

**Testimony of Dean Murphy, Ph.D. and Mark Berkman, Ph.D.**

**Before the New Jersey Legislature**  
**Senate Budget and Appropriations Committee and**  
**Assembly Telecommunications and Utilities Committee**  
**Regarding S-877 and A-2850**

**February 22, 2018**

**Qualifications**

We are Principals of The Brattle Group, an economic and financial consulting firm headquartered in Boston, Massachusetts. Dr. Murphy has over 25 years of experience in energy economics, competitive and regulatory economics and finance, focusing on the electric industry. Dr. Berkman has more than 30 years of experience as an environmental economist with substantial experience regarding the environmental and economic impacts of power plants. Our backgrounds are summarized briefly in Exhibit 1.

**Purpose**

We have been asked by PSEG and Exelon to summarize the findings of our recent study of the economic and environmental contributions of the Salem and Hope Creek nuclear power plants in New Jersey.<sup>1</sup> A third New Jersey nuclear plant, Oyster Creek, will be retired by 2019 and was not analyzed in our study. Excerpts from our study, including the Executive Summary and New Jersey emissions results, are provided as Exhibit 2. We have completed several similar studies that have been cited and utilized by policymakers in New York, Illinois, Pennsylvania and Ohio.<sup>2</sup>

**Summary of Findings**

As our study clearly demonstrates, the Salem and Hope Creek nuclear plants provide substantial environmental benefits by displacing fossil generation and thus preventing the associated emissions. While one might expect that it would be costly for electricity customers to keep these nuclear plants operating to achieve their emissions benefits, it could in fact save customers money on their electricity

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<sup>1</sup> This study was funded by PSEG and Exelon, the owners of the Salem and Hope Creek nuclear plants. The full report is available at [http://files.brattle.com/files/11755\\_salem\\_and\\_hope\\_creek\\_nuclear\\_power\\_plants\\_contribution\\_to\\_the\\_new\\_jersey\\_economy.pdf](http://files.brattle.com/files/11755_salem_and_hope_creek_nuclear_power_plants_contribution_to_the_new_jersey_economy.pdf)

<sup>2</sup> See “New York’s Upstate Nuclear Power Plants’ Contribution to the State Economy,” December 2015; “Electricity Cost and Environmental Effects of Retiring the Quad Cities and Clinton Nuclear Plants,” October 2016; “Pennsylvania Nuclear Power Plants’ Contribution to the State Economy,” December 2016; and “Ohio Nuclear Power Plants’ Contribution to the State Economy,” April 2017.

bills – even if the plants require financial support to remain viable. This is because in addition to keeping emissions down, these nuclear plants also keep electricity prices lower. Beyond the direct benefit to customers, lower electricity prices also provide broader economic benefits in terms of GDP, jobs and state tax receipts.

We modeled both the power sector and New Jersey's economy, first with and then without the Salem and Hope Creek nuclear plants, to estimate their effects on emissions, power prices and New Jersey's economy. This study quantified the significant benefits to New Jersey that would be lost if the plants shut down prematurely. Losing these plants would:

- Increase pollution, raising annual CO<sub>2</sub> emissions by almost 14 million tons, and other pollutants by tens of thousands of tons, corresponding to an estimated \$733 million per year in environmental and human health costs;
- Cause higher electricity prices, costing New Jersey families and businesses \$400 million more per year for electricity, on average over 10 years;
- Harm New Jersey's economy:
  - Reduce annual state GDP by \$809 million on average;
  - Result in the loss of 5,800 jobs across New Jersey's economy;
  - Cause a reduction in state tax receipts estimated at \$37 million.

The power cost and economic benefits reported here are gross values, before accounting for any costs associated with compensating the plants for their environmental attributes; of course any such costs must be considered in estimating the net economic benefits. But the magnitude of the benefits suggests that a proposal to keep these plants operating would warrant careful consideration.

## **Background**

New Jersey's nuclear plants provide nearly half the power generated in the state, and account for over 90 percent of its emission-free power. While New Jersey is part of the much larger PJM power grid that stretches from New Jersey to Virginia and west to Illinois, the New Jersey nuclear plants nonetheless provide substantial environmental and economic value locally for New Jersey, as well as directly employing about 1,600 workers and paying substantial state and local taxes.

But around the country a number of nuclear plants are facing financial challenges that put them at risk of retiring prematurely. The root cause is low wholesale electricity prices, driven primarily by the shale gas revolution which has created an abundance of low-cost natural gas to fuel gas-fired power plants. Low electricity prices are good for customers, but where they cause the loss of a nuclear plant, power prices rebound and pollution rises as additional fossil generation replaces the zero-emission output of the nuclear plant. Consequently, several states including New York and Illinois have recognized this and have chosen to compensate the environmental attributes of their troubled nuclear plants in order to preserve these benefits.

## **Method**

We estimate the environmental and economic impacts of the Salem and Hope Creek plants by simulating the regional power grid and New Jersey's economy, first with the nuclear plants operating,

then a second time without them. We characterize power system operations across the entire Eastern Interconnection over the next ten years using a sophisticated capacity planning model. It shows which plants operate how much and when, their pollutant emissions, and new plant additions when necessary. It also characterizes wholesale electricity prices by region over time, for both energy and capacity products. Doing this first with the nuclear plants operating, then a second time without them, the differences on these dimensions are the effects attributable to the nuclear plants. The emissions impact of the nuclear plants is just the difference in operation of each fossil unit, multiplied by that unit's pollutant emissions rates. The power price effect is the price difference between the "with nuclear" and "without nuclear" cases. The increased customer cost that results from this price difference has subsequent economic impacts on New Jersey, which we analyze using REMI, a commercially available and widely used macroeconomic model, to measure impacts on state GDP and employment.

### **Environmental Impacts**

Of course, the premature closure of the Salem and Hope Creek plants would have significant environmental consequences. Nuclear plants do not emit air pollutants, but shutting them down would necessitate replacing their output with fossil-fired generation, which does pollute. Even though most of the replacement energy would be gas-fired, which is cleaner than coal, replacing the very large output of these two nuclear plants would mean a substantial increase in pollutants. Emissions of criteria pollutants – SO<sub>2</sub>, NO<sub>x</sub> and particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>) – would increase by tens of thousands of tons, and CO<sub>2</sub> emissions would increase by nearly 14 million tons. This is nearly a 70% increase over New Jersey's current power sector CO<sub>2</sub> emissions, making it considerably more difficult for the state to achieve its long-term CO<sub>2</sub> reduction goals, which may become more ambitious in light of Governor Murphy's call for 100% clean energy by 2050. It would certainly undo much of the recent progress that has been made in cutting emissions; the loss of the nuclear plants would add 14% to current total statewide CO<sub>2</sub> emissions. Put another way, these two nuclear plants are the CO<sub>2</sub> equivalent of 3 million cars – which is slightly more than the total number of automobiles registered in New Jersey.

The total social cost of this increase in pollution can be estimated using the social costs of each of the pollutants, which consider their environmental damage and human health impacts. We estimated the total social costs of the additional pollution to be \$733 million per year across all these pollutants, using values calculated by the Interagency Working Group on Social Cost of Greenhouse Gases and the National Research Council of the National Academy of Sciences. These costs are independent of and in addition to the economic impacts discussed above. They reflect costs incurred by society and not directly by the economy; although these environmental and health costs would themselves have additional economic implications, those second-order impacts are not included here.

These impacts reflect total emission changes, including those that occur outside of New Jersey. We also examined the changes in emissions that would occur within the state. Although most of the replacement power would come from out of state, some of it would come from plants within New Jersey. We identified which in-state plants would increase their output and what this implies in terms of increased emissions of criteria pollutants. We also identified the counties within New Jersey that are not currently in compliance with federal air quality standards for these pollutants and observed where this overlaps with an emissions increase. These overlaps would likely result in increased exposures and the associated health risks, and/or make it more costly to bring these pollutant levels into attainment with federal standards. Twelve northern New Jersey counties are in non-attainment for Ozone, which has been linked to a range of health effects from throat irritation to asthma, bronchitis and emphysema,

and NO<sub>x</sub> pollution is the primary precursor of Ozone. The closure of the nuclear plants would increase NO<sub>x</sub> emissions in many of these non-attainment counties, which would likely make it more difficult to meet the Ozone standard.

While we did not find counties out of attainment with respect to the other criteria pollutants, we did observe that emissions increases arise at plants located in or near some densely populated New Jersey counties, including the Newark metropolitan area. Although these increases might result in violations of federal standards and increased health risks, we could not make these determinations at a local level absent a detailed emissions impact study, which was beyond the scope of this study.

### **Electricity Cost and Economic Impacts**

While keeping these two nuclear plants operating to avoid a large emissions increase might be expected to be costly for New Jersey's electricity customers, the reality is that it could actually save them significantly on their electricity bills – even if the plants require new payments for their environmental attributes in order to remain viable. This is because in addition to keeping emissions down, these nuclear plants also keep electricity prices lower.

Given that abundant inexpensive natural gas has driven wholesale power prices down so far that nuclear plants may not be able to recover their ongoing operating costs, it may seem counterintuitive that losing the nuclear plants would increase power costs. Yet it is a natural consequence of the interaction between supply and demand. The two South Jersey nuclear plants are very large suppliers of electricity that together provide a substantial share of New Jersey's total electricity needs, so their closure would cause a major reduction in regional supply. Because nuclear plants generate at full capacity all the time, they accept whatever hourly price the market offers; this keeps overall power prices low. If these plants close, the market would turn to other more costly generators, mostly outside New Jersey, which would push up the market price that customers pay. As is the case in any market, a reduction in supply causes price to rise.

An increase in wholesale electricity prices would translate directly to higher costs for New Jersey electricity customers. We estimate the price increase to be about 0.5¢/kWh, equivalent to a \$3.64 per month increase in the utility bill of a typical New Jersey residential customer. While this may seem modest, this cost increase affects everyone who buys electricity – residences, businesses, commercial and industrial customers, government entities, non-profits – and totals \$400 million per year in higher electricity costs across the state. Higher electricity costs leave businesses and consumers with less money to invest and spend in other ways, stifling economic output, jobs, and the overall economy. The loss of these plants would also reduce in-state productive activity, contributing further to the negative economic effect. About 79 percent of the lost nuclear generation would be replaced by imports from other states, mostly from existing gas-fired generation, turning New Jersey into a large net importer that relies on out-of-state power sources for about a third of its electricity needs.

Higher electricity prices and the loss of in-state production would combine to reduce New Jersey's state GDP by \$809 million per year, cause a loss of 5,800 jobs, and reduce state tax revenue by about \$37

million.<sup>3</sup> Both the GDP and the jobs effects would extend well beyond the nuclear and electricity sectors; much of the impact would occur indirectly in other sectors as a result of the higher cost of electricity, which is distributed throughout the entire economy. So in addition to the nuclear plants' employees, suppliers and contractors, the general reduction in economic activity across New Jersey would cause job losses in virtually every sector of the economy. By preventing these higher electricity costs and keeping production within New Jersey, the South Jersey nuclear plants support the New Jersey economy.

## **Conclusion**

Our research has found that the Salem and Hope Creek nuclear plants provide significant environmental and economic benefits to New Jersey; those benefits would be lost if the plants shut down prematurely. Losing these plants would:

- Increase pollution, raising annual CO<sub>2</sub> emissions by almost 14 million tons, and other pollutants by tens of thousands of tons, corresponding to an estimated \$733 million per year in environmental and human health costs;
- Cause higher electricity prices, costing New Jersey families and businesses \$400 million more per year for electricity, on average over 10 years;
- Harm New Jersey's economy:
  - Reduce annual state GDP by \$809 million on average;
  - Result in the loss of 5,800 jobs across New Jersey's economy;
  - Cause a reduction in state tax receipts estimated at \$37 million.

These nuclear plants hold down emissions of CO<sub>2</sub> and other air pollutants; without them, greater reliance on fossil-fueled power plants would cause a substantial increase in emissions, and accompanying environmental and human health damages. But rather than it being more costly for customers to achieve these environmental benefits, the nuclear plants also keep electricity prices lower and save customers money. This benefits New Jersey's economy; state GDP will be higher with these plants operating than without them. The plants also keep jobs in New Jersey; this includes the direct plant employees and indirect suppliers and contractors, of course, but also many additional jobs spread throughout the economy and across the state. While the costs associated with supporting the plants must be weighed against these benefits, the magnitude of the environmental benefits and the gross economic benefits suggest that a proposal to keep these plants operating would warrant careful consideration.

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<sup>3</sup> It is also important to consider the effect on producers, as well as consumers, to understand the total social welfare effect; our GDP estimate does account for this.

**Summary of Qualifications**

**Dr. Dean Murphy** is an economist with a background in engineering. He has expertise in energy economics, competitive and regulatory economics and finance, as well as quantitative modeling and risk analysis. His work centers on the electric industry, encompassing issues such as resource and investment planning (including power and fuel price forecasting), valuation for contract disputes and asset transactions, climate change policy and analysis, competitive industry structure and market behavior, and market rules and mechanics. He has addressed these issues in the context of business planning and strategy, regulatory hearings and compliance filings, litigation and arbitration. Dr. Murphy has examined these matters from the perspectives of investor-owned and public electric utilities, independent producers and investors, industry groups, regulators, system operators, and consumers. Dr. Murphy holds a Ph.D. in Industrial Engineering and Engineering Management and an M.S. in Engineering-Economic Systems, both from Stanford University, and a B.E.S. in Materials Science and Engineering from the Johns Hopkins University. Prior to joining The Brattle Group in 1995, Dr. Murphy worked as an associate with Applied Decision Analysis, Inc.

**Dr. Mark P. Berkman** is an expert in applied microeconomics. His experience spans the areas of the environment, energy, and natural resources; environmental health and safety; labor and employment; intellectual property; antitrust; commercial litigation and damages; and public finance. He has assisted both public and private clients and provided testimony before state and federal courts, arbitration panels, regulatory bodies, and legislatures. His environmental work has involved the review of proposed air, water, solid waste, and worker and product safety regulations. Dr. Berkman has quantified the costs and benefits of these regulations, as well as toxic tort and product liability claims. In addition, he has valued natural and water resources as well as property damages associated with pollution from Superfund sites, landfills, and power plants. His work on energy matters includes the valuation of coal resources, power plants, and transmission rights-of-way, and he has prepared energy demand and price forecasts. Prior to joining Brattle he was a co-founder and director at Berkeley Economic Consulting and a vice president at both Charles River Associates and NERA Economic Consulting.

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# Salem and Hope Creek Nuclear Power Plants' Contribution to the New Jersey Economy

*Excerpts*<sup>1</sup>

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## PREPARED BY

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THE **Brattle** GROUP

## Executive Summary

In recent years, wholesale electricity prices have declined significantly, due in large part to the shale gas revolution. Natural gas is the price-setting fuel in many U.S. electricity markets, and the dramatic reduction in its price has brought down electricity prices as well. Negligible demand growth and substantial amounts of new policy-driven renewable generation have also contributed. While lower power prices are generally a positive development for consumers, persistently low prices can threaten the economic viability of existing generators, whose

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<sup>1</sup> The full report is available at [http://files.brattle.com/files/11755\\_salem\\_and\\_hope\\_creek\\_nuclear\\_power\\_plants\\_contribution\\_to\\_the\\_new\\_jersey\\_economy.pdf](http://files.brattle.com/files/11755_salem_and_hope_creek_nuclear_power_plants_contribution_to_the_new_jersey_economy.pdf)

premature retirement could offset much of the price reductions that have occurred. Nuclear generators in particular, because of their high fixed costs and effectively zero variable costs, tend to keep market prices low when they are operating, but are themselves financially vulnerable to sustained low power prices. Indeed, in the past few years, several nuclear plants have been retired prematurely for purely economic reasons, and a number of others are threatened. Because of the economic and environmental consequences that accompany the loss of nuclear generation, some states have implemented and others are considering policy mechanisms that would support existing nuclear power plants and prevent their premature retirement.

In this context, The Brattle Group has evaluated the contribution that the Salem and Hope Creek nuclear power plants in New Jersey make to the state's economy. We considered how these plants affect electricity markets and prices as well as in-state productive activity, and studied the resulting ramifications of these factors throughout the New Jersey economy. We found that these plants keep electricity prices lower than they would otherwise be, and also keep productive economic activity in-state. As a result, New Jersey's GDP will be higher with these plants operating than it would be without them. These plants also maintain jobs within New Jersey; not only the direct employees of the plants and the indirect jobs at suppliers and contractors that support plant operations, but also additional jobs throughout the economy that result from the overall economic boost associated with lower electricity prices and more in-state production. In addition, the continued operation of these nuclear plants holds down emissions of CO<sub>2</sub> and other air pollutants both within and outside New Jersey. In their absence, correspondingly more power would be produced by fossil-fueled power plants, causing a substantial increase in emissions.

In this analysis, we have not considered the structure or cost of any potential policy mechanism that may be necessary to ensure the continued operation of these nuclear plants. As a result, this analysis effectively calculates the gross economic benefits of preserving these plants, not the net benefit of a proposed policy that would do so.<sup>2</sup>

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<sup>2</sup> A full analysis of any particular policy or proposal that would support these nuclear plants would need to incorporate the costs of that support, as well as any other aspects of the policy proposal. Also, while reductions in electricity costs do benefit consumers, the offsetting impact on producer revenues must also be considered to determine whether they improve total social welfare. Our analysis of economic impacts—GDP, jobs, and tax revenues—does account for the producer revenue impacts.



Our analysis has determined that over the next ten years (2018–2027), the Salem and Hope Creek plants operating in New Jersey:

- **Contribute approximately \$809 million annually to state gross domestic product (GDP).**
- **Account for 5,800 in-state jobs** (direct and secondary).
- **Help keep electricity prices low.** New Jersey consumers would pay \$400 million more for electricity annually, about \$3.3 billion more in present value over the next ten years, without these two plants.
- **Are responsible for \$37 million in state tax revenues** annually.
- **Avoid 13.8 million metric tons of CO<sub>2</sub> emissions annually** over the next ten years, valued at \$585 million per year.
- **Avoid significant amounts of other air pollutants annually**, valued at \$148 million per year over the next ten years.

These measures reflect the significance of these two nuclear power plants for the New Jersey economy, and are determined by comparing the performance of New Jersey's economy with these plants operating to its performance without them. This approach nets out the economic contribution of the alternative generation that would substitute for these two plants—both the greater utilization of existing plants and the construction of new plants, as necessary—to determine the plants' incremental economic contribution. Absent the energy from these nuclear power plants, New Jersey and the broader region would rely more heavily on natural gas and coal-fired generating plants, many of which are outside New Jersey, leading to considerably greater reliance overall on out-of-state generation, and transforming New Jersey from being a modest importer, producing almost as much electricity as it consumes, to being a substantial net importer, procuring over a third of its electricity requirements from out of state. The increased reliance on fossil generation that would occur in the absence of these nuclear plants would cause higher emissions of carbon and other air pollutants, including in some current non-attainment areas of New Jersey. It would also raise power prices; without these two nuclear power plants, wholesale electricity prices in New Jersey and throughout the broader region would be higher. Higher prices would flow through to residential, commercial and industrial consumers as higher electricity bills. It is this effect on electricity prices that accounts for about half of the overall incremental economic impact; the reduction of in-state generation and associated economic activity is also important. Note that these measures reflect only the impacts within New Jersey, although the absence of these two New Jersey nuclear power plants will have significant additional negative consequences in the form of higher power prices beyond the state's borders.

Emissions of carbon dioxide (CO<sub>2</sub>) and "criteria pollutants" identified by the Clean Air Act, such as nitrogen oxides (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>), would also be much higher in the absence of the Salem and Hope Creek plants, because the replacement generation would be almost entirely fossil-fired. Compliance with national ambient air quality standards (NAAQS), such as for ozone season nitrogen oxides (NO<sub>x</sub>) and small particulate matter (PM<sub>2.5</sub>), could become more costly for other generators, both in-state and out of state. It would likely be more difficult for New Jersey

to achieve targeted CO<sub>2</sub> reductions under any future climate policy. Further, the pollutant impacts are not limited to New Jersey, first because much of the replacement generation would come from outside New Jersey, and second because air pollution impacts can cross state borders—they are often regional in the case of criteria pollutants, and are global in the case of carbon dioxide.

## Environmental Impacts

Table 8 below, reproduced from the full report, shows the total emissions increase due to the absence of the Salem and Hope Creek nuclear plants, both within and outside New Jersey.

**Table 1: Emissions and Social Cost Prevented by the Salem and Hope Creek Plants in the Eastern Interconnection (10-Year Average Annual Impacts, 2018–2027)**

Pollutant	Avoided Emissions (tons)	Social Cost (\$/ton)	Avoided Emissions
			Value (2017 \$millions)
CO <sub>2</sub>	13,779,652	\$42	\$585
SO <sub>2</sub>	4,331	\$7,546	\$33
NO <sub>x</sub>	6,367	\$2,082	\$13
PM <sub>10</sub>	9,537	\$598	\$6
PM <sub>2.5</sub>	7,778	\$12,360	\$96
<b>Total</b>			<b>\$733</b>

Sources: Social cost of carbon is from the Interagency Working Group on the Social Cost of Carbon, United States Government. Social costs of other pollutants are from “Hidden Cost of Energy: Unpriced Consequences of Energy Production and Use,” National Research Council, 2010.

## Appendix A. Local Environmental Impacts

Since criteria pollutants can affect local air quality, it is also important to consider the location of these emissions impacts. We have done so by mapping all of the power plants in New Jersey, locating them within New Jersey counties, and determining what change, if any, they would experience in generation and emissions in the absence of the Salem and Hope Creek plants.

We also considered whether the county is in attainment with Clean Air Act standards for criteria pollutants, and checked for instances where a plant that is located within a non-attainment area for a particular pollutant would increase its emissions of that pollutant in the absence of the Salem and Hope Creek plants. This analysis is illustrated in a series of maps below. Each map

illustrates, for a given pollutant, the New Jersey generating plants, indicating whether their emissions increase (red dot), stay the same (black dot) or fall (blue dot), in the absence of the Salem and Hope Creek plants. The size of the dot indicates the magnitude of the change in emissions. We pay particular attention to those counties that are not currently in attainment with U.S. EPA standards under the Clean Air Act for one or more of the criteria pollutants; these counties are shaded on the relevant maps.

This analysis reveals that absent the Salem and Hope Creek plants, there are a number of instances in which fossil plant emissions of a criteria pollutant would increase in a county that is already in non-attainment for that pollutant. This can be seen where there is a red dot within a shaded county, indicating that a power plant located in a non-attainment area is increasing its emissions. In fact, because those locations are already out of compliance, additional actions may be required to mitigate these emissions increases, possibly including redispatch to utilize more costly generation sources located outside the non-attainment area, or to add costly emissions controls to the affected plants. These additional actions could increase the electricity cost effect beyond our estimates. Emissions increases in locations that are currently in compliance with federal standards could potentially push some of them into non-compliance, creating similar issues in additional locations.

Table A-2 below, reproduced from the Appendix of the full report, presents the aggregate change in emissions within New Jersey absent the Salem and Hope Creek plants (this excludes incremental emissions that occur outside New Jersey, in contrast with Environmental Impacts

Table 8 below, reproduced from the full report, shows the total emissions increase due to the absence of the Salem and Hope Creek nuclear plants, both within and outside New Jersey.

Table 1, which showed the emissions impact for the entire Eastern Interconnection). It is important to note that airborne transport could spread criteria pollutants to nearby and downwind locations; our analysis does not account for such transport and is thus only indicative of the types of problems that may arise. The table also does not present the increase in emissions at power plants that are outside of New Jersey, but might affect New Jersey air quality due to airborne pollutant transport. The table does show that criteria pollutant emissions within the state represent about \$30 million in annual social costs (harm to health, the environment, *etc.*). Almost half of this (\$14 million) is attributed to PM<sub>2.5</sub>. The location and change in emissions by type and New Jersey county are discussed below.

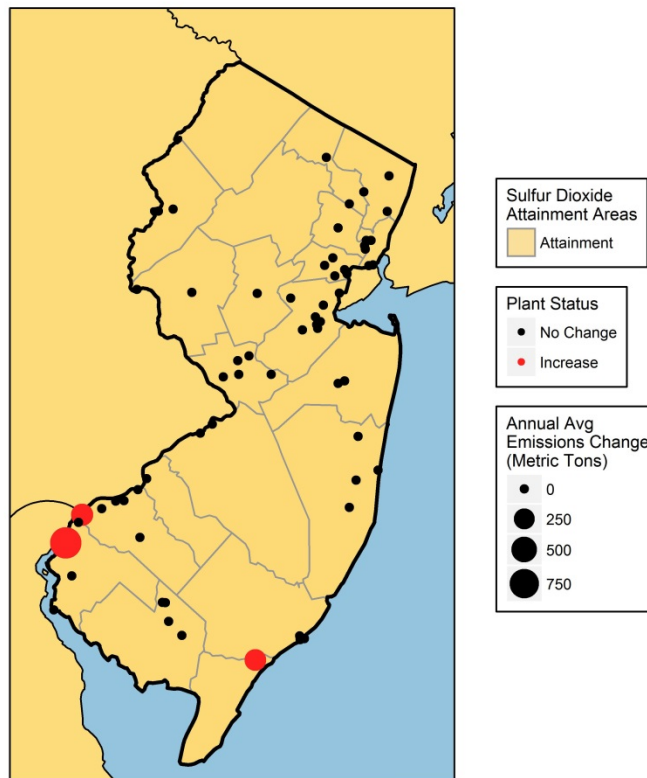
**Table A-2: Emissions and Social Cost Prevented by Salem and Hope Creek Plants  
within New Jersey  
(10-Year Average Annual Impacts, 2018–2027)**

Pollutant	Avoided Emissions (tons)	Social Cost (\$/ton)	Avoided Emissions
			Value (2017 \$millions)
CO <sub>2</sub>	3,323,263	\$42	\$141
SO <sub>2</sub>	1,529	\$7,546	\$12
NO <sub>x</sub>	1,637	\$2,082	\$3
PM <sub>10</sub>	1,382	\$598	\$1
PM <sub>2.5</sub>	1,115	\$12,360	\$14
<b>Total</b>			<b>\$171</b>

SO<sub>2</sub>

The SO<sub>2</sub> annual emissions increase of 1,529 tons within New Jersey incurs an overall social cost of \$12 million annually. At present, no New Jersey counties are in non-attainment for SO<sub>2</sub>. Absent the Salem and Hope Creek plants, net emissions would increase in three of New Jersey's 21 counties, as shown in Figure A-1. This might result in non-attainment in some of those counties, though that was not analyzed here.

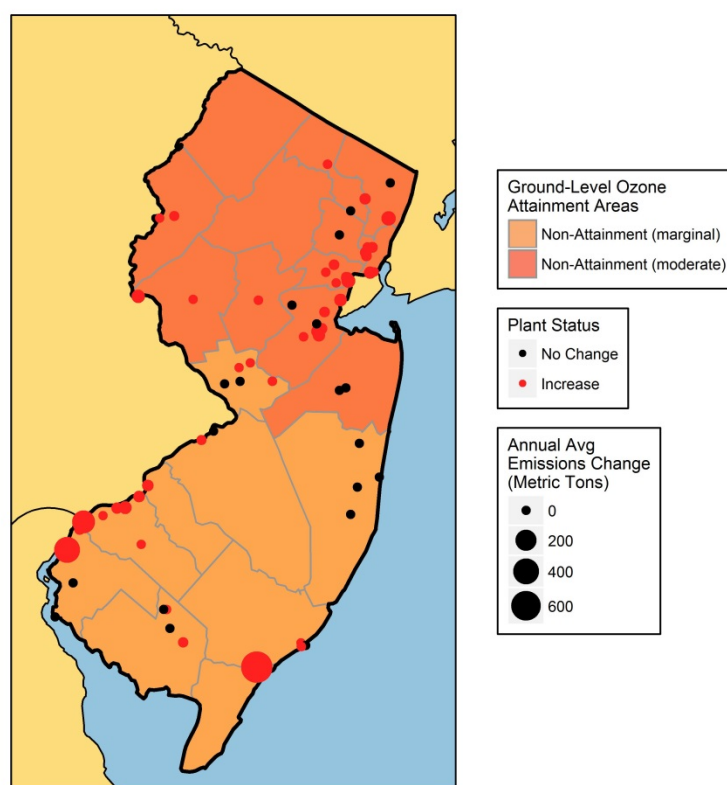
**Figure A-1: SO<sub>2</sub> Emissions Increase absent Salem and Hope Creek Plants**



## NO<sub>x</sub>

The overall social cost of the increase in New Jersey NO<sub>x</sub> emissions absent these nuclear power plants is \$3 million annually, but NO<sub>x</sub> is also a precursor of ground level ozone.<sup>3</sup> At present, no New Jersey counties are in non-attainment for NO<sub>x</sub>, but 12 are in non-attainment for ozone. NO<sub>x</sub> emissions in New Jersey are projected to increase by 1,637 tons per year, absent the Salem and Hope Creek plants. This increase may raise the cost of bringing many of these counties into attainment for ozone. The locations of NO<sub>x</sub> increases are overlaid on the non-attainment areas for ozone in Figure A-2. Much of the increase in NO<sub>x</sub> emissions occurs in the more populous areas of New Jersey, which would exacerbate population exposures.

**Figure A-2: NO<sub>x</sub> Emissions Increase absent Salem and Hope Creek Plants**



<sup>3</sup> Ground level or tropospheric ozone occurs when nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and volatile organic compounds (VOCs), react in the atmosphere in the presence of sunlight. Ozone imposes social costs in the form of adverse health effects, particularly to those with pulmonary system problems including asthma. Ground level ozone has also been found to negatively affect agriculture. Reducing NO<sub>x</sub> is generally the preferred means to lower ozone levels. Determining the impact of power plant NO<sub>x</sub> emissions on ozone levels is beyond the scope of this report, but increased NO<sub>x</sub> emissions is likely to compromise efforts to reduce ozone across much of the state.

## PM<sub>10</sub>

The increase in PM<sub>10</sub> emissions that would occur in New Jersey, absent the Salem and Hope Creek plants, is 1,382 tons, imposing social costs of \$1 million annually. No counties are in non-attainment for PM<sub>10</sub>.

## PM<sub>2.5</sub>

As Table A- indicates, the PM<sub>2.5</sub> emissions increase of over 1,000 tons annually within New Jersey results in a social cost of \$14 million, the highest among the criteria pollutants, reflecting its significant impacts on human health. At present, no New Jersey counties fail to meet air quality standards for PM<sub>2.5</sub>. Without other actions, in the absence of the Salem and Hope Creek plants, PM<sub>2.5</sub> emissions would increase in 17 of 21 counties statewide due to increased fossil generation, as shown in Figure A-3 (again, this does not account for airborne transport). These increases could place some counties into non-attainment with the Clean Air Act.

**Figure A-3: PM<sub>2.5</sub> Emissions Increase absent Salem and Hope Creek Plants**

