Energy & Environmental Policy Analysis

The Impacts of Nuclear Retirements under the Clean Power Plan

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Executive Summary

Nuclear energy is an important source of carbon-free electric power generation. Nuclear plants provide 20 percent of our nation's electric power and 62 percent of all carbon-free electric power. The Environmental Protection Agency's (EPA) Clean Power Plan (CPP) sets emission reduction targets of 30 percent below 2006 levels by 2030 from the electric power sector. Nuclear energy will need to play a critical role within the electricity generation portfolio if these EPA goals are to be met. However, the nuclear industry is facing economic challenges – low natural gas prices, tax credits for renewables, and market design factors – in addition to several regulatory and political pressures that could lead to sizable reductions in the nuclear fleet over the next 10 to 20 years.

FTI applied the PLEXOS electricity model to assess the impact of accelerated nuclear plant closures on electricity prices through 2035 under the CPP. We modeled the Eastern Interconnect under the CPP as the baseline, using the existing fleet and planned nuclear capacity additions. We then modeled a case with the assumption that no additional nuclear permit extensions would be granted. We also included announced nuclear plant closures in this case, along with nine other nuclear reactors that are at risk of closing for economic, regulatory, and political reasons.

Our analysis found that CO_2 emission prices and wholesale electricity prices in the Eastern Interconnect would increase significantly if nuclear plant closures are accelerated. This white paper shows the value of maintaining existing nuclear capacity in order to achieve the goals set by the CPP.

Introduction

This white paper examines the importance of nuclear energy's role under the EPA's Clean Power Plan (CPP). The CPP has set an emission reduction target for the year 2030 that is 30 percent below 2006 levels. In setting these targets, the EPA assumed that nuclear capacity would increase slightly to 98.7 GW in 2030 from 96.8 GW in 2016.[1]

Nuclear power will be an essential component for CPP compliance. It is a carbon-free baseload resource that makes up only 9 percent of total capacity but provides 20 percent of all U.S. electricity generation. In total, nuclear power composes the majority (62 percent) of carbon-free generation, with hydro (19 percent), wind (15 percent) and other renewables (4 percent) representing the rest.[2]

While nuclear power is a carbon-free, baseload resource with low short-run marginal costs, many nuclear plants are under significant economic, regulatory, and political pressure to close much earlier than previously anticipated. These closures would remove carbon-free generation from the overall energy pool, thus making compliance with the CPP even more challenging without driving up electricity prices.

Challenges facing the Nuclear Industry

The nuclear industry is facing challenges due to economic, regulatory, and political pressures. The economic pressures include low natural gas prices, renewable energy tax credits, and capacity market design. Regulatory and political pressures include safety concerns, which particularly escalated after the 2011 Fukushima incident, environmental issues, such as water usage and nuclear waste management, and activist opposition to nuclear power. Together, these pressures could lead to significant reductions in the size of the nuclear fleet in the near future.

Companies are already reacting to these pressures by announcing closures of nuclear plants, in many cases well before their licenses are set to expire. These announced retirements amount to 8.3 GW or 8 percent of total current nuclear capacity:

- Exelon recently announced plans to close its Clinton and Quad Cities nuclear plants in 2017 and 2018, respectively, for economic reasons.[3] Together, these plants represent 2.9 GW of capacity.
- Exelon and Entergy had planned to retire the Ginna and James A. FitzPatrick plants (1.4 GW of combined capacity), respectively, in 2017.[4] However, these plants recently received a New York state subsidy to stay on-line.[5]
- Entergy has announced that it will close the Pilgrim plant in Massachusetts in 2019, which has a capacity of 0.7 GW.[6]
- Exelon reached an agreement with the state of New Jersey to cease operations at the 0.6 GW Oyster Creek by 2019.[7]

[1] Source: EPA Clean Power Plan

[2] Source: U.S. Energy Information Administration (EIA)
[3] http://www.exeloncorp.com/newsroom/clinton-and-quad-cities-retirement
[4] http://www.bna.com/government-attempts-save-n57982073682/
[5] http://www.nytimes.com/2016/08/02/nyregion/new-york-state-aiding-nuclear-plants-with-millions-in-subsidies.html
[6] https://www.boston.com/news/business/2016/04/14/plymouth-power-station-shutdown

- In June 2016, PG&E withdrew its 20-year license renewal application for its 2.2 GW Diablo Canyon reactors in San Luis Obispo County, California.[8]
- The Omaha Public Power District voted to close the 0.5 GW Fort Calhoun plant by the end of 2016 due to economic considerations.[9]

Some industry experts claim that these announcements may be posturing by the plant owners to receive provisions from regulators or legislatures to offset economic pressures. Regardless, the threats of closure are real, as evidenced by several recent occurrences. Entergy closed the 0.6 GW Vermont Yankee plant at the end of 2014 for economic reasons.[10] Three additional plants closed for various reasons in 2013, with a combined capacity of 3.7 GW – the San Onofre plant in California (2.2 GW), the Crystal River plant in Florida (0.9 GW), and the Kewaunee plant (0.6 GW) in Wisconsin.

To make matters worse, in its final ruling of the CPP, the EPA chose not to categorize existing nuclear plants under its "best system of emission reduction," thereby excluding these existing units from being counted towards clean energy mandates. While new reactors are credited for their carbon-free contribution, there are only five reactors that are newly completed or currently under construction that will fall under this classification compared to the 99 existing reactors.

Given the deteriorating conditions for the nuclear industry, forecasters can no longer assume that most of the existing nuclear fleet will be available to provide carbon-free emissions during the CPP compliance period. The following section outlines a modeling approach to better understand the CPP compliance cost impact under an accelerated nuclear retirement case.

CPP Compliance Cost Modeling Approach

FTI used the PLEXOS electricity model to examine the electricity and emissions price impact under a case where nuclear plants retire at an accelerated rate due to economic, regulatory, and political pressures. PLEXOS is a capacity expansion and chronological load model that optimizes generation dispatch, unit commitment, and power flow under a range of future fuel price, load growth, regulatory, and technology advancement scenarios.

For the scope of this white paper, only the Eastern Interconnect (EI) was modeled since it is contains 88 percent of the nation's nuclear generating capacity. We modeled two cases to understand the price impacts of nuclear plant closures under the CPP.

The Baseline Case follows a similar nuclear capacity outlook as the EPA's CPP modeling. The case assumes the 2016 nuclear fleet, along with reactors under construction, would remain in place through 2035 and that planned nuclear capacity uprates would occur.

We then modeled the Alternative Case in which we assumed that announced retirements would occur and that no additional nuclear license extensions would be pursued due to economic, regulatory, and political pressures. The Alternative Case also includes retirements of nine other nuclear reactors that are considered at risk of closing for economic and political reasons.

The assumptions for each case are summarized below:

Baseline Case

- *Nuclear Capacity:*
  - Existing capacity is maintained through 2035
  - Retirements and closures that have been announced do not occur as economic conditions may change or state incentives may keep them operating, similar to what has recently occurred for the Ginna and FitzPatrick plants
  - New units currently under construction are built as planned in 2019 and 2020
  - Older plants will remain open beyond 60 years or will be replaced by new units
- *CPP Modeling:*
  - Mass-based targets by individual state
  - No trading of emission permits between or among states
  - No banking of emission permits
  - Used new source complement for state targets (assumed new natural gas combined cycle units are covered)

Alternative Case

- *Nuclear Capacity:*
  - Nuclear units retire whenever existing license expires
  - Retirements that have been announced occur as planned
  - Nine other nuclear reactors that are considered at risk for economic and political reasons are closed by 2022
  - New units currently under construction are built as planned in 2019 and 2020
- *CPP Modeling is the same as the Baseline Case*
- *All other assumptions same as the Baseline Case*

Figure 1: EI Nuclear Capacity – Baseline vs. Alternative

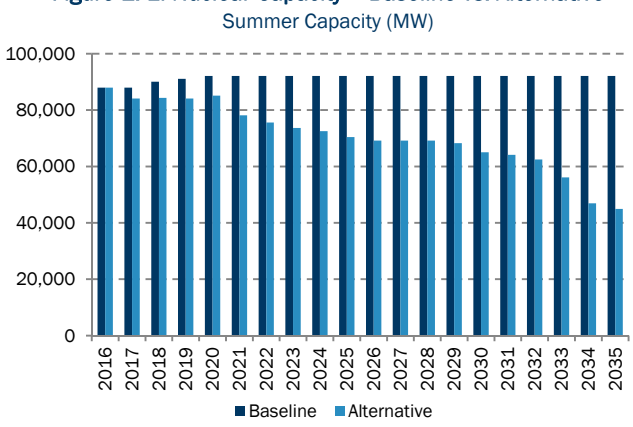


Figure 1 shows the contrast in the EI's nuclear capacity between the Baseline and Alternative Cases. Because there are no plants up for license renewal until 2021, the largest impact of the

[7] http://www.nj.gov/dep/barnegatbay/plan-oystercreek.htm
[8] http://www.latimes.com/business/la-fi-diablo-canyon-nuclear-20160621-snap-story.html
[9] http://www.omaha.com/money/simply-an-economic-decision-oppd-to-close-fort-calhoun-nuclear/article_3fe6ce02-3352-11e6-a426-a7596287dd59.html
[10] http://www.nytimes.com/2015/01/05/us/vermont-yankee-nuclear-plant-begins-slow-process-of-closing.html?_r=0

Alternative Case is pushed out into later years. Twenty-four percent of nuclear capacity is retired in the Alternative Case by 2025. By 2035, only 51 percent of current capacity remains.

The modeling is focused on the sensitivities of different nuclear capacity assumptions. Basic inputs to the model are from third-party sources. For example, fuel price forecasts are from the Energy Information Administration's 2016 Annual Energy Outlook and regional load forecasts are from the Federal Energy Regulatory Commission.

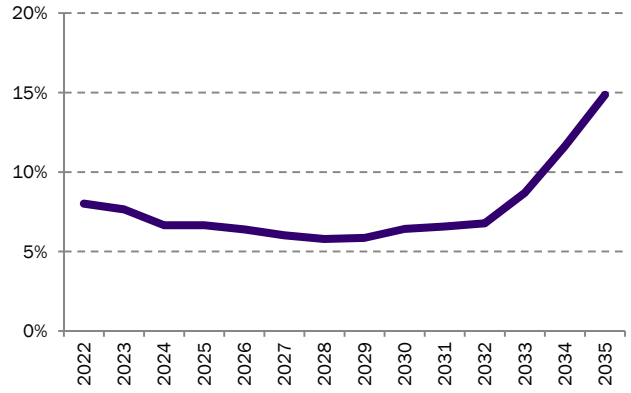
Early Nuclear Retirement Model Results

The nuclear retirements in the Alternative Case increase CPP CO_2 prices in the Eastern Interconnect by an average of 26 percent between 2022 and 2035. As nuclear's carbon-free generation is lost, it is replaced primarily with natural gas, which increases emission levels under the CPP. Renewable capacity cannot be built with sufficient scale or cost effectiveness to replace the nuclear capacity that is retired.

These higher CO_2 prices drive overall electricity prices higher in the Eastern Interconnect as shown in Figure 2 below. Wholesale electricity prices in the Alternative Case are 6 to 8 percent higher than the Baseline Case from 2022 to 2032. By 2035 prices are nearly 15 percent higher compared to the Baseline Case. The increase in prices in the later years of the Alternative Case is due to an acceleration of nuclear retirements after 2031. From 2016 through 2031, 28 GW of nuclear capacity is retired in the Alternative Case. In the final four years (2032 through 2035), an additional 18 GW of nuclear capacity retires.

Figure 2: EI Wholesale Electricity Price Increase – Alternative vs. Baseline[11]

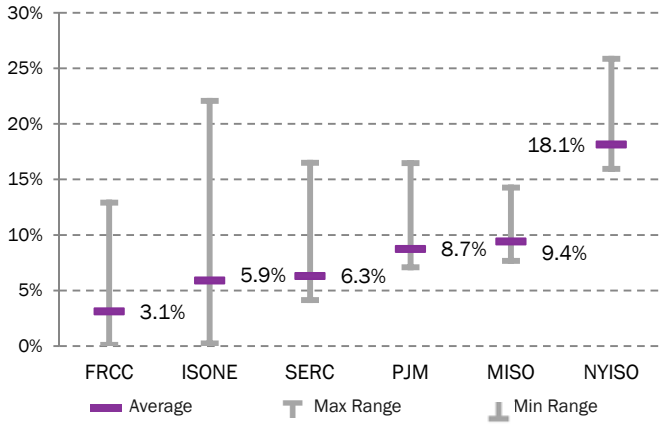
(Percent Difference)



Price increases are more dramatic within individual regional markets as shown in Figure 3. Electricity prices in New York ISO (NYISO) remain higher throughout the period as Indian Point, Ginna, and James A FitzPatrick plants are assumed to retire before 2018 in the Alternative Case. On average, NYISO experiences an 18 percent increase in wholesale prices, on average, between 2022 and 2035 under the Alternative Case. FRCC electricity prices in Florida experience a relatively small impact as there is only one nuclear plant, Turkey Point, in the region that is retired before 2035. The average price impact in other regions is between 6 and 9 percent.

Figure 3: Wholesale Electricity Price Increases for Select Regions – Baseline vs. Alternative (2022-2035)

(Percent Difference)



Our results show that losing the carbon-free energy generated by nuclear plants increases the compliance costs under the CPP, which are reflected in the wholesale electricity prices. These higher prices would be passed along to consumers.

Compared to EPA's CPP modeling, which assumes a much greater availability of nuclear capacity, the Alternative Case's prices are 23 percent and 16 percent higher in 2025 and 2030, respectively, for the Eastern Interconnect.[12] The EPA's assumptions considerably understate the CPP's potential price impacts.

Conclusions

The EPA has assumed that carbon-free electricity generation provided by nuclear plants across the U.S. will continue to be available throughout the compliance period of the CPP. However, the EPA has failed to recognize that the nuclear industry has been under significant economic, regulatory, and political pressures. The current stream of announcements of closures and retirements since the final CPP was released, indicates that the EPA was overly optimistic to simply assume that the nuclear industry would continue to be available to produce clean electricity.

Our modeling reflects the current state of the nuclear industry and shows that the CPP could likely produce higher electricity prices in many Eastern regions than expected. Wholesale electricity prices in the Eastern Interconnect are projected to be 6 to 8 percent higher from 2022 to 2032 under our Alternative Case where significant nuclear capacity is lost to retirements due to economic, regulatory, and political pressures. This difference increases to nearly 15 percent by 2035. This is reinforced when comparing the EPA's modelling results to the Alternative Case, which shows a 23 percent and 16 percent price increase in 2025 and 2030, respectively.

Nuclear energy has long been a reliable source of carbon-free energy in the U.S. Without nuclear energy, achieving the EPA's CPP carbon reduction goals will be not only difficult but also much more costly to the economy than many realize.

[11] Load-weighted prices of EI sub-regions

[12] EPA's CPP Mass-Based Results. Later years only reported in five year increments.

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FTI CONSULTING™

Ken Ditzel
(703) 966-1954
ken.ditzel@fticonsulting.com

Rob Fisher
(202) 589-3408
rob.fisher@fticonsulting.com

Charlie Choe
(202) 589-2373
charlie.choe@fticonsulting.com

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