Economic Benefits of Installing a Closed-Cycle Cooling System at Salem Nuclear Generating Station

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Disclaimer

Delaware Riverkeeper Network commissioned the analysis described in this report.

Throughout the report we have identified our sources of information and assumptions used in the analysis. Within practical limits, ECONW has made every effort to check the reasonableness of the data and assumptions and to test the sensitivity of the results of our analysis to changes in key assumptions.

We gratefully acknowledge the assistance of individuals who provided us with information and insight. But we emphasize that we, alone, are responsible for the report's contents. We have prepared this report based on our own knowledge and training and on information derived from government agencies, the reports of others, and other sources believed to be reliable. ECONorthwest has not verified the accuracy of all such information, however, and makes no representation regarding its accuracy or completeness. Any statements nonfactual in nature constitute the authors' current opinions, which may change as more information becomes available. Responsibility for this research and findings lies solely with the authors.

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Executive Summary

Salem Nuclear Generating Station (Salem) is owned and operated by PSEG Power, LLC (PSEG) and Exelon Generation, LLC (Exelon). The plant, located in New Jersey, has two reactors with a combined capacity of 2,307 MWe. Both of the reactors use once-through cooling systems that withdraw up to 3,024 million gallons a day from the Delaware Bay. These once-through cooling systems result in entrainment and impingement (E&I) of aquatic life that increase mortality in many aquatic species across different life stages. However, there are alternatives, such as closed-cycle cooling systems, that reduce or avoid these impacts on aquatic life.

In this report, we describe the value of some of the potential benefits and costs associated with replacing Salem's existing once-through cooling system with a closed-cycle cooling system. The scope of this analysis is limited and is not intended to represent a comprehensive benefit-cost analysis. Rather, the results of this analysis shed light on some of the primary economic values associated with a closed-cycle cooling system's potential to reduce the harmful impacts on aquatic species in and around the Delaware Bay. In particular, they are intended to inform the economic question facing this context of whether or not the costs of a closed-cycle cooling system are wholly disproportionate to or significantly greater than the benefits they would generate.

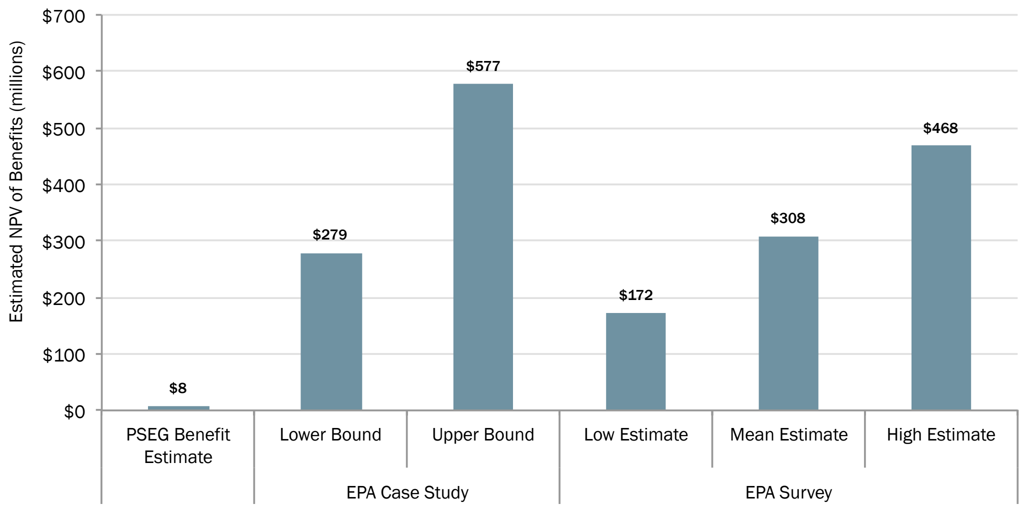
In this context, we describe the benefits in terms of the broad benefits to society that include consumptive and non-consumptive uses of resources at stake. We follow OMB and U.S. EPA guidance in this process, using available data to understand the set of benefits provided by a closed-cycle system at Salem, and the importance of these benefits in the Delaware Bay context. It is clear that the PSEG benefit estimates, which address only consumptive uses, are incomplete.

In its 2006 permit application, PSEG estimated the value of the fish saved by installing a closed-cycle cooling system at Salem – in terms of their potential annual recreational and commercial values, summed over a 34-year period – at roughly $8 million dollars. In contrast, a 2002 Case Study Analysis conducted by the EPA to illustrate the application of the 316(b) rulemaking, estimated the present value of the fish saved over the course of the next 20 years as being between $279 and $577 million.

To further establish the magnitude of the potential benefits from installing closed cycle cooling systems at Salem, we apply the results of a comprehensive, nation-wide valuation survey to estimates of mortality at Salem. The net present value of the 20-year stream of benefits estimated using this method is between $172 and $468 million, which supports the EPA's previous valuation results. Estimates based on the Habitat Equivalency Analysis technique derived from Natural Resource Damage Assessment methods are comparable or higher.

We emphasize, however, that these estimates still do not represent a full accounting of the value of benefits to be gained at Salem from preventing E&I, and that there are other (as-yet unquantified) factors that would magnify and add to these monetized values. These factors include increasing regional scarcity of affected species due to other disturbances in the Delaware Estuary, changing climate conditions, and the large number of endangered species and species with long-term population declines involved. It is likely that efforts to include these additional factors would raise annual benefits of the Project Alternative by millions of dollars.

Summary of Alternative NPV Benefit Estimates



We also review the affordability of costs associated with closed-cycle cooling at Salem, both from the private perspective of PSEG and Exelon as well as ratepayers. Overall, the data available suggest that the costs are affordable, and are not wholly disproportionate to or significantly greater than their resulting benefits to society.

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1 Introduction

The Salem Nuclear Generating Station (Salem) is jointly owned by PSEG Power, LLC (PSEG) and Exelon Generation, LLC (Exelon).[1] The station, located in Lower Alloways Creek, New Jersey, has two reactors with a combined production capacity of 2,307 MW.[2] Both reactors use once-through cooling systems that withdraw up to 3,024 million gallons a day from the Delaware Bay.[3] These once-through cooling systems result in entrainment and impingement (E&I) of aquatic life that increase mortality in many aquatic species across different life stages. However, there are alternatives, such as closed-cycle cooling systems, that reduce or avoid these impacts on aquatic life.

1.1 Objective of this Report

In this report, we look at two potential futures – one without the installation of closed-cycle cooling (the Baseline Scenario), and one with it (the Project Scenario). The objective of this analysis is to identify and describe the primary economic value of the benefits and costs associated with the Project Scenario relative to the Baseline Scenario. The scope of this analysis is limited and is not intended to represent a comprehensive benefit-cost analysis. Rather, the results of this analysis shed light on some of the primary economic values, both public and private, associated with the Project Scenario's potential to reduce the harmful impacts on aquatic species in and around the lower Delaware Bay. Similarly, this report does not include an economic impact analysis, so we do not estimate changes in employment and income, although we do discuss some of the impact implications.

1.2 Main Sources Used in this Report

Throughout our analysis, we rely primarily on a set of relevant documents to guide our understanding of the biophysical characteristics underlying the Baseline and Project Scenarios, and to inform our economic analysis of the potential value of benefits and costs associated with each scenario. Some of these documents are specific to Salem, while others are based on similar plants and also the general context of cooling water intake structures (CWIS). We rely on two studies, in particular, throughout our report - we refer to these sources by their short names (bolded):

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[1] PSEG has a 57.41 percent ownership interest, and the remaining 42.59 percent is owned by Exelon Generation Company, LLC. PSEG is the primary operator of the station. Government Printing Office. 2005. FR Doc No: E5-4101. Available online at: http://www.gpo.gov/fdsys/pkg/FR-2005-08-02/html/E5-4101.htm

[2] PSEG Investor FACT Book 2014-2015. PSEG Power Consolidated Balance Sheets. Page 43. Available online at: https://www.pseg.com/info/investors/pdf/factbook.pdf

[3] New Jersey Department of Environmental Protection. 2015. PSEG NUCLEAR LLC SALEM GENERATING STATION NJPDES - Surface Water Renewal Permit Action. Page 4. Available online at: http://www.nj.gov/dep/dwq/pdf/salem-draft-2015.pdf

- **EPA Case Study.** US Environmental Protection Agency (EPA). 2002. *Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule. Part B: The Delaware Estuary Watershed Case Study*. EPA-821-R-02-002. Office of Water, Washington, DC.
- **EPA Benefits Analysis**. US EPA. 2014. *Benefits Analysis for the Final 316(b) Existing Facilities Rule*. EPA-821-R-14-005. This document also includes the **EPA Survey** *(Chapter 11).*

1.3 Structure of this Report

First, we describe the two scenarios (the Baseline Scenario and the Project Scenario) that we consider in our analysis. Then we present a brief summary of the potential biophysical effects associated with the Project Scenario relative to the Baseline Scenario in terms of economically valuable effects, focused on E&I associated with operations at Salem. In the next section, we use data and methodologies from other studies combined with our understanding of the Salem context to describe the potential value of the benefits and costs associated with the Project Scenario relative to the Baseline Scenario. We also discuss the affordability of the Project Scenario costs. We conclude the report by summarizing our results, and discussing the sensitivity of our results to a number of relevant variables.

2 Baseline and Project Scenarios

To understand the economic value of the benefits and costs associated with installing a closed-cycle cooling system at Salem, we compare two scenarios, the Baseline Scenario and the Project Scenario, to identify differences in effects on valuable goods and services for society.

Baseline Scenario. This describes current and future conditions at Salem with the existing, once-through cooling systems. We assume no changes to the fish protection technologies used at the facility.

Project Scenario. Under the Project Scenario, we assume that a closed-cycle cooling system is installed at Salem in 2016, and that the benefits and costs associated with the closed-cycle cooling system begin in 2016 and continue for a total of 20 years.

We do consider other effects that lead to changes over time for the affected resources. For example, as other conditions make resources and substitutes scarcer, the effects on these resources of the Baseline and Project Scenarios become more valuable.

3 Biophysical Effects of the Baseline and Project Scenarios

In this section, we briefly summarize the biophysical effects of the Baseline and Project Scenarios. Salem is located on Delaware Bay, at the dividing line between the transitional and lower estuary. The facility's surroundings support a functional biological community with both freshwater and estuarine species, including important life stages of commercially and recreationally important fish species, as well as two endangered sturgeon species and three endangered sea turtle species. This area is a crucial component of the regional ecological landscape, and holds broader economic, social, and cultural importance. The existing once-through cooling system employed at Salem under the Baseline Scenario directly kills billions of aquatic organisms through E&I every year. Furthermore, the Baseline Scenario's effects on aquatic habitat have the potential to exacerbate the potential effects associated with climate change. The closed-cycle cooling system that would be employed at Salem under the Project Scenario decreases the extent of these negative effects.

3.1 Entrainment and Impingement

Salem is one of the 50 largest power plants in the U.S, and ranks in the top three in terms of cooling water use.[4] While temporal and spatial variability in fish populations makes direct comparison of E&I at individual facilities difficult, it is clear that Salem also causes some of the largest E&I-related fish mortality in the country. Given the size of Salem's water withdrawals, its location in an estuarine environment that serves as a nursery for a large variety and number of aquatic species, as well as the heightened vulnerability of these early life stages to E&I, it is not surprising that we were only able to identify one other facility, out of 550 evaluated by the EPA, with higher kill rates.[5] As reflected in EPA's survey results (described later in this report), the magnitude of fish kills at Salem are a matter of national interest and importance.

Throughout this document we make reference to both total organisms killed (which includes eggs, larvae, and adult fish), as well as age 1 equivalents (A1E). Converting organism counts to equivalent units of individual adults accounts for the number of eggs and larvae that would be expected to survive to adulthood under natural conditions, and provides a standard metric for comparing losses among species, years, and regions. For the section 316(b) rulemaking, EPA expressed E&I losses and values at all life stages as an equivalent number of age 1 individuals.

EPA summarizes historical E&I data for Salem in a 2002 case study analysis supporting the Section 316(b) Phase II Existing Facilities Rule. This information describes conditions under the

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[4] Salem's maximum intake capacity (3,024 MGD) far surpasses that of other power plants; see appendix listing in Sierra Club. 2011. *Giant Fish Blenders: How Power Plants Kill Fish & Damage Our Waterways*. Available at: http://vault.sierraclub.org/pressroom/media/2011/2011-08-fish-blenders.pdf. Additionally, most plants with comparable intake capacities have dedicated reservoirs and lakes, or the open ocean, as water sources. For additional water use data, see Union of Concerned Scientists. 2012. *UCS EW3 Energy-Water Database V.1.3*. www.ucsusa.org/ew3database.

[5] The Big Bend Power Station, a coal-fired power plant located in Tampa Bay, kills an estimated 7 billion A1E fish a year, on average. Bay Anchovy comprise over 99 percent of this mortality. US Environmental Protection Agency (EPA). 2002. *Case Study Analysis for the Proposed Section 316(b) Phase II Existing Facilities Rule. Part D: Tampa Bay Case Study*. EPA-821-R-02-002. Office of Water, Washington, DC. Page D3-22.