STATE OF NEW JERSEY
BOARD OF PUBLIC UTILITIES

IN THE MATTER OF THE APPLICATION OF PSEG NUCLEAR LLC FOR THE ZERO EMISSION CERTIFICATE PROGRAM – HOPE CREEK

IN THE MATTER OF THE APPLICATION OF PSEG NUCLEAR LLC AND EXELON GENERATION COMPANY, LLC FOR THE ZERO EMISSION CERTIFICATE PROGRAM – SALEM UNIT 1

IN THE MATTER OF THE APPLICATION OF PSEG NUCLEAR LLC AND EXELON GENERATION COMPANY, LLC FOR THE ZERO EMISSION CERTIFICATE PROGRAM – SALEM UNIT 2

BPU Docket Nos. ER20080559, ER20080557 and ER20080558

DIRECT TESTIMONY
OF
CARL FRICKER
VICE PRESIDENT – POWER OPERATIONS SUPPORT
PSEG POWER

January 29, 2021

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I. INTRODUCTION

A. Witness Identification

Q. What is your name?

A. My name is Carl Fricker.

Q. By whom and in what position are you employed?

A. I am the Vice President - Power Operations Support for PSEG Power, LLC ("Power"), the parent of PSEG Nuclear LLC. PSEG Nuclear LLC ("PSEG") is the owner and operator of the Hope Creek plant, and the co-owner[1] and operator of the Salem 1 and Salem 2 plants.

B. Background and Qualifications

Q. What is your prior work experience, and educational and other professional qualifications?

A. I have been with Power and related Public Service Enterprise Group entities for 26 years. For the first 18 years of my career with PSEG, I was working at the Salem and Hope Creek nuclear plants, where I held many positions including Salem Plant Manager and Salem Site Vice President. Prior to PSEG, I worked at nuclear facilities in Washington State and Florida and spent five years serving in the Navy as a nuclear trained submarine officer. I earned a Bachelor of Science degree from the United States Naval Academy and a Master of Business Administration from the University of Delaware. I can speak first-hand to the impacts that operational risk have on nuclear plants.

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[1] PSEG has been vested with the sole and exclusive authority to make retirement decisions for the plants, covering Exelon Generation's 42.59% minority ownership share as well as PSEG's 57.41% majority ownership share. The Salem I and II submittals address all elements of the applications for 100% of the ownership interest and are submitted on behalf of both owners.

C. Purpose of Testimony

Q. What are the purposes of your testimony?

A. I address issues related to the operational risks faced by PSEG's Hope Creek, Salem I, and Salem II units. I also discuss the environmental benefits associated with the continued operation of these plants.

First, with regard to operational risk, I describe how external events, changing regulations, and equipment failure can unexpectedly and materially increase nuclear operating costs. This will include a summary of the impacts of significant, recent operational risks that have been realized at PSEG, and operational risks that have been realized at other plants. I also describe how operational costs would be avoided if the plants were to permanently shut down.

Second, I discuss the environmental benefits of these plants, and establish that the plants each satisfy the ZEC eligibility requirements with respect to emissions reductions.

II. OPERATIONAL RISKS

Q. Based on your experience in operations at the Salem and Hope Creek nuclear plants, please describe the operational risks that a nuclear power plant owner faces.

A. Operational risks are particularly pronounced for nuclear plants, and the risks fall into two primary categories. First, nuclear plants can face significant unforeseen regulatory requirements as a result of the stringent safety and security-focused regulatory oversight by the U.S. Nuclear Regulatory Commission ("NRC"). The ZEC Act refers to this as "the risk that operating costs will be higher than anticipated because of new regulatory mandates." N.J.S.A. 48:3-87.5. These can significantly increase a nuclear plant's operating costs.

Second, operational risk arises when equipment breaks. If a major component unexpectedly fails, the facility could bear the unanticipated and significant cost of repairing or replacing the component. The ZEC Act refers to this as "the risk that operating costs will be higher than anticipated because of … equipment failures." *Id.*

Additionally, during the period of repair, the unit is unable to produce and sell energy. Because a nuclear plant's costs are largely fixed but its revenues are largely variable, a forced outage results in a higher per-MWh cost of producing electricity: the fixed costs yield fewer MWhs of energy. The ZEC Act refers to this as "the risk that per megawatt-hour costs will be higher than anticipated because of a lower than expected capacity factor." *Id*.

Q. You referred to "the risk that operating costs will be higher than anticipated because of new regulatory mandates." Can you provide some examples of new regulatory mandates that unexpectedly increased costs for the nuclear industry and for PSEG specifically?

A. Yes. PSEG's applications included several examples of unexpected events and nuclear regulatory changes that resulted in increased costs at our New Jersey nuclear plants by hundreds of millions of dollars. These include:

- Fukushima. The upgrades required for all U.S. nuclear plants in response to the tsunami that impacted the Fukushima Dai-Ichi nuclear plant in Japan in 2011 are a recent example of operating risk. Following that event, the NRC issued multiple orders that required nuclear plants to make plant modifications, established additional mitigation strategies for external events, and imposed additional requirements for seismic and flooding evaluations, as well as reevaluation of emergency communications systems and staffing levels. These activities required expenditures of approximately $105 million at Salem and Hope Creek between 2012 and 2018.

- September 11. Since September 11, 2001, the NRC has issued many security-related orders to nuclear plants, including measures to protect against an insider terrorist attack and, waterborne, airborne, and land-based assaults. These security measures generally include increased patrols, augmented security forces and capabilities, additional security posts, installation of additional physical barriers, vehicle checks at greater stand-off distances, enhanced coordination with law enforcement and military authorities, and more restrictive site access controls. The post-9/11 security requirements cost approximately $140 million for Salem and Hope Creek.
- NRC Generic Safety Issues. The NRC engages in ongoing research on potential "Generic Safety Issues (GSI)" that can result in mandated modifications or upgrades to nuclear plants. For example, research on high energy arc faults is presently underway, and could result in additional requirements. Past GSI work included a review of nuclear plant cooling systems which ultimately required extensive modifications to the containment sump (part of the energy cooling system) and resulted in expenditures of approximately $26 million for the Salem Units in 2006 and 2007.

While the costs associated with these regulatory mandates are already reflected in PSEG's operating costs, PSEG's plants remain exposed to the risk of new regulatory mandates that might be imposed in the future.

Q. How does the NRC regulatory construct impact operational risk?

A. The NRC regulatory construct has significant effects on operational risk. Nuclear plants across the country perform inspections as mandated by NRC requirements. When issues are identified, additional requirements are placed on all other similar plants, imposing costs on those plants even if they have not yet had any similar issue arise. For example, industry experience at plants similar to Salem since 2015 has resulted in costly repairs and extended outages related to inspections of other reactor components, including reactor vessel penetration, control rod drive mechanism thermal sleeves, and cold leg nozzles. Also, plants similar to Hope Creek have experienced failed inspection results resulting in outage extensions and costly repairs, including repairs to reactor internal components such as jet pumps, the core plate, and the core shroud, to name a few. PSEG plans for costs based on expected results at our plants; however, unexpected results at other plants can trigger new regulatory mandates that can have significant impacts on our operations and costs.

Q. You mentioned the risk that "operating costs will be higher than anticipated because of … equipment failures." Has PSEG realized any significant unexpected costs due to nuclear equipment failure?

A. Yes. For example, in 2008, the four steam generators at Salem II required replacement prematurely. PSEG incurred expenditures of approximately $266 million over 6 years in connection with those replacements, culminating in an outage of over 57 days.

Q. Are there more recent examples of operational risk due to equipment failure that have been realized at PSEG?

A. Yes. Since early 2019 – a period of just two years – the Hope Creek, Salem I, and Salem II plants have experienced over **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** in unplanned costs, and over **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** unplanned outage days as a result of the following issues:

In February of 2020, a leak was identified from a tube in one of the four steam generators on Salem I. This required that PSEG shut the plant down, remove the fuel from the reactor, ultrasonically inspect all of the tubes in the four steam generators, and repair the leak. This leak resulted in a **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** day forced outage and had an unplanned cost impact of approximately **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**.

In the fall of 2019, while Hope Creek was in a refueling outage, an inspection revealed a defect in a system that supports the reactor pressure relief system. It was highly challenging to manage the radiological safety of our personnel based on where the components are located in the plant, resulting in an outage extension of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** days and an unplanned cost impact of approximately **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**.

In Salem I's 2019 spring outage, inspections of reactor vessel internal components identified an extensive amount of bolting that needed to be replaced. These were also complicated, underwater repairs and resulted in over **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** of unplanned costs and an outage extension of over **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** days.

More recently, during Salem I's 2020 fall outage, inspections of reactor vessel internal components identified required weld repairs that were not expected. Again, these were complicated, underwater repairs that resulted in additional cost and **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** additional outage days.

While these examples all relate to equipment failure, PSEG faces risks related to other types of costs as well. For example, the Hope Creek, Salem I, and Salem II plants have experienced over **[BEGIN CONFIDENTIAL]** [redacted] [redacted] **[END CONFIDENTIAL]** of higher costs due to labor inefficiencies, site configuration changes, and additional PPE as a result of COVID-19.

Q. Are there other examples from around the industry of equipment failure that caused incremental expense?

A. Yes. In evaluating the risk of equipment failure and the corresponding incremental expense, it is important to assess not only equipment failure at PSEG facilities, but from around the industry. Such a review provides a more comprehensive picture of the types of potential failures, and the associated risk, that can directly impact Salem I, Salem II, and Hope Creek.

For instance, in 2013, during a refueling outage at the Arkansas Nuclear One facility, the stator of the plant's generator fell and ruptured a water pipe, causing water infiltration to the plant's switchgear, which cut all power to Unit One and caused Unit Two to automatically shut down. The plant was offline for approximately four months, and the repairs were estimated to cost between $95 million and $120 million.

In another example, in September 2008, AEP's Cook Plant Unit I was shut down due to turbine vibrations, likely caused by blade failure, which resulted in a fire on the electric generator. Repairs cost approximately $330 million, and the plant outage stretched to 15 months.

In a third example, in 2002, staff at the Davis-Besse plant discovered coolant had leaked from cracked control rod drive mechanisms directly above the reactor and eaten through the steel on the exterior of the reactor vessel. Repairs and upgrades cost over $600 million, and the plant was offline for approximately two years. This event led to the replacement of reactor vessel heads at many pressurized water reactors including Salem I and II.

Q. When equipment repairs are needed, is the cost of repair predictable, or does PSEG face the risk of repair costs far larger than initially anticipated?

A. The cost of repairs can be significantly higher than initially anticipated. Reactor vessel internal inspections are a pertinent example. At the time of PSEG's first ZEC applications, our estimated costs for the inspection and repair of reactor vessel internal components was approximately **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** for the Salem units. This was our best estimate based on industry experience and input from technical experts. Actual inspection results since the first ZEC application revealed the need for much more extensive repairs than planned, and also gave rise to the need for additional inspections; our current estimate for inspection and repair of reactor vessel internal components has increased to **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]** for the Salem units (an increase of **[BEGIN CONFIDENTIAL]** [redacted] **[END CONFIDENTIAL]**). This example demonstrates not only the risk of needing to make unanticipated repairs, but also that the costs associated with such repairs can increase unexpectedly and quite significantly.

Q. Equipment failure is a common event at any large power plant; is there anything different about the impact of equipment failure at a nuclear plant in particular?

A. Yes. There are many systems and components at a nuclear plant that are designed to respond to unforeseen events and ensure the plants remain safe. These safety systems have stringent design requirements, and undergo extensive ongoing testing. When these components need repairs, the repairs are costly. Additionally, the unavailability of a safety system could force the plants to shut down for an extended period.

Q. Can you give any other examples from your personal experience of an unexpected prolonged outage at a nuclear plant due to equipment failure?

A. The most vivid example in my personal experience occurred when I was working at the Turkey Point nuclear plants south of Miami. I was one of the Senior Reactor Operators on shift when, in August of 1992, Hurricane Andrew, with 145 mph sustained winds, passed directly over the site. The storm caused extensive damage including the loss of all offsite power for more than 5 days, a complete loss of communication systems, closing of the access road, and damage to the fire protection and security systems.

The storm did not impact the nuclear safety systems, which speaks to the robustness of the design of these plants. The damage that I describe did, however, result in many months of lost generation and many of millions of dollars of unplanned costs. This storm not only resulted in increased costs at the Turkey Point plants; the lessons learned from the storm informed additional regulations for all nuclear plants, and those regulations increased costs for the entire industry.

Q. Earlier you mentioned the risk that the "per megawatt-hour costs [could] be higher than anticipated because of a lower than expected capacity factor." ***See*** **N.J.S.A. 48:3-87.5(a). Could you please explain how that risk is presented?**

A. Yes. The vast majority of costs associated with a nuclear facility are fixed costs, meaning that the costs do not decline in proportion to reductions in the capacity factor (the output of the facility). Nuclear units are designed and operated to run 24 hours per day, 7 days per week when they are available. Unlike other types of generation plants, it is practically impossible for nuclear units to significantly ramp their output down and back up in response to market or other signals. In addition, whereas a natural gas plant has variable costs associated with gas supply, which it only incurs when it is running, a nuclear plant has almost no variable inputs. Although nuclear costs are largely fixed, most revenue is variable and is paid on a $/MWh basis.

Consequently, reductions in output result in increased costs per-MWh: the body of fixed costs must be divided over a smaller volume of MWhs produced and sold. To illustrate, consider a nuclear unit with projected costs of $500 million and projected output of 10 million MWh. This plant would have a per-MWh cost of $50/MWh ($500 million / 10 million MWh). However, if the output of the facility is reduced to 9 million MWh (a reduction of 10%) due to an unexpected outage, the projected costs would not decline significantly (and in fact they may increase if an equipment repair is needed). Even assuming costs remain the same, the per-MWh cost would increase to $55.55/MWh ($500 million / 9 million MWh). In other words, a 10% reduction in output causes per-MWh costs to increase by 11.1%. The fixed costs remain the same, but must be divided over a smaller volume of MWh.

Q. If the plants are retired, would they still have on-going costs that would not be avoided?

A. As stated in PSEG's applications, if the plants were to be permanently shut down, all costs would be avoidable with the exception of a portion of Allocated Overhead Costs that would remain with the corporation (< 3% of the total cost). Once fuel is removed from the reactor and notice is given to the NRC (expected to be complete within 30 days after the final plant shutdown), all costs of the unit would be covered by the Decommissioning Trust Fund ("DTF") or reimbursed by the DOE pursuant to a settlement agreement for spent fuel management and therefore are avoidable. PSEG will take the steps necessary to gain full access to the DTF upon removal of fuel after the final shutdown. PSEG's applications demonstrate that the DTF is fully funded and projected to not have any shortfall due to early retirement. *See* PSEG's application responses to IUD-3, IUD-5, IUD-7 and SSA-1.

III. ENVIRONMENTAL BENEFITS

Q. Does the ZEC Act take into account the impact of nuclear power on the environment?

A. Yes it does. In the Act, the New Jersey Legislature recognized that New Jersey's air quality would be seriously degraded if nuclear plants were to close, due to "a substantial increase in emissions of several serious pollutants, and associated adverse public health and environmental impacts" that disproportionately affect "the most vulnerable citizens of New Jersey including children, the elderly, and people living in poverty."[2] The Legislature also determined that "[r]educing emissions of carbon dioxide, and other greenhouse gases . . . within and outside the State is critical to mitigating the impacts of climate change."[3]

Q. Do the Legislature's concerns remain valid?

A. Yes. The New Jersey Legislature's statements are confirmed by the reports of experts in the field, as I will further describe in this testimony, and detailed in portions of the applications regarding the environmental impacts of a potential closure of the Hope Creek and Salem Plants.

Q. Are there real world examples of the environmental impacts of a nuclear plant closure?

A. Yes. One recent example is the closure of the Oyster Creek nuclear plant in 2018. Oyster Creek was New Jersey's smallest nuclear plant (608 MW) when it shut down permanently in October 2018. During the following year, more than two-thirds of the electricity generated to replace Oyster Creek's production came from the increased use of New

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[2] N.J.S.A. 48:3-87 .3(b)(1); N.J.S.A. 48:3-87.3 (a)(10).
[3] N.J.S.A. 48:3-87.3(a)(1).

Jersey's natural gas-burning power plants. The remaining one-third was replaced by out-of-state coal and natural gas facilities. In total, the closure resulted in additional carbon emissions of 3.1 million tons for that year. For comparison, New Jersey's Hope Creek and Salem Plants are approximately five times larger than Oyster Creek, so the carbon emissions impact would be significantly greater if they were to close.

Q. What environmental impact criteria must be established for a plant to be eligible for ZECs?

A. An applicant must demonstrate that:

> [(1)] [a plant] makes a significant and material contribution to the air quality of the State by minimizing emissions that result from electricity consumed in New Jersey,
>
> [(2)] [a plant] minimizes harmful emissions that adversely affect the citizens of the State, and
>
> [(3)] if the nuclear power plant were to be retired, that that retirement would significantly and negatively impact New Jersey's ability to comply with State air emission reduction requirements[.][4]

Q. Do the Salem and Hope Creek plants satisfy these criteria?

A. Yes, they do. PSEG's applications, including in particular PSEG's responses to ENV-1 and ENV-2, demonstrate the significant negative impact that the retirement of one or more of the Hope Creek and Salem Plants would have on the ability of the State to achieve emissions reductions. PSEG's applications include detailed studies conducted by recognized industry experts – PA Consulting and ERM Consulting ("ERM") – showing impacts on fuel diversity, resilience, air quality, or other environmental benefits that would result from the retirement of the Hope Creek and Salem Plants. These studies demonstrate

[4] N.J.S.A. 48:3-87.5(e)(2) (emphasis added).

that the retirement of any one of the three Hope Creek and Salem Plants (and especially all three) would result in significant increases in greenhouse gas emissions and ozone levels.

All of these pollutants are harmful to humans, and the degradation in New Jersey air quality would exacerbate health problems that New Jersey residents experience. Moreover, because environmental impacts – particularly those impacts associated with ozone – are greatest in urban areas with larger populations of low-income residents, the loss of the Hope Creek and Salem Plants could present environmental justice issues.

The retirement of any of the plants would significantly hamper the ability of New Jersey to meet National Ambient Air Quality Standards ("NAAQS") for ozone and to meet carbon reduction targets under the Global Warming Response Act of 2007 ("GWRA"), which established the state's goal to reduce economy-wide state greenhouse gas emissions 80% below 2006 levels by 2050.

Q. How do PSEG's applications establish that the Salem and Hope Creek plants minimize harmful emissions that result from electricity consumed in New Jersey?

A. The applications plainly establish that PSEG has satisfied this criterion. The Hope Creek and Salem plants produce approximately 40% of the State's energy, and if they retire, emissions associated with the electricity consumed in New Jersey will increase. For example, the study by PA Consulting shows the material increases in these pollutants produced in New Jersey and in surrounding states most likely to affect air quality in the State resulting from the retirement of the Hope Creek and Salem Plants. Specifically, the impact of the retirement of the Hope Creek and Salem Plants would be significant because it would result in increases in emissions of CO_2 (13%), NO_x (14%), SO_2 (5%), PM_{10} (13%) and $PM_{2.5}$ (14%) in New Jersey. Levitan & Associates, Inc. ("LAI") compared PA Consulting's 2019 projected emission results to emissions data submitted to EIA and EPA.

LAI noted some differences between the PA Consulting and EIA/EPA data, but they concluded that the differences were insignificant.[5]

Maintaining the operations of the Hope Creek and Salem Plants would result in the avoidance of this increase in harmful emissions that would otherwise adversely affect the citizens of the state. In addition, as noted above, environmental impacts – particularly those impacts associated with ozone – are greatest in urban areas with larger populations of low-income residents; therefore, the loss of the Hope Creek and Salem Plants could present environmental justice issues.

Q. Did ERM also consider the impact that retirement of the Hope Creek and Salem Plants would have on achieving economy-wide greenhouse gas ("GHG") reductions?

A. Yes, it did. ERM prepared a study showing the impact that retirement of the Hope Creek and Salem Plants would have on achieving the GHG reductions under the GWRA. ERM's analysis, in conjunction with PA Consulting's analysis, clearly demonstrates that the operation of PSEG's units have resulted, and are projected to continue to result in, significant, material levels of avoided GHG emissions. For example, for the five-year look forward period, ERM has demonstrated that the retirement of the Hope Creek Plant would result in a 22-34% increase in GHG emissions above current levels from New Jersey's electric sector.[6] The retirement of all three plants would result in a 60-68% increase in GHG emissions above current levels from New Jersey's electric sector.[7] As ERM

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[5] Levitan & Associates, Inc., "New Jersey Zero Emission Certificate Salem 2 Application Preliminary Report on Eligibility and Finances Public Version," at 10.

[6] The indicated increase percentage is computed against the 2010-2019 average of about 18 MMT/year. PSEG Answer to ENV-1, ERM, "Impact of PSEG Nuclear Unit Shutdowns on Greenhouse Gas Emissions," at 19; PSEG Answer to ENV-1, data from ERM, "Impact of PSEG Nuclear Unit Shutdowns on Greenhouse Gas Emissions," at 28.

[7] *Id.*

concluded, if any single plant retires (and especially all three plants), "[t]hese GHG emission increases would have significant negative impact and jeopardize the State's ability to achieve its 2050 GHG reduction goals."[8] LAI agreed that if New Jersey continues to follow its historic CO_2 emission reduction trajectory for the power generation sector, the State would fall short of meeting the GWRA 2050 goal.[9]

Q. How would premature retirement of the Hope Creek and/or Salem Plants affect New Jersey's ability to achieve the National Ambient Air Quality Standards ("NAAQS") for ozone?

A. Retirement of the Plants would exacerbate the significant challenges already faced by New Jersey in achieving the 70 ppb 8-hour ozone NAAQS across the State. As stated in the ERM study:

> <u>Additional controls will be hard for New Jersey to impose and, given this difficulty, achieving even the relatively small reductions in ozone concentrations needed for attainment will be made even more challenging by factors that increase precursor emissions, such as the loss of nuclear units</u>. The NOx emissions increases projected by the PA Consulting study result from a permanent replacement of the electricity generation provided by the nuclear units at Hope Creek and Salem. <u>Any increase in emissions, and the resulting increase in ozone concentrations discussed in the [report], will make attaining the ozone NAAQS in New Jersey all the more difficult</u>.[10]

New Jersey has already made substantial (and expensive) efforts to significantly reduce ozone precursor emissions (*i.e.*, NO_x and volatile organic compounds ("VOCs")) emitted in the State. Many neighboring states do not require state-of-the-art emission reduction technology necessary to minimize ozone-producing emissions. Retirement of the nuclear units, which do not emit NOx or VOC emissions, would force New Jersey to rely more

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[8] *Id.* at 5.

[9] Levitan & Associates, Inc., "New Jersey Zero Emission Certificate Salem 2 Application Preliminary Report on Eligibility and Finances Public Version," at 11.

[10] PSEG Answer to ENV-1, ERM, "Impacts of PSEG Nuclear Unit Shutdowns on New Jersey's Ozone Attainment Goals," at 9 (emphasis added).

heavily on dirtier fossil fuel-fired generation that impacts ambient ozone concentrations. The retirement of carbon-free, existing nuclear resources runs counter to New Jersey's efforts to reduce regional ozone levels. The continued operation of the Hope Creek and Salem Plants is needed to prevent backsliding in the efforts to meet the ozone NAAQS.

Q. Did the Legislature consider the concept of fuel diversity when it enacted the ZEC Act?

A. Yes, it did. The Legislature specifically acknowledged that "New Jersey has historically relied on a diverse mix of energy supply sources, including nuclear power, to meet the needs of its residents and businesses."[11] Moreover, the Legislature expressly determined that "[i]n light of the primacy of natural gas use for heating in New Jersey, increased reliance on natural gas-fired generation will render the electric generation and delivery systems less resilient and more vulnerable to the impacts of extreme winter weather events, natural gas pipeline accidents, and other factors affecting the deliverability of natural gas to electric power generating stations in and around the State."[12]

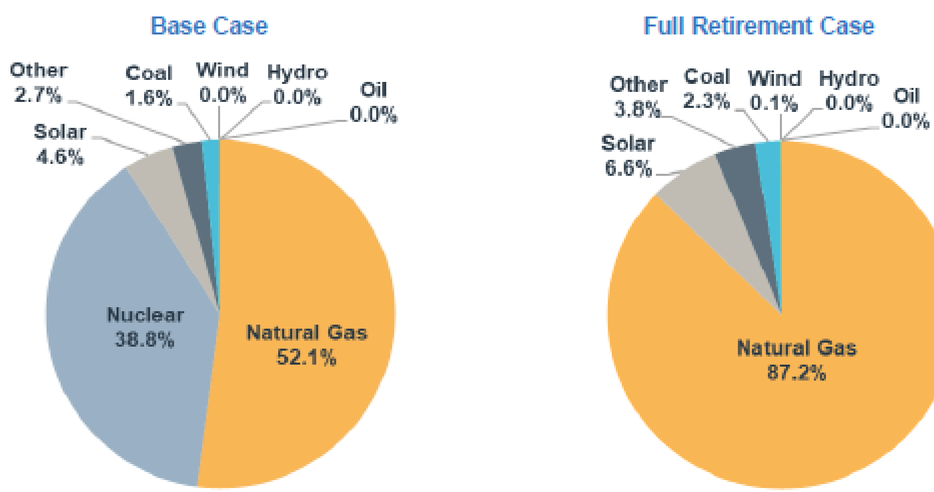
Q. Do PSEG's applications address the fuel diversity impacts of the closure of the Hope Creek and/or Salem plants?

A. Yes. In the report by PA Consulting submitted with PSEG's applications, the authors aptly state that "overreliance on a single fuel or technology places the electricity system at increased risk of higher prices and more frequent and sustained outages."[13] PA Consulting conducted an analysis of the increase in natural gas-fired generation in the event of a "Full Retirement Case" (that is, the retirement of the three New Jersey nuclear units). Figure A,

[11] N.J.S.A. 48:3-87.1(a)(3).
[12] N.J.S.A. 48:3-87.1(b)(3).
[13] PSEG Answer to ENV-1, PA Consulting, "The Impact of Nuclear Generation Retirements on Emissions and Fuel Diversity in New Jersey," at 36.

below, from PA Consulting's report provides the outcome of that analysis: in the Full Retirement case, natural gas-fired generation would comprise about 87% of generation in New Jersey during the 2022 through 2025 time period, an increase of over 35% as compared to a "Base Case" reflecting the continued operation of the New Jersey nuclear units.

Figure A: New Jersey Generation (MWh) - (Across Study Period)[14]



Q. You've been discussing the impact of closure on fuel diversity of generation assets in New Jersey. Did you also consider the impact on the amount of natural gas-fired generation imported from other states into New Jersey?

A. Yes, and the retirement of a nuclear plant would similarly result in increased reliance on natural gas-fired generation imported from other states. This is demonstrated by the fact that while reliance on imported electricity has declined significantly over the past years, imported electricity increased in 2018 as a result of the closure of the Oyster Creek nuclear plant.[15] As a result, ERM concluded that "the loss of any or all of the Hope Creek and/or

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[14] *Id.* at 38.

[15] PSEG Answer to ENV-1, ERM Consulting, "Impact of PSEG Nuclear Unit Shutdowns on Greenhouse Gas Emissions," at 9.

Salem units would continue this trend, by substantially increasing generation and GHG emissions from [imported electricity]."[16]

IV. CONCLUSION

Q. Does this complete your testimony?

A. Yes.

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[16] *Id*.