

Bicameral Nuclear Energy Caucus Report

2017-2018 Session

Co-Chairs

Senator Ryan P. Aument

Senator John T. Yudichak

Representative Becky Corbin

Representative Robert F. Matzie

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1. About the Nuclear Energy Caucus

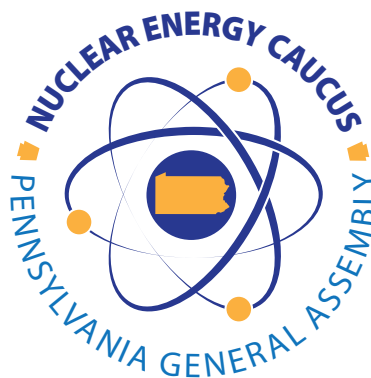
On March 16, 2017, Senators Ryan Aument (R-Lancaster) and John Yudichak (D-Carbon/Luzerne) along with Representatives Becky Corbin (R-Chester) and Rob Matzie (D-Allegheny/Beaver) announced the formation of the Pennsylvania Nuclear Energy Caucus (“NEC” or “caucus”) a bi-partisan, bi-cameral caucus of Pennsylvania’s General Assembly to focus on nuclear energy issues.

The caucus, the first nuclear caucus in a state legislature in the history of the United States, was formed to give members of the General Assembly an opportunity to become more educated about nuclear energy’s importance to the Commonwealth’s energy portfolio, economy, and environment.

To date, the caucus has over 75 members and has hosted numerous educational meetings and tours of the Commonwealth’s nuclear facilities, has supported pro-nuclear resolutions in the State Senate and House of Representatives, and has weighed in as a collective body with the regional electric grid operator, PJM, and with the U.S. Federal Energy Regulatory Commission (“FERC”) on issues relevant to the preservation of Pennsylvania’s nuclear industry.

The guiding principles of the Nuclear Energy Caucus are to:

- Promote nuclear energy as a clean, safe, reliable and affordable source of electricity to power Pennsylvania’s economy and achieve environmental goals.
- Advocate for the Commonwealth of Pennsylvania to recognize nuclear energy’s zero carbon emission attributes, similar to other zero carbon technologies.
- Promote and seek to preserve the positive contributions the nuclear industry provides to the Commonwealth’s economy through employment at the nuclear plants, indirect employment through vendors and contracted labor, civic and philanthropic engagement, and taxes paid by the industry’s workforce and businesses.



2. Report Transmittal Letter from Nuclear Energy Caucus Co-Chairs

TO: Members of the General Assembly

FROM: Chairs of the Nuclear Energy Caucus:
 Senator Ryan Aument
 Senator John Yudichak
 State Representative Becky Corbin
 State Representative Rob Matzie

Subject: Report on the Findings of the Bicameral Nuclear Energy Caucus during the 2017-2018 Session of the Pennsylvania General Assembly

Pennsylvania is the second largest nuclear capacity state in the nation and is home to nine nuclear reactors at five nuclear power plants – Beaver Valley Nuclear Power Station in Beaver County, Susquehanna Nuclear Power Station in Luzerne County, Three Mile Island Unit-1 Generating Station in Dauphin County, Peach Bottom Atomic Power Station in York County, and Limerick Generating Station in Montgomery County.

The power produced by these five nuclear plants represents 42% of the Commonwealth's total electricity production and just over 93% of Pennsylvania's zero-emission energy.

The nuclear industry supports 16,000 jobs in Pennsylvania and contributes more than \$2 billion annually to the Commonwealth's gross domestic product.¹ Promoting and preserving these important benefits provided to our citizens by our Commonwealth's nuclear industry are precisely the reason the Nuclear Energy Caucus was created.

Exelon's May 2017 announcement that its Three Mile Island ("TMI") plant will prematurely retire² in September of 2019, was news that created a great deal of distress both in the community around the plant and with members of the caucus.

Here are an independent consultant's findings about the nuclear power industry in Pennsylvania:³

Our analysis has determined that the nuclear plants operating in Pennsylvania :

- **Contribute approximately \$2 billion to state gross domestic product ("GDP")** (\$3.1 billion in gross output).
- **Account for 15,900 in-state full time jobs** (direct and secondary).
- **Help keep electricity prices low.** Pennsylvania consumers would pay \$788 million more annually (2016\$) and \$6.6 billion more over the next ten years (on a present value basis) without these plants.
- **Are responsible for \$69 million in net state tax revenues** annually.
- **Avoid over 37 million tons¹ of CO₂ emissions annually** over the next ten years, valued at \$1.6 billion per year.
- **Avoid significant amounts of criteria pollutants annually**, valued at \$260 million per year over the next ten years.

The concern about TMI's imminent closure was exacerbated by FirstEnergy's announcement, in March 2018, that it would be prematurely retiring its Beaver Valley Nuclear Power Station in 2021.

¹ Pennsylvania Nuclear Power Plants' Contribution to the State Economy (The Brattle Group, 2016)

² Power plant engineers may think a power plant retired prematurely if it has not yet run to the end of its nominal design life (for instance, approximately 40 years for post-1970 coal plants) or through the term of reasonable plant life extension modifications. Nuclear or hydroelectric plant owners and regulators may think a power plant has retired prematurely if it has not yet run through the full term of its operating license and/or license extension. Federal Energy Regulatory Commission (FERC) hydro licenses run for up to 50 years with potential reauthorizations of 30–50 years, and Nuclear Regulatory Commission (NRC) nuclear operating licenses run for 40 years with potential 20-year extensions. Source: Staff Report on Electricity Markets and Reliability, United States Department of Energy, August, 2017, pg. 7.

³Ibid., 1.

According to the plants' owners, these two plants together directly employ more than 1,500 Pennsylvanians and provide millions of labor hours for thousands of contract workers in the building and construction trades. The loss of both Beaver Valley and TMI, coupled with continuing and unmitigated financial pressures being applied by a dysfunctional wholesale electric market is something that members of the caucus fear could be a devastating and permanent blow to Pennsylvania's economy and environment.

Both plants are being retired well before their current operating licenses are set to expire⁴ and once these plants are shut down, there is no mechanism in place to bring them back into operation. The unfortunate bottom line is that once these plants close, Pennsylvania will lose all the jobs and other benefits they provide, forever.

One of our top priorities in creating the Nuclear Energy Caucus was to ensure our members are educated about the value the nuclear energy industry provides Pennsylvania and our citizens.

As state lawmakers, we take seriously our obligation to set energy policies that help promote Pennsylvania's economy and protect our environment.

On the heels of these shutdown announcements, the caucus sought to understand the underlying causes for their premature retirements, and to determine if these announced closures were an anomaly or if they are a symptom of a larger problem for Pennsylvania's nuclear industry.

The caucus also sought to understand the employment, economic, and environmental impacts associated with the shutdowns and determine if there are any actions the General Assembly or the Commonwealth has or should be undertaking to prevent the premature closure of these plants. The caucus began to host a series of meetings with industry stakeholders and subject matter experts to find answers to these questions.

The first meeting held by the Nuclear Energy Caucus in 2018, following the Beaver Valley announcement, featured a timely industry update from Pennsylvania's nuclear station owners, including FirstEnergy Solutions, Talen Energy and Exelon.⁵

The companies provided their view that, despite operating these facilities at world-class levels of efficiency, they are shortchanged by a marketplace and federal and state policies that do not compensate these plants for the environmental and grid-resilience benefits they provide.

Environmental Benefits – Pennsylvania's nuclear power plants prevent substantial emissions of CO₂, SO₂, NO_x, and particulate matter, compared to the alternatives of natural gas and coal-fired generation that would replace them.

Grid Resilience and Reliability – Unlike natural gas or coal-fired power plants, nuclear plants do not rely on pipelines or train cars to provide a lifeline of fuel to generate electricity. Rather, nuclear plants can run 24/7 for 18-24 months without refueling. The 2014 "Polar Vortex" and the "Bomb Cyclone of 2018" cold weather events were illustrative of nuclear's value to the resilience of the grid.

Dr. Dean Murphy of the Brattle Group also participated in this first meeting to give the caucus an overview of the findings of their report, *Pennsylvania Nuclear Power Plants' Contribution to the State Economy*.

In his comments, Dr. Murphy reinforced the companies' claims and reported that the Brattle study found "*absent Pennsylvania's nuclear plants, Pennsylvania consumers would pay significantly more for electricity, the economy would suffer both in terms of Gross Domestic Product (GDP) and jobs, and there would be substantially higher emissions of CO₂ and other pollutants.*"

The caucus' second meeting last spring focused on the job losses that would result from nuclear plant shutdowns.

Representatives from state and regional building trades councils presented their views of the devastating impact plant closures will have on the livelihoods of their members. The panel of Pennsylvania's labor leaders was unanimous in its view that the work opportunities provided by the nuclear industry are critically important to the careers of the building trades workers because of the sustained nature of the work and the frequent succession of temporary assignments.

⁴ Beaver Valley Power Station Unit 1 is licensed to operate until 2036 and Unit 2 is licensed through 2047. Three Mile Island Generating Station Unit 1 is licensed to operate until 2034.

⁵The Nuclear Energy Caucus convened a year earlier by hearing from grid operator PJM on April 26, 2017.

They shared that nuclear power plant maintenance is especially significant to the building trades given the amount of labor required during each maintenance outage. The panel pointed out that the General Assembly often jumps at the opportunity to find ways to attract jobs to Pennsylvania and encouraged the caucus to consider the opportunity to preserve nearly 16,000 nuclear industry jobs in Pennsylvania as an equally important priority.

The caucus later hosted a meeting with both national and statewide environmental organizations to hear their views on the impact nuclear plants have on Pennsylvania's air quality and their concerns about the negative impact the premature plant shutdowns will have on our environment. The organizations represented at the meeting were the Pennsylvania Environmental Council, the Environmental Defense Fund, the Center for Climate and Energy Solutions, and the Union of Concerned Scientists.

All four of the organizations agreed that the premature shutdown of a nuclear plant would set back Pennsylvania's air quality decades in terms of emission reductions, particularly for carbon emissions. They cited a recent study that showed that nuclear plant closures in Pennsylvania and Ohio (Beaver Valley, Three Mile Island, Davis-Besse and Perry) will increase CO₂ emissions about 21 million metric tons per year, which is the equivalent of increasing cars on Pennsylvania's roads by 50%, virtually erasing 25 years of progress in the development of wind, solar, and other zero-emission resources in the region.

Each one of the environmental groups recommended Pennsylvania should focus on emission outcomes and put in place clear regulatory requirements to ensure those outcomes are met.

For example, they suggested placing a price on carbon and setting carbon reduction targets would allow the market the ability to determine how best to achieve those environmental goals.

Finally, the caucus hosted a meeting to discuss the topic of nuclear energy's value to grid resilience and national security.

Expert testimony was offered by Dr. Paul Stockton, former Assistant Secretary of Defense for Homeland Defense and Americas' Security Affairs, as well as

Edward McGinnis, Principal Deputy Assistant Secretary, Office of Nuclear Energy, United States Department of Energy.

Dr. Stockton and Deputy Assistant Secretary McGinnis vividly outlined why nuclear energy is a critical component to America's overall national security interests noting that the United States' dominance in nuclear energy has allowed the U.S. government to set best practices for nuclear nonproliferation around the world, exert geopolitical influence, and support the U.S. naval propulsion program and nuclear weapons program.

The caucus also reviewed a recently released report, *Back from the Brink: A Threatened Nuclear Energy Industry*, which summarized the negative consequences of losing the commercial nuclear sector relative to U.S. national security objectives.

Finally, the caucus was made aware of a letter from more than 70 national security experts, including former Pennsylvania Governor and U.S. Homeland Security Director, Tom Ridge, urging the U.S. Department of Energy to, "take concrete steps to ensure the national security attributes of U.S. nuclear power plants are properly recognized by the policymakers and are valued in U.S. electricity markets."

In addition to these in-person meetings, members of the caucus have met with and/or corresponded with various experts in the fields of energy policy, national security and grid resilience, wholesale electricity markets, and economics, and all have shared valuable information that has helped the caucus compile the most comprehensive record of the challenges facing the nuclear industry and the impacts these challenges will have on the Commonwealth.

This report contains all this information. It is our hope that our colleagues in the General Assembly will benefit from the information the caucus has collected on this very important topic.

Where to Go from Here

Throughout the 2017-2018 Regular Session of the Pennsylvania General Assembly, various opportunities arose for the caucus and its Chairs to voice our support for Pennsylvania's nuclear industry and to correspond with its regulators about our collective concern for the

future of the industry and encourage them to take actions to address the inequity in the treatment of these resources. In a letter to the PJM Board of Managers, dated February 9, 2018, we cautioned that:

While Pennsylvania currently benefits from numerous sources of electric generation – including coal, nuclear, natural gas, hydroelectric, and renewables – we are losing confidence in the ability of the wholesale electric markets to ensure Pennsylvania maintains a diverse supply of baseload generation resources that ensures stable prices for our citizens and a reliable and resilient electrical grid. Pennsylvania’s baseload power plants continue to face the risk of premature retirement, and we do not see expeditious and sufficient action being taken by PJM or the Federal Energy Regulatory Commission (“FERC”) to correct the market flaws at the heart of this problem – flaws that PJM itself acknowledges.

The caucus leadership was also successful in encouraging the members of the General Assembly to overwhelmingly adopt resolutions calling on FERC to take swift action to address concerns about the loss of baseload generation and its impact on grid diversity and resiliency.

The October 2017 resolutions (SR227 and HR576) recognized that *“absent market reforms to properly compensate generators for currently uncompensated attributes, generation (including nuclear generation) in Pennsylvania is at severe risk of premature retirement.”*

In further efforts to encourage FERC to work towards a solution, the caucus leadership penned a letter to the Pennsylvania Public Utility Commission (“PUC”) asking the PUC to submit comments to FERC opposing PJM’s market reform proposals.

As we noted in our letter, both proposals were seriously flawed because they were designed to undermine state efforts to value the environmental and resiliency attributes of nuclear generation. Should these PJM proposals be adopted our Commonwealth’s ability to successfully achieve these important goals would be lost. The PUC in fact weighed in as requested with the FERC and FERC has recently rejected PJM’s flawed proposals.

In their rejection, FERC decided to do something dramatic to call the question of whether or not states really want to participate in wholesale power markets and to either push them back to reregulation or force them to find a way to price in the attributes (environmental, reliability, etc.) they want the markets to procure. PJM will have to develop a solution to this problem, and the Commonwealth will have an opportunity to influence PJM and encourage them to learn from their past mistakes of ignoring state preferences when developing solutions.

As the Chairs of the Nuclear Energy Caucus, we sought to be more than a cheering section for the industry. We were willing to do the hard work of seeking answers to these pressing questions to arm our fellow members with the information necessary to craft a real solution.

Of this we are now certain, that solution cannot be a federal, state, or regional solution alone.

The solution will require leadership decisions to be made at all levels if we are to retain these valuable assets that benefit our Commonwealth.

Therefore, this report not only contains information about the impact of premature plant shutdowns, but it also contains background on solutions other states have successfully implemented that have survived legal challenge. Other states have decided not to wait for help from PJM or Washington, D.C., and have taken matters into their own hands.

It is the view of the Chairs of this caucus that a similar path may be necessary in Pennsylvania, but that is a decision we will have to make as a collective body along with the Governor.

We look forward to continuing this discussion in the 2019-2020 session.

NEC Activities 2017-2018

March 16, 2017 – Lawmakers announce formation of first ever Nuclear Energy Caucus

March 28, 2017 – Op-Ed: Nuclear Energy: A Keystone for Pennsylvania’s Economy and Environment

April 26, 2017 – Nuclear Energy Caucus hosts hearing with PJM Interconnection, LLC

May 30, 2017 – Nuclear Caucus Chairs issue statement on announcement of closure of Three Mile Island Nuclear Generating Station

October 23, 2017 – Sen. Aument and Sen. White to FERC: Fuel-Secure Baseload Generation at Real Risk

February 9, 2018 – Nuclear Energy Caucus Co-Chairs send letter to PJM Interconnection expressing frustration and concern over current market constructs and requesting expeditious consideration of energy price formation proposal

March 29, 2018 – PA Nuclear Energy Caucus Chairs react to FirstEnergy Nuclear Plant deactivation notices

April 17, 2018 – Nuclear Energy Caucus hosts meeting on nuclear plant operators, and briefing from Brattle Group on economic and environmental consequences of nuclear station closures

April 26, 2018 – Nuclear Energy Caucus Co-Chairs and Chairman of the Senate Consumer Protection and Professional Licensure and House Consumer Affairs Committee forward letter to the PA Public Utility Commission requesting their intervention in FERC proceeding that would eliminate state rights

May 27, 2018 – Nuclear Energy Caucus hosts meeting to discuss the value of nuclear power to Pennsylvania labor

June 19, 2018 – Nuclear Energy Caucus hosts meeting to discuss impact of nuclear station deactivations on air quality

September 25, 2018 – Nuclear Energy Caucus hosts meeting to discuss energy and national security issues.

October 1, 2018 – Nuclear Energy Caucus hosts meeting to receive update from PJM Interconnection and nuclear station operators

3. Pennsylvania's Nuclear Energy Industry

Summary:

- Nuclear energy is the largest source of electricity in the Commonwealth.
- The nuclear energy industry supports nearly 16,000 Pennsylvania jobs.
- It adds \$2 billion annually to state Gross Domestic Product ("GDP").
- Pennsylvania's nuclear plants prevent over 37 million metric tons of CO₂ emissions annually.
- They avoid air pollutants (NO_x, SO₂, PM₁₀ and PM_{2.5}) whose adverse effects would otherwise cost the Commonwealth the equivalent of \$260 million annually.
- If announced early closures proceed, Pennsylvania will lose one fourth of its nuclear power by 2021.

Figure 1: Location of Pennsylvania Nuclear Plants



Source: The Brattle Group. Pennsylvania Nuclear Power Plants' Contribution to the State Economy. Dec. 2016.

Deeper Dive:

Pennsylvania has nine nuclear energy reactors at five sites (Figure 1). Pennsylvania's nuclear power plants provide 9,600 MW of reliable capacity. They generate 83 million MWh of electricity a year, comprising 42% of the state's generation - enough to power 57% of the state's

electricity use - and 93% of the state's emissions-free energy.⁶ In Pennsylvania, nuclear produces more electricity than either natural gas or coal, and 13 times as much as wind, solar, and hydroelectric combined.⁷

Pennsylvania's nuclear power plants are an anchor to the Commonwealth's economy. The nuclear energy industry supports nearly 16,000 Pennsylvania jobs: over 3,000 full-time jobs directly at the plants, and thousands of others for maintenance during scheduled outages, jobs brought to the areas for manufacturing, and others attributable to resulting economic activity.⁸ Between 2014 and 2016, Pennsylvania's five nuclear plants provided the building trades with nearly seven million man-hours of outage and maintenance work.⁹

Pennsylvania is a net exporter of power to the regional electric grid operated by PJM. This advantageous position, which drives economic activity in the state, is made possible by Pennsylvania's rich energy resources including its nuclear fleet.

A study by The Brattle Group of the impacts of Pennsylvania's nuclear power on the state's economy concluded that it adds two billion dollars annually to state Gross Domestic Product ("GDP").¹⁰ Further, without nuclear power, electricity costs to Pennsylvanians would increase by \$788 million per year. These and other impacts estimated by The Brattle Group are shown in Figure 2 (see next page) and from FirstEnergy Solutions testimony at a Nuclear Energy Caucus hearing on April 17, 2018. The Appendix to Chapter 3 contains profiles of each of Pennsylvania's nuclear plants:

- **Beaver Valley Power Station**, a plant with 1,815 megawatts (MW) located in Beaver County. Unit 1 is licensed to operate until 2036 and Unit 2 is licensed



⁶CY2016 percentage of state's electricity use is 83 TWh Pennsylvania nuclear generation (EIA Electric Power Monthly, Feb. 2017) divided by 145 TWh retail sales (PA PUC Electric Power Outlook for Pennsylvania, Aug. 2017: http://www.puc.state.pa.us/General/publications_reports/pdf/EPO_2017.pdf).

⁷Source: EIA Electric Power Monthly, CY2017 data (February 2018)

⁸The Brattle Group. "Pennsylvania Nuclear Power Plants' Contribution to the State Economy." Prepared by Mark Berkman, Ph.D., and Dean Murphy, Ph.D. for Pennsylvania Building and Construction Trades Council, The Pennsylvania Chamber of Business and Industry, Allegheny Conference on Community Development, and Greater Philadelphia Chamber of Commerce. December 2016.

⁹Martin Williams, Business Manager - Boilermakers Local 13, Philadelphia, Testimony for the Pennsylvania Senate Nuclear Caucus Hearing, May 23, 2018, from data provided by Exelon, FirstEnergy, and Talen Energy.

¹⁰Ibid.

until 2047. On March 28, 2018, Beaver Valley owner FirstEnergy Solutions announced that, without state or federal relief, the Beaver Valley reactors will be shut down in 2021.

- **Limerick Generating Station**, a plant with 2,317 MW located in Montgomery County. Unit 1 is licensed to operate through 2044 and Unit 2 through 2049.



- **Peach Bottom Atomic Power Station**, a plant with 2,700 MW located in York County. Unit 2 is licensed to operate until 2033 and Unit 3 until 2034. Exelon Generation co-owns Peach Bottom 50/50 with Public Service Enterprise Group (PSEG). In July 2018 Exelon filed applications with the Nuclear Regulatory Commission for license extensions to allow the Peach Bottom units to operate until 2053 and 2054.



- **Susquehanna Nuclear Plant**, a plant with 2,600 MW located in Luzerne County. Unit 1 is licensed until 2042; Unit 2 is licensed until 2044. Susquehanna Nuclear LLC (rolls up to Talen Energy/Riverstone Holdings) owns 90% of the plant; Allegheny Electric Cooperative Inc. owns 10%.

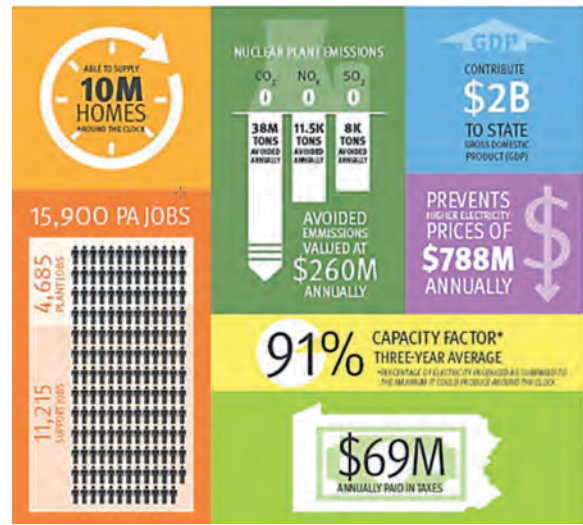


- **Three Mile Island Generating Station**, a plant with 837 MW located in Londonderry Township, Dauphin County. Unit 1 is licensed to operate until 2034. On May 30, 2017, owner Exelon Generation announced that, without policy reforms, Three Mile Island would be closed in September 2019.¹¹



It is not just Three Mile Island and Beaver Valley nuclear generating stations that are at risk of closure.

Figure 2: Impact of Pennsylvania's Nuclear Plants on the State's Economy



Source: Don Moul, President and CNO, First Energy. Testimony to Nuclear Energy Caucus (4/17/18)

It is not just Three Mile Island and Beaver Valley nuclear generating stations that are at risk of closure.

In the 2017 State of the Market Report for PJM, the Independent Market Monitor (“IMM”) estimates that Susquehanna and Peach Bottom did not cover their capital costs in 2016. By 2020, the IMM projects that Susquehanna would not cover industry average capital costs.¹²

Commenting on these findings at the NEC hearing on April 17, 2018, Debra L. Raggio, Senior Vice President, Regulatory & External Affairs Counsel, Talen Energy, said:

“[E]ven though we have not announced shutdown, in the PJM Independent Market Monitor <State of the Market> report . . . shows a financial shortfall for Susquehanna in 2020, looking at whether the plant will cover its avoidable costs including a recovery of capital costs. The IMM’s analysis relies on publicly available pricing data and costs, based upon benchmark information from the Nuclear Energy Institute. In addition, we found that even under generally acceptable accounting principles, GAAP accounting, we would be forecasting a net loss for future years.”

¹¹Three Mile Island Unit 2 is owned by First Energy. The unit is in post-defueling monitored storage. Exelon has an agreement with First Energy to provide oversight of the plant

¹²http://www.monitoringanalytics.com/reports/PJM_State_of_the_Market/2017/2017-som-pjm-sec7.pdf

Stranded Costs: The Nuclear Energy Caucus considered whether stranded cost recovery, which occurred for some nuclear generating assets, should be a factor in evaluating the economics of the plants today.

Although the stranded cost recovery is something that happened more than twenty years ago, we wanted to investigate whether these past payments guaranteed continued operation of the nuclear plants or constituted an argument against intervention now.¹³

Here is what the NEC learned about stranded cost recovery.

Prior to Pennsylvania's 1996 legislation to restructure the state's electric industry, the vertically integrated utilities¹⁴ were granted recovery of capital costs and a rate of return on their generating plant investments. This cost recovery was part of the electricity rates approved by regulators.

The 1996 legislation introduced direct competition and retail choice for electricity suppliers. In the transition, some utilities became eligible for stranded cost payments: the difference between the market value of their generating assets and the value of the plants the utilities still carried on their books for the remaining years of previously approved cost recovery of the investments.

The PUC approved comprehensive settlements for each of the utilities as part of the competitive market policy implementation. Those settlements provided stranded cost recovery for some nuclear assets to some of the utilities in exchange for retail rate reductions and multi-year price caps.

The stranded costs are what economists call "sunk" costs. As such, they are irrelevant to recognizing the future value of the benefits that the nuclear plants will provide.

Moreover, although some utilities received stranded cost payments for their nuclear plants, not all did, because some plants, such as Three Mile Island nuclear generating station and some other generating assets, were sold by the previous owner at prices that were greater than the unrecovered costs. Three Mile Island did not recover

from customers any stranded cost payments.¹⁵

Furthermore, Pennsylvanians have benefitted from competition and retail choice.

Many of Pennsylvania's residential customers benefitted from long-term price caps that protected them from retail price spikes for over a decade. Not only were prices for generation capped, but so were rates for still-regulated transmission and distribution service provided by the restructured local electric utilities.

In all cases consumer benefits far exceeded stranded cost payments, so customers were provided greater value. In addition, restructuring created economic incentives to improve generating plant efficiency, which has also benefitted consumers.

In all cases consumer benefits far exceeded stranded cost payments, so customers were provided greater value. In addition, restructuring created economic incentives to improve generating plant efficiency, which has also benefitted consumers.

In conclusion, Pennsylvania's nuclear plants are the Commonwealth's largest source of electricity. They moderate electricity prices, benefitting Pennsylvania customers an estimated \$788 million per year in lower bills. Lose the state's nuclear plants, and Pennsylvania would have 16,000 fewer good jobs. Air quality would be worse. State GDP would be two billion dollars lower. CO₂ emissions would increase very substantially - by more than 37 million metric tons.

No one disputes the importance of Pennsylvania's nuclear plants in providing reliable, emission-free electricity to millions of households and businesses. However, the plants are at financial risk of early closure. If announced closures proceed, Pennsylvania will lose one fourth of its nuclear power by 2021.

¹³A Policy Choice for Pennsylvania, John Hanger and Philip O'Connor, submitted to Nuclear Energy Caucus, September 5, 2018.

¹⁴A vertically integrated utility is one that owns all levels of the supply chain: generation, transmission and distribution. Historically, all utilities were vertically integrated and had a regulated monopoly on the production and sale of power.

¹⁵Ibid.

Documents in Chapter 3 Appendix:

1. The Brattle Group. *"Pennsylvania Nuclear Power Plants' Contribution to the State Economy."* Report prepared by Mark Berkman, Ph.D., and Dean Murphy, Ph.D. for Pennsylvania Building and Construction Trades Council, The Pennsylvania Chamber of Business and Industry, Allegheny Conference on Community Development, and Greater Philadelphia Chamber of Commerce. December 2016.
2. Fact Sheets for each of Pennsylvania's five nuclear power plants: Beaver Valley, Limerick, Peach Bottom, Susquehanna, and Three Mile Island
3. Martin Williams, Business Manager – Boilermakers Local 13, Philadelphia, Testimony for the Pennsylvania Senate Nuclear Caucus Hearing, May 23, 2018
4. John Hanger and Philip O'Connor stranded costs paper (2018)

4. Epidemic of Premature Plant Shutdowns

Summary:

- Early closures of two Pennsylvania nuclear plants, Three Mile Island and Beaver Valley, have been announced for 2019 and 2021 respectively.
- Up to half the nuclear energy fleet nationally is at risk of early closure.¹⁶
- Market pressures on nuclear power come from low natural gas prices, sluggish growth in electricity demand, subsidized renewable resources, and lack of a national carbon policy.
- Energy markets fail to value an always-there megawatt hour of energy from nuclear any differently from an on-again off-again megawatt hour like wind or solar, and do not compensate for carbon-free electricity production.
- If low-carbon energy is a goal, nuclear energy is cheaper than the alternatives.

Deeper Dive:

In hearings conducted by the Nuclear Energy Caucus, industry, labor, and environmental groups expressed alarm about the epidemic of premature nuclear plant shutdowns.

These shutdowns are eliminating what may be the cheapest, or in some cases the only, options to assure an abundant, low-carbon and secure energy future before policy makers have a chance to map out pathways to achieve these goals.

“It should be a source of profound concern for all who care about climate change that, for entirely predictable and resolvable reasons, the United States appears set to virtually lose nuclear power, and thus a wedge of reliable and low-carbon energy, over the next few decades.”¹⁷

Nationally, five nuclear power plants closed between 2013 and 2016. The loss of energy from these plants is the equivalent of all the solar power in the country combined.¹⁸ 16,000 MW (about 16% of the nation’s nuclear capacity) have either closed already or announced early shutdown. Another 12,000 MW are at risk, as shown in Table 1.

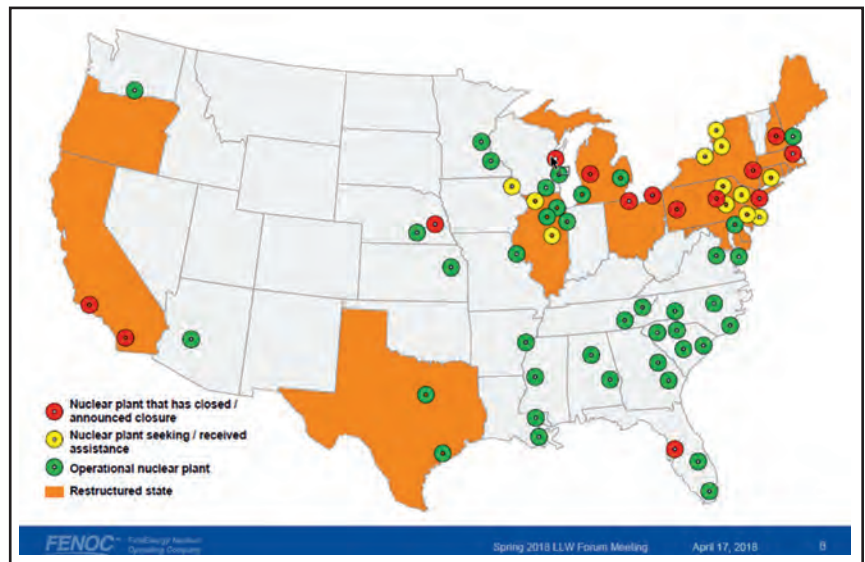
Table 1: Nuclear Plants at Risk of Early Closure

Category	Nuclear Plants	Capacity (MW)	Generation (GWh)
Retired	Crystal River, Fort Calhoun, Kewaunee, Sah 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	8,189	50,044
Repreived	Clinton, Fitzpatrick, Ginna, Nine Mile Point, and Quad Cities	6,232	50,388
"At-Risk" Nuclear Total:		28,204	228,045

Source: ScottMadden, *While You Were Sleeping: The Unnoticed Loss of Carbon-free Generation in the United States* (April 2018)

Premature nuclear plant shutdowns are not unique to Pennsylvania; they have occurred in or are announced in ten other states. The locations of nuclear plants at risk are shown in Figure 3.

Figure 3: Nuclear Plants Closing in Restructured States



Source: Don Moul, President and CNO, First Energy. Testimony to Nuclear Energy Caucus (4/17/18)

¹⁶Bloomberg New Energy Finance. *Half of U.S. Nuclear Power Plants are Underwater*. (6/13/2017)

¹⁷M. Granger Morgan et al. *US nuclear power: The vanishing low-carbon wedge* (July 2, 2018)

¹⁸David Roberts, Vox, *The Simple Argument for Keeping Nuclear Power Plants Open* (April 5, 2018)

Some states have acted and averted plant retirements, while other states did not prevent premature plant closures. When nuclear plants retire, some dislocated workers move out of state to nuclear plants whose future is more secure.

Economic risks of operating nuclear plants are nothing new, but technological developments, structural changes and other pressures have made the last few years especially challenging.¹⁹

Low natural gas prices provide short-term gains, which are appreciated, but these prices fail to factor in the larger picture of fuel diversity and long-term carbon emission reductions.

- On the revenue side, wholesale power prices came down sharply from the high levels of 2006-2008 and have never recovered to their prior levels. An influx of low-cost natural gas from shale production has brought prices lower. Low natural gas prices provide short-term gains, which are appreciated, but these prices fail to factor in the larger picture of fuel diversity and long-term carbon emission reductions.²⁰ In addition, electricity demand has stagnated, mostly due to changes in the structure of the economy such as the failure of industrial demand to fully recover from the deep recession in 2008-2009. Additionally, transmission constraints cause congestion and low prices around some nuclear units. For example, wind generation is built in areas of low demand and stays bottled there because of insufficient transmission to move it where power is needed. Throughout this period, wholesale prices have remained low.
- On the cost side, growth in costs has out-paced growth in power prices, leading to thin or non-

existent cash margins. These costs keep up with commitments to safety, training and hardening for potential extreme events.

- For many years, a price on carbon was being seriously considered by lawmakers and regulators, but markets remain generally unable to recognize the low carbon value of nuclear generation.
- Distressed Assets: Certain nuclear units have especially challenging economics due to cost structure, most especially the smaller stand-alone plants, such as Three Mile Island. When they bid in enough to cover the gap in their costs and energy revenues in the capacity markets, they do not clear PJM's²¹ Base Residual Auction.
- Favored Technologies Exclude Nuclear: Some state laws pick technology winners, and usually these laws favor several zero carbon resources but not nuclear. This is true of Pennsylvania's Alternative Energy Portfolio Standards Act ("AEPS"). In addition, out of market subsidies to non-nuclear technologies have had an impact on energy prices around many nuclear units. The Federal Production Tax Credit has incentivized the build-out of wind in the Midwest that would not have been supported by energy and capacity markets alone. The Federal Production Tax Credit pays per MWh of wind generated, regardless of energy price at the time. Thus, wind can run at negative prices and still make money. Some nuclear units experienced negative prices during off-peak hours, in part from this effect.

Indicative of the severity of the crisis for PJM's nuclear generation, in May 2018 more than one third of PJM's nuclear power capacity failed to clear the capacity auction for 2021-2022, including the Beaver Valley and Three Mile Island nuclear plants. In just a year, the nuclear capacity that failed to clear the PJM capacity auction increased by more than 200 percent.²²

¹⁹Jesse D. Jenkins. *What's Killing Nuclear Power in U.S. Electricity Markets?* MIT Center for Energy and Environmental Policy Research. (January 2018)

²⁰Third Way, *Nuclear Closures Undo Years' Worth of Climate Progress* (April 10, 2018)

²¹PJM, founded in 1927, is charged with ensuring the reliability of the high-voltage electric power system serving 65 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM coordinates and directs the operation of the region's transmission grid, which includes 84,042 miles of transmission lines; administers a competitive wholesale electricity market (including the capacity market); and plans regional transmission expansion improvements to maintain grid reliability and relieve congestion.

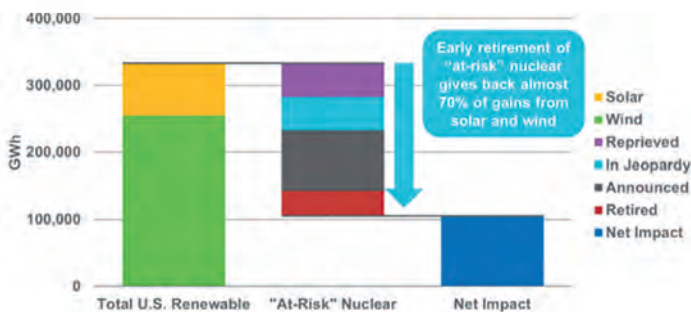
²²PJM Power Auction Foretells Potentially Disastrous Environmental Impact (May 2018)

Actions that other states are taking to achieve their own energy and economic goals may sometimes impinge on Pennsylvania nuclear assets.

Several nearby states are accelerating clean energy production, and that can further stress baseload energy assets in the region. A similar situation is occurring in Arizona, where baseload generation is under stress in part due to renewable energy policies in California, which during some times of day send electricity prices below zero in neighboring Arizona. Arizona will consider a ballot measure to increase its renewables requirement from 15% by 2025 to 50% by 2030. As an alternative, Commissioner Andy Tobin of the Arizona Corporation Commission (“ACC”) has proposed an 80% by 2050 clean energy standard which includes nuclear in the mix. When nuclear plants retire, it undoes the clean energy progress made by years of renewable investments.

This is seen on a national level in Figure 4. The loss of nuclear carbon-free generation reverses most of the gains from wind and solar.²³

Figure 4: Change in U.S. Carbon-Free Generation



ScottMadden *While You Were Sleeping: The Unnoticed Loss of Carbon-free Generation in the United States* (April 2018)

Nuclear power is cost-effective in comparison with other ways of achieving a low carbon energy mix.

“In most cases, electricity produced by existing nuclear reactors is cheaper than alternative sources of clean energy, such as new wind or solar power. Today’s power markets do not fully value the climate and grid benefits of America’s nuclear fleet – something that state and federal policymakers should resolve, as they have for other important sources of clean energy like wind and solar.”

Amber Robson, *Third Way* (12/08/16)

It is less expensive to operate the average existing nuclear plant than it is to build new wind or solar generation.

Documents in Chapter 4 Appendix:

1. Nicholas Steckler. *Half of U.S. Nuclear Power Plants are Underwater*. Bloomberg New Energy Finance (6/13/2017)
2. M. Granger Morgan et al. “*US nuclear power: The vanishing low-carbon wedge*” Carnegie Mellon University’s Department of Engineering and Public Policy. In *Proceedings of the National Academy of Sciences of the United States (PNAS)* July 2, 2018 www.pnas.org/cgi/doi/10.1073/pnas.1804655115 <http://www.pnas.org/content/early/2018/06/26/1804655115>
3. David Roberts, *Vox*, *The Simple Argument for Keeping Nuclear Power Plants Open* (April 5, 2018)
4. Scott Madden, *While You Were Sleeping: The Unnoticed Loss of Carbon-free Generation in the United States* (April 2018)
5. Jesse D. Jenkins. *What’s Killing Nuclear Power in U.S. Electricity Markets?* MIT Center for Energy and Environmental Policy Research. (January 2018)
6. Third Way, *Nuclear Closures Undo Years’ Worth of Climate Progress* (April 10, 2018)
7. *PJM Power Auction Foretells Potentially Disastrous Environmental Impact* (May 2018)
8. Amber Robson. *Preserving America’s Clean Energy Foundation*. Third Way (12/8/16)

²³Third Way, *Nuclear Closures Undo Years’ Worth of Climate Progress* (April 10, 2018)

5. Premature Plant Shutdowns: Jobs, Economy and Consumer Impacts

Summary:

- Announced closures of the Beaver Valley and Three Mile Island nuclear plants will eliminate thousands of steady good-paying jobs.
- Nuclear plants are typically the largest employer in their communities. Plant closures drain the community of tax base and resources and harm local schools, services, and businesses.
- Pennsylvania electricity customers will pay \$285 million more annually on their power bills if Beaver Valley, Three Mile Island, and two Ohio nuclear plants close as announced.

Deeper Dive:

Nuclear power plants contribute nearly \$2 billion to Pennsylvania's gross domestic product and account for approximately 16,000 direct and indirect full-time jobs. Nuclear plants keep Pennsylvania electricity prices lower by approximately \$788 million per year and are responsible for more than \$400 million in annual state and federal tax collections.²⁴ These estimates are from modeling conducted by The Brattle Group using REMI, a widely-used dynamic input-output model of the U.S. economy.²⁵

Nuclear power plants contribute nearly \$2 billion to Pennsylvania's gross domestic product and account for approximately 16,000 direct and indirect full-time jobs.

Negative economic impacts resulting from the early retirement of the Three Mile Island and Beaver Valley nuclear generating stations would be considerable. The Brattle Group modeled these impacts, coupled with impacts from the early closures of the Davis-Besse and Perry nuclear plants announced by FirstEnergy at the same time as Beaver Valley.



“The four plants considered here employ over 3,000 people directly, as well as other non-employee contractors. Most of these jobs would be lost with the plants’ retirement and, based on our previous work, thousands of additional secondary jobs would be lost. In addition, state GDP for Ohio and Pennsylvania would be lower by hundreds of millions of dollars, and state and local tax revenues would fall by tens of millions of dollars.”²⁶

If the Three Mile Island, Beaver Valley, Davis-Besse and Perry nuclear generating stations shut down early, Pennsylvanians can expect to pay **\$285 million per year** more for electricity. Across PJM, electricity costs would increase by \$1.5 billion per year.²⁷

Low and stable electricity prices are critical to Pennsylvania's industrial and commercial-based economic base. First, energy-intensive businesses are more likely to come to Pennsylvania and to stay. Second, continuing to be a net exporter of electricity – an economic strategy of the Commonwealth – depends on the state's nuclear fleet and is an important source of state income and jobs.

²⁴The Brattle Group. Pennsylvania Nuclear Power Plants' Contribution to the State Economy (2016)

²⁵Ibid., p. 4

²⁶The Brattle Group, Impacts of Announced Nuclear Retirements in Ohio and Pennsylvania (April 2018), pp. 8-9

²⁷Ibid. p. 5

Electricity Price Impacts: The Brattle Group estimates the impact to Pennsylvania consumers of losing its nuclear fleet would be higher electricity costs of \$788 million per year, and the impact to consumers in all of PJM would be higher electricity costs of \$3.4 billion per year.²⁸ The Nuclear Energy Caucus sought further detail as to why, if nuclear plants close, electricity prices will increase.

During the April 17, 2018 NEC hearing, Dr. Dean Murphy of The Brattle Group presented the slide shown in Figure 5 and explained how it was possible that if nuclear units are taken out of the market, electricity prices will go up.

“When nuclear plants retire, power prices rise. That seems to be a bit of a conundrum: how could prices rise, when an expensive asset retires. It’s because that expensive asset was not recovering its costs from the market. But, by the law of supply and demand, if demand stays the same and supply decreases, prices rise. . . Other generators are receiving higher prices for the same output they would have produced otherwise, plus the additional output that they are producing to replace the nuclear plants.” Dr. Dean Murphy, Principal, The Brattle Group, testimony to the Nuclear Energy Caucus, April 17, 2018

Figure 5: Electricity Cost Impacts of Four Announced Nuclear Retirements

Nuclear Plants Keep Power Prices Lower

- Power markets don’t necessarily allow nuclear plants to recover full costs
 - This is the cause of their financial challenge
 - Failure to compensate environmental attributes contributes to this
- But when nuclear retires, prices rise – by the law of supply and demand
 - Energy price is set by short-term costs only
 - Nuclear has \$0 short-term cost; fixed costs not recovered from market

	Power Price Change without Nuclear (\$/MWh)	Electricity Consumption (millions of MWh)	Annual Electricity Cost Change (2018 \$Millions)
Ohio	2.43	165	401
Pennsylvania	1.77	162	285
PJM	1.84	825	1,519

Brattle

A recent Penn State University (PSU) study similarly concludes that if Beaver Valley and Three Mile Island retire, energy prices would increase in PJM.

A recent Penn State University (PSU) study similarly concludes that if Beaver Valley and Three Mile Island retire, energy prices would increase in PJM.²⁹ New gas plants would come in at higher cost, and the nuclear power is replaced with higher priced energy. The study observes:

- “In all retirement scenarios, however, the energy output from Beaver Valley and Three Mile Island is effectively replaced with higher-cost energy.”³⁰
- “...any nuclear retirement will tend to increase clearing prices in the PJM real-time market because new natural gas plants as modeled will have slightly higher marginal operating costs than existing nuclear plants.”
- “In a scenario where Beaver Valley and Three Mile Island retire and are not replaced by any new capacity, total energy market costs would rise by around \$750 million over a three year period. In a scenario where Beaver Valley and Three Mile Island are more than replaced by new gas capacity, total energy market costs would rise by around \$600 million over a three year period.”

While the Brattle Group and the PSU numbers do not match exactly, they are directionally the same. In both studies, energy costs go up when the nuclear plants retire.

Other generators are aware of these price effects and would collect more money for the same power if nuclear plants retire. For example, in New York, retirements of some nuclear plants were staved off by regulatory implementation of a Clean Energy Standard that includes Zero Emissions Credit (ZEC) provisions. A filing by a coalition of fossil generation companies complains:

²⁸The Brattle Group. Pennsylvania Nuclear Power Plants’ Contribution to the State Economy (2016)

²⁹Seth Blumsack. “Impacts of the Retirement of the Beaver Valley and Three Mile Island Nuclear Power Plants on Capacity and Energy Prices in Pennsylvania.” Pennsylvania State University. Electricity J. (August 2018)

³⁰The Blumsack study posits three scenarios, but only one is somewhat plausible. The other two scenarios involve implausible market responses (attributing new natural gas builds 1 for 1 or even 3 for 1 to retired nuclear capacity). In the first scenario overall electricity costs to Pennsylvania ratepayers would increase by \$400 million over a three-year period.

"[T]he PSC is using the ZEC subsidy to exert a large depressive effect on energy and capacity prices, which one group of experts estimated at \$15 billion over 12 years."³¹

"harm other generators, including the Plaintiffs, because the lower auction prices will result in lower revenues."³²

Similarly, in Illinois the Electric Power Supply Association wrote in their filing that the ZEC's impact on market prices in the wholesale market will:

This is, of course, one of the reasons behind well-funded campaigns to oppose equal treatment of nuclear with other zero-carbon resources.

ANNOUNCED PREMATURE CLOSURE OF PENNSYLVANIA & OHIO NUCLEAR PLANTS WILL DEVASTATE OUR ECONOMY

DAVIS-BESSE
PERRY
BEAVER VALLEY
THREE MILE ISLAND

Nuclear power is the bridge to a clean energy future, sustaining thousands of jobs, and protecting our environment. Burning that bridge will have widespread consequences for millions of residents.

TAKING THOUSANDS OF JOBS FROM WORKING FAMILIES
The four plants announced for premature closure directly employ more than **3,000 people**. Those well-paying jobs would be lost as a result of these premature plant closures

ECONOMIC LOSS THAT SHUTTERS SMALL BUSINESSES
The impacts won't hurt only the workers and their families. As a result of lost economic activity, **small businesses will close**, and municipalities will lose the tax base needed for roads, schools, and other services

FAMILIES PAYING MORE OUT OF POCKET TO KEEP THE LIGHTS ON
The loss of nuclear energy from PJM's grid will force dependence on a more volatile fossil fuel market. Ohio customers will pay **\$400 million** more per year, while Pennsylvania customers will see their bills increase **\$285 million** per year. Across the region, electricity costs will increase by as much as **\$1.5 billion** per year

LEAVING A HOLE IN OHIO'S ECONOMY
According to one prior study, the overall loss of jobs, tax revenue, unanticipated increased healthcare, and comprehensive statewide economic loss will leave a **\$510 million** hole in Ohio's Gross Domestic Product (GDP) and impact **4,200 jobs**

LEAVING A HOLE IN PENNSYLVANIA'S ECONOMY
According to one prior study, retirement of all five of Pennsylvania's plants would leave a **\$2 billion** hole in Pennsylvania's GDP and impact **15,900 jobs**

STORE CLOSING

*Impacts of Announced Nuclear Retirements in Ohio and Pennsylvania." The Brattle Group (2018)
**Ohio Nuclear Power Plants' Contribution to the State Economy." The Brattle Group (2017)
***Pennsylvania Nuclear Power Plants' Contribution to the State Economy." The Brattle Group (2016)

Source: Clean Jobs for Pennsylvania

³¹Coalition for Competitive Electricity et al. v. Zibelman, et al. U.S. District Court Southern District of New York, 10/19/16

³²Electric Power Supply Association, et al. v. Anthony M. Star et al., Case cv-01164, Filed 2/14/17

Employment Impacts: Pennsylvania’s nuclear fleet directly employs approximately 4,200 people.³³ The fleet also supports skilled labor who service plants during refueling and maintenance.³⁴ Numerous manufacturing and small businesses are supported by the economic activity from the nuclear plants. The Brattle Group model estimates that without its nuclear fleet, the Pennsylvania economy would shrink by 15,900 jobs.³⁵

...without its nuclear fleet, the Pennsylvania economy would shrink by 15,900 jobs.



“Closure of just one facility will eliminate thousands of job opportunities for building trades workers and prove distinctly harmful to Boilermakers since power generation is one of the main industries we service.”
Martin Williams, Boilermakers Local 13, Nuclear Energy Caucus hearing May 23, 2018

"Beaver Valley Power Station provides family-sustaining jobs for hundreds of workers. It supports the local economy, and supplies affordable, reliable, and resilient energy to regional households, hospitals, schools, and businesses. Meanwhile, other parts of our nation face energy shortages because too many other fuel-secure plants closed prematurely. In New England, grid operators rely



on imported energy to meet demand. Pennsylvania should not follow their example. Nationally, our lack of a comprehensive energy policy undermines our security and energy independence. The Beaver Valley Power Station provides resilient power necessary for the electric grid, and it is vital it and others stay open.” **Congressman Keith Rothfus (PA-12)**, press release, April 6, 2018

“Pennsylvania’s nuclear industry supports 16,000 good-paying jobs alone. In addition, nuclear facilities spend \$1.8 billion in our local



economies, benefiting 4,150 Pennsylvania companies, and contribute \$2 billion annually to the commonwealth’s economy. Without nuclear, all of that will disappear.” **Anna Dale, Londonderry Township supervisor**, letter to the editor, *Press & Journal*, November 29, 2017

Local Impacts of Plant Closure in Other States: Nuclear retirements in states that failed to act have had dire, but predictable consequences on local communities. Vermont Yankee is one such case:

“When Vermont Yankee closed, the jobs and the tax revenue disappeared and have not returned. Employees were forced to retire or move to find similar jobs in other states. Housing prices dropped. Also, in response to the closure, property taxes were raised by 20% to help replace lost tax revenue.”
Joe Gusler, Central PA Building & Construction Trades Council, Nuclear Energy Caucus hearing May 23, 2018

Our counterparts in Ohio have heard similar testimony:

“When Vermont Yankee closed, the cornerstone of our local community disappeared, causing families and friends to move away, and in turn, our businesses shuttered and many community members were left searching for jobs.

³³Sources: Company fact sheets for Limerick (890) and Peach Bottom (860). Martin Williams statement at NEC hearing for Three Mile Island and Beaver Valley (1,400 together). Steve Knoebel at NEC hearing for Susquehanna (1,000).

³⁴Kristopher Anderson, IBEW, testimony to Nuclear Energy Caucus 5/23/18

³⁵The Brattle Group. Pennsylvania Nuclear Power Plants’ Contribution to the State Economy (2016)

About 300 million dollars a year no longer circulates in Vermont's economy due to the plant shutdown. Sadly, our small businesses are feeling that crunch the most, with reports as high as 20% in lost revenues. In addition, \$58 million in payroll per year is no longer paid to the over 500 people Vermont Yankee once employed.

This money no longer supports the town of Vernon, the community's small businesses, and the many non-profits around the region that relied on Vermont Yankee. Programs that serve our youngest population have been greatly reduced or eliminated, and services for our elderly population are at risk. The engine that drove our community died, and our town and region have slowed to a halt because of it.

At our last Town Meeting, residents regretfully voted NOT to fund any of the social services that traditionally aided our most at-risk population. Financial pressures in the face of rising taxes have forced residents to make difficult choices in order to make ends meet. Our only local retail store has closed, housing values have plummeted, and taxes are expected to continue to increase. Residents have been forced to fill the financial gap in order to maintain minimum town services. Increases in property taxes and declining home values have placed a significant burden on those members of our community that can least afford it.

The impact has been more than financial. When Vermont Yankee closed, families moved or were torn apart when houses couldn't sell and some parents were forced to find work at other plants – only able to come home on the weekends, if they are lucky. Our friends were scattered to other states when the cornerstone of our economy disappeared. The culture and identity of our town will be forever changed."³⁶ **Josh Unruh, Vermont Selectboard Chairman**, testimony for Ohio House Bill 178, April 25, 2017.

As discussed previously, there is an epidemic of nuclear plant closures in the nation.

The Nuclear Energy Caucus learned of several occasions where states did not act sufficiently and lost or are losing

their plants, such as the above case of Vermont Yankee, the Kewaunee plant in Wisconsin, and, to date, the Davis-Besse and Perry plants in Ohio.

Meanwhile, where states have acted, closures have been forestalled, such as in New York, New Jersey, Illinois, and Connecticut.

"I bet the members of the Pennsylvania House and Senate would jump at the opportunity to help if I said we were creating 16,000 new jobs in Pennsylvania. What we are asking for is your help in saving 16,000 good paying jobs in Pennsylvania." Joe Gusler, Central PA Building & Construction Trades Council, testimony to Nuclear Energy Caucus, May 23, 2018

As a closing thought on the economic impacts, we share this testimony from the Nuclear Energy Caucus May 23 hearing:

"I bet the members of the Pennsylvania House and Senate would jump at the opportunity to help if I said we were creating 16,000 new jobs in Pennsylvania. What we are asking for is your help in saving 16,000 good paying jobs in Pennsylvania." Joe Gusler, Central PA Building & Construction Trades Council, testimony to Nuclear Energy Caucus, May 23, 2018

In fact, as was recently publicly disclosed, Democrat Governor Wolf offered up to \$4.6 billion in state-backed financial incentives to Amazon to entice it to locate its next headquarters in Pittsburgh or Philadelphia³⁷ (which did not include additional incentives from Philadelphia or Pittsburgh).

Likewise, former Republican Governor Corbett advocated for and successfully implemented a \$1.65 billion Resource Manufacturing Tax Credit for companies that build a cracker plant in the Commonwealth. The tax credit would give Royal Dutch Shell – or any other company that builds a petrochemical plant in Pennsylvania –

³⁶Testimony of Josh Unruh, Vermont Selectboard Chairman, Ohio House Bill 178, 4/25/17

³⁷<https://triblive.com/local/alleggheny/14289172-74/gov-tom-wolf-says-pennsylvania-offered-46b-in-incentives-for-amazon>.

a \$2.10 break on every barrel of ethane it purchases from energy companies located in the Commonwealth.³⁸

“What these incentives do, is they don’t just bring a company to Pennsylvania. They bring an entire industry to Pennsylvania,” Labor and Industry Secretary Julia Hearthway said. “They bring an entire industry to northeastern United States. And with it comes jobs. Not a few hundred jobs. Not one company hiring 300 or 400 jobs. But thousands and thousands of jobs to Pennsylvania.”

“What these incentives do, is they don’t just bring a company to Pennsylvania. They bring an entire industry to Pennsylvania,” Labor and Industry Secretary Julia Hearthway said. “They bring an entire industry to northeastern United States. And with it comes jobs. Not a few hundred jobs. Not one company hiring 300 or 400 jobs. But thousands and thousands of jobs to Pennsylvania.”³⁹

Pennsylvania’s nuclear industry certainly deserves no less consideration than Amazon or the oil and natural gas industry.

Documents in Chapter 5 Appendix:

1. The Brattle Group. Pennsylvania Nuclear Power Plants’ Contribution to the State Economy. Dec. 2016. (see Chapter 3 Appendix)
2. The Brattle Group, Impacts of Announced Nuclear Retirements in Ohio and Pennsylvania (April 2018)
3. Dr. Dean Murphy, slides presented to the Nuclear Energy Caucus, 4/17/18
4. Seth Blumsack. “Impacts of the Retirement of the Beaver Valley and Three Mile Island Nuclear Power Plants on Capacity and Energy Prices in Pennsylvania.” Pennsylvania State University. Electricity J. (August 2018) (protected by Electricity J. copyright)

5. Kristopher Anderson, IBEW, testimony to Nuclear Energy Caucus 5/23/18
6. Coalition for Competitive Electricity et al. v. Zibelman, et al. U.S. District Court Southern District of New York, 10/19/16
7. Electric Power Supply Association, et al. v. Anthony M. Star et al., Case cv-01164, Filed 2/14/17
8. Martin Williams, Boilermakers Local 13, testimony to Nuclear Energy Caucus 5/23/18
9. Congressman Keith Rothfus (PA-12), press release, 5/6/18
10. Anna Dale, Londonderry Township supervisor, Press & Journal letter to the editor, 11/29/17
11. Josh Unruh, Vermont Selectboard Chairman, testimony on Ohio House Bill 178, 4/25/17
12. Joe Gusler, Central Pennsylvania Building Trades, testimony to Nuclear Energy Caucus 5/23/18

³⁸<https://triblive.com/business/headlines/10595729-74/tax-shell-pennsylvania>.

³⁹<https://stateimpact.npr.org/pennsylvania/2012/06/14/corbett-administration-sells-ethane-cracker-tax-break-secretary-says-shell-asked-for-it/>

6. Premature Plant Shutdowns: Environment and Public Health Impacts

Summary:

- The shutdown of nuclear plants across the country are a greenhouse gas emergency.⁴⁰
- Losing the Beaver Valley and Three Mile Island nuclear plants will negate five times the emissions benefits of all the solar and wind power installed in Pennsylvania to date.⁴¹
- Nuclear power plants prevent significant quantities of harmful criteria air pollutants, including seasonal NO_x, annual NO_x, SO₂, and PM_{2.5}. These pollutants rise when nuclear plants shut down.

Deeper Dive:

Pennsylvania has made some headway in reducing its carbon dioxide (CO₂) emissions.

During the period from 2010 to 2015, Pennsylvania reduced energy sector CO₂ emissions nine percent, from 256 million metric tons (mmt) to 233 mmt per year, partly due to the shift from coal to gas.

Despite its progress, Pennsylvania still ranks third in the country in CO₂ emissions (but fourth in generation).⁴²

Numerous experts testified to the Nuclear Energy Caucus that existing nuclear plants are a critical component of limiting greenhouse gas emissions, and nuclear plant closures are devastating to greenhouse gas goals.

Nuclear closures cause back-sliding on greenhouse gas reductions.

⁴⁰Testimony to the Nuclear Energy Caucus by the Pennsylvania Environmental Council, the Environmental Defense Fund, and the Union of Concerned Scientists, June 19, 2018.

⁴¹Testimony to Nuclear Energy Caucus of Kathleen Barrón, April 17, 2018. Data publicly sourced from EIA-923, EIA Electric Power Monthly (Feb 2018), and Monitoring Analytics 2017 PJM State of the Market report. See also testimony of Dr. Dean Murphy, The Brattle Group, April 17, 2018 "If you look at the two Pennsylvania plants Three Mile Island and Beaver Valley, they account for 22 million megawatt hours of carbon free electricity. All the renewables in PA, all the wind and all the solar account for about 4 million."

⁴²EIA State Carbon Dioxide Emissions Data for 2015 (10/24/2017), <https://www.eia.gov/environment/emissions/state/>. Texas and California carbon dioxide emissions rank first and second, respectively.

⁴³Testimony to the Nuclear Energy Caucus by the Pennsylvania Environmental Council, the Environmental Defense Fund, and the Union of Concerned Scientists, June 19, 2018

⁴⁴The Brattle Group. "Pennsylvania Nuclear Power Plants' Contribution to the State Economy." December 2016

Numerous experts testified to the Nuclear Energy Caucus that existing nuclear plants are a critical component of limiting greenhouse gas emissions, and nuclear plant closures are devastating to greenhouse gas goals.⁴³ Closures more than negate the emission benefits from switching from coal to natural gas, thereby erasing the emissions benefits of state investments in wind and solar.

"We believe that the loss of today's nuclear fleet would be a terrible blow to the progress already made in reducing Pennsylvania's contribution to climate change and would hamstring all of our combined efforts." **Davitt Woodwell, President, Pennsylvania Environmental Council**, at Nuclear Energy Caucus June 19, 2018

If it were not for its nuclear power plants, Pennsylvania's CO₂ emissions would be an estimated 37 mmt higher each year.

If it were not for its nuclear power plants, Pennsylvania's CO₂ emissions would be an estimated **37 mmt higher each year**.⁴⁴ The premature closure of any of the nuclear plants further perpetuates the loss of the reductions the state has achieved already (see Figure 6).

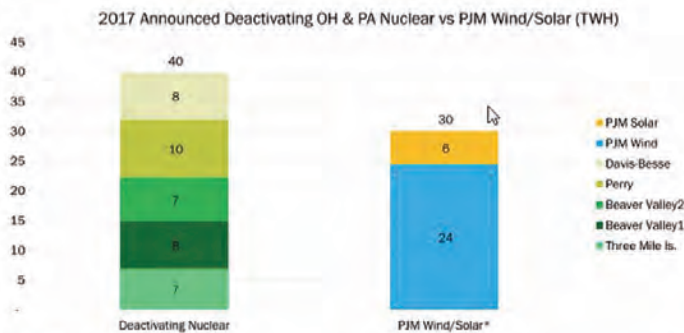
"These four plants...account for one and a half times the total amount of zero emitting generation from all the wind and all the solar across the entire PJM footprint. [Prematurely closing them] would set back more than 25 years of progress." - **Dr. Dean Murphy, The Brattle Group**, NEC hearing April 17, 2018

The nuclear plant closures announced already in Pennsylvania and Ohio (Beaver Valley, Three Mile Island, Davis-Besse and Perry) will increase CO₂ emissions about 21 mmt per year and is equivalent to a 50% increase in the number of Pennsylvania passenger vehicles driven for a year.

Some parties recommend replacing lost output with additional renewable energy, but replacing the lost output from nuclear retirements with renewables would take years at current development rates.

If the Three Mile Island, Beaver Valley, Davis-Besse and Perry plants retire as announced, the growth of renewables would have to double their current growth rate, an unlikely scenario, and it would still take PJM until 2034 to get back to the same levels of non-emitting generation it has today. Meantime, emissions will have been up to 21 mmt higher annually in the intervening years.^{45,46}

Figure 6: Announced OH and PA Nuclear Retirements Produce More Zero-Carbon Electricity than all the Wind and Solar in all of PJM



Sources: EIA-923, PJM GATS
 *Note: includes all wind and solar physically located in PJM plus generators that have been certified to serve an RPS in a PJM state for example, RECs from adjoining states can be used for compliance in the Illinois RPS.

Source: David Roberts, Vox, The Simple Argument for Keeping Nuclear Power Plants Open (4/5/18)

Pennsylvania’s nuclear plants also keep thousands of tons of SO₂, NO_x, and small particulates from the air we breathe.⁴⁷

Pennsylvania air quality would be worse without its nuclear plants, and it would be more difficult for the Commonwealth to comply with Federal environmental regulations.

Loss of the plants would increase air pollution and may trigger ozone alert days, asthma attacks, lung disease, hospital visits, and lost days of work from poor air quality. High-pollution days disproportionately impact urban and suburban residents.

A study of all the Commonwealth’s nuclear plants concluded that without them:⁴⁸

- SO₂ emissions would increase by 8,500 tons annually. SO₂ is regulated by the EPA Cross-State Air Pollution Rule (“CSAPR”) and by Ozone National Ambient Air Quality Standards (“NAAQS”).
- NO_x emissions would increase by 11,500 tons annually. NO_x is regulated by the EPA Ozone NAAQS.
- PM_{2.5} emissions would increase by 13,500 tons annually. PM_{2.5} are criteria pollutants regulated by the EPA NAAQS.
- Ozone would also increase substantially.

Nuclear plant closures in other PJM states also increase NO_x emissions in Pennsylvania.

A report by The Brattle Group, *Nuclear Impact on NO_x Emissions in Designated EPA Ozone Nonattainment Areas* (May 2018), notes that loss of nuclear plants in New Jersey, Pennsylvania, Ohio or Illinois all lead to more NO_x emissions in and affecting Pennsylvania.

Loss of all of Pennsylvania’s nuclear plants would result in an increase in NO_x emissions of about 4,100 metric tons annually, and would result overall in a 15-25% increase over baseline power sector NO_x emissions in combined Mid-Atlantic ozone nonattainment areas in New Jersey, Maryland and eastern Pennsylvania.⁴⁹

Since NO_x emitters in Pennsylvania must purchase Cross State Air Pollution Rule (“CSAPR”) allowances from a limited supply, they will pay more for compliance if NO_x emissions increase, thereby increasing the demand for

⁴⁵Dr. Dean Murphy, presentation to the Pennsylvania Nuclear Energy Caucus, April 17, 2018.

⁴⁶The Brattle Group, *Impacts of Announced Nuclear Retirements in Ohio and Pennsylvania* (April 2018)

⁴⁷The Brattle Group. *“Pennsylvania Nuclear Power Plants’ Contribution to the State Economy.”* December 2016.

⁴⁸Ibid.

⁴⁹The Brattle Group, *Nuclear Impact on NO_x Emissions in Designated EPA Ozone Nonattainment Areas* (May 2018)

allowances and putting pressure on their price (2018 Ozone Season NO_x allowances were trading at \$150 to \$175/ton at season start).⁵⁰ Public health impacts from poor air quality are disproportionately felt in urban areas such as Philadelphia and Pittsburgh neighborhoods.

In 2004, the General Assembly enacted the Alternative Energy Portfolio Standards (“AEPS”) to source a minimum level of electricity supply from certain preferred technologies.

The AEPS percentage began in 2006 at 5.7% of electricity sales across all AEPS tiers and is currently 14.7% of electricity sales. It increases to 18% of sales in 2021. Sixteen technologies are eligible for the AEPS, but nuclear is not one of them.⁵¹

Wind and solar are in Tier 1, but other sources are also given preference. Wood pulp, coal-mine methane, waste coal municipal solid waste, and pulp industry byproducts are all preferred technologies in Pennsylvania’s AEPS program, but not nuclear energy.

In the year ending May 31, 2017, Pennsylvania’s electricity customers spent \$122.7 million on in-state and out-of-state Alternative Energy Credits for compliance with the AEPS. None of these expenditures support zero-carbon generation from existing zero-emission nuclear plants.

For controlling CO₂ emissions, preventing premature nuclear retirement is more cost-effective according to the Institute for Energy Research, and as noted by the Pennsylvania Environmental Council.^{52, 53} It has been the basis for regulatory action in New York State and legislative action in Illinois and New Jersey.

The Pennsylvania Environmental Council and other stakeholders are studying potential energy futures that would achieve further carbon reductions.⁵⁴

A key measure Pennsylvania is exploring to reduce greenhouse gas emissions is the electrification of trans-

portation and other fossil-intensive uses. To obtain the most greenhouse gas reductions from electrification efforts, generation must come from clean resources.

The loss of nuclear power undermines the decarbonization of the electric power sector and makes programs such as those to encourage electric vehicles less effective, moving the Commonwealth in the wrong direction.

Documents in Chapter 6 Appendix:

1. Testimony to the Nuclear Energy Caucus, June 19, 2018
 - a. Davitt Woodwell, President, Pennsylvania Environmental Council
 - b. Rama Zakaria, Sr. Manager, Regulatory Policy & Analysis, Environmental Defense Fund
 - c. Steve Clemmer, Director of Energy Research & Analysis, Union of Concerned Scientists
2. Testimony to Nuclear Energy Caucus of Kathleen Barrón, Senior Vice President Federal Regulatory Affairs & Wholesale Markets, Exelon Corporation (April 17, 2018)
3. The Brattle Group, *Impacts of Announced Nuclear Retirements in Ohio and Pennsylvania* (April 2018) (see Chapter 5 Appendix)
4. Dr. Dean Murphy, presentation to the Pennsylvania Nuclear Energy Caucus, April 17, 2018.
5. The Brattle Group, *Nuclear Impact on NO_x Emissions in Designated EPA Ozone Nonattainment Areas* (May 2018)
6. Pennsylvania Environmental Council, *Achieving Deep Carbon Reductions: Paths for Pennsylvania’s Electricity Future* (June 2017)
7. David Roberts, *Vox, The Simple Argument for Keeping Nuclear Power Plants Open* (April 5, 2018)

⁵⁰http://www.evomarkets.com/content/news/reports_28_report_file.pdf

⁵¹In Tier 1, nine qualified technologies include solar, wind, low-impact hydro, geothermal, wood pulp, coal-mine methane, biologically-derived methane gas, fuel cells, and manufacturing byproducts from in-state energy facilities. In Tier 2, seven qualified technologies include waste coal, large-scale hydro, municipal solid waste, byproducts of the pulping process, integrated combined coal gasification technology, distributed generation systems, and demand-side management. Many of these technologies have environmental impacts nuclear does not, such as harmful air emissions or polluted discharges.

⁵²Institute for Energy Research, *The Levelized Cost of Electricity from Existing Generation Resources* (July 2016).

⁵³Pennsylvania Environmental Council, *Achieving Deep Carbon Reductions: Paths for Pennsylvania’s Electricity Future*, (June 2017), p. 15

⁵⁴*Ibid.*

7. Premature Plant Shutdowns: Grid Resilience and National Security Impacts

The FERC, NERC, PJM and other RTOs and ISOs are assessing the power system's vulnerability to low probability high impact disruptions, such as multiple pipeline disruptions, that are not currently part of system planning.

Summary:

- A diverse portfolio of energy generation resources contributes to grid reliability and resilience while keeping costs low for consumers.
- Due to its ability to operate in any weather and any time of day, nuclear energy excels as a uniquely steady and reliable energy generation source.
- A continued leading role by the U.S. in international safety and non-proliferation standards depend on the continued vitality of the nuclear energy sector. U.S. nuclear expertise and capabilities are maintained because the nuclear energy industry provides jobs, professional development, and a practice area outside of the defense industry.
- The FERC, NERC, PJM and other RTOs and ISOs are assessing the power system's vulnerability to low probability high impact disruptions, such as multiple pipeline disruptions, that are not currently part of system planning.
 - Such threats are real, according to experts.⁵⁵
 - Fuel security (the ability to deliver fuel to a generating plant during a disruptive event) is known to be one of the factors needed for a resilient system.^{56, 57}
- Loss of nuclear generation through plant closures increases Pennsylvania's and PJM's dependence on a few major and potentially vulnerable gas pipelines and on intermittent resources such as wind.
- Dual-fuel and oil-only resources can't be relied upon for longer than a few days during natural gas curtailment periods.⁵⁸
- A significant gas infrastructure event, which could be the result of a natural or man-produced disaster, such as a cyber-security attack⁵⁹ or other serious event, could prevent the PJM Mid-Atlantic area from serving electric load on several days, weeks or months if existing nuclear capacity was retired.⁶⁰

Deeper Dive:

The costs of long-term power outages are enormous. Historically, design mechanisms assure the reliability of the bulk power system by creating alternative pathways for nodes in the event of potential failure. However, emerging physical and cyber-security threats mean these traditional assurance mechanisms may not be sufficient given today's potential threats.

As a result, efforts are currently under way to understand what design basis to use to prevent disruptions from these emerging threats or if they occur, to assure quick recovery. In addition, recent extended extreme weather events have revealed vulnerabilities when numerous generators failed to be on-line when needed most.

Nuclear resources are among the most fuel secure and weather-resilient resources.

They typically maintain between 18 to 24 months of fuel, can operate during virtually any weather scenario while complying with strict security regulations (both cyber and physical). However, nuclear resources are not compensated for the value of these fuel security and

⁵⁵Paul Stockton. *Fuel Resilience for the Bulk Power System: Threat-Based Modeling and Analysis*. SonEcon (5/8/2018)

⁵⁶Lawrence Makovich and James Richards. *Ensuring Resilient and Efficient Electricity Generation*. IHS Markit. (Sept. 2017)

⁵⁷Power Engineering editors, Report Breaks from PJM Interconnection, Says Nuclear Closings Could Harm Resiliency (5/3/18)

⁵⁸Navigant Consulting. PJM Liquid Fuel Survey and Research Results and Recommendations. (4/25/2018)

⁵⁹See <https://www.nytimes.com/2018/04/04/business/energy-environment/pipeline-cyberattack.html>

⁶⁰ICF. *The Impact of Fuel Supply Security on Grid Resilience in PJM - Final Report*. (6/8/2018)

resilience attributes. Both PJM and FERC have activities under way to determine how to strengthen bulk power system resilience including how to assure fuel security.⁶¹

What is Resilience: “A *reliable* system is not the same thing as a *resilient* electric system. . . a resilient grid is one with the following characteristics: It is one where the grid planners, operators and regulators assume that they cannot foresee and avoid every type of event that could take out the system in a very big way; where they therefore plan for how they will ride through big-impact events with as much of the system still intact as possible”⁶² – Susan Tierney Utility Dive (December 13, 2017)

PJM is operating at very high levels of reliability, but according to PJM testimony to the Nuclear Energy Caucus, they may need operational and pricing changes to increase the resilience of the system and improve price formation.⁶³ Such changes have not yet occurred.

Extreme Weather: In January 2014, a broad swath of the country, including Pennsylvania, experienced an extended period of extreme cold in a weather event known as a “Polar Vortex”. Temperatures were 20 to 30°F below average in places, and these temperatures resulted in record high regional electrical demand. The weather conditions exceeded the design basis of some generating units, and limits on natural gas transportation curtailed fuel supplies to gas generation plants.⁶⁴ Some coal plants were shutting down because of frozen coal piles.

Following the 2014 Polar Vortex, PJM established a capacity performance product which partially prices weather-related resilience into the PJM capacity auction.

However, a multi-region cold snap in January 2018 showed the weather-related hardening to date is insufficient. By the sixth day of the January 2018 cold snap, PJM had 23,750 MW of forced outages disrupting its supply. As Figure 7 shows, most of these outages continued to be from non-performance or unavailability of natural gas, coal, and oil. Nuclear plants are clearly needed to

assure power supply in the event of major gas delivery disruptions and gas and coal outages.

One of the cold-hardening measures natural gas plants take is to install dual-fuel capabilities to enable burning oil for up to a couple of days in the event natural gas is not delivered.

The efficacy of such measures was tested in January 2018 when an unusually powerful winter storm traveled up the East Coast. In New England, dual-fuel units burned through not only oil, but most of their emissions limits for the year when they needed to switch fuels. This will keep them unavailable to similarly respond in another cold spell for the remainder of the calendar year, unless they run anyway in violation of their air permits.⁶⁵

Forbes contributor James Conca detailed nuclear’s value in a September, 2018 article entitled, “Hurricane Florence No Problem for Nuclear Power Plants.”⁶⁶

In his article, Conca details examples of extreme weather events and how nuclear power producers safely and reliably performed during those challenges.

For example, Duke’s Brunswick nuclear station was in the direct path of Hurricane Florence and, “has withstood several hurricanes since the two reactors there began operation in the mid-1970s, including Category 3 Hurricane Diana in 1984 and Category 3 Hurricane Fran in 1996. Category 4 Hurricane Hugo, the most often-compared to Florence, made landfall about 150 miles southwest of Brunswick in South Carolina in 1989.”⁶⁷

Conca notes that unlike other power plants, nuclear operators keep food, water and other necessities onsite to prepare for potential isolation of the site, and staff needed during the storm are brought in to ensure proper resources are available for an extended period.⁶⁸

In fact, he writes, “Nuclear is the only energy source immune to all extreme weather events – by design.

⁶¹See <http://www.pjm.com/-/media/library/reports-notice/special-reports/2018/20180430-valuing-fuel-security.ashx>, and FERC Docket No. AD18-7

⁶²<https://www.utilitydive.com/news/about-that-national-conversation-on-resilience-of-the-electric-grid-the-ur/512545/>

⁶³PJM FERC filing, State Policies and Wholesale Markets Docket No. AD17-11-000, provided to NEC in 4/26/2017 hearing NERC Polar Vortex Review (Sept. 2014)

⁶⁴https://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

⁶⁵Andrew Coffman Smith. *New England Dual-Fuel Units Burning Through Oil, Emissions Limits Amid Cold Snap*. S&P Global (1/2/2018)

⁶⁶<https://www.forbes.com/sites/jamesconca/2018/09/13/hurricane-florence-no-problem-for-nuclear-power-plants/#2e5e1e17a71b>

⁶⁷ibid.

⁶⁸ibid

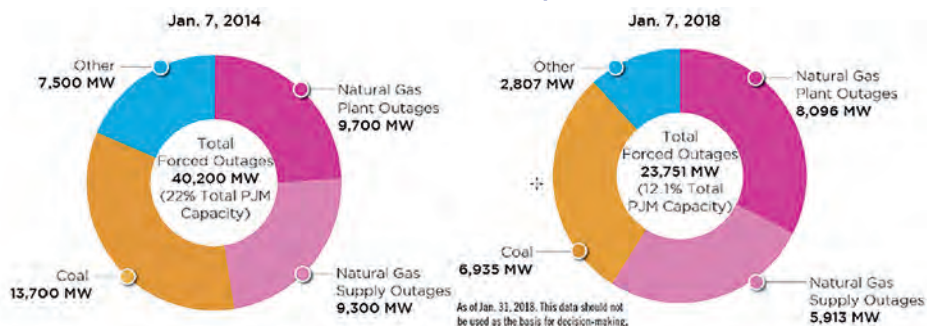
Plants have steel-reinforced concrete containments with over 4-foot thick walls. The buildings housing the reactors, vital equipment and used fuel have steel-reinforced concrete walls up to 7 feet thick, which are built to withstand any category hurricane or tornado. They can even withstand a plane flying directly into them.”⁶⁹

As was repeated time and again during the Nuclear Energy Caucus’ review of nuclear power’s reliability and resiliency, regardless of weather event – hurricane, flood, earthquake, heat wave or severe cold, nuclear units outperformed other generation types consistently to the benefit of electricity customers.

Citing another example, Conca notes that in the Summer of 2017, a heat wave blanketed the United States with extreme temperatures, which affected most energy production, causing electricity use to spike as 122 million Americans were under heat alerts. “Fortunately, nuclear power didn’t mind, scoring record capacity factors of 96% and up, with no increase in price.”⁷⁰

As was repeated time and again during the Nuclear Energy Caucus’ review of nuclear power’s reliability and resiliency, regardless of weather event – hurricane, flood, earthquake, heat wave or severe cold, nuclear units outperformed other generation types consistently to the benefit of electricity customers.

Figure 7: 2014 and 2018 Forced Outages by Fuel Type



Source: PJM Cold Snap Performance: Dec. 28, 2017 to Jan. 7, 2018. PJM Interconnection (2/26/18)

⁶⁹bid.

⁷⁰bid.

⁷¹<http://www.pjm.com/-/media/library/reports-notice/special-reports/2018/20180430-valuing-fuel-security.ashx>

⁷²Paul Stockton. *Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions*. SonEcon. June 8, 2018.

⁷³Nuclear Energy Institute (NEI), *The Impact of Fuel Supply Security on Grid Resilience in PJM* (6/8/18)

Man-Made Threats: Weather contingencies are only part of the resilience problem.

PJM is conducting a study, *Valuing Fuel Security*, to simulate grid disruptions that could occur from extreme weather or from other threats, such as coordinated physical or cyber-attacks.⁷¹

In recommendations to PJM, Dr. Paul Stockton writes: “the risks of physical attacks on natural gas systems merit special concern.” Dr. Stockton was Assistant Secretary of Defense for Homeland Defense and America’s Security Affairs from June 2009 until January 2013. In his recommendations to PJM, Dr. Stockton discusses the need for PJM to assess manmade disruption scenarios that would disrupt multiple pipelines and storage facilities simultaneously, either reducing delivery capability on constrained pipelines, or a realistic but extreme contingency where adversaries disrupt 80% of the gas pipelines in the PJM region for six months.⁷²

“the risks of physical attacks on natural gas systems merit special concern.”

A study by the consulting company ICF, *The Impact of Fuel Supply Security on Grid Resilience in PJM*, similarly found PJM is vulnerable to extended electricity outages if there are major pipeline disruptions.⁷³

The results of the ICF analysis show that “a significant gas infrastructure event could prevent the PJM Mid-Atlantic area from serving electric load on a number of days if existing nuclear capacity was retired. Such an event could result in the loss of nearly 27 GW of gas-fired generation, with 18 GW serving the PJM Mid-Atlantic area, depending on the severity and location of such event.

When combined with the retirement of a similar amount of nuclear capacity, the analysis implies such an event would put as much as 22 percent of the area’s load at



risk of being shed in the highest load hours. Of the nearly 18 GW of gas-fired capacity that could be impacted by such an event, over 45 percent has no backup fuel capability and would be immediately unavailable during such an event.

While the remaining capacity reports having dual-fuel backup capabilities, on-site fuel resources would last generally less than 5 days, if these units are operated at higher load factors as a result of the loss of gas-only resources during such an event. While backup supplies could be ordered to replace fuel used during such an interruption, the ability of the upstream oil distribution network to replenish such supplies during such an event, and the associated logistics of such refill, is questionable, particularly if such event is widespread. The study also shows that the preservation of nuclear capacity in PJM would successfully mitigate the loss of load risk.

Gas curtailment periods may be the result of extreme weather events, major gas infrastructure failures and/or interruption due to other events such as terrorism.

In a recent study, Navigant Consulting found that “if a curtailment event lasts longer than a few days, significant quantities of dual fuel and oil-only resources could be forced out due to a lack of fuel and be unable to timely receive new fuel supplies.”

The study showed that more than 50% of the capacity would be off line within 4 days and more than 75% would be off-line within six days.

Plants would face an even greater challenge in refilling

their tanks promptly if the entire dual-fuel and oil-only PJM fleet were simultaneously trying to refill their tanks, and if they were competing for scarce delivery sources with other fuel oil users, such as hospitals, governmental institutions, and others operating generators. Logistics for refilling this level of fuel oil in a reasonable amount of time would likely exceed the current delivery capabilities.

The Department of Energy (“DOE”) has publicly stated on numerous occasions that the grid must be “resilient and secure.”

Resources that have a secure on-site fuel supply, including nuclear, are essential to support the nation’s defense facilities and critical infrastructure. In October 2017, the DOE used Section 403 of the Department of Energy Organization Act of 1977 to order FERC to consider action to preserve fuel-secure generation within 60 days (“DOE NOPR”).⁷⁴ The DOE action found that the resiliency of the nation’s electric grid is threatened by the premature retirements of power plants that can withstand major fuel supply disruptions and, in those critical times, continue to provide electric energy, capacity, and essential grid reliability services.

In October 2017, the Pennsylvania House of Representatives adopted (176-9) HR 576, and the Pennsylvania Senate adopted (42-8) SR 227, bi-partisan Resolutions in support preserving the Commonwealth’s fuel-secure generation resources.

In October 2017, the Pennsylvania House of Representatives adopted (176-9) HR 576, and the Pennsylvania Senate adopted (42-8) SR 227, bi-partisan Resolutions in support preserving the Commonwealth’s fuel-secure generation resources.

The General Assembly urged the FERC to swiftly consider DOE’s proposed Grid Resiliency Pricing Rule and implement policies to ensure fuel-secure generation resources receive proper compensation for their reliability and resiliency.⁷⁵ Despite the call for swift action, FERC did not respond accordingly. Instead, it issued an order in early

⁷⁴<https://www.energy.gov/articles/secretary-perry-urges-ferc-take-swift-action-address-threats-grid-resiliency>

⁷⁵<https://legiscan.com/PA/text/HR576/2017>

2018 terminating the DOE NOPR and opening an administrative docket on resilience. That docket provides a forum for further study, but by the time it materializes into action, some of the resources needed for resiliency will already be gone.

Experts feel so strongly about the role of nuclear energy in enhancing national security that 77 national security officials, former statesmen, and business leaders in June 2018 wrote an open letter to U.S. Secretary of Energy Perry urging DOE to take immediate action to prevent the closure of U.S. nuclear energy reactors.⁷⁶

That letter echoes an earlier letter of warning by Tom Ridge, in which he states “As Congress and the administration work in the years ahead to advance economic opportunity while preventing threats to our security, they must strengthen and preserve our nation’s baseload nuclear fleet, thus protecting our national security while ensuring a diverse, resilient energy grid.”⁷⁷

Or, as James Conca put it in a Forbes op-ed: “Nuclear in America is on a cusp between two very different paths. One path leads to continued global leadership. The other leads to a slow fading of our nuclear program to that of a third-rate power, leaving Russia and China to lead the world.”⁷⁸

Resilience to man-made high-impact disruptions is not priced into the market.

There is no price signal that indicates dependency on natural gas has grown to be “too high.” In the meantime, the urgency for nuclear operators is growing.

In the May 2018 PJM Base Residual Auction for capacity, over one-third of PJM’s nuclear power failed to clear – a 200% increase in uncleared capacity since the previous year.⁷⁹ According to Exelon and FirstEnergy Solutions company announcements, the uncleared capacity included both the Three Mile Island and Beaver Valley nuclear generating stations.

Latest PJM Report Confirms the Problem: On November 1, 2018, PJM released the results of a fuel security analysis designed to test the grid’s limits to endure high-impact, long-term disruptions to generators’ fuel supply.

“The study also identified scenarios in which the system would face power outages, applying extreme, but reasonably plausible assumptions for weather, customer demand, generator retirements and fuel availability.”

According to PJM, “The study also identified scenarios in which the system would face power outages, applying extreme, but reasonably plausible assumptions for weather, customer demand, generator retirements and fuel availability.”⁸⁰

The results of the study confirm what the NEC has feared – that while today’s grid can withstand extreme conditions, tomorrow’s grid without the reliability and resiliency of nuclear power could, “result in material levels of generation unavailability and load shedding.”⁸¹

In practical terms, this means that, after conducting hundreds of stress test scenarios, starting in 2023, “...the more the grid was stressed, the more important fuel supply characteristics, location of fuel supply disruption and demand response became,” according to Michael Bryson, Vice President of PJM Operations.⁸²

PJM’s analysis identified key variables to the security of the grid’s fuel supply, including availability of non-firm gas service, ability of the fuel-oil delivery system, physical breaks at key locations on the pipeline system, customer demand (load), generator retirements and replacements, and the use of operating procedures to conserve fuel during peak winter conditions.

⁷⁶Akerson et al.; Letter to DOE Secretary Rick Perry (6/26/18) <https://www.nei.org/CorporateSite/media/filefolder/resources/letters-filings-comments/letter-secretary-energy-rick-perry-nuclear-national-security-20180626.pdf>

⁷⁷Tom Ridge. *Keeping Nuclear in the Nation’s Energy Mix*. The Philadelphia Inquirer (8/9/17)

⁷⁸James Conca. *Nuclear Energy in America is Teetering On A Cusp*. Forbes (11/2/17)

⁷⁹Press release. “Exelon Announces Outcome of 2021-2022 PJM Capacity Auction.” (5/24/18)

⁸⁰See <https://www.pjm.com/-/media/about-pjm/newsroom/2018-releases/20181101-pjm-completes-fuel-security-study-as-part-of-resilience-initiative.ashx>

⁸¹Ibid.

⁸²Ibid.

In uncharacteristic directness, PJM reported that, “The findings underscore the importance of PJM exploring proactive measures to value fuel security attributes, and PJM believes this is best done through the competitive wholesale markets.”⁸³

It is important to note that other than the premature closure of nuclear plants, nuclear energy sources help avoid all of the key variables identified by PJM.

The NEC is hopeful that the benefits of nuclear power can be part of PJM’s solution and we encourage PJM to take seriously their obligation to ensure the reliability of the high-voltage electric power system, particularly because the loss of a nuclear asset is irreversible.

Documents in Chapter 7 Appendix:

1. Paul Stockton. *Fuel Resilience for the Bulk Power System: Threat-Based Modeling and Analysis*. SonEcon (5/8/2018)
2. Lawrence Makovich and James Richards. *Ensuring Resilient and Efficient Electricity Generation*. IHS Markit. (Sept. 2017)
3. Power Engineering editors, *Report Breaks from PJM Interconnection, Says Nuclear Closings Could Harm Resiliency* (5/3/18) <https://www.power-eng.com/articles/2018/05/report-breaks-from-pjm-interconnection-says-nuclear-closings-could-harm-resiliency.html>
4. Navigant Consulting. *PJM Liquid Fuel Survey and Research Results and Recommendations*. (4/25/2018)
5. ICF. *The Impact of Fuel Supply Security on Grid Resilience in PJM - Final Report*. (6/8/2018)
6. PJM Interconnection. *PJM Cold Snap Performance: Dec. 28, 2017 to Jan. 7, 2018*. (2/26/18)
7. PJM FERC filing, *State Policies and Wholesale Markets Docket No. AD17-11-000*, provided to NEC in 4/26/2017 hearing
8. <https://www.utilitydive.com/news/about-that-national-conversation-on-resilience-of-the-electric-grid-the-ur/512545/>
9. NERC Polar Vortex Review (Sept. 2014) https://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf
10. Andrew Coffman Smith. *New England Dual-Fuel Units Burning Through Oil, Emissions Limits Amid Cold Snap*. S&P Global (1/2/2018)
11. <http://www.pjm.com/-/media/library/reports-notices/special-reports/2018/20180430-valuing-fuel-security.ashx>
12. Paul Stockton. *Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions*. SonEcon. June 8, 2018.
13. <https://www.energy.gov/articles/secretary-perry-urges-ferc-take-swift-action-address-threats-grid-resiliency>
14. <https://legiscan.com/PA/text/HR576/2017>
15. Akerson et al.; Letter to DOE Secretary Rick Perry (6/26/18) <https://www.nei.org/CorporateSite/media/filefolder/resources/letters-filings-comments/letter-secretary-energy-rick-perry-nuclear-national-security-20180626.pdf>
16. Tom Ridge. *Keeping Nuclear in the Nation’s Energy Mix*. The Philadelphia Inquirer (8/9/17)
17. James Conca. *Nuclear Energy in America is Teetering On A Cusp*. Forbes (11/2/17)
18. Press release. “Exelon Announces Outcome of 2021-2022 PJM Capacity Auction.” (5/24/18)

⁸³bid.

8. Other State Actions and Potential Options

Summary:

- Several states have placed their faith in Regional Transmission Organizations ("RTOs") like PJM and federal policymakers to prevent the premature shut down of their nuclear plants but have instead witnessed a lack of action (and, in some instances, resistance to helpful action) resulting in the devastating economic, environmental, and consumer impacts associated with losing their state's nuclear industry.
- Other states learned from these mistakes, and have taken action into their own hands and implemented creative policies that would preserve their states' nuclear industry:
 - In 2016, New York and Illinois implemented Zero Emission Credit ("ZEC") programs that, like Renewable Energy Credits ("RECs"), are designed to pay generation resources for their "zero-emission" attributes.
 - In 2017, Connecticut enacted legislation allowing their nuclear plant to compete in energy markets with renewable generators, such as solar and wind.
 - In 2018, New Jersey created a Zero Emission Certificate program designed to compensate nuclear plants for their zero-emission and environmental attributes; as well as their fuel diversity attributes.
- In addition to their own inaction, PJM actively opposed states' efforts to prevent the premature shut down of their nuclear plants and initiated litigation at FERC to implement rule changes that would have led to higher prices in states that enact clean energy policies. For example, both the PJM Board and the PJM Market Monitor filed amicus briefs in federal court opposing the ZEC program in Illinois. In addition, in April 2018, PJM filed two proposed changes to its capacity markets that would have required capacity market prices to increase significantly for states supporting nuclear resources.

The FERC is now engaged in an ongoing proceeding to determine a way for PJM to accommodate state programs designed to support preferred energy resources...

The FERC is now engaged in an ongoing proceeding to determine a way for PJM to accommodate state programs designed to support preferred energy resources (including Pennsylvania's Alternative Energy Portfolio Standards program, among others). Depending on the outcome of this FERC proceeding Pennsylvania likely will be left with four options to preserve the Commonwealth's clean energy resources, including its nuclear plants. These options are:

1. Do nothing and leave Pennsylvania's clean energy resources, including its nuclear plants, on a trajectory to early retirement – effectively allowing PJM to dictate the mix of resources serving Pennsylvania.
2. Modify AEPS (or establish a ZEC program) to put nuclear generation on equal footing with other zero-emission electric generation resources in Pennsylvania.
3. Modify AEPS (or establish a ZEC program) with a "safety valve" mechanism that (depending on the outcome of the FERC proceeding) would allow Pennsylvania to adopt a new capacity construct proposed by FERC that is designed to accommodate state programs to support preferred generation resources.
4. Establish a Pennsylvania carbon pricing program.

Deeper Dive:

Since 2013, six nuclear reactors in the United States have permanently and prematurely shut down and another 12 reactors have been scheduled to shut down. In the Commonwealth, TMI and Beaver Valley have announced they will be permanently and prematurely closed.

The issue has played out over the past several years, but our Commonwealth has now reached the point of no return and, like other states, must decide whether to properly value all the attributes of these enormously important assets or let them and all the benefits that come with them (jobs, economic, security, reliability, resiliency, fuel diversity, and environmental benefits) disappear forever, to the detriment of our Commonwealth and the families and businesses we are responsible for representing.

This section of the Report focuses on actions other states initiated to preserve nuclear generation and potential options for Pennsylvania to consider.

It provides specific state legislative and regulatory actions proposed in various states and what has worked and not worked, so far.

Despite the enormous benefits of preserving in-state nuclear generation, as described throughout this report, only a few initiatives (legislative or regulatory) have advanced.

Nevertheless, policymakers in several states are increasingly discussing this issue as more plants come under pressure. Policies range from offering tax incentives or imposing carbon emission fees, to the creation of statewide programs that require utilities to purchase a specified amount of the environmental attribute of nuclear power, similar to AEPS. The intent of this section is to describe state level actions that have been effective in preserving affordable, reliable and clean energy.

The Commonwealth needs a solution that recognizes the value of existing nuclear plants to energy reliability, the economy and the environment.

...the ongoing FERC proceeding to adopt a new market construct that recognizes the right of states to regulate its generators and the environment, ... may add a new layer of required action

One framework already exists: Pennsylvania, through AEPS, already recognizes the value of other clean energy technologies, with Alternative Energy Credits ("AECs"). However, the ongoing FERC proceeding to adopt a new

market construct that recognizes the right of states to regulate its generators and the environment, and accommodate state programs like AEPS, may add a new layer of required action that will be further discussed in this section.

I. States That Did Not Act: Several states placed their faith in regional and federal policymakers to prevent the premature shutdown of their nuclear plants. A passive strategy and lack of initiative resulted in the devastating economic, environmental, and consumer impacts associated with losing their state's nuclear industry. The following are the outcomes experienced by states that failed to take matters into their own hands:

✓ Vermont

Vermont Yankee – The 620 MW Vermont Yankee nuclear plant shut down in 2014, citing the same economic pressures that have put other U.S. nuclear



plants at risk. The plant had 625 full time employees and employment grew significantly during outages.

Because of the premature closure, many people lost their jobs and New England carbon emissions increased. The projected economic impact is a loss of more than 1,100 jobs and \$480 million in annual economic activity.

Despite all the benefits the plant brought to Vermont and the broader New England region, there was lack of effective action by the state and unfortunately, the plant closed.

✓ Wisconsin

Kewaunee Power Station – The 550 MW nuclear plant shut down in 2013, citing the same economic pressures that have put other U.S. nuclear plants at risk.



The plant had 650 full time employees that grew to 900 every 18 months during scheduled outages.

For decades, the Kewaunee nuclear plant was a financial powerhouse in northeastern Wisconsin, boosting the annual economy in a three-county region by \$630 million.

While the plant was operating, Dominion paid utility taxes to the state of Wisconsin, which in turn distributed roughly \$750,000 annually to Kewaunee County and around \$400,000 to Carlton.

Despite all the benefits the plant brought to Wisconsin, on October 22, 2012, Dominion publicly announced plans to close the Kewaunee Power Station. Unfortunately for the residents of Kewaunee County and the state of Wisconsin, action was not taken by the state to preserve the plant.

✓ **California**

San Onofre – When the San Onofre nuclear plant in Southern California closed due to equipment failure in 2012, its 2,200 MW output was replaced mostly by natural gas. The result: enormous increases in emissions and negative environmental impact.



A 2015 study found that, during the year after the shutdown, California carbon emissions rose by 9 million metric tons – equivalent to putting 2 million additional cars on the road.

Additionally, an economic study found electricity generating costs rose by \$350 million during the year following the closing of the twin-unit San Onofre nuclear plant in Southern California.⁸⁴

II. State Actions to Preserve Existing Nuclear Plants:

Other states have learned from the mistakes made by Vermont, Wisconsin, and California.

Rather than hope that Congress, FERC or the RTOs would intervene to preserve their states’ nuclear plants, New York, Illinois, Connecticut, and New Jersey have each initiated new state level policies to prevent the premature retirement of their nuclear plants.

Although each state followed a slightly different approach, the policy initiatives are all based on the core principles that: (i) nuclear generation has enormous economic, security, reliability, resiliency, fuel diversity, and environmental benefits; (ii) nuclear retirements cannot

be reversed, and after shut-down, all nuclear generation derived benefits are lost forever; and (iii) environmental and other attributes from nuclear generation have not been compensated by the market.

Rather than hope that Congress, FERC or the RTOs would intervene to preserve their states’ nuclear plants, New York, Illinois, Connecticut, and New Jersey have each initiated new state level policies to prevent the premature retirement of their nuclear plants.

Although the recent FERC order, to be discussed later in this section, undermines the programs developed in Illinois and New Jersey, the elements of these state programs and as well as programs created in New York and Connecticut are described here:

✓ **Illinois**

Illinois, the country’s top producer of nuclear energy with 11 nuclear reactors at six plants, was faced with the same dilemma we have before the Commonwealth today. Those 11 reactors generate approximately 50% of the state’s electricity and over 90% of the state clean energy.

In late 2016, the Future Energy Jobs Act (“FEJA”) was enacted into law, with broad bi-partisan support. Among other things, FEJA updates Illinois’ RPS, net metering, and energy efficiency standards, as well as creates a new Zero Emissions Credit (“ZEC”) program. It is calculated that the Illinois ZEC program will preserve over \$1.2 billion in economic activity annually.

ZEC Program Details: Per the ZEC program and beginning in 2017, any electric utility serving at least



⁸⁴Davis and Hausman, Market Impacts of a Nuclear Closure, American Economic Journal of Applied Economics 2016, 8(2):92-122.

100,000 retail customers in Illinois is to procure zero emissions credits (ZECs) to cover 16% of the actual amount of electricity to its retail customers in the 2014 calendar year.

It is calculated that the Illinois program will preserve over \$1.2 billion in economic activity annually.

ZECs are to be contracted for a period of 10 years - ending May 2027. Like a renewable energy credit, a ZEC can only be used once to comply with a single portfolio or other standard. The price per ZEC is computed as the social cost of carbon (\$16.50 per MWh), adjusted downward according to a market price index for wholesale power. Importantly, as market prices increase, ZEC prices decrease. Customer costs are further restrained by an overall cap which limits the total annual cost of ZEC payments.

The Illinois ZEC program:

- Preserves the most cost-effective zero-emission resource.
- Protects thousands of jobs and preserves billions in state economic activity annually.
- Prevents significant increases in air pollution emissions.
- Preserving nuclear with these programs is a less expensive outcome for customers than the alternative.

The Illinois ZEC program has been challenged in the courts.⁸⁵

⁸⁵On February 14, 2017, two lawsuits were filed in the Northern District of Illinois against the Illinois Power Agency (“IPA”) alleging that the state’s ZEC program violated certain provisions of the U.S. Constitution. One complaint was filed by a group of ComEd customers, and the other was brought by the Electric Power Supply Association (“EPSA”) and three other electric suppliers. The focus of both complaints is that the IL ZEC program would distort the FERC-approved energy and capacity market auction system of setting wholesale prices, and both actions sought preliminary and permanent injunctive relief preventing the implementation of the program. On July 14, 2017, the judge issued an order dismissing the case. Oral argument was held January 3, 2018. At the oral argument, the 7th Circuit requested supplemental briefs, which were filed on January 26, 2018. On February 21, 2018, the 7th Circuit issued an order inviting the views of the United States as amicus. The Solicitor General filed the amicus brief on May 29, 2018, which largely supported the position that the ZEC program was lawful. On September 13, 2018, the Seventh Circuit Court of Appeals affirmed the lower court’s dismissal of both lawsuits. On September 27, 2018, the plaintiffs filed a request for a panel rehearing with the U.S. Circuit Court of Appeals for the Seventh Circuit, which has been denied.

✓ New York

In December 2015, Governor Andrew Cuomo directed the New York State Department of Public Service (“DPS”) to develop a Clean Energy Standard (“CES”) to meet the state energy plan’s 50% renewable energy by 2030 target through an enforceable mandate. The Governor also directed the DPS to explore ways to keep emission-free nuclear power facilities operational to continue New York’s greenhouse gas emissions reductions.

Then in early 2016, Governor Cuomo’s staff issued a report that proposed including nuclear power in the state renewable portfolio standard, along with making nuclear facilities eligible for ZECs.

On Aug. 1, 2016, the New York Public Service Commission approved a proposal that included ZECs for upstate nuclear plants but dropped the RPS-style mandate. The policy went into effect in 2017, and it compensates upstate nuclear plants for every megawatt-hour (“MWh”) of emissions-free electricity generated. The Public Service Commission staff said the state will experience “significant economic and environmental benefits” as a result of the ZEC program.

By retaining the state’s nuclear fleet, New York avoids replacing the lost baseload capacity with plants that would result in emissions of around 31 million metric tons of carbon dioxide during the next two years

As background, nuclear power accounts for roughly 30% of New York’s electricity generation. There are six operating nuclear reactors at four nuclear power facilities in the state. The Ginna and FitzPatrick facilities are single-reactor power plants, while Indian Point and Nine Mile Point each operate two reactors.

ZEC Program Details: In the first two years, upstate nuclear plants are receiving compensation from ZECs at a rate of \$17.48 per MWh, based on the social cost of carbon and the avoided carbon emissions the plants represent. The rate will be adjusted every two years based on several factors, including the social cost of carbon and market conditions. Importantly, if the forecast price of electricity and capacity rises above \$39 per MWh, ZECs compensation would drop correspondingly. Lastly the program preserves competitive rates and saves customers \$1 billion annually.

The New York ZEC program:

- Preserves the most cost-effective zero-emission resource.
- Protects thousands of jobs and preserves \$1 billion in state economic activity annually.
- Prevents significant increases in air pollution emissions.
- Preserving nuclear with these programs is a less expensive outcome for customers than the alternative.

The New York ZEC program has been challenged in the courts.⁸⁶

✓ New Jersey

On May 23, 2018, Governor Phil Murphy signed two bills into law. The first bill, S-2313, creates a Zero Emissions Certificate ("ZEC") program to maintain New Jersey's nuclear energy supply. The second bill, A-3723, among other things, has a 35% renewables mandate by 2025 and eventually 50% by 2030. Concerning nuclear generation Governor Murphy said, "I believe the biggest bridge we have to our clean energy future are the nukes and, not to mention, the thousands of jobs they support." Both bills passed by wide margins in both the New Jersey Assembly and Senate.

New Jersey has four nuclear reactors - the single-unit Hope Creek, the twin-unit Salem plants, and the single-unit Oyster Creek. Together these plants generate nearly half of that state's electricity and more than 90% of New Jersey's clean generation. New Jersey's nuclear plants help avoid the release of 14 million tons of air pollution each year – the equivalent of 3 million more cars on the road.



ZEC Program Details: The ZEC legislation directs the state's Board of Public Utilities ("BPU") to issue Zero Emission Certificates, which represent the fuel diversity, air quality, and environmental attributes of one megawatt-hour of electricity generated by an eligible nuclear power plant which has been selected by the BPU to participate in the ZEC program.

To be eligible, a plant must, in addition to other requirements, be licensed to operate until 2030, demonstrate that it makes a significant contribution to New Jersey's air quality and that it is at risk of closure within three years.

Importantly, the amount an eligible nuclear plant can receive under New Jersey's ZEC program is capped and any excess funds are refunded. Finally, New Jersey's ZEC program protects thousands of jobs and preserves over \$800 million in state economic activity and \$400 million in avoided rate increases annually.

⁸⁶On October 19, 2016, a group of fossil generators filed a complaint in federal court seeking to overturn the August 1 Order on constitutional grounds (Coalition for Competitive Electricity v. Zibelman et al.). The state filed a motion to dismiss the complaint. The court heard oral arguments on the motions on March 29, 2017, but held discovery in abeyance. On July 25, 2017, the court granted both motions to dismiss. On Aug. 24, 2017, the fossil generators appealed to the Second Circuit. Fossil generators' initial brief on appeal was filed on October 13, 2017. Oral argument was held on March 12, 2018. On September 27, 2018, the Second Circuit affirmed the district court's decision dismissing CCE's preemption and dormant Commerce Clause challenges to New York's ZEC Program.

In addition to the U.S. District Court challenge, the New York ZEC program has been challenged in the New York Trial Court. That matter has not been fully briefed due to pending resolution relating to the dispute over the record. Plaintiff's reply brief is due December 17, 2018.

The New Jersey ZEC program:

- Preserves the most cost-effective zero-emission resource.
- Protects thousands of jobs and preserves over \$800 million in state economic activity and \$400 million in avoided rate increases annually.
- Prevents significant increases in air pollution emissions.
- Preserving nuclear with these programs is a less expensive outcome for customers than the alternative.

✓ Connecticut

In October 2017, Connecticut's governor signed a bill into law that recognized the carbon-free attributes of nuclear power by allowing the Millstone



nuclear plant to compete for state contracts of zero emission generation that contribute to the reliability, fuel diversity, and environmental goals of the state. The Millstone nuclear power plant, which provides more than 70% of Connecticut's electric generation, is at risk of closing.⁸⁷

In 2017, the State of Connecticut adopted into law provisions to enable the purchase of energy, capacity and attributes from existing nuclear generation facilities under long term power contracts with electric distribution utilities.

To implement this new authority, the State is conducting a resource assessment. The Connecticut Department of Energy and Environmental Protection ("DEEP") and Public Utilities Regulatory Authority ("PURA") issued the draft final report on Jan. 22, 2018 and asked industry stakeholders to submit comments.

Recently, DEEP issued a final RFP soliciting energy from eligible nuclear, hydro, RPS Class I and paired and co-located storage resources. These resources may be new, existing or "existing confirmed at-risk." The RFP defines "at-risk" resources as generating facilities that are "pro-

jected to have inadequate market revenues as determined by DEEP and will likely retire without ratepayer support."

Millstone's owner, Dominion Energy, had petitioned PURA seeking such at-risk status in a separate but related proceeding. The initial draft RFP created an "At-Risk Time Period" that effectively precluded Dominion from entering into contracts for the output from its Millstone nuclear facility until June 1, 2023.

Dominion and several State legislators protested, asserting that the financial status of the units as well as the legislation enabling the RFP mandated immediate action. As a result, the final RFP sets the At-Risk Time Period for June 1, 2022 – a full year earlier than the draft RFP. It also allows an eligible resource to demonstrate to DEEP that its at-risk status requires it to enter into a contract even sooner than June 1, 2022. The agency expects to select winning bidders by late 2018 or early 2019, and then bidders will submit final contracts to PURA for review and approval by Spring of 2019.

Millstone is Connecticut's only nuclear plant and produces nearly all the state's zero-carbon energy. If Millstone were to close, it could jeopardize the state's emission reduction targets and result in the loss of 1,500 jobs.

III. Recent FERC Action Provides Guidance on Potential Options for Pennsylvania: Discussions have taken place for years about how PJM's competitive wholesale electricity market should recognize the right of states to regulate electric generation and the protect the environment, and accommodate state programs designed to support preferred sources of electricity like wind, solar, and nuclear while maintaining free-market competition.

Despite decades of co-existence of the competitive market and state renewable energy programs, like Pennsylvania's AEPS program, PJM recently decided that state efforts to value the environmental attributes of nuclear energy represented an existential threat to its "competitive" wholesale electric markets.

Rather than working to implement a market-based solution that would accommodate state policy goals, PJM

⁸⁷Millstone produces 2,100 megawatts of power through two operating reactors that distribute energy throughout New England.

actively opposed states' pursuit of policies to prevent the premature shut down of their nuclear plants, while assuring state policymakers that they were working diligently to correct flaws in the market that PJM itself had long identified and recognized are negatively impacting nuclear generation.

In its order, FERC concluded:

- 1. That the current capacity market is not just and reasonable and needs to be reformed; and,***
 - 2. PJM must accommodate state clean energy programs.***
-

In April 2018, after over twelve months of stakeholder input, PJM submitted two proposals to FERC that, disappointingly, would have raised costs for consumers in states that enact clean energy programs.

On June 29, 2018, FERC issued a 3-2 decision rejecting both PJM proposals and directed PJM to accommodate the public policy choices states have made to support renewable and nuclear energy. In its order, FERC concluded:

1. That the current capacity market is not just and reasonable and needs to be reformed; and,
2. PJM must accommodate state clean energy programs.

Since PJM was unable to come up with a policy mechanism on its own to accommodate state clean energy programs, FERC provided PJM and states with a two-part mechanism that could protect the PJM market while also accommodating state programs.

Under the first part of the mechanism, the bids into PJM's capacity market from any resource receiving state support would be reset (e.g., increased) to the level the resource would have offered if it had no state-authorized support payments.

If only the first part of the FERC-recommended mechanism is implemented, the state-supported resources, e.g. Pennsylvania AEPS resources, would be at risk of not "clearing" in the PJM capacity market, as their reset bid levels could be too high, and other capacity resources

would be procured in place of the state-supported resource.

As a result, the resource receiving state support would not receive a capacity payment, and customers would over-pay for capacity (once through the state program, and again for the capacity being procured by PJM in place of the state-supported resource).

However, FERC also suggested a second part of the mechanism, called the Fixed Resource Requirement ("FRR") Alternative that is designed to accommodate the state programs while preserving the PJM market.

The "FRR Alternative" mechanism allows states to independently procure capacity for a portion of their load from specific state-preferred generation resources and remove the generation and associated load from the PJM capacity market. It can be viewed as a "safety valve" that states can utilize to protect their programs from the impact of the first part of the mechanism described above.

The FRR Alternative is a variation of PJM's current FRR construct, which has been utilized by some vertically integrated states within the PJM footprint for years so that utilities in these states can use their own preferred resources to serve capacity for all of the load in the utilities' service territory rather than rely on the resource mix generated by PJM's capacity auction.

FERC's proposed "FRR Alternative" offers the prospect of a more tailored approach that would apply only to specific resources and a commensurate amount of load in order to preserve the PJM capacity market while respecting state policy choices.

Unlike the existing FRR construct, the FRR Alternative only applies to specific identified resources and a commensurate portion of load. Load not allocated to specific state-supported resources would continue to participate in PJM's capacity market. FERC's proposed "FRR Alternative" offers the prospect of a more tailored approach that would apply only to specific resources and a commensurate amount of load in order to preserve the PJM capacity market while respecting state policy choices.

The FERC proceeding to establish this new capacity construct is still ongoing. The FERC conducted a 90-day "paper hearing" process to establish the new capacity market option, and is expected to issue an order in January 2019, just months before the 2019 Capacity Auction (for the delivery year beginning June 2022).

Regulatory and/or legislative actions may be necessary once FERC issues its final order in early 2019 if Pennsylvania desires to preserve its clean energy resources programs prior to the 2019 PJM Capacity Auction.

Depending on FERC rules in its anticipated January 2019 order, States may soon need to reevaluate their clean energy programs to ensure they are compatible with PJM's new capacity market rules and the new FRR Alternative. Regulatory and/or legislative actions may be necessary once FERC issues its final order in early 2019 if Pennsylvania desires to preserve its clean energy resources programs prior to the 2019 PJM Capacity Auction. As such, Pennsylvania should begin exploring state-level procurement processes that would take advantage of the existing FRR construct, and possibly some form of the new FRR Alternative, in preparation for the January issuance of the FERC order.

The impact of PJM's long history of inaction and FERC's ruling are far-reaching, and appears to leave Pennsylvania with four options:

1. **Do nothing and leave Pennsylvania's clean energy resources, including its nuclear plants, on a trajectory to early retirement.**

Taking no action, is in and of itself, a very deliberate choice to allow Beaver Valley and TMI to prematurely shut down, and to allow Pennsylvania's remaining nuclear fleet to eventually suffer the same financial challenges in an admittedly flawed marketplace.

Allowing any nuclear plant in the Commonwealth to close would have significant consequences for fuel diversity, resiliency, the environment, customers, and the state's economy. As abundantly supported in this report, the value of nuclear energy is clearly evident. One need only look at other states where nuclear plants have been

allowed to shut down - where decision-makers have failed to act - to understand the consequences.

2. **Modify AEPS (or establish a ZEC program) to put nuclear generation on equal footing with other zero-emission electric generation resources in Pennsylvania.**

The rationale behind this approach is simple – Pennsylvania, through AEPS, currently recognizes and compensates 16 sources of electric generation for their environmental attributes, but nuclear generation is not one of them. A modification to AEPS to include nuclear generation or the establishment of a ZEC program would utilize a construct already in existence in Pennsylvania to compensate nuclear generation for its environmental attribute, fairly put nuclear generation on similar footing as other clean energy resources, and help ensure that the continued benefits of these attributes are preserved for the Commonwealth.

The potential outcome of the FERC proceeding, however, puts at risk the long-term efficacy of a ZEC program or an Alternative Energy Portfolio Standard (AEPS) modification as a stand-alone solution. Depending on the outcome of the FERC proceeding, starting as early as the 2019 capacity auction (for the delivery year starting June 2022), the support provided by any ZEC program or AEPS will trigger a high minimum bid for clean generators in the PJM capacity market, putting them at risk of not clearing in the capacity auction.

Allowing any nuclear plant in the Commonwealth to close would have significant consequences for fuel diversity, resiliency, the environment, customers, and the state's economy.

This means that as early as 2019, AEPS and other state-supported resources may have to make a difficult choice between participating in a state program like AEPS or participating in PJM's capacity market (where revenues may not be sufficient to prevent them from retiring). Consumers' costs will increase significantly either way. To avoid such an unhelpful outcome, the ZEC programs and AEPS modifications must be used in combination with the FRR Alternative, which brings us to the next option.

3. Modify AEPS (or Establish a ZEC Program) in Combination with a “Safety Valve” Mechanism that Would Allow a Transition to the FRR Alternative

Each state in PJM will need to have its own response or approach to the final outcome of the FERC proceeding in order to maintain its state policy priorities. As discussed above, FERC has proposed the FRR Alternative as a straightforward option to allow states to support and maintain preferred resources for their desired attributes. The FRR Alternative appears to be the tool recommended by FERC to allow Pennsylvania to provide a near-term solution for its nuclear fleet. If a final order from FERC includes the FRR Alternative, it could be utilized either in combination with a revised AEPS/ZEC structure or as a complete replacement.

If a final order from FERC includes the FRR alternative, it could be utilized either in combination with a revised AEPS/ZEC structure or as a complete replacement.

An additional option is for the Commonwealth to pursue a phased approach to provide assistance to nuclear units immediately and then transition to a longer-term program, such as a Pennsylvania carbon pricing regime. This phased policy option would provide near-term assistance to nuclear plants, appears to be consistent with the FERC order, and would allow a reasonable amount of time to implement a carbon pricing program, leading us to option #4.

4. Establish a state carbon fee program – the long term solution

The Commonwealth could adopt a market solution based on carbon emissions. The concept of putting a price on carbon has broad and bi-partisan recognition as the most efficient, effective, and market-based environmental policy solution.

Currently, damages and associated costs to society caused by carbon pollution are largely not reflected in the price of generating electricity.

Consequently, energy users do not pay the true cost for electricity because the impacts of carbon emissions will

be paid by property owners, taxpayers, and the general populace in the form of increased health care costs, insurance premiums and damages caused by climate change.



Policy approaches that directly assign the costs of CO₂ pollution to CO₂ emitters will encourage emission reductions.

At the same time, zero-emitting generators like nuclear power are not subject to emission fees and become relatively more economical and thus perhaps delay or avoid nuclear power plant retirements.

The Commonwealth could initiate a market-based carbon fee policy, aimed at reducing CO₂ emissions, either unilaterally (through a Pennsylvania-specific cap and trade program) or regionally (by joining the Regional Greenhouse Gas Initiative "RGGI").

In either case, the carbon fee would need to be at least an amount great enough to result in a meaningful improvement in the economics of the zero carbon generators in the Commonwealth.

Policy approaches that directly assign the costs of CO₂ pollution to CO₂ emitters will encourage emission reductions.

Another important issue is the concept of emissions "leakage" which means the shifting of dispatch from covered generators within the carbon policy region to uncovered generators outside the policy region. (If gas generation in Pennsylvania is replaced by gas generation in Ohio, there will be a reduction in Pennsylvania emissions, but no overall emission reductions.)

In order to ensure that Pennsylvania resources are not disadvantaged and the carbon fee policy operates effectively and results in actual emission reductions, the policy should include leakage mitigation. For example, PJM has developed a virtual carbon price adder on imported power to ensure that generators in a carbon policy region compete on a level field with generators from states that have no carbon fee.

...carbon pricing is likely best viewed as a long-term solution, with AEPS and the FRR Alternative being the more readily-available short term policy solutions for the Commonwealth's nuclear generation plants.

Finally, the use of the collected fees should be considered. At a \$15/ton price, the annual carbon fees for Pennsylvania would total roughly \$1 billion per year. Typical uses of carbon fees include: refunds to retail electric customers, energy efficiency programs, and general revenue for the state.

A disadvantage of relying solely on a carbon fee policy is that it may take too long to implement in a time frame that would prevent the already planned early nuclear retirements. As such, carbon pricing is likely best viewed as a long-term solution, with AEPS and the FRR Alternative being the more readily-available short term policy solutions for the Commonwealth's nuclear generation plants.

9. Other Considerations

Summary:

As the Nuclear Energy Caucus undertook its review of the current challenges facing the nuclear power industry, it became clear that a common theme across the issues identified in this report is the lack of a coordinated structure to manage the many interconnected components of state and national energy policy.

...we make long-term energy policy decisions based only on what is cheap today.

This short-sighted approach incentivizes states to ignore the very real implications of what is happening over the long-term, and for nuclear assets, those choices are irreversible.

For example, the current determining factor for whether or not a Pennsylvania nuclear station remains online is on short term marginal prices established through the 13 state PJM wholesale electric markets. Stated another way, we make long-term energy policy decisions based only on what is cheap today.

This short-sighted approach incentivizes states to ignore the very real implications of what is happening over the long-term, and for nuclear assets, those choices are irreversible.

Success in achieving environmental goals, economic goals, national and energy security goals, as well as consumer goals cannot be accomplished without a harmonized approach where all these vital issues are appropriately considered, and compensated for, in a market.

The inevitable result without such an approach will be a disjointed, expensive and ineffective assortment of policies that, taken individually, will fail to maximize resources such as nuclear energy, which has many benefits beyond the production of electrons.

In short, how a power plant makes electricity matters, and because a source happens to be the most economic by price today does not necessarily mean it reflects all of the other important policy goals the Commonwealth has for its people.

Given the multi-jurisdictional nature of how Pennsylvania and other PJM states interact with PJM and FERC, and in consideration of the many uniquely important goals surrounding the production of electricity, the Nuclear Energy Caucus recommends that the Commonwealth consider creating, with existing resources, a cabinet-level position to help coordinate and manage the various energy issues so that a more comprehensive view spanning cross-disciplines (environmental, economic, consumer, reliability and resiliency, energy and national security) can be achieved.

Put another way, part of what has contributed to the current situation is the lack of a coordinated, forward-thinking state energy policy that takes into account all the issues involved in the production of electricity.

If Pennsylvania is to effectively use its power sector to reduce emissions, promote economic prosperity, contribute to the national defense and ensure energy security, and provide for long-term consumer price stability, it must have policies that consider and value all those attributes.

10. Conclusion

Conclusion:

Nuclear energy in Pennsylvania is at a crossroads.

The Commonwealth stands to lose a quarter of its nuclear power, to the detriment of its communities, economic standing, and environment. The Commonwealth must avert further nuclear plant closures or suffer job loss, community disruption, and higher electricity prices.

If the state does nothing, the pending nuclear retirements will take place as announced, and more closures may follow.

Concurrently, the PJM electricity capacity market in which Pennsylvania generation resources participate is changing in 2019 due to a late June order from the FERC. Pennsylvania, like other states in the PJM market, will need to craft a response if it is to maintain state energy policy priorities rather than having those priorities undermined by the coming changes.

If the state does nothing, the pending nuclear retirements will take place as announced, and more closures may follow.

We think there is a better path forward which will preserve the nuclear industry in the Commonwealth.

In the process of our hearings on Pennsylvania nuclear energy, the members of the Nuclear Energy Caucus attained an expanded knowledge of PJM's electricity markets. As such, while we do not claim to be experts, we are positioned to educate and assist our colleagues in the legislature as we collectively consider the state's response to FERC's order on mitigating state policy impacts in PJM's capacity market.

The actions needed to retain nuclear plants can be taken in tandem with the Commonwealth's response, needed in any case, to the FERC order. The FRR Alternative provided to the states by the FERC, may be just the solution that we need to tailor Pennsylvania's energy future to Pennsylvanians' values and priorities, including the important role of nuclear energy in that future.

11. Acknowledgements

The Nuclear Energy Caucus wishes to thank all the testifiers, organizations, advocacy groups, businesses and industries that provided their expertise and technical guidance throughout this fact-finding mission.

...the caucus would like to acknowledge and thank the hard-working men and women who every day go to work in one of the Commonwealth's five nuclear stations and who provide such an incredible value to Pennsylvania by safely producing electricity in an environmentally responsible manner to meet our 21st century energy needs.

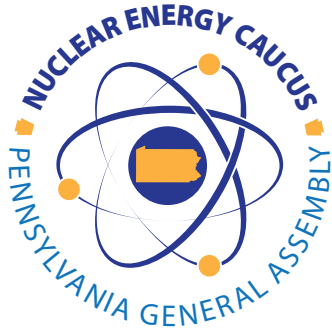
Most importantly, the caucus would like to acknowledge and thank the hard-working men and women who every day go to work in one of the Commonwealth's five nuclear stations and who provide such an incredible value to Pennsylvania by safely producing electricity in an environmentally responsible manner to meet our 21st century energy needs.

And to the people of Pennsylvania, the caucus would like to thank you for your patience as we sought to understand a very complex – but incredibly important – issue.

Our effort was solely on your behalf – so that you can have economic prosperity, energy security, long-term price stability, clean air and all of the associated benefits that are derived from the highest performing, most reliable forms of energy production in our state and nation – nuclear power.

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