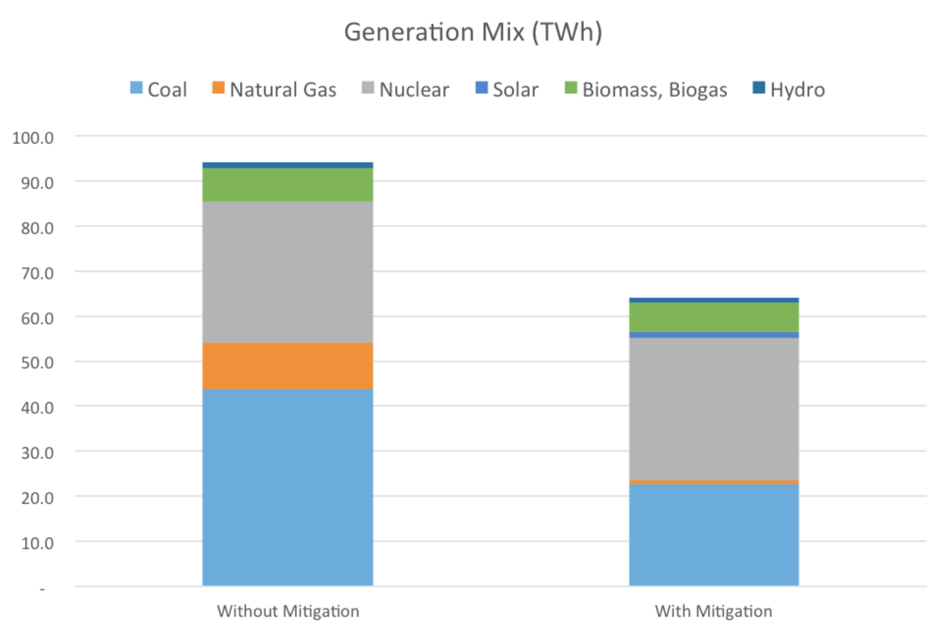


Figure 7. Scenario A: Percent of Mitigation Achieved by Measure for Least-Cost 2030 CPP Compliance

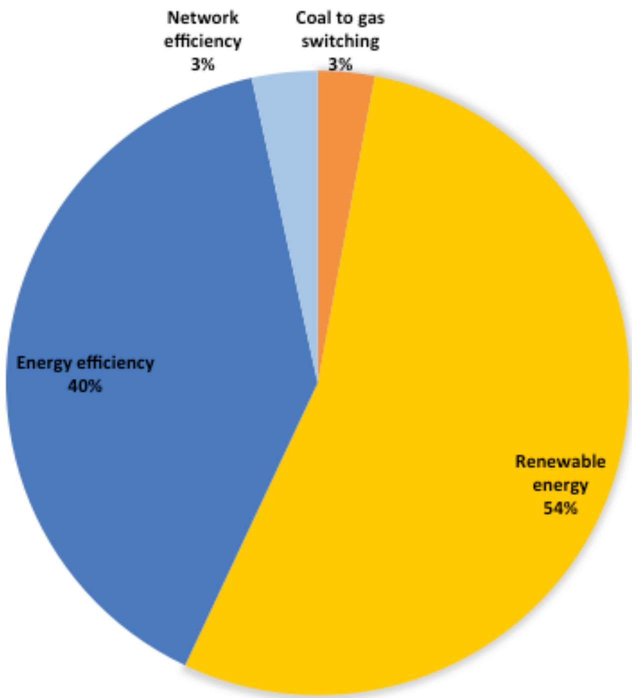
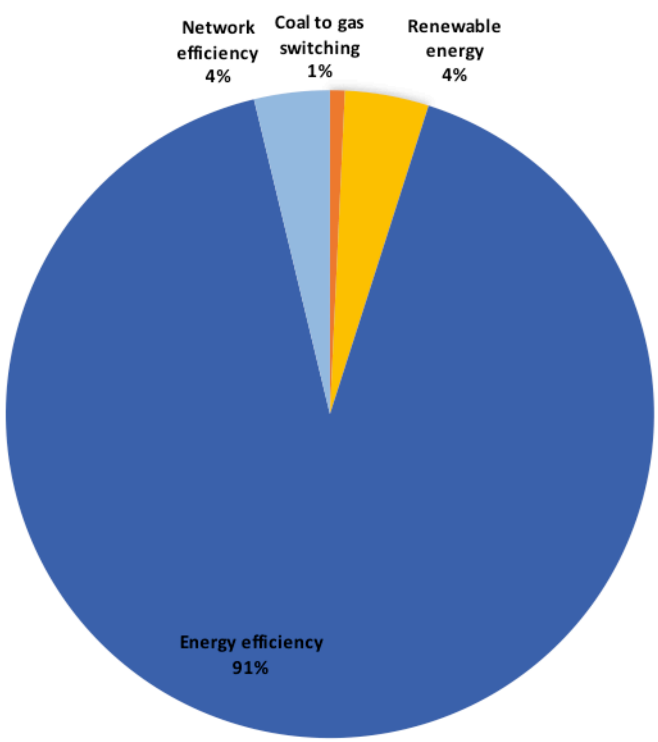


Figure 8. Scenario B: Percent of Mitigation Achieved by Measure for Least-Cost 2030 CPP Compliance



Conclusion

When developing a least-cost compliance plan for meeting the Clean Power Plan, Virginia can take advantage of a wide array of commercially available, innovative new technologies, including renewable energy, energy efficiency, combined heat and power, and heat rate improvements at existing coal generation facilities. Based on the scenarios examined in this paper, it is clear that carbon mitigation need not impose significant costs to ratepayers. In fact, under some scenarios, there is likely to be a decline in rates compared to business-as-usual.

“The Clean Power Plan is recognition of the need for action and creates a pathway for clean energy initiatives that will grow jobs and help diversify Virginia’s economy,” said Governor Terry McAuliffe, upon the finalization of the Clean Power Plan.[4] By using STEER as a resource to examine the different policy and market scenarios the state may face in the next 15 years, Virginia can balance these considerations to develop a cost-effective plan that meets Clean Power Plan requirements and satisfies the state’s energy needs and economic ambitions at the same time.

[4] “McAuliffe: Clean Power Plan in Virginia,” Richmond Times-Dispatch, October 5, 2015. http://www.richmond.com/opinion/their-opinion/guest-columnists/article_0ed2e6bc-a48f-522f-90d0-444d8b7f40b7.html

Staff White Paper on
Guidance Principles for Clean Power Plan Modeling
Docket No. AD16-14-000

I. Executive Summary

On August 3, 2015, the U.S. Environmental Protection Agency (EPA) issued the Clean Power Plan (CPP)[1] under Clean Air Act 111(d). The CPP limits carbon dioxide emissions from existing fossil fuel-fired electric power plants by providing state specific goals for carbon dioxide emissions from affected electric generating units. As part of the CPP, EPA considered the potential impacts of the CPP on electric system reliability. Specifically, the CPP requires each state to demonstrate in its final state plan submittal that it has considered reliability issues in developing its plan.[2] Separately, on August 3, 2015, EPA, the U.S. Department of Energy (DOE) and the Commission agreed to coordinate certain activities to help ensure continued reliable electricity generation and transmission during the implementation of the CPP.[3]

While the CPP assigns no direct role to the Commission, it is possible that the Commission may be called upon, through the EPA-DOE-FERC Coordination Document[4] or for other reasons, to address concerns about reliability as the CPP is implemented. In that case, the use of appropriate modeling tools and techniques will be helpful to the Commission in carrying out its responsibilities for reliability.[5]

This white paper identifies four guiding principles that may assist transmission planning entities, which may include regional transmission organizations (RTOs), independent system operators (ISOs), electric utilities, or

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[1] *See Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*, 80 Fed. Reg. 64,662 (2015) (CPP).

[2] *Id*. at 64,671.

[3] EPA-DOE-FERC Coordination on Implementation of the Clean Power Plan (Aug. 3, 2015), http://www.ferc.gov/media/headlines/2015/CPP-EPA-DOE-FERC.pdf.

[4] *Id*.

[5] The Commission's jurisdiction and its expertise with respect to reliability is limited to the Bulk Power System.

other interested stakeholders, in conducting effective analysis of the CPP and associated state plans, federal plans or multi-state plans (compliance plans). The North American Electric Reliability Corporation (NERC) and the regional electric reliability organizations may also benefit from following these guiding principles as they perform CPP-related analyses. These guiding principles address four areas: (1) transparency and stakeholder engagement; (2) study methodology and interactions between studies; (3) study inputs, sensitivities and probabilistic analysis; and (4) tools and techniques.

Incorporating these guiding principles in the modeling of the CPP compliance plans is one way to promote a robust analysis of the reliability impacts of the CPP**.** The guiding principles discussed herein may form the basis for additional action by staff, such as industry outreach or technical conferences, or future action by the Commission.

II. Background

On August 3, 2015, the EPA issued the Clean Power Plan to limit carbon dioxide emissions from existing fossil fuel-fired electric power plants. In the final rule, EPA provides state specific goals for carbon dioxide emissions from affected electric generating units. Each state is required to meet interim emissions goals from 2022 to 2029 and a final goal starting in 2030.

In formulating the final rule, EPA considered input from many electric industry stakeholders, including comments from the technical conferences hosted by the Commission in early 2015. As a result of these comments, the final rule provides ways to assess the potential impacts of the CPP on electric system reliability. Specifically, the CPP requires each state to demonstrate in its state plan that it has considered reliability issues in developing its plan.[6] EPA states that one particularly effective way that states could make this demonstration is by consulting with the relevant RTO, ISO, or other planning authorities as they develop their plans and documenting this consultation process in their state plans.[7] If a state chooses to consider reliability through consultation with an ISO/RTO or other planning authority, the EPA recommends that the state request that the planning authority review the state plan at least once during the plan development stage and provide its assessment of any reliability implication of the plan.[8]

[6] CPP at 64,671.

[7] *Id*.

[8] *Id*.

In the CPP, EPA notes that, in June 2015, M.J. Bradley & Associates issued a report that enumerated a set of useful guiding principles for studying and evaluating the reliability impacts of the final rule.[9] EPA states that the report enumerated six principles: (1) a study should be transparent about the assumptions and data used; (2) a study should accurately reflect the existing status of the grid in its modeling assumptions; (3) a study should clearly identify the base case and not confuse what will happen as a result of the final rule with what would have happened anyway; (4) where possible, a study should contain sensitivities and probabilities as they are looking into the future which is necessarily uncertain; (5) a study should reflect the flexibility provided to states to allow them to design compliance approaches to maximize reliability; and (6) a study should provide realistic and reliability-focused results. EPA stated that these principles are helpful to keep in mind when reviewing recent studies on CPP implementation.

III. Purpose of Staff White Paper

Effectively evaluating the potential reliability impacts of the CPP associated with the development of compliance plans presents a number of challenges for transmission planning entities. Although the CPP allows states significant flexibility in determining how to meet state goals and this flexibility can be beneficial, it may introduce additional uncertainty and complexity into transmission planning studies. Because all states in the continental United States[10] are required to comply with the CPP, state-by-state variations in compliance approaches may add additional uncertainty and complexity, particularly for transmission planning entities that cover multiple states or states with multiple transmission planning entities. Further, the use of inconsistent models, or inconsistent modeling inputs, may suggest reliability problems where none exist, or may mask problems that do exist. If models and modeling inputs are not transparent, it will be difficult for stakeholders, state commissions, planning authorities or the Commission to identify, understand or address potential problems.

Although effectively evaluating the impacts of the CPP may present challenges, these challenges may be reduced by using appropriate modeling tools and techniques. This white paper identifies four guiding principles that may assist transmission planning entities in conducting effective analysis of the CPP and

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[9] CPP at 1132-1133 (citing M.J. Bradley & Associates, *Guiding Principles for Reliability Assessments Under EPA's Clean Power Plan* (June 3, 2015), http://www.mjbradley.com/node/295 (Bradley Report)).

[10] We note, however, that the EPA has determined that Vermont is not required to submit a compliance plan.

associated compliance plans. This analysis could occur as part of established transmission planning processes or as part of a different process, such as the reliability review required as part of state plans. These guiding principles address four areas: (1) transparency and stakeholder engagement; (2) study methodology and interactions between studies; (3) study inputs, sensitivities and probabilistic analysis; and (4) tools and techniques. Implementation of these principles is one way to help transmission planning entities conduct robust analysis of the impacts of the CPP and associated compliance plans. The principles discussed below may form the basis for additional action by staff, such as industry outreach or technical conferences, or future action by the Commission.

IV. Types of Studies

There are a number of different types of studies that could be useful to effectively assess the impacts of the CPP and associated compliance plans. Long-term transmission planning processes already involve a number of discrete studies that examine a variety of technical and economic factors, which could also be applied to analysis under the CPP. These studies can include, but are not limited to: resource adequacy, production cost, integrated gas-electric systems simulations, powerflow and transient stability analysis, and frequency response**.**

Resource adequacy planning generally examines the electric system's ability to provide adequate supply of generation to meet demand and maintain reserves to support generation outages. Resource adequacy planning studies can be used to develop short-term and long-term resource expansion plans. These studies allow entities to evaluate options for maintaining reliability while accommodating changes in resources and load and complying with state and federal policy directives.

A production cost study is a unit commitment and economic dispatch study that takes into account the uncertainties of the availability of generation plants, transmission facilities, fuel costs, and load forecasts while honoring operating reserve, transmission, and generation system requirements and constraints. The production cost study is central to the economic and reliability evaluation of generation and transmission projects by evaluating differences in production costs, potential transmission bottlenecks, and unserved load.

Integrated gas-electric systems simulations use new software models that allow transmission planning entities to identify constraints on the natural gas system, which could impact the electric transmission system by allowing simultaneous simulations of flows on both the electric transmission and natural gas pipeline systems. This type of study allows transmission planning entities to analyze the impact of varying demands of the natural gas electric generation on the natural gas pipeline system. Efforts are also underway to include gas system contingencies as an input to the software models.[11]

Powerflow and transient stability simulations are used to assess whether the future system can reliably serve expected load and withstand credible contingencies as required by the North American Electric Reliability Corporation (NERC) reliability standards, particularly the TPL (transmission planning) standards.

Powerflow and transient stability simulation tools are also used for frequency response analysis studies, which are needed to assess whether the electric system will remain stable following contingencies.

To provide appropriate context for the application of the transmission planning study principles proposed below, Appendix A provides further information on each study type that is used in the transmission planning process.

V. Study Elements

Transmission planning processes require important decisions about different elements of the planning process. These can include software, study methodology, data sources, base case development, assumptions, presentation of results, and recommendations based on study results. Transmission planning entities use a variety of internal and external resources to develop their studies.

Most of the generation, transmission and load data used as input into planning software is provided by industry data collection processes (such as the data collection and base case process in the Western Electricity Coordinating Council (WECC), the WECC Transmission Expansion Planning Policy Committee and Planning Committee, and the Eastern Interconnection Reliability Assessment Group) to build interconnection-wide base cases for powerflow and stability programs. The transmission planning regions modify this data to study the particular details of the region(s) of interest. Transmission planning entities also subscribe to services that research publically available data to build base cases for other applications. Specific assumptions that are of interest to particular stakeholders are submitted and addressed through stakeholder processes or through participation in the committees that are in the study processes of each transmission planning region. The stakeholders include the participating

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[11] *See e.g.,* MISO Planning Advisory Committee, *An Intro to Gas-Electric Modeling in MISO's Clean Power Plan (CPP) Phase III Study* (April 2015), https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/PAC/2015/20150415/20150415%20PAC%20Item%2003%20CPP%20Phase%20III%20Gas-Electric%20Modeling%20Overview.pdf.

transmission owners/operators, generation owners/operators, generation developers, state regulators and elected officials, consultants and customer groups. Stakeholders also provide input into the study plans so that the studies can formulate scenarios that will provide information on the stakeholders' interests. Each region's transmission planning process and/or methodology lists the timing and requests for input and comments.

VI. Guiding Principles

The following four guiding principles can help transmission planning entities effectively evaluate the impacts of the CPP and associated compliance plans.

1. Transparency and Stakeholder Engagement

Transparency and stakeholder engagement in the development of the models, model inputs and study designs can help identify appropriate policy alternatives and provide important feedback to evaluate assumptions and other inputs. The studies performed as part of the transmission planning process involve a number of subjective decisions. For example, there are many ways to determine the value of uncertain inputs such as fuel costs or capital costs for new resources and many inherently subjective decisions in the planning process. A transparent process that allows stakeholder input on important aspects of the planning process provides the most practical way to assure that reasonable assumptions and inputs into the study processes are considered. In addition, the modeling entity should provide sufficient access to information so that stakeholders can replicate the results of studies. Using a transparent process that engages stakeholders to review and identify study inputs, modeling techniques, base case content, and study results can help promote the use of accurate assumptions, the employment of rigorous study methods, and the reasonable interpretation of results.

The Commission recognized the importance of openness and transparency in transmission planning by adopting the openness and transparency principles in Order No. 890 and Order No. 1000. In Order No. 890, the Commission required that transmission planning meetings must be open to all affected parties including, but not limited to, all transmission and interconnection customers, state commissioners, and other stakeholders.[12] Additionally, Order 890 required

[12] *Preventing Undue Discrimination and Preference in Transmission Service*, Order No. 890, FERC Stats. & Regs. ¶ 31,241, at P 460, *order on reh'g*, Order No. 890-A, FERC Stats. & Regs. ¶ 31,261 (2007), *order on reh'g*, Order No. 890-B, 123 FERC ¶ 61,299 (2008), *order on reh'g*, Order No. 890-C, 126 FERC ¶ 61,228 (2009), *order on clarification*, Order No. 890-D, 129 FERC ¶ 61,126 (2009).

transmission providers to disclose to all customers and other stakeholders the basic criteria, assumptions, and data that underlie their transmission system plans.[13] Transmission providers are required to reduce to writing and make available the basic methodology, criteria, and processes they use to develop their transmission plans.[14] In so doing, stakeholders or an independent third party can replicate the results of transmission planning studies to confirm that transmission planning was not conducted in an unduly discriminatory fashion. The Commission also noted that, since one of the primary objectives of Order No. 890 is to allow customers to consider future resource options, it is necessary for market participants to have access to basic transmission planning information in order to consider those options.[15] The openness and transparency principles were also adopted as part of the regional transmission planning reforms in Order No. 1000.[16]

Similar levels of openness and transparency across all transmission planning processes can help promote studies that consider the broad range of emerging factors such as environmental regulations, gas-electric coordination, and generator performance. In its white paper, M.J. Bradley suggests that organized and focused stakeholder involvement will help incorporate up-to-date assumptions, create consistency across assessments, and ensure that reliability assessments are, to the extent possible, based in objective facts and data.[17] For CPP compliance planning, M.J. Bradley recommends that detailed results and assumptions be discussed as part of the technical review process and be released in concurrence with each final report.[18] Further, M.J. Bradley points to WECC's

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13 Order No. 890, FERC Stats. & Regs. ¶ 31,241 at P 471.

14 Order No. 890, FERC Stats. & Regs. ¶ 31,241 at P 471.

15 Order No. 890, FERC Stats. & Regs. ¶ 31,241 at P 476.

16 *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, Order No. 1000, FERC Stats. & Regs. ¶ 31,323, at P 151 (2011), *order on reh'g*, Order No. 1000-A, 139 FERC ¶ 61,132, *order on reh'g and clarification*, Order No. 1000-B, 141 FERC ¶ 61,044 (2012), *aff'd sub nom. S.C. Pub. Serv. Auth.* v. *FERC*, 762 F.3d 41 (D.C. Cir. 2014). The Commission also required public utility transmission providers, either individually or through their transmission planning region, to maintain a website or e-mail list for the communication of information related to interregional transmission coordination procedures. *Id.* at PP 458, 465-467.

17 Bradley Report at 13.

18 *Id*.

assessment of the proposed CPP as an example of a planning entity that articulated the goals of the analysis, technical assumptions and reasoning, and model methodologies and limitations, and developed base cases based on stakeholder involvement.[19]

Openness and transparency will not only improve modeling practices within the region but also help coordination of modeling efforts across neighboring planning regions. States developing CPP compliance plans may find it useful to incorporate in their models neighboring state's or region's inputs and assumptions regarding the utilization of existing generation and new energy resources. Such transparency will help states and neighboring planning regions assess the impact of another state's compliance plan on the electric system within their state or region. It will also help them to evaluate and prepare for changes in power flows and transmission system needs that may result when implementing CPP compliance plans.

Open and transparent processes that provide sufficient access to information can also recognize that critical energy infrastructure information (CEII) and commercially sensitive data may be subject to certain protections. As an example of this balance, while also recognizing the importance of openness and transparency in Order No. 890, the Commission required transmission providers to develop safeguards in their transmission planning processes to ensure that confidentiality and CEII concerns are adequately addressed.[20]

Ultimately, stakeholder engagement in model development can provide an opportunity for a more thorough review of study decisions and provide input on the various policy alternatives available under the CPP and associated compliance plans. As noted in the WECC study, the transmission planning entity benefitted from the input of its stakeholders at each phase of its transmission planning process to develop base cases and verify assumptions and data.[21] A broad range of stakeholder input at each step in the process can help transmission planning entities improve the quality of the technical work, identify the various compliance options, and reasonably evaluate the reliability implications of each approach.

2. <u>Study Methodology and Interactions Between Studies</u>

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[19] *Id.*

[20] Order No. 1000, FERC Stats. & Regs. ¶ 31,323 at P 460.

[21] WECC 2013 Interconnection-Wide Plan, Summary (Sept. 19, 2013), https://www.wecc.biz/Reliability/2013Plan_PlanSummary.pdf.

Incorporating changes to current study methodologies can allow transmission planning entities to more effectively assess the impact of the CPP and associated compliance plans. For example, transmission planning processes could be modified to better consider the interactions between interrelated studies. To fully assess the impacts of the CPP and associated compliance plans, different types of studies may be required to account for the range of compliance options and other influences leading to changes to the transmission system and the generation fleet. Incorporating the results of one study into a subsequent study can result in a more robust analysis. For example, the results of a resource adequacy analysis can be used to define the assumptions for the composition of the generation fleet used in a production cost or natural gas infrastructure study. This iterative process can lead to more robust results than using static assumptions.

Software applications and models can be used to assess the range of influences on reliability, including the impact of market dynamics, and the impact of policy and regulatory requirements, such as how the state plans will affect load growth, fuel availability and prices, the generation mix, and generator operation. Study methodologies can be modified to take advantage of multiple tools to better capture the impacts on different aspects of the electric grid. For example, a resource adequacy tool could be used to predict potential changes to the composition of the generating fleet, while a tool modeling natural gas infrastructure could indicate whether sufficient pipeline capacity exists to supply the modeled generation mix.

Incorporating relevant information from one study into subsequent studies, to the greatest extent practicable, can help the overall study process better reflect the complex interactions between the various decisions. One important benefit of this approach is that key variables are based on the outputs of specific studies rather than being based on static assumptions. In this way, it is possible to assess a variety of future scenarios. This approach can help capture the influence of changing conditions and identifies outcomes that may be unexpected or that differ from past experience. For example, results from a fuel supply study could be used to refine a production cost or resource adequacy study to provide more realistic results.

Other changes to current study methodologies may also help assess the impacts of the CPP and associated compliance plans. For example, if a transmission planning entity covers multiple states, it may need to reflect varying state compliance approaches across its area. To accurately model the impact of the CPP in this instance, additional modeling work and preparation may be needed to refine study tools and databases in some regions. Working with multiple software applications and study tools may also help planners leverage data not previously available in some tools. For example, many production cost models offer geographic data in addition to transmission topology data, which could be used to augment load flow models that focus exclusively on regional and public utility boundaries.

In addition, given the long timeframe for phasing in compliance with certain state and federal policy directives, such as the CPP, study methodologies could consider allowing for an extended assessment period and the ability to adjust key variables for different periods. Moreover, given variation in regional transmission planning processes, some regions may need to extend the timeframe of certain models for longer transmission planning horizons.

Finally, given the potential complexity associated with incorporating the results of studies into subsequent studies, outlining the study process in adequate detail can help stakeholders understand the inputs to each study and how the outputs of each study may be used in subsequent studies. Defining the study methodology can reduce uncertainty both for transmission planning entities and for stakeholders**.**

3. Study Inputs, Sensitivities and Probabilistic Analysis

Using study inputs that account for uncertainty and test for sensitivity can help effectively assess the impact of the CPP and associated compliance plans. Selecting such inputs requires development of base cases that accurately reflect the current and future state of the electric grid under business as usual conditions and, as noted above, can benefit from stakeholder input. After developing base cases and policy scenarios, results can be tested for the influence of forecast uncertainty and sensitivity to particular variables. These tests using probabilistic analysis and sensitivity studies allow uncertainty and potential sources of errors to be quantified.

All studies begin with the development of a base case, which is used for comparison with other scenarios. A well-developed base case allows for the review of the results of all other cases against a single base case for benchmarking final study conclusions. Base case inputs reflect the current and expected future state of the electric grid under business as usual conditions. The composition of the electric grid is constantly changing; therefore, to accurately model expected future conditions, base case inputs should be current and reflect the most up-to-date plans for renewable energy development, the expansion of electric and natural gas infrastructure, new energy efficiency programs, and other environmental regulations. By using current data that incorporates the various developments and trends in the industry, it is possible to develop a robust base case. This type of robust base case allows for an informed analysis of study results and, when compared with scenario results, more accurately captures the influence of policy changes.

Examining various policy scenarios and sensitivities against the base case can provide an effective way to assess the potential impacts of the CPP and associated compliance plans. A scenario models additional changes to the base case based on policy decisions, such as various approaches to comply with state and federal policy directives. Examining multiple scenarios can provide stakeholders with a better understanding of the impacts of various policy choices. Analyzing multiple scenarios can also help optimize investments in transmission and generation resources by highlighting benefits across various possible scenarios.

To address the uncertainty inherent in long-term planning studies, planners can also incorporate multiple sensitivities, when possible. Sensitivity cases examine how uncertain variables, such as fuel prices, load growth, energy efficiency or other factors, affect the results of a policy scenario or base case. Sensitivity cases could also include natural gas pipeline contingencies that may impact electric generation, for instance loss of a pipeline that is the only source of gas to several electric generators. By accounting for the full range of probable outcomes, rather than just “best” or “worst” cases, studies are more likely to identify effective compliance options or potential reliability concerns.

In addition to using sensitivity cases, the use of probabilistic analysis can also help stakeholders evaluate uncertain futures and make decisions under various potential conditions. In forward-looking studies, there is some degree of uncertainty, even in commonly-used forecasts such as for load or fuel prices. Probabilistic analysis defines the degree of uncertainty for a given variable by testing a range of values, which can improve the chance of identifying reliability concerns and their probability of occurring. Similar to sensitivity analysis, probabilistic analysis can help transmission planning entities assess a range of potential outcomes to inform compliance options or potential reliability concerns.

4. Tools and Techniques

Adopting new modeling tools and techniques can help transmission planning entities better assess the impacts of the CPP and associated compliance plans. The electric grid has recently undergone a number of changes, including increased renewable penetration, increased reliance on natural gas-fired generation, and the implementation of new environmental regulations. Other changes are possible given the numerous compliance options under the CPP that could affect the generation mix, load, and operational practices. Adopting new modeling tools and techniques may help transmission planning entities better analyze the complex interactions between these various changes.

In order to adopt new modeling tools and techniques to thoroughly evaluate the complex interactions between various decisions, transmission planning entities may need specialized software tools, modeling data and expertise with specialized studies. For example, with ongoing changes to the fuel mix, including the increasing use of natural gas, leading to increased interdependence of the electric and natural gas industries, more transmission planning entities may need to develop their capabilities to study the interdependency of electric and natural gas infrastructure to create the most comprehensive studies possible. Therefore, transmission planning entities may want to assess their current capabilities and, if necessary, develop new data sources, software tools, and training programs to demonstrate that they are able to share results between related analyses and fully assess emerging and ongoing trends in the power industry.

VI. Conclusion

Although effectively evaluating the impacts of the CPP may present challenges, these challenges can be mitigated by using appropriate modeling tools and techniques. This white paper identifies four guiding principles that may assist transmission planning entities in conducting effective analysis of the CPP and associated compliance plans. First, transparency and stakeholder engagement in model development, model inputs and study designs can help identify policy alternatives and effectively evaluate assumptions, while also improving coordination across transmission planning regions. Second, incorporating changes to current study methodologies can allow transmission planning entities to more effectively assess the impact of the CPP and associated compliance plans. Third, using study inputs that account for uncertainty and test for sensitivity can help effectively assess the impact of the CPP and associated compliance plans. Finally, adopting new modeling tools and techniques may help transmission planning entities better assess the overall impact of the CPP and associated compliance plans.

Appendix A
Description of Study Types

Resource Adequacy

Resource adequacy planning requires complex decisions based on a number of important factors. For example, decisions must account for: (1) capital and operating costs of resources; (2) availability of generation resources; (3) operating characteristics (e.g., base load, peaking, variable, quick start, frequency response capable, or able to ramp regularly); (4) timing of planned generation additions, generation deactivations, and transmission projects and their potential impacts on import or export capability; (5) rate of load growth; (6) future wholesale energy prices in other parts of the interconnection (e.g., long-term power purchases); and (7) compliance with state and federal policy directives.

Resource adequacy planning studies can be used to predict the optimal economic generation expansion necessary to meet demand and maintain reserves to support generation outages over a given time period. These studies may also consider how to achieve compliance with state and federal policy directives in an economical manner.

In addition, resource adequacy studies can also focus on more granular predictions of loss-of-load probability and planning preserve margins. In some planning processes, resource adequacy is examined by evaluating planning reserve margins. Planning reserve margins are often set so that involuntary load shedding due to inadequate supply occurs only one day in 10 years, also known as the 1-in-10 Resource Adequacy Standard or 0.1 loss of load expectation (LOLE);[22] however, some regions have specialized processes for determining the appropriate planning reserve margin.[23] By establishing an adequate reserve margin, it is implied that there is sufficient capacity to meet the needs of all consumers during peak times at a reasonable cost. While resource adequacy studies do not necessarily determine what specific resources are eventually constructed or retired, they provide valuable information to many stakeholders, including state regulators, load serving entities, generation developers and transmission operators.

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[22] Brattle Group, *Resource Adequacy Requirements: Reliability and Economic Implications* (Sept. 2013), https://www.ferc.gov/legal/staff-reports/2014/02-07-14-consultant-report.pdf.

[23] *See, e.g.*, PJM Manual 20: PJM Resource Adequacy Analysis, at 13 (Aug. 1, 2015), http://www.pjm.com/~/media/documents/manuals/m20.ashx

Because resource adequacy considers a large number of dynamic factors, resource adequacy planning is an ongoing process. Most regional transmission planning entities utilize formal stakeholder processes to shape the inputs and the study plans for a resource adequacy study. In addition, stakeholders review the results of and provide comments on the resource adequacy study.

To evaluate options for maintaining reliability while accommodating changes in resources and load and complying with state and federal policy directives, transmission planning entities may perform resource adequacy or generation expansion studies. These studies generally attempt to optimize new investments in generation resources given expected changes in resources, load, and compliance with policy directives. These studies generally consider a number of economic factors (such as capital costs, operating costs, maintenance costs, and expected price of electricity) to attempt to optimize investments in new resources. For example, as part of its long-term transmission expansion study, the Midcontinent Independent System Operator, Inc. (MISO) runs the Electric Generation Expansion Analysis System (a/k/a EGEAS) to examine the potential long-term generation expansion in the MISO footprint.[24]

Resource adequacy and generation expansion studies are also important because changes in resource availability may impact the need for new gas and electric transmission facilities. The need for new or modified transmission facilities are assessed in different types of transmission studies; however, as discussed further below, the results of resource adequacy decisions may have a significant impact on the need for new gas and electric transmission facilities.

<u>Production Cost</u>

A production cost study is a unit commitment and economic dispatch study that takes into account the uncertainties of the availability of generation plants, transmission facilities, fuel costs, and load forecasts while honoring operating reserve, transmission, and generation system requirements and constraints.[25] A production cost study uses statistical optimizing techniques in order to provide

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[24] *See* MISO MTEP14 Report, Book 1: Transmission Studies, 5.1 Economic Analysis Introduction, at 83 (2014) **Error! Hyperlink reference not valid.**https://www.misoenergy.org/Library/Repository/Study/MTEP/MTEP14/MTEP14%20Full%20Report.pdf.

[25] Doug Murray, *Production Cost Modeling Primer and Selection of Modeling Software* (Jan. 2011), *http://www.ercot.com/content/meetings/lts/keydocs/2011/0110/Production_Cost_Modeling_Presentation_10JAN2011.pdf*.

forecasts of hourly locational marginal prices, emissions, congestion costs, shadow prices, LOLE, and other operating variables. Production cost studies can be done on the present system and future systems incorporating expected future changes to generation, loads and transmission.

The production cost study is central to the economic and reliability evaluation of generation and transmission projects. Comparison cases are usually set up with and without a proposed project to evaluate the differences in production costs of the system or areas of interest and the respective hours of unserved load. In addition, the emission calculations from the simulation show the environmental impacts of a certain change in the electric system. Transmission planning entities can use a production cost study to discover the drivers that can influence the outcome, such as how natural gas fuel costs will change electric production or how much to alter the dispatch of carbon-emitting sources, or other resources, in order to meet proposed emissions goals. Some transmission planning entities use the results of the production cost study to evaluate the natural gas demand and the capability of the gas system.[26]

Some transmission planning regions use the production cost study to calculate hours of unserved load and maintain the 1-in-10 criterion to limit the likelihood of load interruptions caused by resource adequacy issues.[27] Generation resources, such as wind and other intermittent resources, are evaluated region by region to assess their impact on ramping and hours of unserved load so that a region can establish and plan for an adequate reserve margin.

Transmission planning entities use production cost studies to evaluate the economic benefits of proposed economic transmission projects, such as reduced congestion. Most economic transmission planning processes must have evidence that a project's benefit will exceed its cost by a certain threshold before it is recommended to the respective boards for approval, funding, and construction. For example, CAISO uses production cost analysis to analyze the benefits of potential economic transmission projects.[28]

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[26] *See, e.g.*, ISO New England, 2014 Regional System Plan, at 127 (Nov. 6, 2014), http://www.iso-ne.com/system-planning/system-plans-studies/rsp.

[27] *See, e.g.*, PJM Manual 14B: PJM Region Transmission Planning Process, at 53 (Feb. 26, 2015), https://pjm.com/~/media/documents/manuals/m14b.ashx

[28] *See* CAISO 2014-2015 Transmission Plan, Executive Summary and Chapter 5 (Mar. 27, 2015), http://www.caiso.com/Documents/Board-Approved2014-2015TransmissionPlan.pdf.

Integrated Gas-Electric Systems Simulations

New software models allow transmission planning entities to identify constraints on the natural gas system that could impact the electric transmission system. Specifically, new software models allow simultaneous simulations of flows on both the electric transmission and natural gas pipeline systems. This new modeling capability allows transmission planning entities to analyze the impact of varying demands of the natural gas-based electric generation plants on the natural gas pipeline system. The natural gas system's customer loads, pipelines, system elements, and gas field sources are modeled. An expansion of the natural gas generation fleet will appear as an electric generation resource on the electric transmission system and a customer load on the natural gas system. As electric generation varies, natural gas demands varies, which changes flows and possibly pressures on the natural gas system model. This modeling allows the transmission planning entities to identify constraints on the electric transmission and natural gas systems.

As the generation fleet moves toward natural gas, the increased demand on natural gas pipelines means that transmission planning entities may need to consider constraints on the natural gas system and the resulting impact on electric generation. For example, during periods of high demand on a natural gas pipeline, constraints may reduce the fuel available for electric generators. Combined simulations of both the natural gas and electric systems potentially reveals the interaction between the electric and natural gas systems and permit solutions to be developed, planned, and implemented.

Staff's review of the various transmission planning studies indicates that limited natural gas pipeline analyses are being performed. For example, MISO has implemented some limited studies of natural gas pipeline constraints.[29] Gas system contingencies are also under development as part of MISO's CPP analysis.[30] In addition, some transmission planning entities in the eastern

[29] Gregory L. Peters, *Phase III Generation Infrastructure Analysis*, (Nov. 2013), https://www.misoenergy.org/Library/Repository/Communication%20Material/Key%20Presentations%20and%20Whitepapers/PhaseIIIGasElectricInfrastructureReportSummary.pdf.

[30] MISO Planning Advisory Committee, *An Intro to Gas-Electric Modeling in MISO's Clean Power Plan (CPP) Phase III Study* (April 2015), https://www.misoenergy.org/Library/Repository/Meeting%20Material/Stakeholder/PAC/2015/20150415/20150415%20PAC%20Item%2003%20CPP%20Phase%20III%20Gas-Electric%20Modeling%20Overview.pdf.

interconnection have collaborated with the Eastern Interconnection Planning Collaborative (a/k/a EIPC) to evaluate natural gas pipeline issues.[31] This qualitative analysis is still underway.

Powerflow and Transient Stability Analysis

Powerflow and transient stability simulations are used to assess whether the future system can reliably serve expected load and withstand credible contingencies as required by the NERC reliability standards, particularly the TPL standards. Under this analysis, the future system is modeled to perform with all elements in service and following various outages of elements of the transmission system. Powerflow and transient stability analysis can identify the potential shortcomings of transmission system so that transmission planning entities can identify and quantify transmission or generation solutions to meet NERC reliability standards.

Most transmission planning studies perform powerflow and transient stability analysis to assess whether there are system operating limits based on transient stability. More complicated powerflow and transient stability limits may involve more than two simultaneous variables or loadings on multiple transmission paths because the transmission system can be stressed from flows on multiple paths.

The current transmission planning studies show that there is significant stakeholder input on building the base cases and the development of the study methodology and/or plan used to evaluate if the transmission system will meet or exceed reliability requirements. Most transmission planning studies concentrate on worst case conditions during electric peak load periods in summer or winter. Transmission projects are identified in future scenarios to meet the NERC reliability standards. Short-term transmission projects are approved by various bodies, funded, and set for construction to meet deadlines to ensure the future transmission system will meet the NERC reliability standards.

Frequency Response

Frequency response and stability analysis studies are needed to assess whether the electric system will remain stable following contingencies. Following

[31] Eastern Interconnection Planning Collaborative, Phase 2 Report: Interregional Transmission Development and Analysis for Three Stakeholder Selected Scenarios and Gas-Electric System Interface Study (July 2, 2015), http://www.eipconline.com/uploads/Phase_2_Report_Volume_07__Section_9__Final_7-2-15.pdf.

the contingencies, the response of the system depends on certain electric system condition such as heavy and/or light load or heavy transfer periods. Frequency response studies assess the electric system's ability to arrest the changes in frequency for generation or load loss events. Without adequate frequency response and transient stability, the electric system may experience cascading outages due to loss of generation. Inadequate frequency response can also cause the system frequency to deviate to levels that will activate under-frequency load shed relays or over-frequency protection on generation units, which could result in an interconnection-wide blackout. Frequency response studies evaluate the interconnections performance at various load levels, especially at the minimum net load conditions, with the minimum required frequency response.

Frequency response studies are relatively new and not commonly performed in the long-term transmission planning processes. One of the challenges in this area is building a valid case to perform the assessment. Regional transmission planning processes usually focus on a specific region. However, in order to adequately perform frequency response studies, the studies should be performed on an interconnection-wide basis.