EMISSIONS IMPLICATIONS OF NUCLEAR RETIREMENTS

C2ES SOLUTIONS FORUM

Doug Vine, Center for Climate and Energy Solutions

Since late 2012, five power companies retired six nuclear reactors in the United States (Table 1). Across the country, an additional seven reactors are scheduled to close by 2025 (Table 2). If this trend continues or accelerates, there could be serious climate implications. Nuclear power supplies 20 percent of total U.S. electricity production, but 57 percent of zero-carbon electricity.[1] As all recent U.S. nuclear retirements have led to increased fossil fuel-fired generation, any additional loss of nuclear generating capacity could be expected to increase carbon dioxide emissions (Figure 1).[2] Preserving the existing U.S. nuclear reactor fleet for as long as possible is a critical element in the transition to a low-carbon future.

TABLE 1: Recent Reactor Retirements

PLANT NAME, LOCATION	SIZE (MW)	OWNER	RETIREMENT DATE
Crystal River, Florida	860	Duke Energy	February 2013*
Kewaunee, Wisconsin	556	Dominion	May 2013
San Onofre, California	2,150 (2 reactors)	Southern California Edison	June 2013*
Vermont Yankee, Vermont	605	Entergy	December 2014
Fort Calhoun, Nebraska	476	Omaha PPD	October 2016

Total size of reactor retirements: 4,800 MW (4.8 GW).

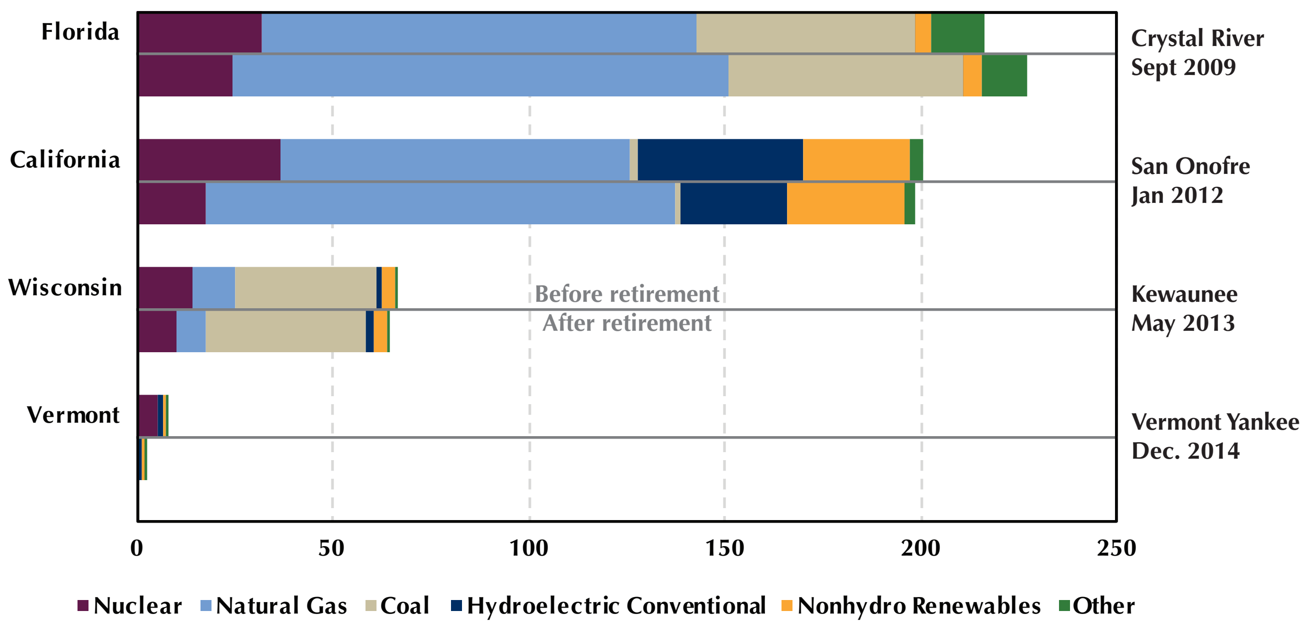
* Date that retirement was announced; units stopped producing power earlier due to maintenance issues.

TABLE 2: Announced Reactor Retirements

PLANT NAME, LOCATION	SIZE (MW)	OWNER	RETIREMENT DATE
Palisades, Michigan	685	Entergy	2018
Oyster Creek, New Jersey	636	Exelon	2019
Pilgrim, Massachusetts	811	Entergy	2019
Indian Point, New York	2,069 (2 reactors)	Entergy	2020, 2021
Diablo Canyon, California	2,240 (2 reactors)	PG&E	2024, 2025

Total size of planned reactor retirements: 6,441 MW (6.4 GW).

FIGURE 1: In-State Electricity Generation in 12-Month Periods Before and After Nuclear Retirements (Billion Kilowatthours)



California in-state electric power sector emissions rose by 10 million metric tons the year after San Onofre retired; as of 2015 they are still 9 million metric tons (21 percent) above the 2011 low. In Wisconsin, coal-fired generation largely replaced the missing electricity from the retired Kewaunee Power Station.

Source: EIA (2016), California Environmental Protection Agency (2017)

EMISSIONS IMPLICATIONS OF RETIREMENTS

Since nuclear power plants are large zero-emission electricity power sources, it is not a simple matter to replace them quickly with non-emitting alternatives (e.g. wind, solar, hydro, energy efficiency). Siting new power plants can be challenging in populated areas, especially when a large amount of land is required, and not all areas are necessarily suitable (e.g., average wind speeds are much lower in many East Coast states, which makes onshore wind less viable than across the central United States).[3] For these reasons, all recent reactor retirements have led to increases in natural gas- and coal-fired electricity generation, which has increased carbon dioxide emissions (Figure 1). For example, Vermont has no in-state fossil-fueled electricity generation, but emissions in New England increased 2.5 percent in 2015 as a result of the Vermont Yankee closure in December 2014.[4]

The magnitude of emissions increases depends on the amount of nuclear capacity that is retired. It also depends on the carbon intensity of the power grid in the region where the nuclear plant is retired, as the replacement generation is most likely to come from a range of sources located within the same balancing authority. The carbon intensity or emissions rate is the average weight (lbs) of all emitted carbon dioxide divided by the electrical output (MWh) from all power plants operating in a defined area.[5] A balancing authority is an electric system operator, who constantly balances all of the electrical generation (supply) with all of the end-use consumption (demand) within a defined area.

Table 3 shows the emissions increase that would likely occur if a hypothetical 2-unit (2,200 MW) nuclear power plant were to retire in three different balancing authorities. The New York Independent System Operator (NY ISO) has a relatively low carbon intensity because it

TABLE 3: Emissions Increase from Hypothetical 2-Unit (2,200 MW) Reactor* Retirement

BALANCING AUTHORITY	CARBON INTENSITY (LBS CO2/MWH)	EMISSION INCREASE (MILLION METRIC TONS CARBON DIOXIDE)
NY ISO	538	4.24
PJM	1,100	8.66
MISO	1,444	11.37

*Reactor is assumed to have a 90 percent capacity factor

Source: EPA eGRID (2017)

derives 42 percent of its power from natural gas, 31 percent from nuclear, 20 percent from hydro, and 3 percent from wind.[6] PJM, which covers all or part of 13 states from Illinois to New Jersey, and MISO, which controls a wide swath of territory from the upper Midwest down to Louisiana have much more coal-fired generation than NY ISO.

Currently, 6.4 GW of nuclear generation is expected to retire by 2025 (Table 2); however, four new reactors (i.e., Vogtle and Summer) with 4.4 GW of capacity are likely to enter service in the same period, which would result in a net loss of 2 GW.

Nuclear power faces many economic challenges, including sustained low natural gas prices, declining renewable energy costs, slower growth in electricity demand, power market structures that do not place a value on zero-carbon baseload power, and the absence of a price on carbon. Additionally, life-extending capital investments, mandated post-Fukushima safety enhancements, and other maintenance activities are adding to plant costs. These challenges could force additional reactors into premature retirement unless remedies are put in place.

In general, the U.S. nuclear reactor fleet is expected to begin retiring en masse in the 2030s as 60-year plant licenses begin to expire.[7] The Nuclear Regulatory Commission (NRC) has only begun to look at the possibility of extending reactor licenses an additional 20 years, allowing the reactors to run for 80 years in total.[8]

CONCLUSION

Nuclear power, the United States' largest source of zero-emission electricity, must play a role in any long-term, low-carbon climate strategy. Since nuclear plants are large sources of zero-emission power, they are challenging to replace quickly. The loss of nuclear plants from the electricity grid would likely lead to millions of tons of additional carbon dioxide in the atmosphere each year, moving efforts to address climate change in the wrong direction.

ENDNOTES

1 "Total Energy: Monthly Energy Review: Electricity: Table 7.2a Total (All Sectors)," U.S. Energy Information Administration, last accessed March 28, 2017, https://www.eia.gov/totalenergy/data/monthly/#electricity.

2 "Today in Energy: Fort Calhoun becomes fifth U.S. nuclear plant to retire in past five years," U.S. Energy Information Administration, October 31, 2016, https://www.eia.gov/todayinenergy/detail.php?id=28572.

3 "Wind Maps," National Renewable Energy Laboratory, last accessed July 20, 2017, http://www.nrel.gov/gis/wind.html.

4 "2015 ISO New England Electric Generator Air Emissions Report," ISO New England, January 2017, https://www.iso-ne.com/static-assets/documents/2017/01/2015_emissions_report.pdf.

5 "Emissions & Generation Resource Integrated Database (eGRID)," U.S. Environmental Protection Agency, February 27, 2017. https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.

6 "Electricity: Detailed State Data," U.S. Energy Information Administration, last modified March 29, 2017, https://www.eia.gov/electricity/data/state/.

7 "U.S. nuclear capacity and generation expected to decline as existing generators retire," U.S. Energy Information Administration, May 12, 2017, https://www.eia.gov/todayinenergy/detail.php?id=31192.

8 "NRC Seeks Public Comment on Draft Guidance for Subsequent Renewal of Nuclear Power Plant Operating Licenses," Nuclear Regulatory Commission, December 17, 2015, https://www.nrc.gov/docs/ML1535/ML15351A175.pdf.