The United States is losing nuclear power when we need it the most

By Ed Kee

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The Biden administration has a goal to decarbonize the U.S. electricity sector by 2035.[1] Achieving this goal would require a massive nuclear power build program. The U.S. nuclear power industry's size and historical success signal that we are in a good position to do this, but at present the U.S. nuclear fleet is shrinking. Why is this so, and what can be done to turn the trend around?

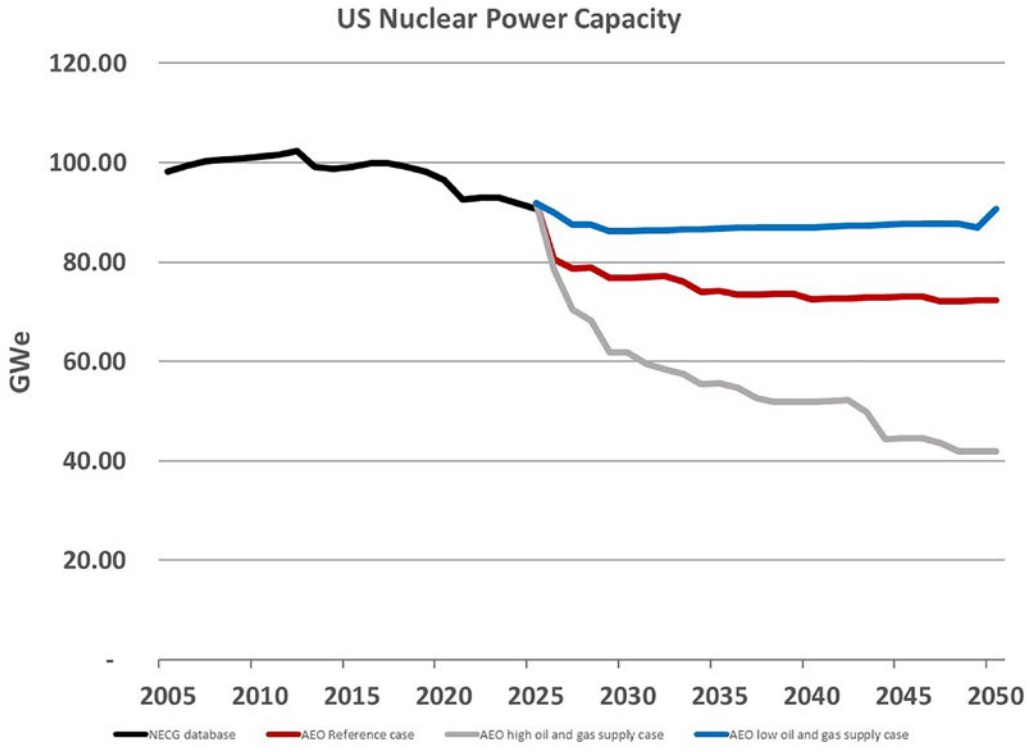
The future of U.S. nuclear power

Nuclear power capacity in the United States is shrinking and will drop to 90.5 GWe by the end of 2025. The U.S. Energy Information Administration (EIA) *Annual Energy Outlook 2021* (AEO 2021)[2] reference case predicts that U.S. nuclear capacity will drop to 72 GWe by 2050. The AEO 2021 low oil and gas supply case (i.e., with nominal Henry Hub natural gas prices escalating to more than $12/MMBtu by 2050) has U.S. nuclear capacity holding steady at about 90 GWe, but the high oil and gas supply case has U.S. nuclear capacity dropping to 42 GWe (see figure below).

This negative outlook for U.S. nuclear power is not consistent with the goal to decarbonize the electricity sector by 2035 or even later. The drop in U.S. nuclear power results from early closures of operating nuclear power plants and a lack of new nuclear power plant capacity.

Early closures, nearly no replacements

Over the past 20 years, U.S. nuclear power plant closures resulted in a loss of 8.4 GWe. Some of these plants closed early due to financial issues, including Kewaunee, Vermont Yankee, Fort Calhoun, Pilgrim, Three Mile Island-1, and Duane Arnold. Another 8.2 GWe of U.S. nuclear power capacity is scheduled to vanish by 2025, with some plants scheduled to close for financial issues, including Byron, Dresden, and Palisades. Even more nuclear power plants are at risk of early closure due to financial issues, including LaSalle, Braidwood, Beaver Valley, Davis-Besse, and Perry.



Data from the Nuclear Economics Consulting Group nuclear power database and the U.S. EIA AEO 2021.

[1] Fact sheet on the Biden administration executive action to tackle the climate crisis, January 27, 2021; whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/.
[2] *Annual Energy Outlook 2021*, U.S. Energy Information Administration, February 3, 2021; https://www.eia.gov/outlooks/aeo/.

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Some U.S. nuclear power plants with financial issues remain in operation due to individual states' action, including zero-emission credit (ZEC) programs. New York, Illinois, and New Jersey ZEC programs thus far have saved multiple nuclear power plants from early closure. Connecticut allowed Millstone to participate in a clean energy auction, and Pennsylvania's plan to join the Regional Greenhouse Gas Initiative was noted as a factor in stopping the planned early closure of Beaver Valley. Davis-Besse and Perry were saved from early closure by the Ohio ZEC program, but these two plants are at risk now because this program was repealed at the end of March.

Meanwhile, the Vogtle-3 and -4 units are under construction in Georgia, but many other proposed new nuclear power plant projects have been abandoned, canceled, or delayed. Only the Oklo Aurora project, a 1.5-MWe prototype to be built at Idaho National Laboratory, has a combined license (COL) application under review by the Nuclear Regulatory Commission, with the NuScale-affiliated Utah Associated Municipal Power Systems project expected to file a COL application in 2021.

Uprates and license renewal

Over the years, U.S. nuclear power capacity has seen consistent but small growth due to power uprates. The nuclear power plants that remain in operation are expected to have more uprates approved, adding a small amount of new nuclear power capacity over time.

Additionally, operating nuclear power plants can have their NRC operating licenses extended through initial and subsequent license renewal. However, many operating nuclear power plants have closed even though they had decades left on their approved operating licenses. Other nuclear power plants will close when their original operating license expires with no license renewal (e.g., Diablo Canyon). Just because a nuclear power plant has years left on its operating license, or could seek approval for license renewal, does not mean it will continue to operate.

Why is U.S. nuclear power shrinking?

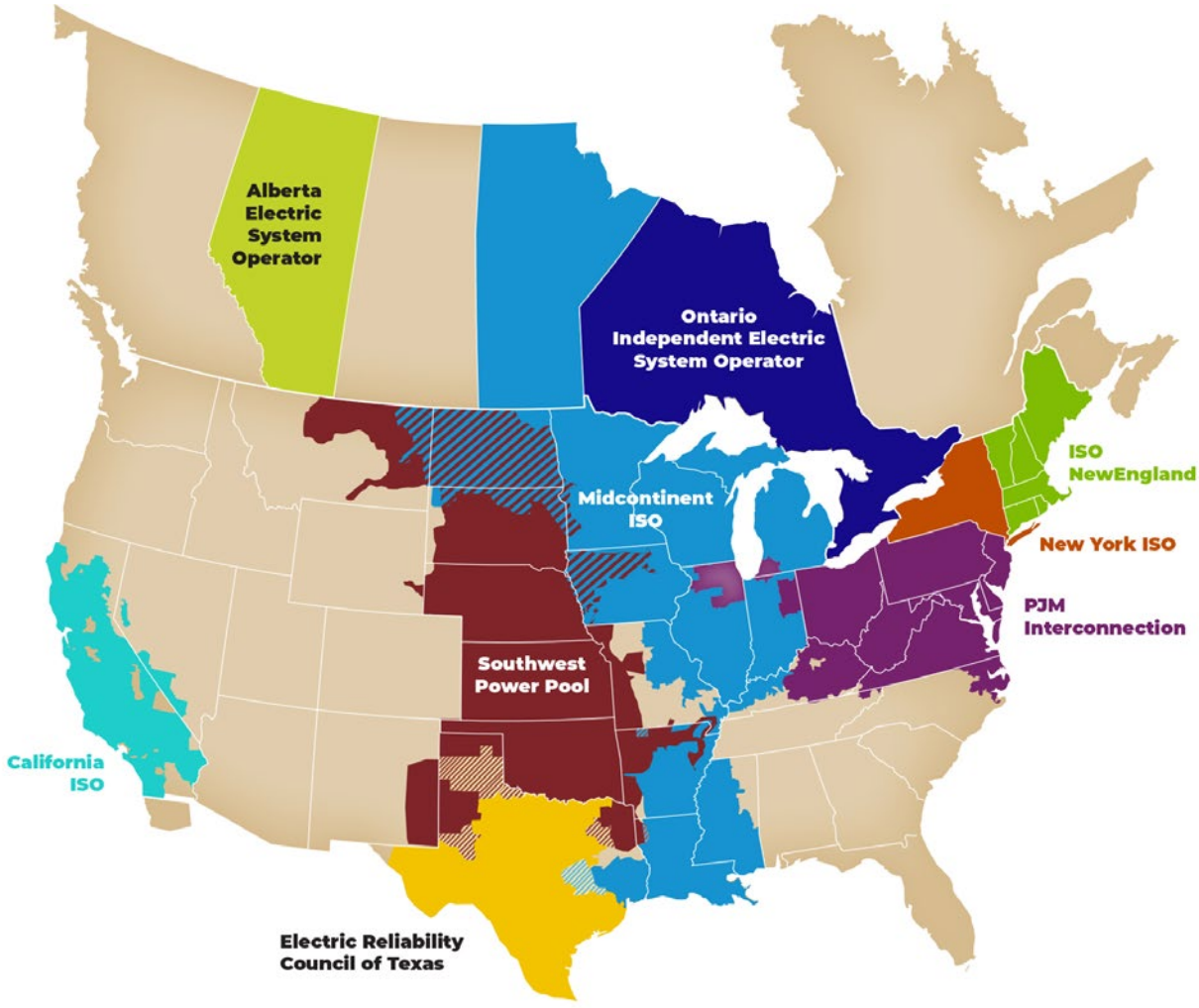
In more than a decade of writing and talking about nuclear energy economics,[3] the most important reason I've found for the decline in U.S. nuclear power is the country's market approach to the electricity and nuclear power industries. Existing nuclear power plants have closed early because of low electricity market prices, with more nuclear power plants scheduled to close early in the next few years for the same reason. More worrying, a market approach to nuclear power means that few new nuclear power plants are being developed. Low electricity market prices mean a lower value for nuclear electricity.

The U.S. electricity industry follows two approaches. The traditional electricity industry approach, with regulated or government-owned utilities, remains in some states. Starting in the 1990s, other states, except those in the West outside California and in the Southeast, adopted a new approach (see figure at right). The new approach has a restructured and deregulated electricity sector and bid-based electricity markets. This new approach created so-called merchant nuclear power plants that rely on electricity market prices for revenue instead of the cost recovery and return on investment in the traditional approach.

Nuclear power in parts of the United States with a traditional electricity industry approach seems less threatened, but problems remain. A few regulated nuclear power plants have closed early, and others are at risk. If electricity rates are lower without a regulated or government-owned nuclear power plant, there will be pressure even on regulated plants to close early.

The issues facing nuclear power are seen most clearly in the states and regions that have adopted the new approach and created merchant nuclear power plants.

[3] See Nuclear Economics Consulting Group Commentaries, nuclear-economics.com/commentary/, and my new book, *Market Failure*.



A map of independent system operators and regional transmission organizations—groups that participate in bid-based electricity markets. Source: ISO/RTO Council

Merchant nuclear

U.S. electricity industry reform and state utility restructuring resulted in merchant nuclear power plants when regulated plants were sold to deregulated power companies or transferred to unregulated affiliates. For revenue, these plants rely on the sale of electricity into wholesale electricity markets, with additional revenue from capacity and ancillary services in some electricity markets.

Most merchant nuclear power plants were transferred to their new owners along with a transition power purchase agreement (PPA) that insulated the merchant nuclear power plant owner and the original utility owner from financial exposure to wholesale electricity market prices. Except for Point Beach and Palisades, transition PPAs have expired, leaving merchant nuclear power plants with direct financial exposure to electricity market prices.

The unregulated power companies that acquired these merchant nuclear power plants expected electricity market prices to increase due to assumptions about future natural gas prices, demand growth, carbon taxes, and other factors. Higher expected electricity market prices would provide profits to justify the initial purchase price and recover post-acquisition investments to improve plant performance and obtain NRC license renewal approval.

What went wrong?

Today, merchant nuclear power plants face low electricity market prices that are caused by a combination of low natural gas prices (i.e., due to U.S. shale gas production), low demand growth (i.e., due to a shift away from traditional manufacturing in the United States), subsidized investment in renewable energy projects, and other factors. Low wholesale electricity market prices mean low profits or losses for merchant nuclear power plants. With marginal costs of zero and relatively high fixed generating costs, nuclear power plant owners see early closure as the only way to stop financial losses.

Low wholesale electricity market prices are expected to continue, negatively impacting operating nuclear power plants and disincentivizing potential investment in new nuclear power plants.

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Market failure

Market failure is when market outcomes decrease the net public good. A market-based approach to electricity and nuclear power leads to market failure for nuclear power. This market failure is seen in the early closure of operating nuclear power plants and the lack of new nuclear power plants.

A market approach to the electricity industry fails to reflect the full value of nuclear electricity, allowing nuclear power plants to lose money in electricity markets while providing little or no compensation for the public good nuclear power plants provide (e.g., clean and reliable electricity).

This nuclear power market failure reduces the public good. Increasing the public good is an important role of government. Government action is needed to resolve market failure for nuclear power and deliver the public good that nuclear power can provide.

What can be done?

A market-based approach to nuclear power will not maintain the operating fleet or deliver new nuclear capacity. We need to take urgent action to stop the early closure of operating nuclear power plants.

Other countries with a traditional electricity sector and strong government support for nuclear power have avoided the nuclear power market failure seen in the United States. Some of these countries are building a strong nuclear power industry—with, for example, China soon expected to have more nuclear power than France and the United States.

Nuclear power market failure can be resolved without replicating the Chinese approach to nuclear power. The 2016 American Nuclear Society Toolkit has a list of actions to resolve U.S. nuclear power market failure.[4]

An increased role of government tops the list. A government role in nuclear power might include government-owned electric utilities that own, purchase, and build nuclear power plants. These government utilities might buy financially distressed merchant nuclear power plants to save them from early closure or buy nuclear electricity from existing or new nuclear power plants using long-term power contracts that provide financial security.

A return to traditional electricity industry structure might allow regulated utilities to own nuclear power plants even if they operate in electricity markets (i.e., like California and Virginia do today). The 2016 Ohio proposal to create a new power contract between a merchant nuclear power plant and its regulated affiliated retail electricity company provides an example of how a merchant nuclear power plant might be re-regulated. The 2017 DOE-proposed Grid Resiliency Pricing Rule[5] provided another approach to this.

Another way to resolve market failure for nuclear power is to control unpriced negative externalities from other power plant technologies. This might involve a carbon tax or other approaches to increase electricity costs from combustion-based generation and indirectly increase the value of nuclear power.

Finally, providing compensation to nuclear power plants for the public benefits they provide can help resolve nuclear power market failure, as seen in the New York, Illinois, and New Jersey ZEC programs.

Insights

Nuclear power is too important to be left to the market.

The U.S. market-based approach to nuclear power will not maintain or grow nuclear power.

We need to find a better way to organize the electricity and nuclear power industries to save the nuclear power industry and build a reliable zero-carbon electricity sector.

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[4] *Nuclear in the States Toolkit: Policy options for states considering the role of nuclear power in their energy mix*, Version 2.0, ANS Special Committee on Nuclear in the States, June 2016; nuclearconnect.org/wp-content/uploads/2016/02/ANS-NIS-Toolkit-V2.pdf.

[5] federalregister.gov/documents/2017/10/10/2017-21396/grid-resiliency-pricing-rule.