

While You Were Sleeping

The Unnoticed Loss of Carbon-free
Generation in the United States

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The United States has embarked on actions to combat climate change by putting a focus on lowering the carbon emissions from the electric generation sector. A pillar of this approach is to promote the greater use of renewable resources, such as wind and solar. The past decade has seen significant growth in carbon-free energy from wind and solar. Generation from these resources reached 333,000 GWh in 2017. However, unbeknownst to many who care about climate change, most of the progress made to date through renewables is at significant risk due to the loss or potential loss of more than 228,000 GWh of nuclear carbon-free generation.

RENEWABLES GROWTH: INVESTMENT IN CARBON-FREE GENERATION

Over the past decade, wind and solar have grown in large part due to policies such as renewable portfolio standards, federal tax incentives, and in some cases state tax incentives. Few would argue that the addition of renewable generation is a critical element of a comprehensive carbon-reduction strategy.

Since 2008, the policy focus on renewables has attracted hundreds of billions of dollars of investment for the development of wind and solar. The results have been significant—in the past decade 90% of the current operating wind and solar capacity was added, roughly 75 GW of wind and 52 GW solar.¹ Another result of these investments has been to help wind and solar drive down the cost curve reaching a more competitive position. The policies promoting renewables have clearly contributed to the addition of a meaningful amount of carbon-free electricity as well as to jump-starting an industry in the United States.

EARLY RETIREMENT: NUCLEAR GENERATORS FACE CHALLENGES

In the same timeframe, natural gas prices have driven down power prices, causing difficulties for both renewables and existing generation. The nuclear industry in particular has been challenged by low natural gas prices and the lack of overall policy support for its zero-carbon attributes. As a result, the nuclear industry has faced a wave of actual and announced retirements. The most vulnerable nuclear plants have been small, single-unit plants and merchant facilities in deregulated markets with low energy and capacity values. Under these conditions, existing nuclear plants are having difficulty competing in bid-based markets and in some regulated as well. Some states have recognized this issue and have explored zero-carbon incentives to keep plants open that would otherwise have shut down. However, these incentives are being challenged and still make these plants, while technically “rerieved,” what we categorize as “at risk.”

In 2016, the New York Public Service Commission approved a Clean Energy Standard (CES), which supported the continuation of more than 3 GW of nuclear capacity (i.e., Fitzpatrick, Ginna, and Nine Mile Point nuclear plants).² In the same year, Illinois passed The Future Energy Jobs Bill that provides nuclear plants with \$0.01/kWh, saving almost 3 GW of nuclear capacity (i.e., Clinton and Quad Cities nuclear

¹ Data obtained from Bloomberg New Energy Finance’s *2018 Sustainable Energy in America Factbook*. Wind capacity is reported in AC; solar capacity is reported in DC.

² New York State Department of Public Service, *Governor Cuomo Announces Establishment of Clean Energy Standard that Mandates 50 Percent Renewables by 2030*.

plants).³ The actions in New York and Illinois sustained more than 50,000 GWh of carbon-free generation per year. Meanwhile, Connecticut recently estimated it would cost roughly \$5.5 billion to replace the carbon-free generation from Dominion Energy’s Millstone station with renewables.⁴

To understand the potential for loss of carbon-free generation, ScottMadden identified four categories of “at-risk” nuclear assets. Each nuclear plant operating in 2008 (a date that coincides with the rapid growth in renewables) was reviewed and, if applicable, placed into one of the following “at-risk” categories:

- **Retired** – Any nuclear plant that has ceased operations since 2008. Some plants on the list had physical issues driving retirement, but they may have continued to operate under different economic circumstances, including markets valuing carbon-free generation
- **Announced** – Any nuclear plants where the owner has announced plans to cease operations early
- **In Jeopardy** – Any nuclear plant where the owner has indicated the plant may close if market conditions do not improve
- **Rerieved** – Any nuclear plant that has received state support to remain open. These were on the cusp of closure, and absent follow-through on these programs, the plants will likely close

For each “at-risk” category, we calculated total capacity and annual generation.⁵ As seen in the table below, more than 28,000 MW of nuclear capacity has retired or is facing early retirement. The 228,045 GWh of nuclear generation retired since 2008 or at risk of early retirement represents 5.6% of total U.S. net generation in 2016.

Category	Nuclear Plants	Capacity (MW)	Generation (GWh)
Retired	Crystal River, Fort Calhoun, Kewaunee, San Onofre, and Vermont Yankee	4,674	37,795
Announced	Beaver Valley, Davis-Besse, Diablo Canyon, Indian Point, Oyster Creek, Palisades, Perry, Pilgrim, and Three Mile Island	11,109	89,818
In Jeopardy	Duane Arnold, Hope Creek, Millstone, and Salem	6,189	50,044
Rerieved	Clinton, Fitzpatrick, Ginna, Nine Mile Point, and Quad Cities	6,232	50,388
“At-Risk” Nuclear Total:		28,204	228,045

CARBON IMPACT: EARLY RETIREMENT OF NUCLEAR DIMINISHES RENEWABLE GAINS

To understand the potential impact on carbon-free energy, ScottMadden compared “at-risk” nuclear assets facing early retirement to all wind and solar assets operating at the end of 2017.⁶ As discussed previously, there has been great publicity around the wind and solar capacity that has been added over the past decade. If compared on this popular measure, nuclear capacity at risk of early retirement only accounts for 20% of the total 2017 renewable capacity. If at first glance, it is not alarming, it is because

³ Forbes, *Illinois Sees The Light – Retains Nuclear Power*. December 4, 2016.

⁴ Connecticut Department of Energy & Environmental Protection Connecticut Public Utilities Regulatory Authority, *Resource Assessment of Millstone Pursuant to Executive Order No. 59 and Public Act 17-3; Determination Pursuant to Public Act 17-3*. February 1, 2018.

⁵ Capacity was calculated using net summer peak capacity obtained from SNL Financial. Generation was calculated using 92.3% capacity factor, which represents the average capacity factor for the U.S. nuclear fleet in 2016 as reported by the Energy Information Administration.

⁶ Data obtained from Bloomberg New Energy Finance’s *2018 Sustainable Energy in America Factbook*. Wind capacity is reported in AC; solar capacity is reported in DC.

capacity is not the right measure to show impact on carbon. To understand that, we must compare on electric output, or energy.

When compared on energy output, the potential loss of nuclear presents a greater concern. With capacity factors greater than 90%, losing a smaller amount of nuclear can produce outsized impacts on carbon-free generation compared to the low-capacity factor of wind and solar (35% to 22%).⁷ In 2017, wind and solar produced a combined total of 333,000 GWh of carbon-free generation (see Figure 1). This gain has the potential to be reduced by 68% or 228,045 GWh through the early retirement of nuclear capacity. In fact, the United States has lost 11% of the renewable generation from plants already retired.

In the states that host “at-risk” nuclear assets, the potential lost carbon-free generation from nuclear energy exceeds total in-state renewable energy generation (see Figure 2).⁸ This represents a significant barrier to achieving near-term state-level reductions in greenhouse gas emissions.

A further potential challenge is the relicensing of nuclear plants. Those plants not currently at risk of early retirement must renew their operating licenses with the U.S. Nuclear Regulatory Commission in the next 20 years. If these plants do not renew their licenses, even more carbon-free generation would be lost. In fact, wind and solar output would need to more than double just to break even on the loss of carbon-free generation from the retirement of the entire nuclear fleet (see Figure 3).

Figure 1. Change in U.S. Carbon-Free Generation

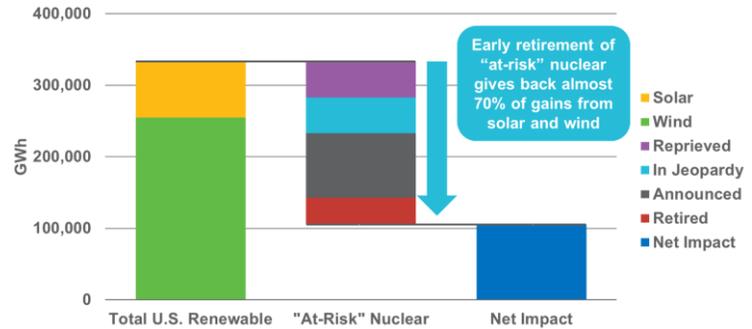


Figure 2. In-State Renewable Generation vs. “At-Risk” U.S. Nuclear Generation

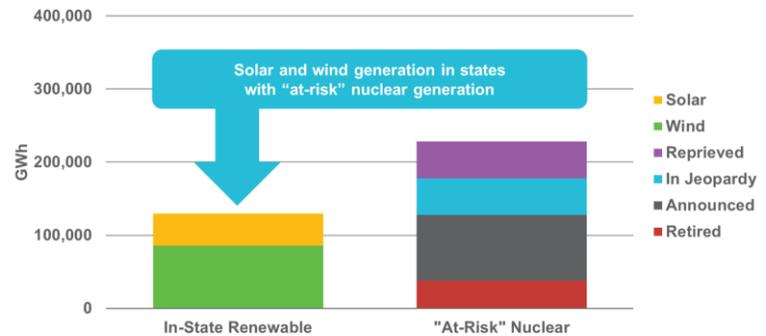
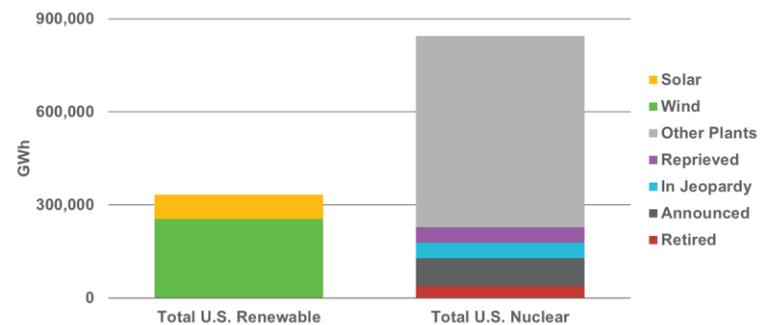


Figure 3. Total U.S. Renewable Generation vs. Total U.S. Nuclear Generation



⁷ Average capacity factor of utility-scale generators in 2016: nuclear 92.3%, wind 34.5%, utility-scale solar 25.1%, and solar thermal 22.2%. Source: Energy Information Administration, Electric Power Annual. Distributed solar capacity factors are often below 20%.

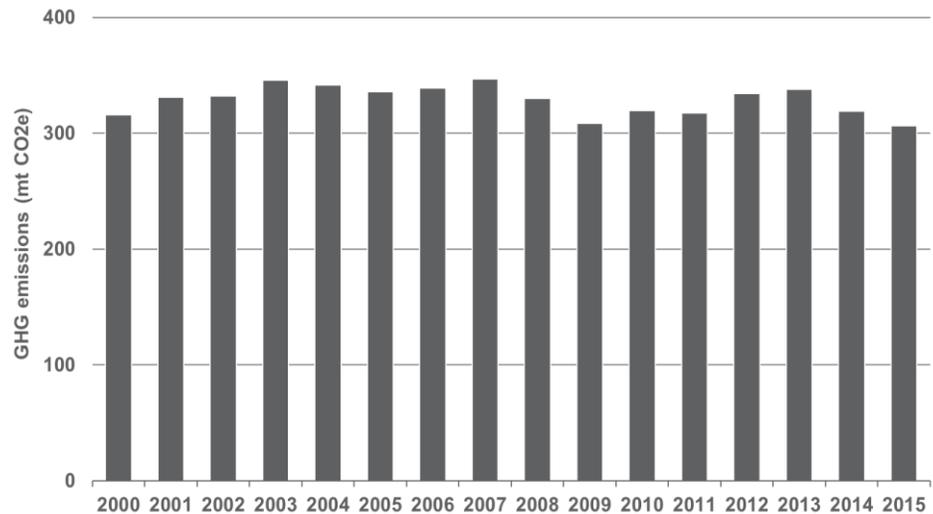
⁸ These states include California, Connecticut, Florida, Illinois, Iowa, Massachusetts, Michigan, Nebraska, New Jersey, New York, Ohio, Pennsylvania, Vermont, and Wisconsin.

GERMANY: A CAUTIONARY TALE

Many have pointed to Germany as a shining example of a country that has led the way in deploying renewables. In 2000, the Renewable Energy Act established feed-in tariffs and priority grid access for renewables. The action represents a key milestone in the *Energiewende* or transition to a low-carbon economy based on renewable resources. Since then, the country has spent roughly \$222 billion on renewable subsidies.⁹ The result is renewable energy as a percentage of gross electricity generation increasing from 6.2% in 2000 to 31.3% in 2015.¹⁰

At the same time however, Germany has embarked on a strategy of shuttering its nuclear plants. Roughly 40% of the country's nuclear capacity was shut down in 2011, following the Fukushima nuclear accident.¹¹ As a result, despite the addition of significant renewable resources, there is limited progress in reducing total carbon emissions in the electricity sector due to the early retirement of nuclear plants. In fact, greenhouse gas emission from the electricity sector has only decreased 3% from 2000 to 2015 (see Figure 4).¹²

Figure 4. Annual Greenhouse Gas Emissions in German Electricity Sector



CONCLUSION: RAPID AND DEEP CARBON REDUCTIONS REQUIRE NUCLEAR ASSETS

Investments in renewables have made a significant contribution to emission-free electricity generation. For those concerned with climate change, this represents a meaningful step in the right direction. The early retirement of “at-risk” nuclear, however, puts the United States in danger of “giving back” an amount equivalent to two-thirds of the overall carbon-free generation supplied from wind and solar. In states with these nuclear assets, the loss represents a significantly larger impact. The losses could become even greater if more nuclear plants do not renew operating relicenses.

However, a glimmer of hope emerges as states, such as New York and Illinois, are developing policies to value the carbon-free generation provided by nuclear plants. Even environmentalists are beginning to offer support for nuclear energy. In Illinois, the Union of Concerned Scientists called the Future Energy Jobs Bill “one of the most comprehensive state energy bills ever crafted and is the most important climate bill in Illinois history.”¹³ In addition, an open letter signed by more than 70 ecologists and conservation

⁹ The New York Times. *Germany's Shift to Green Power Stalls, Despite Huge Investments*. October 7, 2017.

¹⁰ German Environment Agency on the basis of Working Group on Renewable Energy Statistics (AGEE-Stat)

¹¹ The Economist. *Is Germany's Energiewende Cutting GHG Emissions?* March 20, 2017.

¹² United Nations Framework Convention on Climate Change Data Interface

¹³ Union of Concerned Scientists. *A Huge Success in Illinois: Future Energy Jobs Bill Signed Into Law*. December 8, 2016.

researchers stated that wind and solar are promising, but “nuclear power—being by far the most compact and energy dense of sources—could also make a major, and perhaps leading, contribution” to carbon emission reductions.¹⁴

If nuclear plants are not saved in the near term, it will put the entire industry at risk. For once a nuclear plant shuts down, it will not come back. If enough nuclear plants shut down, a tipping point may be reached for the entire industry in the United States, and we will lose forever that carbon-free generation. While one might argue that in the long run, this nuclear hole may be filled with renewables and other evolving clean technologies, in the near term it is certain that a rapid and deep carbon reduction will require these nuclear assets.

ABOUT SCOTTMADDEN

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ABOUT SCOTTMADDEN’S ENERGY PRACTICE

We know energy from the ground up. Since 1983, we have been energy consultants. We have served more than 400 clients, including 20 of the top 20 energy utilities. We have performed more than 3,000 projects across every energy utility business unit and every function. We have helped our clients develop strategies, improve operations, reorganize companies, and implement initiatives. Our broad and deep energy utility expertise is not theoretical—it is experience based.

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This report is one of a series of ScottMadden white papers on clean energy technologies and is based on our independent analysis. The contents have been updated from the initial version to reflect the recent change of FirstEnergy Solutions units from “in jeopardy” to “announced.”

¹⁴ The Washington Post. *Why Climate Change Is Forcing Some Environmentalists to Back Nuclear Power*. December 16, 2014.