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U.S. Nuclear Plant Shutdowns, State Interventions, and Policy Concerns

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U.S. Nuclear Plant Shutdowns, State Interventions, and Policy Concerns

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The United States has the largest nuclear power plant fleet in the world, with 93 reactors that can generate approximately 95,522 megawatts (MW) of electricity. Nuclear power has accounted for about 20% of annual U.S. electricity generation since the late 1980s; in 2020 it was 19.7%. However, the U.S. nuclear power industry in recent years has been facing economic and financial challenges, particularly plants located in competitive power markets where natural gas and renewable power generators influence wholesale electricity prices.

Twelve U.S. nuclear power reactors have permanently closed since 2012, with the most recent being Indian Point 3 on April 30, 2021. The closed reactors had electric generating capacity of 9,436 MW, nearly 10% of the total capacity of current U.S. reactors. Another three U.S. reactor retirements have been announced through 2025, with total generating capacity of 3,012 MW (equal to roughly 3% of current U.S. nuclear capacity).

However, announced retirements have not always occurred as planned. Most recently, an Illinois law signed September 15, 2021, provided subsidies that halted the planned shutdown of two nuclear plants in the state with a total of four reactors. Including those units, 20 reactors previously announced for permanent closure within the past five years have continued operating pursuant to state interventions that provide them with additional revenue sources or other assistance. State nuclear power subsidies, such as zero emissions credits and power purchases, are typically about $100 million per year for each reactor. The 20 reactors whose shutdowns were averted—in Connecticut, Illinois, New Jersey, New York, Ohio, and Pennsylvania—represent 19,831 MW of electricity generation capacity (21% of total U.S. nuclear capacity). Many other U.S. reactors have been identified by recent studies as being "at risk" of shutdown for economic reasons, although their closures have not been announced.

Economic pressure on nuclear power plants is less immediate in areas of the country where electricity prices are set by state regulators rather than markets, such as in much of the Southeast. Under such "traditional" rate regulation, all power plant expenditures must be approved by state regulators, and electricity customers are charged rates sufficient to recover those costs plus a reasonable investment return. However, many other factors can affect plant-specific costs, revenues, and operating profits.

The recent U.S. nuclear power plant retirements and announced future shutdowns have drawn congressional attention, including proposed legislation, committee hearings and markups, and enacted authorizations and appropriations. In particular, a new federal program to provide financial support to nuclear power plants at risk of closure is included in the Infrastructure Investment and Jobs Act (P.L. 117-58) signed into law November 15, 2021. The law includes an appropriation of $6 billion for the program—$1.2 billion per year from FY2022 through FY2026. A tax credit for existing nuclear power plants was included in budget reconciliation legislation passed by the House on November 19, 2021 (Build Back Better Act, H.R. 5376). Under the tax provision (Section 136109), existing nuclear power plants would receive a production tax credit of up to 1.5 cents per kilowatt-hour (kwh), or $15/MWh, through the end of 2026.

Following are the three currently operating U.S. reactors that have been announced for closure by their owners:

- Palisades, Michigan, scheduled to shut down in May 2022 because of operating losses and the expiration of a power purchase agreement; and
- Diablo Canyon 1 and 2, California, scheduled to shut down in November 2024 and August 2025, respectively, because of a settlement with labor and environmental groups to replace the plant's output with renewable energy and energy efficiency measures.

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Introduction

The United States has the largest nuclear power plant fleet in the world, with 93 reactors that can generate approximately 95,522 megawatts (MW) of electricity.[1] Nuclear power has accounted for about 20% of annual U.S. electricity generation since the late 1980s; in 2020 it was 19.7%.[2] However, the U.S. nuclear power industry in recent years has been facing economic and financial challenges, particularly plants located in competitive power markets where natural gas and renewable power generators influence wholesale electricity prices.

Twelve U.S. nuclear power reactors have permanently closed since February 2013, following a 14-year period without any shutdowns.[3] The most recent reactor retirement was Indian Point 3 on April 30, 2021.[4] The plant's owner, Entergy, cited low electricity prices driven by low-cost natural gas generation and increased operating costs as major reasons.[5]

Another three U.S. reactor retirements have been announced through 2025. However, announced retirements have not always occurred as planned: 20 reactors previously scheduled for permanent closure have continued operating pursuant to state interventions that provide them with additional revenue sources or improved competitive conditions (see **Figure 1**). An Illinois law signed September 15, 2021, provided subsidies that halted the planned shutdown of two nuclear plants in the state with a total of four reactors. Many other U.S. reactors have been identified by recent studies as being "at risk" of shutdown for economic reasons, although their closures have not been announced.[6]

[1] Energy Information Administration, *Monthly Energy Review*, January 2021. Megawatts in this report reflect "net summer" generating capacity, defined as the maximum electrical output that can be supplied to system load, as demonstrated by a multi-hour test, during summer peak demand (June 1 through September 30). EIA capacity total reduced by 1,038 MW to reflect the April 20, 2021, permanent shutdown of Indian Point 3.

[2] Energy Information Administration, "Electricity Data Browser," https://www.eia.gov/electricity/data/browser, and *Monthly Energy Review*, Table 7.2, February 2021, https://www.eia.gov/totalenergy/data/monthly/. Percentage refers to utility-scale generation.

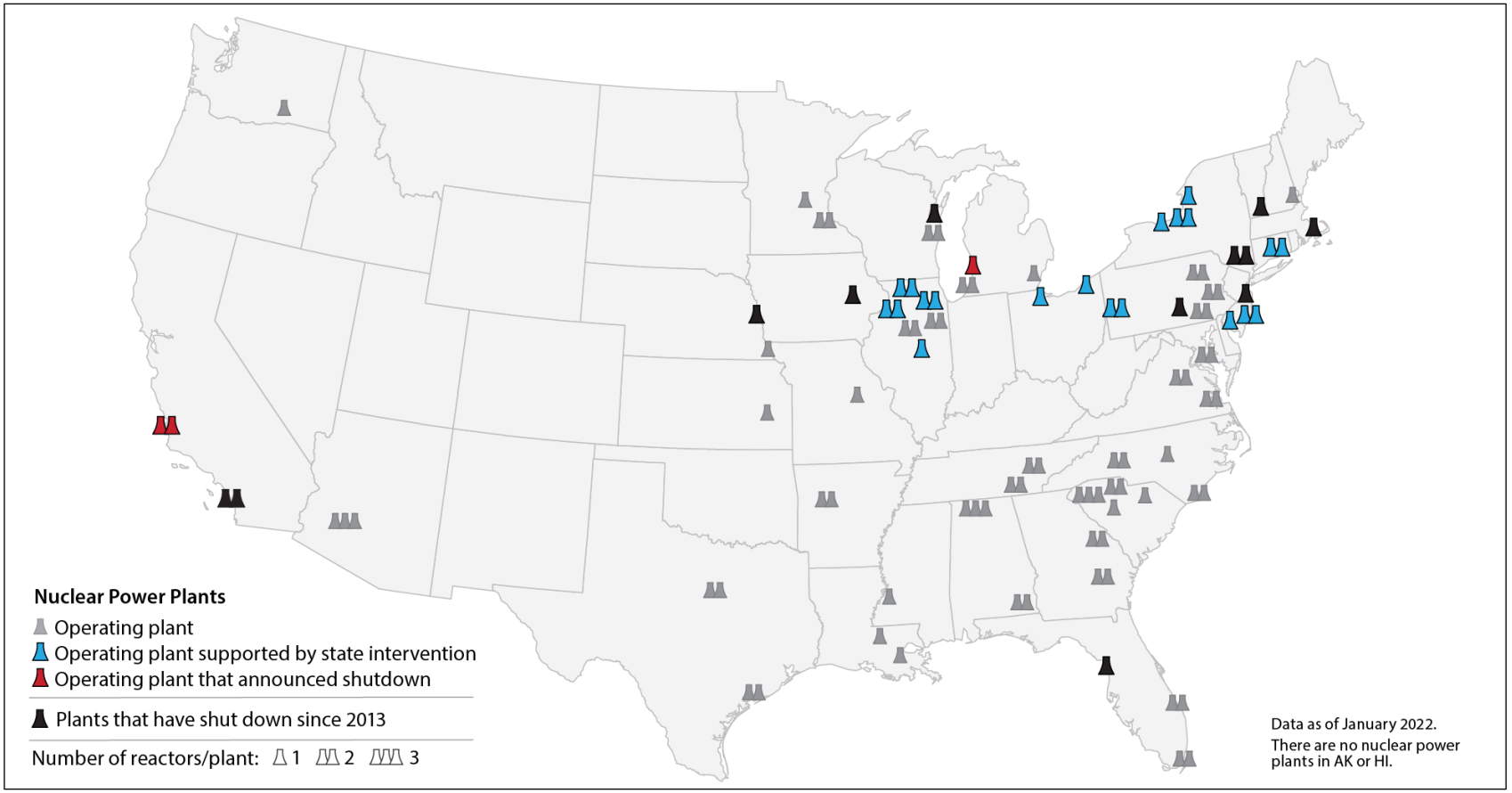
[3] Energy Information Administration, "Nuclear Reactor Shutdown List," https://www.eia.gov/nuclear/reactors/shutdown/.

[4] Indian Point 3 was the last operating reactor at the Indian Point plant, whose initial nuclear reactor began generating electricity in 1962. The plant had been controversial for decades because of its location about 25 miles north of New York City along the Hudson River. The State of New York opposed Indian Point's operating license extension by the U.S. Nuclear Regulatory Commission (NRC) and reached an agreement with the plant's owner, Entergy, in 2017 to close the final operating units in 2020 and 2021. See New York State, "Governor Cuomo Announces 10th Proposal of the 2017 State of the State: Closure of the Indian Point Nuclear Power Plant by 2021," news release, January 9, 2017, https://www.governor.ny.gov/news/governor-cuomo-announces-10th-proposal-2017-state-state-closure-indian-point-nuclear-power.

[5] Entergy Corporation, "Entergy, NY Officials Agree on Indian Point Closure in 2020-2021," news release, January 9, 2017, https://www.prnewswire.com/news-releases/entergy-ny-officials-agree-on-indian-point-closure-in-2020-2021-300387633.html.

[6] For an example of such studies, see Union of Concerned Scientists, *More Than One-Third of Nation's Nuclear Plants at Risk of Early Closure or Slated for Retirement*, November 8, 2018, https://www.ucsusa.org/about/news/nuclear-plants-risk-early-closure.

Figure 1. U.S. Nuclear Power Plants Currently Operating, Shut Down Since 2013, Announced Plans for Shutdown, and Operating Pursuant to State Intervention



Source: CRS, using data from S&P Global Platts, Esri Data and Maps, with information from the U.S. Energy Information Administration and plant operator announcements.

Notes: Plant shutdowns are from February 2013 through the end of April 2021. See **Table 1**. Two U.S. reactors are currently under construction: Units 3 and 4 at the Vogtle nuclear power plant in Georgia. There are no nuclear power plants in Alaska, Hawaii, or U.S. territories.

Reactors that have been identified in recent studies as being "at risk" of near-term retirement, but with no shutdown date announced by their owners, are not shown in the accompanying maps and tables, because of widely varying study methodologies, data, and results. Identifying "at risk" reactors with broad screening studies is difficult because each nuclear reactor can have a unique set of market, location, cost, revenue stream, maintenance, contract, and regulatory factors that operators may consider when deciding to shut down reactor operations earlier than previously anticipated.

The maps in this report graphically illustrate that actual and planned reactor shutdowns are mostly concentrated in particular regions of the country, such as the Northeast and Midwest, where supply, demand, transmission constraints, and fuel costs in regional markets largely determine wholesale electricity prices and generator revenues. If the wholesale market price of electricity (the price received by power plants) is chronically lower than a nuclear plant's operating costs, the owner of the plant may decide to shut it down rather than endure losses indefinitely. Plant owners in such situations also may be unwilling to make large capital investments that may be necessary to keep their reactors operating.

Wholesale electricity prices were pushed to historically low levels in recent years by rising amounts of low-cost generation from natural gas, wind, and solar, and by weak electricity demand growth. Low prices were cited by plant owners in the permanent closure of at least eight reactors during the past decade (see **Table 1**). However, rising natural gas prices in 2021 led to substantial increases in wholesale electricity prices in the second half of the year, according to the Energy Information Administration (EIA). Average electricity prices rose in all regions during 2021, including a near-doubling in the Midcontinent region and a 37% increase in California from the previous year.[7] A continuation of this trend could ease future economic pressure on nuclear power plants in regions with market-based rates.

Economic pressure on nuclear power plants is less immediate in areas of the country where electricity prices are set by state regulators rather than markets, such as in much of the Southeast. Under such "traditional" rate regulation, all power plant expenditures must be approved by state regulators, and electricity customers are charged rates sufficient to recover those costs plus a reasonable investment return. However, as noted above, many other factors can affect plant-specific costs, revenues, and operating profits. In particular, plants that have guaranteed revenue streams through long-term power purchase agreements may be somewhat insulated from wholesale price fluctuations. For background information about some of the variables and complexities that affect nuclear power economics, see CRS Report R44715, *Financial Challenges of Operating Nuclear Power Plants in the United States*, by Phillip Brown and Mark Holt.

Concerns about reactor shutdowns, particularly their potential effects on local economies and efforts to reduce power sector greenhouse gas emissions, have prompted action in the 117th Congress to provide incentives and financial support for operating nuclear power plants. In particular, a new federal program to provide financial support to nuclear power plants at risk of closure is included in the Infrastructure Assistance and Jobs Act (P.L. 117-58), signed into law November 15, 2021. Other legislative proposals such as federal clean electricity standards and tax credits could support existing nuclear power plants and reduce the likelihood of earlier-than-planned shutdowns.

Scope of Report

This report provides maps and tables that show nuclear reactor shutdowns, announced closures, and state interventions to prevent reactor shutdowns. For clarity, each of those categories is shown in a separate set of maps and tables, along with a general map that shows all currently operating U.S. nuclear reactors and their status. The map of reactors that have been kept operating by state action is accompanied by brief

[7] Energy Information Administration, "Wholesale electricity prices trended higher in 2021 due to increasing natural gas prices," January 7, 2022, https://www.eia.gov/todayinenergy/detail.php?id=50798.

descriptions of those actions; many involve the establishment of "zero emission credits" that electric utilities must purchase from nuclear plants, increasing nuclear plant revenues.

Nuclear Reactor Shutdowns: 2013-2021

From 2013 through April 2021, power plant operators permanently shut down 12 nuclear reactors representing 9,436 MW of electricity generation capacity. **Table 1** contains additional information about each reactor. **Figure 2** includes a map showing the location of each reactor listed in the table.

Table 1. U.S. Nuclear Reactor Shutdowns: 2013-2021

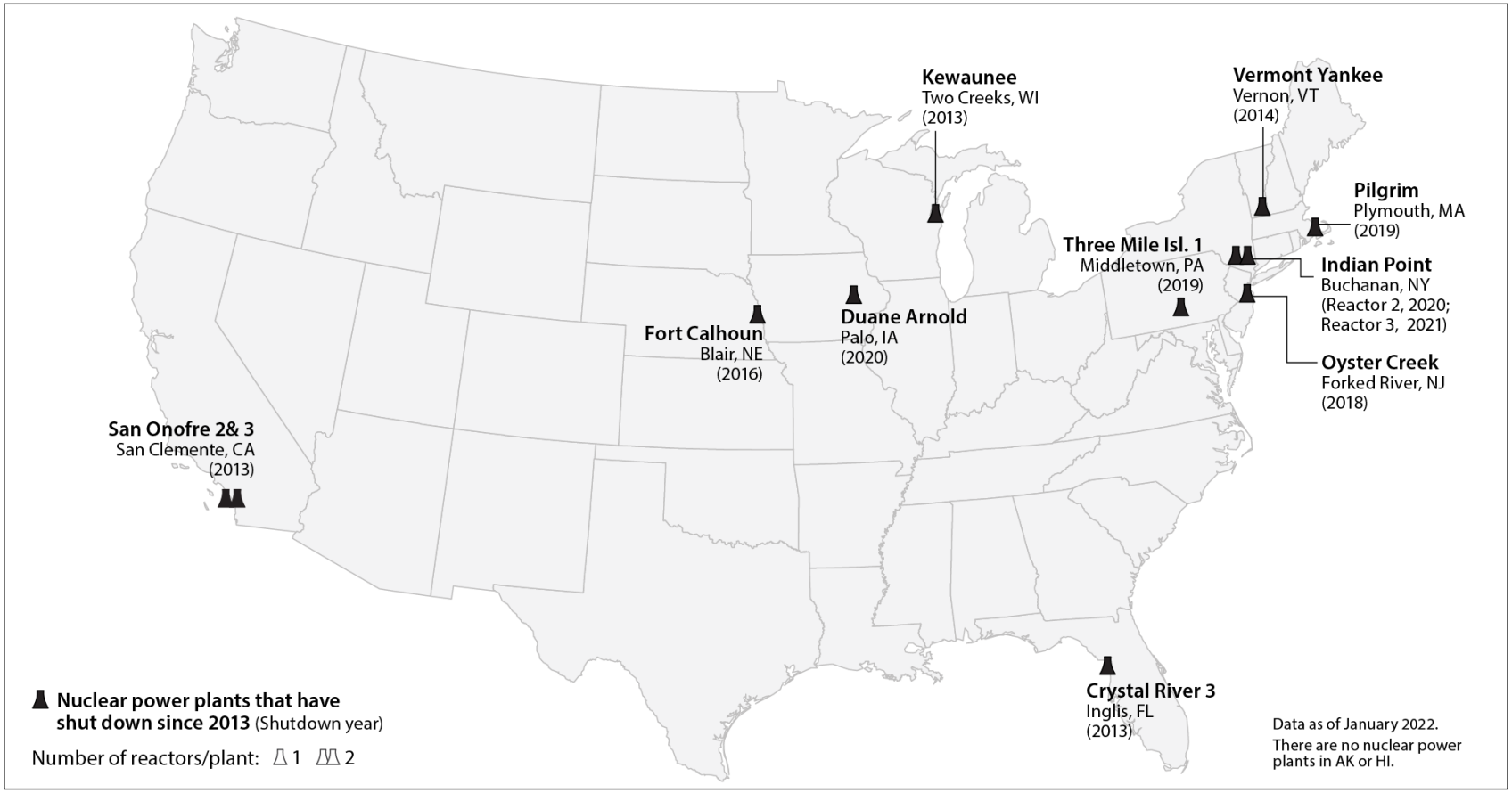
Organized by Shutdown Date

Reactor	State (Cong. District)	Shutdown Date	Generating Capacity (Megawatts)	Start-Up Year	Major Factor(s) Contributing to Shutdown
Crystal River 3	Florida (FL-11)	Feb. 2013	860	1977	Cost of major repairs to reactor containment
Kewaunee	Wisconsin (WI-8)	May 2013	566	1974	Operating losses
San Onofre 2	California (CA-49)	June 2013	1,070	1983	Cost of replacing defective steam generators
San Onofre 3	California (CA-49)	June 2013	1,080	1984	Cost of replacing defective steam generators
Vermont Yankee	Vermont (VT-at large)	Dec. 2014	620	1972	Operating losses
Fort Calhoun	Nebraska (NE-1)	Oct. 2016	479	1973	Operating losses
Oyster Creek	New Jersey (NJ-3)	Sept. 2018	614	1969	Agreement with state to avoid building cooling towers
Pilgrim	Massachusetts (MA-9)	May 2019	685	1972	Operating losses; rising capital expenditures
Three Mile Island 1	Pennsylvania (PA-10)	Oct. 2019	803	1974	Operating losses
Indian Point 2	New York (NY-17)	April 2020	1,020	1974	Low electricity prices; settlement with state
Duane Arnold	Iowa (IA-1)	Aug. 2020	601	1975	Lower-cost alternative power purchases
Indian Point 3	New York (NY-17)	April 2021	1,038	1976	Low electricity prices; settlement with state
		Total	**9,436**		

Source: CRS, with information from the U.S. Energy Information Administration and plant operator announcements.

Notes: Generating capacity numbers reflect "Net Summer" capacity.

Figure 2. Nuclear Reactor Shutdowns, 2013-2021



Source: CRS, using data from S&P Global Platts, Esri Data and Maps, with information from the Energy Information Administration and plant operator announcements.

Notes: Plant shutdowns are from February 2013 through the end of April 2021. There are no nuclear power plants in Alaska, Hawaii, or U.S. territories.

Announced Nuclear Reactor Shutdown Plans

As of the date of this report, power plant operators have announced their intent to shut down three operating nuclear reactors, representing 3,012 MW of electricity generation capacity (about 3% of total current U.S. nuclear capacity). **Table 2** contains additional information about each reactor. **Figure 3** includes a map showing the location of each reactor listed in the table, along with all other operating reactors in the country.

Table 2. Announced Nuclear Reactor Shutdown Plans

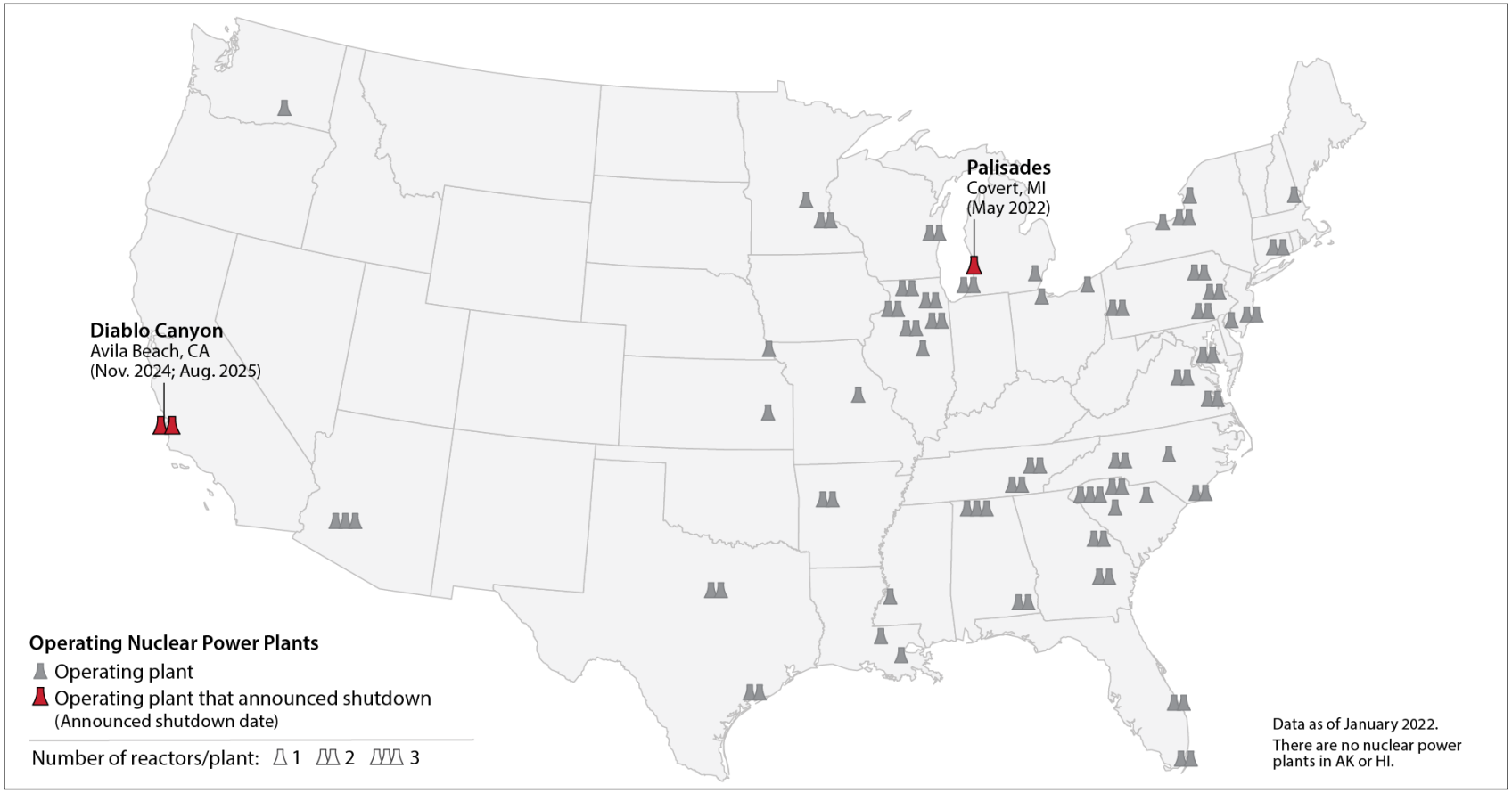
Organized by Announced Shutdown Date

Reactor	State (Cong. District)	Announced Shutdown Date	Generating Capacity (Megawatts)	Start-Up Year	Major Factors Contributing to Announced Shutdown
Palisades	Michigan (MI-6)	May 2022	772	1972	Operating losses; end of power purchase agreement
Diablo Canyon 1	California (CA-24)	Nov. 2024	1,122	1985	Settlement with labor and environmental groups to use renewables and efficiency
Diablo Canyon 2	California (CA-24)	Aug. 2025	1,118	1986	Settlement with labor and environmental groups to use renewables and efficiency
		Total	**7,1093,012**		

Source: CRS, with information from the U.S. Energy Information Administration and plant operator announcements.

Notes: Generating capacity numbers reflect "Net Summer" generating capacity.

Figure 3. Announced Nuclear Reactor Shutdown Plans



Source: CRS, using data from S&P Global Platts, Esri Data and Maps, with information from the U.S. Energy Information Administration and plant operator announcements.

State Interventions to Support Nuclear Power Generation

Six states have intervened to provide financial support or other assistance for 20 nuclear reactors—representing 19,831 MW of electricity generation capacity (21% of total U.S. nuclear capacity)—that had been previously announced for closure or identified as likely to close. Most recently, an Illinois law signed September 15, 2021, provided subsidies that halted the planned shutdown of two nuclear plants in the state with a total of four reactors. State subsidies that benefit nuclear power, such as zero emissions credits or power purchase agreements, have typically been up to $100 million per year for each reactor. **Table 3** contains additional information about each reactor, including the type of intervention. **Figure 4** shows the location of each reactor listed in the table, along with all other operating reactors in the country. Background information, reference materials, and context about the six state incentive programs are also included below.

Table 3. U.S. Nuclear Reactors Supported by State Intervention

Organized Alphabetically by State

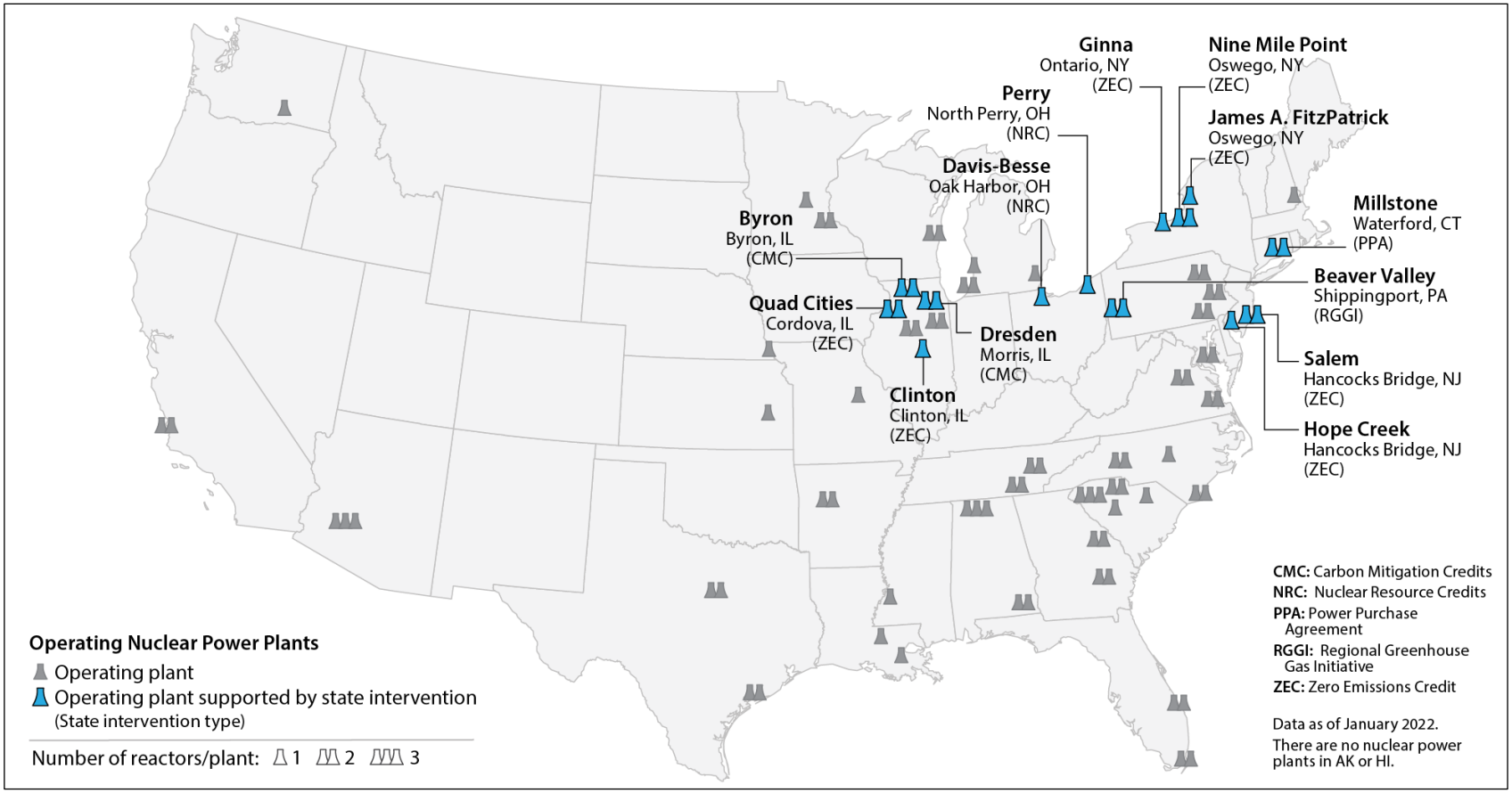
Reactor	State (Cong. District)	Generating Capacity (Megawatts)	Start-Up Year	State Intervention Type
Millstone 2	Connecticut (CT-2)	853	1975	Power Purchase Agreement
Millstone 3	Connecticut (CT-2)	1,233	1986	Power Purchase Agreement
Byron 1	Illinois (IL-16)	1,164	1985	Carbon Mitigation Credits
Byron 2	Illinois (IL-16)	1,136	1987	Carbon Mitigation Credits
Clinton	Illinois (IL-13)	1,065	1987	Zero Emission Credits
Dresden 2	Illinois (IL-16)	902	1970	Carbon Mitigation Credits
Dresden 3	Illinois (IL-16)	895	1971	Carbon Mitigation Credits
Quad Cities 1	Illinois (IL-17)	908	1972	Zero Emission Credits
Quad Cities 2	Illinois (IL-17)	911	1972	Zero Emission Credits
Hope Creek	New Jersey (NJ-2)	1,172	1986	Zero Emission Credits
Salem 1	New Jersey (NJ-2)	1,153	1977	Zero Emission Credits
Salem 2	New Jersey (NJ-2)	1,142	1981	Zero Emission Credits
Ginna	New York (NY-24)	580	1970	Zero Emission Credits
James A. FitzPatrick	New York (NY-24)	848	1976	Zero Emission Credits
Nine Mile Point 1	New York (NY-24)	621	1969	Zero Emission Credits
Nine Mile Point 2	New York (NY-24)	1,292	1987	Zero Emission Credits
Davis-Besse	Ohio (OH-9)	908	1977	Nuclear Resource Credits
Perry	Ohio (OH-14)	1,240	1987	Nuclear Resource Credits
Beaver Valley 1	Pennsylvania (PA-17)	907	1976	PA joined Regional Greenhouse Gas Initiative (RGGI)
Beaver Valley 2	Pennsylvania (PA-17)	901	1987	PA joined RGGI

Reactor	State (Cong. District)	Generating Capacity (Megawatts)	Start-Up Year	State Intervention Type
Total		**19,831**		

Source: CRS, with data from the U.S. Energy Information Administration and state policy documents.

Notes: Generating capacity numbers reflect "Net Summer" generating capacity. All nuclear power reactors in Pennsylvania could benefit from the state joining RGGI, a carbon dioxide cap-and-trade system in the Northeast and Mid-Atlantic. Beaver Valley is included in this table because the plant owner rescinded its closure order, and cited RGGI as the reason for not shutting down the reactors. Ohio subsidies were postponed and then repealed without being implemented, although the two Ohio nuclear plants have continued to operate. Exelon announced in July 2021 that its two-unit Braidwood plant could close "sometime in the next few years," with no specific date; Braidwood has also been awarded carbon mitigation credits by Illinois as an "at risk" plant.

Figure 4. U.S. Nuclear Reactors Supported by State Intervention



Source: CRS, using data from S&P Global Platts, Esri Data and Maps, with data from the Energy Information Administration and state intervention policies.

Notes: NRC = Nuclear Resource Credits (similar to ZECs); PPA = Power Purchase Agreement; RGGI = Regional Greenhouse Gas Initiative; ZEC = Zero Emission Credits; CMC = Carbon Mitigation Credits. All nuclear power reactors in Pennsylvania could benefit from the state joining RGGI. Beaver Valley is included in this map because the plant owner rescinded its closure order, and cited RGGI as the reason for not shutting down the reactors. Ohio subsidies were postponed and then repealed without being implemented, but the two Ohio nuclear plants have continued to operate. The two-unit Braidwood plant in Illinois has also been awarded carbon mitigation credits as an "at risk" plant, but it is not shown on this map because it never had an announced shutdown date.

Connecticut

Connecticut enacted a law in 2017 to authorize the state's Department of Energy and Environmental Protection (DEEP) to hold competitive procurements for power from nuclear plants found to be at risk of retirement.[8] Two power reactors are currently operating in Connecticut, Millstone 2 and 3 (with unit 1 having been previously retired). DEEP and the Connecticut Office of Consumer Counsel determined in 2019 that Millstone 2 and 3 were at risk of permanent shutdown beginning on June 1, 2023, when the Millstone plant's current capacity obligations with the regional transmission organization expire.[9]

In the power purchase solicitation that took place after Millstone was found to be at risk, DEEP approved Millstone's bid to sell half the plant's output for a 10-year period running through 2029, or 9 million megawatt-hours per year. Connecticut's two regulated electric utilities were required to purchase the power from Millstone at $49.99 per megawatt-hour, for a total of about $450 million per year. The power purchase includes all of Millstone's zero emission credits (ZECs), which can be resold.[10] New England real-time wholesale electricity prices averaged $30.67 per megawatt-hour in 2019,[11] $19.32 below the price in the Millstone power purchase contracts. At those rates, the resulting subsidy to Millstone would average about $174 million per year.

Illinois

Exelon announced in 2016 that it would shut down its single-unit Clinton plant and the two-unit Quad Cities plant in 2017 and 2018, respectively.[12] The Illinois General Assembly enacted a law (Public Act 99-0906) on December 1, 2016, to provide ZECs to keep the plants operating for 10 years. The law set the price of a ZEC at $16.50 per megawatt-hour, based on the social cost of carbon,[13] to be adjusted for market conditions and other factors. Under criteria in the law, the Illinois Power Authority procures the ZECs from the three reactors at Clinton and Quad cities at the mandated price and sells them to utilities in the state. The total cost of the ZECs over 10 years is estimated to be about $3.6 billion, or about $360 million per year for the three eligible

[8] An Act Concerning Zero Carbon Solicitation and Procurement, Public Act No. 17-3, signed October 31, 2017, https://cga.ct.gov/asp/cgabillstatus/CGAbillstatus.asp?selBillType=Bill&bill_num=1501&which_year=2017IS. Connecticut Governor Dannel P. Malloy had signed Executive Order 59 with similar provisions July 25, 2017.

[9] Connecticut Public Utilities Regulatory Authority, *Brief of the Department of Energy and Environmental Protection's Bureau of Energy and Technology Policy and the Office of Consumer Counsel*, September 28, 2018, http://www.dpuc.state.ct.us/DOCKCURR.NSF/60903cc7b9de44728525746b006e8ffb/45b46c73aeca4c6285258319003d9a97/$FILE/68115619.pdf/scanned%20DEEP-OCC%20At%20Risk%20brief%20with%20attachments%2018-09-28.pdf.

[10] Connecticut Legislature, Office of Legislative Research, *Millstone Power Procurement*, September 1, 2020, https://www.cga.ct.gov/2020/rpt/pdf/2020-R-0203.pdf.

[11] ISO New England, "Markets: Fast Stats," https://www.iso-ne.com/about/key-stats/markets.

[12] Exelon, "Exelon Announces Early Retirement of Clinton and Quad Cities Nuclear Plants," news release, June 2, 2016, http://www.exeloncorp.com/newsroom/clinton-and-quad-cities-retirement.

[13] Estimated by the U.S. Interagency Working Group on Social Cost of Greenhouse Gases, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf.

reactors.[14] The Illinois ZEC program and a similar program in New York were challenged in federal court but ultimately upheld.[15]

Although the Illinois ZEC program averted the planned closure of the Clinton and Quad Cities plants, Exelon announced in August 2020 that it would retire two other nuclear plants in the state: the two-unit Byron plant in September 2021 and the final two operating reactors at its Dresden plant in November 2021. Exelon said the two plants "face revenue shortfalls in the hundreds of millions of dollars" despite efficient and reliable operation.[16] As noted above, the planned shutdowns were averted by an Illinois law signed September 15, 2021, that provides "carbon mitigation credits" to nuclear plants at risk of closure for economic reasons.[17] Exelon also had warned that its two-reactor Braidwood plant could close "sometime in the next few years,"[18] and that plant is also receiving carbon mitigation credits.

Under the new law, each carbon mitigation credit represents 1 MWh of eligible nuclear power generation. The Illinois Power Agency is to procure five-year contracts for 54.5 million credits per year from eligible nuclear plants.[19] The credits are to be purchased by utilities serving at least 3 million retail customers in the state, with automatic pass-through to ratepayers.

Under the act, eligible nuclear plants submitted bids to supply the credits. To bid, plants were required to submit cost, revenue, and operational data to prove they faced economic risk. Eligibility was limited to nuclear plants in the Illinois portion of the PJM interconnection, of which there are three: Byron, Dresden, and Braidwood. At 1 credit/MWh, the 54.5 million available credits almost exactly equal the electric generation of the three eligible nuclear plants in 2019, according to EIA. On December 1, 2021, the Illinois Commerce Commission awarded the three plants the 54.5 million credits annually through the end of May 2027.[20]

The price paid for the credits is to be the bid price minus other plant revenues, so the value of the credits may vary from month to month. Bids were not allowed to exceed a customer protection cap equal to baseline costs set at $30.30/MWh in 2022 and rising to $34.50/MWh in 2026.

[14] Illinois Commerce Commission, *Report to the General Assembly in Compliance with Section 1-75(d-5) of the Illinois Power Agency Act*, August 2019, https://www.ilga.gov/reports/ReportsSubmitted/553RSGAEmail1216RSGAAttach2019%20Report%20to%20General%20Assembly%20in%20Compliance%20with%20Section%201-75(d-5)%20IL%20Power%20Agency%20Act.pdf.

[15] Walton, Rod, "Supreme Court Refuses to Hear Appeals Against Nuclear Subsidies in New York, Illinois," *Power Engineering*, April 16, 2019, https://www.power-eng.com/emissions/supreme-court-refuses-to-hear-appeals-against-nuclear-subsidies-in-new-york-illinois/#gref.

[16] Exelon, "Exelon Generation to Retire Illinois' Byron and Dresden Nuclear Plants in 2021," news release, August 27, 2020, https://www.exeloncorp.com/newsroom/exelon-generation-to-retire-illinois%E2%80%99-byron-and-dresden-nuclear-plants-in-2021.

[17] Illinois General Assembly, Energy Transition Act (Nuclear Plant Assistance), Public Act 102-0662, section d-10, https://ilga.gov/legislation/publicacts/102/102-0662.htm.

[18] Exelon, "Exelon Generation Submits Decommissioning Plans for Byron and Dresden Nuclear Plants," July 28, 2021, https://www.exeloncorp.com/newsroom/exelon-generation-submits-decommissioning-plans-for-byron-and-dresden-nuclear-plants.

[19] Illinois Power Agency, "Carbon Mitigation Credits RFP," https://www.ipa-energyrfp.com/carbon-mitigation-credits.

[20] Illinois Commerce Commission, "Public Notice of Successful Bidders and Average Prices," December 1, 2021, https://www.ipa-energyrfp.com/wordpress/wp-content/uploads/2021/12/Public-Notice-of-CMC-Procurement-Results-12-1-2021.pdf.

New Jersey

New Jersey enacted a law in 2018 to provide ZECs to nuclear power plants in the state that could demonstrate a need for subsidies to continue operating.[21] PSEG Nuclear, the operator of New Jersey's three nuclear reactors—Salem 1 and 2 and Hope Creek—applied for the ZECs in December 2018. The application stated that "PSEG intends to retire the plants within the next three years unless there [is] a material beneficial financial change."[22]

The New Jersey Board of Public Utilities (BPU) in April 2019 awarded ZECs to the three reactors worth about $100 million each for three years. The BPU staff concluded that the reactors were financially viable without the subsidies. However, the BPU Board found that "operational risks" and "market risk" as defined by the law made the three reactors eligible for ZECs. In dissenting from the BPU decision, one commissioner contended that the three reactors had not "satisfactorily demonstrated" that they would shut down without state subsidies.[23]

New York

The owners of four nuclear reactors in upstate New York announced in 2016 that they would permanently be closed for economic reasons.[24] To keep the plants operating, the State of New York Public Service Commission approved a ZEC system in August 2016 that provided additional revenue for the four reactors and required them to continue operating through 2029.[25] The order required the New York State Energy Research and Development Authority (NYSERDA) to purchase ZECs from the four reactors and resell them to state-regulated electric utilities ("load serving entities"). The initial ZEC price was set at $17.48 per megawatt-hour at a cap of 27.618 million megawatt-hours per year. This yielded a maximum annual ZEC subsidy for the four reactors of $483 million for the first two years of the program, with adjustments to be made every two years.

Ohio

The permanent shutdown of Ohio's two nuclear power plants, Davis-Besse and Perry, was announced in an April 25, 2018, filing with the Nuclear Regulatory Commission (NRC) by the plants' owner, FirstEnergy Solutions (now Energy Harbor after a bankruptcy reorganization). The

[21] NJ Rev Stat § 48:3-87.3 (2018), Findings, declarations relative to nuclear energy, https://law.justia.com/codes/new-jersey/2018/title-48/chapter-3/section-48-3-87.3/.

[22] PSEG Services Corporation, Application to New Jersey Board of Public Utilities for Hope Creek Generating Station to receive ZECs, December 19, 2018, p. 5, https://corporate.pseg.com/aboutpseg/companyinformation/thepsegfamilyofcompanies/-/media/E26DB24D6B074FEB8CD0895A1ED1D45C.ashx.

[23] McAuliffe, Michael, "New Jersey Customer Advocate Mulls ZEC Appeal," *Nucleonics Week*, April 25, 2019; New Jersey Board of Public Utilities, *Order Determining the Eligibility of Hope Creek, Salem 1, and Salem 2 Nuclear Generators to Receive ZECs*, April 17, 2019, https://www.bpu.state.nj.us/bpu/pdf/boardorders/2019/20190418/4-18-19-9A.pdf.

[24] Entergy, "Entergy to Close James A. FitzPatrick Nuclear Power Plant in Central New York," news release, February 23, 2016, http://www.entergynewsroom.com/latest-news/entergy-close-jamesfitzpatrick-nuclear-power-plant-central-new-york-1829/; Knauss, Tim, "Another Oswego County Nuke Threatens to Close: Nine Mile 1 on the Brink," *Syracuse.com*, June 15, 2016, updated March 22, 2019, https://www.syracuse.com/news/2016/06/another_oswego_county_nuke_threatens_to_close_nine_mile_1_on_the_brink.html.

[25] State of New York Public Service Commission, *Order Adopting a Clean Energy Standard*, Issued and Effective August 1, 2016, https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard/Important-Orders-Reports-and-Filings/Filings-Orders-and-Reports. See Appendix E.

NRC filing said FirstEnergy Solutions would cease operation of Davis-Besse by May 31, 2020, and Perry by May 31, 2021.[26]

FirstEnergy Solutions rescinded the shutdown notice for the two nuclear plants on July 26, 2019,[27] three days after the Ohio Legislature enacted a bill, H.B. 6, to provide subsidies to keep them operating.[28] H.B. 6 authorized the collection of $150 million per year from ratepayers for a "nuclear generation fund," which would provide financial support to Davis-Besse and Perry. The nuclear subsidy collections were to begin on January 1, 2021.[29]

A proposed referendum to repeal H.B. 6 was abandoned in January 2020 after sufficient signatures were not gathered in time.[30] However, on July 16, 2020, the U.S. Attorney for the Southern District of Ohio filed a criminal complaint that the enactment of H.B. 6 and failure of the repeal effort had been directly affected by "multiple acts of bribery" by the Ohio Speaker of the House and other state officials.[31]

Citing the scandal and other concerns about the implementation of H.B. 6, an Ohio industry association appealed to the Ohio Supreme Court to stay the scheduled January 1, 2021, initiation of ratepayer charges for the act's nuclear and other electric generation subsidies.[32] The Ohio Supreme Court granted the temporary stay on December 28, 2020.[33] Ohio Governor Mike DeWine signed legislation on March 31, 2021, that repealed the H.B. 6 nuclear subsidies.[34] Following the nuclear subsidy suspension and repeal, Energy Harbor has not announced any changes to the status of Davis-Besse and Perry, which are continuing to operate.

Future use of any Ohio subsidies could also be affected by a Federal Energy Regulatory Commission (FERC) order to expand the Minimum Offer Price Rule (MOPR) issued by the PJM regional transmission organization. The Ohio nuclear plants are in the PJM region. FERC may revisit its order under the Biden Administration. For more information, see CRS Insight IN11223, *FERC Directs PJM to Expand Minimum Offer Price Rule*, by Richard J. Campbell.

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[26] Ryser, Jeffrey, "FirstEnergy Reaches Creditor Agreements Related to Subsidiary Bankruptcy," *Nucleonics Week*, April 26, 2018.

[27] FirstEnergy Solutions, "FirstEnergy Solutions Rescinds Deactivation Notices for Competitive Generating Plants in Ohio," news release, July 26, 2019, https://www.prnewswire.com/news-releases/firstenergy-solutions-rescinds-deactivation-notices-for-competitive-generating-plants-in-ohio-300891786.html.

[28] Ohio Legislature, 133rd General Assembly, House Bill 6 Status, https://www.legislature.ohio.gov/legislation/legislation-status?id=GA133-HB-6.

[29] Ohio Legislature, 133rd General Assembly, House Bill 6 as enrolled, Sec. 3706.46, https://www.legislature.ohio.gov/legislation/legislation-summary?id=GA133-HB-6. Other electric generation subsidies were also included in the legislation.

[30] "House Bill 6 Referendum Effort Is Dead After Group Drops Lawsuit Appeal," January 22, 2020, https://www.cleveland.com/open/2020/01/house-bill-6-referendum-effort-is-dead-after-group-drops-lawsuit-appeal.html.

[31] Criminal Complaint Before the U.S. District Court for the Southern District of Ohio, United States of America v. Matthew Borges, Case No. 1:20-MJ-00526, July 16, 2020, https://fox8.com/wp-content/uploads/sites/12/2020/07/show_temp.pdf.

[32] Supreme Court of Ohio, "Motion to Stay Charges Assessed to Customers to Subsidize the H.B. 6 Clean Air Fund by the Ohio Manufacturers' Association Energy Group," Case No. 2020-1488, December 17, 2020, http://supremecourt.ohio.gov/pdf_viewer/pdf_viewer.aspx?pdf=895795.pdf.

[33] Supreme Court of Ohio, In re Matter of Establishing the Clean Air Fund Rider Pursuant to R.C. 3706.46, December 28, 2020, http://supremecourt.ohio.gov/pdf_viewer/pdf_viewer.aspx?pdf=895795.pdf.

[34] Mike DeWine, Governor of Ohio, "Governor DeWine Signs Ohio Transportation Budget," news release, March 31, 2021, https://governor.ohio.gov/wps/portal/gov/governor/media/news-and-media/transportation-budget-signed-03312021.

Pennsylvania

FirstEnergy (now Energy Harbor), owner of the two-unit Beaver Valley nuclear plant in western Pennsylvania, announced in March 2018 that the plant would close in 2021.[35] Energy Harbor rescinded Beaver Valley's planned retirement in March 2020, after observing the Pennsylvania Governor's efforts to join the Regional Greenhouse Gas Initiative (RGGI), a carbon dioxide cap-and-trade program in the Northeast and Mid-Atlantic. Energy Harbor said its decision to keep the plant operating was "largely driven" by the governor's actions to join RGGI, "which will begin to help level the playing field for our carbon-free nuclear generators."[36]

Governor Wolf issued an Executive Order in October 2019 directing the Pennsylvania Department of Environmental Protection (DEP) to develop a rulemaking that would establish the framework to join RGGI.[37] DEP's final rule to participate in RGGI was approved by the state's Independent Regulatory Review Commission on September 1, 2021.[38] Policymakers in Pennsylvania's legislative bodies have voiced strong opposition to joining RGGI and the governor's actions to join the program without enacting new legislation.[39]

The 11 northeastern and mid-Atlantic states that participate in RGGI have agreed to a regional cap on carbon dioxide (CO_2) emissions from fossil-fuel-fired electric power plants. The RGGI emissions cap increases costs for fossil fuel plants relative to non-emitting generating sources such as nuclear plants. To demonstrate compliance with the emissions cap, covered power plants must submit emission allowances to the implementing state agency to cover the number of short tons of CO_2 the plant emitted over the past compliance period (three years in the RGGI program). The vast majority of RGGI emission allowances are initially distributed through quarterly auctions, and power plants may buy and sell allowances among themselves throughout the compliance period. In RGGI's most recent auction (March 2021), the auction clearing price for allowances was $7.60 per short ton of CO_2, the highest price in RGGI's history. For more information, see CRS Report R41836, *The Regional Greenhouse Gas Initiative: Background, Impacts, and Selected Issues*, by Jonathan L. Ramseur.

Congressional Action

The 117th Congress has enacted or is considering multiple approaches to addressing potential shutdowns of existing nuclear power plants. Some bills currently under consideration would target at-risk plants by providing direct payments or tax credits. Another major approach would indirectly help existing reactors by including nuclear power in broader "clean energy" incentives and mandates. The future of nuclear power has been discussed at several recent hearings, with

[35] FirstEnergy Solutions, "FirstEnergy Solutions Files Deactivation Notice for Three Competitive Nuclear Generating Plants in Ohio and Pennsylvania," news release, March 28, 2018, https://www.sec.gov/Archives/edgar/data/1407703/000119312518104000/d561242dex991.htm.

[36] Energy Harbor, "Energy Harbor Corp Rescinds Deactivation Notice for Nuclear Generating Plant in Pennsylvania," news release, March 13, 2020, https://energyharbor.com/en/about/news-and-information/energy-harbor-corp-rescinds-deactivation-notice-for-nuclear-gene.

[37] Governor Wolf Executive Order 2019-07, first signed October 3 2019, amended June 22, 2020, https://www.oa.pa.gov/Policies/eo/Documents/2019-07.pdf.

[38] For more information, see the Pennsylvania Department of Environmental Protection RGGI website, https://www.dep.pa.gov/Citizens/climate/Pages/RGGI.aspx.

[39] See, e.g., EnergyWire, "Battle Rages over Pa. Plan to Join RGGI," May 6, 2021, https://www.eenews.net/energywire/2021/05/06/stories/1063731853.

concerns raised about continued shutdowns as well as about ensuring that safety standards are maintained for at-risk plants.

Infrastructure Assistance and Jobs Act

A new federal program to provide financial support to nuclear power plants at risk of closure is included in the Infrastructure Assistance and Jobs Act (P.L. 117-58) signed into law November 15, 2021.

A nuclear reactor is eligible for the bill's assistance program (Section 40323) if it "competes in a competitive electricity market"[40] and the Secretary of Energy certifies that it is likely to close because of economic factors, that such closure would result in increased pollution, and that NRC has reasonable assurance that the reactor would operate safely. Priority is given to reactors that maximize their use of U.S.-origin fuel. In applying to the Secretary for certification, reactors at risk of closure would have to submit cost and revenue data and an estimate of potential increased air pollution that would result from their shutdown. The revenue data would include the impact of any state assistance programs, unless the federal credits would be used to reduce the state payments. For example, the Illinois law authorizing carbon mitigation credits (cited above) requires nuclear plants applying for the credits to include any anticipated federal support in their revenue projections.

Reactors certified by the Secretary could submit bids to receive credits for four years, specifying an amount per megawatt-hour of electricity generated that would be paid for each credit. The bids would include a commitment to generate a specific number of megawatt-hours during the four-year period. The bids could not exceed the losses that the certification process had projected that a reactor would incur without assistance. Certification for the assistance program can be renewed until September 30, 2031. The Secretary is to use the bidding results to award credits to as many certified reactors as possible within available funding.

Appropriations for the nuclear plant assistance program were provided in the same bill by Division J, Title III, Energy and Water Development and Related Agencies. The program received a total of $6 billion, with $1.2 billion appropriated per year from FY2022 through FY2026.

Production Tax Credit for Existing Reactors

A tax credit for existing nuclear power plants was included in budget reconciliation legislation passed by the House on November 19, 2021 (Build Back Better Act, H.R. 5376).

Under the tax provision (Section 136109), existing nuclear power plants would receive a production tax credit of up to 1.5 cents per kilowatt-hour (kwh), or $15/MWh, through the end of 2026. To qualify for the credit, a nuclear plant would have to satisfy requirements on prevailing wages and apprenticeships or have a generating capacity below 1 MW. An existing nuclear plant not meeting those requirements would qualify for a credit of up to 0.3 cents/kwh.

[40] The term "competitive electricity market" is not defined in the act. After the law's enactment, DOE issued a statement that the credit program will be "open to all 93 reactors operating in the U.S." See DOE, "Saving Existing Nuclear Fleet Brings Net-Zero Future Closer," December 6, 2021, https://www.energy.gov/articles/saving-existing-nuclear-fleet-brings-net-zero-future-closer. According to the Federal Energy Regulatory Commission, "two-thirds of the nation's electricity load" is served by "bid-based markets." See Federal Energy Regulatory Commission, "Electric Power Markets," https://www.ferc.gov/electric-power-markets.

The credit would be reduced if the price of electricity generated by an eligible plant rose above specific levels. The credit would also be offset in specified circumstances by amounts received from state or federal zero-emission credit (ZEC) programs.

Clean Electricity Performance Program

The House-passed Build Back Better Act (H.R. 5376) also includes a program of grants and fees to encourage utilities to increase their supply of low-carbon electricity, including nuclear energy.

The Clean Energy Performance Program in H.R. 5376 would require the Department of Energy (DOE) to provide annual grants to utilities that increase their clean electricity percentage by at least four percentage points over the previous year. If a utility did not increase its clean electricity share by that amount, it would owe a payment to DOE. After the first year, a utility would have to meet the four percentage point goal to receive a grant the following year. Grants would be $150 for every MWh of clean electricity that exceeded a level of 1.5% more than the amount a utility had generated the previous year. The payment for failure to meet the 4 percentage point increase would be $40/MWh of the generation shortfall.

While those grants and payments would not directly benefit nuclear power plants, they could influence an electric utility's decisions on nuclear plant closures, expanding a nuclear plant's generating capacity, or even building new reactors.

Other Bills and Hearings

The Senate Energy and Natural Resources Committee held a hearing on nuclear energy March 25, 2021, which included a focus on existing U.S. nuclear plants. Chair Joe Manchin said in his opening statement, "Lifetime extensions are cheaper than new builds and are generally cost competitive with other generation technologies. We cannot afford to let this carbon-free energy resource fade out."[41] Manchin subsequently sent a letter to President Biden urging him "to take action to preserve our existing nuclear fleet and prevent further closures."[42] An amendment to provide a production tax credit for existing nuclear power plants was proposed by Senator Ben Cardin in the Senate Finance Committee but not offered for a vote during a markup of draft energy tax legislation on May 26, 2021.[43]

Nuclear plant closures were discussed at a May 6, 2021, hearing by the House Appropriations Subcommittee on Energy and Water Development on the DOE FY2022 budget request.[44] Under questioning, Energy Secretary Jennifer M. Granholm pledged to work with Congress to find ways

[41] Chairman Joe Manchin's Opening Statement, *Hearing to Examine the Latest Developments in the Nuclear Energy Sector*, Senate Committee on Energy and Natural Resources, March 25, 2021, https://www.energy.senate.gov/services/files/FD68DDC9-1352-4189-B1C8-4AF3A44E7235.

[42] Senate Energy and Natural Resources Committee Chairman Joe Manchin, letter to President Joseph R. Biden, April 20, 2021, https://www.energy.senate.gov/2021/4/manchin-urges-biden-to-support-domestic-nuclear-fleet-prevent-plant-closures.

[43] Senate Committee on Finance, "Open Executive Session to Consider an Original Bill Entitled The Clean Energy for America Act," May 26, 2021, https://www.finance.senate.gov/hearings/open-executive-session-to-consider-an-original-bill-entitled-the-clean-energy-for-america-act.

[44] House Committee on Appropriations, Subcommittee on Energy and Water Development and Related Agencies, *FY2022 Budget Request for the Department of Energy*, Hearing, May 6, 2021, https://appropriations.house.gov/events/hearings/fy-2022-budget-request-for-the-department-of-energy.

to keep existing reactors operating, a goal that was supported by Subcommittee Chair Marcy Kaptur.

The 10th anniversary of the March 2011 Fukushima nuclear accident in Japan also prompted congressional comment on the future of U.S. nuclear power, especially the safety of existing plants. Senator Edward Markey, Chair of the Subcommittee on Clean Energy, Climate, and Nuclear Safety of the Environment and Public Works Committee, issued a statement on the Fukushima anniversary calling on the Nuclear Regulatory Commission (NRC) to ensure that the lessons of Fukushima are applied to existing U.S. reactors and not relaxed to ensure nuclear industry profitability.[45]

Legislation has been introduced in the 117th Congress to establish a national clean energy standard (CES), which would require electric utilities to provide specific amounts of power to their customers from eligible low- or zero-carbon generators. A CES that includes nuclear energy could increase the demand for electricity from existing reactors and possibly provide an economic incentive for building new ones. The CLEAN Future Act (H.R. 1512), introduced March 2, 2021, by House Energy and Commerce Committee Chair Frank Pallone Jr., includes a CES that would gradually rise to 100% zero-emission electricity generation by 2035 and afterward. Nuclear power is eligible in the CLEAN Future Act. The House Energy and Commerce Committee held a hearing on the bill March 24, 2021.[46]

The 116th Congress enacted the Energy Act of 2020 (Division Z of P.L. 116-260), which authorized appropriations for DOE's ongoing "sustainability" research and development program to improve the economics, safety, and continued operation of existing nuclear power plants. Division D of P.L. 116-260 provided appropriations of $47 million for the sustainability program for FY2021, the same as in FY2020.

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[45] Senator Ed Markey, Statement on U.S. Nuclear Safety Agenda on 10th Anniversary of Fukushima Nuclear Disaster, March 11, 2021, cited by Indian Point Safe Energy Coalition, https://www.ipsecinfo.org/2021/03/17/lap-dogs-for-the-industry-senator-markey-statement-on-u-s-nuclear-safety-agenda-on-10th-anniversary-of-fukushima-nuclear-disaster/.

[46] House Committee on Energy and Commerce, "The Clean Future Act: Powering a Resilient and Prosperous America," hearing, March 24, 2021, https://energycommerce.house.gov/committee-activity/hearings/hearing-on-the-clean-future-act-powering-a-resilient-and-prosperous.

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