Zero Emission Certificate Application

I. Impact on NJ Air Quality and Air Emissions – Salem 2

A. Required Environmental Impact Demonstrations

The ZEC Act contains three expressly-stated environmental impact criteria establishing eligibility. An applicant must provide a "demonstration . . . that:

> [(1)] [a plant] make 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."[1]

The Salem and Hope Creek plants satisfy each of these three criteria.

1. "[A] significant and material contribution to the air quality of the State by minimizing emissions that result from electricity consumed in New Jersey."

Establishing eligibility under the first criterion requires satisfaction of two elements: (i) that a significant portion of the output of the applicant's nuclear plants are consumed by loads located within New Jersey; and (ii) that the output from the replacement sources for the retired nuclear plants would cause a "significant and material" deterioration in the air quality of the State. Both elements are present for the Hope Creek and Salem plants.

(a) Salem's and Hope Creek's Production is Primarily Consumed within New Jersey:

It is clear that the predominant portion of the energy output from Salem and Hope Creek is consumed in New Jersey. Salem and Hope Creek are connected via high tension transmission lines to large load centers in New Jersey and clearly supply substantial portions of their output to loads within the State. Three of the four 500 kV transmission lines extending from the plants are interconnected to transmission facilities serving New Jersey consumers. Specifically, the 500 kV transmission lines that extend from the plants are interconnected to the robust 230 kV transmission system serving PSE&G's franchised electric territory at the Deans SW and Branchburg substations. The capability of the transmission path between the PSE&G central zone and its northern zone has recently been strengthened by the completion of the Bergen-to-

[1] New Jersey ZEC Act, Section 3(e)(2).

Linden double circuit 345 kV transmission lines, thus increasing the capability of the nuclear plants to serve these New Jersey loads. In addition, the plants also have strong connections to Camden from the 500 kV transmission system via interconnection at the New Freedom SW substation to the 230 kV transmission system that serves Camden. Further, the plants are also interconnected with the 138 kV transmission system serving Trenton via interconnection with the 500 kV transmissions lines at Ward Avenue SW.

A study recently prepared by PJM further supports the importance of the Salem and Hope Creek plants to New Jersey consumers. As one of several possible alternatives to the solution-based DFAX method, PJM prepared an analysis that it called the "Stability Interface DFAX Method." According to PJM, this methodology demonstrates "the robustness of the transmission that connects the generator(s) to the rest of the system (i.e. how tightly the generator(s) are coupled to the rest of the system)."[2] Based on PJM's analysis, which includes the impact of the proposed 230-kilovolt transmission line from the plants into Delaware, the plants will still predominantly service New Jersey *even after the new line goes into service.* PJM found that 64.4 % of the flows associated with the plants will benefit New Jersey zones even with the new line in operation.[3] The present share of plants serving New Jersey load under the PJM methodology is even greater because the new line does not currently exist.

Finally, as discussed in greater detail below and in the response to IV-ZECJENV-2, under the legislatively-mandated methodology used by the New Jersey Department of Environmental Protection for identifying "In-State Electric" generation output for the purposes of establishing compliance with New Jersey's Global Warming Reduction Act, all of the output of the plants is considered to be available for meeting New Jersey's electric demand. This is a further indication of the energy contributions made by the plants to New Jersey residents.

Capacity produced by Salem and Hope Creek is also predominantly consumed within the State. The Hope Creek and Salem plants are located in the Eastern MAAC capacity zone as determined by PJM Interconnection LLC, which includes the entirety of the State of New Jersey, the PECO transmission zone in Pennsylvania and a small portion of Maryland and Delaware. New Jersey load comprises about 59 % of total EMAAC load. In recent capacity auctions, the EMAAC Zone has been "constrained," meaning that the transmission interconnections between EMAAC

[2] "Alternative Approaches to Identification of Artificial Island Project Beneficiaries," PJM Interconnection, L.L.C., June 9, 2017, p. 7 (https://www.pjm.com/~/media/committees-groups/committees/teac/20170609/20170609-stability-project-beneficiary-identification.ashx).

[3] Id., p. 8. The PSEG Companies note that while they generally agree with PJM's analysis regarding the overall strength of the transmission system regarding power flows from the Salem and Hope Creek plants, they do not agree with PJM that the "Stability Interface DFAX Method" is the proper methodology for assigning costs related to the new 230 kV line. For a single new line, the solution-based DFAX methodology is correct as it fairly represents the beneficiaries for that particular facility.

and the rest of PJM were inadequate to meet the internal load requirement within EMACC during the studied peak conditions without paying higher capacity prices to in-zone resources.[4] Given New Jersey's predominant share of EMAAC load and the constrained nature of EMAAC in PJM capacity auctions, it is clear that the Salem and Hope Creek capacity is needed to serve New Jersey consumers.

In sum, both Salem and Hope Creek satisfy this element of the required demonstration because both their energy and capacity output are consumed primarily in New Jersey.

b. The Retirement of Salem and/or Hope Creek Would Have a Significant and Material Impact on the Air Quality Within the State

The retirement of Salem and/or Hope Creek would have a significant and material impact on New Jersey's air quality. PSEG has obtained assistance from a recognized outside expert in order to demonstrate the impact on New Jersey air quality associated with the retirement of the Salem and/or Hope Creek plants. These analyses – conducted by PA Consulting, an internationally recognized firm with substantial experience in conducting these types of analyses – show this fact unequivocally.

Conclusions: As shown in the tables below that summarize the main findings of the PA Consulting analysis regarding air emissions, the retirement of Salem and/or Hope Creek results in substantial increases in Modeled Pollutants from fossil fuel-fired power plants for New Jersey and the states in closest proximity to New Jersey that would be expected to most significantly affect New Jersey air quality. As shown below, under the Full Retirement Case, for the MAAC region, the increases in Modeled Pollutants range from 2.1% to 7.1% over the entire three-year study period – with most of the pollutants registering increases of 6% or above. These increases would have a substantial detrimental impact on air quality in New Jersey. In addition, in the Full Retirement Case, for the Eastern Interconnection, the increase in CO_2 emissions would be 29,181,000 short tons (26,473,000 metric tons)[5] over that full three-year study period. To place this value into perspective, at the $42/metric ton rate for the social cost of carbon as determined by the Environmental Protection Agency for 2020 and referenced in the ZEC Act,[6] the associated cost of this increase would be about $1.11 billion over the three-year study period.

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[4] *See, e.g.,* 2021/2022 RPM Base Residual Auction Results, p.3 ("EMAAC, [and other zones] were constrained [Locational Delivery Areas] in the 2021/2022 [Base Residual Auction]") (https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2021-2022/2021-2022-base-residual-auction-report.ashx?la=en); 2020/2021 RPM Base Residual Auction Results, p.1 ("EMAAC, [and other zones] were constrained [Locational Delivery Areas] in the 2020/2021 [Base Residual Auction]") (https://www.pjm.com/-/media/markets-ops/rpm/rpm-auction-info/2020-2021-base-residual-auction-report.ashx?la=en).

[5] Short tons was converted to metric tons by multiplying by a factor of 0.907185.

[6] *See* "The Social Cost of Carbon," United States Environmental Protection Agency, (https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html)

Impacts associated with the Hope Creek Retirement Case (proxy for Salem 2) are not as large but are still clearly material. These increases range from 0.4% to 2.3% for the Modeled Pollutants. In addition, the total CO_2 increase to the Eastern Interconnection would be 12,821,000 short tons (11,631,000 metric tons) – an amount that corresponds to about $489 million over the three-year study period using the $42/metric ton value for the social cost of carbon. These demonstrations show satisfaction of the statutory criterion based on their "significant and material impact on New Jersey's air quality."

Finally, assuming that this criterion requires the emissions impacts also take into account the extent to which the energy and capacity output of the plants serve New Jersey, the Plants still meet the statutory standards. As shown below, the Plants *predominantly* serve New Jersey load. Even if the emission impacts were to be discounted to reflect services provided by Salem and Hope Creek to out-of-state consumers, the New Jersey impacts are still "significant and material."

Impacts: The PA Consulting report clearly demonstrates a significant and material adverse impact on air quality in the State in the event the Plants are retired. As shown in the report, most of the replacement generation will be produced by gas-fired and coal-fired generators both in New Jersey and in other states. The chart below depicts the results of the PA Consulting study for the scenario in which only Hope Creek retires ("Hope Creek Retirement") and the scenario in which all three plants retire ("Full Retirement Case"). The geographic scope shown in these results is for New Jersey and the Mid-Atlantic Area Council Region ("MAAC"), a study area within PJM that encompasses the entirety of New Jersey and all or parts of Delaware, the District of Columbia, Maryland and Pennsylvania. In addition, New Jersey impacts, in combination with the northeastern RGGI states,[7] and the Eastern Interconnection are also depicted in the PA Consulting report with respect to the results for aggregate CO_2 emissions.

[7] The Regional Greenhouse Gas Initiative ("RGGI") is an electric power sector-specific GHG emission cap-and-trade program comprised of ten participating Northeastern and Mid-Atlantic States. Virginia will be the eleventh participating state starting on January 1, 2021.

CASE 1 – Hope Creek Retirement Assumption (Proxy for Salem 2)

Table 1-3: Increase in Emissions Across Study Period—Hope Creek Retirement Case (Proxy for Salem 2)[8]

Geography	CO_2 ('000 short tons)	NOx (short tons)	SO_2 (short tons)	Hg (lbs)	PM10 (short tons)	PM2.5 (short tons)
New Jersey	2,779	567	57	0.0	168	162
MAAC	8,436	2,512	1,173	1.4	557	517

Table 5-4: Increase in MAAC Region Aggregate Emissions - Hope Creek Retirement Case (Proxy for Salem 2)[9]

Time Period	CO_2 ('000 short tons)	NOx (short tons)	SO_2 (short tons)	Hg (lbs)	PM10 (short tons)	PM2.5 (short tons)
Study Period Total	8,435.5 (2.3%)	2,511.9 (1.9%)	1,172.8 (0.7%)	1.4 (0.4%)	556.9 (2.0%)	516.6 (2.1%)
2022/23 DY	2,645.1 (2.1%)	730.5 (1.6%)	329.6 (0.5%)	0.4 (0.3%)	172.4 (1.7%)	160.9 (1.9%)
2023/24 DY	2,831.2 (2.3%)	832.4 (1.9%)	324.0 (0.6%)	0.4 (0.3%)	187.8 (2.0%)	174.6 (2.2%)
2024/25 DY	2,959.2 (2.5%)	949.0 (2.3%)	519.3 (1.1%)	0.6 (0.5%)	196.8 (2.1%)	181.1 (2.3%)
Typical Summer Day	8.7 (2.2%)	2.4 (1.6%)	0.2 (0.1%)	0.0 (-0.3%)	0.6 (1.7%)	0.5 (1.9%)
HEDD	8.3 (1.6%)	6.3 (3.1%)	0.5 (0.2%)	0.0 (0.6%)	0.6 (1.3%)	0.5 (1.5%)
Peak Winter Day	6.1 (1.6%)	2.0 (1.3%)	1.8 (0.8%)	0.0 (0.9%)	0.5 (1.4%)	0.4 (1.5%)

[8] PA Consulting, "The Impact of Nuclear Generation Retirements on Emissions and Fuel Diversity in New Jersey", pg. 11.
[9] Id., pg. 32.

Table 5-6: Increase in Aggregate CO_2 Emissions – Hope Creek Retirement Case (Proxy for Salem 2) ('000 short tons)[10]

Time Period	RGGI	Eastern Interconnect
Study Period Total	1.2%	0.4%
2022/23 DY	1.1%	0.3%
2023/24 DY	1.2%	0.4%
2024/25 DY	1.3%	0.4%

CASE 2 – Full Retirement Assumption

Table 1-2: Increase in Emissions Across Study Period—Full Retirement Case[11]

Geography	CO_2 ('000 short tons)	NOx (short tons)	SO_2 (short tons)	Hg (lbs)	PM10 (short tons)	PM2.5 (short tons)
New Jersey	8,892	2,074	202	0.2	547	526
MAAC	26,053	8,999	4,851	8.3	1,808	1,649

[10] Id., pg. 35.
[11] Id., pg. 10.

Table 5-1: Increase in MAAC Region Aggregate Emissions - Full Retirement Case[12]

Time Period	CO_2 ('000 short tons)	NOx (short tons)	SO_2 (short tons)	Hg (lbs)	PM10 (short tons)	PM2.5 (short tons)
Study Period Total	26,053.3 (7.1%)	8,998.7 (6.9%)	4,850.9 (3.0%)	8.3 (2.1%)	1,808.5 (6.4%)	1,649.0 (6.7%)
2022/23 DY	8,556.2 (6.8%)	2,722.2 (5.9%)	1,707.8 (2.8%)	2.9 (2.0%)	591.3 (6.0%)	539.1 (6.4%)
2023/24 DY	8,805.6 (7.3%)	3,090.2 (7.2%)	1,435.8 (2.7%)	2.9 (2.2%)	614.7 (6.6%)	561.8 (7.0%)
2024/25 DY	8,691.5 (7.2%)	3,186.3 (7.7%)	1,707.2 (3.5%)	2.5 (2.2%)	602.4 (6.5%)	548.2 (6.8%)
Typical Summer Day	28.9 (7.2%)	8.7 (5.8%)	3.6 (1.9%)	0.0 (2.1%)	2.1 (6.5%)	1.9 (6.8%)
HEDD	27.6 (5.3%)	26.0 (12.9%)	20.2 (8.0%)	0.0 (6.3%)	2.7 (6.5%)	2.2 (6.3%)
Peak Winter Day	20.4 (5.3%)	6.0 (3.9%)	6.2 (2.7%)	0.0 (2.4%)	1.4 (4.3%)	1.2 (4.5%)

Table 5-3: Increase in Aggregate CO_2 Emissions – Full Retirement Case ('000 short tons)[13]

Time Period	RGGI	Eastern Interconnect
Study Period Total	3.7%	0.8%
2022/23 DY	3.9%	0.5%
2023/24 DY	3.7%	0.7%
2024/25 DY	3.6%	1.3%

Methodology Used: The methodology used to determine the impact on air quality associated with the retirement of Salem and Hope Creek consists of the following steps:

[12] Id., pg. 28.
[13] Id., pg. 31.

(i) determine a "base case" of the emissions affecting New Jersey associated with the projected portfolio of generators in proximity to the State;
(ii) determine the emissions affecting New Jersey under a sensitivity case which assumes that Salem and Hope Creek are retired in their entirety; and
(iii) determine the emissions affecting New Jersey under a sensitivity case which assumes that only Hope Creek is retired (this is also a proxy for the retirement of any one unit at the Salem/Hope Creek site).

The base case and the sensitivity cases were modeled by PA Consulting with the AURORA^{xmp}model, a widely used power transmission and generation dispatch simulation model, over the entire Eastern Interconnect, which includes the PJM power market. The simulation for this study was done on a nodal basis. This model projects hourly power prices, energy flows, and the operating profiles of the electric generating resources (including dispatch, fuel consumption, and emissions). As an input to AURORA^{xmp}, in order to forecast long-term wholesale natural gas prices and to evaluate how changes in natural gas generation impact the natural gas markets in the scenario cases, PA Consulting used the GPCM® Natural Gas Market Forecasting System™, another widely-used industry model.

The modeled emissions are CO_2, NO_x, SO_2, Hg, PM_{10}, and $PM_{2.5}$ ("Modeled Pollutants"). PA Consulting developed generating unit-level operating assumptions, including emission rates (i.e., lbs. or tons of emissions per MMBtu of fuel consumed) based on historical emissions data to determine emission levels of affected units. For any unit that did not have recent historical emissions data reported, PA Consulting used a class average emission rate based on the fuel type and technology type of the generating unit, as well as any installed emission controls. For each study case, PA Consulting reported annual emissions for each of the Modeled Pollutants from June 2022 through May 2025 (the "Study Period"). The report also calculated daily emissions of the Modeled Pollutants for the "Typical Summer Demand Day," "High Energy Demand Day" ("HEDD"), and "Peak Winter Day", all of which take place in calendar year 2022. The PA Consulting Report describes the methodologies used in greater detail.

2. Preservation of the plants "minimize[] harmful emissions that adversely affect the citizens of the State"

The analysis discussed in the previous section regarding the emissions impact under the PA Consulting analysis applies with equal force to the satisfaction of this criterion. All of the Modeled Pollutants are widely recognized as harmful to humans. This is further supported by the studies prepared by Environmental Resources Management (ERM) Consulting, a leading global provider of environmentally-related services, with more than 160 offices in over 40 countries and territories and employing more than 4,700 people. The ERM studies, discussed in

greater detail below, focus on the impact of the Salem and/or Hope Creek retirements on New Jersey's ability to meet its air emissions goals as related to ozone and greenhouse emissions.

Ground level ozone is a harmful air pollutant. It is formed by chemical reactions between NOx and VOC in the presence of sunlight. Ozone is most likely to reach unhealthy levels on dry, hot sunny days in urban environments. High ozone levels in the northeast region are caused by both local emissions and those emissions released upwind of an area and transported over time to the area of concern. High levels of ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and airway inflammation. It also can reduce lung function and harm lung tissue. Ozone can worsen bronchitis, emphysema, and asthma, leading to increased medical care.[14]

Anyone who spends time outdoors is at risk to the health effects of high levels of ozone, but five specific groups are especially vulnerable:

- Children and teens;
- Anyone 65 and over;
- People who work or exercise outdoors;
- People with existing lung disease, such as asthma and chronic obstructive pulmonary disease; and
- People with cardiovascular disease.[15]

Both ozone nonattainment areas were ranked as two of the 25 most ozone-polluted areas in the American Lung Association's (ALA) "State of the Air 2020" report. The New York-Northern New Jersey-Connecticut area was ranked twelfth while the Philadelphia-Southern New Jersey-Delaware area was ranked 23th.[16] Nine out of sixteen counties with ambient air quality monitors for ozone in New Jersey received an "F" grade:

- Bergen
- Camden
- Gloucester
- Hudson
- Hunterdon
- Mercer
- Middlesex
- Morris
- Ocean

[14] https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics#effects

[15] American Lung Association, "State of the Air 2018." p. 36.

[16] Id., p. 22.

Essex and Passaic Counties received a "D" while Monmouth and Warren counties received a "C".[17]

Climate change is one of the greatest threats facing our world today and in the future. The New Jersey Legislature 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."[18] Climate change caused by human activities that emit greenhouse gases into the air is expected to affect the frequency of extreme weather events, including hotter summers. As stated above, ozone is most likely to reach unhealthy levels on dry, hot sunny days in urban environments. In fact, the U.S. Global Change Research Program stated in their "Fourth National Climate Assessment:

> Unless offset by additional emissions reductions of ozone precursor emissions, there is high confidence that climate change will increase ozone levels over most of the United States, particularly over already polluted areas, thereby worsening the detrimental health and environmental effects due to ozone. The climate penalty results from changes in local weather conditions, including temperature and atmospheric patterns, as well as changes in ozone precursor emissions that are influenced by meteorology.[19]

Therefore, climate change will also have a detrimental effect on ozone levels at a time when ozone standards have become more stringent. Further, because New Jersey has a long coast line with inhabited islands, many New Jersey residents are susceptible to the harmful impacts of rising ocean levels that global warming is projected to cause.

SO_2 and NO_x react with other compounds in the atmosphere to form fine particles ($PM_{2.5}$). Exposure to PM_{10} and $PM_{2.5}$ can affect both a person's lungs and heart. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including:[20]

- Premature death in people with heart or lung disease
- Nonfatal heart attacks
- Irregular heartbeat
- Aggravated asthma
- Decreased lung function
- Increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing

Anyone who lives in areas with high levels of particulate pollution is at risk of adverse health effects, but six specific groups are especially vulnerable:

[17] Id., p. 121

[18] New Jersey ZEC Act, Section 1(a)(1)

[19] U.S. Global Change Research Program, "Fourth National Climate Assessment", p. 99

[20] https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm

- Infants, children and teens;
- Anyone 65 and over;
- People who work or are active outdoors;
- People with existing lung disease, such as asthma and chronic obstructive pulmonary Disease (COPD);
- People with heart disease or diabetes;
- People with low incomes.[21]

Children are at particular risk from ozone and particulate pollution because their lungs are still growing and they tend to spend more time outdoors. The ALA states that "[c]hildren have more respiratory infections than adults, which also seems to increase their susceptibility to air pollution."[22] In addition, the ALA found that poorer people and ethnic minorities often face higher exposure to air pollution.[23] According to the State of New Jersey Department of Health:

> In New Jersey, more than 600,000 adults and 167,000 children have asthma. Asthma affects all races, ages and genders. More boys have asthma than girls, but in adulthood, more women are diagnosed with asthma than men. Blacks, Hispanics and urban residents are more likely to be affected with asthma symptoms, as are individuals with a family history of the disease.[24]

Because the increase in emissions under the PA Consulting analysis is "significant and material" under the retirement cases and as further demonstrated in the ERM studies focused on ozone and greenhouse gases, preserving the Plants will "minimize[] harmful emissions that adversely affect the citizens of the State." Further, because this criterion considers the full impact of the Plants' retirement on air quality, *i.e.*, not just the share of energy and capacity consumed in New Jersey, all the projected increases in Modeled Pollutants should be considered.

3. "If the nuclear power plant were to be retired, that that requirement would significantly and negatively impact New Jersey's ability to comply with State air emission reduction requirements."

This criterion addresses the extent to which retirement of an applicant plant would have an adverse impact on the New Jersey's ability to achieve its defined air quality goals. Retirement of Salem and/or Hope Creek would satisfy this criterion because of the impact that retirement would have on the ability of the State to meet its goals for ozone reductions under the State

[21] American Lung Association, "State of the Air 2018," p. 36.

[22] Id., p. 42.

[23] Id., p. 46.

[24] https://nj.gov/health/fhs/chronic/asthma/in-nj/.

Implementation Plan (SIP) submitted by New Jersey in December 2017[25] and to meet the reduction goals in greenhouse gas ("GHG") emissions required under New Jersey's Global Warming Response Act ("GWRA"). As noted above, to assist in making this demonstration, PSEG retained ERM, a leading global provider of environmentally-related services. ERM has prepared two studies: one showing the impact that retirement of the plants would have on meeting the 2015 National Ambient Air Quality Standard (NAAQS) for ozone of 70 parts per billion (ppb) and a second study showing the impact that retirement would have on achieving economy-wide GHG reductions under the GWRA.

(a) Ozone Standards

The ERM study demonstrates significant negative impacts on the ability of New Jersey to achieve its goals for ozone reductions.

Conclusion: The ERM study shows that, while modeled increases in ozone concentrations appear relatively small in comparison to the overall level of NAAQS, increases in ozone levels associated with the retirement of the Salem and/or Hope Creek nuclear 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:

> 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. 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. 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.[26]

Based on the modeling results and the difficulty that New Jersey will experience in achieving additional ozone reductions, the retirement of Salem and Hope Creek, or even the retirement of an individual unit, would "significantly and negatively impact New Jersey's ability to comply" with the ozone NAAQS within the meaning of the ZEC Act.

Impacts: As of September 2020, all of New Jersey, along with adjacent counties in Pennsylvania and New York, are designated nonattainment for the 2015 NAAQS for 8-hour ozone of 70 ppb. New Jersey is part of two interstate air quality control regions, namely, the Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE area ("Southern New Jersey") and the

[25] The State of New Jersey Department of Environmental Protection, State Implementation Plan (SIP) Revision for the Attainment and Maintenance of the Ozone National Ambient Air Quality Standards. December 2017
[26] ERM, "Impacts of PSEG Nuclear Unit Shutdowns on New Jersey's Ozone Attainment Goals", pg. 9.

New York-Northern New Jersey-Long Island, NY-NJ-CT area ("Northern New Jersey"). Southern New Jersey is designated as marginal nonattainment, with a monitor in Camden showing the highest in-state design value for 2019 (4th high, maximum daily 8-hour concentration, averaged over 3 years) of 73 ppb. Northern New Jersey is designated as moderate nonattainment with a monitor at Leonia (Bergen County) showing the highest in-state design value for 2019 of 74 ppb. Higher ozone design values for both nonattainment areas are located out-of-state.

The marginal nonattainment designation for the interstate area including Southern New Jersey signifies that the largest design value at a monitor representing the area is between 71 and 81 ppb. Attainment is required to be met within three years after receipt of this designation (which occurred in June 2018), i.e. by June 2021. The June 2021 attainment determination would be based on the design value representing measurements in 2018, 2019, and 2020. The design values for the area in 2018 and 2019 are 81 ppb and 76 ppb, respectively. Therefore, it is highly unlikely the area will meet the 70 ppb attainment concentration by the attainment date. The moderate nonattainment designation for the interstate area including Northern New Jersey signifies that the largest design value at a monitor representing the area is between 81 and 93 ppb. Attainment is required to be met within six years after receipt of the designation (which occurred in June 2018), i.e. by June 2024. The June 2024 attainment determination would be based on the design value representing measurements in 2021, 2022, and 2023. The area continues to monitor high ozone levels with design values of 82 ppb for both 2018 and 2019.

The PA Consulting study showed that the loss of any or all of the Hope Creek and Salem units would result in increases in NO_x emissions regionally with resultant increases in ozone concentrations in New Jersey per ERM's analysis. NO_x emissions for the HEDD, Hope Creek Retirement Case (Proxy for Salem 2) scenario resulted in an increase of 6.25 tons per day (tpd) of NO_x from primarily fossil fuel-fired PJM MAAC electric generation units (an increase of 3.1% over the base case PJM MAAC electric generator unit emissions). This resulted in maximum 8-hour ozone increase of 0.115 ppb in New Jersey, and a maximum increase 0.016 ppb for a New Jersey monitor. NO_x emissions for the HEDD, Full Retirement Case scenario resulted in an increase of 26 tons per day (tpd) of NO_x from primarily fossil fuel-fired PJM MAAC electric generation units (an increase of 12.9% over the base case PJM MAAC electric generator unit emissions). This resulted in maximum 8-hour ozone increase of 0.109 ppb in New Jersey, and a maximum increase 0.025 ppb for a New Jersey monitor.

The ERM study also stresses that the modeled impacts need to be placed in context. New Jersey has already expended substantial (and expensive) efforts to significantly reduce ozone precursor emissions (i.e., NO_x and volatile organic compounds (VOCs)) emitted in the state. For example, New Jersey currently has State-wide restrictions on power plant emissions that are among the most stringent of restrictions in adjoining states and has contended in its SIP that other states should adopt similar measures in order to make progress towards ozone attainment. Additionally, New Jersey has implemented voluntary measures (beyond what is required by the

Federal government) to control emissions from both on-road and non-road mobile sources. These measures, as described in the SIP submittal, include: reducing the allowable smoke from heavy-duty diesel vehicles during inspection; adding on-board diagnostic (OBD) inspection and maintenance requirements for heavy duty vehicles; adoption of a Low Emission Vehicle (LEV) program, and many others. The ERM study also stresses "the struggle to maintain ozone levels below the 2008 ozone NAAQS of 75 ppb" and demonstrates that "some backsliding" at particular monitors has occurred.[27]

Methodology Used: The ERM study conducted photochemical modeling using the Comprehensive Air Quality Model with Extensions (CAMx) model to estimate the increases in ozone concentrations in New Jersey due to regional increases in NOx emissions that are anticipated to occur based on the retirement of any or all of the nuclear units at Hope Creek or Salem. CAMx requires a variety of inputs that contain information pertaining to the modeling domain and simulation period. These inputs include gridded hourly precursor emissions from the Sparse Matrix Operator Kernel Emissions (SMOKE) [28] modeling system, meteorological data, and initial and boundary concentrations. The simulations utilized Weather Research and Forecasting (WRF) to develop hourly three dimensional meteorological fields for year 2011.

To determine ozone concentration increases in the two retirement cases, ERM relied on PA Consulting's analysis, focusing on NOx emissions as a precursor to ozone. ERM also made adjustments to the EPA's 2011 National Emission Inventory ("NEI") emissions to reflect the future base case emissions for years 2019-2022 as well as the scenarios depicted in the PA Consulting analysis. The scenarios analyzed are the retirement of one single unit and retirement of all three units, covering the HEDD and Typical Summer Day episodes.

The model results are based on an ozone episode in 2011. ERM explains that modeling platforms based on the 2011 ozone episode have been used by many states and interstate organizations in the northeast U.S. to estimate future ozone concentrations for the purpose of attainment planning. ERM also states that although the modeled ozone values presented in this study are based on the 2011 ozone episode, they are not specific to a particular year; rather, they represent increases that could occur, based on the projected emissions increases, in any future year.

(b) G**lobal Warming Reduction Act Mandates**

Conclusion: Retirement of the Salem and Hope Creek nuclear plants or even the retirement of Hope Creek alone or any one of the three plants "would significantly and negatively impact New Jersey's ability to comply with" the GWRA goals. The GWRA has aggressive greenhouse gas (GHG) emission reduction goals. As indicated in the NJBPU's Energy Master Plan (EMP), the

[27] ERM, "Impacts of PSEG Nuclear Unit Shutdowns on New Jersey's Ozone Attainment Goals", pg. 9.
[28] Sparse Matrix Operator Kerner Emissions (SMOKE) Modeling System, https://www.cmascenter.org/smoke/accessed in October 2018.

cornerstone of the GWRA's goal to reduce economy-wide state GHG emissions 80% below 2006 levels by 2050 is an 100% clean energy target established in Governor Phil Murphy's Executive Order 28. Regarding the clean energy goal, the current EMP acknowledges that "New Jersey's current trajectory and efforts will be insufficient to reach the goals . . ."[29] Therefore, the state should take actions that prevents any increase in GHG emissions from the electricity generation sector. As stated in the ERM Report:

> These GHG emission increases would significantly impact and jeopardize the State's ability to achieve its 2050 GHG reduction goals. Also, the Intergovernmental Panel on Climate Change (IPCC) stresses the urgency for transformative policy efforts to reduce GHG emissions in the short term. The retirement of clean, existing nuclear resources runs counter to these efforts. The continued operation of the Hope Creek and Salem units is needed to prevent backsliding in the efforts to combat climate change.[30]

Accordingly, the ERM Report clearly shows compliance with the ZEC Act eligibility standard as applied to the GWRA.

Results: The revised ZEC application order requires a study of the avoided GHG emissions ten (10) years prior to and projected (5) years beyond the application date. The ten-year lookback covers calendar years 2010 through 2019. A range of estimated avoided emissions using three emission rates: PJM marginal emission rate, PJM system average emission rate and an average NGCC emission rate. Table 3-2 represents the Full Retirement Case. Avoided GHG emissions, based on PJM marginal emission rates, range from 13.5 to 19.6 million metric tons (MMT) per year. Avoided GHG emissions based on PJM system average emission rates range from 9.4 to 13.7 MMT per year. Avoided GHG emissions based on the average emission rate for a NGCC facility range from 9.4 to 10.6 MMT per year.

[29] NJBPU, "2019 Energy Master Plan Pathways to 2050", pg. 10.
[30] ERM, "Impact of PSEG Nuclear Unit Shutdowns on Greenhouse Gas Emissions", pg. 30.

Table 3-2. Estimated Range of Avoided GHG Emissions, 2010-2019: Full Retirement Case[31]

Year	Nuclear Generation (MWh) Hope Creek, Salem 1 and 2	Avoided GHG Emissions Based on PJM Marginal Emission Rate (MMT)	Avoided GHG Emissions Based on PJM System Average Emission Rate (MMT)	Avoided GHG Emissions Based on Average NGCC Rate (MMT)
2010	28,169,910	18.3	13.7	10.4
2011	28,308,000	18.0	13.5	10.5
2012	28,395,547	17.1	12.8	10.5
2013	28,278,134	19.6	13.0	10.5
2014	26,656,214	18.5	12.2	9.9
2015	28,002,931	18.5	11.8	10.4
2016	25,300,096	16.7	10.4	9.4
2017	28,602,507	16.3	11.2	10.6
2018	28,441,791	15.3	10.5	10.5
2019	26,637,324	13.5	9.4	9.9

Table 3-3 represents the Hope Creek Retirement Case (proxy for Salem 2). Avoided GHG emissions from the Hope Creek facility using PJM marginal emission rates range from 4.4 to 7.2 MMT per year. Avoided GHG emissions based on PJM system average emission rates range from 3.1 to 5.0 MMT per year. Avoided GHG emissions based on the average emission rate for a NGCC facility range from 3.2 to 3.9 MMT per year.

[31] Id., pg. 18.

Table 3-3. Estimated Range of Avoided GHG Emissions, 2010-2019: Hope Creek Retirement Case (proxy for Salem 2)[32]

Year	Nuclear Generation (MWh) Hope Creek only	Avoided Emissions Estimate Based on PJM Marginal Emission Rate (MMT)	Avoided Emissions Estimate Based on PJM System Average Emission Rate (MMT)	Avoided Emissions Estimate Based on Average NGCC Rate (MMT)
2010	9,438,542	6.1	4.6	3.5
2011	10,474,891	6.7	5.0	3.9
2012	9,551,241	5.8	4.3	3.5
2013	9,070,386	6.3	4.2	3.4
2014	10,373,816	7.2	4.8	3.8
2015	9,409,357	6.2	4.0	3.5
2016	9,603,443	6.4	3.9	3.6
2017	10,627,333	6.0	4.2	3.9
2018	9,546,684	5.1	3.5	3.5
2019	8,726,946	4.4	3.1	3.2

GHG emissions from all electric generators in New Jersey have averaged about 18 MMT per year from 2010 to 2019. The avoided GHG emissions from the Hope Creek Retirement Case (proxy for Salem 2) represent about a 15-40% higher level of New Jersey electric sector GHG emissions. The avoided GHG emissions from the Full Retirement Case reflect what would otherwise have been a 50-100% higher level of New Jersey electric sector GHG emissions.

The five-year projected emissions cover the period from 2020 through 2015. Table 3-4 includes the projected In-State GHG emission increase from New Jersey generators for the Hope Creek Retirement Case (proxy for Salem 2) ranges from 0.4 to 1.0 MMT and 1.6 to 3.2 MMT for the Full Retirement Case. These values represent the In-State Electric GHG emissions component as it would be calculated for 2020 through 2025 under the GWRA.

[32] Id., pg. 19.

Table 3-4. Avoided In State Electric GHG Emissions, 2020-2025 (MMT)[33]

Retirement Case	2020	2021	2022	2023	2024	2025
Hope Creek	0.7	0.4	0.7	0.8	0.9	1.0
Full	2.2	1.6	2.3	2.8	2.7	3.2

ERM estimated imported electric generation using EIA data in conjunction with the PA Consulting model output date. ERM estimated annual total electric sales using a five-year average of 74,822,955 MWh from 2014 to 2018 EIA data. The annual total electric sales projection was adjusted to 80,454,790 MWh to account for T&D losses similar to New Jersey Department of Environmental Protection's (NJDEP) analysis. Imported Electric was calculated by subtracting in-state generation from total adjusted electric sales for each year 2020 through 2025.

ERM calculated CO_2 emissions using a projected PJM system average annual CO_2 emission factor based on EIA's 2020 Annual Energy Outlook (AEO). ERM calculated total GHG emissions by applying an adjustment factor of 1.006304 to represent the additional GHG emissions contribution of combustion-related CH_4 and N_2O.

The Table below includes avoided GHG emissions from Imported Electric from Tables 3-8 (Hope Creek Retirement Case (proxy for Salem 2)) and 3-9 (Full Retirement Case) in ERM's report.

Table. Avoided Imported Electric GHG Emissions, 2020-2025 (MMT)[34]

Retirement Case	2020	2021	2022	2023	2024	2025
Hope Creek	5.4	5.8	4.3	3.4	3.7	2.9
Full	10.0	10.3	9.6	8.5	8.8	7.6

[33] Id., pg. 21.
[34] Id., pgs. 25 and 26.

Table 3-10 summarizes the total avoided GHG emissions (In-State Electric + Imported Electric) for both the Hope Creek Retirement Case (proxy for Salem 2) and the Full Retirement Case.

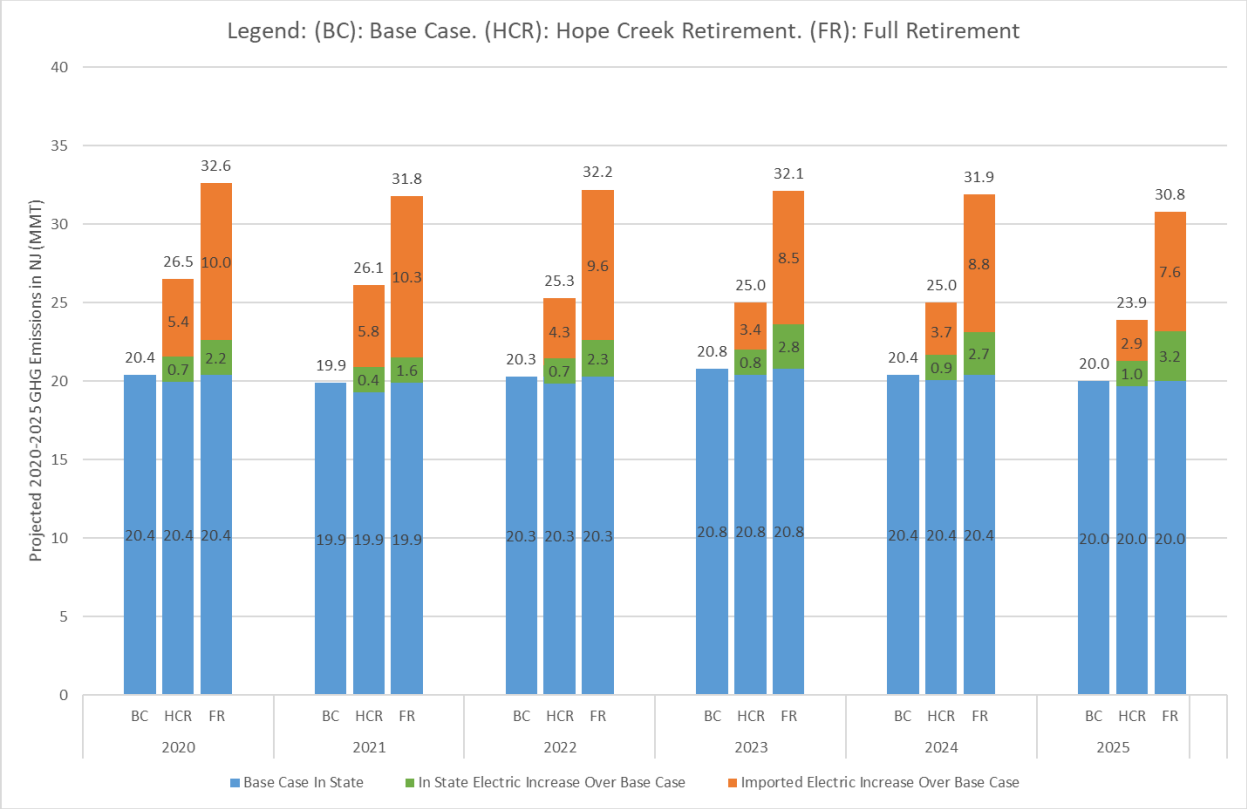
Table 3-10. Total Avoided GHG Emissions, 2020-2025 (MMT)[35]

Year	Hope Creek Retirement			Full Retirement		
	Avoided In-State GHG	Avoided Imported GHG	Total Avoided GHG	Avoided In-State GHG	Avoided Imported GHG	Total Avoided GHG
2020	0.7	5.4	6.1	2.2	10.0	12.2
2021	0.4	5.8	6.1	1.6	10.3	11.9
2022	0.7	4.3	5.0	2.3	9.6	11.8
2023	0.8	3.4	4.3	2.8	8.5	11.2
2024	0.9	3.7	4.5	2.7	8.8	11.5
2025	1.0	2.9	3.9	3.2	7.6	10.9

[35] Id., pg. 28.

Figure 3-9 represents the sizeable increases from the Hope Creek Retirement Case (proxy for Salem 2) and the Full Retirement Case over the projected 2020-2025 Base Case GHG emissions.

Figure 3-9. Projected 2020-2025 GHG Emissions in NJ (MMT)[36]



Methodology Used: The GWRA establishes the rules and regulations for the NJDEP to follow regarding the monitoring and reporting of GHG. The ERM study calculates the impact of the retirement of Salem and Hope Creek on New Jersey's ability to meet the GWRA standards based upon the described methodology.

N.J.S.A 26:2C-41(5)(c)(2) sets forth the methodology for the monitoring and reporting of GHG emissions in the Electricity Generation Sector as follows:

> c. Pursuant to the rules and regulations adopted pursuant to subsection a. of this section, the department shall require reporting of the greenhouse gas emissions:

[36] Id., pg. 29.

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> (2) from any entity generating electricity in the State and from any entity that generates electricity outside the State that is delivered for end use in the State. With respect to electricity generated outside the State and imported into the State, the department shall determine the emissions from that generation by subtracting the kilowatt-hours of electricity generated in the State from the kilowatt-hours of electricity consumed in the State, and multiplying the difference by a default emissions rate determined by the department;

NJDEP breaks down the types of generators covered in the phrase "from any entity generating electricity in the State" into two inventory components: "In-State Electric" and "MSW Incineration" (municipal solid waste incineration). NJDEP interprets the phrase "and from any entity that generates electricity outside the State that is delivered for end use in the State as "Imported Electric". The GHG contribution for the "Electricity Generation Sector" inventory thus consists of the sum of three components: In-State Electric, Imported Electric, and MSW Incineration.

Under the GWRA, accordingly, In-State Electric refers to GHG emissions from entities that generate electricity in the State.[37] Imported Electric refers to GHG emissions from entities that generate electricity outside the State that is assumed to be delivered for end use into the State. The GWRA specifies that with respect to Imported Electric, NJDEP shall determine the emissions from that generation by subtracting the kilowatt-hours (kWh) of electricity generated in the State from the kWh of electricity consumed in the State, and multiplying the difference by a default emissions rate determined by NJDEP.

To calculate expected In-State Electric emissions, ERM relied mainly on PA Consulting's analysis, focused on the modeled CO_2 emissions. To determine the MWh quantity of electricity imports/exports across state lines, ERM estimated net import generation amounts (and associated GHG emissions) using EIA data in conjunction with the PA Consulting model output data. Consistent with NJDEP's original GHG inventory published in 2008, ERM assumed Transmission and Distribution losses of 7%. ERM also used historical EIA data to project In-State and Imported Energy which took account of energy type. The Full Retirement Case and the Hope Creek Retirement Case (proxy for Salem 2) were both considered. Consistent with NJDEP's previously used methodology, ERM applied projected PJM system average annual CO_2 emission factors in its GHG inventories to calculate Imported Electric emissions. Annual PJM system average annual CO_2 emission factors were developed using projections from EIA's 2020 AEO. Consistent with NJDEP's previously used methodology, ERM also applied an adjustment

[37] The modeling analyses performed by PA Consulting included MSW incinerators in New Jersey within the modeling domain. The GHG emission contributions from MSW Incineration therefore are assumed to be included in the totals for In-State Electric.

factor of 1.006304 to account for emissions of CH_4 and N_2O which were not explicitly modeled by PA Consulting.