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Are zero emission credits the right rationale for saving economically challenged U.S. nuclear plants?☆

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ABSTRACT

The economic viability of many U.S. nuclear plants has been deteriorating rapidly since 2010. To save in-state, zero-emission baseload generation, several states have passed zero-emission credits to subsidize their economically challenged plants. Our power market dispatch modeling, however, suggests that keeping nuclear plants online does not necessarily mean a reduction in carbon emissions within the region or state, as the amount of regional emissions also depends on grid characteristics and the evolution of the generation fuel mix.

1. Introduction

The economic viability of many U.S. nuclear plants, despite their established records of high capacity factors and relatively stable operating costs, has been deteriorating rapidly since 2010. Low natural gas prices have kept wholesale electricity prices low, especially in competitive electric power markets. The increasing penetration of subsidized renewables with low operating costs has further undermined price signals in certain markets. Owners of U.S. nuclear plants had retired 4.8 gigawatt (GW) of generation capacity prematurely by the end of 2016. More than 10 GW of nuclear capacity is set to be retired through 2024 (most by 2021) prior to the expiration of their operating licenses.[1]

The prospect of rapid premature retirement of these large baseload generation facilities induced actions in several states to save their nuclear generation facilities via out-of-market compensation.[2] To date, New York and Illinois have finalized programs. Other states, including Connecticut, New Jersey, Ohio, and Pennsylvania, are considering similar solutions to save their baseload nuclear plants. However, various stakeholders, including merchant generators, have raised concerns about the distortionary effect of state subsidies on the functioning of wholesale electricity markets. Several parties have filed either petitions with the Federal Energy Regulatory Commission (FERC) asking for the overturn of these subsidies[3] or lawsuits against relevant state public utility commissions and asked federal courts to intervene.[4]

2. Zero emission credits

In August 2016, New York passed its Clean Energy Standard, which provides zero emission credits (ZECs) to eligible nuclear plants with an initial value of $17.48 per megawatt-hour (MWh), including three upstate nuclear plants FitzPatrick (retirement announced in late 2015), Ginna, and Nine Mile Point. Load-serving entities (LSEs) in New York are obligated to purchase ZECs based on the portion of the electric energy load served by the LSE in relation to the total electric energy load served by all such LSEs. LSEs will recover costs of purchasing ZECs through customer bills. The ZEC price will be adjusted every two years based on market conditions and the social cost of carbon.

In December 2016, the Illinois General Assembly passed the Future Energy Jobs Bill (SB 2814), which also provide ZECs (about $10 per MWh) to two nuclear plants (Clinton and Quad Cities). Exelon, the owner of these two plants, originally announced in May 2016 its plan to retire these two facilities by June 2018. Similar to the program in New

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[1] See Center for Energy Economics research snapshot "U.S. Nuclear Power Reactors: At a Crossroads" for a list of plants (http://www.beg.utexas.edu/energyecon/thinkcorner/CEE_Snapshot-Nuclear_Retirements-Jan17.pdf).

[2] We categorize all payments made to generators in addition to revenues from energy markets as "out-of-market." See CEE research note "Competitive Electricity Markets: What Future?" for a more detailed discussion (http://www.beg.utexas.edu/energyecon/thinkcorner/CEE_Research_Note-What_Future_for_Electricity_Markets-Mar17.pdf).

[3] See FERC Docket No. EL13-62-002.

[4] The lawsuit against New York subsidy is currently under U.S. District Court for the Southern District of New York, Case No. 1:16-CV-8164-VEC; the lawsuit against Illinois subsidy is currently under U.S. District Court for the Northern District of Illinois eastern Division, Case No. 17-cv-1163.

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York, electric utilities in Illinois are required to purchase ZECs from qualified zero-emission nuclear plants and recover the costs through consumer bills, effective June 1, 2017.

Although these programs emphasize the zero-carbon attribute of nuclear generation, the health of the local economies was also of concern to political leaders, as the name of the Illinois bill suggests. In any case, the carbon-reduction benefits of keeping nuclear plants online should be tested. Whether retiring a nuclear plant will lead to increased carbon emissions depends on several interactive factors, including but not limited to, the location of the retiring nuclear plants relative to zonal load growth, grid topology, and the rest of the generation fuel mix. Continued advances in other zero-carbon generation technologies and their expected penetration into the generation portfolio are important factors. In some regions, changes on the demand side of the market such as demand response, energy efficiency, and self-generation (e.g., rooftop solar) have also started to have a noticeable impact on both load growth and shape. Accordingly, we utilize a dispatch economics approach to investigate the interactive impact of these elements for New York and Illinois.

2.1. Illinois

The Quad Cities nuclear plant located in northern Illinois is operated by Exelon in the Commonwealth Edison load zone (ComEd zone) as part of the PJM wholesale market.[5,6] Exelon originally announced its plan to retire Quad Cities by June 2018, 14 years before the expiration of its 60-year operating license. The enactment of the Future Energy Jobs Bill saved the plant, and Exelon was reported to add 400 jobs for multiple capital projects.

To investigate the long-term impact of keeping Quad Cities online on zonal fossil generation and carbon emissions through 2025, we developed four sets of scenarios depending on renewable capacity buildout and long-term natural gas price outlook (Table 1). We assumed 3.2 GW and 6.5 GW of installed wind capacity in ComEd zone by 2025 in the Current Trends and Aggressive Renewables scenarios, respectively.[7] We also assumed two sets of monthly Henry Hub prices as shown in Fig. 1.[8] The price of natural gas delivered to generators at ComEd and other zones are adjusted by basis differentials.

In Fig. 2, we report the generation output from existing fossil plants in ComEd zone by modeling long-term resource expansion and generation dispatch from 2016 to 2025.[9] Our modeling exercises show that a more aggressive installation of wind capacity would effectively reduce fossil-fueled generation by around 10% (Scenario 2/4 versus Scenario 1/3). However, the continuing operation of Quad Cities has a much smaller impact (1% to 3%) on fossil-fueled generation across four scenarios. More strikingly, with Quad Cities continuing to operate, fossil-fueled generation is even higher in Scenarios 2 and 4.

The pattern of CO_2 emissions closely follows fossil generation outputs (Fig. 3). Keeping Quad Cities online does not lower zonal emissions in any of the four scenarios. In contrast, aggressive deployment of wind generation which helps to reduce CO_2 emissions by 4% to 8%, comparing Scenario 1 with Scenario 2 (or comparing Scenario 3 with Scenario 4). The effect of aggressive wind deployment on reducing CO_2 emissions would be smaller when natural gas price is higher, which helps keep coal generation online. With low natural gas prices, CO_2 emissions decrease by 8% between Scenario 1 and 2. In contrast, with high natural gas prices, CO_2 emissions decrease only by 4% between Scenario 3 and 4.

Table 1
Model Scenarios.

Scenario	NG Price	Renewable Capacity
1	Reference	Current Trends
2	Reference	Aggressive Renewables
3	EIA	Current Trends
4	EIA	Aggressive Renewables

Demand for electricity is around 102,000 GWh annually in the ComEd zone. Exelon nuclear plants in the ComEd zone together could supply almost 90,000 GWh each year, or roughly 90% of the zonal demand. The operation of the PJM market ensures cheap electricity generated by nuclear and coal plants in the ComEd zone to flow to other PJM territories. Indeed, our modeling, when assuming Quad Cities operating, suggests that more electricity flows out of the ComEd zone (Fig. 4) but zonal fossil generation does not decline (Fig. 2).

2.2. New York

Unlike Illinois, where coal is second to nuclear in terms of electricity generation, natural gas has already become the dominant fuel source for power generation in the NYISO market, followed by nuclear and hydro. In a staff white paper filed on Jan. 25, 2016, the State of New York Public Service Commission emphasized the importance of keeping its emission-free nuclear plants to "prevent backsliding from State's efforts to limit greenhouse gas emissions." Hence, it is puzzling that the state treats its zero-carbon nuclear generation plants inconsistently. On the one hand, the FitzPatrick plant, an 852 MW single unit plant located in upstate on the southeast shore of Lake Ontario, is eligible to receive ZECs. On the other hand, Indian Point, a 2060 MW dual-unit plant that supplies 25% of electricity consumed by the New York City metropolitan area, does not qualify for ZECs.

The previous owner of the FitzPatrick plant, Entergy, originally announced in December 2015 its plan to retire it no later than early 2017. Exelon acquired the plant in fall 2016 after the ZEC program was announced. In contrast, a decade of litigation with the state not only prevented Entergy from obtaining operating license renewal for Indian Point but also cost the company $20 million a year, which became a key factor in the decision to retire the plant by 2021. Indian Point, by virtue of its size, has a larger carbon reduction capacity. Perhaps, more significantly, it does not necessarily need out-of-market support to remain in business as wholesale power prices near New York City were on average about $11 higher than wholesale prices in upstate between 2011 and 2015.

We modeled two scenarios: retiring Indian Point in 2021 while keeping FitzPatrick online, and retiring FitzPatrick in 2017 but keeping Indian Point in operation. In the Current Trends case, we hardwired 1.7 GW of installed wind capacity by 2025, and in the Aggressive Renewables case we hardwired 6.1 GW of new wind by 2025 in the NYISO footprint. Retiring Indian Point, which has more than twice the generation capacity of FitzPatrick, increases the state's reliance on natural gas as the dominant fuel for generation and hence increases CO_2 emissions in all scenarios, when comparing with the alternative of letting FitzPatrick close but keeping Indian Point (Fig. 5).

[5] A map of the PJM footprint and load zones can be found at PJM website (http://www.pjm.com/library/~/media/about-pjm/pjm-zones.ashx).

[6] Clinton nuclear plant, which is also owned by Exelon and qualified for Illinois ZECs, is operated within the MISO market. A map of the MISO footprint and load zones can be found at MISO website.

[7] We hardwire wind capacity that is under construction in the Current Trends scenario. In the Aggressive Renewable scenario, we add wind capacity that is under various stages of development. Typically, the model does not build as much wind or solar capacity as currently in the pipeline in the near term based on its economic algorithm despite incorporating federal tax credits and assuming significant overnight capital cost declines.

[8] The reference HH price is based on Hahn et al. (2016), "Market-calibrated Forecasts for Natural Gas Prices," White Paper UTEI/2016-07-1, 2016. The second forecast is the reference case forecast from the Annual Energy Outlook 2016 by the EIA. We added monthly variation to forecasted annual prices based on historical patterns.

[9] We utilize AURORAxmp, a commercial economic dispatch tool, to model long-term (LT) resource expansion in the U.S. power market. The model retires existing resources and builds new resources based on annualized resource value of the asset, following an iterative optimization algorithm.