

The U.S. without Nuclear Energy: A Report on the Public Impact of Plant Closures



ANS Special Committee on Nuclear in the States
April 2016



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Disclaimer

The American Nuclear Society's Special Committee on Nuclear in the States is proud to present its inaugural publication, Nuclear in the States Toolkit. Meant to provide policy options to states that are considering the role of nuclear power in their energy mix, the toolkit does not advocate for specific policy implementations, nor does the American Nuclear Society (ANS) promote any one solution for nuclear power. This discussion draft is meant to help state decision-makers better understand the range of policy options available, and the ANS welcomes feedback and input from readers on the material included in this report. References to any specific commercial product, process, or service by trade name, trademark, manufacturer or otherwise does not constitute or imply its endorsement or recommendation by the American Nuclear Society.

About the American Nuclear Society

The Society is a not-for-profit, international, scientific and educational organization. It was established by a group of individuals who recognized the need to unify professional activities within the various fields of nuclear science and technology. December 11, 1954, marks the Society's historic beginning at the National Academy of Sciences in Washington, D.C. ANS has since developed a diverse membership composed of approximately 11,000 engineers, scientists, administrators, and educators representing 1,600 plus corporations, educational institutions, and government agencies. It is governed by four officers and a board of directors elected by the membership.

About the Special Committee

In 2015, the American Nuclear Society established a Special Committee on Nuclear in the States focused on providing information to state policymakers on the benefits of new and existing nuclear energy facilities.

The impetus for the Committee's work was the release of the Environmental Protection Agency's (EPA) Clean Power Plan (CPP), which directs the states to create their own energy plans to meet target emission goals. "We want to give the states every opportunity to realize the benefits of nuclear power and help them understand what tools they have, and how nuclear can be part of that," said ANS President Eugene S. Grecheck.

The Special Committee is led by Dr. Peter B. Lyons, former Department of Energy (DOE) Assistant Secretary, and Donald R. Hoffman, President and CEO of Excel Services Corporation. They organized a team of ANS members in developing potential policy options for states that include nuclear energy in their Clean Power Plan compliance plans. The toolkit includes a range of other ideas to help existing and new nuclear power plants remain economically viable. This is an initial version of the toolkit, and a final version will be an integral part of a larger report on nuclear energy at the state level, due to be released later in 2016.

Executive Summary

- Nuclear power plants provide a number of public benefits, including carbon emission-free, reliable, dispatchable electricity, and economic benefits for the nation and the regions in which they are located.
Without nuclear power:
 - Replacement power will result in higher prices for less reliable electricity.
 - U.S. economic and job growth would be negatively impacted.
 - The U.S. will not be able to meet its carbon dioxide reduction goals.
- The electric power market is subject to consumer demands. If nuclear megawatts are removed from the market, the lost generation would be replaced primarily by carbon-emitting fossil generation.
- The average nuclear facility provides enough electricity to power approximately 1.3 million U.S. homes. Building enough wind and solar to replace the lost nuclear generation will take many years and hundreds of billions of dollars.
- Intermittent renewables are less economic as their market penetration increases. Furthermore, they require large land areas. To reduce carbon emissions to meet emission goals, reliable, available, compact, zero-carbon sources of energy like nuclear are necessary.

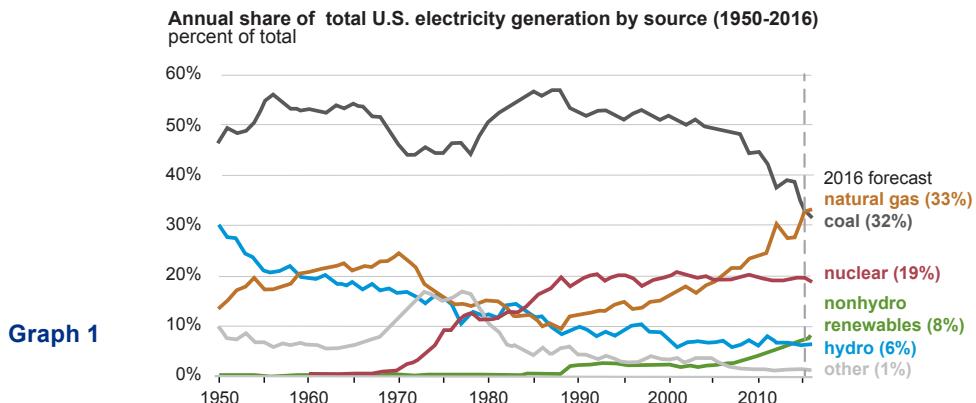
Background

The United States has more nuclear plants and produces more nuclear power than any nation on earth, with 99 reactors producing nearly 800 TWh of electricity per year.¹ For more than 40 years, nuclear plants have anchored the American electric power generation system, providing 19% of the nation's electricity and more than 60% of its carbon-free electricity.

Nuclear provides the public with reliable, economical, clean, and safe power. A 1,000 MW reactor at 90% capacity provides enough electricity to power approximately 720,000 residential households (i.e. Boston, Seattle or Washington D.C.).² Nuclear power plants provide hundreds of skilled jobs per plant and millions of dollars in economic benefits to the surrounding area.

¹ "Nuclear Power Explained: Nuclear Power Plants," *U.S. Energy Information Administration*, last modified June 9, 2015, http://www.eia.gov/energyexplained/index.cfm?page=nuclear_power_plants

² <http://www.nei.org/Knowledge-Center/Nuclear-Statistics/US-Nuclear-Power-Plants>



Between 1990 and 2010, U.S. demand for electricity grew from three to over four trillion kilowatt hours of generation.³ As Graph 1 shows, nuclear energy has largely kept its share of the electricity market over the past several decades.⁴ Renewables have significantly increased their share because they have been aided by various economic incentives: state renewable standards or mandates, federal tax subsidies, and R&D subsidies. In contrast, while nuclear energy receives government support primarily for research and development activities, it has maintained its 19% share largely because plant owner-operators have invested billions of dollars in plant uprates, plant license renewals, and improved operational reliability. This reliability of market share is critical:

"Nuclear power plants provide baseload power; they operate at very high capacity factors (from 2000-2009, the average nuclear capacity factor was 90%). Nuclear units, while representing only 10% of the nation's generating capacity (over 101,000 MWe), supplied 20% of the electricity generation for the U.S. in 2010."⁵

Nuclear plants are at an increasing disadvantage in deregulated markets due to unstable prices. Over the past two decades, some states have deregulated their electricity sectors and put wholesale markets in their place. As a result, non-utility merchant generators are producing a larger share of electricity in these markets. These electricity generation companies are free to sell electricity at market prices and have short-term and long-term operational flexibility. They include independent power producers with long-term power contracts and merchant generators that sell into organized electricity markets. While wholesale markets are adept at maintaining low short-term electricity prices, they ignore fixed costs and do not inherently place a value on public benefits such as low emissions rates, overall system reliability, and low volatility in fuel costs. Finally, nuclear plants require large upfront costs that receive a return on investment over a longer period of time and are not compensated for their other positive attributes.

Recent experience with premature nuclear shutdowns in the U.S., Japan, and Germany demonstrate that government policies not only affect market decisions about what type of new generation to build, but also whether existing generators will continue to operate.⁶

³ "Analysis of the Impacts of the Clean Power Plan," U.S. Energy Information Administration, May 2015, <https://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf>

⁴ "Natural gas expected to surpass coal in mix of fuel used for U.S. power generation in 2016," U.S. Energy Information Administration, last modified March 16, 2016, <http://www.eia.gov/todayinenergy/detail.cfm?id=25392#>

⁵ "U.S. commercial nuclear capacity comes from reactors built primarily between 1970 and 1990." U.S. Energy Information Administration, last modified June 30, 2011, <http://www.eia.gov/todayinenergy/detail.cfm?id=2030>

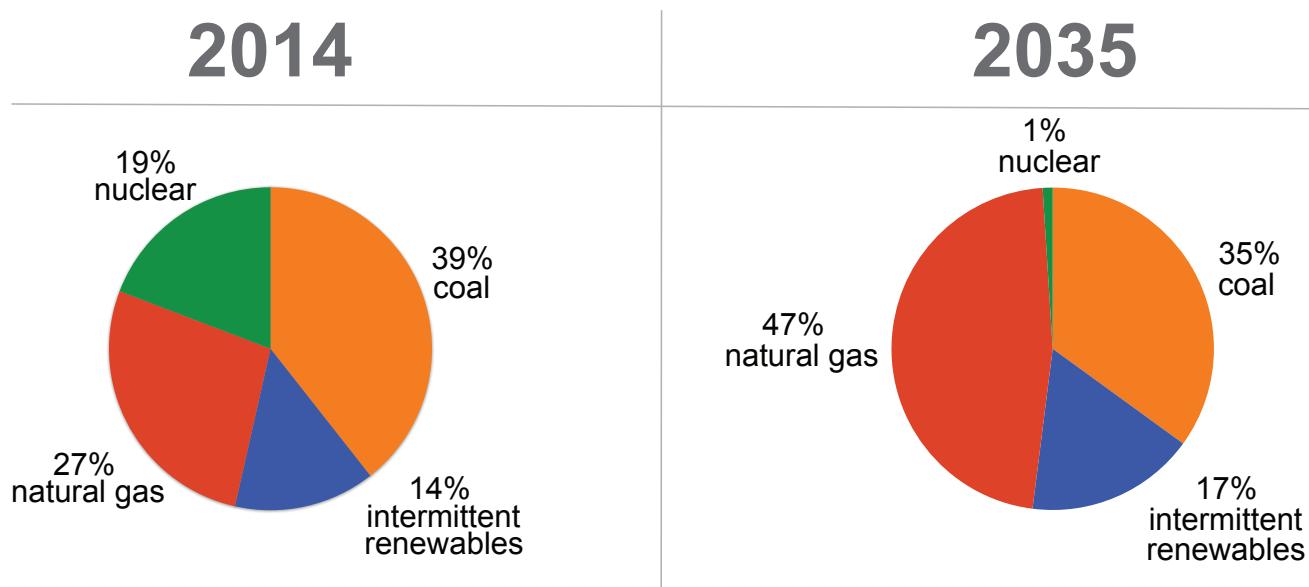
⁶ Marvin Fertel, "Nuclear Energy 2016: Status And Outlook." <http://www.nei.org/CorporateSite/media/filefolder/Policy/Wall%20Street/WallStreetBriefing2016.pdf?ext=.pdf>

Although the United States currently has 99 reactors operating in 30 states and five new reactors in the pipeline, merchant operators are prematurely closing nuclear plants faster than they can be replaced.

This report examines the long-term consequences of policies that encourage premature nuclear shutdowns by contemplating a complete shutdown of the current U.S. nuclear fleet. While some may argue that such a scenario is farfetched, as Senator Lamar Alexander mentioned in a 2015 speech, "... a United States without nuclear power – or with very little nuclear power – is a very real possibility. It's a possibility we should not want, if we want a strong country and a strong economy. Shutting down even one nuclear reactor has severe economic and environmental consequences both for the region and for the country as a whole."⁷

If nuclear plant owners were to let their current licenses expire rather than go through a long and costly renewal process, virtually all of today's operating nuclear reactors will be shut down by 2035, when only a few of the newest reactors would remain. While it is unlikely that all plant owners will let their licenses expire, it is not out of the realm of possibility given that merchant nuclear plant owners are already closing some reactors in deregulated markets due to their persistent unprofitability.⁷

Section 1: What Would Replace Nuclear Power?



Charts 1A and 1B: 2014 power market share⁸ and Third Way 2035 estimated market shares⁹

⁷ "Sen. Lamar Alexander, 'The United States Without Nuclear Power,'" [nei.org](http://www.nei.org/News-Media/Speeches/Sen-Lamar-Alexander,-%E2%80%9CThe-United-States-Without-Nu), last modified Feb. 5, 2015. <http://www.nei.org/News-Media/Speeches/Sen-Lamar-Alexander,-%E2%80%9CThe-United-States-Without-Nu>

⁸ "What is U.S. electricity generation by source?" *U.S. Energy Information Administration*, last modified March 31, 2015, <https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3>

⁹ Samuel Brinton and Josh Freed, "When Nuclear Ends: How Nuclear Retirements Might Undermine Clean Power Plan Progress." *Third Way*, August 19, 2015, <http://www.thirdway.org/report/when-nuclear-ends-how-nuclear-retirements-might-undermine-clean-power-plan-progress>

This report relies on a forecast developed by Third Way, a centrist think tank, to gauge the impact of removing nuclear generation from the U.S. grid on market share of total generation. Although alternative scenarios were considered, most assumed that nuclear energy would retain at least a 16% share of the market through 2035. The third scenario developed by Third Way in their study, “When Nuclear Ends: How Nuclear Retirements Might Undermine Clean Power Plan Progress,” best illustrates the dramatic consequences of a nuclear power plant shutdown on electricity market shares. This rapid phase-out scenario assumes that all licenses are allowed to expire and there are no reactors left operating by 2035 except the five reactors currently under construction.¹⁰ The power provided by these five plants would be roughly equivalent to 1% of the electricity market.¹¹

Of course, the abandonment of 19% of U.S. electricity generation assets raises the question: what would replace nuclear? Third Way found that **a significant expansion of natural gas-fired generation would be the predominant replacement of lost nuclear capacity. Renewable energy generation could potentially expand to replace some of the market demand met by nuclear power; however, it is non-dispatchable, meaning it cannot deliver a steady supply of electricity, and therefore requires either fossil-fuel-powered backup generation capacity or a massive increase in grid-scale energy storage using unproven technology.** In addition, because solar and wind energy are diffuse sources by their very nature, each requires an enormous land footprint per megawatt generated, which poses serious land use and transmission right-of-way challenges.¹² Furthermore, research shows that the average price of renewable energy falls significantly with increased market penetration, thereby reducing the profitability – and therefore the likelihood – of significant additional capacity additions, barring large future price reductions in renewable costs.¹³ **Renewables therefore do not necessarily provide consumers with lower-priced electricity.**

Hydropower is generally considered to be an unlikely replacement for nuclear, given the absence of any large scale sites available for development. New coal plants face almost insurmountable regulatory hurdles; new coal generation is implausible given the Environmental Protection Agency’s current regulatory requirements under the Clean Air Act. The Energy Information Agency reports that natural gas has been replacing coal in the mix of fuel used for U.S. electricity generation for 25 years, and that in 2016 the natural gas share of the electricity market is expected to surpass the coal share.¹⁴ Natural gas has its own challenges: carbon emissions, historically-volatile pricing, and limited expansion capability of pipeline infrastructure. Nonetheless, Third Way found that a significant expansion of natural gas-fired generation is the only plausible path for replacement of lost nuclear capacity in the short- to medium-term.

¹⁰ Ibid.

¹¹ Ibid.

¹² “Land Requirements for Carbon-Free Technologies,” Nuclear Energy Institute, June 2015, http://www.nei.org/CorporateSite/media/filefolder/Policy/Papers/Land_Use_Carbon_Free_Technologies.pdf?ext=.pdf

¹³ Lion Hirth, “The market value of variable renewables: the effect of solar wind power variability on their relative price,” *Energy Economics* 38 (2013): 218-236.

¹⁴ “Natural gas expected to surpass coal in mix of fuel used for U.S. power generation in 2016.”

Section 2: The Economic Impact of Losing Nuclear Power

U.S. nuclear power plants operate at an overall fleet average capacity factor above 90%. Coal and natural gas can also attain high capacity factors, but have negative environmental impacts. Renewables have minimal emissions but they only generate electricity when the sun shines and the wind blows and are thus unable to respond to short term peak electric system requirements.

In electricity markets, renewable mandates and federal and state tax subsidies sometimes result in negative price bidding where power producers pay customers to take their generated electricity, distorting market prices. In traditional utility states, “must take” provisions, in which any electricity generated must be bought, apply to qualifying renewables facilities. This disrupts an electric company’s economic operation of its portfolio of generation resources. The result in both regulated and deregulated electricity markets is lower efficiency and higher emissions due to the other forms of generation.

Customers need electricity when they need it: to run hospitals, factories, the internet, their homes, and to light their stores and offices. **To meet mandated emissions reductions goals and maintain reliability without nuclear, the U.S. will have to rely heavily on natural gas, despite its carbon emissions. Renewable energy sources cannot replace nuclear on their own.**

A report by the Brattle Group detailed the nuclear industry’s contribution to the U.S. economy and found that system reliability in some regions would be particularly vulnerable to the loss of nuclear capacity. In particular, in the VACAR, PJM, Central, New York, and Desert Southwest regions, nuclear provides 24% or more of regional electricity generation.¹⁵ According to the Brattle Group, “without nuclear plants, the economy would rely more heavily on existing and new natural gas-fired generating plants, and to a lesser extent, more generation from existing coal-fired plants.”¹⁶ Note that because of their high capacity factor, nuclear plants are only 9% of U.S. generation capacity, but supply 19% of U.S. electricity.

Displacing nuclear electricity with greater use of fossil generation would mean higher electricity prices – wholesale prices would be 10% higher on average; retail prices would rise about 6%.¹⁷ The cost of building new generation, transmission, and storage facilities to replace existing nuclear facilities would also contribute to electricity price increases, especially in regions like New York (15%), New England (24%), and the Northwest (34%) as calculated by the Brattle Group.¹⁸ Customers would also be more exposed to natural gas price volatility, which nuclear generation currently helps mitigate with its consistent operational costs. This price hedging effect that nuclear plants provide accounts for the majority of nuclear’s overall economic impact.

James Hansen, a leading figure in the climate change movement has written:

“We need affordable, abundant clean energy, but there is no particular reason why we should favour renewable energy over other forms of abundant energy. ...The climate system cares about greenhouse gas emissions – not about whether energy comes from renewable power or abundant nuclear power...The future of our planet and our descendants depends on basing decisions on facts, and letting go of long-held biases when it comes to nuclear power.”¹⁹

¹⁵ Mark Berman and Dean Murphy, “The Nuclear Industry’s Contribution to the U.S. Economy.” *The Brattle Group*, July 7, 2015: Table 1. http://www.brattle.com/system/news/pdfs/000/000/895/original/The_Nuclear_Industry's_Contribution_to_the_U.S._Economy.pdf?1436280444

¹⁶ Ibid, 1.

¹⁷ Ibid, 1.

¹⁸ Ibid, 4.

¹⁹ James Hansen, Kerry Emanuel, Ken Caldeira and Tom Wigley, “Nuclear power paves the only viable path forward on climate change.” *The Guardian*, last modified December 3 2015. <http://www.theguardian.com/environment/2015/dec/03/nuclear-power-paves-the-only-viable-path-forward-on-climate-change>

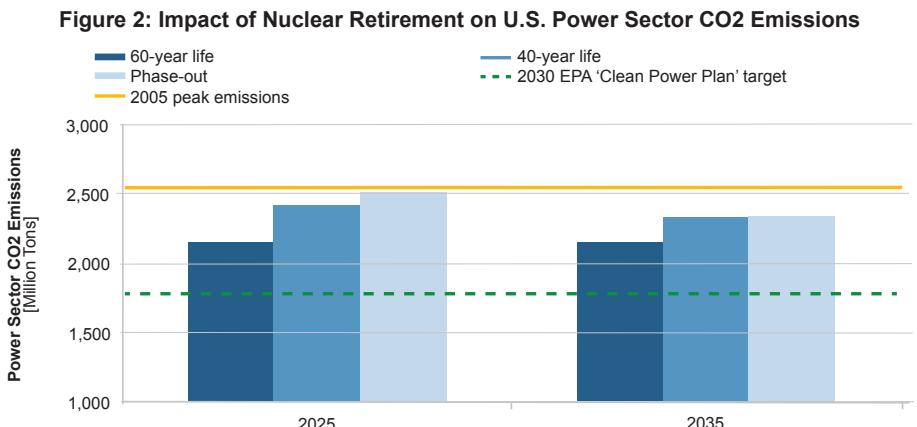
Third Way wrote:

“...it is important to be clear-minded about what renewables can deliver as part of an affordable, reliable, and low-emissions electricity system. Despite tremendous technological advances in renewable generation, storage, and transmission, there are still serious challenges. A large-scale penetration of renewables into the power grid would require:

1. Significant overbuilding of generation to meet demand;
2. Costly grid upgrades and storage expansion;
3. Storage that might not be available in time; and
4. A huge build-out of transmission infrastructure.”²⁰

Both Hansen and Third Way highlight the practical constraints to pinning clean energy hopes entirely on renewables. Transitioning to a zero-emissions energy infrastructure without nuclear would involve a 50% greater capital investment, to the tune of \$73.7 trillion dollars globally.²¹ In short, it is becoming increasingly clear that a realistic pathway to emissions reductions within the coming decades must include nuclear, and that every nuclear plant shutdown makes achieving those objectives significantly more difficult, if not impossible.

Section 3: The Environmental Impact of Losing Nuclear Power



The Third Way scenario used to calculate market share by energy generation also calculated the effect on carbon emissions. (See Figure 2)²²

²⁰ Josh Freed, Matt Bennet, and Matt Goldberg, “The Climate Challenge: Can Renewables Really do it Alone?” *Third Way*, last modified December 16, 2016. <http://www.thirdway.org/report/the-climate-challenge-can-renewables-really-do-it-alone>

²¹ Sanghyun Hong, Corey J.A. Bradshaw, and Barry W. Brook, “Global zero-carbon energy pathways using viable mixes of nuclear and renewables.” *Applied Energy* 143 (2015): 451.

²² Brinton and Freed.

The reliability and cost issues associated with replacing carbon-free nuclear with renewables make it likely that natural gas-fueled power plants will be the primary replacement for nuclear power, leading to an increase rather than a decrease in carbon emissions.

As shown in Chart 1B of Section 1, this means the combined gas and coal fossil share of U.S. electricity generation would likely grow to 82%, compared its current share of 69%. Any state that shuts down a nuclear plant may find it difficult to reduce its fossil plant emissions and comply with Clean Power Plan requirements. Third Way notes that **complete shutdown** “...translates to 190 million metric tons of additional CO₂ emissions in 2035, enough to wipe out three-quarters of the reductions the Clean Power Plan aspires to achieve.”²³

The only clear winner in the nuclear shutdown scenario is carbon-emitting natural gas generation. The market share of natural gas generation nearly doubles from 24% to 47%. Third Way’s scenario shows renewables increasing their market share, from 14% to 17%. Coal would decline from 39% to 35%. Because solar and wind generation are intermittent and not dispatchable, reliability concerns may limit the amount of renewables that the electricity markets can absorb. This may require even more gas-fired generation to balance the system for optimal reliability. In addition, renewable electricity generation has expanded in part due to a combination of federal and state tax credits and state renewable mandates. Growth in renewable generation is unlikely without continued economic incentives.

Germany is conducting a rapid nuclear phase-out similar to the Third Way 2035 U.S. scenario. Eight of Germany’s seventeen reactors have been shut down and replaced with coal and solar as part of a cap-and-trade policy, which will cost the German government an estimated \$1.2 trillion U.S. dollars. However, the German electricity market still needs consistent, reliable power, and so it is buying nuclear power from France, natural gas from Russia, and building more coal plants at home.²⁴ This outcome is closely aligned with Third Way’s projections for the U.S. Germany’s nuclear phase-out so far has resulted in an increase in carbon emissions. A similar phase-out of nuclear in the U.S. could also make electricity markets more reliant on natural gas and coal, perhaps exceeding the 82% share forecast by Third Way. **This will expose electricity consumers to fuel price fluctuations, higher prices, and potentially even outages.** This is especially true during high-stress events, such as extended heat or cold waves like a polar vortex, as natural gas pipelines face volume or temperature constraints during periods of high demand.

Shutting down the current U.S. nuclear fleet would also increase the emission of hazardous air pollutants, such as nitrogen oxides (NO_X), sulfur dioxide (SO₂), and particulates as shown in Table 1. These impacts are not limited to the state where the plant is located and would result in regional, national, and global pollution.

²³ Brinton and Freed.

²⁴ “Sen. Lamar Alexander, ‘The United States Without Nuclear Power,’ ” Nuclear Energy Institute, last modified Feb. 5, 2015. <http://www.nei.org/News-Media/Speeches/Sen-Lamar-Alexander,-%E2%80%9CThe-United-States-Without-Nu>

Table 1. Value of Emissions Prevented by the U.S. Nuclear Industry
 (Average Annual, 2015-2024)²⁵

Pollutant	Avoided Emissions (thousands of tons)	Emissions Cost per Ton (\$/ton)	Avoided Emissions Value (Billions of 2015 Dollars)
CO2	573,160	\$43	\$24.82
SO2	1,055	\$6,789	\$7.16
NOx	657	\$1,873	\$1.23
PM 2.5	64	\$11,119	\$0.71
PM 10	78	\$538	\$0.04
Total			\$33.97

Third Way's scenario did not assume more tax and other incentives for renewables. However, the production tax credit for wind and the investment tax credit for solar have been extended.²⁶ As a 2013 study by the National Renewable Energy Lab found, "Renewable energy development, to date, has mostly been in response to state mandates."²⁷ However, even if federal and state incentives continue, "it is unlikely that renewables could pick up all the slack left by retiring nuclear units" due to the massive costs behind the rapid infrastructure expansion necessary to generate more renewable power.²⁸

In short, shutting down nuclear plants would prevent significant progress in U.S. efforts to reduce carbon emissions. Carbon-emitting natural gas generation is the short-term predominant replacement for nuclear, as it would be difficult to grow the renewable sector fast enough to match nuclear's current level of carbon-free electricity. **If this scenario occurs, carbon emissions would revert to their peak 2005 levels, undoing a decade's worth of progress in carbon reduction.**²⁹

Section 4: The Socioeconomic Impact of Losing Nuclear Power

Nuclear plants make a considerable contribution to the U.S. economy as a whole, as summarized in Table 2, page 10. Nationwide, nuclear energy supports \$12.1 billion dollars in federal and state tax revenues and approximately 475,000 jobs. In addition, the U.S. nuclear sector boosts employment in surrounding communities through secondary employment. The largest job losses would be in Texas (38,400), New York (26,800), Ohio (21,600), Pennsylvania (20,900), and Illinois (19,300).³⁰ Finally, nuclear power accounts for billions of dollars of output in a variety of sectors, including manufacturing (\$26.4 B), construction (\$11.6B), and real estate (\$9.4B).³¹

²⁵ Berkman and Murphy, 14.

²⁶ Katie Tubb, "Why We Shouldn't Keep Subsidizing Wind And Solar," *Daily Signal*, December 14, 2015. <http://dailysignal.com/2015/12/14/5-reasons-why-we-shouldnt-keep-subsidizing-wind-and-solar-energy/>

²⁷ "NREL Study Suggests Cost Gap for Western Renewables Could Narrow By 2025," NREL, last modified August 23, 2015. <http://www.nrel.gov/news/press/2013/2283>

²⁸ Brinton and Freed.

²⁹ Ibid.

³⁰ Berkman and Murphy, 10.

³¹ Ibid.

Table 2. The contributed value lost in a nuclear power shutdown³²

Contribution	Potential Lost (U.S.) ³³
Gross domestic product	\$103 billion annually in gross output
Full time jobs	475,000
Saved electricity costs	Average wholesale rates would be \$4.18/MWh (10%) higher and average retail rates would be about 6% higher
Tax revenue	\$9.9 billion annually in federal tax revenues
State and local taxes	\$2.2 billion in state tax revenues
Avoided CO ₂ Emissions	573 million tons annually, with a societal value of \$25 billion/yr based on federal estimates

Without nuclear plants, “the economy would rely more heavily on existing and new natural gas-fired generating plants, and to a lesser extent, more generation from existing coal-fired plants.”³⁴ This greater use of fossil generation would mean higher electricity prices for the general public.

While these economic impacts are spread broadly across the country, the shutdown of a nuclear plant has severe negative socioeconomic consequences for the host community. Local government and citizens alike are impacted by the loss of taxes nuclear power plants pay, but also by the taxes the employees generate for the state and the revenue they generate for local businesses. As studies have noted, “as nuclear plants close down, state and local governments struggle to maintain budgets through tax increases and the use of reserve funds...the decrease in quality of life faced by the small town is a uniquely human impact that cannot be ignored.”³⁵ Decisions to close nuclear power plants in the past tended to ignore the effects on their local communities, especially those in rural areas. In many ways, communities where nuclear power plants close face the same kinds of issues as do those that lose military bases, hospitals, or government installations. However, because of the lengthy process of decommissioning the reactors, demolishing the structures, and preparing the land for public use, communities are left with sites that are difficult to revitalize.

The impact of plant closures varies from community to community, but all face negative consequences. Maine Yankee closed in 1996, but its hometown of Wiscasset, Maine, is still feeling the effects. The town’s 3,700 residents are currently struggling with rapidly increasing property taxes, a poverty rate that has doubled, and a declining ability to provide basic services for free. “I have yet to meet anyone happy that Maine Yankee is gone,” said Laurie Smith, the town manager. “All these years later, we’re still feeling the loss of jobs, the economic downturn, and the huge tax increases.”³⁶ The plant’s taxes paid about 96% of the town’s budget until 1996,

³² Berkman and Murphy.

³³ Ibid.

³⁴ Ibid, 6.

³⁵ Melissa Haller, “The Socioeconomic Effects of Decommissioning on Local Communities: A Media Framing Analysis of the Experience of Wiscasset, Maine.” *Middle States Geographer* 47, 2014: 48-59.

³⁶ David Abel, “Its nuclear plant shut, Maine town full of regret,” *Boston Globe* (Boston, MA), September 18, 2013.

and the owners remain the largest payer of property taxes in the area, as Wiscasset officials struggle to find a business willing to take over the decommissioned plant.³⁷ This phenomenon is not unique to Maine Yankee. The Keweenaw Power Station in Keweenaw, Wisconsin, supported over 1,000 jobs, producing \$85.5 million in income and over \$6 million in state and local taxes, all of which was lost upon closure.³⁸ Vernon, Vermont, faces similar struggles: the Vermont Yankee plant recently shuttered and the residents of Vernon now face mass unemployment and the loss of about half the town's tax revenues.³⁹

Keweenaw and Vermont Yankee provide stark warning signals for future plant closures. The planned closure of Entergy's Pilgrim Nuclear Power Station in Massachusetts will eliminate 600 jobs at an annual payroll of \$77 million dollars and put 500 jobs in local businesses at severe risk. Additionally, Pilgrim was a prolific contributor to local nonprofits; these organizations will see \$300,000 less per year when it closes.⁴⁰ New York State's FitzPatrick plant also faces similar economic losses: 600 jobs, along with a \$70 million+ dollar impact on the local and state economies, will disappear.⁴¹

Conclusion

At 19% of the current national electricity market, nuclear power is a vital part of United States electricity production and is critical to meeting national carbon emissions targets. It is a reliable power source which provides positive long-term economic benefits to the regions it serves at a low environmental impact. However, it is currently threatened. State and federal policies, as well as deregulated electricity markets that fail to reward the positive attributes and public benefits of nuclear power, have been causing nuclear plant owners to shut down unprofitable reactors, forcing the public to get electricity from fossil generators with carbon emissions. Without nuclear power, Americans would pay higher prices for their electricity, and U.S. Gross Domestic Product and job growth would be negatively impacted. No other form of electricity generation can replace nuclear power's low-cost, emissions-free, dispatchable, reliable electricity production.

³⁷ Ibid.

³⁸ "Market-Driven Reactor Shutdowns Threaten Local Economies," *Nuclear Energy Institute*, February 2015, <http://www.nei.org/Master-Document-Folder/Backgrounders/Fact-Sheets/Market-Driven-Reactor-Shutdowns-Threaten-Local-Eco>

³⁹ Abel.

⁴⁰ James A. Rousmaniere Jr., "Local economies take a hit when nuclear plants close," *Boston Globe* (Boston, MA), October 17, 2015.

⁴¹ John T. Sullivan Jr., "New York Power Authority should buy FitzPatrick back," *Syracuse Herald Journal* (Syracuse, NY), November 3, 2015.

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