WHITE PAPER

Clean Power Plan Transmission Investments: It's Not How Much, It's How Soon

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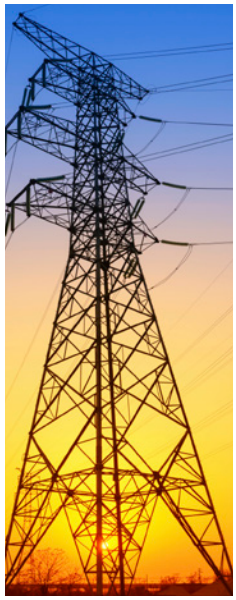


The Bottom Line

1. The Clean Power Plan (CPP) is likely to drive significant retirements and changes in generating resource mix and dispatch patterns that will alter transmission flows and could impact overall system reliability.
2. Focusing only on transmission security, we estimate that the United States will require at least $1.5 to $2.5 billion in transmission grid investments to maintain grid reliability. This amount is well within historical levels, but the timeline for planning and constructing new infrastructure is a relatively greater challenge.
3. Transmission infrastructure will be important for CPP's successful implementation and presents an investment opportunity. To identify and ensure timely development of the appropriate portfolio of solutions, stakeholders must start their analysis and planning as soon as the rule is final.

Executive Summary

Although regulators and industry stakeholders have begun to analyze how the CPP could affect the reliability of the power grid, relatively less focus has occurred on the specific issue of transmission security, a subset of overall system reliability that refers to the ability of the power system to withstand sudden, unexpected contingencies. Transmission security is worth paying attention to: The CPP is likely to augment some trends that are already occurring in the marketplace, specifically the recent wave of coal unit retirements and penetration of renewables and distributed generation. These changes could cause new transmission flow patterns that, if not addressed appropriately, will result in line overloads and wide variations in substation voltages. The reliability of the bulk electric system could be compromised.

ICF has modeled these effects and developed for the first time an estimate of the national impact of the CPP from a transmission security perspective. We estimate conservatively that the changes caused by the proposed Clean Power Plan will drive a need for at least $1.5 to $2.5 billion in added investments to address transmission security issues, much of it by 2020. This level of investment is less than 3 percent of the national five-year capital expenditure on transmission and is therefore easily manageable in pure dollar terms. However, the timeline to build the needed infrastructure will pose a relatively greater challenge, one that will be met if and only if stakeholders are proactive in finding where specific needs will occur and act quickly to develop the appropriate solutions. In fact, in the competitive transmission environment, those who are proactive could garner a first-mover advantage and realize an added opportunity above and beyond the level of investment in transmission that will occur at baseline during the next 5 to 10 years, regardless of the final form of the Clean Power Plan.

Transmission Security: A Critical, Under-the-Radar Issue

The announcement of the Clean Power Plan has driven a discussion among regulators and industry stakeholders on how to adjust, mitigate risks, and find opportunities. Stakeholders have generally

DEFINITIONS

Resource Adequacy: Having sufficient resources to provide a continuous supply of electricity in spite of scheduled or unscheduled outages

Transmission Security: The ability of the power system to withstand sudden, unexpected contingencies

Transmission Adequacy: Having sufficient transmission capacity to move power across key interfaces and corridors in the system

Contingency: The unplanned loss of a generation or transmission facility

appreciated that the new rules may accelerate trends already seen in the market today, especially the retirement of generation—mostly coal generation—but also the increasing penetration of renewables and distributed energy resources (DER). These trends have led a broad focus on resource adequacy and on what mix of generation will be incentivized to come online under the new rule. Relatively less appreciated, and certainly less discussed so far, is the effect the trends can have on transmission, particularly transmission security.

The overall reliability of the power system rests on overlapping factors: having enough resources to meet customer needs in spite of scheduled and unscheduled outages, and the ability to continue operating reliably following sudden and unexpected contingencies. These factors are referred to as resource adequacy and transmission security, respectively.

In general, if a healthy surplus of power capacity is available in a region and new generating units are in the pipeline, generation unit retirement may have a minimal impact on the reliability of the grid. However, significant retirements and changes in generating resource mix, locations and dispatch can cause changes in transmission flow patterns and in substation voltages. The result is usage of the transmission system different than what was designed. Indeed, the retirement of a single generating facility may be considered critical to the operation of the grid if it increases power flows over certain transmission lines to the point where it causes them to overload or creates variations in substation voltages beyond the reliable operating limits.[1]

We focus here on these types of changes can occur as the Clean Power Plan is implemented. The issue of the impacts of state compliance guidance and utility decisions on the overall electricity system has been examined by several independent system operators (ISOs) and regional transmission organizations (RTOs), including some of the transmission-related challenges that they can foresee.[2] However, no attempt has been made yet to estimate the nationwide scale and timing of transmission-related investments that will be required to ensure continued transmission security. ICF presents this important analysis below.

Clean Power Plan Essential Information

- The Environmental Protection Agency's (EPA's) proposed Clean Power Plan would regulate CO_2 emissions of existing generating units through state-level emission rate standards. EPA estimates that total U.S. power sector emissions will be reduced by 30 percent from 2005 levels by 2030.
- EPA modeled four building blocks of compliance for each state that included system redispatch from coal to natural gas and increased generation from renewables. Each state is ultimately allowed to determine its own plan design and

[1] To ensure reliable operation of the system, substation voltages are generally maintained within a 5 percent bandwidth of the nominal voltage levels. Voltages outside the bandwidth are considered to be violations. The criteria may vary in some systems.

[2] Some of the comments and analyses from ISOs and RTOs on the CPP's effects on system reliability, retirements, and transmission can be found in the following sources: 1) American Electric Power (AEP). 2014. AEP Comment on Docket ID No. EPA-HQ-OAR-2013-0602; 2) Electric Reliability Council of Texas, Inc. 2014. ERCOT Analysis of the impacts of Clean Power Plan; 3) Florida Public Service Commission. 2014. Comment filed by Florida Public Service Commission on Docket ID No. EPA-HQ-OAR-2013-0602; 4) MISO. 2014. Comment filed by MISO to Docket ID No. EPA-HQ-OAR-2013-0602. MISO; 5) New York Independent System Operator, Inc. 2014. Comments of the New York Independent System Operator, Inc. on the carbon pollution emission guidelines for existing stationary sources: electric utility generating units; 6) PJM INTERCONNECTION, LLC. 2014. COMMENTS OF PJM INTERCONNECTION, LLC to Docket No. EPA-HQ-OAR-2013-0602; 7) Southwest Power Pool (SPP). 2014. Comment filed by SPP to Docket ID No. EPA-HQ-OAR-2013-0602.

components. To the extent that states rely on these building blocks to achieve compliance, the recent national trend of coal units choosing to economically retire will continue or accelerate.

- The final rule is expected from EPA this summer. Initial state plans are due to EPA for review in 2016, with final plans due for states acting alone in 2017 and for states in multistate compliance groups in 2018. The glide path for emissions reductions could begin as early as 2020.
- detailed review of the plan and its high-level implications can be found in ICF's white paper "EPA's Clean Power Plan—Challenges Ahead for Sources and States."

Transmission Security Investment: Where, How Much, and Most Importantly, How Soon?

Approach ICF conducted a transmission security analysis in the Midcontinent Independent System Operator, Inc. (MISO) region to develop an estimate of the amount of investment required to meet transmission security needs as the CPP is implemented. We chose MISO[3] as a fair representation of national trends and because it comprises a significant portion of U.S. generation and transmission.

METHODOLOGY

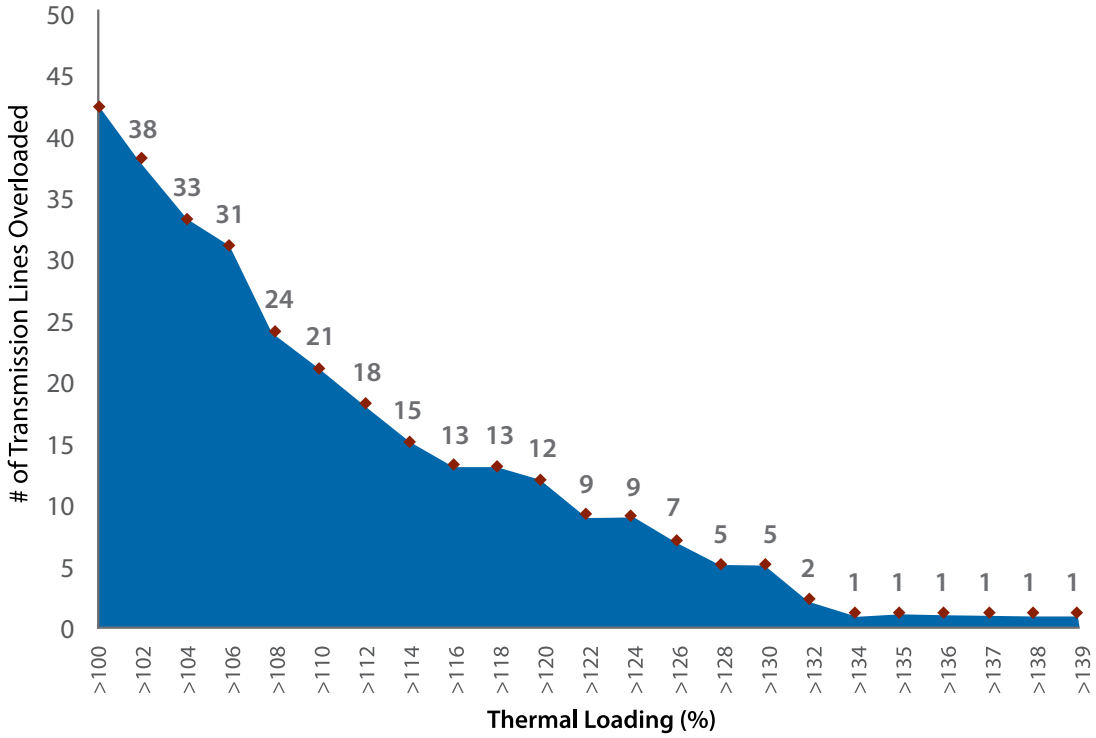
To conduct the analysis, we first used our proprietary IPM® tool to project economic retirements (i.e., mostly coal units) and the new generation builds that will be required to meet resource adequacy needs under the proposed regulation. We began with the same set of assumptions used in EPA's Clean Power Plan Regulatory Impact Analysis and assumed that each state would comply with the proposed interim and 2030 CO_2 emission rate standards without interstate credit trading. Under this scenario, using supply and demand fundamentals, the model optimized capacity expansion and retirements system wide. We arrived at projected retirements and new builds that were consistent with EPA's analysis. We then used this information to develop a transmission model that represented system conditions under the proposed regulation after implementation of retirements and generation additions. We incorporated available information on approved transmission projects into the analysis.

We analyzed the new power flow patterns and potential stresses on the grid using the GE-PSLF model, a tool widely used by transmission planners. Specifically, we examined the operation of the grid under normal and contingency conditions, noting transmission overloads and excessive voltage variations resulting from the projected changes. We resolved overloads by adding new transmission projects, and we addressed voltage violations by introducing reactive power devices. Violations that could be resolved by already approved transmission projects were excluded. For this assessment, we considered only single element contingencies. In actual fact, transmission planners conducting system planning studies will analyze multiple element contingency conditions. In our experience, this type of analysis could increase the number of contingencies (and the scale of the challenge). Our analysis therefore provides a conservative estimate of the potential transmission opportunity.

[3] For this analysis, ICF used the MISO interconnection queue to help guide the addition of new economic builds into the transmission model. MISO system information summarized at https://www.misoenergy.org/Library/Repository/Communication%20Material/Corporate/At-A-Glance.pdf.

Results Our analysis found that the MISO region would need at least $500 to $750 million in additional transmission investments in order to address transmission security issues from the implementation of the proposed CPP, not including transmission projects that have already been approved. The range and severity of the transmission line overloads we observed are shown in the chart below. In our study, we found 43 transmission lines that are at or above their long-term emergency (LTE) ratings. Of these, 12 are loaded more than 120 percent of their LTE ratings[4], indicating a significant reliability concern. Transmission planners typically consider various types of solutions to address these types of system reliability concerns. We assumed the violations would be resolved by the addition of new transmission lines. We also identified voltage violations that we assumed would be resolved by the addition of reactive power devices.

MISO Incremental Transmission Line Overloads Under Proposed CPP



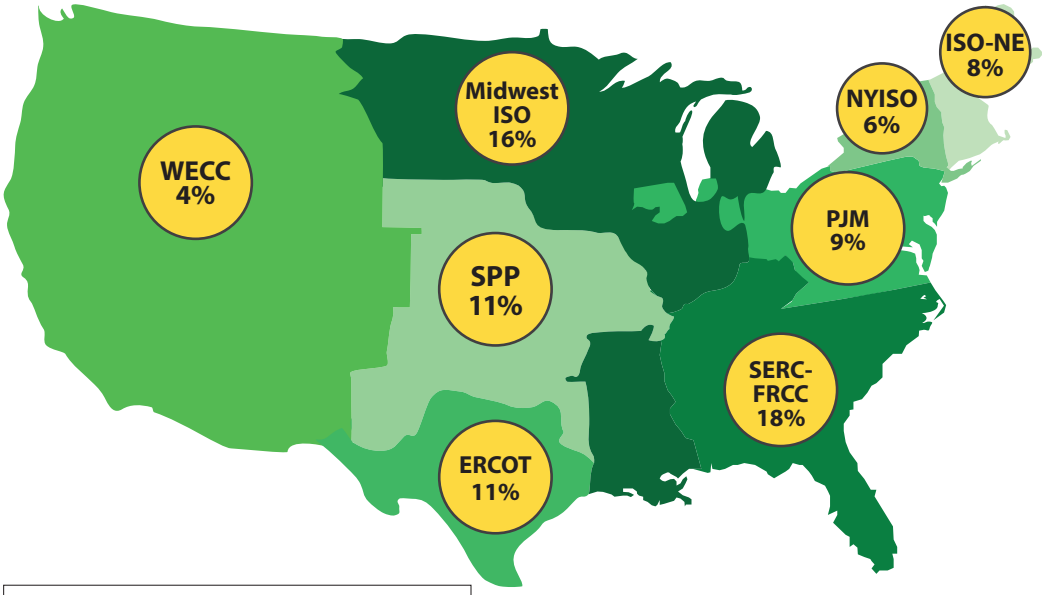
As anticipated, the retirement of large coal plants in key load pockets and the addition of new resources at different locations in the grid changes power flows in the broader region, necessitating additional investments to maintain system reliability. Because anticipated retirements and new builds are front-loaded within the 2020–2030 compliance window, the timeframe for transmission investments would be correspondingly front-loaded. That is to say, not all anticipated transmission security investments would need to be made by 2020. In this scenario, many would have to be in place by that year, and the majority would need to be made in the years immediately following.

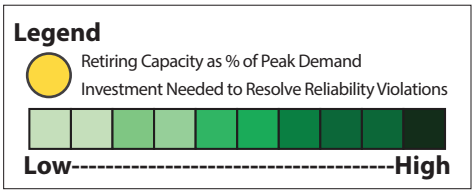
To develop a nationwide estimate of such investment needs, we then extrapolated our MISO findings by assuming that the average impact of a generator retirement on transmission security is similar in other regions.

[4] Under contingency conditions, transmission lines can be operated temporarily at emergency ratings that are usually higher than the normal ratings.

This approach indicates that at least $1.5 to $2.5 billion in new transmission investments will be required nationally beyond business-as-usual levels reflected in current transmission planning. The distribution of investments by region is shown in the map below.

CPP Projected to Drive $1.5 to $2.5 Billion in Transmission Security Investments





Results based on an extrapolation of a detailed transmission analysis of the MISO region. Assumes that the average impact of generator retirements on transmission security is similar in other regions.

LIMITATIONS

As with all estimation and modeling techniques, this approach does have certain limitations. A degree of uncertainty occurs in the final form, requirements, and glide path for implementation associated with the Clean Power Plan. ICF's investment estimate is driven entirely by transmission security needs and not by the full spectrum of investment drivers, including resource adequacy and transmission adequacy. Likely the estimate does not capture all CPP-driven incremental transmission needs. The estimate is conservative because system planners will analyze contingencies that are even more severe than those included in our assessment. Extrapolating the results from MISO to a national level in this fashion is appropriate for developing a reasonable range for an overall estimate. The only way to accurately analyze the needed investment in each particular region would be to run a detailed transmission security analysis for that region. Nonetheless, this approach provides a reasonable estimate of the level of CPP-driven regional transmission security investments that will be needed.

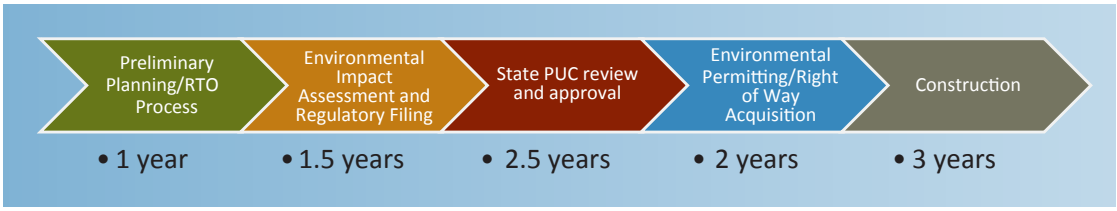
Implications: Timeline Requires Prompt Action

The cost of these incremental transmission security investments is not particularly daunting, especially when placed in a broader context. An incremental $1.5 to $2.5 billion investment stemming from transmission security spread over several years represents a small fraction of the national five-year capital expenditure on transmission—less than 3 percent—and will not be an impediment to CPP implementation.[5]

Rather, the challenge will lie in identifying specific needs and developing the appropriate portfolio of solutions quickly enough to match the relatively rapid timeline of retirements and new builds that will occur as states implement their CPP compliance plans. Under the draft proposal, states must begin to show progress toward compliance in 2020, and continue to show annual progress through 2030. Much of the estimated additional economic coal retirements anticipated to occur under the Clean Power Plan according to EPA's analysis are front-loaded in this timeframe.

At the same time, adding new transmission infrastructure can be a lengthy process. As shown in the exhibit below, major tasks of assessment, study, and planning are required before the time-consuming process of siting and permitting begins. Many projects can be completed in five to seven years after initial planning. The process also can easily stretch to 10 years for high voltage projects. The challenge will lie in moving through the transmission project process in time to match the changes brought about by additional coal retirements and new renewable capacity. Stakeholders should strongly consider conducting detailed regional analyses as soon as this summer upon the announcement of the final rule.

A Transmission Project Can Take Up to 10 Years from Concept to Completion



As related to transmission investment opportunities, our estimate is conservative. We considered only single element contingency conditions. Transmission planners will analyze multiple element contingency conditions which will result in even more opportunities for transmission system investments.

Furthermore, we have focused only on the need to resolve transmission security challenges. We have not included transmission improvements needed to interconnect new generation or to address congestion. Identifying these needs also will provide additional opportunities.

Lastly, we implemented a narrow set of transmission solutions—transmission additions for line overloads and reactive devices for voltage violations. System planners have numerous options available to address transmission problems. For example, some line overloads may be resolved by building new transmission projects or by upgrading existing lines. Others may be addressed more

[5] In MISO since 2003, $7.3 billion in transmission projects have been approved and placed in service. Nationwide, Edison Electric Institute (EEI) estimated that in 2012, total transmission investment among its members was $14.8 billion, rising to $17.5 billion in 2013; its 2014 report highlighted 170 new projects during the next 10 years totaling $60.6 billion in new investment. More information available at https://www.misoenergy.org/Library/Repository/Communication%20Material/Corporate/At-A-Glance.pdf and http://www.eei.org/issuesandpolicy/transmission/Documents/Trans_Project_lowres_bookmarked.pdf.

efficiently using nontransmission solutions, such as demand response. Some voltage violations are resolved using any one of a number of reactive power devices. However, transmission additions and upgrades are sometimes identified as the cost-effective solutions.

Regardless of the final disposition of the Clean Power Plan, major opportunities in transmission will exist in the next 5 to 10 years. Edison Electric Institute estimates that three-fourths of the more than $60 billion in transmission investment coming from its members in the next 10 years is driven by the integration of renewables.[6] More broadly, investment is necessary to bring greater flexibility, potential to incorporate distributed generation, and resiliency as well as the chance to replace aging infrastructure.

The CPP accentuates these background needs and trends, and thereby shifts and re-orders priorities. The plan adds opportunity for those who recognize the imperative to act promptly.

Conclusion

The Clean Power Plan has the potential to fundamentally reshape the U.S. power map. Less clear is exactly how quickly systems and stakeholders will adjust, and who will identify and seize the opportunities that will open up in time to match the changes in available resources. The size and scope of the needed transmission investment is manageable. The timeline to conceive and complete projects is a greater challenge. In short, we find that the grid can remain reliable through the implementation of the Clean Power Plan as currently proposed, but the grid will not do remain so by itself. Proactive planning and investors looking to capitalize on opportunities are essential. The nation cannot simply rely on assertions that the grid will be reliable.

ICF is actively working with clients on identifying future transmission needs in their regions, valuing existing or planned assets, assessing the impact of projected generating unit retirements, and mitigating overall risks in a rapidly changing environment.

Authors

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[6] http://www.eei.org/issuesandpolicy/transmission/Documents/Trans_Project_lowres_bookmarked.pdf

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assessment, and utility restructuring. Ms. Cotrone uses GE-MAPS for detailed modeling and analysis. Prior to working at ICF, Ms. Cotrone attended the University of Michigan and earned a BA in economics and mathematics.

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