C. Net Costs of CWWS and Continuously Operating Cooling Towers

Table H-5 shows the estimated present values of net costs (i.e., costs minus benefits) for CWWS and the continuously operated Cooling Towers alternative. As noted above, these net costs assume that the capital costs and construction outage are the same regardless of how often the plant will be operated. As the table shows, net costs for both the screens and the Cooling Towers are positive, but the net costs of the screens are significantly less than those of the Cooling Towers.

Table H-5. Summary of Present Value of Estimated Costs, Benefits, and Net Costs

Alternative	Discount Rate	
	r = 3%	r = 7%
CWWS		
Costs	$169.5	$123.8
Benefits	$11.3	$6.1
Net Costs	$158.2	$117.7
Cooling Towers		
Costs	$1,230.6	$760.5
Benefits	$10.0	$5.2
Net Costs	$1,220.6	$755.3

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. Net costs may differ slightly from costs minus benefits because of rounding.

Source: Costs from Table H-1, benefits from Table H-4, and NERA calculations as explained in text

D. Incremental Costs and Incremental Theoretical Benefits for Continuously Operating Cooling Towers Relative to CWWS

Table H-6 below shows a comparison of costs and benefits for CWWS and Cooling Towers. The table shows that under both 3 percent and 7 percent discount rates, Cooling Towers have both higher costs and lower theoretical benefits than CWWS. We thus describe the Cooling Towers alternative as "dominated" by CWWS.

Table H-6. Present Value Costs and Benefits of Cooling Towers Relative to CWWS

	Discount Rate	
Alternative	**r = 3%**	**r = 7%**
Costs		
CWWS	$169.5	$123.8
Cooling Towers	$1,230.6	$760.5
Difference	+$1,061.1	+$636.7
Benefits		
CWWS	$11.3	$6.1
Cooling Towers	$10.0	$5.2
Difference	-$1.3	-$0.9

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. Net costs may differ slightly from costs minus benefits because of rounding.

Source: Costs from Table H-1, benefits from Table H-4, and NERA calculations as explained in text

E. Sensitivity Analysis

We considered the sensitivity of the results to various uncertain parameters in the main report. Table H-7 show two "extreme" sensitivity cases. The assumptions used in the "All Favorable" (i.e., costs lower and benefits higher) and "All Unfavorable" (i.e., costs higher and benefits lower) cases are summarized in Table 32 of the main report. The sensitivity cases show that even in the extreme case of all favorable assumptions, costs are still greater than benefits for both CWWS and Cooling Towers. Moreover, in both "extreme" sensitivity cases, Cooling Towers have greater costs and lower benefits than CWWS.

Table H-7. Estimated Costs and Benefits with All Favorable Assumptions and All Unfavorable Assumptions

	Costs	Benefits	Net Costs	Change in Net Costs
r = 3%				
Base Case				
CWWS	$169.5	$11.3	$158.2	
Cooling Towers	$1,230.6	$10.0	$1,220.6	
Cooling Towers Incremental to CWWS	+$1,061.1	-$1.3	+$1,062.4	
All-Favorable				
CWWS	$153.9	$16.7	$137.2	-$21.0
Cooling Towers	$944.1	$16.3	$927.8	-$292.8
Cooling Towers Incremental to CWWS	+$790.3	-$0.4	+$790.6	-$271.8
All-Unfavorable				
CWWS	$202.5	$6.0	$196.5	$38.3
Cooling Towers	$1,612.9	$3.1	$1,609.8	$389.2
Cooling Towers Incremental to CWWS	+$1,410.4	-$2.9	+$1,413.3	+$350.9
r = 7%				
Base Case				
CWWS	$123.8	$6.1	$117.7	
Cooling Towers	$760.5	$5.2	$755.3	
Cooling Towers Incremental to CWWS	+$636.7	-$0.9	+$637.6	
All-Favorable				
CWWS	$112.2	$9.0	$103.2	-$14.6
Cooling Towers	$603.8	$8.7	$595.2	-$160.1
Cooling Towers Incremental to CWWS	+$491.6	-$0.3	+$492.0	-$145.6
All-Unfavorable				
CWWS	$148.1	$3.2	$144.9	$27.2
Cooling Towers	$871.8	$1.5	$870.3	$115.0
Cooling Towers Incremental to CWWS	+$723.7	-$1.8	+$725.4	+$87.9

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.
Source: NERA calculations as explained in text

F. Conclusions

Cooling Towers would provide greater potential benefits if they could operate without the constraints of air permitting requirements. However, none of the major conclusions of the benefit-cost study would change if we assumed Cooling Towers could operate continuously. In particular:

1. Costs are substantially greater than benefits for both CWWS and Cooling Towers, although we understand Energy has communicated its commitment to CWWS despite this conclusion;

2. Cooling Towers have substantially greater costs than CWWS;

3. Cooling Towers would result in smaller aggregate theoretical benefits than CWWS; and

4. Thus, Cooling Towers would be "dominated" by CWWS.

G. References

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to Benefits Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

ENERCON Services. 2010. *Analysis of Closed-Look Cooling Salinity Levels: Indian Point Units 2 & 3*. November 2010.

Tetra Tech. 2013. *Indian Point Closed-Cycle Cooling System Retrofit Evaluation.* Prepared for the New York State Department of Environmental Conservation. June 2013.

TRC. 2009. *Cooling Tower Impact Analysis for the Entergy Indian Point Energy Center*. September 1.

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"Wholly Disproportionate" Assessments of Cylindrical Wedgewire Screens and Cooling Towers at IPEC

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Contents

Executive Summary

This report provides an economic assessment of two cooling water intake structure (CWIS) technologies that have been proposed as Best Technology Available (BTA) for reducing impingement and entrainment (I&E) mortality at Indian Point Energy Center (IPEC). The two technologies are cylindrical wedgewire screens (CWWS), proposed by Entergy, and closed-cycle cooling towers (Cooling Towers), proposed by New York State Department of Environmental Conservation (NYSDEC) Staff and Riverkeeper. NYSDEC has developed a four-step process for evaluating whether a given CWIS technology is BTA. This report relates to the fourth step, i.e., whether the costs are "wholly disproportionate" to the environmental benefits.

The report includes descriptions of the methodologies and data we use to conduct our "wholly disproportionate" analyses. Our analyses build on information developed by various engineering and biological firms that have evaluated the costs and biological impacts of CWWS and Cooling Towers. We use well-established economic methods of calculating social costs, drawing on guidance developed by New York State, the U.S. Environmental Protection Agency (EPA), the U.S. Office of Management and Budget (OMB), and the economics literature (e.g., Boardman et al. 2011). We use guidance provided by the NYSDEC to develop estimates of biological benefits for use in the "wholly disproportionate" assessments.

A. Overview of Alternatives

1. Cylindrical Wedgewire Screens

CWWS consist of specially designed screens made with wedge-shaped wires. With CWWS installed, the units at IPEC would withdraw water from the river through these structures. This modification to the CWIS would reduce I&E in three ways:

1. Through established mechanical forces, organisms are swept past the intake by the tidal flow in the Hudson River.

2. The large screen area reduces flow rates through the screens, thus facilitating behavioral avoidance and therefore I&E.

3. To a lesser degree, they provide a physical barrier preventing organisms larger than the screen spacing from being entrained.

ENERCON and the biological team investigated several alternative configurations for the screens that vary in the spacing of the slots and the velocity of water flowing through the screens (which is inversely proportional to the surface area of the screens). Entergy's proposed design includes a screen configuration with a slot size of 2 mm and through-screen flow velocity of 0.25 feet per second (ENERCON 2013a). ENERCON's analysis indicates that CWWS would take approximately six years to permit and build; based upon an assumption that the regulatory process could be completed by mid-2018, CWWS would be operational by 2024 (see ENERCON 2013a).

Our cost analyses for CWWS are based upon ENERCON (2013a). The benefit estimates for CWWS are based on theoretical estimates developed by ASA Analysis & Communication (ASAAC 2013). We measure biological benefits relative to the current configuration. We refer to benefits as theoretical biological benefits because biological analyses indicate that reducing I&E at IPEC in fact would not lead to any measurable increase in fish populations (Barnthouse et al 2008). ASAAC (2013) has developed theoretical calculations for the purposes of this analysis.[1]

2. Cooling Towers

The Cooling Towers alternatives proposed by NYSDEC Staff and Riverkeeper assume that IPEC would install closed-cycle cooling systems that would reduce the volume of water withdrawn from the Hudson River by approximately 97 percent if operated continuously over the year. ENERCON (2013b) has evaluated the Cooling Tower designs submitted by the consultants engaged by NYSDEC Staff and Riverkeeper and concluded that neither likely is feasible. For purposes of this analysis, however, we assume for sake of argument that the Cooling Towers alternative could be installed at IPEC. ENERCON (2013b) concludes that the design proposal from Tetra Tech on behalf of the NYSDEC Staff (Tetra Tech 2013) is more fully developed than the proposal from Riverkeeper (Powers 2013), although ENERCON (2013b) also concludes that the Tetra Tech design proposal is materially deficient.

For purposes of our evaluations, however, we rely upon the Tetra Tech report for information related to the cost and effectiveness of Cooling Towers, as well as for the timing of their installation. At one point Tetra Tech states that Cooling Towers would take between 7 and 9 years to install, although the Tetra Tech report provides other information on timing for individual phases that conflicts with this range. Taking the midpoint of the 7-9 year range and assuming the period would begin in mid-2018 (the same assumption as for CWWS), the Tetra Tech analysis thus would mean that Cooling Towers would be operational in mid-2026. As noted below, we also provide sensitivity analyses for different timing assumptions based upon information provided by Tetra Tech on ranges for the different phases of the project.

We supplement the Tetra Tech information on Cooling Towers where the information is incomplete. In particular, as discussed in Chapter 2 of TRC (2009), operation of the Cooling Towers would not comply with air emissions permitting requirements in some periods of the year, a factor that was not assessed by Tetra Tech. Thus, we presume that Cooling Towers would only be operated when operation would not violate air quality constraints. ENERCON (2010a) and ASAAC (2013) provide information on the implications of these constraints for operation of the Cooling Towers and their biological impacts and benefits. Appendix G to this report provides cost and benefit results assuming for sake of argument that air emissions permitting requirements do not constrain operation of the Cooling Towers.

[1] To avoid awkward phrasing, in some parts of the report we do not include "theoretical" in our description of benefit metrics but all the estimates are understood to be theoretical because of the biological assessments noted in the text.

B. Methodology for Comparing Costs and Potential Biological Benefits

1. Timing and Discounting

As noted above, based upon a presumed start date of mid-2018, our cost and benefit estimates presume that CWWS would begin operation in 2024 and Cooling Towers would begin operation in 2026. For Cooling Towers, we provide sensitivity cases based upon information provided by Tetra Tech on ranges for the individual elements of the project. Until the alternatives are operational, we assume that IPEC would continue to operate with its current CWIS configuration. Costs and benefits are projected until September 2033 for Unit 2, which would be the end of the 20-year license extension for which Entergy is applying at the NRC. Similarly, for Unit 3, costs and benefits are projected until December 2035, when the equivalent 20-year license extension would end.

We summarize the cumulative costs and biological benefits of the two alternatives during the period from 2018 to 2035 by calculating present values. For this calculation, we converted all annual costs and biological benefits by discounting them back to a common date (January 1, 2013) using annual real (inflation-adjusted) discount rates of 3 percent and 7 percent, based upon guidelines developed by the U.S. Office of Management and Budget (OMB) and the U.S. Environmental Protection Agency (EPA). We express all costs in constant 2012 dollars. Benefits are not monetized in this report, although some information concerning the value that individuals place on certain biological benefits is provided to aid in determining whether costs are "wholly disproportionate" to benefits or "unreasonable" in light of benefits.

2. Measuring Social Costs

We use well-established economic methods of calculating the social costs of CWWS and Cooling Towers, drawing on guidance developed by New York State, the U.S. Environmental Protection Agency (EPA), the U.S. Office of Management and Budget (OMB), and the economics literature (e.g., Boardman et al. 2011). We develop estimates for three major categories of costs: (1) capital costs; (2) operation and maintenance costs; and (3) electricity costs. The report provides details on the calculation of these costs.

In accordance with economic principles, our assessments of costs do not include comparisons to IPEC revenues in terms of the "wholly disproportionate" test. Upon our review of the NYSDEC decisions in *Athens* and *Bowline*, the November 28, 2012 decision of the Regional Director in this case, and CP-52, a comparison of costs to facility revenues is not relevant. We therefore do not use facility revenue as a basis for any calculations in this report.

3. Measuring Theoretical Biological Benefits

Our comparisons of costs and biological benefits begin with comparisons between costs and reductions in the numbers of organisms lost due to I&E at IPEC due to CWWS and Cooling Towers, as called for by NYSDEC (2012). NYSDEC (2012) requires that parties proposing a technology as BTA show the "increase in the protection of aquatic organisms that would be gained from installing and operating the proposed technology as compared to current operations."

Organisms represent a large variety of aquatic life, from eggs and larvae to adult fish, and these different life stages are not equal in terms of the theoretical benefits they would provide to the fishery. A very small fraction of eggs and larvae become fish that provide direct gains to the fishery or to anglers. This point has been recognized by the NYSDEC in some contexts, in which it has suggested the use of "juvenile equivalents" as a metric.[2] The measure of "age-1 equivalents" is analogous to "juvenile equivalents" in accounting for the differences in the significance of different life stages of the organisms impacted by I&E. This metric aggregates organisms to account for mortality at different life stages and thus avoids the unrealism of treating all organisms the same. We therefore provide, in addition to information concerning total organisms, information on age-1 equivalents lost due to I&E at IPEC.

Information on gains in organisms and age-1 equivalents can be useful in indicating the implications of I&E changes due to installing CWWS and Cooling Towers at IPEC. To assess whether costs are "wholly disproportionate" to the benefits, however, it is important to consider a measure of biological benefits that correspond to gains that individuals would experience. We measure gains to individuals by increases in the numbers of additional harvested fish (commercial and recreational), as provided by ASA (2013). As noted below, we also consider whether there are significant benefits that might be omitted using harvested fish as a measure of benefits; these potential omissions include so-called "non-use benefits."

4. Incremental Analysis

Prior NYSDEC decisions, notably *Athens* and *Bowline*, provide guidance regarding the nature of the comparisons of costs and biological benefits for purposes of the "wholly disproportionate" test. These decisions indicate that the "wholly disproportionate" test involves comparisons across potential BTA technologies. That is, in considering two technologies, the "wholly disproportionate" test compares the additional environmental benefits with the additional costs of the more expensive technology. This focus on the incremental costs and incremental benefits of alternative technologies is consistent with New York State and EPA guidelines and sound benefit cost principles (see New York Governors Office of Regulatory Reform 2008, EPA 2010 and e.g., Boardman et al. 2011).[3]

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[2] Comment 316bEFR.402.008 by D. Sheehan, NYSDEC Commissioner: "As an alternative to quantifying losses due to entrainment by a tally of the total numbers of organisms entrained, without differentiating between eggs and larval stages, the Department suggests converting all the early life stages to Juvenile Equivalents. Estimates of natural mortality for early life stages of many species are available in scientific literature. This information would enable conversions of the numbers of eggs, yolk sac, and post yolk sac fishes to one consolidated number for each species which reflects life stage value." cited in Barnthouse et al. (2011), p. 15.

[3] New York Governor's Office of Regulatory Reform (2008), p. 5:

"Where several alternatives along a continuum exist, agency staff may want to consider how each will affect the cost-benefit analysis. In many cases, both the costs and benefits from regulatory action increase as the rule is made more stringent. In such cases, it is essential to consider the costs and benefits on the margin. For example, We develop information on incremental costs and biological benefits consistent with this precedent and guidance. It is customary to order incremental comparisons in terms of increasing costs. Since Cooling Towers have greater costs than CWWS, we develop the following two comparisons:

- Costs and benefits of CWWS incremental to the current configuration at IPEC, and
- Costs and benefits of Cooling Towers incremental to CWWS.

C. Evaluation of Incremental Costs and Incremental Theoretical Biological Benefits for Cylindrical Wedgewire Screens

As noted, we compare the costs and biological benefits of CWWS relative to the current configuration at IPEC, which includes the use of Ristroph screens and other measures.

1. Comparisons of Incremental Costs and Incremental Biological Benefits

Table E-1 shows the costs and biological metrics of CWWS under the two discount rates. The present value of costs is about $170 million at a 3 percent discount rate and about $124 million at a 7 percent discount rate. For simplicity, we combine in a single table the two metrics showing the implications of I&E changes (organisms and age-1 equivalents) as well as the metric relating to benefits experienced by individuals (harvested game fish). The metrics differ greatly in magnitude. Using a discount rate of 7 percent, for example, CWWS would lead to theoretical gains of about 1.5 billion organisms, about 9.3 million age-1 equivalents, and about 100,000 additional harvested fish over the full period of the analysis.

Table E-1. Costs and Theoretical Biological Benefits of CWWS

CWWS	Organisms	Age-1 Equivalents	Fish Harvest
Present Value (r = 3%)			
Cost (Million 2012$)	$169.5	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17	0.192
Cost / Benefits	$0.06	$9.87	$884.94
Present Value (r = 7%)			
Cost (Million 2012$)	$123.8	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29	0.103
Cost / Benefits	$0.08	$13.34	$1,198.56

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

suppose that a 50% reduction in waste production costs $100 million and yields $150 million in benefits, and that a 90% reduction costs $250 million and yields $275 million in benefits. The 90% adds $150 million in costs for $125 million in extra benefits, which the agency may determine is not warranted."

2. Implications of Cost-Benefit Comparisons

Table E-1 calculates the cost per unit of benefit for all three metrics, although as emphasized above, the first two metrics do not provide an appropriate basis for the "wholly disproportionate" test. Although they do provide information on the implications of I&E organism gains, neither metric corresponds closely to benefits experienced by individuals.

The costs and theoretical biological benefits of CWWS imply a cost of about $885 per additional fish harvested at a 3 percent discount rate or about $1,200 per additional fish harvested at a 7 percent discount rate. These values can be put in perspective by comparing them to indicators of the values that people attach to increased fish harvest. Fish species are harvested commercially and/or recreationally. Appendices C and D provide information on the dollar values that individuals place on additional commercial and recreational harvests for the species affected at IPEC. The 10-year average commercial price of striped bass—the most valuable of the species modeled for our analysis—is $6.15 per kilogram, or about $20 per fish. The recreational value of additional striped bass is estimated to be about $67 per fish harvested. Both measures of the value of additional fish harvest are a small fraction of the cost per additional fish harvested if CWWS were put in place at IPEC.

These comparisons of the cost per harvested fish with the values that individuals place on harvested fish suggest that the costs of CWWS are "wholly disproportionate" to the benefits. We understand, however, that Entergy has communicated its commitment to CWWS regardless of whether the cost is wholly disproportionate to its benefits.

D. Evaluation of Incremental Costs and Incremental Theoretical Biological Benefits for Cooling Towers

As noted, the "wholly disproportionate" test calls for comparing the incremental costs and incremental benefits of Cooling Towers relative to those of CWWS.

1. Comparisons of Incremental Costs and Incremental Biological Benefits

Table E-2 shows the incremental costs and incremental biological benefits of Cooling Towers relative to CWWS. The costs of Cooling Towers are greater than CWWS by about $887 million at 3 percent discount rate and by about $547 million at a 7 percent discount rate. As with Table E-1 for CWWS, for convenience we include all three metrics related to benefits in this single table, including the two metrics related to I&E implications and the metric related to the benefits individuals would experience.

Although as with CWWS the magnitudes of the three metrics differ considerably, the figures in the table for Cooling Towers are different because they are all negative. That is, for all metrics, the gains from installing Cooling Towers are substantially less than the gains from installing CWWS. On a present value basis and a 7 percent discount rate, Cooling Towers would save about 1.2 billion fewer organisms, 8.8 million fewer age-1 equivalents, and 90,000 fewer harvested fish.

Table E-2. Incremental Costs and Biological Impacts of Cooling Towers

Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

2. Implications of Cost-Benefit Comparisons

Table E-2 does not include calculations of costs divided by any of the three benefit metrics because such calculations would have no valid economic meaning; Cooling Towers are much more expensive than CWWS and yield smaller gains in terms of all three metrics. Following standard economic terminology for this situation, we refer to Cooling Towers as "dominated" (see Boardman et al. 2011). Dominance refers to a situation such as this, when an alternative has greater costs and lesser benefits.

These comparisons indicate that the costs of Cooling Towers are "wholly disproportionate" to the benefits, a conclusion that does not depend upon assessing the appropriate value that individuals place on potential biological benefits. Assuming there are no offsetting considerations, a rational decision maker would not choose a dominated alternative, i.e., an alternative with lower benefits and higher costs.

E. Implications of Other Considerations

The comparisons of costs and biological benefits result in two principal conclusions:

1. Both CWWS and Cooling Towers have costs that are "wholly disproportionate" to their benefits (although we understand that Entergy has communicated its commitment to CWWS regardless of whether the cost is wholly disproportionate to its benefits).

2. Cooling Towers have greater costs and smaller biological benefits than CWWS (so that Cooling Towers are dominated by CWWS).

In this section, we provide summaries on whether either of these two conclusions would be likely to change as a result of other considerations, including assumptions on the cost and benefit assessments, non-quantified costs and benefits, uncertainties in costs and benefits, and the effects of air permit considerations. The analyses underlying these summaries are provided in the report.

1. Assumptions Regarding Benefits and Costs

The potential benefit and cost estimates incorporate various assumptions that are likely to overstate benefits and understate costs for both CWWS and Cooling Towers. We conclude that the two principal conclusions noted above—that both CWWS and Cooling Towers have costs that are "wholly disproportionate" to the benefits and that Cooling Towers are dominated by CWWS—are robust with respect to these assumptions.

2. Non-Quantified Costs and Benefits

We conclude that benefit and cost categories that are not quantified are not likely to be significant. These include so-called "non-use" benefits, as explained in the report. As a result, none of the non-quantified benefit categories, individually or collectively, are likely to significantly affect the comparisons of costs and biological benefits of CWWS and Cooling Towers at IPEC. Thus, our two principal conclusions—that costs are "wholly disproportionate" to benefits for both technologies and that Cooling Towers are dominated by CWWS—are robust with respect to omitted costs and benefits.

3. Uncertainties in Costs and Benefits

We developed sensitivity analyses for various cost and benefit parameters, including construction costs, construction period, and CWWS fishery efficacy. These results indicate that even if one makes extreme assumptions in favor of CWWS and Cooling Towers, neither would pass a "wholly disproportionate" test. Sensitivity analyses even under extreme assumptions thus reinforce the two conclusions noted above, i.e., that both CWWS and Cooling Towers have costs that are "wholly disproportionate" to their benefits and that Cooling Towers are dominated by CWWS.

4. Air Permit Considerations

Appendix G to the report provides information on the incremental costs and biological benefits of Cooling Towers under the assumption that there are no constraints on operating the towers due to air permit considerations. This change in the assumed operation of the cooling towers changes both the costs and the biological benefits of Cooling Towers and thus the incremental costs and biological benefits relative to CWWS (whose costs and benefits are unchanged).

Ignoring the effects of air permit considerations on the operation of the Cooling Towers does not change the major conclusions regarding Cooling Towers—Cooling Towers would have costs that are "wholly disproportionate" to the benefits and Cooling Towers would be dominated by CWWS. Full operation of the Cooling Towers would mean costs greater than CWWS by about $1.1 billion with a 3 percent discount rate and about $637 million with a 7 percent discount rate. Harvest benefits still would be greater for CWWS than for Cooling Towers in this case, and thus the incremental benefits would be negative. Information in Appendix G indicates that these conclusions are robust with respect to uncertainties in costs and benefits.

F. Conclusions Regarding the "Wholly Disproportionate" Test

1. Cylindrical Wedgewire Screens

The analyses provided in this report indicate that CWWS have costs that are "wholly disproportionate" to the benefits. This conclusion is robust with respect to assumptions on quantified costs and benefits, cost and benefit categories that are not quantified, and uncertainties in the costs and benefits. We understand, however, that Entergy has communicated its commitment to CWWS regardless of whether the cost is wholly disproportionate to its benefits.

2. Cooling Towers

The analyses provided in this report indicate that Cooling Towers have costs that are "wholly disproportionate" to the benefits and, in particular, that Cooling Towers are "dominated" by CWWS because they involve substantially greater costs and lead to smaller biological benefits. These conclusions are robust with respect to assumptions on quantified costs and benefits, cost and benefit categories that are not quantified, uncertainties in costs and benefits, and air permit considerations.

I. Introduction

This report provides an economic assessment of two cooling water intake structure (CWIS) technologies that have been proposed as Best Technology Available (BTA) for reducing impingement and entrainment (I&E) mortality at Indian Point Energy Center (IPEC). The two technologies are cylindrical wedgewire screens (CWWS), as proposed by three subsidiaries of Entergy Corporation ("Entergy"), and closed-cycle Cooling Towers (Cooling Towers), as proposed by the New York State Department of Environmental Conservation (NYSDEC) Staff and Riverkeeper. NYSDEC has developed a four-step process for evaluating whether a given CWIS technology is BTA. This report relates to the fourth step, i.e., whether the costs are "wholly disproportionate" to the environmental benefits.

This report includes descriptions of the methodologies and data we use to conduct the "wholly disproportionate" analyses. Our analyses build on information developed by various engineering and biological firms that have evaluated the costs and biological benefits of CWWS and Cooling Towers. We use well-established economic methods of calculating social costs, drawing on guidance developed by New York State, the U.S. Environmental Protection Agency (EPA), the U.S. Office of Management and Budget (OMB), and the economics literature (e.g., Boardman et al. 2011).

This chapter provides background on IPEC and on the methodology NYSDEC has developed for assessing BTA, including the "wholly disproportionate" determination. The final section provides an overview of the organization of the report.

A. Background on Indian Point Energy Center

IPEC is located in the Village of Buchanan in Westchester County, New York, on the eastern shore of the Hudson River. The 239-acre site includes three nuclear units owned by Entergy. Unit 1 is no longer generating electricity and is managed under the U.S. Nuclear Regulatory Commission's (NRC) SAFSTOR program pending final decommissioning. Units 2 and 3 have been in operation since 1974 and 1976, respectively. Their initial licenses from the NRC were set to expire in 2013 and 2015, respectively, but operations will continue under NRC's "timely renewal" mandate. Assuming NRC approval of Entergy's applications to obtain 20-year renewals, Units 2 and 3 will operate until 2033 and 2035, respectively. Units 2 and 3 have maximum dependable net capacities of 1020 megawatts (MW) and 1040 MW, respectively (NYISO 2013, p. 30). IPEC is the largest baseload power source in southeastern New York (NYISO 2013, p. 48).

IPEC uses water from the Hudson River to cool both operating units. The intakes and discharges are authorized by a joint NYSDEC-issued State Pollutant Discharge Elimination System (SPDES) permit. The units use once-through cooling systems, but over the years have undertaken various measures to minimize I&E. Measures in the current configuration include optimized Ristroph-type traveling screens with low-pressure washes and a state-of-the-art fish return system, as well as multispeed pumps that reduce the flow of water to allow for efficient operation of the units with reduced water use.

As part of the renewal process for the SPDES permit, NYSDEC Staff has recommended Cooling Towers (i.e., the use of Cooling Towers to reuse cooling water) as BTA for the NRC-approved license-renewal period if that technology is demonstrated to be available and if it receives the required permits. Entergy is proposing CWWS as BTA.

B. Background on Best Technology Available (BTA) Determinations and "Wholly Disproportionate" Test

This section provides brief background on the legal basis for BTA determinations and on the administrative guidance in New York State regarding the "wholly disproportionate" test for assessing potential BTA technologies.

1. Legal Standard for BTA Determination

The NYSDEC is responsible in New York for implementing the Clean Water Act (CWA) § 316(b), and the corresponding rule in the New York Codes, Rules and Regulations, 6 NYCRR § 704.5, which states,

> The location, design, construction and capacity of cooling water intake structures, in connection with point source thermal discharges, shall reflect the best technology available for minimizing adverse environmental impact.

NYSDEC has developed Commissioner Policy 52 (CP-52) to guide the implementation of 6 NYCRR § 704.5 and to clarify the determination of the "best technology available" (BTA).

2. Four-Step Process for BTA Determination

NYSDEC has developed a four-step analysis for applying § 704.5. The steps include the following determinations:

1. whether the facility's cooling water intake structure may result in adverse environment impact;

2. if so, whether the location, design, construction and capacity of the cooling water intake structure reflects BTA for minimizing adverse environmental impact;

3. whether practicable alternate technologies are available to minimize the adverse environmental effects; and

4. whether the costs of practicable technologies are *"wholly disproportionate"* to the environmental benefits conferred by such measures.

We focus on the fourth step since it relies upon calculations that include economic information (as well as engineering and biological information).

3. Prior Decisions

NYSDEC BTA determinations provide some guidance regarding the "wholly disproportionate" test. Two relevant decisions are *Athens* (NYSDEC 2000) and *Bowline* (NYSDEC 2002).

In the *Athens* decision, the DEC compared the costs of a dry cooling system with the costs of a hybrid cooling system as follows.

> "Thus, dry cooling costs (without a Gunderboom) exceed the costs of hybrid cooling by approximately $38.75 billion over 20 years, or $1.9 million per year for 20 years. In view of the minimized impact to aquatic organisms arising from application of dry cooling technology and the relatively insignificant increase in the total cost of the facility from application of dry cooling, I do not find the costs of dry cooling to be 'wholly disproportionate' to the environmental benefits to be gained." (p. 14)

In the *Bowline* decision, the Commissioner reported the following.

> "Staff, in exercising its best professional judgment, did conduct its BTA analysis for the Bowline facility generally in accordance with the analysis adopted by the Commissioner in *Athens*. Staff reviewed the cooling technology proposed by the Applicant, as well as other feasible technologies, including dry cooling. ... Staff concluded that the protection afforded aquatic resources by dry cooling was 'approximately equivalent' to the protection afforded by hybrid cooling with 2.0 mm wedge wire screen and Gunderboom.... Staff further found that the incremental added cost of dry cooling did not justify the minimal environmental benefits to be gained.... Thus, Staff concluded that the hybrid cooling/Gunderboom proposal was BTA." (p. 10)

These decisions suggest that the "wholly disproportionate" test involves comparisons across potential BTA technologies. That is, in considering two technologies, the "wholly disproportionate" test compares the additional environmental benefits with the additional costs. This concern for the incremental costs and benefits of alternative technologies is consistent with EPA guidelines and sound benefit cost principles (see EPA 2010 and e.g., Boardman et al.).

4. IPEC Guidance Related to the "Wholly Disproportionate" Determination

The meaning of the "wholly disproportionate" test has been the subject of several recent regulatory rulings specifically designed for IPEC.[4] Most recently, in a ruling published on November 28, 2012, the Regional Director of the NYSDEC responded to an Entergy motion to

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[4] The regulatory history of this step is summarized in *Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC*. Ruling of the Regional Director, November 28, 2012.

reconsider the steps required to analyze what is BTA for fish protection at IPEC in light of the Supreme Court decision in *Entergy Corp. v. Riverkeeper, Inc.*, 556 U.S. 208 (2009). The ruling replaced the Interim Decision's "reasonably-be-borne" standard with the "wholly disproportionate" test that was in place prior to the 2007 Second Circuit decision in *Riverkeeper, Inc. v. EPA*, 475 F.3d 83 (2007).

The November 2012 Ruling describes the "wholly disproportionate" test as involving comparisons of the following two calculations:

1. The increase in the protection of aquatic organisms that would be gained from installing and operating the proposed technology as compared to current operations; and

2. The increase in cost of the proposed technology at the stations (including but not limited to costs of installation, maintenance and operation) as compared to the costs of current maintenance and operation (NYSDEC 2012, p. 8).

The NYSDEC ruling notes that "once the proportional benefits and costs of the technology are estimated, a determination will be made whether the costs of the technology are "wholly disproportionate" to the environmental benefits to be gained from the technology" (NYSDEC 2012, p. 8).

In accordance with economic principles, our assessments of costs do not include comparisons to IPEC revenues in terms of the "wholly disproportionate" test. Upon our review of the NYSDEC decisions in *Athens* and *Bowline*, the November 28, 2012 decision of the Regional Director in this case, and CP-52, a comparison of costs to facility revenues is not relevant. We therefore do not use facility revenue as a basis for any calculations in this report.

C. Objectives of This Report

In order to develop BTA assessments under the "wholly disproportionate" test, we develop information on costs and biological benefits of CWWS and Cooling Towers in accordance with NYSDEC direction to Entergy and applicable law. The specific elements of this report include the following.

- Information on the social costs of CWWS and Cooling Towers, using relevant engineering and economic information.

- Information on the biological benefits of CWWS and Cooling Towers, using relevant biological information.

- Assessments for both CWWS and Cooling Towers of whether costs are "wholly disproportionate" to biological benefits, including comparative analysis for costs and benefits of Cooling Towers relative to those of CWWS.

D. Organization of This Report

The remainder of this report is organized as follows. Chapter II provides overviews of entrainment and impingement, as well as the two CWIS technologies we evaluate in this report. Chapter III develops information on the social costs of CWWS and Cooling Towers. Chapter IV develops information on the biological impacts of CWWS and Cooling Towers. Chapter V provides our analyses of whether the two technologies have social costs that are "wholly disproportionate" to the biological impacts, taking into account the benefits flowing from those impacts. Chapter VI presents information on the uncertainties of the empirical information and the implications for "wholly disproportionate" determinations. The final chapter summarizes our conclusions regarding CWWS and Cooling Towers and the "wholly disproportionate" test.

II. Overview of Cylindrical Wedgewire Screens and Cooling Towers

This chapter provides overviews of the nature of I&E, the current technologies and operational measures at IPEC that reduce I&E, and CWWS and Cooling Towers.

A. Overview of Impingement and Entrainment

The two IPEC generating units, like other nuclear and large fossil-fired plants, depend on cooling water and service water to operate safely and efficiently. The units draw cooling and surface water from the Hudson River through their own CWIS and, under certain conditions, service water through the CWIS for Unit 1, which no longer operates. Large pumps circulate most of the water through the units' cooling systems, where the water absorbs waste heat and is then discharged back to the river. Smaller pumps withdraw relatively modest amounts of service water.

Theoretically, CWIS can affect aquatic life in two primary ways:

1. *Impingement*: Fish—primarily small adult fish or juveniles of larger species—may be drawn against screens protecting the intake, and some of the impinged fish may suffer mortality. IPEC's current systems are "state-of-the-art" for impingement, as reflected in the requirements of EPA's proposed 316(b) Replacement Rule (EPA 2011).

2. *Entrainment*: Eggs and larvae of marine organisms may be drawn through the CWIS and into the plant, and some of the eggs and larvae may suffer mortality. IPEC's current systems reduce entrainment, but incremental entrainment reductions are the focus of our report.

CWWS reduce the number of aquatic organisms that are entrained through the CWIS, and thus lead to changes in impingement and entrainment. Similarly, Cooling Towers would reuse much of the water taken in, reducing the volume of intake water required and thereby lowering I&E.

B. Current Configuration

In some evaluations, NYSDEC has assessed the effectiveness of alternative I&E reduction technologies relative to a "regulatory baseline" set of conditions. The regulatory baseline conditions include relatively simple intake screens designed and operated only for debris removal, full-flow operation for 365 days per year, and assumes no survival for impinged or entrained organisms.

Current controls and conditions at IPEC reduce I&E below the regulatory baseline level through several mechanisms.

1. Unit 2 has dual-speed pumps and Unit 3 has variable-speed pumps that enable plant operators to reduce the flow of cooling water for efficient operation.

2. The units have Ristroph-type traveling screens and a fish return system that minimize impingement mortality.

3. The units have relatively low temperature differentials across the condensers, thus reducing entrainment mortality from the regulatory baseline level.

4. Each unit undergoes periodic shutdowns for refueling (staggered so that the two units do not have shutdowns at the same time) typically during the spring season, thus reducing I&E.

Our estimates of the costs and potential benefits of CWWS and Cooling Towers initially are measured relative to the current configuration that includes these controls and conditions. In the absence of the installation of new I&E reducing technologies, the current configuration would continue to reduce I&E at IPEC over the time period of our analysis. The current configuration is therefore the appropriate initial "baseline" for the benefit-cost analysis of the two alternatives. Using the current configuration as the initial baseline is consistent with the calculations described by the November 28, 2012 ruling of the Regional Director of the NYSDEC for applying the "wholly disproportionate" test at IPEC.

C. Technologies Being Considered as Best Technology Available

As noted, this report focuses on the two BTA alternatives: (1) CWWS; and (2) Cooling Towers. The following are brief summaries of these two technologies and the information that has been developed on their costs and biological benefits. As discussed below, we rely upon information provided by the experts retained by each technology's proponents except in case in which the information is incomplete, in which case we rely upon supplementary information provided by other experts.

1. Cylindrical Wedgewire Screens

CWWS consist of specially designed screens made with wedge-shaped wires. With CWWS installed, the units at IPEC would withdraw water from the river through these structures. This modification to the CWIS would reduce I&E in three ways:

1. Through established mechanical forces, organisms are swept past the intake by the tidal flow in the Hudson River.

2. The large screen area reduces flow rates through the screens, thus facilitating behavioral avoidance and therefore I&E.

3. To a lesser degree, they provide a physical barrier preventing organisms larger than the screen spacing from being entrained.

ENERCON and the biological team investigated several alternative configurations for the screens that vary in the spacing of the slots and the velocity of water flowing through the screens (which is inversely proportional to the surface area of the screens). Entergy's proposed design includes a screen configuration with a slot size of 2 mm and through-screen flow velocity of 0.25 feet per second (ENERCON 2013a).

ENERCON's analysis indicates CWWS could be installed at IPEC over a period of six years (ENERCON 2013a). Assuming a start date of mid-2018, this assumption means that CWWS would become operational in 2024.

2. Closed-Cycle Cooling Towers

Under the Cooling Towers alternative, IPEC theoretically could install closed-cycle cooling systems that could reduce the volume of water withdrawn from the Hudson River by up to approximately 97 percent, if operated on a year-round basis. In fact, however, ENERCON (2013b) has evaluated Cooling Tower designs by the two consultants engaged by NYSDEC Staff and Riverkeeper, and concluded that neither design likely is feasible. The design proposal from Tetra Tech on behalf of NYSDEC Staff (Tetra Tech 2013) is more fully developed than the design proposal from Riverkeeper, which ENERCON has determined is materially deficient. Thus, we rely upon the Tetra Tech report for information related to the cost and effectiveness of Cooling Towers.

Tetra Tech's analysis assumes Cooling Towers would take between 7 and 9 years to install, although it also provided estimates for stages in the permitting and construction process that together add up to roughly 8-12 years.[5] Given the uncertainty of Tetra Tech's own estimates, and in an effort to be conservative, we took the midpoint of the smaller (7-9 year) range and, assuming that the permitting period begins in mid-2018, we assumed that Cooling Towers would be operational in mid-2026. If we had used the midpoint of the longer (8-12 years) range instead, we would have assumed a start date for Cooling Towers in 2028. According to both ENERCON (2010b) and Young/Sommer (2013), a period of much longer than eight years would be required for permitting and construction of Cooling Towers at IPEC. Our assumption that Cooling Towers are operational in 2026 results in a longer operational period for Cooling Towers than would the use of other Tetra Tech, ENERCON (2010b) or Young/Sommer (2013) estimates, and hence greater biological benefits.

We supplement the Tetra Tech information on Cooling Towers where the information is incomplete. In particular, as discussed in Chapter 2 of TRC (2009), operation of the Cooling Towers would not comply with air emissions permitting requirements in some periods of the year, a factor that was not assessed by Tetra Tech. Thus, we presume that Cooling Towers would only be operated when operation would not violate air quality constraints. ENERCON (2010a) and ASAAC (2013) provide information on the implications of these constraints for operation of the Cooling Towers and their biological benefits. Appendix G to this report provides cost and benefit results if air emissions permitting requirements did not constrain operation of the Cooling Towers.

[5] The following are commentaries on the timing of individual stages for Cooling Towers in Tetra Tech (2013). "It is not unreasonable to assume the permitting effort alone would take 3 to 5 years, while the final design effort required to produce construction-level plans and drawings could easily lag behind final approval by 1 year or more." (p. 27). "Construction could occur over a period of approximately 4-6 years." (p. 77).

III. Costs of Cylindrical Wedgewire Screens and Cooling Towers

This chapter provides information on the costs of CWWS and Cooling Towers. We first provide an overview of the basic cost methodology. We then develop estimates for the three major categories of costs: (1) capital costs; (2) operation and maintenance costs; and (3) electricity costs. The final section presents total quantified costs for CWWS and Cooling Towers.

A. Overview of Cost Methodology

To measure the potential costs of a regulatory-based decision, the appropriate measure is social costs, as noted in the EPA *Guidelines for Preparing Economic Analyses* ("*Guidelines*") (EPA 2010):

> Social cost represents the total burden that a regulation will impose on the economy. It is defined as the sum of all opportunity costs incurred as a result of a regulation where an opportunity cost is the value lost to society of any goods and services that will not be produced and consumed as a result of a regulation. These opportunity costs consist of the value lost to society of all the goods and services that will not be produced and consumed if firms comply with the regulation and reallocate resources away from production activities and towards pollution abatement (EPA 2010, pp. 8-1, 8-2).

Although the *Guidelines* deal with regulatory decisions, the general principles they present are valid for comparisons of benefits and costs, including this analysis of CWWS and Cooling Towers at IPEC.[6]

When the effects of a regulation or a regulatory-based decision are primarily confined to a small number of efficient markets,[7] it is appropriate to focus the cost assessment on changes in the specific market in which the costs are imposed[8] (EPA 2010, p. 8-2). In that case, the social cost of a particular regulatory-based decision is equal to the sum of the compliance costs and any changes in economic efficiency (or "deadweight loss") that may result (EPA 2010, p. 8-3). As long as any price impacts are negligible, the deadweight loss is not significant and compliance costs provide a sufficiently complete measure of the conceptually appropriate measure of costs (Boardman et. al 2011, p. 99). We assume that the compliance costs related to CWWS and Cooling Towers at IPEC would not affect electricity prices, and thus that the compliance costs would not result in any loss in economic efficiency. We do, however, include the possibility of inefficiencies related to the electricity market; in particular, we consider changes in air emissions that are not covered by the market prices of electricity.

6 Note that similar principles are developed in textbooks on benefit-cost analyses (see, e.g., Boardman et al. 2011).

7 An "efficient market" does not have distortions that affect social welfare. In an efficient market, for example, there are no costs that are imposed on others that are not incorporated ("internalized") in the market.

8 This analysis is referred to in economics as a "partial equilibrium analysis" to distinguish it from a "general equilibrium analysis" in which potential effects on other markets are incorporated in the analysis.

Compliance costs are generally composed of two main components: (1) capital costs; and (2) operating costs (EPA 2010, p. 8-8).[9] Because costs are incurred in future years, we use social discount rates to convert them into present values and thus enable comparisons with benefits, as recommended in the EPA *Guidelines* (EPA 2010, p 8-10).

1. Components of Compliance Costs

As noted above, compliance costs are generally composed of capital costs and operating costs (EPA 2010, p. 8-8). It is useful, however, to distinguish costs related to changes in IPEC electricity generation and capacity from other operating costs. It is also useful to include maintenance costs with operating costs, both of which are generally incurred each year. Thus, to assess the compliance costs of installing and operating CWWS and Cooling Towers at IPEC, we use the following three categories:

1. *Capital costs* are one-time costs associated with acquiring, constructing, and installing equipment.

2. *Operation and maintenance (O&M) costs* are recurring costs associated with operation and maintenance of the equipment, with the exception of any costs related to ongoing power losses.

3. *Electricity costs* represent the costs to society related to changes in net electricity generation at IPEC. The social costs associated with these changes include the materials (e.g., fuels) and other costs incurred to supply energy, capacity and ancillary services in order to replace changes in electricity output at IPEC. As noted, the costs may include other "external" costs associated with changes in generation (e.g., certain air emissions).

2. Information Used in Cost Assessments

Information on the costs of CWWS is from ENERCON (2013a), whereas information on the costs of Cooling Towers is from Tetra Tech (2013). As noted above, we supplement the Tetra Tech information where it is incomplete. In particular, as explained in Chapter II, we presume that Cooling Towers would only be operated when operation would not violate air quality constraints. Neither Tetra Tech (2013) nor NYSDEC Staff provided information on the operating implications of the air quality constraints, and thus we rely upon ENERCON (2010a, 2013a) for information on the implications of air permit restrictions on generation at IPEC after Cooling Towers are installed.

We use the current plant conditions as the baseline from which we measure the costs of CWWS and Cooling Towers. These current conditions include the current use of Ristroph screens as well as other technologies and operational measures. As discussed below, the net electricity impacts

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[9] As the *Guidelines* note, there are other potential categories of social costs beyond compliance costs. These include transaction costs, government regulatory costs, transitional costs and distributional costs (EPA 2010, p. 8-9). We assess these other social costs in Chapter V.

of CWWS and Cooling Towers reflect changes in the use of the Ristroph screen technology if these other two technologies were in place.

As noted, we express all cost estimates in constant 2012 dollars. We calculate all present values as of January 1, 2013. These choices of constant dollars and beginning date for the calculation of present values do not make a material difference in the results. In computing present values we use real (net of inflation) discount rates of 3 and 7 percent, as recommended by OMB (1992, 2003) and EPA (2010).

Costs are projected until September 2033 for Unit 2, which would be the end of the 20-year license extension for which Entergy is applying at the NRC. Similarly, for Unit 3, costs are projected until December 2035, when the equivalent 20-year license extension would end.

B. Capital Costs

Capital costs consist of the labor and material costs associated with the acquisition, construction, and installation of the two alternatives. In this section we provide estimates of the total overnight construction costs and the construction costs discounted to present value terms when account is taken of the potential timing of costs.

1. Overnight Capital Costs

Overnight capital costs are engineering estimates of the total costs of installing the necessary structures and equipment based on contemporary prices for materials, equipment, and labor, assuming the modifications could be completed immediately (i.e., "overnight"). Thus, they exclude interest charges during construction, which engineering cost estimates sometimes include; discounting implicitly incorporates such interest charges because earlier expenditures receive more weight in the present value calculations.

ENERCON (2013a) provides estimates of the costs of CWWS at IPEC. The cost estimates provided in ENERCON (2013a) include elements related to an air burst system but some additional costs may be involved if experience indicated that additional elements were required for proper operation of the CWWS.

Tetra Tech (2013) provides estimates of the overnight capital costs of its design for Cooling Towers. These estimates do not account for the modifications that would be required for the towers to be operated intermittently. We understand that no detailed engineering analysis has been conducted on the additional construction costs to allow intermittent operation of the Cooling Towers, but we assume that adding that capability would increase capital costs. Thus, the estimate provided by Tetra Tech (2013) will underestimate the overnight capital cost of the Cooling Towers required at IPEC.

The cost estimates from ENERCON (2013a) and Tetra Tech (2013) have been adjusted in various ways to make the costs for CWWS and Cooling Towers as comparable as possible. First, Tetra Tech (2013) does not provide information on costs related to designing and permitting the Cooling Towers, so the estimates from ENERCON (2013a) do not include any design and permitting costs for CWWS either. Second, ENERCON (2013a) does not include contingency costs in the capital cost estimates for CWWS (although a range of uncertainty underlying the capital cost estimate is included, as discussed in Chapter VI), so we removed the contingency costs assumed by Tetra Tech (2013) for the Cooling Towers (25 percent of total direct and indirect construction costs). The result of excluding design, permitting and contingency costs is that the total costs of both alternatives will be understated to some extent, and hence both alternatives will appear more attractive than otherwise in comparison to the current configuration.

Table 1 summarizes the overnight construction costs of CWWS and Cooling Towers based upon ENERCON (2013a) and Tetra Tech (2013), with the modifications summarized above.

Table 1. Capital Overnight Costs ($millions)

Alternative	Overnight Cost
CWWS	$223.2
Cooling Towers	$822.2

Note: All dollar values are in millions of constant 2012 dollars.
Construction costs exclude design, permitting, and contingency costs.
Source: ENERCON (2013a), Tetra Tech (2013) and NERA calculations as explained in text

2. Present Value of Capital Costs

We use information from ENERCON (2013a) and Tetra Tech (2013) on the duration of each phase of construction for CWWS and Cooling Towers. This information allows us to determine the construction expenditures that would be incurred in each year and then discount the future costs to present value terms.

ENERCON (2013a) indicates that CWWS at IPEC could be installed over a period of six years. First, the design phase of the project is projected to last approximately two years, which we assume begins in July of 2018. In-river construction activities would take place in the following three years, with procurement costs for construction materials beginning the year before construction starts. The final "tie-ins" of the CWWS would follow the in-river construction and would be coordinated with refueling outages at IPEC. Based on the estimated six year duration of the project and the assumed start date of July of 2018, CWWS would begin operation in July of 2024.

For Cooling Towers, we also assume that permitting would begin in July of 2018. Tetra Tech (2013) provides information on the timing of permitting and construction. Based on the information provided in Tetra Tech (2013) and as discussed above, we presume that design and permitting would take place during the years 2018 to 2021 and that construction would occur during the years 2021 to 2026.[10] Using the Tetra Tech timing assumptions, the Cooling Towers would begin to operate in July of 2026.

[10] According to Tetra Tech (2013), the complete implementation of the Cooling Towers project (including design, permitting, construction, tie-in and testing) would last from seven to nine years. We take the mid-point of this

ENERCON (2013a) and Tetra Tech (2013) also provide information on when the capital expenditures would be incurred for CWWS and Cooling Towers, respectively. We use that information to develop estimates of the present values of capital expenditures. Table 2 shows the construction costs of CWWS and Cooling Towers based upon these expenditures discounted to present value terms at 3 and 7 percent discount rates. The construction start and end dates refer to the dates on which permitting would begin and construction activities would end. The construction costs for Cooling Towers do not include the costs due to the forced outage of IPEC during construction; these electricity system costs are discussed below.

The present value of capital costs for CWWS as of January 1, 2013 are $173.9 million using a 3 percent discount rate and $126.2 million using a 7 percent discount rate. The present value of construction costs for Cooling Towers are $595.2 million using a 3 percent discount rate and $393.6 million using a 7 percent discount rate. Note that the present values of capital costs are substantially lower than the overnight costs because the costs would be incurred over many years in the future.

Table 2. Present Value of Capital Costs ($millions)

	Discount Rate		Project Start Date	Project End
Alternative	**r = 3%**	**r = 7%**		**Date**
CWWS	$173.9	$126.2	Jul 2018	Jun 2024
Cooling Towers	$595.2	$393.6	Jul 2018	Jun 2026

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. Project timelines include design, permitting, construction and final tie-ins.
Source: ENERCON (2013a) and Tetra Tech (2013) and NERA calculations as explained in text

ENERCON (2010b) and Young/Sommer (2013) have provided alternative estimates of the time required for permitting and construction of Cooling Towers at IPEC, and conclude that Cooling Towers would require substantially more time to develop and install than presumed in Tetra Tech (2013).

C. Operation and Maintenance Costs

Both CWWS and Cooling Towers would involve the installation of equipment that would require ongoing upkeep. Maintaining this equipment entails O&M costs. Those costs include labor, materials, and outside services. In addition, both of the technologies would involve changes in the use of the existing Ristroph screens, and thus the net O&M costs depend upon changes in the usage and costs of the Ristroph screens. The following subsections provide information on the O&M costs of the various technologies and the net O&M costs of CWWS and Cooling Towers. Note that ongoing electricity costs are considered separately below.

range and assume the full project takes eight years, three years for permitting/design and five years for construction. As noted above (p. 6), however, the specific information on the timing of individual tasks yields a wider range of 8 to 12 years to complete construction, assuming no overlap between the stages.

1. Ristroph Screens Operation and Maintenance Costs

We rely upon Entergy for information on the O&M costs for the existing Ristroph screens. Entergy (2013a) estimates that annual O&M costs for the existing Ristroph screens are $2.8 million (in 2012 dollars). For both CWWS and Cooling Towers, Entergy anticipates that the Ristroph screens would continue to be operated, although the costs are expected to be lower than under current operations. The estimates of net O&M costs for CWWS and Cooling Towers therefore reflect some cost savings from reducing the need for the existing Ristroph screens.

For CWWS, Entergy (2013a) estimates that O&M costs related to Ristroph screens would decrease by 60 percent, or about $1.7 million. The remaining 40 percent of O&M costs—estimated at $1.1 million—would still be incurred for testing and other activities needed to keep the existing Ristroph screens available for potential reinstallation and use.

For Cooling Towers, as noted in Chapter II, ENERCON (2010a) estimates that the Cooling Towers operation could vary by month—operating on average about 13 percent of the time over the course of the year—in order to comply with air quality regulations. The Ristroph screens would not be used when the Cooling Towers were operating but would be used for the remaining 87 percent of the time when Cooling Towers were not operating. The O&M costs of the Ristroph screens are assumed to decrease in proportion to the decrease in usage of the screens. On average, the monthly O&M costs associated with Ristroph screens would decrease by 13 percent—or about $0.4 million—under the Cooling Tower alternative. The remaining 87 percent of annual O&M costs—estimated at $2.4 million —would still be incurred for the Ristroph screens.

2. CWWS Operation and Maintenance Costs

ENERCON has not provided information on the (non-electricity) O&M costs associated with the CWWS at IPEC. Our cost estimate will therefore be understated by the amount of any potential O&M needed for the CWWS. We would not expect these O&M activities, which presumably include periodic defouling of the screens, to involve costs that are significant relative to construction costs.

3. Cooling Towers Operation and Maintenance Costs

Tetra Tech (2013) provides estimates of the O&M costs that would be incurred to operate the Cooling Towers. These include expenditures for labor, equipment maintenance, and water treatment chemicals. O&M costs are projected to increase over time due to additional periodic costs to repair and replace equipment as it ages, such as fill material, spray heads, fan blades and gear boxes. We understand that there is much uncertainty surrounding the actual O&M costs that would be required for Cooling Towers at IPEC, but due to the absence of alternative information, we use the estimates provided by Tetra Tech.

Tetra Tech (2013) estimates that annual O&M costs for Cooling Towers are $2.5 million for the first five years of operation, $3.8 million for the next ten years, and $4.4 for the following five years. As noted above, we assume that Ristroph screens operate when the Cooling Towers are not operating.

The annual O&M costs for Cooling Towers and Ristroph screens are assumed to decrease in proportion to their respective operation percentages. The limited use of Cooling Towers due to air quality constraints means that the annual O&M costs for Cooling Towers are lower than the values in Tetra Tech (2013), which do not take into account air quality constraints. The Tetra Tech (2013) cost estimates are therefore decreased in proportion to the assumed reduction in usage of the Cooling Towers based on the operational schedule developed by ENERCON (2010a). On average, the monthly O&M costs for Cooling Towers thus are reduced by 87 percent from the Tetra Tech (2013) cost estimates.

4. Net Operation and Maintenance Costs

Table 3 summarizes the estimated annual O&M costs for Cooling Towers, including the cost savings from the reduced usage of the existing Ristroph screens. The table shows that the net O&M costs for Cooling Towers differ by year over the relevant time frame covered by our analysis.

Table 3. Annual O&M Costs ($millions)

Alternative	New Tech. O&M Costs	Ristroph O&M Savings	Net O&M Costs
CWWS	N/A	N/A	N/A
Cooling Towers			
Years 1-5	$0.33	$0.37	-$0.05
Years 6-15	$0.49	$0.37	$0.11

Note: All values are in millions of constant 2012 dollars per year of operation for both units combined. "Year 1" represents the first year following completion of the Cooling Towers (i.e. 2026 to 2027). We assume Ristroph screens will not operating during a plant outage, so additional O&M savings is incurred during the Cooling Tower construction outage period.

Source: Entergy (2013a), Tetra Tech (2013) and NERA calculations as explained in text

Table 4 shows the present values of net O&M costs discounted at 3 and 7 percent. The calculations incorporate the assumption that Ristroph screens will not operate during the Cooling Tower construction outage period, leading to additional cost savings for the Cooling Tower alternative. The present values of O&M costs for Cooling Towers result in net savings of $1.09 million using a 3 percent discount rate and $0.69 million using a 7 percent discount rate.

Table 4. Present Values of O&M Costs ($millions)

Alternative	Discount Rate r = 3%	Discount Rate r = 7%
CWWS	N/A	N/A
Cooling Towers	-$1.09	-$0.69

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text.

D. Electricity Costs

This section considers the social costs related to changes in IPEC's contributions to the electricity system due to CWWS and Cooling Towers. As noted below, market prices for electricity are used to value changes in electricity output at IPEC due to the construction and operation of CWWS and Cooling Towers.

1. Potential Types of Electricity Costs

The construction and operation of a technology change to the CWIS at IPEC could have three potential effects on IPEC's contributions to the electricity system:

1. *Construction outages.* This category refers to reductions in the electricity output of the plant when a new technology requires an outage that is in addition to the regularly-scheduled maintenance outages of the plant.

2. *Efficiency losses.* This category refers to reductions in the electricity output of the plant when a new technology decreases the efficiency of electricity generation at the plant.

3. *Parasitic losses.* This category refers to reductions in the electricity output of the plant when a new technology requires energy from the plant.

2. Electricity Costs from Construction Outages

ENERCON (2013a) has determined that installation of CWWS would not lead to a reduction in electricity output due to construction outages. Because the tie-ins of the CWWS to the two units at IPEC would be coordinated with scheduled refueling outages, no incremental electricity output losses would be incurred during construction.

Tetra Tech (2013) indicates that an additional outage would be required for Cooling Towers. Table 5 summarizes Tetra Tech's (2013) estimates of the incremental reductions in net electricity output due to the additional outage period. The reductions reflect 35 weeks of shutdown of both units at the end of the construction period, a period that is reduced by five weeks for Unit 2 on the presumption that the tie-in would coincide with a scheduled maintenance outage for Unit 2. Note that based upon the construction schedule noted above, these generation losses due to the Cooling Towers are projected to occur in the 2025-2026 time frame.

Table 5. Construction-Related Reductions in Net Electricity Output

Technology	MWh
CWWS	0
Cooling Towers	11,136,096

Note: MWh is megawatt-hours
Source: Tetra Tech (2013), ENERCON (2013a)

3. Net Changes in Operational Efficiency

ENERCON (2013a) estimates that because the current electricity required for condenser backwashing would not be required when CWWS was installed, replacing the continuous operation of Ristroph screens with CWWS would lead to electricity gains. ENERCON (2013a) estimates that the gains in electricity output at IPEC would be 600 MWh per year.

Tetra Tech (2013) estimates that the operating efficiency of IPEC would be reduced if Cooling Towers were installed. Tetra Tech (2013) estimates that Cooling Towers would lead to average annual capacity reductions of 16 MW at Unit 1 and 4 MW at Unit 2. These annual estimates were weighted by month using monthly efficiency loss estimates from ENERCON (2013b). Based upon the Cooling Towers operational schedule developed by ENERCON (2010a), this reduction would translate into an annual loss in electricity output of 22,783 MWh per year.

Table 6 summarizes the losses in electricity output due to operational efficiency effects of CWWS and Cooling Towers based upon this information. Losses in efficiency result in social costs. Note that because CWWS would result in efficiency gains, the entry for CWWS is negative, meaning that instead of costs there would be social benefits due to efficiency effects of CWWS.

Table 6. Annual Efficiency Losses (MWh)

	Efficiency Losses
CWWS	-600
Cooling Towers	22,783

Note: Negative value represents an increase in electricity output at IPEC.
Source: ENERCON (2013a), Tetra Tech (2013)

4. Net Changes in Parasitic Losses

There would be two partially offsetting changes related to parasitic losses due to the operation of CWWS and Cooling Towers:

1. *Added electricity needed to operate either CWWS or Cooling Towers.* The operation of either CWWS or Cooling Towers would require electricity and thus reduce the net electricity output of IPEC.

2. *Reduced electricity needed to operate the Ristroph screens.* The use of either CWWS or Cooling Towers would reduce the hours in which the Ristroph screens would be operated. This change would increase the net electricity output of IPEC relative to the existing conditions.

The net effect on parasitic losses—and thus on the generation and capacity of IPEC—thus depends upon the combination of these two factors.

a. Parasitic Losses from Ristroph Screens

With the operation of either CWWS or Cooling Towers, electricity would be saved by reducing the need to run the existing Ristroph screens. The Ristroph screens use approximately 9,400 MWh of electricity annually (ENERCON 2013a).

For the CWWS alternative, the Ristroph screens would be tested and operated only occasionally to ensure their continued availability. Entergy (2013b) estimates that power requirements would be reduced by roughly 90 percent, which means that existing parasitic losses would be reduced by 8,460 MWh annually.

For the Cooling Towers alternative, we assume the parasitic losses from Ristroph screens decrease in proportion to the usage of Cooling Towers. Based on the operating schedule developed by ENERCON (2010a), the existing parasitic losses would be reduced by 1,128 MWh annually.

b. Parasitic Losses from CWWS

According to ENERCON (2013a), the initial construction of the CWWS air burst system would not include components of an air-burst system that would require electricity. We therefore assume there are no parasitic losses associated with the operations of CWWS at IPEC. To the extent that the air-burst system is needed and parasitic losses result, our cost estimated will be understated. However, we would not expect these losses to involve costs that are significant relative to construction costs.

c. Parasitic Losses from Cooling Towers

Tetra Tech (2013) notes that cooling towers would require electricity to operate its fans and pumps. Tetra Tech (2013) estimates that operating the cooling towers would result in a loss of capacity of roughly 40 MW, which, under the Cooling Towers operational schedule developed by ENERCON (2010a), corresponds to a reduction in electricity output of 47,187 MWh annually.

d. Net Changes in Parasitic Losses for CWWS and Cooling Towers

Table 7 summarizes estimates of the changes in parasitic losses due to the operation CWWS and Cooling Towers. Table 7 shows that on net, CWWS would lead to a savings of 8,460 MWh annually because of the avoided parasitic losses of the Ristroph screens. In contrast, the Cooling Towers alternative would lead to losses of 46,059 MWh annually.

Table 7. Changes in Annual Parasitic Losses (MWh)

	Direct Parasitic Losses	Avoided Parasitic Losses	Net Parasitic Losses
CWWS	0	-8,460	-8,460
Cooling Towers	47,187	-1,128	46,059

Note: Negative values represent increases in electricity output at IPEC.
Source: ENERCON (2013a), Entergy (2013b), and NERA calculations as explained in text

5. Total Changes in Electricity Output due to CWWS and Cooling Towers

Table 8 provides estimates of the annual changes in electricity output at IPEC for CWWS and Cooling Towers due to the effects of the construction outage, efficiency losses and parasitic losses described above. The changes reflect the assumed timing of installation and operation of the CWWS and Cooling Towers at the two IPEC units. The calculations incorporate the assumption that Ristroph screens will not operate during the Cooling Tower construction outage period, leading to additional cost savings for the Cooling Tower alternative. The final row shows the undiscounted sum of the annual changes.

Table 8. Total Losses in Annual Electricity Generation (MWh)

	CWWS				Cooling Towers			
	Construction Outage Losses	Net Efficiency Losses	Net Parasitic Losses	Total Electricity Losses	Construction Outage Losses	Net Efficiency Losses	Net Parasitic Losses	Total Electricity Losses
2024	0	-300	-4,230	-4,530	0	0	0	0
2025	0	-600	-8,460	-9,060	2,233,008	0	-1,178	2,231,830
2026	0	-600	-8,460	-9,060	8,903,088	5,609	7,966	8,916,663
2027	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2028	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2029	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2030	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2031	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2032	0	-600	-8,460	-9,060	0	22,783	46,059	68,842
2033	0	-525	-7,403	-7,928	0	19,017	40,734	59,751
2034	0	-300	-4,230	-4,530	0	3,275	23,030	26,305
2035	0	-300	-4,230	-4,530	0	3,275	23,030	26,305
Total	0	-6,225	-87,773	-93,998	11,136,096	167,873	369,936	11,673,905

Note: Negative values represent increases in electricity output at IPEC.
Source: NERA calculations as explained in text

6. Wholesale Electricity Prices

We assume the changes in net generation at IPEC due to the installation and operation of CWWS and Cooling Towers would not in general significantly affect electricity prices or electricity consumption on an annual basis. Thus, we assume only that a decrease (increase) in IPEC generation would lead to an increase (decrease) in the electricity generated at other facilities. The increase (decrease) in generation at other facilities would lead to an increase (decrease) in the social costs of providing electricity to consumers. There could, however, be significant impacts on an hourly or daily basis.

Wholesale electricity prices provide estimates of the social costs of replacement electricity (or the social benefits of avoiding the need for electricity from other facilities) because they reflect the cost of supplying an additional unit of electricity to the grid.[11] We developed forecasts of monthly wholesale electricity prices over the relevant time period for a region consisting of New York City and Westchester County, New York to value replacement electricity at IPEC. These projections are based on annual wholesale electricity price projections from the U.S. Energy Information Administration (EIA) and historical data on wholesale electricity prices (for scaling the annual price projections into monthly projections) from the New York Independent System Operator (NYISO).[12] Appendix A describes our methodology and shows our monthly electricity price forecasts.

7. Social Costs of Changes in Electricity Output

Table 9 summarizes the present values of the estimated changes in social costs of providing replacement electricity as a result of changes in net generation at IPEC due to the installation and operation of CWWS and Cooling Towers. As the table shows, the installation of CWWS would lead to social benefits because IPEC generation is estimated to increase; the benefits are $4.4 million based on a 3 percent discount rate and $2.4 million based on a 7 percent discount rate. As noted above, because the tie-in for CWWS would take place during a planned refueling outage, no outage costs would be incurred.

Cooling Towers require an installation period that extends beyond the plant's annual planned outages. It is therefore necessary to account for the net costs that are incurred while the plant is not operational. The gross costs include the costs of replacement power generation.[13] But costs would be reduced due to reductions in costs at IPEC that would not be incurred during this outage period. As an estimate of these cost savings, we use an estimate from EIA (2013) that the variable O&M costs for a new nuclear power plant are $12.30 per MWh.[14] Taking each of these

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11 A portion of IPEC's output is sold to utilities (electricity retailers) via power purchase agreements. Wholesale prices are the appropriate measure of social costs or benefits even with these agreements.

12 As discussed in Appendix A, the electricity price projections developed by EIA reflect capacity and ancillary services as well as generation. Real-time, hour-ahead, and day-ahead wholesale electricity prices from NYISO, however, reflect only generation.

13 As stated earlier, Unit 2 and Unit 3 will undergo construction outages of 30 and 35 weeks, respectively, during the installation of the Cooling Towers.

14 U.S. EIA (2013) does not provide an estimate of O&M costs for existing nuclear units. EIA estimates the levelized cost of new generation resources in its 2013 Annual Energy Outlook. The value of $12.30 per MWh

components into account, the installation and operation of Cooling Towers would lead to social costs of $462.5 million based on a 3 percent discount rate, and $278.0 million based on a 7 percent discount rate.

Table 9. Present Values of Social Costs (Benefits) of Changes in Electricity Output at IPEC ($millions)

	Discount Rate	
Alternative	**r = 3%**	**r = 7%**
CWWS		
Parasitic and efficiency costs	-$4.4	-$2.4
Construction outage replacement power costs	$0.0	$0.0
Construction outage cost savings	$0.0	$0.0
Total	-$4.4	-$2.4
Cooling Towers		
Parasitic and efficiency costs	$24.5	$12.6
Construction outage replacement power costs	$532.5	$322.7
Construction outage cost savings	-$94.6	-$57.3
Total	$462.5	$278.0

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

8. External Costs Related to Changes in Electricity Generation

The social costs of changes in the sources of electricity generation should include external costs, i.e., costs such as air emissions that are not included in the market electricity prices. The wholesale electricity prices described above include the external costs of emissions covered by cap-and-trade programs, because overall emissions are capped and sources bidding into the system would include the cost of allowances needed to cover their emissions. In New York, the emissions covered by cap-and-trade programs are sulfur dioxide (covered by federal programs), nitrogen oxides (also covered by federal programs), and carbon dioxide (covered by the Regional Greenhouse Gas Initiative).

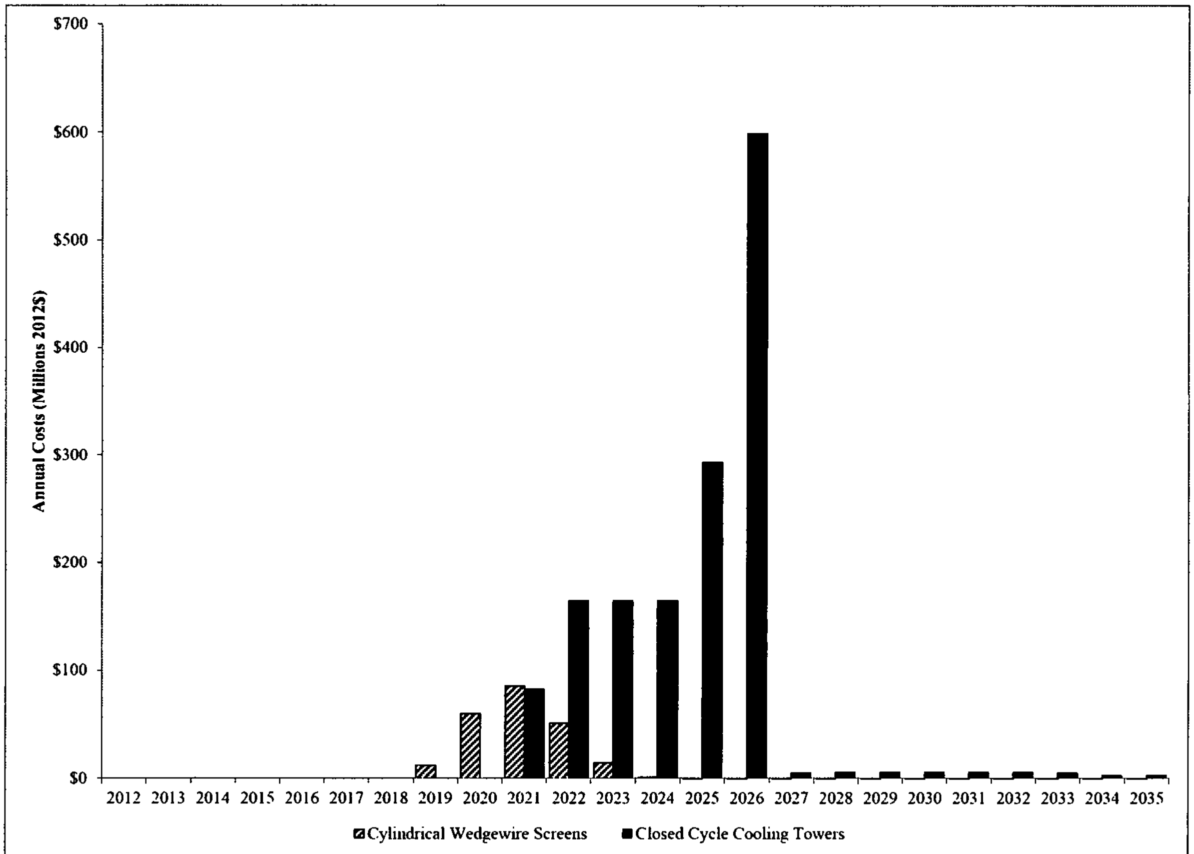
There are several potential sources of additional social costs related to air emissions that we have not quantified. The social costs of emissions not covered by cap-and-trade programs—such as mercury—are not incorporated in the wholesale electricity price forecast. In addition, the cap-and-trade programs noted above may not be binding in some years, in which case emissions from additional fossil generation would represent net additions rather than substitutes for other

represents the average levelized variable O&M cost for an advanced nuclear plant entering service in 2018 in 2011 dollars, which we adjusted to 2012 dollars. This EIA value includes fuel costs as well as other costs that are assumed to vary with electricity output. The EIA value could overstate the potential cost savings if the full amount of fuel expenditures would not be saved during the construction outage period and/or if certain non-fuel variable O&M costs would not be saved during the outage period. If cost savings at IPEC are overstated, the net construction outage costs would be understated.

emissions. Our estimates assume these emissions caps are binding throughout our modeling period.

E. Total Quantified Costs

Figure 1 shows annual estimates of capital, O&M, and power costs for CWWS and Cooling Towers. Note that we use the same scale for the two alternatives to provide an accurate visual comparison of the relative costs.



Source: NERA calculations as explained in text

Figure 1. Annual Cost Estimates

Table 10 summarizes the present values of the estimated costs for CWWS and Cooling Towers. At a 3 percent discount rate, the present value of estimated total costs is $169.5 million for the CWWS alternative and about $1.1 billion for the Cooling Towers alternative; at this discount rate, Cooling Towers costs a little more than six times as much as CWWS. At a 7 percent discount rate the present values are lower, $123.8 million for CWWS and $670.9 million for Cooling Towers; at this discount rate, Cooling Towers costs a little less than six times as much as CWWS.

Table 10. Estimated Total Costs for CWWS and Cooling Towers

	Discount Rate	
Technology	**3%**	**7%**
CWWS		
Construction	$173.9	$126.2
O&M	N/A	N/A
Electricity	-$4.4	-$2.4
Total	$169.5	$123.8
Cooling Towers		
Construction	$595.2	$393.6
O&M	-$1.1	-$0.7
Electricity	$462.5	$278.0
Total	$1,056.6	$670.9

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

IV. Biological Benefits of Cylindrical Wedgewire Screens and Cooling Towers for "Wholly Disproportionate" Analysis

This chapter provides information on the theoretical benefits of CWWS and Cooling Towers that we use in the next chapter to evaluate whether the costs of these alternatives are "wholly disproportionate" to their benefits. We first provide an overview of the methodology we use to consider biological benefits in light of NYSDEC guidance and the information needed to provide a basis for comparing benefits to the social costs that were developed in the prior chapter.

A. Overview of Biological Benefit Methodology for "Wholly Disproportionate" Analysis

Our benefit methodology consists of developing metrics that can be used to characterize the biological benefits of CWWS and Cooling Towers for purposes of the "wholly disproportionate" analyses provided in the following chapter.

We provide information on three metrics of theoretical biological impacts:

1. *Organism gains.* Changes in the number of organisms that suffer mortality from being impinged and entrained at IPEC. As noted above, the November 28, 2012 ruling of the Regional Director of the NYSDEC requires that parties proposing a technology as BTA show "the increase in the protection of aquatic organisms that would be gained from installing and operating the proposed technology as compared to current operations."

2. *Age-1 Equivalent gains.* Age-1 equivalents is a measure analogous to the metric of juvenile equivalents recommended by NYSDEC (as discussed below) to take into account differences in the significance of different life stages and thus the likely biological implications of reductions in I&E due to CWWS and Cooling Towers.

3. *Harvest benefits.* Increases in the number of harvested fish (commercial and recreational). As discussed below, this measure reflects individuals' valuation of the I&E reductions due to CWWS and Cooling Towers.

1. Reductions in Organisms and Age-1 Equivalents

ASAAC (2013) has developed estimates of the numbers of aquatic organisms that would suffer mortality from impingement or entrainment if CWWS and Cooling Towers were in place at IPEC. ASAAC also provides estimates of I&E mortality due to the current conditions and due to a regulatory baseline, which allows us to provide determine the effects of the current conditions and thus provide perspective on the gains from CWWS and Cooling Towers.

Organisms represent a large variety of aquatic life, from eggs and larvae to adult fish, and these different life stages are not equal in terms of the theoretical benefits they would provide to the fishery. A very small fraction of eggs and larvae become fish that provide direct gains to the fishery or to anglers. This point has been recognized by the NYSDEC, which has suggested the use of "juvenile equivalents" as a metric.[15] This metric aggregates organisms to account for mortality at different life stages and thus avoids treating all organisms the same. This metric is similar to age-1 equivalents, a metric that is included in ASAAC (2013).

The age-1 equivalent measure does not distinguish, however, between different types of fish. In particular, the measure does not distinguish "game fish" (i.e., fish caught by recreational and commercial fishermen) from other fish that do not have direct value to people, although they do have indirect value as forage fish (i.e., fish that are available as food for game fish) through their contribution to greater numbers or weight of game fish. In addition, the age-1 equivalent metric does not take into account that only a relatively small fraction of the marginal game fish made available to the fishery due to CWWS or Cooling Towers actually would be caught or harvested.

2. Measure of Biological Benefits

Estimates related to numbers of organisms that would suffer mortality and numbers of age-1 equivalent fish can be useful for comparing the effectiveness of CWWS and Cooling Towers in reducing I&E mortality at IPEC. But to assess whether the costs of CWWS and Cooling Towers are "wholly disproportionate" to the benefits (and whether incremental costs are "unreasonable" as discussed in *Athens,* NYSDEC 2000), it is appropriate to develop a benefit metric that corresponds to the value that individuals place on the changes.

ASAAC (2013) provides information on the additional harvested fish that would result from CWWS and Cooling Towers. Gains in harvest include increases in the numbers of commercial and recreational harvest due to CWWS and Cooling Towers. This measure distinguishes between game and forage fish, providing estimates of the direct and indirect gains to commercial and recreational fishermen due to I&E reductions. We use this measure in the "wholly disproportionate" analysis.

It also is important to consider whether there are other potential gains from marginal organisms or age-1 equivalents beyond the commercial and recreational harvest. In particular, the economic literature refers to a category of "non-use benefits" that reflect potential gains not based upon "use gains" (commercial and recreational fishing) but rather to long-lived gains to the sustainability of important species. Thus, in addition to reporting results for fish harvest, we also consider whether there are significant "non-use" benefits that may not be captured by this measure.

There is an important caveat for all of the benefit metrics we use. As discussed in ASAAC (2013), biological analyses indicate that reducing I&E at IPEC would not increase fish populations or harvests. For purposes of these analyses, ASAAC has developed theoretical

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[15] Comment 316bEFR.402.008 by D. Sheehan, NYSDEC Commissioner: "As an alternative to quantifying losses due to entrainment by a tally of the total numbers of organisms entrained, without differentiating between eggs and larval stages, the Department suggests converting all the early life stages to Juvenile Equivalents. Estimates of natural mortality for early life stages of many species are available in scientific literature. This information would enable conversions of the numbers of eggs, yolk sac, and post yolk sac fishes to one consolidated number for each species which reflects life stage value." cited in Barnthouse et al. (2011), p. 15.

calculations of harvest impacts. Because of this important caveat, we refer to the estimates provided by ASAAC (2013) as "theoretical benefits."[16]

B. Impingement and Entrainment Implications of Cylindrical Wedgewire Screens and Cooling Towers

This section provides estimates of the biological implications of CWWS and Cooling Towers in terms of reductions in the number of organisms and age-1 equivalents. Table 11 shows annual organism losses (mortality) for the regulatory baseline and for various CWIS configurations. Under the Cooling Towers configuration (in which operation is divided between Cooling Towers and Ristroph screens to comply with air permit restrictions), annual I&E organism and age-1 equivalent losses are substantially greater than with CWWS and only slightly smaller than full operation of the current Ristroph screens.

Table 11. Annual Organism and Age-1 Equivalent Losses by Technology Type (Millions)

	Organisms	Age-1 Equivalents
Regulatory Baseline	1,286.4	3.94
Current Configuration	677.9	2.82
CWWS	248.6	0.25
Cooling Towers	618.5	2.70

Source: ASAAC (2013)

Table 12 shows cumulative organism and age-1 equivalent losses for the two metrics. Present values are calculated as of January 1, 2013 and include monthly losses through the end of 20-year renewed operating licenses for each unit,[17] i.e., September 2033 and December 2035 for units 2 and 3, respectively. We assume that operation of CWWS would begin in July 2024, and Cooling Towers would begin operating for both units in July 2026 (although, as noted previously, various technical experts do not support the Tetra Tech implementation schedule for Cooling Towers). The estimates assume that the plant would operate the current Ristroph screens during construction of the other technologies.

[16] To avoid awkward phrasing, in some parts of the report we do not "theoretical" in our description of benefit metrics but all the estimates are understood to be theoretical because of the biological assessments noted in the text.

[17] Note that we discount cumulative biological impacts in order to make them comparable with discounted costs.

Table 12. Cumulative Organism and Age-1 Equivalent Losses by Technology Type (Millions)

	Organisms	Age-1 Equivalents
Regulatory Baseline		
Discount Rate: 3%	20,844M	63.6M
Discount Rate: 7%	14,785M	45.0M
Current Configuration		
Discount Rate: 3%	10,970.2M	45.5M
Discount Rate: 7%	7,769.5M	32.1M
CWWS		
Discount Rate: 3%	8,194.2M	28.3M
Discount Rate: 7%	6,275.5M	22.9M
Cooling Towers		
Discount Rate: 3%	10,456.5M	44.7M
Discount Rate: 7%	7,486.5M	31.7M

Note: Losses are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

To estimate theoretical biological gains, we calculate the *reduction* in I&E losses associated with each CWIS relative to different baseline scenarios. Table 13 shows that there are substantial gains associated with the current configuration; the current configuration reduces organism losses by 47 percent relative to the regulatory baseline, and reduces age-1 equivalent losses by 29 percent relative to the regulatory baseline.

Table 13. Cumulative Organism and Age-1 Equivalent Gains of Current Configuration Relative to the Regulatory Baseline

Losses (Millions)	Organisms	Age-1 Equivalent
Present Value (r = 3%)		
Regulatory Baseline	20,843.6	63.64
Current Configuration	10,970.2	45.51
Difference (Saved)	9,873.3	18.13
% Difference (Saved)	47%	29%
Present Value (r = 7%)		
Regulatory Baseline	14,785.2	45.02
Current Configuration	7,769.5	32.14
Difference (Saved)	7,015.8	12.88
% Difference (Saved)	47%	29%

Note: Gains are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

Table 14 shows cumulative organism and age-1 equivalent impacts for the proposed CWWS and Cooling Towers relative to the current configuration.

Table 14. Cumulative Organism and Age-1 Equivalent Gains of CWWS and Cooling Towers Relative to the Current Configuration

Technology	Organisms	Age-1 Equivalent
CWWS		
Present Value (r = 3%)	2,776.0M	17.17M
Present Value (r = 7%)	1,494.0M	9.29M
Cooling Towers		
Present Value (r = 3%)	513.7M	0.84M
Present Value (r = 7%)	283.0M	0.45M

Note: Gains are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

C. Theoretical Biological Benefits of Cylindrical Wedgewire Screens and Cooling Towers

1. Theoretical Biological Benefits of the Current Configuration

Table 13 shows the theoretical cumulative gains in fish harvest associated with the current configuration. The current configuration leads to gains in harvested fish of about 63 percent relative to the regulatory baseline under both discount rate assumptions.

Table 15. Biological Benefits of the Current Configuration Relative to the Regulatory Baseline

Losses (Millions)	Fish Harvest
Present Value (r = 3%)	
Regulatory Baseline	1.447
Current Configuration	0.541
Difference (Saved)	0.906
% Difference (Saved)	63%
Present Value (r = 7%)	
Regulatory Baseline	1.026
Current Configuration	0.383
Difference (Saved)	0.643
% Difference (Saved)	63%

Note: Gains are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

2. Theoretical Biological Benefits of CWWS and Cooling Towers

Table 16 shows theoretical cumulative gains of fish harvests for the two potential technologies. The biological benefits, as measured by gains in harvested fish, are substantially smaller for Cooling Towers than for CWWS.

Table 16. Cumulative Gains Relative to the Current Configuration

Technology	Fish Harvest
CWWS	
Present Value (r = 3%)	0.192M
Present Value (r = 7%)	0.103M
Cooling Towers	
Present Value (r = 3%)	0.020M
Present Value (r = 7%)	0.011M

Note: Gains are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

V. "Wholly Disproportionate" Analyses for Cylindrical Wedgewire Screens and Cooling Towers

This chapter provides comparisons of the costs and biological effects of CWWS and Cooling Towers at IPEC in order to develop assessments of whether costs are "wholly disproportionate" to benefits. As noted in Chapter I, when evaluating policy alternatives—in this case, CWWS and Cooling Towers—it is important to compare *incremental* costs and *incremental* benefits. It is customary to develop comparisons in terms of increasing costs. Thus, we evaluate whether the costs are "wholly disproportionate" to the benefits for CWWS and Cooling Towers using the following comparisons:

1. Costs and benefits of CWWS incremental to the current configuration, and
2. Costs and benefits of Cooling Towers incremental to CWWS.

Section A presents results for CWWS, and Section B presents results for Cooling Towers. Sections C and D discuss the implications of various assumptions and other considerations for the major conclusions. Section E summarizes our conclusions regarding the "wholly disproportionate" test based upon the information in this chapter.

A. Evaluation of Cylindrical Wedgewire Screens

This section provides comparisons of the costs of CWWS with the three biological metrics described above. As noted in Chapter IV, we distinguish between the metrics that relate to the implications from I&E and the metric that relates to the benefits that individuals experience from additional harvest.

1. Comparisons of Costs and Impingement and Entrainment Implications

Table 17 compares the costs of CWWS with the two metrics reflecting I&E implications, changes in organisms and changes in age-1 equivalents. The cost per organism saved by CWWS is $0.06 at a 3 percent discount rate and $0.08 at a 7 percent discount rate. The cost per age-1 equivalent gain is $9.87 at a 3 percent discount rate and $13.34 at a 7 percent discount rate. As discussed in Chapter IV, it is difficult to interpret any direct comparison between organism or age-1 equivalent gains and costs. In the next section, we compare costs with the biological measure that is more directly related to benefits experienced by individuals.

Table 17. Costs and Biological Impacts of CWWS

CWWS	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Cost (Million 2012$)	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17
Cost / Benefits	$0.06	$9.87
Present Value (r = 7%)		
Cost (Million 2012$)	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29
Cost / Benefits	$0.08	$13.34

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

2. Comparison of Costs and Harvest Benefits

Table 18 summarizes the costs and additional harvest of CWWS relative to the current configuration. Results are presented separately for the two discount rates (3 percent and 7 percent). The costs and biological impacts of CWWS imply a cost of $885 per marginal fish harvest at a 3 percent discount rate or just under $1,200 per marginal fish harvest at a 7 percent discount rate.

It is important to put these costs in perspective by comparing them to indicators of the value that people attach to increased fish harvest. Fish are harvested either commercially or recreationally. Appendix C indicates that the 10-year average commercial price of striped bass—the most valuable of the species modeled for our analysis—is $6.15 per kilogram. Using the ASAAC (2013) estimate of the mean weight of harvested striped bass (about 3.31kg/fish), this 10-year commercial price is $20.39 per striped bass harvest. As discussed in Appendix D, we estimate the recreational value of striped bass to be $67 per fish harvested. Even if we assume that all marginal fish harvest is striped bass (the most valuable of the species modeled) and that all harvests are recreational (the higher-value use),[18] $67 in benefits per marginal fish harvest is a small fraction of the cost per marginal fish harvest resulting from CWWS.

18 If we were instead to use the 90 percent recreational and 10 percent commercial harvest split for striped bass developed in Appendix B, the average use value for marginal harvested striped bass would be about $62.19.

Table 18. Costs and Biological Benefits of CWWS

CWWS	Fish Harvest
Present Value (r = 3%)	
Cost (Million 2012$)	$169.5
Benefits (Millions)	0.192
Cost / Benefits	$884.94
Present Value (r = 7%)	
Cost (Million 2012$)	$123.8
Benefits (Millions)	0.103
Cost / Benefits	$1,198.56

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

B. Evaluation of Cooling Towers

This section provides information on the incremental costs and incremental biological effects of Cooling Towers compared to CWWS, the appropriate comparison for a "wholly disproportionate" test. We also provide information on costs and biological effects of Cooling Towers relative to the current configuration, although this information is not used for purposes of the "wholly disproportionate" test.

1. Calculation of Incremental Costs and Incremental Biological Metrics

We begin by using the information developed in the prior chapters to calculate the incremental costs and biological effects of Cooling Towers relative to CWWS. Table 19 shows the incremental costs of Cooling Towers relative to CWWS. Cooling Towers costs are about $887 billion or about $547 million higher than CWWS costs, depending on the discount rate.

Table 19. Incremental Costs of Cooling Towers Relative to CWWS

Technology	Cost (M2012$)
Present Value (r = 3%)	
CWWS	$169.5
Cooling Towers	$1,056.6
Difference	+$887.1
Present Value (r = 7%)	
CWWS	$123.8
Cooling Towers	$670.9
Difference	+$547.0

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

Table 20 shows the incremental organism and age-1 equivalent gains of Cooling Towers relative to CWWS. Cooling Towers provide substantially smaller cumulative organism and age-1 equivalent gains than CWWS.

Table 20. Incremental Biological Impacts of Cooling Towers Relative to CWWS

Technology	Organisms	Age-1 Equivalent
Present Value (r = 3%)		
CWWS	2,776.0M	17.17M
Cooling Towers	513.7M	0.84M
Difference	-2,262.3M	-16.33M
Present Value (r = 7%)		
CWWS	1,494.0M	9.29M
Cooling Towers	283.0M	0.45M
Difference	-1,211.0M	-8.84M

Note: Losses are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

Table 21 summarizes the theoretical incremental biological benefits of Cooling Towers, measured in reduced fish harvest. Harvest gains are substantially smaller for Cooling Towers than CWWS at both discount rates.

Table 21. Incremental Biological Benefits of Cooling Towers Relative to CWWS

Technology	Fish Harvest
Present Value (r = 3%)	
CWWS	0.192M
Cooling Towers	0.020M
Difference	-0.172M
Present Value (r = 7%)	
CWWS	0.103M
Cooling Towers	0.011M
Difference	-0.092M

Note: Losses are calculated as present values as of Jan 1, 2013.
Source: NERA calculations based on ASAAC (2013)

2. Comparison of Incremental Costs and Impingement and Entrainment Implications

Table 22 compares the incremental costs and gains in organisms and age-1 equivalents of Cooling Towers relative to CWWS. Cooling Towers have higher costs and lower organism and age-1 equivalent gains than CWWS. Following standard economic terminology, we refer to

Cooling Towers as "dominated" in this situation (see Boardman et al. 2011).[19] Dominance refers to a situation such as this, when an alternative has greater costs and lesser benefits.

Table 22. Incremental Costs and Biological Impacts of Cooling Towers

Cooling Towers	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Incremental Cost (Million 2012$)	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33
Cost / Benefits	Dominated	Dominated
Present Value (r = 7%)		
Incremental Cost (Million 2012$)	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84
Cost / Benefits	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

3. Comparison of Incremental Costs and Harvest Benefits

Table 23 shows the incremental costs and biological harvest benefits of Cooling Towers relative to CWWS. Because Cooling Towers yield *lower* harvest benefits at substantially *higher* costs than CWWS, we conclude that Cooling Towers are "dominated" by the CWWS. Assuming there are no offsetting considerations, a rational decision maker would not choose a dominated alternative, i.e., an alternative with lower benefits and higher costs.

Table 23. Incremental Costs and Biological Benefits of Cooling Towers

Cooling Towers	Fish Harvest
Present Value (r = 3%)	
Incremental Cost (Million 2012$)	$887.1
Incremental Benefits (Millions)	-0.172
Cost / Benefits	Dominated
Present Value (r = 7%)	
Incremental Cost (Million 2012$)	$547.0
Incremental Benefits (Millions)	-0.092
Cost / Benefits	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

[19] The economic term "dominant" or "dominate," most commonly used to describe strategies in game theory, conveys that a choice is superior to an alternative by every relevant criterion. Boardman et al. (2011, p. 469) explains its use in cost-benefit analysis: "One alternative can dominate another even if they have neither the same cost nor the same effectiveness, as long as it is superior on both dimensions. Clearly, dominated alternatives should not be selected."

4. Comparisons of Cooling Towers Relative to the Current Configuration

As noted above, incremental analysis of costs, biological impacts, and biological benefits is consistent with sound economic principles and New York State guidance on policy analysis (NY Governor's Office of Regulatory Reform 2008, p. 5). Under an incremental analysis, Cooling Towers are dominated by CWWS and therefore would not be selected by a rationale regulator. Nonetheless, for informational purposes only, in this Section we present analyses for Cooling Towers relative to the current configuration. Note again that these analyses do not reflect the *marginal* costs and benefits of Cooling Towers in comparison to CWWS, as necessary for a "wholly disproportionate" test.

a. Comparison of Costs and Impingement and Entrainment Implications

Table 24 compares the costs and impingement and entrainment implications of Cooling Towers relative to the current configuration at IPEC. The cost per organism saved is $2.06 at a 3 percent discount rate or $2.37 at a 7 percent discount rate. (By comparison, the cost per organism saved for CWWS relative to the current configuration is $0.06 at a 3 percent discount rate or $0.08 at a 7 percent discount rate.) The cost per age-1 equivalent saved is about $1,300 at a 3 percent discount rate or about $1,500 at a 7 percent discount rate. (By comparison, the cost per age-1 equivalent saved for CWWS relative to the current configuration is $9.87 at a 3 percent discount rate or $13.34 at a 7 percent discount rate.)

Table 24. Costs and Biological Impacts of Cooling Towers Relative to Current Configuration

Cooling Towers	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Cost (Million 2012$)	$1,056.6	$1,056.6
Benefits (Millions)	513.7	0.84
Cost / Benefits	$2.06	$1,265.19
Present Value (r = 7%)		
Cost (Million 2012$)	$670.9	$670.9
Benefits (Millions)	283.0	0.45
Cost / Benefits	$2.37	$1,489.73

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

b. Comparison of Costs and Harvest Benefits

Table 25 shows the costs and harvest benefits of Cooling Towers relative to the current configuration at IPEC. The cost per additional fish theoretically harvested is more than $50,000 at a 3 percent discount rate and more than $60,000 at a 7 percent discount rate. As noted above, the monetary value that individuals place on additional fish harvested recreationally is estimated to be approximately $67 per fish.

Table 25. Costs and Biological Benefits of Cooling Towers Relative to Current Configuration

Cooling Towers	Fish Harvest
Present Value (r = 3%)	
Cost (Million 2012$)	$1,056.6
Benefits (Millions)	0.020
Cost / Benefits	$52,957.25
Present Value (r = 7%)	
Cost (Million 2012$)	$670.9
Benefits (Millions)	0.011
Cost / Benefits	$61,632.45

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

C. Implications of Assumptions Regarding Benefits and Costs

This section assesses factors that might modify the conclusions reached above regarding the costs and biological effects of CWWS and Cooling Towers and the dominance of CWWS relative to Cooling Towers. In this section we consider assumptions regarding quantified costs and the biological benefits. The following section considers the potential significance of effects that were not quantified.

1. Assumptions Regarding Biological Benefits

The benefits analyses incorporate various assumptions that are likely to overstate the biological benefits as well as our estimates of the value that individuals would place on additional harvest. This section summarizes these conservative assumptions.

a. Empirical Evidence of No Measurable Harvest Impacts

As discussed in ASAAC (2013), empirical analyses of historical data for the Hudson River (including Barnthouse et al. 2008 and Barnthouse et al. 2010) indicate that reducing losses of eggs, larvae, and juvenile fish due to I&E at IPEC would not result in larger populations or harvests of adult fish. Thus, there may be no benefits for CWWS or Cooling Towers in terms of commercial or recreational harvests. As noted, our estimates of biological benefits are based upon theoretical calculations by ASAAC (2013).

b. Fishery Restrictions That Could Lower Commercial Fishing Benefits

New York and other states along the Atlantic coast have imposed various restrictions on commercial and recreational fishing of striped bass and other modeled species. ASAAC (2013) estimated changes in fishery harvests using standard fishing mortality parameters without accounting for these restrictions. Reducing the harvest impacts to account for the fishery restrictions could reduce the theoretical benefits of CWWS and Cooling Towers.

c. Attributing All Indirect Benefits to the Highest Value Fished Species (Striped Bass)

We have assumed that all additional forage fish and other forms of production forgone would be consumed by striped bass, a species with relatively high commercial and recreational values. Accounting for consumption by other species instead of striped bass would reduce the value attributable to additional harvest.

d. Valuing Non-Modeled Species at the Value of the Modeled Species

ASAAC (2013) includes data on I&E for species that are not modeled. That is, ASAAC does not develop estimates of the marginal harvest due to these "other species" since it does not have the information to do the calculations. The I&E data indicate that these other species represent an additional 5 percent of the I&E. We increase our estimates of benefits for both CWWS and Cooling Towers by 5 percent, which implies that these other species would translate into additional harvest with value equal to the modeled species. Since the modeled species were selected as "representative important species" (ASAAC 2013), these other species are likely to be less valuable than the modeled species; in this case, we would be overstating the benefits of non-modeled species.

e. No Lag between Reducing I&E and Harvesting Additional Adult Fish

The increases in fish harvests are assumed to begin immediately upon installation of CWWS and Cooling Towers. Incorporating a lag between installation of CWWS and Cooling Towers and increased harvests to reflect growth of eggs, larvae, and juvenile fish into harvestable adult fish would decrease the present value of theoretical benefits because benefits would occur farther in the future and be discounted accordingly. Our assumption of immediate harvest increases, then, likely leads us to overstate theoretical benefits.

2. Assumptions Regarding Costs

The quantified cost analyses include various assumptions regarding costs, all of which would tend to understate the costs. Some of the assumptions relate to both CWWS and Cooling Towers, while others relate only to one of the two technologies.

a. No Costs for Construction Design and Permitting

We have excluded costs related to construction design and planning for both technologies in order to provide comparable estimates for the two technologies. As noted in Chapter III, Tetra Tech (2013) does not provide costs for designing and permitting Cooling Towers. Thus, to avoid biasing the comparison of costs, design and permit costs are also not included for CWWS. This assumption understates the costs for both CWWS and Cooling Towers.

b. No Costs for Construction Contingencies

We also have excluded costs related to potential cost contingencies. As noted in Chapter III, ENERCON (2013a) does not provide information on possible contingencies (although a range of uncertainty underlying the capital cost estimate is included, as discussed in Chapter VI). Thus, to avoid biasing the comparison of costs, we have excluded contingency costs for Cooling Towers. This assumption understates the costs for both CWWS and Cooling Towers.

c. Not All Costs are Included for Possible Air Burst System for CWWS

As noted in Chapter III, the costs developed by ENERCON for the CWWS do not include certain components of an air-burst system that might be installed at a later date. After acquiring operating experience, it will be decided whether additional elements are required for satisfactory operation of the CWWS system (ENERCON 2013a). Thus, our estimate would understate the costs of CWWS if additional elements ultimately were required.

d. No O&M Costs for CWWS

As noted in Chapter III, ENERCON has not developed estimates of the possible O&M costs for CWWS. Thus, our cost estimate will underestimate the potential costs of CWWS. We do not expect such costs to be significant or to undermine our basic conclusions.

3. Summary

The factors above represent assumptions that have the potential to affect our estimates of quantified costs and biological benefits as well as assessments of the value that individuals place on additional harvest. This information on our assumptions suggests the following implications for our two principle conclusions:

1. *Conclusion is reinforced that costs are much greater than biological benefits for both CWWS and Cooling Towers.* Accounting for these factors would tend to reduce biological benefits and increase costs. Thus, our conclusion that costs are much greater than biological benefits for both CWWS and Cooling Towers is reinforced by consideration of these factors.

2. *Conclusion is robust that Cooling Towers dominated by CWWS.* The biological benefits factors would tend to have the same proportional effect for CWWS and Cooling Towers and thus would not affect their relative size substantially. The omitted cost components may be different for the two technologies, but given the large quantified cost difference, we would not expect any adjustments in the cost factors to affect the relative costs of the two technologies substantially. Thus, our conclusion regarding the dominance of CWWS over Cooling Towers is robust with respect to these omitted factors.

D. Implications of Non-quantified Costs and Benefits

This section considers the effects of factors that are not included in the quantified harvest benefits or in the dollar values developed for recreational and commercial benefits.

1. Non-market Direct Use Benefits

EPA (2011) describes potential non-market direct use benefits as an "increase in recreational fishing participation." This benefit category relates to the potential increase in the number of people who would fish recreationally as a result of the reductions in I&E due to CWWS or Cooling Towers. We do not have data to develop such estimates but we expect them to be small because of the small effects of reduced I&E on overall harvest/catch rates of striped bass, the species accounting for the vast majority of gains. Thus, we conclude that this benefit category is not likely to be significant.

a. Indirect Use Benefits

Indirect use benefits include the contribution of food chain effects (i.e., forage) to commercial and recreational fishing benefits. EPA (2011, p. 4-3) lists other potential indirect benefit categories and organizes them into market goods and non-market goods. Appendix F provides an analysis of the nature of these potential benefit categories and assessments for each category. We conclude that apart from forage fish effects, no potential indirect use benefit from CWWS or Cooling Towers is likely to be significant.

b. Non-use Benefits

Appendix E provides our assessment of potential non-use benefits from CWWS and Cooling Towers at IPEC. We conclude that any potential non-use benefits are not likely to be significant based upon the criteria for significance that have been developed in the economic literature.

2. Qualitative Assessments of Non-quantified Costs

As noted in Chapter III, our estimate of social costs will focus on compliance costs, which include the costs of construction and operation of CWWS and Cooling Towers at IPEC. There are, however, other potential categories of social costs beyond compliance costs. The following are summaries of certain potential additional categories of costs of CWWS and Cooling Towers at IPEC (EPA 2010, p. 8-9):

a. Government regulatory costs

Government regulatory costs are those borne by various government entities in the course of researching, enacting, and enforcing a policy or regulation. These would include costs incurred by state and federal regulators to establish and enforce regulations for fish protection at IPEC.

b. Distributional costs

In general, benefit-cost analysis focuses on total net benefits instead of any individual "winners" or "losers." Distributional costs are those that relate to how certain entities or societal groups are impacted by the imposition of a regulation. For example, changes in electricity prices are generally assumed to have the largest impact on the poor, because electricity costs represent a larger portion of their total household expenditures.

c. Transaction costs

Transactions costs are those incurred in making an economic exchange beyond the cost of production of a good or service. They may include the costs of searching out sellers, bargaining, and enforcing contracts for any additional required purchases.

d. Transitional costs

Transitional costs are any short-term costs incurred during the adjustment to a new market equilibrium. These costs may include the costs of training workers in the use of new pollution control equipment.

3. Summary and Implications of Non-quantified Costs and Benefits

We conclude that the additional benefits and cost categories discussed above—which are not quantified—are not likely to be significant. As a result, none of the non-quantified cost and benefit categories, individually or collectively, is likely to significantly affect the comparisons of benefits and costs of CWWS or Cooling Towers at IPEC. Thus, our two principal conclusions—that costs are "wholly disproportionate" to benefits for both technologies and that Cooling Towers are dominated by CWWS—are robust with respect to omitted costs and benefits.

E. Summary

This chapter has provided information to assess whether the costs of CWWS and Cooling Towers are "wholly disproportionate" to the benefits. The following is a summary of the results and our conclusions.

Our analysis shows that CWWS have costs and harvest benefits that would equate to a cost of about $885, or $1,199 per marginal fish harvest, at 3 and 7 percent discount rates, respectively. These values are many times the values that individuals place on marginal commercial and recreational harvest. The analyses show that the costs of Cooling Towers are substantially greater than the costs of CWWS. In contrast, CWWS results in substantially greater harvest gains than Cooling Towers.

Based on these results, we conclude the following:

- Costs are "wholly disproportionate" to benefits for both CWWS and Cooling Towers, although we understand Energy has communicated its commitment to CWWS despite this conclusion.
- Cooling Towers are dominated by CWWS

These results are robust with respect to the assumptions regarding the quantified costs and benefits as well as to non-quantified costs and benefits.

VI. Uncertainty Analyses

The benefit and cost results presented thus far can be thought of as our "base-case" results. The estimates of the individual components of costs and biological benefits are based on sound methods applied by experts in the relevant fields using technical information, analysis of biological sampling data, reasonable assumptions, and best professional judgment. Aside from the assumptions that we have noted are likely to cause costs or benefits to be overstated or understated, the base-case estimates and assumptions represent "best" estimates.

In this chapter, we further examine the robustness of our basic conclusions by accounting for the fact that some of the components of the benefit and cost estimates are subject to some degree of uncertainty. We address those uncertainties systematically to identify the magnitudes of the potential uncertainties in our estimates. We begin by discussing the role of uncertainty analysis. We then present results from several sensitivity analyses. Sensitivity analyses provide strong support for our conclusions that the costs of CWWS and Cooling Towers are "wholly disproportionate" to their benefits and that the Cooling Towers alternative has higher costs and lower benefits than the CWWS alternative.

A. Background on Uncertainty Analysis

Economists and policy analysts have long recognized that analyses of costs and benefits, no matter how careful and thorough, inevitably are subject to some degree of uncertainty. A robust cost-benefit analysis will include either a discussion of the major uncertainties or a formal quantitative analysis of uncertainty.

Sensitivity analysis is one of the most widely used approaches to considering uncertainty in a quantitative manner. Sensitivity analyses help to determine which uncertainties are most critical and whether plausible changes in the parameter values and assumptions could change the conclusions reached using base-case assumptions.

1. Guidelines on the Treatment of Uncertainty in Benefit-Cost Analysis

Guidelines on benefit-cost analysis from EPA, OMB, and New York State address the importance of uncertainty analysis and the conditions under which quantitative uncertainty analysis should be undertaken. These guidelines are primarily focused on the analysis of new rules; however, for site-specific regulatory decisions and analysis such as BTA determinations, it is fitting to apply the same principles used in broader rulemakings.

a. New York State

New York State guidelines for benefit-cost assessments issued by the Governor's Office of Regulatory Reform also instruct analysts to consider uncertainty. The guidelines state, "The presentation must also include enough discussion of the limitations, uncertainties and sensitivities of each part of the analysis to permit others to assess the results of the analysis (e.g.,

… if certain factual estimates, if off by a slight percentage, would drastically alter the conclusions reached)" (NY Governor's Office of Regulatory Reform 2008, p. 17).

b. EPA Guidelines

EPA's *Guidelines* states that "[E]very analysis should address uncertainties resulting from the choices the analyst has made" (EPA 2010, p. 11-11). EPA stresses the importance of assessing and describing uncertainty in economic analyses and notes that the impact of using alternative assumptions or alternative models can be assessed quantitatively. EPA notes that sensitivity analyses can be useful to assess how a model's output changes as one of its input parameters change (EPA 2010, p. 11-11).

EPA's *Guidelines* also recognize that consideration of all possible uncertainties is not possible or even desirable. As a result, uncertainty analyses should focus on the most critical uncertainties, those most likely to make a material difference to decision makers:

> Because performing an alternative analysis on all the assumptions in an analysis is prohibitively resource intensive, the analyst should focus on the assumptions that have the largest impact on the final results of the particular analysis (EPA 2010, p. 11-11).

c. OMB Guidelines

In its most recent guidance for regulatory agencies, OMB stresses that important uncertainties connected with regulatory decisions need to be analyzed and presented as part of an overall regulatory analysis (OMB 2003).

OMB provides specific guidance on when a quantitative analysis of uncertainty is appropriate. For "major rules" involving "annual economic effects" of $1 billion or more, a formal uncertainty analysis is required. OMB also recommends a rigorous approach to uncertainty in regulations for which "net benefits are close to zero" (OMB 2003).

In other situations (when economic effects are less than $1 billion and net benefits are not close to zero), OMB suggests the following:

> Disclose qualitatively the main uncertainties in each important input to the calculation of benefits and costs. These disclosures should address the uncertainties in the data as well as in the analytical results (OMB 2003).

2. Sensitivity Analysis

Sensitivity analyses help to determine which uncertainties are most critical and whether plausible changes in the parameter values and assumptions could change the overall results and conclusions—in this case, whether CWWS and Cooling Towers at IPEC have costs that are "wholly disproportionate" to their benefits. "The purpose of sensitivity analysis is to acknowledge underlying uncertainty. In particular, it should convey how sensitive predicted net benefits are to changes in assumptions. If the sign of net benefits does not change when we consider the range of reasonable assumptions, then our results are robust and we can have greater confidence in them" (Boardman et al. 2011, p. 177).

Sensitivity analysis involves varying key input parameters, both one at a time and in combination, over appropriate ranges to determine their effects on net costs (Boardman et al. 2011). Such analyses are often more appropriately termed "partial" sensitivity analysis. "Partial sensitivity is most appropriately applied to what the analyst believes to be the most important and uncertain assumptions" (Boardman et al. 2011, p. 178).

One of the advantages of using sensitivity analysis is its computational ease. It is relatively easy to modify the values of key inputs to see how they affect the results. For each parameter considered, typically "low" and "high" values are tested in addition to the base-case value.

B. Sensitivity Analyses of Costs and Biological Outcomes of Cylindrical Wedgewire Screens and Cooling Tower Alternatives

We identified five different parameters that could have significant impacts on costs and biological outcomes and that are subject to some degree of uncertainty. We group them as follows.

- Two parameters only affecting cost estimates:
    - construction costs; and
    - wholesale electricity prices.
- One parameter only affecting biological outcomes:
    - biological effectiveness of the CWWS alternative.
- Two parameters affecting implementation schedules, which affect both costs and biological outcomes:
    - Cooling Towers permitting and construction schedule; and
    - Cooling Towers construction outage length (assuming concurrent operation of IPEC with blasting).

3. Parameters Affecting Estimated Costs

a. Construction Costs

Construction cost estimates for projects expected to be undertaken at some point in the future are always uncertain. ENERCON (2013a) provides an expected accuracy range for their CWWS construction cost estimates of -10% / +20%. We apply this range to the base-case CWWS construction costs to find "low" and "high" case construction cost values. Tetra Tech (2013) does not provide a range for their Cooling Tower construction cost estimates, although it did include an additional 25% amount for contingencies, which, as discussed above, we did not include in our cost estimates. We do not have any information on the relative magnitudes of the uncertainty between the construction costs for the two alternatives, so we apply the same -10% / +20% range to the construction costs for the Cooling Towers alterative, even though the costs of more conceptual Cooling Tower design may be expected to be more uncertain than those for the CWWS.

Table 26. Costs and Biological Outcomes of CWWS with Alternative Construction Costs

	Implications for I&E Mortality		**Biological Benefits**
CWWS	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Cost (Million 2012$)	$169.5	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17	0.192
Cost / Benefits	$0.06	$9.87	$884.94
Present Value (r = 7%)			
Cost (Million 2012$)	$123.8	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29	0.103
Cost / Benefits	$0.08	$13.34	$1,198.56
Low Construction Costs			
Present Value (r = 3%)			
Cost (Million 2012$)	$152.1	$152.1	$152.1
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.05	$8.86	$794.13
Present Value (r = 7%)			
Cost (Million 2012$)	$111.2	$111.2	$111.2
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.07	$11.98	$1,076.41
High Construction Costs			
Present Value (r = 3%)			
Cost (Million 2012$)	$204.3	$204.3	$204.3
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.07	$11.90	$1,066.55
Present Value (r = 7%)			
Cost (Million 2012$)	$149.1	$149.1	$149.1
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.10	$16.05	$1,442.87

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.
Source: NERA calculations as explained in text

As shown in Table 26, the "high" estimates of construction costs increase the present value of costs by about $35 million for CWWS at a 3 percent discount rate. Conversely, the "low" estimate of construction costs reduces the present value of costs by about $17 million for CWWS. In the "low" cost case, which is most favorable to CWWS, the cost per marginal fish harvest is still about $794 at a 3 percent discount rate—still far greater than the $67 estimated benefit of recreational striped bass harvest discussed in Appendix D.

Table 27. Incremental Costs and Biological Outcomes of Cooling Towers with Alternative Construction Costs

	Implications for I&E Mortality		**Biological Benefits**
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
Low Construction Costs			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$845.0	$845.0	$845.0
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$520.3	$520.3	$520.3
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
High Construction Costs			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$971.4	$971.4	$971.4
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$600.5	$600.5	$600.5
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.
Source: NERA calculations as explained in text

Table 27 presents incremental costs and biological outcomes for Cooling Towers under alternative construction cost assumptions. Even in the "low" cost case, Cooling Towers are still more costly than CWWS (and therefore have positive incremental costs). These sensitivity cases do not affect biological outcomes, so Cooling Towers continue to have lower biological gains than CWWS in each case.

b. Wholesale Electricity Prices

Both CWWS and Cooling Towers lead to changes in IPEC electricity generation. As discussed in Chapter III, there are three sources of potential electricity generation losses: construction outages, efficiency losses, and parasitic losses. We estimate the costs of these changes by multiplying the changes by forecasted wholesale electricity prices. As a result, electricity price forecasts affect power replacement costs; lower-than-forecasted electricity prices would decrease the cost of replacement power, and higher electricity prices would have the opposite effect.

Electricity prices have historically been volatile and forecasts involve a number of modeling assumptions and are thus subject to some uncertainty. To quantify the impact of different electricity prices, we performed sensitivity analyses with higher and lower electricity prices than those used in the base-case analysis, which are based on the "Reference Case" price forecast for New York City and Westchester County developed by the Energy Information Administration (EIA) of the Department of Energy in its Annual Energy Outlook 2013 (EIA 2013). For our "high" price sensitivity case, we use prices 40% higher than the EIA (2013) Reference Case prices in each forecast year; for the "low" price sensitivity case, we similarly use prices 40% lower than the EIA (2013) Reference Case.[20]

[20] This sensitivity range is close to the maximum range of comparable electricity prices in two EIA (2013) side case projections – the Low and High Oil and Gas Resource cases. These side cases primarily reflect uncertainty in the supply of natural gas, which is a key determinant of future electricity prices.

Table 28. Costs and Biological Outcomes of CWWS with Alternative Wholesale Electricity Prices

	Implications for I&E Mortality		Biological Benefits
CWWS	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Cost (Million 2012$)	$169.5	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17	0.192
Cost / Benefits	$0.06	$9.87	$884.94
Present Value (r = 7%)			
Cost (Million 2012$)	$123.8	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29	0.103
Cost / Benefits	$0.08	$13.34	$1,198.56
Low Wholesale Electricity Prices			
Present Value (r = 3%)			
Cost (Million 2012$)	$171.3	$171.3	$171.3
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.06	$9.97	$894.19
Present Value (r = 7%)			
Cost (Million 2012$)	$124.8	$124.8	$124.8
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.08	$13.44	$1,207.75
High Wholesale Electricity Prices			
Present Value (r = 3%)			
Cost (Million 2012$)	$167.7	$167.7	$167.7
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.06	$9.77	$875.69
Present Value (r = 7%)			
Cost (Million 2012$)	$122.9	$122.9	$122.9
Benefits (Millions)	Base	Base	Base
Cost / Benefits	$0.08	$13.23	$1,189.37

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case. Changes in electricity prices have opposite cost impacts on CWWS and Cooling Towers because CWWS causes a net increase in electricity generation at IPEC while Cooling Towers causes construction outages and a net loss in ongoing generation.

Source: NERA calculations as explained in text

Table 28 presents the results for CWWS. Lower (higher) electricity prices cause the total costs of CWWS to increase (decrease) by about $1.8 million at a 3 percent discount rate. Costs increase when electricity prices decrease because the use of CWWS results in a net *increase* in electricity output at IPEC; this net increase is actually a benefit valued at the wholesale price of electricity. Even in the most favorable case with "high" electricity prices, the cost per fish falls only slightly to about $876 at a 3 percent discount rate.

Table 29. Incremental Costs and Biological Outcomes of Cooling Towers with Alternative Wholesale Electricity Prices

	Implications for I&E Mortality		**Biological Benefits**
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
Low Wholesale Electricity Prices			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$662.5	$662.5	$662.5
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$412.0	$412.0	$412.0
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
High Wholesale Electricity Prices			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$1,111.7	$1,111.7	$1,111.7
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$682.1	$682.1	$682.1
Incremental Benefits (Millions)	Base	Base	Base
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case. Changes in electricity prices have opposite cost impacts on CWWS and Cooling Towers because CWWS causes a net increase in electricity generation at IPEC while Cooling Towers causes construction outages and a net loss in ongoing generation.

Source: NERA calculations as explained in text

Incremental costs for Cooling Towers move in the opposite direction of CWWS costs, since the installation of Cooling Towers requires a construction outage and ongoing generation losses at IPEC. Table 29 shows that the sizes of the changes in costs are also much larger for Cooling Towers; incremental costs decrease by about $225 million in the "low" electricity price case and increase by the same amount in the "high" electricity price case at a 3 percent discount rate. In each sensitivity case, incremental costs continue to be considerably higher for Cooling Towers than for CWWS.

These sensitivity analyses do not change either of our main conclusions—that both CWIS have costs that are "wholly disproportionate" to their benefits and that Cooling Towers are dominated by CWWS.

4. Parameters Affecting Estimated Benefits

a. Efficacy of CWWS

Our base-case benefits estimates are based on theoretical fishery harvest impacts developed by ASA Analysis & Communication (ASAAC 2013). The fishery impact estimates for CWWS are subject to some uncertainty, and ASAAC provided an upper and lower bound on the fishery impacts in ASAAC (2013) to reflect that uncertainty. We use these two bounds on CWWS efficacy as "low" and "high" sensitivity cases.

Table 30. Costs and Biological Outcomes of CWWS with Alternative CWWS Efficacy

	Implications for I&E Mortality		Biological Benefits
CWWS	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Cost (Million 2012$)	$169.5	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17	0.192
Cost / Benefits	$0.06	$9.87	$884.94
Present Value (r = 7%)			
Cost (Million 2012$)	$123.8	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29	0.103
Cost / Benefits	$0.08	$13.34	$1,198.56
Low CWWS Efficacy			
Present Value (r = 3%)			
Cost (Million 2012$)	Base	Base	Base
Benefits (Millions)	2,442.4	16.60	0.179
Cost / Benefits	$0.07	$10.21	$946.62
Present Value (r = 7%)			
Cost (Million 2012$)	Base	Base	Base
Benefits (Millions)	1,314.8	8.98	0.097
Cost / Benefits	$0.09	$13.79	$1,281.25
High CWWS Efficacy			
Present Value (r = 3%)			
Cost (Million 2012$)	Base	Base	Base
Benefits (Millions)	3,468.5	17.63	0.196
Cost / Benefits	$0.05	$9.61	$864.47
Present Value (r = 7%)			
Cost (Million 2012$)	Base	Base	Base
Benefits (Millions)	1,865.9	9.54	0.106
Cost / Benefits	$0.07	$12.99	$1,171.10

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

Table 30 shows CWWS costs and biological benefits for the "low" and "high" efficacy cases. Even in the "high" efficacy case (which is most favorable to CWWS), the cost per fish harvested is about $864 at a 3 percent discount rate—over ten times greater than the $67 recreational value of striped bass harvest discussed in Appendix D.

Table 31. Incremental Costs and Biological Outcomes of Cooling Towers with Alternative CWWS Efficacy

	Implications for I&E Mortality		Biological Benefits
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
Low CWWS Efficacy			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	Base	Base	Base
Incremental Benefits (Millions)	-1,928.7	-15.77	-0.159
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	Base	Base	Base
Incremental Benefits (Millions)	-1,031.8	-8.53	-0.086
Cost / Benefits	Dominated	Dominated	Dominated
High CWWS Efficacy			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	Base	Base	Base
Incremental Benefits (Millions)	-2,954.8	-16.80	-0.176
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	Base	Base	Base
Incremental Benefits (Millions)	-1,582.9	-9.09	-0.095
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

Table 31 shows that biological benefits of CWWS continue to exceed biological benefits of Cooling Towers even in the "low" CWWS efficacy case.

These sensitivity analyses support our conclusions that costs of CWWS and Cooling Towers are "wholly disproportionate" to the benefits, and that Cooling Towers are dominated by CWWS.

5. Sensitivity Analyses Affecting Implementation Schedules (Costs and Benefits)

a. Cooling Towers Permitting and Construction Schedule

In our base case, we assume an eight-year implementation period for Cooling Towers—the midpoint of seven- to nine-year implementation schedule estimated in Tetra Tech (2013). However, there is considerable uncertainty about the actual schedule for Cooling Tower implementation at IPEC.

To test the sensitivity of our results to alternative schedule assumptions on the Cooling Towers construction schedule, we define "short" and "long" implementation schedules. For the "short" schedule, we reduce the construction period by one year to make the total implementation period seven years—the low end of Tetra Tech's estimated range for the full project; under this schedule, Cooling Towers would begin operating in July 2025 (just one year after the start of CWWS operation). If there is no overlap of permitting, final design, and construction periods, Tetra Tech's (2013) timing estimates sum to as long as twelve years.[21] We use this as our "long" schedule, though ENERCON (2010a) and Young/Sommer (2013) estimates both imply even longer implementation periods.[22] In this sensitivity, Cooling Towers would begin operation in July 2030.

In each sensitivity case, we assume the total costs for each phase of implementation remain unchanged; however, because the timing of phases changes, the present value of those costs is affected. For example, the "short" schedule results in higher cumulative present value costs for Cooling Towers because some construction costs are incurred earlier than in the base case.

[21] The following are commentaries on the timing of individual stages for Cooling Towers in Tetra Tech (2013). "It is not unreasonable to assume the permitting effort alone would take 3 to 5 years, while the final design effort required to produce construction-level plans and drawings could easily lag behind final approval by 1 year or more." (p. 27). "Construction could occur over a period of approximately 4-6 years." (p. 77).

[22] Young/Sommer (2013) estimate a minimum local permitting period of 7.1 years and an expected local permitting period of 13.8 years, both beginning after BTA identification and issuance of SEIS; the maximum permitting estimate in Tetra Tech (2013) is 5 years. ENERCON (2010a, p. v) estimates a total implementation period of almost 13 years.

Table 32. Incremental Costs and Biological Outcomes of Cooling Towers with Alternative Permitting and Construction Schedules

	Implications for I&E Mortality		Biological Benefits
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
Short Permitting and Construction Period			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$969.2	$969.2	$969.2
Incremental Benefits (Millions)	-2,215.3	-16.25	-0.170
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$616.2	$616.2	$616.2
Incremental Benefits (Millions)	-1,177.2	-8.78	-0.091
Cost / Benefits	Dominated	Dominated	Dominated
Long Permitting and Construction Period			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$841.1	$841.1	$841.1
Incremental Benefits (Millions)	-2,437.0	-16.66	-0.179
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$432.8	$432.8	$432.8
Incremental Benefits (Millions)	-1,325.5	-9.04	-0.097
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

Table 32 shows that Cooling Towers have higher incremental costs and fewer incremental organism and fish harvest losses under a seven-year permitting and construction period (the "short" case), and the opposite occurs in the "long" case. Cooling Towers continue to be dominated by CWWS in both cases.

b. Cooling Tower Construction Outage Length

Assuming concurrent IPEC operation and blasting is possible, Tetra Tech (2013) estimates that Cooling Tower tie-in would require 35 weeks of shutdown of both units at the end of the construction period, less 5 weeks for a concurrent scheduled maintenance outage for Unit 2. These outage estimates are used in our base case estimates. ENERCON (2010b), however, estimates a construction outage period of 42 weeks for both units, less 4 weeks for a scheduled outage for Unit 2 (ENERCON 2010b, p. 46); these estimates also assume the continued operation of both units during blasting (ENERCON 2010b, p.25). Table 33 shows the sensitivity of our cost and benefits estimates to ENERCON's (2010b) estimates of the Cooling Tower construction outage lengths. For the purpose of this analysis, we assume the construction costs and the length of the design and construction period remain the same.

Table 33. Incremental Costs and Biological Outcomes of Cooling Towers with Alternative Construction Outage Length

	Implications for I&E Mortality		**Biological Benefits**
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case -- Tetra Tech (2013) Cooling Tower Outage			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
ENERCON (2010b) Cooling Tower Outage Length			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$989.2	$989.2	$989.2
Incremental Benefits (Millions)	-2,249.5	-16.09	-0.169
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$609.9	$609.9	$609.9
Incremental Benefits (Millions)	-1,203.1	-8.69	-0.091
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

Table 33 shows that the longer construction outage period estimated by ENERCON (2010b) leads to an increase in Cooling Tower incremental costs of about $102 million at a 3 percent discount rate and about $63 million at a 7 percent discount rate. Table 33 also continues to show negative incremental benefits in the sensitivity case with a longer Cooling Tower construction outage; Cooling Towers continue to have lower benefits than CWWS. (Note that Cooling Tower benefits are slightly larger for the sensitivity case because there would be no fish losses during the additional weeks IPEC is assumed not to operate during the construction outage.)

These results reinforce our conclusions that Cooling Tower costs are "wholly disproportionate" to benefits and that Cooling Towers are dominated by CWWS.

6. Sensitivity Analyses Changing Multiple Parameters

Thus far, our sensitivity analyses have varied only one parameter at a time. In reality, of course, multiple parameters may differ from their base-case values simultaneously. Here we provide upper and lower bounds by combining all of the values favorable to CWWS or Cooling Towers or all of those unfavorable to them. Table 34 summarizes the parameters varied and the assumptions used in the Base case, the All-Favorable case, and the All-Unfavorable case.

Note that these two extreme cases are highly unlikely because they assume that all of the uncertainties are resolved in the same way, either in a manner favorable to CWWS and Cooling Towers or in a manner unfavorable to them. As one well-known text on benefit-cost analysis notes:

> ...if we believe that values near the base-case assumptions are more likely to occur than values near the extremes of their plausible ranges, then the worst and best cases are highly unlikely to occur because they require the joint occurrence of a large number of independent low-probability events. (Boardman et al. 2011, p. 184)

Table 34. Summary of Parameters in Extreme Sensitivity Analysis

	Base Value	All-Favorable Case	All-Unfavorable Case	Source
Cost Parameters				
Construction Costs				
CWWS	$173.9 million (3% D.R.)	-10%	+20%	ENERCON (2013a)
Cooling Towers	$595.2 million (3% D.R.)	-10%	+20%	NERA assumption
Electricity Prices	EIA Reference Case	-40%*	+40%*	AEO (2013) NYISO (2013)
Benefit Parameters				
CWWS Fish Protection Efficacy	Base Efficacy	High Efficacy†	Low Efficacy†	ASAAC (2013)
Schedule Parameters				
Permitting and Construction Schedule	8 years	7 years^	12 years^	Tetra Tech (2013)
Construction Outage Length	Tetra Tech (2013)	Tetra Tech (2013)	ENERCON (2010b)	Tetra Tech (2013) ENERCON (2010b)

*Electricity prices affect CWWS and Cooling Tower costs differently. In the All Favorable case, we use assumptions favoring Cooling Towers.
†High CWWS efficacy results in lower *incremental* benefits for Cooling Towers (and vice versa for low CWWS efficacy). It is included in the All-Favorable case because it increases CWWS benefits and does not affect non-incremental Cooling Tower benefits.
^The short schedule case increases present value costs relative to the base case because of discounting. We use the short schedule in the All-Favorable case because it increases cumulative benefits.
Source: See rightmost column of table.

Table 35 summarizes the CWWS costs and biological benefits from the two extreme sensitivity analyses. When all of the parameters are chosen to be favorable to CWWS and Cooling Towers (the "All-Favorable" case), biological benefits rise and costs fall, resulting in costs per fish harvest that are substantially smaller than in the base case. However, even in this extreme case, the cost per fish harvest using a 3 percent discount rate is about $785—much greater than the $67 recreational value of striped bass harvest discussed in Appendix D.

Table 35. Costs and Biological Outcomes of CWWS with All Favorable Assumptions and All Unfavorable Assumptions

	Implications for I&E Mortality		Biological Benefits
CWWS	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Cost (Million 2012$)	$169.5	$169.5	$169.5
Benefits (Millions)	2,776.0	17.17	0.192
Cost / Benefits	$0.06	$9.87	$884.94
Present Value (r = 7%)			
Cost (Million 2012$)	$123.8	$123.8	$123.8
Benefits (Millions)	1,494.0	9.29	0.103
Cost / Benefits	$0.08	$13.34	$1,198.56
All-Favorable			
Present Value (r = 3%)			
Cost (Million 2012$)	$153.9	$153.9	$153.9
Benefits (Millions)	3,468.5	17.63	0.196
Cost / Benefits	$0.04	$8.73	$784.80
Present Value (r = 7%)			
Cost (Million 2012$)	$112.2	$112.2	$112.2
Benefits (Millions)	1,865.9	9.54	0.106
Cost / Benefits	$0.06	$11.76	$1,060.72
All-Unfavorable			
Present Value (r = 3%)			
Cost (Million 2012$)	$202.5	$202.5	$202.5
Benefits (Millions)	2,442.4	16.60	0.179
Cost / Benefits	$0.08	$12.20	$1,131.00
Present Value (r = 7%)			
Cost (Million 2012$)	$148.1	$148.1	$148.1
Benefits (Millions)	1,314.8	8.98	0.097
Cost / Benefits	$0.11	$16.49	$1,532.59

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

Table 36 shows that Cooling Towers continue to have higher costs and lower benefits than CWWS in each of the "extreme" sensitivity cases.

Table 36. Incremental Costs and Biological Outcomes of Cooling Towers with All Favorable Assumptions and All Unfavorable Assumptions

	Implications for I&E Mortality		Biological Benefits
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$887.1	$887.1	$887.1
Incremental Benefits (Millions)	-2,262.3	-16.33	-0.172
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$547.0	$547.0	$547.0
Incremental Benefits (Millions)	-1,211.0	-8.84	-0.092
Cost / Benefits	Dominated	Dominated	Dominated
All-Favorable			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$671.1	$671.1	$671.1
Incremental Benefits (Millions)	-2,907.8	-16.71	-0.174
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$429.0	$429.0	$429.0
Incremental Benefits (Millions)	-1,549.1	-9.03	-0.094
Cost / Benefits	Dominated	Dominated	Dominated
All-Unfavorable			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$1,291.8	$1,291.8	$1,291.8
Incremental Benefits (Millions)	-2,092.0	-15.88	-0.164
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$667.5	$667.5	$667.5
Incremental Benefits (Millions)	-1,140.3	-8.62	-0.089
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

C. Summary

This chapter has provided sensitivity cases related to construction costs, electricity prices, CWWS fishery protection efficacy, Cooling Tower permitting and construction schedules, and Cooling Tower outage period lengths. These results show that even with extreme assumptions in favor of CWWS and Cooling Towers, neither alternative would pass a "wholly disproportionate" test. Sensitivity analyses reinforce, even under extreme assumptions, the main conclusions reached in Chapter V using the base-case assumptions:

Both CWWS and Cooling Towers have costs that are "wholly disproportionate" to their benefits, although we understand Energy has communicated its commitment to CWWS despite this conclusion.

Cooling Towers have greater costs and lower harvest benefits than CWWS (so that Cooling Towers are dominated by CWWS).

VII. Conclusions Regarding Whether Costs are "Wholly Disproportionate" to Benefits for Cylindrical Wedgewire Screens and Cooling Towers

The following are our conclusions regarding CWWS and Cooling Towers.

A. Cylindrical Wedgewire Screens

The analyses provided in this report indicate that the CWWS alternative has costs that are "wholly disproportionate" to the benefits. This conclusion is robust with respect to assumptions on quantified costs and benefits, cost and benefit categories that are not quantified, and uncertainties in the costs and benefits. We understand, however, that Entergy has communicated its commitment to CWWS regardless of whether the cost is "wholly disproportionate" to the benefits.

B. Cooling Towers

The analyses provided in this report indicate that the Cooling Towers alternative has costs that are "wholly disproportionate" to the benefits and that Cooling Towers are "dominated" by CWWS because they involve substantially greater costs and smaller biological benefits. These conclusions are robust with respect to assumptions on quantified costs and benefits, cost and benefit categories that are not quantified, uncertainties in costs and benefits, and air permit considerations.

References

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center.* December.

Atlantic States Marine Fisheries Commission (ASMFC). 2011. *Atlantic Marine Fisheries Commission Striped Bass Stock Assessment Update.* May.

Barnthouse, Lawrence W., Douglas G. Heimbuch, Mark Mattson, and John Young. 2011. "Response to Biological Aspects of NYSDEC 401 Certification Letter,

Barnthouse, Lawrence W., Douglas G. Heimbuch, Mark Mattson, and John Young. 2010. *Attachment 6: Evaluation Biological Effectiveness of Alternative Intake Technologies for Indian Point Units 2 and 3.* February.

Barnthouse, Lawrence W., Douglas G. Heimbuch, Webster Van Winkle, and John Young. 2008. *Entrainment and Impingement at IP2 and IP3: A Biological Impact Assessment.* January.

Boardman, A., D. Greenberg, A. Vining, and D. Weimer. 2011. *Cost-Benefit Analysis: Concepts and Practice*, 4th Edition. Prentice-Hall.

ENERCON Services, Inc. 2010a. *Analysis of Closed-Loop Cooling Salinity Levels: Indian Point Units 2 & 3.* November 2010.

ENERCON Services, Inc. 2010b. *Engineering Feasibility and Costs of Conversion of Indian Point Units 2 and 3 to a Closed-Loop Condenser Cooling Water Configuration.* February 12, 2010.

ENERCON Services, Inc. 2013a. *Construction Estimate and Power Assessment for Entergy's Proposed Implementation Scenario for the CWWS Intake System.* December 2013.

ENERCON Services, Inc. 2013b. *ENERCON Response to Tetra Tech's Indian Point Closed-Cycle Cooling System Retrofit Evaluation Report.* Prepared for Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC. December 2013.

Entergy Corporation. 2013a. Reduction in O&M Costs of Ristroph Screens. Electronic communication with Charlie Caputo of Entergy. January 3, 2013.

Entergy Corporation. 2013b. Reduction in Electricity Usage of Ristroph Screens. Electronic communication with Charlie Caputo of Entergy. January 29, 2013.

Freeman, A. Myrick III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods.* Second Edition. Washington, D.C.: Resources for the Future.

Kolstad, Charles D. 2011. *Environmental Economics*, 2nd Edition. Oxford University Press.

NERA Economic Consulting (NERA). 2013. *Benefits and Costs of Cylindrical Wedgewire Screens and Cooling Towers*. December 2013.

New York Governor's Office of Regulatory Reform. 2008. Cost-Benefit Assessment in Rulemaking: A Guide for State Agencies. July.

New York Independent System Operator (NYISO). 2013. *2013 Load & Capacity Data* ("Gold Book"). April.

New York State Department of Environmental Conservation (NYSDEC). 2000. *Athens Generating Company, LP – Interim Decision*. June 2, 2000. http://www.dec.ny.gov/hearings/10976.html

New York State Department of Environmental Conservation (NYSDEC). 2002. Mirant Bowline, LLC – Decisions. March 19, 2002. http://www.dec.ny.gov/hearings/11479.html

New York State Department of Environmental Conservation (NYSDEC). 2003. *Draft State Pollutant Discharge Elimination System (SPDES) Discharge Permit for Indian Point*.

New York State Department of Environmental Conservation (NYSDEC). 2010. *The SEQR Handbook*. 3rd ed.

New York State Department of Environmental Conservation (NYSDEC). 2012. *Ruling of the Regional Director* (Indian Point Energy Center SPDES permits). November 28.

Tetra Tech. 2013. *Indian Point Closed-Cycle Cooling System Retrofit Evaluation*. Prepared for the New York State Department of Environmental Conservation. June 2013.

TRC. 2009. *Cooling Tower Impact Analysis for the Entergy Indian Point Energy Center*. September 1.

U.S. Energy Information Administration (EIA). 2013. Annual Energy Outlook 2013. U.S. EIA. Washington, DC. April.

U.S. Environmental Protection Agency (EPA). 2000. *Guidelines for Preparing Economic Analyses*. September.

U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses*. Washington, DC: EPA, December.

U.S. Environmental Protection Agency (EPA). 2011. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule*. March 28.

U.S. Office of Management and Budget (OMB). 1992. *Circular No. A-94 Revised (Transmittal Memo No. 64) Memorandum for Heads of Executive Departments and Establishments*. October 19.

U.S. Office of Management and Budget (OMB). 2003. *Circular A-4 to the Heads of Executive Agencies and Establishments Regarding Regulatory Analysis*. September 17.

Young/Sommer LLC. 2013. *Analysis of Municipal and County Permitting for Closed-Cycle Cooling System Retrofit at Indian Point.* Prepared by Kevin M. Young and Elizabeth M. Morss. December 2013.

Appendix A: Electricity Price Forecasts

This appendix describes the methodology used to estimate monthly wholesale electricity prices from 2015 to 2035 for a region that consists of New York City and Westchester County, New York. As explained in Chapter III, wholesale electricity prices are used to value the social benefits of the increase in power output at IPEC due to the installation and operation of CWWS and Cooling Towers. Wholesale electricity prices are an appropriate measure of the real-resource costs or benefits of small changes in power output because they reflect the marginal cost of supplying an additional unit of electricity to the grid.

This appendix provides background on the New York State wholesale electricity markets, describes the methodology for developing electricity price projections, and presents the resulting forecasts.

A. Background on New York State Wholesale Electricity Markets

Until late in the twentieth century, electricity throughout the United States was generated and distributed primarily by vertically-integrated utilities that had an exclusive franchise within a given area and were subject to rate-of-return (cost-of-service) price regulation. Many states still rely on that traditional regulatory structure.

Starting in the 1990s, New York and several other states moved to a vertically-disintegrated system in which regulated investor-owned utilities ("IOUs") buy most of the power they need to serve their customers' demand from wholesale generating companies, such as Entergy, with the prices being determined by the market. These purchases can occur through spot markets administered by "Independent System Operators," such as the New York Independent System Operator ("NYISO"), that manage markets in which generators bid to provide power to the system. The NYISO was established in 1999 (NYSEPB 2009a, p. 16), and the electricity from IPEC is sold in power markets organized by the NYISO.

The NYISO is responsible for the operation of New York's nearly 11,000 miles of high-voltage transmission and the dispatch of over 500 electric power generators. In addition, the NYISO administers bulk power markets that trade an average of $7.5 billion in electricity and related products annually (NYISO 2013). The NYISO coordinates dispatch and sets wholesale electricity prices (which differ from retail electricity prices primarily because they do not include transmission and distribution costs) through hourly uniform-price auctions using bids from suppliers and demand-response resources.

The two main components of the NYISO wholesale electricity market are: (1) energy markets, and (2) a capacity market.[23]

[23] The energy and capacity prices are the largest components of wholesale electricity prices, but various "ancillary services" are also required to support the reliable operation of the transmission system. The two most important ancillary services are reserves and regulation (NYISO 2013). Reserves are generating units that are available to provide fast ramping power in the event of any unforeseen occurrences. "Spinning reserves" are already

1. NYISO Energy Markets

The NYISO runs a day-ahead market and a real-time market for electricity. The day-ahead market provides generators with advanced notice of power requirements and incentive to perform as scheduled. The real-time market enables the NYISO to efficiently balance the system because conditions can change from the time the day-ahead market is run. The NYISO also handles the scheduling of direct transactions between buyers and sellers—known as bilateral transactions—which account for roughly half of the energy settled in the day-ahead market (NYISO 2013).

These energy markets ensure reliability and least-cost generation through the use of clearing price auctions and competitive bid structures. As the New York State Energy Planning Board explains in its 2009 Energy Plan:

> Using the bids of both suppliers and demand-response resources, the NYISO software economically commits and dispatches resources at the least cost consistent with transmission and other system constraints using a uniform-price auction format. Essentially, this means that the market clearing price paid to all suppliers is based upon the marginal cost of the last unit chosen to serve load. Under this arrangement, suppliers, absent market power, have every incentive to bid into the market their marginal costs of production, because if they bid below it they may run at a loss and if they bid above it they may not be selected for dispatch and will neither run nor be paid. This results in the system being dispatched in the most efficient manner that minimizes total production costs, thus providing power to consumers at the lowest possible price (NYSEPB 2009a, p. 17).

The result is a series of Locational Based Marginal Prices ("LBMP"), which are equal to the cost of energy production plus the transportation (losses and congestion) cost at each location. Figure A-1 displays the various "load zones" across the New York, for which LMBPs differ based primarily on the cost of providing sufficient electricity to each zone to satisfy demand (NYISO 2013).

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generating electricity, but have the capability to generate more if needed. "Non-spinning reserves" are off-line units that can start providing generation to the grid relatively quickly (NYISO 2013). Because load and generation must be kept in constant balance on the grid, short-term changes in electricity use can affect the stability of the power system. NYISO relies on "regulating resources" to rapidly adjust their output or consumption in response to constantly changing load conditions, and thus keep load and generation in balance (NYISO 2013).

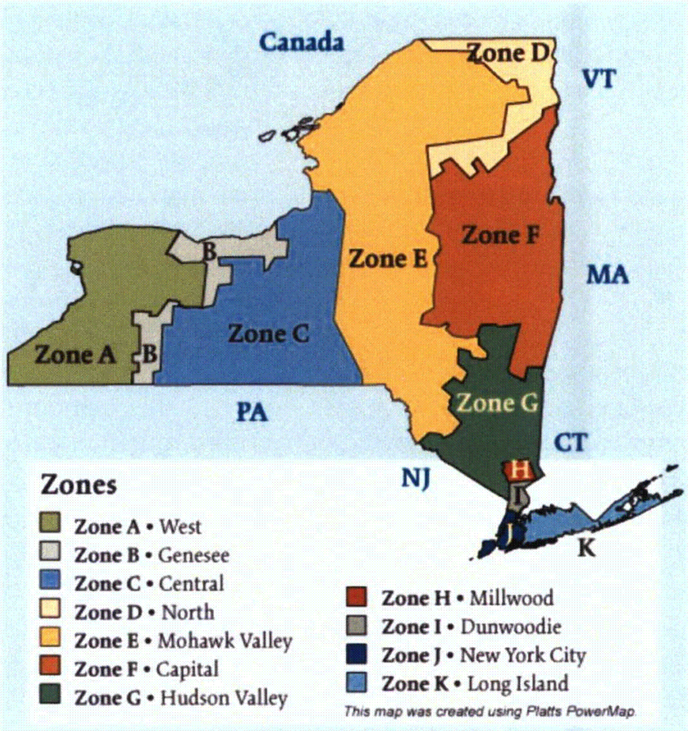


Figure A-1. NYISO Load Zones

As a result of this competitive bid structure, the temporal variations in demand that characterize electricity markets cause different types of units to be dispatched at different times. During off-peak periods when demand is relatively low, typically only those units with relatively low marginal costs (including IPEC and other nuclear units) operate. During peak periods, when demand is relatively high, units with higher marginal costs also operate to satisfy demand.

The market price in each period is the system's marginal cost, which is calculated as the marginal cost of the most expensive unit added to meet demand. Small changes in net power output at IPEC thus would lead to changes in power generated at the "marginal unit" at a cost equal to the market price of power during the relevant period.

2. NYISO Capacity Market

NYISO also administers a capacity market in which companies supplying power to customers (i.e., load-serving entities, or "LSEs") can purchase the capacity required to meet their capacity obligations. The goal of the capacity market is to ensure that sufficient resources are available to meet projected load on a long-term basis and encourage the development and maintenance of sufficient generation capacity in New York State.

Capacity providers (i.e. power plants) make their generation capacity available to load-serving entities (that is, they "bid into" the capacity market), and in return receive payments from LSEs. In effect, LSEs pay the power plants for the assurance that the power plants could provide power if called upon. The presence of capacity markets thus provides incentives for investment in generation capacity so that there will be capacity sufficient to meet load, even in times of peak electricity demand. The capacity market provides a mechanism for generation units that operate only in peak demand periods—which typically have high marginal costs and relatively low fixed costs—to recover their fixed costs.

To set capacity prices, NYISO uses a demand curve relating capacity and price that incorporates a "reserve margin" by which generation capacity should exceed projected peak load. Small changes in generation capacity at IPEC would be valued based upon prices in the NYISO capacity market.

The NYISO also supports various "demand response" programs designed to encourage reductions in electricity usage based on economic or reliability signals (NYISO 2013). Similar to capacity markets, the objective of these programs is to ensure that resources are available to meet the long-term demand for electricity in New York.

B. Electricity Price Projections

Our analysis assumes that the small changes in electricity generation due to CWWS would not affect electricity prices and thus overall electricity demand would be unchanged. Thus, the change in IPEC generation due to the installation and operation of CWWS at IPEC would be balanced by a change in electricity output from other generators. The installation of Cooling Towers at IPEC would require a sustained capacity outage that would trigger a temporary price response from the market. We would expect that prices during the outage would temporarily rise to a level equal to that if IPEC were retired. This temporary electricity price jump would not affect the trajectory of electricity prices over time and prices would return to lower levels once the installation is complete. We make the conservative assumption to ignore this temporary price jump that would increase total costs to the system, since it will not affect our results in the long-run. We estimate the social costs of changes in net electricity output at IPEC using the marginal cost of replacement energy on the grid. As explained above, the real-resource costs of supplying an additional unit of electricity to the grid can be estimated using the wholesale prices of electricity. This section describes our methodology for estimating wholesale electricity prices over the relevant period, which is from 2013 to 2035. Although wholesale energy prices are set hourly, it is sensible to provide price projections for more aggregated time periods. As discussed below, we develop average monthly price projections.

1. Overview of Methodology

We develop monthly wholesale electricity price projections using data from the U.S. Energy Information Administration's ("EIA") National Energy Modeling System ("NEMS") and the NYISO. From both sources, we gather data on electricity prices for a region consisting of New York City and Westchester County, New York. The NEMS data consist of annual projections of wholesale electricity prices (including generation, capacity and ancillary services) for the years 2013 to 2035, and are the basis of our price projections. The NYISO data are monthly historical wholesale electricity prices from 2007 and 2012, which we use to estimate the average variations in prices by month over the course of the years.

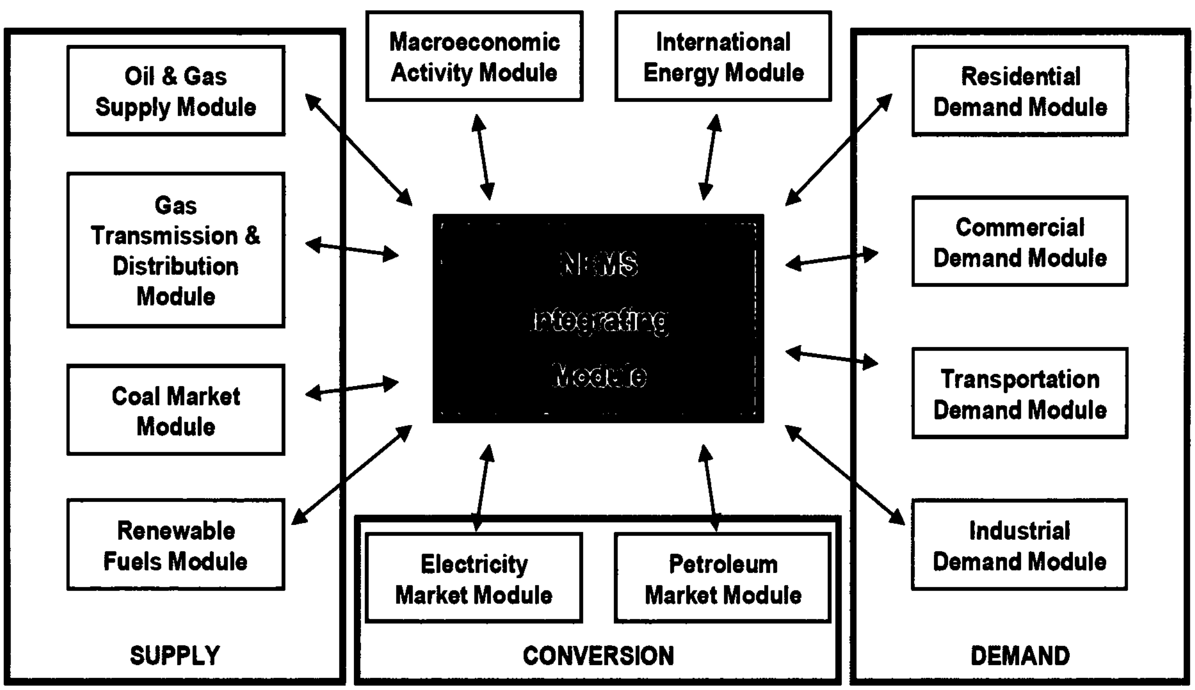
2. Overview of the National Energy Modeling System (NEMS)

Annual electricity price forecasts were obtained from the *Annual Energy Outlook ("AEO") 2013 Early Release* (EIA 2012). This report, published annually by the EIA, uses NEMS to form baseline projections for national and regional energy prices and quantities. NEMS is a detailed energy and economic model developed and maintained by the EIA Office of Energy Analysis to provide projections of domestic energy-economy markets in the long term and to perform policy analyses requested by decision-makers in the White House, Congress, Department of Energy, and other government agencies. The EIA projections are used by analysts and planners in government agencies and other outside organizations, including the New York State Energy Research and Development Authority ("NYSERDA").

NEMS models the supply and demand of energy and other markets at regional levels, taking into account interactions among regions. The level of regional detail for the end-use demand modules is the nine Census divisions used by the United States Census Bureau. Other regional structures include production and consumption regions specific to oil, natural gas, and coal supply and distribution, the North American Electric Reliability Corporation ("NERC") regions and sub-regions for electricity, and the Petroleum Administration for Defense Districts ("PADDs") for refineries.

For each fuel and consuming sector, NEMS balances the energy supply and demand, accounting for the economic competition between the various energy fuels and sources. NEMS is organized and implemented as a modular system, as shown in Figure A-2 below.

Figure A-2. Structure of NEMS



Source: Adapted from EIA (2012)

The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. NEMS also includes a macroeconomic module and an international module. The primary flows of information between each of these modules are the delivered prices of energy to the end user and the quantities consumed by product, region, and sector. The delivered prices of fuel encompass all the activities necessary to produce, import, and transport fuels to the end user. The information flows also include other data such as economic activity, domestic production, and international petroleum supply availability.

The integrating module of NEMS controls the execution of each of the component modules. To facilitate modularity, the components do not pass information to each other directly but communicate through a central data storage location. This modular design provides the capability to execute modules individually, thus allowing decentralized development of the system and independent analysis and testing of individual modules. This modularity allows use of the methodology and level of detail most appropriate for each energy sector. NEMS solves by calling each supply, conversion, and end-use demand module in sequence until the delivered prices of energy and the quantities demanded have converged within tolerance, thus achieving an economic equilibrium of supply and demand in the consuming sectors. Other variables are also evaluated for convergence such as petroleum product imports, crude oil imports, and several macroeconomic indicators.

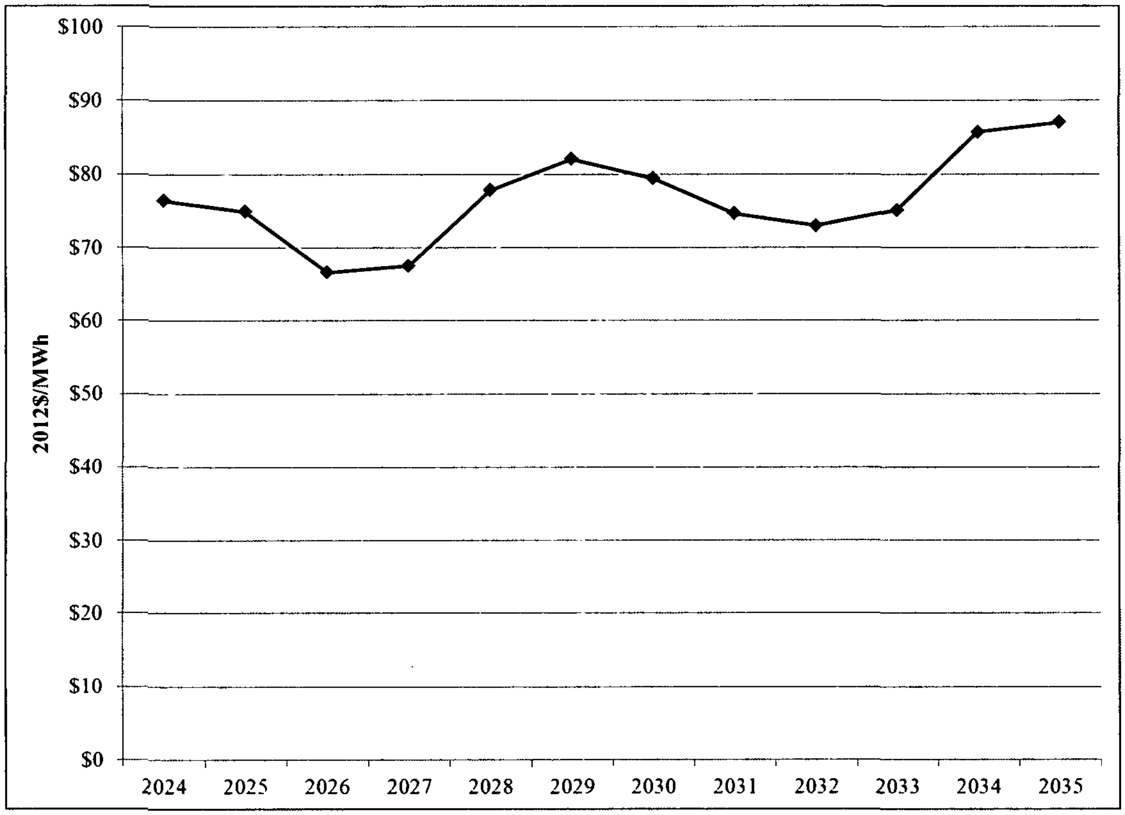
The Electricity Market Module has three primary "submodules": (1) capacity planning; (2) fuel dispatching; and (3) finance and pricing. The finance and pricing submodule determines transmission costs as well as regional electricity prices. This submodule uses capital costs, fuel costs, macroeconomic parameters, environmental regulations, and load shapes to estimate generation costs for each technology.

3. NEMS Annual Price Projections

NEMS divides New York State into three regions: (1) New York City (NYC) / Westchester; (2) Long Island; and (3) Upstate New York. We use the NYC / Westchester region prices because generation affected by changes at IPEC will likely be supplied to that region.

Figure A-3 displays the NEMS projections of average annual wholesale electricity prices (in constant 2012 dollars) for the NYC / Westchester region. The average annual NYC / Westchester wholesale electricity price is projected to be $87/MWh (in 2012 dollars) in 2035.

Figure A-3. Projected Average Annual New York City / Westchester County Wholesale Electricity Prices



Source: NEMS (EIA 2013)

4. Monthly Electricity Price Variability

Electricity prices can vary substantially on a month-to-month basis, due largely to changes in electricity demand during different seasons of the year. However, the NEMS model provides only annual price projections. To our knowledge, there are no comparable forecasts of New York wholesale electricity prices available on a monthly basis. We therefore use historical data from the NYISO to estimate the likely variability in electricity prices by month over the course of the year.

In particular, we calculate historical ratios of average monthly prices to average annual prices for the NYC / Westchester region. We use 2007 to 2012 monthly prices from NYISO zones H, I and J[24] to calculate these ratios. As shown in Table A-1, the ratios of average monthly to average annual wholesale electricity prices range from 0.79 in November to 1.24 in July and August. These ratios show that electricity prices are generally higher in the summer and winter when demand is high and lower in the fall and spring when demand is relatively low. Thus, a change in

[24] NYISO Zones H, I, and J roughly correspond to the EIA NYC / Westchester region. To estimate a composite price for these three zones, we weighted the prices by the monthly load in each Zone.

electricity output at IPEC during the summer or winter months would result in a higher societal cost or benefit than one that occurred during the fall or spring.

Table A-1. Ratios of Monthly to Annual Electricity Prices in NYISO Zones H, I and J

Month	Ratio
January	1.13
February	1.04
March	0.92
April	0.95
May	1.03
June	1.18
July	1.24
August	1.04
September	0.90
October	0.79
November	0.81
December	0.98

Note: Ratio of average monthly to average annual electricity prices in NYISO Zones H, I and J.
Source: NERA calculations based on NYISO historical data (NYISO 2013)

5. Electricity Price Projections

The final step of our methodology is to combine the annual wholesale electricity price projections from NEMS with the estimates of monthly price variability from the NYISO data. We multiply the annual wholesale electricity prices by the ratios of monthly price variability to obtain estimates of monthly wholesale electricity prices from 2024 to 2035. Table A-2 and Figure A-4 provide information on the resulting average monthly wholesale electricity price projections for NYC / Westchester in 2012 dollars.

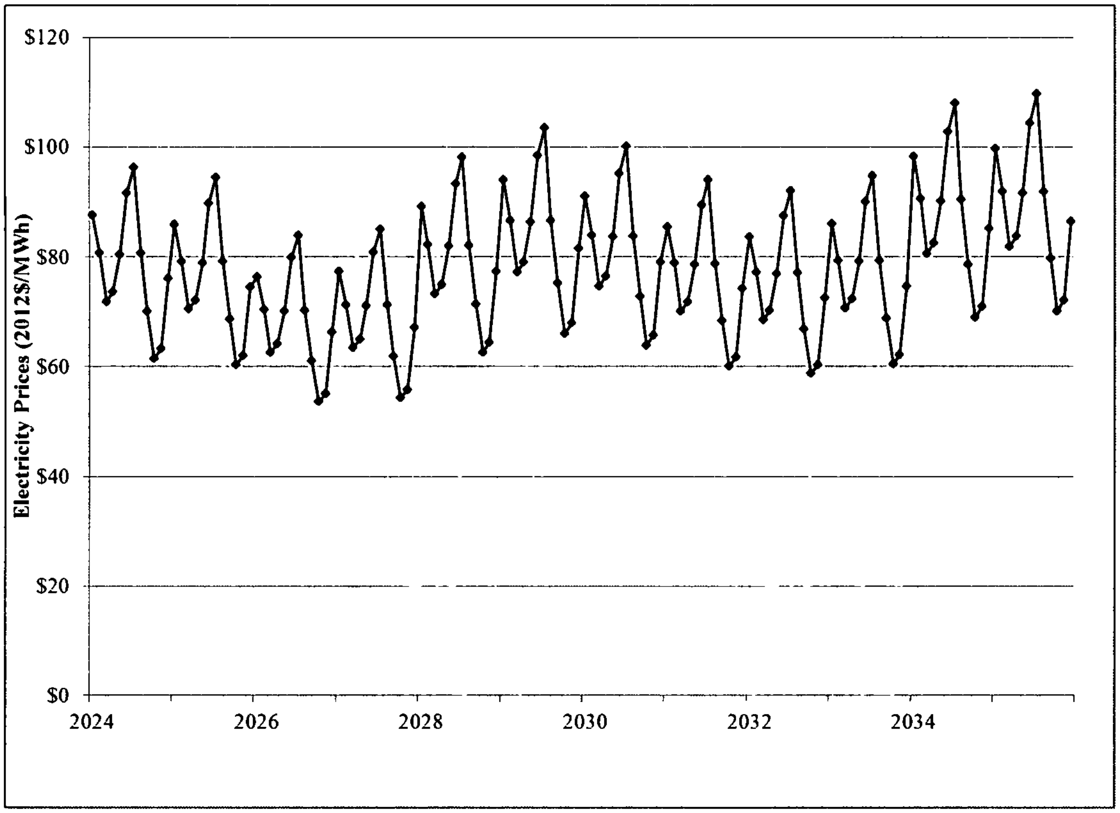
Table A-2. Monthly NYC / Westchester Wholesale Electricity Price Projections (2012$/MWh)

	2025	2030	2035
January	84.37	89.42	97.98
February	77.78	82.43	90.32
March	69.20	73.33	80.36
April	70.87	75.10	82.29
May	77.53	82.16	90.03
June	88.24	93.51	102.47
July	92.80	98.34	107.76
August	77.70	82.34	90.23
September	67.47	71.50	78.35
October	59.26	62.80	68.81
November	60.92	64.56	70.74
December	73.17	77.55	84.98

Note: Prices have been converted from 2011 dollars in the EIA data to 2012 dollars using the GDP implicit price deflator from the U.S. Bureau of Economic Analysis.

Source: NERA calculations based on NYISO historical data (2013) and EIA forecasts (2013)

Figure A-4. Monthly NYC/Westchester Wholesale Electricity Price Projections (2012$/MWh)



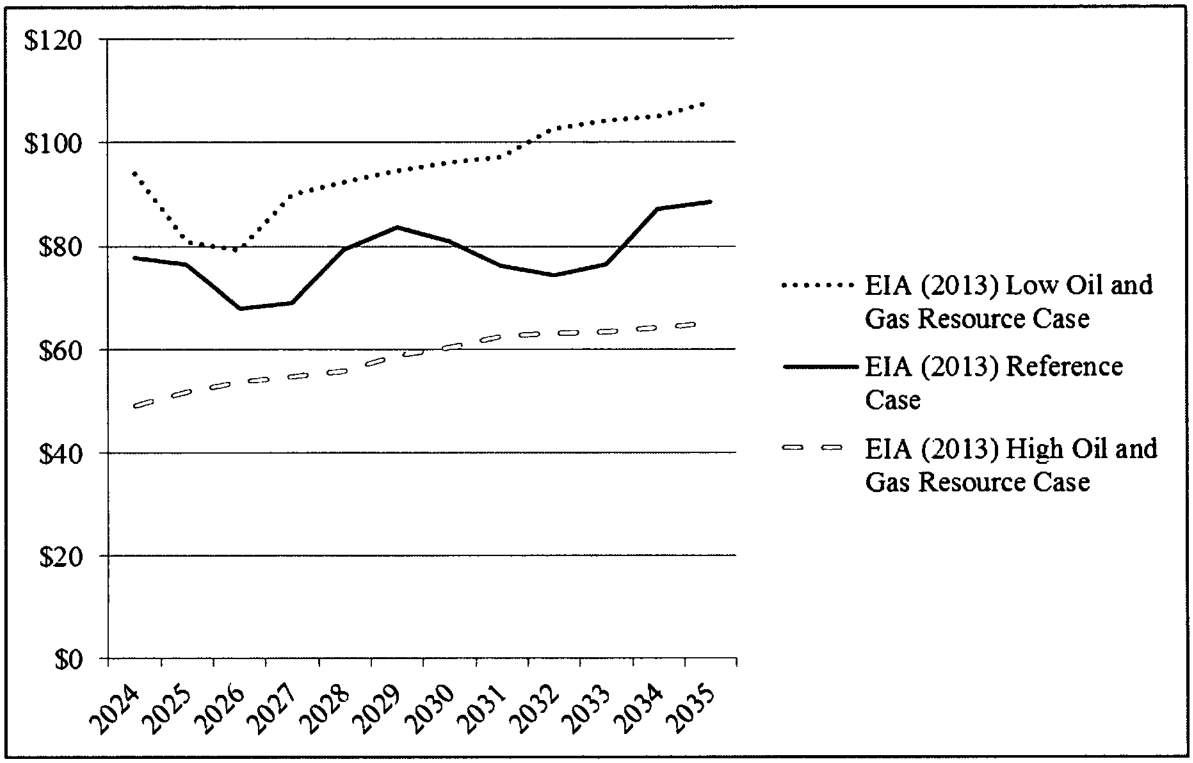
Source: NERA calculations as explained in text

C. Electricity Price Uncertainty

Any projection of electricity prices is subject to some uncertainty. We test whether our conclusions are robust to this uncertainty using alternative assumptions about future wholesale electricity prices.

Our sensitivity cases for wholesale electricity prices are informed by two side case projections from EIA (2013)—the Low Oil and Gas Resource case and the High Oil and Gas Resource case. These side cases represent scenarios in which the supply of natural gas and oil is lower or higher than in the EIA (2013) Reference case (which we use to construct our base case projections); lower supply of these fuels leads to higher electricity price projections and vice versa for higher supply. Natural gas supply specifically is a key determinant of electricity prices, so the variation in these side case projections provides a plausible spread of future wholesale electricity prices.

Figure A-5. Projected Average Annual New York City / Westchester County Wholesale Electricity Prices



Source: NEMS (EIA 2013)

Figure A-3 shows these EIA (2013) side case projections from 2024 to 2035. The largest percentage differences from the Reference case projection are -37 percent in 2024 and +43 percent in 2036. In order to reflect variation of this magnitude while retaining the general shape of the Reference case projection, we assume prices are 40 percent below base case price projections in our "low" price sensitivity case and 40 percent above base case prices in our "high" price sensitivity case.

D. References

New York State Energy Planning Board (NYSEPB). 2009a. *2009 State Energy Plan - Electricity Assessment: Resources and Markets*. December.

New York State Energy Planning Board (NYSEPB). 2009b. *2009 State Energy Plan - Natural Gas Assessment*. December.

New York Independent System Operator (NYISO). 2013. Information from the NYISO website: www.nyiso.com (accessed February 8, 2013).

New York Independent System Operator (NYISO). 2013. *NYISO Pricing Data*. http://www.nyiso.com/public/markets_operations/market_data/pricing_data/index.jsp. (accessed February 20, 2013).

Paynter, Thomas. 2004. New York's Capacity "Demand Curve." October 4-5.

U.S. Energy Information Administration (EIA). 2013. Annual Energy Outlook 2013. U.S. EIA. Washington, DC. April.

Appendix B: Commercial and Recreational Harvest Percentages

This appendix describes our methodology for allocating theoretical increases in harvest between commercial and recreational fisheries. These allocations are used to estimate monetized benefits in our SEQRA analysis (NERA 2013). In this report, they provide context to the fish harvest increases due to CWWS and Cooling Towers. As discussed in Appendix C and Appendix D, the value of marginal fish harvest to recreational anglers is different than the value of fish harvested commercially; thus, the allocation of increased fish harvest to these two uses affects our interpretation of comparisons between CWIS costs and fish harvest increases.

We estimated commercial-recreational percentages for the four species for which ASAAC (2013) estimated theoretical increases in harvest:

1. Striped bass (which accounts for the vast majority of total increases in harvest, as shown in Chapter IV);

2. White perch;

3. American shad; and

4. *Alosa* sp. (alewife and blueback herring).

Our methodology for allocating the theoretical increase in harvest between recreational and commercial fishery is based on historical information on commercial and recreational landings. In particular, we use data from the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) on commercial and recreational harvest landings for New York (including the Hudson River up to the Federal Dam at Troy) and the Atlantic coast over the ten-year period from 2003 to 2012 (most recent data) to calculate average commercial and recreational percentages over this historical period. We then use the historical percentages as estimates of the likely future commercial and recreational percentages.

The following sections provide background on the management of the four species as well as the information on commercial and recreational landings that we use to develop our estimates. The final section provides a summary of our conclusions.

A. Background on Regulation of Commercial and Recreational Fisheries

Three of the four analyzed species (striped bass, American shad, and *Alosa*) are managed by the Atlantic States Marine Fisheries Commission ("ASMFC") and the New York State Department of Environment Conservation ("NYSDEC"). As discussed in Appendix C, management of fish species is motivated by concerns related to "overfishing," since fish have historically been common property resources.

1. Summary of Atlantic and New York Restrictions

The following table summarizes the restrictions on commercial and recreational fishing at the Atlantic and New York levels.

Table B-1. Restrictions on Commercial and Recreational Fisheries

	Atlantic		New York	
	Commercial	**Recreational**	**Commercial**	**Recreational**
Striped bass	Banned in several states, quotas for other states, size limits, season restrictions, gear restrictions	Size limits, daily bag limits, season restrictions, gear restrictions	Banned in Hudson, state quota (828,293 lbs), size limit (24"-36"), season restriction (July 1 to Dec 15), gear restrictions (e.g., no gill nets in some areas)	Size limits (e.g., 18" min in Hudson), daily bag limits (e.g., 1 in Hudson), gear restrictions (angling or spearing only), season restrictions (e.g., Apr 15 to Dec 15 in Hudson)
American shad	States must have sustainable fishery plans	States must have sustainable fishery plans	Banned	Banned
Alosa sp.	States must have sustainable fishery plans	States must have sustainable fishery plans	Banned except for Hudson and Federal ocean waters with Federal permit, season restriction in Hudson (March 15 to June 15), state permit required in Hudson	Banned except in Hudson, season restriction (March 15 to June 15), daily bag limit (10 per day), gear restrictions (angling or personal-use nets), state permit required

Sources: ASMFC (2009, 2010, 2013), NYSDEC (2011, 2013)

2. Implications of the Restrictions

These regulations could affect the extent to which the ASAAC calculations of theoretical harvest gains would translate into actual increases in fishery harvests. In the case of American shad, for example, additional harvest would not result in any additional harvest in New York because of the ban on both commercial and recreational American shad fishing.

The situation for striped bass is most important because striped bass represent more than 95 percent of total theoretical additional harvest due to CWWS or Cooling Towers at IPEC. New York has a current quota of about 828,000 pounds (or about 375 metric tons) for commercial striped bass harvest. If the quota were binding, the additional theoretical harvest due to CWWS or Cooling Towers at IPEC would not result in additional actual commercial harvest in New York. As noted below, however, the landings data suggest that the commercial quota in New York has not been binding (i.e., landings have been below the quota) and thus that the quota will not be binding in the future. Thus, we assume that additional commercial harvest of striped bass would occur as a result of the harvest benefits of CWWS or Cooling Towers. With regard to the recreational catch, the recreational limits (size, gear, and season) could mean that the likely additional recreational harvest is less than the theoretical harvest estimated by ASAAC (2013).

B. Commercial Landings Data

Table B-2 presents NMFS data on commercial landings weights (in metric tons) from 2003 to 2012 in New York and the Atlantic coast.[25] Note that commercial landings for striped bass have been relatively steady in both New York and the Atlantic coast, but commercial landings for white perch, American shad, and *Alosa* have fluctuated sharply in New York and have generally been steadier in the Atlantic coast. Note also that the annual striped bass landings are less than the current quota in every year except 2011.

Table B-2. Commercial Landings (metric tons)

	Striped Bass		White Perch		American Shad		Alosa sp.	
	New York	Atlantic	New York	Atlantic	New York	Atlantic	New York	Atlantic
2003	355.9	3,213.5	4.2	1,001.7	67.2	684.9	9.3	679.9
2004	338.6	2,850.4	0.5	447.7	6.8	515.6	6.6	604.1
2005	322.4	3,577.0	0.4	853.3	2.0	308.0	2.6	332.4
2006	312.3	2,978.5	1.1	454.9	4.2	245.8	5.0	683.6
2007	331.7	3,326.1	0.2	596.4	22.7	340.7	12.8	415.9
2008	296.2	3,389.3	0.3	635.9	10.3	221.7	9.5	644.1
2009	338.9	3,416.4	0.9	882.1	4.7	113.7	5.3	747.2
2010	339.1	3,444.7	0.1	982.2	1.2	260.3	5.7	1,041.3
2011	388.0	3,294.9	0.7	1,167.9	1.3	283.4	6.8	620.0
2012	310.2	3,253.9	2.5	970.9	1.5	289.1	0.1	750.6
Total	3,333.3	32,744.7	10.9	7,993.0	121.9	3,263.2	63.7	6,519.1

Source: NMFS (2013a)

C. Recreational Landings Data

Table B-3 presents recreational landings weights (in metric tons) from 2003 to 2012 in New York and the Atlantic coast. Note that recreational landings of white perch, American shad, and *Alosa* in New York are unavailable in most years.

[25] In the NMFS data, the Atlantic coast includes Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida's east coast.

Table B-3. Recreational Landings (metric tons)

	Striped Bass		White Perch		American Shad		Alosa sp.	
	New York	Atlantic	New York	Atlantic	New York	Atlantic	New York	Atlantic
2003	1,546.6	10,411.3	1.5	545.1	-	-	-	13.2
2004	1,690.6	13,649.0	6.8	387.8	-	0.0	-	50.3
2005	2,511.8	13,808.8	-	453.3	-	4.2	-	2.6
2006	2,734.5	14,181.3	-	633.4	-	35.9	-	0.5
2007	3,589.7	12,288.4	-	716.2	-	-	-	6.5
2008	4,955.7	13,901.5	-	946.4	-	0.2	-	20.6
2009	2,270.1	10,413.4	-	175.5	-	0.7	-	8.1
2010	3,173.9	10,458.1	-	625.5	-	0.0	-	3.6
2011	4,068.7	12,391.0	-	443.3	-	-	-	0.7
2012	2,942.1	8,858.8	-	430.4	-	1.9	-	1.7
Total	29,483.6	120,361.5	8.3	5,356.8	-	42.9	-	107.8

Note: "-" denotes that no landings data are available.
Source: NMFS (2013b)

D. Commercial and Recreational Harvest Percentages

Table B-4 presents commercial percentages for each species in each year based on the commercial and recreational landings weights provided above. Percentages for white perch, American shad, and *Alosa* are only calculated for the Atlantic coast because sufficient data are not available for New York.

Table B-4. Commercial Percentages

	Striped Bass		White Perch		American Shad		Alosa sp.	
	New York	Atlantic	New York	Atlantic	New York	Atlantic	New York	Atlantic
2003	19%	24%	-	65%	-	100%	-	98%
2004	17%	17%	-	54%	-	100%	-	92%
2005	11%	21%	-	65%	-	99%	-	99%
2006	10%	17%	-	42%	-	87%	-	100%
2007	8%	21%	-	45%	-	100%	-	98%
2008	6%	20%	-	40%	-	100%	-	97%
2009	13%	25%	-	83%	-	99%	-	99%
2010	10%	25%	-	61%	-	100%	-	100%
2011	9%	21%	-	72%	-	100%	-	100%
2012	10%	27%	-	69%	-	99%	-	100%
Average	10%	21%	-	60%	-	99%	-	98%

Note: "-" denotes that commercial-recreational splits are not calculated for this range.
Source: NERA calculations as explained in text

We based our estimates of the commercial-recreational splits on the averages over the period from 2003 to 2012 shown in the bottom row of the table above. We based our split for striped bass on landings data for New York for two reasons:

1. *Range*. As noted in ASAAC (2013), the majority of the additional striped bass harvest from reduced I&E at IPEC would most likely occur in New York.

2. *Data availability*. NMFS provides complete data on striped bass commercial and recreational landings for New York.

For the other three species (white perch, American shad, and *Alosa*), we based our split on landings data for the Atlantic coast. Although the harvests of these other species may be concentrated in and around New York, the data available for New York is not sufficient to provide reliable estimates of percentages. We do not expect the lack of New York data for these other species to have a substantial effect on the benefit estimates because these other three species account for a very small percentage of the theoretical additional harvest.

Table B-5 summarizes the commercial and recreational percentages we used for the four species. Note that striped bass, the largest source of lost fishery harvest, is only 10 percent commercially harvested, a much lower percentage than the other species.

Table B-5. Commercial and Recreational Percentages by Species

	Striped Bass	White Perch	American Shad	Alosa sp.
Commercial	10%	60%	99%	98%
Recreational	90%	40%	1%	2%
Total	100%	100%	100%	100%

Source: NERA calculations as explained in text

E. Summary

We base our estimates of commercial and recreational percentages for striped bass on landings data for New York State. We base our estimates for the other three species on landings data for the Atlantic region because New York data are not available. These estimates all presume that existing restrictions on the commercial and recreational harvest of these species are not binding—in which case the additional theoretical harvest may not be reflected in additional actual harvest—and that the historical data on commercial and recreational harvest provide appropriate estimates of future percentages.

F. References

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

Atlantic States Marine Fisheries Commission (ASMFC). 2009. 2009 Fishery Regulations – Atlantic Striped Bass. http://www.asmfc.org/speciesDocuments/stripedBass/stateRegulations/Striped%20Bass%20Regulations%202009.pdf.

Atlantic States Marine Fisheries Commission (ASMFC). 2010. *Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management)*. February. http://www.asmfc.org/speciesDocuments/shad/fmps/Amendment3_FINALshad.pdf.

Atlantic States Marine Fisheries Commission (ASMFC). 2013. http://www.asmfc.org.

National Marine Fisheries Service (NMFS). 2013a. "Annual Commercial Landings Statistics." www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html.

National Marine Fisheries Service (NMFS). 2013b. "Recreational Fisheries Statistics Queries." http://www.st.nmfs.noaa.gov/recreational-fisheries/access-data/run-a-data-query/queries/index.

New York State Department of Environment Conservation (NYSDEC). 2011. *Sustainable Fishing Plan for New York River Herring Stocks*. September. http://www.dec.ny.gov/docs/fish_marine_pdf/rhsustplan0811.pdf

New York State Department of Environment Conservation (NYSDEC). 2013. "Regulations: Part 40: Marine Fish." http://www.dec.ny.gov/regs/4015.html.

Appendix C: Commercial Fishing Benefits

This appendix describes the methodology and data used to estimate the commercial fishing benefits associated with reduced I&E due to CWWS or Cooling Towers at IPEC. This methodology is used to estimate monetized benefits in our SEQRA analysis (NERA 2013). In this report it provides context for increases in commercial fish harvest from CWWS and Cooling Towers and allows us to meaningfully compare costs and biological benefits of these CWIS. We begin with an overview of our methodology, which is consistent with EPA 2011 (Chapter 6). The following section provides information on the data we used to develop our empirical estimates. The final section discusses certain caveats to this methodology and their potential implications for our commercial fishing benefits estimates.

A. Methodology for Estimating Commercial Fishing Benefits

1. Overview of Commercial Fishing Benefits

The total economic gain from reduced I&E for commercially harvested fish species is equal to the sum of changes in producer and consumer surplus. The basic approach to estimating benefits consists of the following three steps (adapted from Bishop and Holt 2003, as referenced in EPA 2011).

1. Assess the net welfare changes for fish consumers due to changes in fish harvest and the corresponding change in fish prices;

2. Assess the net welfare changes for fish harvesters due to changes in fish harvest, fish prices and the cost of harvesting;

3. Calculate the net social benefits due to increases in commercial fish harvest as the sum of changes in consumers and producers surplus.

These calculations presume that the commercial fishery is regulated since, as explained in the final section of this appendix, in an unregulated fishery, the gains to producers from increased commercial catch would be expected to be zero.

Figure C-1 provides a graphical overview of the potential changes in consumer and producer surplus due to a change in commercial fishing harvest. The graph presumes that commercial fish harvest increases from F1 to F2. If demand curves are downward-sloping (as is generally assumed), increases in fish populations would lead to decreases in fish prices. These price changes would have implications for both producers and consumers.

The following are the potential gains to fish consumers and harvesters as well as the implications for total gains in consumer and producer surplus.

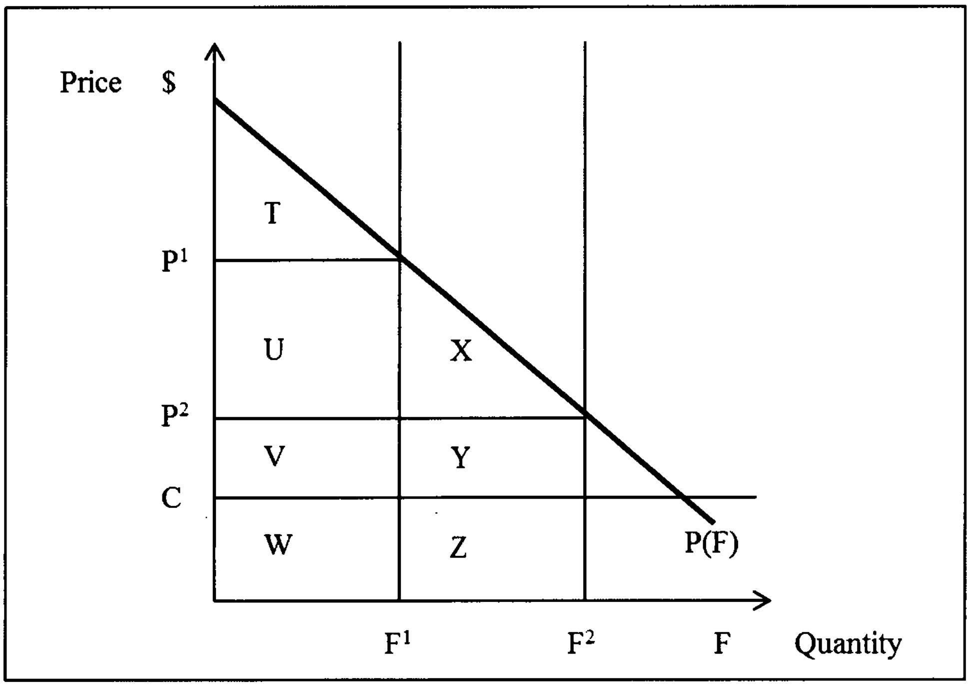
Appendix C: Commercial Fishing Benefits

- *Fish consumers.* Fish consumers gain consumer surplus if prices decrease. The figure shows price decreasing from P^1 to P^2. At P^1, the original consumers' surplus is equal to T and the change in consumers' surplus due to the decrease in price is equal to U + X.

- *Fish harvesters.* Fish harvesters gain from increases in revenues net to changes in costs. The original harvesters' surplus is equal to U + V, based upon revenues equal to U+V+W and costs of W. The reduction in price leads to a loss to fish harvesters equal to U (which represents a transfer from harvesters to consumers). The increased harvest leads to a gain in revenue of Y + Z and a net gain in harvested surplus equal to Y.

- *Net potential increase for fish consumers and harvesters.* The net gain in potential consumers and producers surplus due to the change in harvest can be represented by the sum of X (gain to consumers from additional catch) and Y (net gain to harvesters taking into account the added costs of the additional catch).

- *Implications of no price decrease.* The gains to consumers depend upon the increased harvest leading to lower fish prices. If the increased harvest for a given species is small relative to the size of the market, the market price would not change. In that case, the net gain would accrue to fish harvesters and would be equal to the net revenues from the additional catch (i.e., added revenues minus added costs, or Y in the diagram). As discussed below, this is the likely situation for 316(b) commercial fishing benefits.



Source: EPA (2011), p. 6-2

Figure C-1. Fishery Market Model

2. Application of Methodology to 316(b) Commercial Fishing Benefits

EPA (2011) provides an application of the methodology outlined above in its assessment of regional commercial fishing benefits for the proposed 316(b) Replacement Rule. The following is a summary of the nature of these calculations.

1. *Estimate the changes in commercial harvests due to reduced I&E.* EPA assumes a linear relationship between stock and harvest (p. 6-1). In other words, the percentage increase in commercial harvest is assumed to be the same as the percentage increase in commercial fish due to reduced I&E.

2. *Estimate the changes in commercial prices due to the change in fish populations.* EPA estimates the potential price changes due to I&E for individual fish species in various regions and concludes that they are small for all of the relevant species and fisheries (between 0.13 and 2.1 percent). Thus, for purposes of estimating commercial fishing gains, EPA assumes that the commercial fish prices would not change due to increases in commercial fish populations from reduced I&E (p. 6-4).

3. *Estimate the change in consumer surplus.* As noted above, consumers would benefit only if fish prices change. Since prices do not change, the change in consumer surplus is necessarily equal to zero as in EPA's calculations.

4. *Estimate the change in producer surplus.* EPA notes that, in theory, producer surplus is equal to normal profits (total revenue minus fixed and variable costs) minus the opportunity cost of capital. EPA determines that the opportunity cost of capital is sufficiently small (less than 3 percent of producer surplus) that it can reasonably be assumed to equal zero (p. 6-4). Producer surplus is thus equal to "normal profits," or gross revenues minus variable costs. Gross revenues are estimated based on the changes in commercial prices (which, as noted above, are assumed to be constant) and the changes in commercial harvest. Because variable costs (labor, fuel, etc.) vary directly with the level of landings, EPA assumes that the changes in producer surplus are equal to certain proportions of the change in gross revenues. These proportions are referred to as the "Net Benefits Ratios," which differ by region and species, and range from 0.15 to 0.85 (p. 6-4).

5. *Estimate commercial fishing benefits.* Commercial fishing benefits are equal to the sum of the changes in producer surplus and the changes in consumer surplus. The changes in consumer surplus are assumed to equal zero, so commercial fishing benefits are equal to the changes in producer surplus (p. 6-1).

B. Estimating Commercial Fishing Benefits at IPEC

Following the methodology outlined above, this section summarizes our methodology for estimating commercial fishing benefits of CWWS and Cooling Towers at IPEC.

Appendix C: Commercial Fishing Benefits

1. Changes in Commercial Harvest

We calculate changes in commercial harvest based on estimates of the total theoretical additional harvest and the percentage of that additional harvest that is caught by commercial fisherman. The estimates of annual theoretical additional harvest due to CWWS and Cooling Towers at IPEC are from ASAAC (2013) and are described in detail in Chapter IV. The estimates of the proportions attributed to commercial fishing are based on commercial and recreational landings data from NOAA, and is described in detail in Appendix B. Again, following EPA's methodology outlined above, we assume a linear relationship between fish stock and harvest.

2. Prices of Commercially Harvested Fish

Data on commercial fish prices are needed to estimate the changes in producer and consumer surplus due to reduced I&E.

a. Data on Commercial Fish Prices

We used *ex-vessel* prices (*i.e.*, prices that fishermen receive at the dock for their catch) to estimate the value of fish caught commercially similar to EPA in its proposed 316(b) Replacement Rule (EPA 2011). Annual average values for the ex-vessel prices of various commercially-fished species can be calculated using data available from the National Marine Fisheries Service (NMFS). NMFS provides state- or region-level data on annual landings (kg) and total sales values (nominal dollars). Prices calculated from these data therefore differ by location, time period and species. Although it would be desirable to use projected future prices—since commercial benefits, if any, from an implemented fish-protection alternative could extend into the future for several decades—such projected prices are not available.

We estimated commercial prices for the four species for which ASAAC estimated theoretical increases in harvest:

1. Striped bass (which accounts for the vast majority of total increases in harvest, as shown in Chapter IV);
2. White perch;
3. American shad; and
4. *Alosa* sp. (alewife and blueback herring).

We obtained NMFS data on commercial landings weight and total value for these species for the 10-year period from 2003 to 2012 (NMFS 2013). We evaluated two alternative ranges for each species: New York and the Atlantic coast. Appendix B presents commercial landings weights for the three species from 2003 to 2012 in New York and the Atlantic coast. As noted in Appendix B, we used New York data to estimate the commercial-recreational split for striped bass and Atlantic coast data for the other species.

Appendix C: Commercial Fishing Benefits

Table C-1 presents commercial prices per kg for the four species from 2003 to 2012 in New York and the Atlantic coast (converted to 2012 dollars using the GDP implicit price deflator). These commercial prices are based on the landings weights in Appendix B and nominal total values from NMFS (2013).

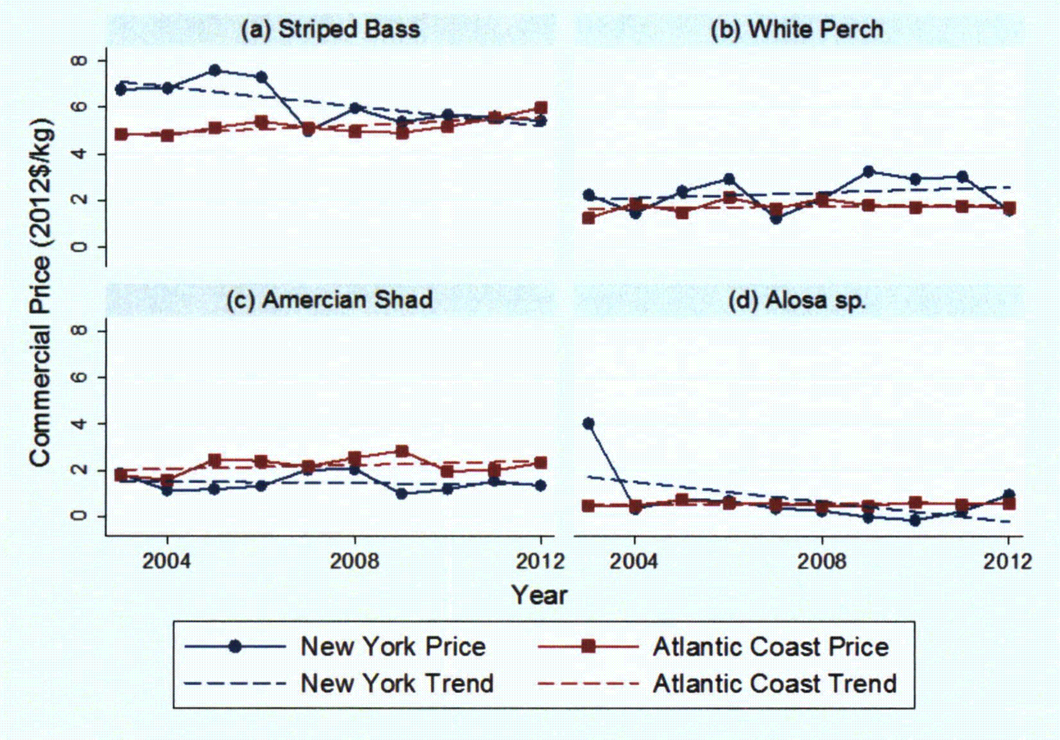
Table C-1. Commercial Prices in Constant Dollars (2012$/kg)

	Striped Bass		White Perch		American Shad		Alosa sp.	
	New York	Atlantic	New York	Atlantic	New York	Atlantic	New York	Atlantic
2003	$6.78	$4.86	$2.22	$1.24	$1.87	$1.79	$4.05	$0.50
2004	$6.83	$4.76	$1.47	$1.88	$1.11	$1.60	$0.33	$0.48
2005	$7.60	$5.13	$2.40	$1.50	$1.16	$2.47	$0.76	$0.72
2006	$7.30	$5.41	$2.92	$2.11	$1.32	$2.41	$0.69	$0.59
2007	$5.00	$5.12	$1.23	$1.66	$2.03	$2.16	$0.37	$0.53
2008	$5.95	$4.95	$2.07	$2.08	$2.07	$2.55	$0.27	$0.49
2009	$5.38	$4.91	$3.26	$1.79	$0.99	$2.86	-	$0.49
2010	$5.68	$5.18	$2.92	$1.71	$1.17	$1.98	-	$0.61
2011	$5.61	$5.55	$3.04	$1.76	$1.54	$2.01	$0.24	$0.55
2012	$5.45	$5.99	$1.58	$1.67	$1.33	$2.33	$0.95	$0.58
Average	$6.16	$5.19	$2.31	$1.74	$1.46	$2.22	$0.96	$0.55

Note: Nominal prices were converted to constant 2012 dollars using the GDP deflator.
Source: NMFS (2013) and NERA calculations as explained in text

Figure C-2 illustrates the trends in commercial prices. Note that commercial prices for striped bass have been relatively flat in both New York and the Atlantic coast, but commercial prices for white perch, American shad, and *Alosa* have fluctuated sharply in New York and have generally been steadier on the Atlantic coast.

Appendix C: Commercial Fishing Benefits



Source: NERA calculations as explained in text

Figure C-2. Commercial Price Trends

b. Commercial Fish Prices Weighted by Landings

We use the prices from Table C-1 and data on annual commercial landings to estimate weighted average commercial prices for each species.

We based our weighted-average commercial prices for striped bass on price and landings data for New York, whereas the commercial prices for white perch, American shad, and *Alosa* were based on price and landings data for the Atlantic coast. The sharp fluctuations in the weight and price data in New York for white perch, American shad, and *Alosa* (as shown in Figure C-2) made this dataset less suitable than the Atlantic coast dataset for the development of long-term commercial price projections. Moreover, note that commercial prices for striped bass are higher in New York than in the Atlantic coast, and striped bass prices in New York have a downward trend (while prices in the Atlantic coast are relatively flat). This suggests that future commercial prices for striped bass may not be as high in real terms as the historical New York averages we use. Commercial prices for white perch, American shad, and *Alosa* are similar in New York and the Atlantic coast and are generally flat (except for a price spike for *Alosa* in 2003).

Table C-2 summarizes the resulting weighted commercial prices, which are used to estimate commercial fishing benefits.

Appendix C: Commercial Fishing Benefits

Table C-2. Commercial Prices Weighted by Annual Landings (2012$/kg)

Striped Bass	White Perch	American Shad	Alosa sp.
$6.15	$1.70	$2.05	$0.54

Source: NERA calculations as explained in text

c. Changes in Commercial Fishing Prices

As noted above, increases in commercial fish populations due to reduced I&E could, in theory, lead to decreases in commercial fish prices. We follow EPA (2011) in assuming the price changes are equal to zero based upon the relatively small changes in harvest relative to the relevant market. For striped bass, EPA reports that elimination of all I&E losses would change commercial fish prices from $2.02 per pound to $1.98 per pound, or less than 2 percent. The effect of changes in I&E due to the introduction of CWWS or Cooling Towers at IPEC would of course be much smaller.

3. Changes in Producer Surplus

We follow EPA (2011) methodology in calculating the changes in producer surplus as fixed proportions of the changes in gross revenue from the increases in commercial harvests.

We estimate the changes in gross revenue using the data described above on the increases in commercial harvest and the commercial fish prices. That is, we multiply the expected changes in commercial catch by the ex-vessel prices established from data collected prior to any expected increase in catch.[26]

Increases in catch will lead to increases in gross revenues, but also to increases in costs, because there are some costs that vary with actual catch (e.g., boats might make more trips to the extent their storage capacity was filled in less time per trip, or boats might need more ice to preserve larger catches). We use the "Net Benefits Ratios" for the Mid-Atlantic region from the Proposed 316(b) Replacement Rule to estimate the fixed proportions of gross revenue that are increases in producer surplus (EPA 2011b, p. 6-7). These ratios are displayed in Table C-3.

Table C-3. Net Benefits as a Ratio of Gross Revenue

Striped Bass	White Perch	American Shad	Alosa sp.
67%	82%	84%	85%

Source: EPA (2011), p. 6-5

To estimate the change in net revenue, we apply the ratios in Table C-3 to the changes in gross revenue. The changes in gross and net revenue are displayed in Table C-4. As noted in EPA (2011) and as discussed above, our estimates of commercial fishing benefits due to CWWS and Cooling Towers at IPEC are equal to the increases in producer surplus.

[26] We assume that the markets for fish distribution and retail sales are competitive, with the prices charged by those intermediaries equal to the marginal costs of the services provided.

Table C-4. Annual Gross and Net Revenues (2012$)

	Striped Bass	White Perch	American Shad	Alosa sp
Gross Revenues				
CWWS	54,065.5	318.6	60.7	213.3
Cooling Towers	4,695.4	56.8	8.0	32.4
Net Revenues				
CWWS	36,223.9	261.3	51.0	181.3
Cooling Towers	3,145.9	46.6	6.7	27.6

Source: NERA calculations as explained in text

C. Potential Implications of Unregulated Fisheries

A fishery does not function in a typical market. Fishermen do not own the ocean, so they are in direct competition with each other to catch a limited supply of a commonly-owned resource. Without government intervention, "open access" to a resource will lead to market failures. This section discusses how these market failures could potentially affect producer surplus in the commercial fishing industry.

1. Theory of the Tragedy of the Commons

Each fisherman imposes a negative externality on all other fishermen by fishing for the same stock. The more one fisherman catches, the fewer fish are available for others to catch (or the greater the effort they will have to exert to maintain a given level of catch). No individual fisherman has an incentive to consider his impact on other fishermen. In an unregulated (or under-regulated) fishery, the result is excessive fishing, which leads to sub-optimal stock levels and can lead, under some circumstances, to a collapse of the fish population. The level of fishing effort will be excessive because fishermen will continue to enter (or fail to exit) the industry so long as there is any gain to them individually, even if their private gain is more than offset by the negative externalities they impose on other fishermen.

This general phenomenon has been dubbed the "tragedy of the commons" (Hardin 1968), referring to the "open-access" problem associated with grazing on community-held land. In Hardin's example, no individual livestock owner ultimately gains any net benefit from use of the common property because each has the incentive to graze additional stock so long as there is any private gain. The result is that each livestock owner grazes more livestock than the optimum, and the community land is degraded by over-grazing, dissipating the benefits of all stock owners. Open-access fisheries are another classic example of this potential for over-use, and the resultant degradation (and perhaps, ultimately, destruction) of a common resource. Empirical studies of open-access fisheries have confirmed the theoretical insight that open-access use of a common resource erodes economic profits (Anderson 1986 and OECD 1997).

In an unregulated fishery, fishing will increase until all profits have been exhausted, in that the total gross sales revenue will exactly offset the total costs of fishing (Kolstad 2011). The

Appendix C: Commercial Fishing Benefits

producer surplus is thus equal to zero, as is the change in producer surplus due to any change in fish populations. The implication is that for an unregulated (or under-regulated) fishery, commercial fishing benefits due to reduced I&E would equal zero.

2. How Regulated Fisheries Attempt to Avoid the Tragedy of the Commons

To avoid excessive depletion of a fishery stock, regulators may set quotas, close the fishery at certain times, impose gear limitations, or take other steps to reduce the catch to sustainable levels. If such regulations limit entry efficiently (e.g., by auctioning quotas or by allocating quotas in a manner that is not influenced by future fishing effort or entry), they can in theory correct any market failures and avoid the "tragedy of the commons" entirely.

However, various common methods of regulating fisheries do not limit entry efficiently, and therefore fail to prevent the dissipation of value described above. For example, if an overall catch quota is established for a given time period (e.g., a year or quarter), and the relevant fishery is to be closed when that quota is reached, then the level of fishing effort devoted to catching that quota will be excessive. This is because no individual fisherman will take account of the fact that the more fish he catches, the sooner the fishery will be closed for the period; he receives all of the revenues from catching more fish before closure, but the cost of earlier closure is spread across all fishermen. If the price of fish rises as a result of higher demand or the cost of catching fish falls, additional fishermen will enter (and/or existing fishermen will intensify their levels of effort), and the closure will occur sooner. Boats and other equipment and, to some extent, fishermen, will be idle for a larger fraction of the year, raising overall costs per kg caught. Higher prices therefore will not benefit fishermen, except in the short run when entry is limited. Similarly, if the stock increases due to reduced mortality of eggs, larvae, or juvenile fish, entry (and/or increased effort) will similarly dissipate any theoretical gains to fishermen.[27]

3. Fishery Regulations in the Vicinity of IPEC

The impact of the "commons problem" necessarily depends on the characteristics of the regulations governing the fishery. As noted in Appendix B, striped bass, American shad, and *Alosa* are managed by the Atlantic States Marine Fisheries Commission ("ASMFC") and the New York State Department of Environment Conservation ("NYSDEC"). Restrictions on the species discussed in this study include:

- *Quotas*. Commercial fishing of striped bass in coastal waters is restricted through state quotas coordinated by the Atlantic States Marine Fisheries Commission (ASMFC 2003, 2010, 2013). NYSDEC produces serialized striped bass tags each year based on the New York quota and distributes these tags before the commercial fishing season to holders of striped bass commercial permits. Commercial fishermen must attach a tag to each striped bass they catch so that the commercial harvest can be tracked. Neither the tags nor the permits are transferable, and at present NYSDEC is not issuing new striped bass commercial permits (NYSDEC 2013a, b).

[27] To the extent that the price falls as a result of increased quantity, there will be some benefit to consumers.

Appendix C: Commercial Fishing Benefits

- *Fishery closures*. NYSDEC allows striped bass to be caught commercially only between July 1 and December 15 or an earlier end date if the quota is projected to be met prior to December 15 (NYSDEC 2013a).

- *Minimum and maximum fish sizes*. NYSDEC allows striped bass to be caught commercially only for total lengths between 24 and 36 inches (NYSDEC 2013a).

- *Gear restrictions*. NYSDEC allows striped bass to be caught commercially using the following gear types only: hook and line, pound net, trap net, gill net, or as bycatch in otter trawls (NYSDEC 2013a).

These regulations, including limitations on entry into the striped bass commercial fishery, tend to mitigate the "tragedy of the commons" effects that have occurred in open-access fisheries. However, some portion of the potential value of increased fish stocks to commercial fisheries is still likely to be dissipated because commercial fishing permits are not distributed efficiently (through auctions or markets) and the commercial fishing season could close early if individual commercial fishermen intensify their effort.

4. Implications for Estimates of Commercial Fishing Benefits

If the fishery regulations in the vicinity of IPEC were perfectly efficient, the "tragedy of the commons" would not affect the estimates of commercial fishing benefits. As explained above, however, the actual regulations in place likely only mitigate the market failure instead of correcting for it entirely. These considerations suggest that, all else equal, the commercial fishing benefits would be lower than the calculations using the methodology described above, perhaps equal to zero.

D. References

Anderson, Lee G. 1986. *The Economics of Fisheries Management*. Revised and enlarged edition. Baltimore: Johns Hopkins.

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

Atlantic States Marine Fisheries Commission (ASMFC). 2003. *Amendment 6 to the Interstate Fishery Management Plan for Atlantic Striped Bass*. Washington, DC: ASMFC, February.

Atlantic States Marine Fisheries Commission (ASMFC). 2010. *Draft Addendum II to Amendment 6 to the Atlantic Striped Bass Interstate Fishery Management Plan*. Washington, DC: ASMFC, May.

Atlantic States Marine Fisheries Commission (ASMFC). 2013. http://www.asmfc.org.

Appendix C: Commercial Fishing Benefits

Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162: 1243-1248.

Kolstad, Charles D. 2011. *Environmental Economics*, 2nd Edition. Oxford University Press.

National Marine Fisheries Service (NMFS). 2013. Annual Commercial Landings Statistics. www.st.nmfs.noaa.gov/st1/commercial/landings/annual_landings.html.

New York State Department of Environmental Conservation (NYSDEC). 2013a. "Regulations: Chapter I – Fish and Wildlife: Part 40: Marine Fish." www.dec.ny.gov/regs/4015.html.

New York State Department of Environmental Conservation (NYSDEC). 2013b. "Striped Bass." www.dec.ny.gov/animals/50070.html.

Organization for Economic Co-operation and Development (OECD). 1997. *Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources*.

U.S. Environmental Protection Agency (EPA). 2011. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule, Chapter 6: Commercial Fishing Benefits Methodology*. Washington, DC: EPA, December.

Appendix D: Recreational Fishing Benefits

This appendix describes the methodology and data used to estimate the value that recreational anglers place on additional harvested fish due to reduced I&E due to CWWS and Cooling Towers at IPEC. This methodology is used to estimate monetized benefits in our SEQRA analysis (NERA 2013). In this report it provides context for increases in recreational fish harvest from CWWS and Cooling Towers and allows us to meaningfully compare costs and biological benefits of these CWIS. We begin with an overview of the methodological issues related to valuing recreational catch and the methodology that EPA has used to develop estimates in the proposed 316(b) Replacement Rule (2011, Chapter 7), which include results for recreational anglers in the Mid-Atlantic (among other regions). The following section provides details on the specific information and methodology we used to develop our empirical estimates. The final section provides a comparison between the results of our study and the results we would obtain if we used the EPA's results for the Mid-Atlantic region.

A. Methodology for Estimating Recreational Fishing Benefits

1. Overview of Methodological Issues in Estimating Recreational Fishing Benefits

As discussed in Chapter IV, the total economic gain (consumers' surplus) from reduced I&E for recreationally harvested fish species is equal to the marginal value of recreational fish harvested multiplied by the increase in the number of recreationally harvested fish. The marginal value is equal to the value (i.e., willingness-to-pay) that recreational anglers would place on an additional harvested fish. As discussed below, we account for catch-and-release in calculating the value of changes in recreational harvest.

Recreational fishing and fish caught by recreational anglers are classic non-market commodities. Typically, recreational fishing services are not packaged and sold by private producers to private customers (although guide services and the like do exist), so market prices do not exist to indicate the value that recreational anglers place on fishing trips or fish caught. Nevertheless, economists have developed and implemented methods for valuing recreational fishing benefits.

The following is a brief summary of the issues involved in estimating the marginal value of recreational fish at a specific site such as IPEC:

1. *Travel Costs as Indicators of Willingness to Pay.* Travel costs to fishing sites include costs associated with vehicle use (e.g., gasoline and wear and tear on a personal vehicle) and the opportunity cost of time spent traveling. For a particular fishing site, different anglers face different travel costs. Similarly, an individual angler faces different travel costs for sites with differing characteristics (e.g., expected catch rates). Travel costs do not capture anglers' complete willingness to pay for recreational fishing trips to a site, but analysis of travel costs does allow for the estimation of anglers' responses to changes in variables that influence anglers' willingness to pay. The actual decisions made by anglers

Appendix D: Recreational Fishing Benefits

in response to differences among available sites—the anglers' "revealed preferences"[28]—provide an economically sound basis for estimating the value of recreational fishing opportunities and of fishing site attributes such as the expected fishing success or catch rate at a site (Freeman 2003).

2. *Models of Recreational Fishing Demand.* Economists have developed two basic empirical approaches that use travel costs to estimate the values that recreational anglers place on the marginal pound of fish caught: (1) the travel cost model of recreation demand ("TCM") and (2) the random utility model ("RUM") (Freeman 2003). The development of valid recreational fishing demand models using either TCM or RUM requires careful implementation (Freeman 2003 and Lesser, Dodds and Zerbe 1997). Data on recreational fishing trips are generally from surveys of actual fishing trips; a sound empirical analysis should ensure that the design and administration of the surveys avoid various types of bias (e.g., sampling bias, non-response bias). Additionally, since travel costs include the opportunity cost of time spent traveling, the analysis should include reasonable assumptions about the value of anglers' time. If these and other considerations (e.g., model specification) are handled appropriately, an analysis using either a TCM or RUM can produce useful valuation estimates that incorporate data on the actual behavior of anglers.

3. *Benefits Transfer using Pre-existing Studies.* Most benefit-cost analyses of regulations or permitting decisions do not attempt to develop original empirical studies. Instead, they rely on "benefits transfer" methods, which involve synthesizing results from pre-existing studies of recreational fishing benefits at similar sites into a valuation estimate for the specific site(s) under consideration. Benefits transfer methods can use the results from one or, ideally, numerous pre-existing valuation studies.

4. *Estimate a Marginal Benefits Curve using Meta-analysis.* A meta-analysis combines the results from various empirical studies by using statistical methods to fit a base model that provides a theoretical relationship between common study variables. In addition to utilizing sound statistical analysis, studies are suitable for inclusion in the meta-analysis if they are comparable to the site under consideration in regard to geographic location and fish species. Although studies may have different results for the value placed on additional catch, these differences may arise from widely different circumstances. For example, two studies of recreational fishing benefits may provide different results for the marginal value of an additional fish caught, but the results may reflect differences in the initial catch rate, i.e., the "baseline" catch rate to which the marginal fish caught is

[28] There are two methods that can be used for estimating anglers' willingness to pay for recreational fishing opportunities. The first is the "stated preference" method, where hypothetical questions are posed to consumers in a survey (Freeman 2003). The second and more traditional method is the "revealed preferences" method, which involves observing how consumers' preferences for a product are revealed by their market behavior in response to changes in the price or quality of a product. Although some recreational fishing studies have used stated preference valuation techniques, many economists are concerned that estimates of willingness to pay based on these techniques may not reflect actual values, as survey respondents may not actually behave in accordance with estimates of their WTP based on stated preference techniques (Portney 1994). Accordingly, where data of actual behavior is available, revealed preference techniques are preferred.

Appendix D: Recreational Fishing Benefits

additional. The study with the lower marginal value might be based on an area where recreational anglers already catch many fish, while the study with the higher marginal value might be based upon an area where recreational anglers typically catch relatively few fish. In this case, the studies' results would not be inconsistent; they could simply represent different points on a single curve that relates the marginal value of an additional fish caught to the initial catch rate. The result of the meta-analysis is an estimated marginal benefit curve, representing the value of additional catch to recreational anglers for varying site characteristics.

5. *Develop an Estimate of Marginal Fish Value to Recreational Anglers.* The results of the meta-analysis can be applied to the characteristics of the site under consideration to develop an estimate for the value of additional catch to recreational anglers at that site. For example, if the result of the meta-analysis includes the relationship between the expected catch rates and marginal fish values, the expected catch rate at the site under consideration can be used to estimate the marginal recreational fish value at that site.

2. Recreational Fishing Benefits

EPA (2011) provides an example of using the methodology outlined above based upon a national meta-analysis in its assessment of recreational fishing benefits for the proposed 316(b) Replacement Rule. Marginal values per fish for the species affected by I&E mortality were estimated using benefits transfer from a meta-analysis of 48 studies published between 1982 and 2004, with a sample of 391 observations of marginal values per fish (EPA 2011). The studies cover geographic regions throughout the United States and a wide variety of species caught in these regions.

The EPA meta-analysis (Johnston et al. 2006) included studies that used several different methods (including revealed and stated preference techniques), many different species, and different parts of the country. The benefit transfer function for the meta-analysis of recreational fishing studies was assumed to have the following form:

$$\ln(WTP) = intercept + \sum (coefficient_i)(Independent\ Variable\ Values_i)$$

The dependent variable is the natural log of the willingness-to-pay for catching an additional fish, and the independent variables characterize the species being valued, study location, baseline catch rate, elicitation and survey methods, demographics of survey respondents, and other specific characteristics of each study (EPA 2011, p. 7-2). The values for the various methodological attributes are set at the mean values from the metadata unless theoretical considerations dictate alternative specifications (EPA 2011, p. 7-3).

EPA uses regression analysis to estimate the coefficients of the functional equation described above. The regression equation is then used to predict the marginal values per fish. EPA excludes the error term in predicting marginal fish values, which results in benefits estimates that are more conservative and more consistent with the underlying studies (EPA 2011, p. 7-3).

Finally, to calculate the recreational welfare gain for each 316(b) regulatory alternative, EPA multiplied the marginal value per fish by the change in the number of fish that are lost due to I&E mortality that would otherwise be caught by recreational anglers (EPA 2011, p.7-6).

B. Estimating Recreational Fishing Benefits at IPEC

Following EPA (2011) and the general methodology outlined above, recreational fishing benefits at IPEC are calculated by multiplying the estimated changes in recreational fish harvests by an estimate of the marginal value per fish. The remainder of this appendix summarizes our methodology, focusing on the methodology we use to estimate that marginal value per fish.

1. Changes in Recreational Fish Harvests

We calculate gains in recreational harvest based on estimates of the total theoretical additional harvest and the percentage of that additional harvest that is caught by recreational fishermen. The estimates of annual theoretical additional harvest due to CWWS and Cooling Towers at IPEC are from ASAAC (2013) and are described in detail in Chapter IV. The estimates of the proportions attributed to recreational fishing are based on commercial and recreational landings data from NOAA, and is described in detail in Appendix B.

2. Marginal Value of Recreational Fish at IPEC

We follow the general methodology outlined in the previous section to estimate the marginal value of recreational fish at IPEC. Rather than use the EPA meta-analysis, however, we develop our own meta-analysis that is focused on the specific application to IPEC. Although the Johnston et al. (2006) includes a large number of studies and observations, the vast majority of these studies and observations relate to different species and different locations than the species and locations relevant for I&E reductions at IPEC. Moreover, EPA's use of a single estimate of the coefficient on catch rate for the wide range of species and locations makes applying the estimate to specific sites and species problematic. Thus, we use a more focused benefits transfer method—that involves a meta-analysis of relevant studies of recreational fishing benefits to determine the relationship between the catch rate and the value per fish—to develop our estimate of the social benefits of additional recreational catch due to CWWS or Cooling Towers.

a. Benefits Transfer Method

An original study of the species and areas relevant to the recreational fishing benefits evaluated in Chapter IV would require the development of an extensive dataset and accompanying data analysis. Many studies using TCM and RUM methods (in which willingness-to-pay is based on travel costs, as described above) have valued the benefits of improved recreational catch rates for a variety of fish species, fishing modes, and fishing locations relevant to IPEC. A benefits transfer approach—in which studies are chosen based on their quality and relevance to recreational fishing benefits at IPEC—is thus likely to provide reasonable estimates of marginal fish values.

b. Overview of the Meta-analysis

We developed a meta-analysis to estimate the relationship between the marginal value that recreational anglers place on fish caught or harvested and the average per-trip catch rate. This constitutes a marginal benefit curve for recreationally caught fish. The meta-analysis draws on studies that are particularly relevant to reductions in I&E at IPEC. The recreational benefits of the fish-protection alternatives are expressed in terms of the estimated number of additional fish that recreational anglers would harvest (i.e., catch and keep). Thus, the meta-analysis assesses values placed on the number of recreationally caught or harvested fish for locations and species relevant to the evaluated benefits. The study results included in the meta-analysis either provide, or allow the calculation of, estimates of the marginal value of a caught or harvested fish for the particular conditions evaluated in that study, specifically, the particular initial catch rate to which the estimated marginal value applies.

Catch rates for harvested fish are related to overall catch rates, which include harvested fish plus fish that are caught and released. Although the biological estimates of recreational fishing benefits in Chapter IV report only increases in number of harvested fish, such increases would likely coincide with increases in fish that are caught and released. Recreational anglers generally value catching fish, even if they do not keep (harvest) them. Because harvest catch rates and overall catch rates are related, the meta-analysis can, as described below, effectively estimate marginal values for number of harvested fish that include the values for corresponding caught and released fish.

Our meta-analysis involves four steps:

1. Develop the base model to determine the appropriate shape for the marginal benefit curve;

2. Obtain/select the relevant recreational fishing benefits studies;

3. Identify usable valuation results and corresponding catch rates; and

4. Use valuation and catch rate inputs to estimate the marginal benefit curve.

The estimated marginal benefit curve shows how the marginal value of a fish depends on the catch rate (within the range of the catch rates included in the meta-analysis). Given an appropriate catch rate for the recreational fishing benefits evaluated in Chapter IV, the estimated marginal benefit curve can provide a value for the recreational benefits.

c. Basic Statistical Model

Figure D-1 illustrates a hypothetical relationship, based on standard economic theory, between the value that an angler assigns to a recreational fishing trip and the number of fish caught or harvested (or expected to be caught or harvested) on the trip. As the number of fish caught or harvested increases, the value of the trip increases. However, as the number of fish increase, the value of each additional fish decreases. Formally, the value of the marginal fish decreases as the

Appendix D: Recreational Fishing Benefits

number of fish increases. The marginal value is the derivative of the function that relates the value of the fishing trip to the number of fish caught or harvested. The slope of the value curve at a given point is the marginal value at that point, i.e., at that catch rate.

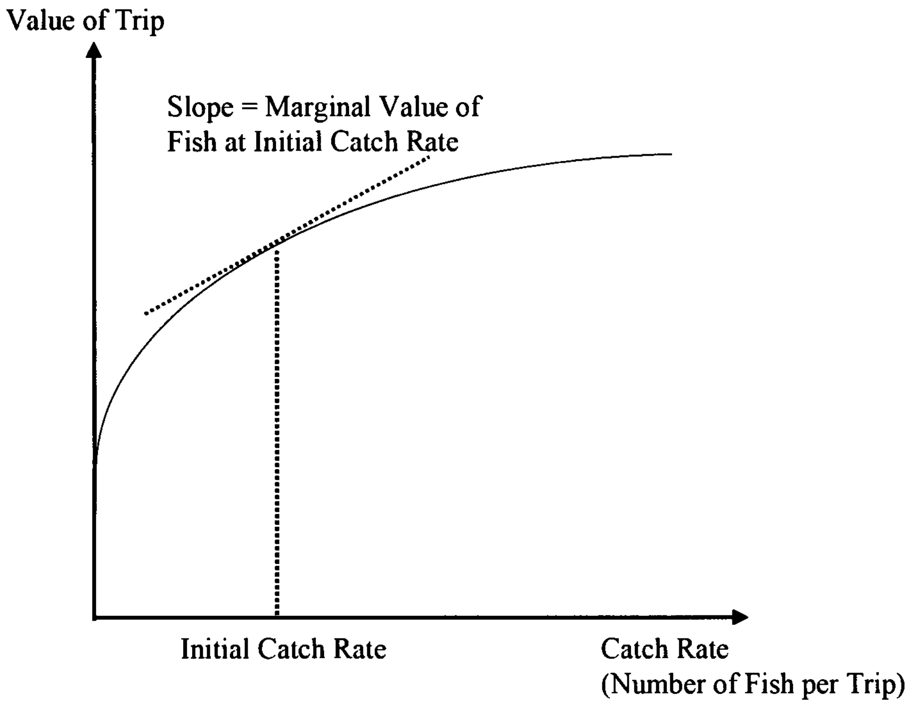


Figure D-1. Hypothetical Relationship between Value of Recreational Fishing Trip and Catch Rate

Suppose the marginal values from the hypothetical value curve in Figure D-1 have the relationship to the number of caught or harvested fish shown in Figure D-2. The curve is a hypothetical marginal benefit curve for the number of fish caught or harvested on a recreational trip. Given an initial catch rate, the curve shows the marginal value of an additional caught or harvested fish. As the catch rate increases, the marginal value of an additional fish decreases.

Appendix D: Recreational Fishing Benefits

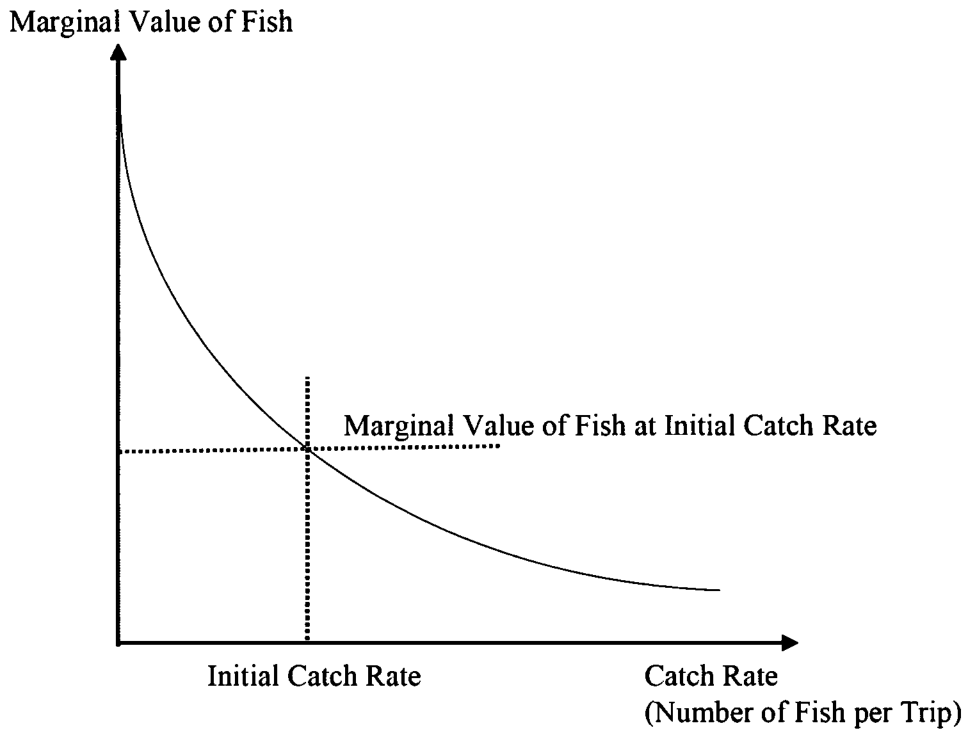


Figure D-2. Hypothetical Relationship between Marginal Value of Fish and Catch Rate

The meta-analysis assumes, as depicted in the hypothetical value curve, that the dollar value of a trip, V, depends on the square root of number of fish caught or harvested. Formally,

$$V = \alpha + \beta\sqrt{catch}\ , \qquad (1)$$

where $catch$ is the number of fish caught or harvested during the trip, and α and β are parameters specific to the curve. The form of this curve is consistent with the economic theory of diminishing marginal returns and with specifications used in the valuation literature (see e.g., Hicks et al. 1999, Gautam and Steinback 1998, and EPA 2011). From Equation (1), the marginal value, MV, of additional caught or harvested fish is:

$$MV = \frac{\partial V}{\partial catch} = \frac{\beta}{2\sqrt{catch}} \qquad (2)$$

The meta-analysis estimates the value of β based on the values of MV and $catch$ implied by results from the relevant literature. Specifically, the meta-analysis estimates marginal value using the equation:

$$MV = \frac{\partial V}{\partial catch} = \frac{\beta}{2\sqrt{catch}} + \varepsilon, \qquad (3)$$

Appendix D: Recreational Fishing Benefits

where ε is an error term. Given appropriate catch rates, such results translate readily into the dependent and independent variables ($\partial V/\partial catch$ and $1/\left(2\sqrt{catch}\right)$, respectively) in Equation 3.

Each study included in the meta-analysis provides a single data point which consists of a catch rate and a valuation result (in a form suitable for Equation 3).

d. Relevant Fishing Value Studies

From scores of potentially applicable studies of recreational fishing benefits that vary in scope by geographic location, type of water body (*e.g.,* bays, lakes, rivers, or oceans), type of fishing (shore fishing, private boat fishing, or charter boat fishing), targeted species, and estimation methodology, our meta-analysis includes studies selected according to four criteria (based on the guidance of EPA 2010, 2011):

1. *Location*. Studies that evaluate recreational fishing benefits for marine or tidal river locations on the Atlantic coast are presumed to be relevant.

2. *Fish species*. Because striped bass account for the vast majority of the estimated increases in recreational harvest from reduced I&E at IPEC (as shown in Chapter IV), we focused on studies that evaluate recreational fishing benefits for that species or more general evaluations for small game species (which include striped bass). We developed meta-analysis results for striped bass and small game collectively, but the different fish species potentially affected by implementation of fish-protection alternatives at IPEC have different values, and some species (e.g., *Alosa* sp.) probably have lower value to recreational anglers than we assign them based on the results for striped bass and small game from our meta-analysis. Our use of a marginal value for striped bass and small game for all species is thus a conservative assumption that tends to overstate the benefits of fish-protection alternatives at IPEC.

3. *Sound analysis*. Relevant studies should exhibit sound economic analysis. In particular, sampling protocols and estimation techniques in any included study should follow reasonable economic practice. The studies chosen are limited to those that employ either TCM or RUM approaches.

4. *Sufficient information*. The studies must report enough information about their results for the development of usable catch rates and valuation results for the meta-analysis. Note that in some cases the studies did not report complete details about the catch rates, but we were able to use data from the National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS) to develop the appropriate inputs.

These criteria allow the meta-analysis to include many studies (to improve the precision of the meta-analysis results) while excluding studies that lack quality or direct applicability to the current case (to avoid compromising the accuracy or relevance of the meta-analysis results). Table D-1 lists the studies included in the meta-analysis and identifies the locations and species evaluated in each study.

Table D-1. Studies Included in NERA Meta-Analysis

Authors	Publication	Location	Species
Gautam and Steinback	1998	VA to ME	Striped bass
Haab et al.	2000	FL to VA	Small game
Haab et al.	2009	FL to NC	Small game
Hicks et al.	1999	VA to ME	Small game
Norton et al.	1983	DE to NY	Striped bass
EPA	2004	DE to NJ	Striped bass
EPA	2004	DE to NJ	Small game

Developing the inputs for these studies involved the use of supplemental NMFS and FWS data related to catch rates. Specifically, NMFS data were used to estimate the total amount of recreational catch in each location and time period (including fish caught and released). FWS data were used to estimate the total number of trips for striped bass or small game in each location and period. The NMFS and FWS data were combined to estimate catch rates per trip for striped bass or small game.

e. Meta-Analysis Inputs

Table D-2 lists the data points included in the meta-analysis from each study. Some of the studies supply multiple inputs for the meta-analysis, because they develop values for multiple locations, species, or valuation methods, all of which fall within the bounds of the selection criteria. As noted above, the data points included in the meta-analysis reflect the combination of study results with supplemental NMFS and FWS data.

Table D-2. Inputs for NERA Meta-Analysis

			Originally Catch or	Initial Catch Rate (fish/trip)		Marginal Value (2012$/fish)	
Study	Method	Species	Harvest?	Catch	Harvest	Catch	Harvest
Gautam and Steinback (1998)	TCM	Striped bass	Catch	1.26	0.07	$6.12	$109.11
Gautam and Steinback (1998)	RUM	Striped bass	Catch	1.71	0.10	$4.59	$81.89
Haab et al. (2000)	RUM	Small game	Harvest	1.43	0.68	$4.22	$8.94
Haab et al. (2009)	RUM	Small game	Harvest	3.06	1.25	$1.30	$3.19
Hicks et al. (1999)	RUM	Small game	Catch	7.96	4.47	$3.90	$6.93
Norton et al. (1983)	TCM	Striped bass	Catch	0.48	0.33	$15.48	$22.27
EPA (2004)	RUM	Striped bass	Catch	2.48	0.23	$19.37	$207.36
EPA (2004)	RUM	Small game	Catch	2.32	1.21	$8.26	$15.81
Average						$7.91	$56.94

Note: Norton et al. (1983) estimate a discrete increase in value from an additional number of fish caught, and all other studies estimate marginal values.

Source: NERA calculations based on study values, NMFS (2013), and FWS (various years) as explained in text

As discussed above, to use study results that are reported in terms of overall caught fish (harvested fish plus caught and released fish), the meta-analysis assumes that, for a specific location and species (and other trip characteristics), the harvest catch rate and the overall catch rate are proportional. This assumption reflects the idea that, at a single site, marginal values estimated in terms of overall caught fish should agree (when scaled appropriately) with marginal values estimated in terms of harvested fish. Under this assumption, study results that are reported in terms of overall caught fish can be translated directly into equivalent results in terms of harvested fish (i.e., fish caught and kept).

For example, two economists may each perform a valuation study at the same site, but one may focus on harvested fish and the other on overall caught fish (including those caught and released). The two should agree as to the overall value of an average trip to that site. Suppose the estimated value of an additional fish caught (harvested plus catch-and-release) in one study is $10. If anglers could expect, on average to keep one fish for every three caught, then we would expect a study that estimated the marginal value of a fish *harvested* to be about 3 x $10 = $30. Note that the latter estimate of value per fish caught in fact captures the value of the two additional fish caught but not kept for every fish harvested. We could use either value in a benefits-transfer study so long as the value per fish was applied to the corresponding change in total catch or in harvest.

Under the assumption described above, the meta-analysis can include studies that report results in terms of overall caught fish (i.e., harvest plus catch-and-release) or in terms of harvest only. NMFS data allow the translation of study results reported in terms of overall caught fish into equivalent results in terms of harvested fish, and vice versa. Additionally, because one harvested fish is equivalent to more than one overall caught fish, the estimated marginal value of harvested fish includes the marginal value of the additional fish that are caught but released. Table D-2 shows whether each study originally evaluated overall catch or harvested fish. Catch rates per trip and marginal values per fish were developed for all studies in terms of both overall catch and harvest.

f. Results of NERA Meta-Analysis

Table D-3 presents the results of two OLS regressions based on the functional form displayed in Equation 3 and the marginal values in Table D-2 in terms of total catch and harvest. The estimated value of the coefficient β is $20.07 for the meta-analysis in terms of total catch and $66.76 for the meta-analysis in terms of harvest.

Table D-3. Regression Results of NERA Meta-Analysis

	Catch	Harvest
Estimated β	20.07	66.76
Standard error of β	4.88	19.43
Adjusted R^2 of regression	0.71	0.63
Standard error of equation	5.70	57.64

Source: NERA calculations as explained in text, based on the information in the studies included in the meta-analysis as well as NMFS (2013) and FWS (various years)

The estimated marginal value (2012$) in terms of total catch rate is thus:

$$MV = \frac{\partial V}{\partial catch} = \frac{\$20.07}{2\sqrt{catch\ (total)}} = \frac{\$10.04}{\sqrt{catch\ (total)}} \quad \textbf{(4)}$$

The estimated marginal value (2012$) in terms of harvest rate is thus:

$$MV = \frac{\partial V}{\partial catch} = \frac{\$66.76}{2\sqrt{catch\ (harvest)}} = \frac{\$33.38}{\sqrt{catch\ (harvest)}} \quad \textbf{(5)}$$

We used data from NMFS (2013) and FWS (various years) to estimate the catch rate per trip for additional fish caught or harvested due to reduced I&E at IPEC. Table D-4 presents information on recreational striped bass fishing trips, total striped bass recreational catch (including catch-and-release), and striped bass recreational harvest in New York from 2007 to 2011.

Table D-4. Striped Bass Trips, Total Catch, and Harvest in New York (2007-2011)

Trips (millions)	10.7
Total catch (millions of fish)	8.3
Harvest (millions of fish)	2.7
Ratio of total catch to harvest	3.1
Catch rate per trip: Total catch	0.77
Catch rate per trip: Harvest	0.25

Source: NERA calculations based on NMFS (2013) and FWS (various years)

Based on these numbers, the catch rate in terms of total catch is 0.77 fish per trip, and the catch rate in terms of harvest is 0.25 fish per trip. Using these catch rates, the marginal value in terms of total catch (based on Equation 4) is $11.45 per fish caught, and the marginal value in terms of harvest (based on Equation 5) is $66.84 per fish harvested.[29]

As discussed in Chapter IV, ASAAC (2013) provided estimates of theoretical increases in fish harvests from reducing I&E at IPEC. The marginal value above in terms of total catch can be converted to a marginal value in terms of harvest using the ratio of total catch to harvest in Table D-4. This yields $35.28 per fish harvested, which is lower than the marginal value from the meta-analysis directly in terms of harvest ($66.84 per fish). We used the higher marginal value in terms of harvest ($66.84 per fish) to develop benefits estimates.

C. Comparison with Results Using EPA Meta-Analysis

As described above, EPA's proposed 316(b) Replacement Rule uses a meta-analysis of 48 studies published between 1982 and 2004, with a sample of 391 observations of marginal values per fish (EPA 2011). As discussed above, however, the majority of these studies and observations relate to different species and different locations than the species and locations relevant for I&E reductions at IPEC. Moreover, EPA's use of a single estimate of the coefficient on catch rate for the wide range of species and locations makes applying the estimate to specific sites and species somewhat problematic. Despite these limitations of the EPA meta-analysis, it is useful to compare the estimate above from our meta-analysis with the corresponding information from EPA's meta-analysis.

[29] Note that the catch rates shown in the text are rounded. Catch rates used to calculate values per fish caught and per fish harvested were at a greater precision than values shown in the text.

EPA (2011, p. 7-5) estimated that additional overall catch of small game in the Mid-Atlantic region has a marginal value of $5.88 per fish caught per trip day (2009$). Based on the GDP price inflator, this is $6.19 per fish caught per trip day (2012$). EPA mentions in a footnote in an earlier version of this analysis that:

> Although some studies included both multiple and single day trips, the average angling trip length was often not provided. However, the majority of recreational angling trips are single-day trips. According to the 2001 National Survey of Hunting, Fishing, and Wildlife Associated Recreation (FWS, 2002), the average angling trip length was 1.27 days. (EPA 2006, p. A5-13, footnote 5)

Thus, converting EPA's marginal value of an additional fish per day into the marginal value of an additional fish per trip, using the suggested scaling factor of 1.27, yields an estimate of $7.86 per fish caught per trip (2012$). As shown above in Table D-4, NMFS and FWS data indicate that about 3.1 striped bass are caught overall in New York for each fish harvested. Thus, the EPA marginal value of $7.86 per fish caught can be converted for IPEC to $24.37 per fish harvested (2012$).

This EPA value can be compared to the marginal value we calculate. In terms of harvested fish, the marginal value we use for our benefits estimates ($66.84 per fish harvested) is substantially higher than the marginal value of $24.37 derived from EPA (2011).

D. References

Arrow, Kenneth, Robert Solow, Paul Portney, Edward Leamer, Roy Radner, and Howard Schuman. 1993. *Report of the NOAA Panel on Contingent Valuation*. January 11.

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

Fish and Wildlife Service (FWS). Various years. *National Survey of Fishing, Hunting, and Wildlife-Related Recreation*. Various states. Washington, DC: FWS.

Freeman, A. Myrick III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. 2nd ed. Washington, DC: Resources for the Future.

Gautam, A. and S. Steinback. 1998. "Valuation of recreational fisheries in the north-east—U.S. striped bass: a case study." Chapter 23 in *Recreational Fisheries: Social, Economic and Management Aspects*.

Haab, Timothy C., John C. Whitehead, and Ted McConnell. 2000. "The Economic Value of Marine Recreational Fishing in the Southeast United States—1997 Southeast Economic Data Analysis." July.

Haab, Timothy, Robert Hicks, Kurt Schnier, and John C. Whitehead. 2009. "Angler Heterogeneity and the Species-Specific Demand for Marine Recreational Fishing." November 2.

Hicks, Rob, Scott Steinback, Amy Gautam, and Eric Thunberg. 1999. "Volume II: The Economic Value of New England and Mid-Atlantic Sportfishing in 1994." NOAA Technical Memorandum NMFS-F/SPO-38. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. August.

Johnston, Robert J, Matthew H. Ranson, Elena Y. Besedin and Erik Helm. 2006 "What Determines Willingness to Pay per Fish? A Meta-Analysis of Recreational Fishing Values." *Marine Resource Economics*. Vol. 21: 1-32.

Lesser, Jonathan A., Daniel E. Dodds, and Richard O. Zerbe, Jr. 1997. *Environmental Economics and Policy*. New York: Addison Wesley.

National Marine Fisheries Service (NMFS). 2013. "Recreational Fisheries Statistics Queries." www.st.nmfs.noaa.gov/st1/recreational/queries/custom_time_series.html.

Norton, Virgil, Terry Smith, and Ivar Strand. 1983. "Stripers: The Economic Value of the Atlantic Coast Commercial and Recreational Striped Bass Fisheries." College Park, MD: University of Maryland.

Portney, Paul. 1994. "The Contingent Valuation Debate: Why Economists Should Care." *Journal of Economic Perspectives* 8(4): 3-17.

Tietenberg, Thomas H and Lynne Lewis. 2008. *Environmental and Natural Resource Economics*. 8th ed. New York: Addison Wesley.

U.S. Environmental Protection Agency (EPA). 2006. *Section 316(b) Final Rule: Phase III – Regional Benefits Assessment, Part A: Evaluation Methods*. Chapter A5: Recreational Fishing Benefits Methodology. Washington, DC: EPA, October.

U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses*. Washington, DC: EPA, December.

U.S. Environmental Protection Agency (EPA). 2011. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule, Chapter 5: Recreational Fishing Benefits Methodology*. Washington, DC: EPA, December.

Appendix E: Assessment of Potential Non-use Benefits

This appendix summarizes our assessment of potential non-use benefits from cylindrical wedgewire screens (CWWS) and Cooling Towers at IPEC. The appendix provides background on the nature of non-use benefits, summarizes relevant biological information regarding the impacts of impingement and entrainment (I&E) at IPEC, and discusses guidance from various sources—including EPA and the economics literature—for assessing the potential significance of non-use benefits in situations in which no empirical study is available. We are not aware of any study that has assessed the potential non-use benefits of reducing I&E at IPEC or any study that could be used appropriately to provide the basis for assessing non-use benefits due to reduction in I&E at IPEC. The economics literature provides information on the only method that can be used to monetize non-use benefits—surveys of willingness-to-pay—noting their substantial cost and the difficulty of developing reliable estimates.

Economists also have considered the circumstances in which non-use benefits are likely to be significant and these analyses provide the bases for a qualitative assessment of non-use benefits of installing CWWS or Cooling Towers at IPEC. These assessments indicate that non-use benefits are not likely to be significant when the gains are to a subpopulation of a widely dispersed wildlife species—which the biological information indicates is the situation in this case—and thus we conclude that installing CWWS or Cooling Towers at IPEC is not likely to generate significant non-use benefits.

A. Background on Non-use Benefits

1. Nature of Potential Non-use Benefits

As noted in Chapter IV, EPA materials and the economic literature include discussions of benefits not associated with any direct use by people. Non-use benefits may arise if people value the change in an ecological resource without the prospect of using the resource or enjoying the option to use it in the future. The EPA *Guidelines*, for example, note that there are various possible types of non-use values.

1. Bequest value, where an individual places a value on the availability of a resource to future generations;

2. Existence value, where an individual values the mere knowledge of the existence of a good or resource; and

3. Paternalistic altruism, where an individual places a value on others' enjoyment of the resource (EPA 2010, p. xiv).

The *Guidelines* note that environmental policies may have non-use benefits from improvements to "relevant species populations, communities, or ecosystems" (EPA 2010, p. 7-9). In terms of improvements to relevant species populations, for instance, people may attach non-use benefits to preserving a threatened or endangered species (EPA 2010, p. 7-18).

2. Developing Monetary Values for Non-use Benefits

As the *Guidelines* and other commentators note, the potential monetary value of these non-use benefits cannot be measured using the traditional market-related techniques that economists have developed to measure use benefits. These traditional methods involve using market prices, either directly or indirectly, to provide information on the value that households place on environmental goods and services. The *Guidelines* note that non-use benefits can be estimated only through stated preference (SP) valuation methods. In SP methods, surveys are designed to elicit information on the value that people would attach to hypothetical scenarios (EPA 2010, p. 7-18). As the *Guidelines* note, however, a major disadvantage of SP methods is that they may be subject to systematic biases that are difficult to test for and correct (EPA 2010, p. 7-35). Moreover, as many analysts have pointed out, it is difficult, time-consuming, and expensive to undertake surveys to estimate non-use benefits.

There is a large literature on SP techniques and the means that might be used to avoid systematic biases and other potential problems. As the *Guidelines* note, a report prepared by a panel of experts convened by the National Oceanic and Atmospheric Administration (NOAA) is often cited as a primary source of guidelines for SP techniques. The panel consisted of five distinguished economists—including two Nobel laureates, Kenneth Arrow and Robert Solow—and considered the usefulness of SP for policy analysis. Their report (Arrow et al. 1993) provides an extensive set of guidelines for survey construction, administration, and analysis. In the Panel's view, "...the more closely the guidelines are followed, the more reliable the result will be" (p. 4609). The report also provides a list of key elements that it considers "burden of proof requirements" in order to develop a valid survey (p. 4609).

Given these guidelines and burden of proof requirements, the Arrow-Solow Panel concludes its report noting that:

> [U]nder those conditions (and others specified above), CV [contingent valuation[30]] studies convey useful information. We think it is fair to describe such information as reliable by the standards that seem to be implicit in similar contexts, like market analysis for new and innovative products and the assessment of other damages normally allowed in court proceedings. ...CV [contingent valuation] produces estimates reliable enough to be the starting point of a judicial process of damage assessment, including passive use values [i.e., nonuse values] (p. 4610).

The validity of SP techniques and studies has been the source of much subsequent discussion and commentary in the academic literature as well as in textbooks on benefit-cost analysis and environmental economics. Boardman et al. (2011) point out that although estimating the value of a "unique and long-lived" resource is important, the methods that currently exist lack sufficient reliability to be reasonably included in cost-benefit analysis in most cases (p. 228). Kolstad (2011) similarly explains that SP surveys are controversial because they do not reflect real

[30] Stated preferences studies are sometimes referred to as "contingent valuation" studies.

choices (p. 207). A recent symposium considered comments from supporters and detractors of the approach.[31]

Given the difficulties of developing a valid SP study, various commentators have suggested first assessing whether non-use values are likely to be significant before undertaking a study to estimate them.[32] Bateman et al. (2002), for example, note that "[o]ne of the issues to be determined before commissioning a study is the extent to which non-use values are likely to be important" (p. 74). The economic literature provides a basis for qualitative assessments by identifying the circumstances in which non-use values are likely to be significant.

3. Implications for Potential Non-use Benefits of CWWS or Cooling Towers at IPEC

The fact that non-use benefits are expensive and difficult to assess with accuracy suggests the usefulness of determining in the first instance whether non-use benefits are likely to be significant and thus whether monetization is justified. For this analysis, it is useful first to clarify the nature of theoretical biological benefits from CWWS and Cooling Towers at IPEC. This information can be used to judge likely significance of non-use benefits and also provide the basis for a qualitative assessment.

B. Overview of Relevant Biological Information on CWWS and Cooling Tower Benefits

To evaluate whether installation of CWWS or Cooling Towers at IPEC could lead to significant non-use benefits, it is useful to begin with assessments of the theoretical biological impacts of IPEC I&E. For biological assessments, we rely primarily upon information developed by the National Marine Fisheries Service and by Barnthouse et al. (2002), Van Winkle and Young (2008), Barnthouse et al. (2008), Barnthouse et al. (2010), and Barnthouse (2013). In this section, we summarize the relevant biological assessments, first for threatened and endangered species and then for other species.

1. Threatened and Endangered Species Affected by CWWS and Cooling Towers at IPEC

Entergy (2007), NRC (2010), and the CWWS SEQRA report provide information on the species that have been impinged and entrained at IPEC. Of these species, only two have special status as threatened or endangered species: (1) shortnose sturgeon; and (2) Atlantic sturgeon. The shortnose sturgeon has been listed as an endangered species by the federal government since 1967 (FWS 2013) and the New York State Department of Environmental Conservation (DEC) since 1973 (DEC 2013). The Atlantic sturgeon has been listed as an endangered species in the New York Bight by the federal government since 2012 (NOAA 2013) but does not have special

[31] The symposium is in the Fall 2012 issue of the *Journal of Economic Perspectives* (Volume 26, Number 4). See Kling et al. (2012), Carson (2012), and Hausman (2012).

[32] This presumes that an appropriate existing study is not available that could be used directly or as the basis for a valid benefit transfer application.

status from DEC. Both species forage in the part of the Hudson River where IPEC is located, but they spawn further north. Their migratory and spawning patterns make them susceptible to impingement at IPEC but not susceptible to entrainment.

a. National Marine Fisheries Service Biological Opinion on Potential Impacts of IPEC

The National Marine Fisheries Service (NMFS) prepared a recent report to the U.S. Nuclear Regulatory Commission (NRC) regarding IPEC's impacts under the current configuration on shortnose and Atlantic sturgeon. The following is a summary of the conclusions:

> After reviewing the best available information on the status of endangered and threatened species under NMFS jurisdiction, the environmental baseline for the action area, the effects of the proposed action, interdependent and interrelated actions and the cumulative effects, it is NMFS' biological opinion that the continued operation of Indian Point Unit 2 [and Unit 3] is likely to adversely affect but is not likely to jeopardize the continued existence of shortnose sturgeon or the New York Bight, Gulf of Maine or Chesapeake Bay DPS [distinct population segment] of Atlantic sturgeon (NMFS 2013, p. 126).

As noted in this excerpt, the NMFS conclusion is based on detailed review of species range and population trends as well as substantial historical data on I&E at IPEC. In terms of range and population trends for shortnose sturgeon, NMFS notes "anecdotal evidence that shortnose sturgeon are expanding their range in the Hudson River" and "evidence that the Hudson River population of shortnose sturgeon experienced tremendous growth between the 1970s and 1990s and that the population is now stable at high numbers" (p. 115). For Atlantic sturgeon, NMFS notes that "the available information on trends indicates that there may be a slight increasing trend in juvenile abundance in the Hudson River since the mid-1990s" (p. 122).

Regarding entrainment at IPEC, NMFS notes that "[b]ased on the life history of the shortnose sturgeon [and Atlantic sturgeon], the location of spawning grounds within the Hudson River, and the patterns of movement for eggs and larvae, it is extremely unlikely that any shortnose sturgeon [or Atlantic sturgeon] early life stages would be entrained at IP2 and/or IP3" (pp. 58-59).[33] Indeed, there is no evidence from historical I&E studies of entrainment of shortnose sturgeon or Atlantic sturgeon at IPEC (pp. 58-59). Thus, the focus of the NMFS analysis is on impingement impacts.

Based on historical impingement data for IPEC, NMFS assumes that 26 shortnose sturgeon would be impinged each year at IPEC, leading to a cumulative total of 562 impinged individuals over the NRC relicense period (through 2033 for Unit 2 and 2035 for Unit 3). NMFS further assumes that all impinged individuals would suffer mortality. While these deaths "will reduce the number of shortnose sturgeon in the population compared to the number that would have been present absent the proposed action [i.e., relicensing], it is not likely that this reduction in

33 NMFS uses the same language in two separate sections for evaluating impacts on shortnose sturgeon and Atlantic sturgeon.

numbers will change the status of this population or its stable trend" because the loss represents less than 1 percent of the relevant population of adult shortnose sturgeon (p. 117). For Atlantic sturgeon, NMFS concludes that "the death of an average of 19 juvenile New York Bight DPS [distinct population segment] Atlantic sturgeon annually for 23 years will not appreciably reduce the likelihood of survival of the New York Bight DPS (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment)" (p. 124).

For these reasons, NMFS concludes that although the current configuration at IPEC leads to impingement mortality for some shortnose and Atlantic sturgeon each year, these losses are "not likely to jeopardize the continued existence" of these species subpopulations in the Hudson River (p. 126). Thus, reducing or even eliminating I&E at IPEC is not likely to significantly improve the status of the species subpopulations. NMFS notes, however, that its report does not directly relate to construction of CWWS or Cooling Towers at IPEC, which would require a separate analysis (p. 12). This issue is addressed below.

b. Other Biological Evaluations on Potential Impacts of IPEC on Threatened and Endangered Species

Barnthouse et al. (2008, p. 7) report that they do not evaluate impacts on shortnose sturgeon "because there is broad consensus that CWIS at IP2 and IP3 have no impact [on shortnose sturgeon]." In a brief (2-page) "case study" for IPEC prepared by EPA as part of its analysis of the Replacement Rule, however, EPA notes that in April 2010, DEC denied Entergy's request for a Clean Water Act Section 401 Water Quality Certificate for IPEC and EPA indicates that that the "NYSDEC denial letter cited, among other concerns, continuing concerns over I&E mortality including potential impacts to two sensitive species—the Shortnose Sturgeon (currently listed as endangered) and the Atlantic Sturgeon (under consideration for endangered species status" (EPA 2011a, p. 2-21).

Barnthouse (2013) evaluates the information in the 2011 EPA case study with regard to concerns related to the two species in the context of the NYSDEC Staff denial letter. Barnthouse (2013) notes that EPA (2011a) failed to mention that a 1979 NMFS Biological Opinion stated that I&E at IPEC did not jeopardize the recovery of shortnose sturgeon. As noted above, this conclusion was reaffirmed by NMFS in its 2013 biological opinion. Barnthouse (2013) also notes that EPA (2011a) failed to mention that the 2003 Final Environmental Impact Statement (FSEIS) for Indian Point, Roseton, and Bowline Point "did not identify impacts of I&E on either sturgeon species as being of concern." Thus, Barnthouse (2013) concludes that the statements in EPA (2011a) about shortnose and Atlantic sturgeon are misleading and conflict with the NMFS (2013) conclusion that the CWIS at IPEC does not adversely affect the sustainability of shortnose and Atlantic sturgeon.

c. Assessment of CWWS and Cooling Tower Construction and Operation

The CWWS SEQRA report (TRC 2013) includes assessments of whether construction and operation of CWWS at IPEC would have an adverse impact on shortnose or Atlantic sturgeon.

Any potential adverse impacts from construction and operation of CWWS or Cooling Towers would tend to offset any potential non-use benefits of CWWS or Cooling Towers from reducing impingement of these species.

In terms of construction, the assessments in the CWWS SEQRA report note that sturgeon could be affected by dredging. They conclude, however, that any adverse impacts from construction would likely be small.

> Given the small area of the river bottom to be dredged, the use of tall sheet piling to isolate some dredge areas, the relatively low numbers of sturgeon likely to be in the dredging area, and the general construction noise and activity eliciting avoidance behavior, it is unlikely that either sturgeon species would be injured by the dredging equipment. Potential adverse impacts from indirect effects related to dredging, such as increased localized suspended sediments or loss of benthic prey, would be small (TRC 2013, Section 4.5.1.4).

These small construction impacts would occur only during the construction period for CWWS.

In terms of operation, the assessments in the main SEQRA report note that sturgeon could be affected by the air burst system (ABS). They conclude, however, that any adverse impacts from operation would likely be small.

> While there is a possibility that juvenile or adult sturgeon may occur in the vicinity of the CWWS during operation [of the air burst system], the effect would be to startle the sturgeon. However, given the small probability of the co-occurrence in time and space of sturgeon at the CWWS array, adverse impacts to juvenile and/or adult sturgeon would only be small from operation of the ABS were it to be installed (TRC 2013, Section 4.5.2.4).

Thus, while operation of CWWS at IPEC would reduce impingement of sturgeon, dredging during the construction period and use of the ABS during operation could have small adverse impacts on sturgeon. These would tend to offset any non-use benefits for CWWS at IPEC. The Response Report contains information related to the potential impacts of Cooling Tower construction and operation on sturgeon.

2. Other Species Affected by CWWS and Cooling Towers at IPEC

This section summarizes biological assessments for species that are not on a list of threatened or endangered species. We provide a summary of expert biological assessments of the health of the various species potentially affected at IPEC; these assessments conclude that reductions in I&E at IPEC would not lead to any measurable increase in fish populations. Note that this conclusion applies both to harvested species and forage species.

a. Biological Expert Assessments

This section summarizes information from four biological evaluations related to I&E at IPEC. The species addressed in these reports include both harvested species and unharvested forage species such as bay anchovy and spottail shiner. These expert reports conclude that eliminating I&E at IPEC would increase neither the abundance of harvested species available to fishermen nor the abundance of forage species that support the Hudson River food web.

- **Barnthouse et al. (2002)**

Barnthouse et al. (2002) evaluate whether I&E at Indian Point and two other power stations on the Hudson River—Roseton and Bowline Point—have reduced fish population levels. They conclude that I&E has not reduced population levels:

> The data presented in the DSEIS [Draft Supplemental Environmental Impact Study] indicate that changes that most fisheries biologists would view as "adverse" have not occurred. Further, changes that have occurred appear to be inconsistent with the impact hypotheses discussed above [whether I&E at the stations has reduced fish population levels] and, therefore, are not reasonably attributable to the stations (p. 3).

- **Van Winkle and Young (2008)**

Van Winkle and Young (2008) analyzed nineteen taxa/species of fish, including all fish modeled by ASAAC (striped bass, white perch, American shad, *Alosa* sp. [alewife and blueback herring], bay anchovy, and Atlantic tomcod). Van Winkle and Young note:

> If entrainment at IP2 and IP3 were having an adverse impact on the Hudson River fish community, then species with high susceptibility to entrainment would have decreased, or increased less in abundance, over the past 32 years than would species with low susceptibility (p. 1).

Van Winkle and Young (2008) conclude from their statistical analysis of entrainment susceptibility and abundance trends for the various species that I&E at IPEC is not responsible for changes in abundance:

> This result is opposite the expected significant negative correlation if Indian Point entrainment were adversely affecting the population trends of susceptible species. Therefore, the effect of Indian Point entrainment on abundance patterns, if there is one, is not large enough to be statistically detectable in the 32 years of monitoring data (p. 7).

- **Barnthouse et al. (2008)**

Barnthouse et al. (2008) conclude that "entrainment and impingement associated with cooling-water withdrawals by IP2 and IP3 have not had an adverse impact on Hudson River fish populations and communities" (p. 79). They note:

> Considered together, the evidence evaluated in this report shows that the operation of IP2 and IP3 has not caused effects on early life stages of fish that reasonably would be considered "adverse" by fisheries scientists and/or managers. The effects of mortality at IP2 and IP3 on the survival and abundance of susceptible populations cannot be detected, even after 30 years of intensive monitoring. Those changes that have occurred are more likely attributable to predation by the Hudson River's rapidly growing striped bass population (p. 79).

These conclusions are based upon two principal types of analyses.[34] First, Barnthouse et al. (2008) address the causes of decline in abundance of young-of-year white perch, Atlantic tomcod, bay anchovy, American shad, and river herring (*Alosa* sp.). They find that the declines of these populations are closely associated with overharvesting (in the case of American shad) and increased predation from a rebounding striped bass population in the Hudson River, rather than I&E at IPEC (p. 79).

Second, Barnthouse et al. (2008) find that, in the case of striped bass and American shad, entrainment and impingement mortality at IPEC is negligible compared to fishing mortality and does not affect the ability of the fish populations to sustain themselves (p. 11). Entrainment losses consist of mainly eggs and larvae which have low probability of surviving to adulthood. These losses are unlikely to affect an aquatic community in a manner that would demonstrate "Adverse Environmental Impact" (p. 12).

- **Barnthouse et al. (2010)**

An additional analysis documented in Barnthouse et al. (2010) found that "even if entrainment of fish larvae at Units 2 and 3 were completely eliminated, no measurable changes in the abundance of older, juvenile fish are likely to occur" (p. 47).

Barnthouse et al. (2010) notes that the species modeled by ASAAC account for the vast majority of losses at Hudson River power stations:

> In addition to being considered important due to their recreational, commercial, and ecological value, these species have historically accounted for more than 98% of fish larvae and 92% and of juvenile (YOY) fish captured, respectively, in the utilities' LRS [Long River Survey] and Beach Survey (p. 9).

They summarize the results of their analysis as follows:

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[34] Barnthouse et al. (2008) also summarize the results of previous analyses, including Van Winkle and Young (2008).

> These figures also show the range of increases that would be expected to occur if current levels of entrainment losses at IPEC were eliminated. For all taxa, the range of projected increases in numbers of age-1 equivalents due to eliminating entrainment is very small compared to the range of year-to-year increases calculated from historical data. Within this small range, decreases in corresponding abundance of juveniles have occurred as frequently as increases. The estimated probability of observing an increase in juvenile abundance, when the increase in PYSL abundance is within the range that would be projected due to elimination of entrainment, is not significantly different than 50:50 for any of the four taxa evaluated (p. 40).

Appendix C of Barnthouse et al. (2010), by AKRF, provides the following additional information regarding the analytical methodology and results:

> Field measurements of changes in juvenile abundance in response to increases in larval abundance have been recorded by the Long River Survey ("LRS"), Beach Seine Survey ("BSS"), and Fall Juvenile Survey ("FJS") for over 30 years on the Hudson River (field data documented in annual "Year Class Reports", e.g. EA, 1996). The historical data document what can be viewed as naturally-occurring experiments (i.e., the response of abundance at the juvenile lifestage to a change in abundance at the larval lifestage) of the effects of increases in riverwide post-yolk sac larva ("PYSL") abundance (that can be expressed in terms of age-1 equivalents) on changes in riverwide juvenile abundance. Those naturally-occurring experiments can be used to address the question of what demonstrable changes in fish populations can be expected from reducing entrainment losses at the IPEC Stations (Appendix C, p. 2)
>
> For each of the 4 taxa (American shad, river herring, striped bass and white perch), the projected range of potential annual increases in age-1 equivalents due to eliminating current entrainment losses associated with the Stations' operation is very small compared to the range of year-to-year increases in riverwide PYSL abundance calculated from historical data (Figures 13 through 16). Within the projected range of potential annual increases in age-1 equivalents due to eliminating current entrainment losses associated with the Stations' operation, the estimated probability of observing an increase in juvenile abundance is not significantly different than 50:50 for any of the 4 taxa (Table 2). Within that range, the estimated average annual change in juvenile abundance is not significantly different from zero for any of the 4 taxa (Appendix C, p. 8)
>
> Based on: (1) empirical relationships between year-to-year increases in riverwide PYSL abundance (expressed in terms of age-1 equivalents) and year-to-year changes in riverwide juvenile abundance, and (2) the projected ranges of relatively small potential increases in age-1 equivalents due to eliminating current entrainment losses associated with IPEC Stations' operation, no alternative intake technology considered as part of Entergy's alternative technology assessment

would be expected to result in a demonstrable increase in juvenile abundance of American shad, river herring, striped bass or white perch (Appendix C, p. 8).

b. Other Biological Evaluations

As noted above, EPA in its Replacement Rule includes a brief case study related to IPEC (EPA 2011a, pp. 2-20 to 2-21). The case study provides the following paragraph regarding the potential effects of IPEC on fish species.

> Results suggest that I&E mortality impacts to the local and transient anadromous fish species are substantial. For example, studies of fish entrainment in 1980 predicted fish class reductions ranging from 6 to 79 percent, depending on fish species (Boreman and Goodyear 1988). Subsequent sampling work predicted year-class reductions due to I&E mortality of 20 percent for striped bass, 25 percent for bay anchovy, and 43 percent for Atlantic tomcod. The Final Environmental Impact Statement (FEIS) prepared by the New York State Department of Environmental Conservation (NYSDEC) concluded these levels of mortality 'could seriously deplete any resilience or compensatory capacity of the species needed to survive unfavorable environmental conditions (USEPA 2004a) (EPA 2011a, pp. 2-2- to 2-21).

Barnthouse (2013) evaluates the information provided in this case study. He notes that impact estimates from Boreman and Goodyear (1988) represent the cumulative impacts from six Hudson River power plants, not IPEC alone. Moreover, he notes that the range of estimates that EPA used from Boreman and Goodyear (1988) is misleading and that EPA does not identify the studies it cites as "subsequent sampling work." Indeed, the 1999 Draft Environmental Impact Statement (DSEIS) for Indian Point, Roseton, and Bowline Point indicated significantly smaller impacts on striped bass, bay anchovy, and Atlantic tomcod than the values given by EPA. Moreover, Barnthouse (2013) states that the FEIS conclusions regarding population and community impacts are unsupported and incorrect. Barnthouse (2013) concludes that the information cited in EPA (2011a) regarding population and community impacts "contains significant errors and omissions and does not accurately reflect current understanding." He concludes that the information in EPA (2011a) does not change his conclusion that I&E at IPEC does not have a measurable effect on the various fish populations mentioned.

3. Implications for Potential Non-use Benefits of CWWS and Cooling Towers at IPEC

The biological assessments summarized above indicate that I&E at IPEC does not have a significant impact on the sustainability of fish populations, including threatened and endangered species as well as other species. As discussed below, sustainability of populations is a major factor influencing whether non-use benefits are likely to be important from the standpoint of an economic evaluation. Thus, reducing I&E at IPEC with CWWS or Cooling Towers is not likely to have important non-use benefits associated with adverse effects on the viability of various fish species. Below we use this information in conjunction with the relevant economic guidance to assess the likely significance of non-use benefits from CWWS and Cooling Towers at IPEC.

C. EPA Guidance for Site-Specific Evaluation of Non-use Benefits in 316(b) Rules and Proposed Replacement Rule

This section describes the treatment of potential non-use benefits in recent EPA rules for cooling water intake under Section 316(b) of the Clean Water Act. In particular, we consider the guidelines EPA has provided for the assessment of non-use benefits in individual permit cases in these various documents to provide background and context for our assessment of non-use benefits for CWWS and Cooling Towers at IPEC. These rules include (1) the Phase II Rule issued in 2004; (2) the Phase III Rule issued in 2006; and (3) the proposed Replacement Rule issued (as a proposal) in 2011. As discussed below, EPA also released information in 2012 on a SP survey that may be used to estimate the potential benefits of the Replacement Rule.

1. EPA 316(b) Phase II Rule (2004)

EPA's Phase II Rule, issued in 2004, sets cooling water intake standards for power generation facilities operating or under construction by January 2002. The rule applies to facilities that are designed to use at least 50 million gallons of cooling water per day.

a. Guidance for Site-Specific Assessments

The Phase II Rule recommends first reviewing biological information to determine whether to monetize potential non-use benefits. The rule recommends that analysts consider monetizing potential non-use benefits in cases where impingement and entrainment cause substantial harm to:

1. A threatened or endangered species;
2. The sustainability of populations of important species of fish, shellfish or wildlife; or
3. The maintenance of community structure and function in a facility's waterbody or watershed" (EPA 2004, p. 41648).

If none of these three criteria is met, "monetization is not necessary" (p. 41648).

b. Implications for Potential Non-use Benefits of CWWS and Cooling Towers at IPEC

As noted above in the section on biological impacts, NMFS (2013) implies that reducing I&E at IPEC (e.g., through installation of CWWS or Cooling Towers) would not lead to significant improvements in the status of threatened or endangered species (namely shortnose or Atlantic sturgeon). Moreover, Barnthouse et al. (2008 and 2010) conclude that reducing I&E at IPEC would not materially improve fish populations and would not affect the maintenance of community structure or function. Since none of EPA's three criteria in the Phase II Rule is met, potential non-use benefits from installation of CWWS or Cooling Towers at IPEC do not need to be monetized based on this guidance.

2. EPA 316(b) Phase III Rule (2006)

EPA's Phase III Rule, issued in 2006, establishes standards for the cooling water intake systems of new offshore and coastal oil and gas facilities that are designed to use more than 2 million gallons of water per day.

a. Guidance for Site-Specific Assessments

The Phase III Rule includes the following guidance regarding monetization of potential non-use benefits for site-specific assessments.

> Non-use benefits can generally only be monetized when two steps have been completed:
>
> 1. Environmental impacts are quantified; and
> 2. A monetary value is available to be assigned to those impacts (EPA 2006, p. 35017).

b. Implications for Potential Non-use Benefits of CWWS and Cooling Towers at IPEC

The second of EPA's two criteria for monetization in the Phase III Rule is that a monetary value be available for assignment to relevant environmental impacts. We are not aware of any study that has assessed the potential non-use benefits of reducing I&E at IPEC or any study that could be used appropriately to provide the basis for assessing non-use benefits due to reduction in I&E at IPEC. Thus, the second criterion outlined above is not met. As a result, this guidance implies that monetization is not necessary for this analysis.

3. EPA 316(b) Proposed Replacement Rule (2011)

EPA's proposed Replacement Rule would set standards on best technology available (BTA) for all existing power generating and manufacturing facilities that withdraw more than 2 million gallons per day. EPA evaluated four alternative regulatory approaches in the proposal and stated that it was inclined to base the final rule on Option 1, which would set impingement standards for facilities withdrawing more than 2 million gallons per day and would use site-specific determinations to select BTA for entrainment.

a. Guidance for Site-Specific Assessments

EPA's proposed Replacement Rule provides the following background on assessing non-use benefits:

> Non-use benefits…may be assessed on the basis of benefits transfer analysis (using findings from prior analyses involving a similar study context) or by performance of a peer-reviewed stated preference survey to assess the value

assigned for the environmental improvements resulting from the technology installation (EPA 2011, p. 22261).

The proposed rule also provides the following guidance for monetizing non-use benefits:

> If appropriate data are available from stated preference studies or other sources that can be applied to the site being evaluated, these should be used to monetize non-use values. Otherwise, non-use values should be evaluated qualitatively (EPA 2011, p. 22261).

b. Implications for Potential Non-use Benefits of CWWS and Cooling Towers at IPEC

The guidance in EPA's proposed Replacement Rule indicates that non-use benefits are to be assessed using existing benefit transfer or peer-reviewed stated preference studies. That information is required for quantifying and monetizing potential non-use benefits. When such studies are not available, however, EPA states in the proposed Replacement Rule that it is appropriate to assess non-use values qualitatively. Since we are aware of no stated benefit study regarding non-use benefits at IPEC and no study that would appropriately provide the basis for benefit transfer to calculate non-use benefits from reduced I&E at IPEC, this guidance indicates it is appropriate to assess potential non-use benefits of CWWS and Cooling Towers at IPEC qualitatively.

4. EPA 316(b) Survey (2012)

In June 2012, EPA released a Notice of Data Availability (NODA) with some preliminary results from a survey it had conducted to estimate the potential benefits of the Replacement Rule (EPA 2012). The survey presented respondents with background information that included various assertions about the status of fish populations and ecosystems and illustrations concerning the importance of fish and the effects on fish populations of cooling water intake structures used by power plants and other industrial facilities. The survey then presented three choice questions, each of which asked respondents to choose one of three hypothetical policy options—the status quo, for which one would pay nothing, and two hypothetical policy options that would provide hypothetical regional or national improvements in various environmental attributes in exchange for paying some cost in the form of higher electricity and other prices.

EPA conducted its stated preference survey in mail format, sending a questionnaire to the population samples in each of its five target regions: the Northeast, Southeast, Inland, and Pacific areas of the country, as well as a "National" sample drawn from the nationwide population. The address sample for the mail survey was drawn from a database that covers 97 percent of residences in the United States. EPA sent out a total of 6,800 of the regional surveys and 960 of the national surveys, with a target sample size of 2,000 and 288 for the regional and national surveys, respectively. The number of surveys sent to each region differed based on household populations. For example, 1,440 households were surveyed in the Northeast region for target sample size of 417, whereas 2,480 households were surveyed in the Inland region for a target sample size of 732. At the time of EPA's statistical analyses (as reported in the NODA), EPA had received 2,313 completed and returned surveys across all regions. The average response rate was 33 percent.

As discussed in NERA and Desvousges (2012), the EPA survey appears to suffer several significant flaws, including inadequate and misleading biological information, failure to communicate the complexity of potential regional and national 316(b) biological benefits, improper context for policy choice, and hypothetical bias. Moreover, EPA's econometric analysis of the survey results appears to suffer from lack of replication, flawed model selection, and "irrational" respondent behavior. This makes the survey results deeply problematic for use in evaluating the national benefits of the Replacement Rule, let alone for site-specific assessments.

a. Guidance for Site-Specific Assessments

EPA notes that the results of the survey may not be appropriate for site-specific estimates because the conditions at the sites would differ from the conditions described in the survey.

> EPA notes that the preliminary results presented in this NODA are dependent on the background information that was presented to respondents to the stated preference survey, including information about regional and national impacts on aquatic resources both in the baseline and under various policy scenarios. Thus, these preliminary national and regional results are not directly transferable to site specific assessments (EPA 2012, p. 34928).

b. Implications for Potential Non-use Benefits of CWWS and Cooling Towers at IPEC

EPA's survey was developed for national rather than site-specific analysis. As EPA notes, it would not be appropriate to use the national results for site specific analyses. Moreover, as noted above, the survey suffers from many limitations.

5. Overall Implications of EPA Guidance on Site-Specific Assessment of Non-Use Benefits

EPA has provided some guidance for the treatment of non-use benefits in individual site-specific assessments in its various rules and the recent Replacement Rule proposal. Unless specific studies are available, the general guidance is to rely upon qualitative assessments for non-use benefits. In one case, EPA provided specific guidance on the conditions under which monetization should be considered.

With regard to the installation of CWWS and Cooling Towers at IPEC, we are not aware of any study that could be used to develop reliable monetary values for potential non-use benefits. Thus, prior EPA guidance as well as economic criteria suggest that it is not necessary or appropriate to prepare a study of potential non-use benefits in this case. Instead, we provide a qualitative assessment, as outlined below.

D. Assessment of Non-use Benefits from CWWS and Cooling Towers at IPEC

The economics literature on non-use valuation provides some guidance on situations in which non-use values are likely to be significant. We use this literature to structure a qualitative assessment of the likely significance of non-use benefits due to the installation of CWWS and Cooling Towers at IPEC.

1. Economic Criteria on the Likely Significance of Non-use Benefits

In his well-regarded text on measuring environmental and resource values, Freeman (2003) reviews the literature on non-use values, considering the situations in which non-use values are likely to be important/significant:

> Another important question is, when are nonuse values likely to be important? The long literature on nonuse values emphasizes the *uniqueness or specialness of the resource in question* and the *irreversibility of loss or injury*. For example, economists have suggested that there are important nonuse values in preserving the Grand Canyon in its natural state and in preventing the global or local extinction of species and the destruction of unique ecological communities. In contrast, resources such as ordinary streams and lakes or a subpopulation of a widely dispersed wildlife species are not likely to generate significant nonuse values because of the availability of close substitutes. Moreover, the literature does not suggest that nonuse values are likely to be important where recovery from an injury is quick and complete, either through natural processes or restoration (Freeman 2003, pp. 156-157, emphasis added).

Thus, Freeman's (2003) review of this literature suggests two operative criteria for evaluating whether non-use value for fish protection is likely to be important:

1. the resource is unique, in contrast to subpopulations of a widely dispersed wildlife species; and

2. the loss would be irreversible or subject to a long recovery period.

Unless both of these criteria are met, Freeman (2003) suggests that the non-use values are unlikely to be important.[35] Freeman (2003) also notes that SP methods should be used cautiously, as it is extremely difficult to perform such studies well (p. 183).

[35] EPA (2011c) addresses the Freeman criteria in responding to comments it received in 2010 from NERA and WH Desvousges on a draft of the 316(b) survey. EPA references the Bateman et al. (2002, p. 75) statement that there are "no easy rules for determining at the outset" whether non-use values are likely to be significant. However, as noted above in this appendix, Bateman et al. (2002) also state that "[o]ne of the issues to be determined before commissioning a study is the extent to which non-use values are likely to be important" (p. 74). In addition, Bateman et al. (2002) do not imply that non-use values should be monetized regardless of the cost of doing so or

2. Implications for Potential Significance of Non-use Benefits of CWWS and Cooling Towers at IPEC

The Freeman criteria can be used to evaluate the potential significance of non-use changes due to the installation of CWWS or Cooling Towers at IPEC. We consider the two factors (uniqueness and irreversibility) in terms of the changes in T&E species and other species.

a. Threatened and Endangered Species

The information provided above indicates that the installation of CWWS or Cooling Towers at IPEC would not lead to protection of a unique resource as indicated by impacts on T&E species. Although the species themselves could be considered unique, evaluations by NRC as well as expert biologists indicate that the effects of changes due to the installation of CWWS or Cooling Towers at IPEC would be minimal. As noted above, NMFS (2013) concludes that I&E at IPEC "is not likely to jeopardize the continued existence of shortnose sturgeon or the New York Bight...[distinct population segment] of Atlantic sturgeon" (p. 126).

Since the gains due to CWWS and Cooling Towers at IPEC would be ongoing rather than based upon a single event, the irreversibility consideration seems less relevant. Nevertheless, if one considers the long-term sustainability of the species, any adverse effects due to I&E at IPEC presumably would cease at the point at which IPEC would retire.

b. Other Species

The information provided above indicate that I&E at IPEC does not cause substantial harm to the sustainability of other species (including game fish and forage fish) and thus would not lead to loss of a "unique" resource. Instead, the potential gains would be to a "subpopulation of a widely dispersed wildlife species," which Freeman notes would not be likely to generate significant non-use values. Moreover, because any impacts would cease as the point at which IPEC would retire, any adverse effects of IPEC would be reversible.

These considerations indicate that the subpopulations affected by I&E at IPEC would not constitute unique resources and, indeed, any damage would not be irreversible. Thus, by Freeman's (2003) criteria, non-use benefits of adding CWWS or Cooling Towers at IPEC are not likely to be significant as judged by impacts on non-T&E species.

E. Conclusions Regarding Non-Use Benefits of CWWS and Cooling Towers

This appendix summarizes relevant biological information regarding the impacts of reductions in I&E at IPEC from the installation of CWWS or Cooling Towers, and provides a discussion of the guidance from various sources, including EPA and the economics literature, for assessing

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the likely importance of the results. Sensible regulatory policy requires the consideration of the potential nature of non-use benefits and how they might be estimated before committing to a costly and time-consuming study.

non-use benefits. In particular, the various sources provide guidance for determining the circumstances in which it is likely to be important to monetize non-use benefits.

Based on the relevant biological information, the absence of an existing study of non-use values directly related to I&E at IPEC, the absence of a study that could be used appropriately as the basis for benefit transfer, and the various sources of guidance, we conclude that it is appropriate to provide a qualitative evaluation of non-use benefits from CWWS and Cooling Towers at IPEC and that the substantial costs and difficulties of undertaking a SP survey would not be justified. Thus, we evaluate non-use benefits in a qualitative manner.

We conclude that any potential non-use benefits from CWWS and Cooling Towers are not likely to be important or significant based upon economic criteria that have been developed to assess importance and significance in light of the relevant biological information. This conclusion is based upon effects both on T&E species and on the other species for which biological information has been developed.

F. References

Arrow, Kenneth, Robert Solow, Paul R. Portney, Edward E. Leamer, and Roy Radner. 1993. "Report of the NOAA Panel on Contingent Valuation." *Federal Register*, January 15, 4601-4614.

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

Barnthouse, Lawrence W., Charles C. Coutant, and Webster Van Winkle. 2002. *Status and Trends of Hudson River Fish Populations and Communities Since the 1970s: Evaluation of Evidence Concerning Impacts of Cooling Water Withdrawals*.

Barnthouse, Lawrence W., Douglas G. Heimbuch, Mark Mattson, and John Young. 2010. *Attachment 6: Evaluation Biological Effectiveness of Alternative Intake Technologies for Indian Point Units 2 and 3*. February.

Barnthouse, Lawrence W., Douglas G. Heimbuch, Webster Van Winkle, and John Young. 2008. *Entrainment and Impingement at IP2 and IP3: A Biological Impact Assessment*. January.

Barnthouse, L. W. 2013. *Review of USEPA Indian Point Case Study Material Presented in 2011 Environmental and Economic Benefits Analysis*. March.

Bateman, I.J. et al. 2002. *Economic Valuation with Stated Preference Surveys: A Manual*. Northampton, MA: Edward Elgar.

Boardman, A., D. Greenberg, A. Vining, and D. Weimer. 2011. *Cost-Benefit Analysis: Concepts and Practice*, 4th Edition. Prentice-Hall.

Carson, Richard T. 2012. "Contingent Valuation: A Practical Alternative When Prices Aren't Available?" *Journal of Economic Perspectives*: 26(4).

Entergy Nuclear Operations Inc. 2007. Letter NL-07-156, Supplement to License Renewal Application (LRA) – Environmental Report References. December 20, 2007.

Fletcher, R. I. 1990. "Flow dynamics and fish recovery experiments: water intake systems." *Transactions of the American Fisheries Society*. 119:393-415.

Freeman, A. Myrick III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. Second Edition. Washington, D.C.: Resources for the Future.

Hausman, Jerry. 2012. "Contingent Valuation: From Dubious to Hopeless." *Journal of Economic Perspectives*: 26(4).

Kling, Catherine L., Daniel J. Phaneuf, and Jinhua Zhao. 2012. "From Exxon to BP: Has Some Number Become Better than No Number?" *Journal of Economic Perspectives*: 26(4).

Kolstad, Charles D. 2011. *Environmental Economics*, 2nd Edition. Oxford University Press.

National Marine Fisheries Service (NMFS). 2013. Endangered Species Act Section 7 Consultation Biological Opinion: Continued Operation of the Indian Point Nuclear Generating Station." January 30. (www.nero.noaa.gov/Protected/section7/bo/actbiops/nrc_indian_point_2_and_3.pdf)

National Oceanic and Atmospheric Administration (NOAA). 2013. "Atlantic Sturgeon." (http://www.nmfs.noaa.gov/pr/species/fish/atlanticsturgeon.htm)

NERA Economic Consulting and WH Desvousges & Associates. 2012. *Comments on EPA's Notice of Data Availability for §316(b) Stated Preference Survey*. Report prepared for Utility Water Act Group and Edison Electric Institute. July.

New York State Department of Environmental Conservation (DEC). 2013. "Shortnose Sturgeon Fact Sheet." (http://www.dec.ny.gov/animals/26012.html)

Nuclear Regulatory Commission (NRC). 2010. Generic Environmental Impact Statement for License Renewal of Nuclear Plants: Supplement 38 Regarding Indian Point Nuclear Generating Unit Nos. 2 and 3: Final Report. Washington, DC: NRC, December.

TRC. 2013. *CWWS SEQRA Environmental Report*. Entergy Exhibit 184. March.

U.S. Environmental Protection Agency (EPA). 2004. National Pollution Discharge Elimination System-Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities. July 9. 69 *Federal Register* 41605.

U.S. Environmental Protection Agency (EPA). 2006. National Pollutant Discharge Elimination System; Establishing Requirements for Cooling Water Intake Structures at Phase III Facilities; Final Rule. June 16. 71 *Federal Register* 35006.

U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses*. Washington, DC: EPA, December.

U.S. Environmental Protection Agency (EPA). 2011a. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule*. Washington, DC: EPA, March 28.

U.S. Environmental Protection Agency (EPA). 2011b. National Pollutant Discharge Elimination System—Cooling Water Intake Structures at Existing Facilities and Phase I Facilities; Proposed Rule. April 9. 76 Federal Register 22174.

U.S. Environmental Protection Agency (EPA). 2011c. Response to "Comments of American Chemistry Council, American Forest & Paper Association, American Petroleum Institute, and Utility Water Act Group on ICR for Willingness to Pay Survey for Section 316(b) Existing Facilities Cooling Water Intake Structures" (Federal Register Vol. 75, No. 139: 42438-42440; July 21, 2010) and EPA Supporting Documents.

U.S. Environmental Protection Agency (EPA). 2012a. National Pollutant Discharge Elimination System—Proposed Regulations To Establish Requirements for Cooling Water Intake Structures at Existing Facilities; Notice of Data Availability Related to EPA's Stated Preference Survey. June 12. 77 *Federal Register* 34927.

U.S. Fish and Wildlife Service (FWS). 2013. "Listings and Occurrences for New York." http://ecos.fws.gov/tess_public/pub/stateListingAndOccurrenceIndividual.jsp?state=NY.

U.S. Fish and Wildlife Service (FWS). 2013. "Shortnose Sturgeon." (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=E00B)

Van Winkle, Webster and John Young. 2008. *Entrainment Susceptibility at Indian Point and Change in YOY Abundance*.

Young/Sommer LLC. 2013. *Analysis of Municipal and County Permitting for Closed-Cycle Cooling System Retrofit at Indian Point*. Prepared by Kevin M. Young and Elizabeth M. Morss. December 2013.

Appendix F: Assessment of Potential Indirect Use Benefits

This appendix summarizes our assessment of potential indirect use benefits from CWWS and Cooling Towers at IPEC. As noted in the main report, indirect use benefits are those that contribute indirectly to an increase in welfare for users of the resource. EPA's 316(b) Proposed Rule (EPA 2011) distinguishes indirect use benefits into market and non-market categories. We adopt the same distinction and provide evaluations of potential indirect benefits in these two categories.

A. Market Indirect Use Benefits

Market indirect use benefits are benefits that occur through indirect or secondary effects on marketed goods. As noted, the primary market effects relate to changes in commercial fishing, and the value of the increased commercial harvest to commercial fishermen in particular.

1. Specific Market Indirect Benefit Categories

The following are the specific items listed in EPA's summary of market indirect goods:

1. Increases in commercially valuable species due to an increase in the number of forage fish.[36]
2. Increases in equipment sales, rental, and repair.
3. Increases in bait and tackle sales.
4. Increases in consumer market choices.
5. Increases in choices in restaurant meals.
6. Increases in property values near the water.
7. Increases in ecotourism (charter trips, festivals, and other organized activities with fees such as river walks).

Note that EPA's 316(b) Proposed Rule (EPA 2011) does not provide specific explanations for why these particular items are listed as indirect market use benefits. We distinguish forage fish effects from the other items, which relate to effects on secondary markets as discussed below.

[36] The table does not include the effects of increases in forage fish on commercial species, although it is provided as the example of indirect market benefits (EPA 2011, p. 4-2).

2. Indirect Market Benefits Related to Additional Forage Fish

As discussed in Chapter IV, species without direct commercial (market) value have indirect effects on species with direct use value. In particular, increases in forage fish species serve as additional food sources for valuable species. We have included these indirect benefits in our analysis by determining the additional striped bass biomass that would result from additional forage fish in the commercial catch estimates. The details of our methodology are described in Appendix C.

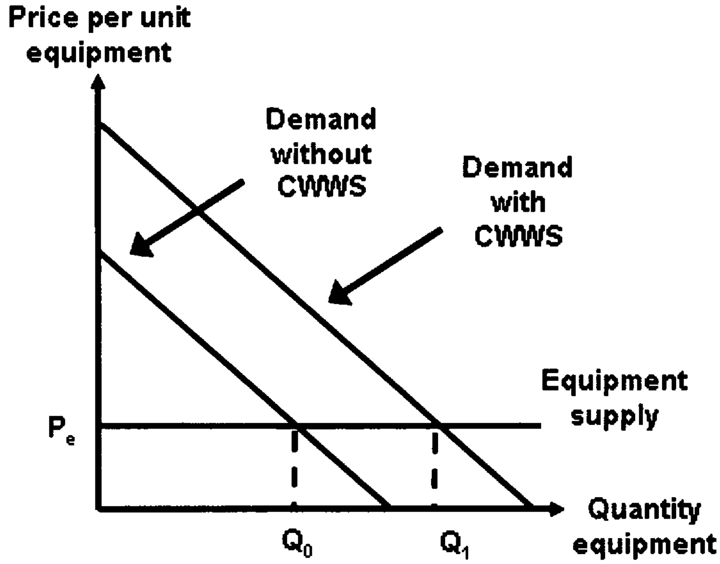
3. Other Indirect Benefit Categories Based Upon Changes in Secondary Markets

When valuing costs and benefits relevant to cost-benefit analysis (CBA), economists distinguish the impacts on primary versus secondary markets. Primary markets are those directly affected by a policy while secondary markets are those that are indirectly affected (Boardman et al. 2011, p. 115, Kolstad 2011, p. 117). In this case, the primary markets are those related to commercial fisheries. As previously noted, the estimates of theoretical benefits based upon additional commercial fish due to CWWS and Cooling Towers are described in the main report and in Appendix C.

The items other than forage fish effects listed above relate to secondary market effects, i.e., impacts on other markets due to the increase in commercial fish as represented by increased landings by commercial fishermen. Many markets might be affected; increases in fishing could increase the demand for fishing boats and equipment, which in turn could increase the demand for aluminum, which could increase the demand for electricity. The question related to benefit assessment is, how many of these markets do we need to evaluate in order to determine the benefits of the policy, in this case the policy to require CWWS and Cooling Towers at IPEC?

These secondary market effects can be ignored so long as prices do not change in these markets (Kolstad 2011, p. 117).[37] Figure F-1 illustrates the situation for an illustrative secondary market (e.g., fishing equipment). As assumed in textbook explanations, the market for fishing equipment is assumed to be a constant cost sector, i.e., one in which the long-run cost of production (and thus the price) does not change as the quantity produced changes (Kolstad 2011, p. 118).

[37] This presumes that there are no market distortions, as Kolstad notes (Kolstad 2011, p. 117, fn. 3).



Source: Illustration as discussed in text.

Figure F-1. Illustrative Secondary Market for Fishing Equipment

Also shown in the figure are two demand curves for commercial fishing equipment, one with no CWWS and one (further to the right) with CWWS. (The change in demand is exaggerated to illustrate the effect.) Note that under the assumption of constant costs, there will be no price effect in the commercial fishing equipment market.[38] Thus, the indirect effects in the commercial fishing market would not lead to additional social benefits (i.e., consumer and producer surplus) other than those included in the primary market. The same logic applies for Cooling Towers.

With regard to the specific items listed above, we would not expect the relatively small increases in additional fishing harvest due to CWWS or Cooling Towers to lead to increases in prices in any of the various secondary markets.[39] This conclusion applies to three of the specific items listed: equipment sales, rentals, and repairs; bait and tackle sales; and ecotourism.

Two of the items listed—consumer market choices and choices in restaurant meals—relate to the possibility that increased harvest could expand consumer opportunities, either in general or in restaurant meals. Such an effect might occur if, for example, the increased commercial catch resulted in introducing some type of fish that was not otherwise available to consumers or restaurant customers. This situation does not seem plausible in the case of CWWS or Cooling Towers, in which the additional commercial fish are not species that would be new to consumers or restaurant customers. Indeed, the fact that our benefit estimates are based upon established commercial fishing prices indicates that these factors are not relevant.

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[38] The assumption of constant cost is only in the area of the cost curve relevant to the change in demand.

[39] Even if the prices in the secondary market do change, the change would not lead to indirect benefits as long the changes in the primary market are not measured based upon an assumption that prices of all other goods are held constant, which is the case in our analysis. See Boardman et al. 2011, pp. 119-121.

The situation with respect to property values near the water introduces some complications because of the fact that property can be viewed as a fixed supply, rather than the situation illustrated in Figure F-1. Thus, it would be possible in principal for changes in harvest that were concentrated in particular regions to lead to increases in the value of the land adjacent to the water. This effect seems highly unlikely in this situation given the small changes in harvest and the wide potential area in which the increases would be experienced.

Even if property values increased, however, the increases should not be included in benefit estimates because it would likely lead to double counting. Since the benefit estimates already capture the benefits (i.e., producers' and consumers' surplus) arising from additional fishing harvest, to the extent that these are reflected in potential housing price increases as well, incorporating property values in our analysis would result in our counting these benefits twice. The classical rent theory indicates that where environmental characteristics affect the value of land, these changes will be reflected in land rents / prices (Freeman 2003, p. 354).

In summary, we conclude that omitting the indirect market benefits related to secondary market (and related) effects from the quantified benefits estimates is not likely to significantly affect the overall benefit results. We note that EPA's 316(b) Proposed Rule (EPA 2011) does not estimate the value of these potential benefits.

B. Non-Market Indirect Use Benefits

Non-market indirect use benefits are benefits that occur through indirect or secondary effects on non-marketed goods. As noted, higher catch/harvest for recreational fishermen provides the direct use non-market benefits.

1. Specific Non-Market Indirect Benefit Categories

The following are the specific items listed in EPA's summary of non-market indirect goods.

1. Increase in recreationally valuable species due to an increase in the number of forage fish.40

2. Increase in value of boating, scuba diving and near-water recreational experiences due to enjoying/observing fish while boating, scuba diving, hiking or picnicking.

3. Increase in the value of boating, scuba diving and near-water recreational experiences due to watching aquatic birds fish or catch aquatic invertebrates.

4. Increase in boating, scuba diving and near-water recreational participation.

Note that as with market goods, EPA's 316(b) Proposed Rule (EPA 2011) does not provide specific explanations for why all of these items are listed as indirect non-market use benefits and

[40] As with market indirect benefits, EPA does not list forage fish effects in this table. They are relevant for non-market effects for the same reasons explained by EPA (as noted above) for market effects.

does not estimate the value of these potential benefits. We distinguish forage fish effects from the other items.

2. Indirect Non-Market Benefits Related to Additional Forage Fish

As discussed in Chapter IV, species without direct recreational (non-market) value have indirect effects on species with direct use value. In particular, increases in forage fish species serve as additional food sources for valuable species. We have included these indirect benefits in our analysis by determining the additional striped bass biomass that would result from additional forage fish in the recreational catch estimates. The details of our methodology are described in Appendix D.

3. Other Indirect Benefit Categories Based Upon Non-Market Changes

These other categories are based upon the possibility that the value to participants in various non-market activities (boating, scuba diving and near-water recreational experiences) would be enhanced as a result of the increase in fish due to a particular policy. For example, an increase in the fish populations could in theory lead to an increase in the value of boating and thus in the consumer surplus associated with boating.

In the case of this situation, however, we would not expect the relatively small theoretical increases in fish populations and harvests from CWWS or Cooling Towers at IPEC to lead to a significantly increased value of aquatic and near-water recreational activities, including enjoying or observing fish while boating, scuba-diving, hiking, or picnicking or watching aquatic birds fish or catch aquatic invertebrates.

- Using boating as an example, we would not expect the increased numbers of fish due to CWWS or Cooling Towers to provide a substantially more enjoyable experience boating in the Hudson (or other locations in which additional fish might be present). Moreover, installation of CWWS or Cooling Towers would not lead to a greater diversity of fish (another factor potentially affecting the quality of a boating experience), given that no new species of fish would be available.

- Without an in-depth study of the theoretical impacts of increased fish populations and harvests on the quality of these aquatic activities, it is not possible to determine the potential indirect benefits that might be provided from CWWS or Cooling Towers. As noted, however, since the theoretical increases in fish populations are small relative to overall populations and would be spread over a large area, the additional value of these recreational experiences that would accrue, if any, would also be small. Thus, we conclude that omitting this potential benefit category from the quantified benefits estimates is not likely to significantly affect the overall results.

- Similarly, we would not expect the relatively small theoretical increases in fish populations and harvests from CWWS and Cooling Towers at IPEC to lead to a significantly increased participation in boating, scuba-diving, bird-watching, or other aquatic and near-water recreational activities. Therefore, as in the case of the value of aquatic activities, we conclude that omitting this potential benefit category from the quantified benefits estimates is not likely to significantly affect the overall results.

C. Conclusions Regarding Indirect Use Benefits of CWWS and Cooling Towers

This appendix provides an assessment of the significance of indirect use benefits arising from the installation of CWWS or Cooling Towers at IPEC, primarily based on economic theory and guidance from the economics literature. The following are our conclusions on the specific categories of potential indirect effects identified in EPA 2011 and evaluated above.

- Indirect effects due to additional forage fish (both forage species and un-harvested game fish) are included in the benefit assessments, as discussed in the report.
- Indirect secondary market effects are not likely to be significant because they are not likely to lead to price effects that could lead to additional consumers' or producers' surplus.
- No significant additional market opportunities would result from CWWS or Cooling Towers effects.
- Effects on property values due to effects of CWWS and Cooling Towers on fish populations are not likely to be significant and, even if they were, should not be included because of the likelihood of double counting.
- Effects on the value of non-market activities due to CWWS or Cooling Towers are not likely to be significant given the small effects on fish populations.
- Effects on participation in non-market activities due to CWWS or Cooling Towers are not likely to be significant given the small effects on fish populations.

In summary, we conclude that apart from forage fish effects, no potential indirect use benefits from CWWS or Cooling Towers are likely to be significant or change any of the conclusions in the report.

D. References

Boardman, Anthony, David Greenberg, Aidan Vining, and David Wimer (Boardman *et al.*). 2011. *Cost-Benefit Analysis Concepts and Practice.* 4th Ed. Saddle River, NJ: Prentice Hall.

Freeman, A. Myrick. 2003. *The Measurement of Environmental and Resource Values Theory and Methods.* 2nd Ed. Washington, D.C.: Resources for the Future.

Kolstad, Charles. 2011. *Environmental Economics.* 2nd Ed. New York, NY: Oxford University Press, Inc.

U.S. Environmental Protection Agency (EPA). 2011. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule*. Washington, DC: EPA, March 28.

Appendix G: Analyses of Whether Cooling Towers Costs are "Wholly Disproportionate" to the Benefits Disregarding Air Permit Considerations

This appendix provides information on the costs and benefits of Cooling Towers under the assumption that there are no constraints on operating the towers due to air permit considerations. As discussed in the report body, TRC (2009) concluded that Cooling Towers could not operate at substantial times during the year because of the need to meet air emissions permitting requirements. For illustrative purposes, this appendix provides an alternative "wholly disproportionate" analysis of Cooling Towers if they could be operated continuously. The information is based on currently available engineering inputs from ENERCON and biological inputs from ASAAC. Cost and benefit estimates for cylindrical wedgewire screens (CWWS) are also provided for the purpose of comparison.

We use the methodology described in Chapters III and IV of the main report to estimate the costs and benefits of continuously operated Cooling Towers. We assume the same timeline for the construction and installation of the Cooling Towers, based on information in Tetra Tech (2013).

A. Costs of Continuous Operation of Cooling Towers

1. Methodology and Assumptions

In the body of our report, we applied Tetra Tech's (2013) estimates for Cooling Towers to a scenario where the Cooling Towers are constrained by local air quality regulations and do not operate continuously. ENERCON (2010) notes that it has only performed a detailed engineering analysis of a Cooling Towers alternative without the constraints of air permitting requirements; it expects the capital costs for a plant capable of variable operation to be at least as large as for continuous operation.

In this appendix, we use the Tetra Tech (2013) estimates to calculate the expected costs for the construction and operation of Cooling Towers that operate continuously. Although capital costs are assumed to be the same in both scenarios (for lack of better information on the higher capital costs of intermittent operation), both O&M costs and ongoing power losses would be higher under continuous operation, since both are incurred during plant operation. Based on the operating schedule in ENERCON (2010), we revise O&M costs and ongoing power losses in proportion to the expected operation of the Cooling Towers.

2. Cost Results

The estimated present values of costs for CWWS and Cooling Towers are shown in Table G-1. Costs for CWWS are unchanged from the body of the report. Specifically, the screens cost $169.5 million using a 3 percent discount rate and $123.9 million using a 7 percent discount rate whereas the Cooling Towers cost about $1.2 billion using a 3 percent discount rate and $758.5

billion using a 7 percent discount rate. To ensure comparability with the results presented in the body of this report, no cost contingency is assumed for both alternatives. Cooling Tower capital costs and outage costs remain unchanged under the assumption of continuous operation. The increased total cost of the Cooling Towers alternative is due to increases in O&M and Electricity costs that reflect the increased usage of the Cooling Towers. On average, these variable costs are approximately 7 to 8 times higher under the assumption of continuous operation.

Table G-1. Estimated Total Costs of CWWS and Continuously Operated Cooling Towers

	Discount Rate	
Technology	**3%**	**7%**
CWWS		
Construction	$173.9	$126.2
O&M	N/A	N/A
Electricity	-$4.4	-$2.4
Total	$169.5	$123.8
Cooling Towers		
Construction	$595.2	$393.6
O&M	$0.8	$0.3
Electricity	$634.6	$366.6
Total	$1,230.6	$760.5

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

3. Incremental Costs of Cooling Towers

Table G-2 presents incremental costs for CWWS and Cooling Towers. As mentioned above, running the Cooling Towers continuously increases O&M and electricity costs, leading to larger incremental costs compared to CWWS.

Table G-2. Incremental Costs of CWWS and Continuously Operated Cooling Towers

Technology	Cost (M2012$)
Present Value (r = 3%)	
CWWS	$169.5
Cooling Towers	$1,230.6
Difference	+$1,061.1
Present Value (r = 7%)	
CWWS	$123.8
Cooling Towers	$760.5
Difference	+$636.7

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

B. Benefits of Continuous Operation of Cooling Towers

1. Methodology and Assumptions

We used the methodology described in Chapter IV of the main report to estimate the theoretical benefits of the continuously operated Cooling Towers alternative. (As noted in the report, we refer to the benefits as theoretical benefits because of expert biological information that fish harvests would not actually be increased with CWWS and Cooling Towers in place.) ASAAC (2013) provides estimates of the biological losses in terms of harvest and catch under the assumption that the Cooling Towers would operate continuously under historical water flows at IPEC.

2. Theoretical Biological Impacts of Cooling Towers (Organisms and Age-1 Equivalents)

Table G-3 shows the estimated annual organism and age-1 equivalent losses due to I&E under various CWIS configurations. Note that CWWS is capable of preventing approximately 81 percent of organism losses and 94 percent of age-1 equivalent losses, with Cooling Towers capable of preventing 97 percent of organism losses and 97 percent of age-1 equivalent losses. These calculations indicate that when finally installed and if operating continuously, Cooling Towers result in lower theoretical organism and age-1 equivalent losses than CWWS.

Table G-3. Estimated Annual Organism Losses Due to I&E at IPEC (Millions)

	Organisms	Age-1 Equivalents
Regulatory Baseline	1,286.4	3.94
Current Configuration	677.9	2.82
CWWS	248.6	0.25
Cooling Towers	36.6	0.10

Source: ASAAC (2013)

Table G-4 shows annual organism and age-1 equivalent gains relative to the current configuration. The calculations show that Cooling Towers are more effective than CWWS on an annual basis if one assumes Cooling Towers can operate continuously. As discussed below, if one assumes Cooling Towers can operate continuously, they will in the aggregate save somewhat more organisms than CWWS during the license renewal term, though at a far greater cost.

Table G-4. Estimated Incremental Annual Organism Gains Due to Decreased I&E at IPEC (Millions)

	Organisms	Age-1 Equivalents
Current Configuration*	608.5	1.12
CWWS	429.3	2.57
Cooling Towers	641.4	2.72

Source: ASAAC (2013)

3. Theoretical Benefits of Cooling Towers

Table G-5 shows estimated annual fishery harvest losses due to I&E. CWWS are capable of preventing approximately 95 percent of theoretical harvest losses, with Cooling Towers preventing approximately 98 percent if one assumes Cooling Towers can operate continuously. These calculations indicate that when installed, Cooling Towers would result in somewhat greater theoretical gains in harvest if one assumes Cooling Towers can operate continuously, although the difference between CWWS and Cooling Towers is relatively small.

Table G-5. Estimated Annual Harvest Losses Due to I&E at IPEC (Millions)

	Fish Harvest
Regulatory Baseline	0.089
Current Configuration	0.033
CWWS	0.004
Cooling Towers	0.002

Source: ASAAC (2013)

Table G-6 shows annual fishery harvest gains relative to the current configuration. The calculations show that Cooling Towers are slightly more effective than CWWS on an annual basis if one assumes Cooling Towers can operate continuously. As discussed below, when account is taken of the earlier installation of CWWS, CWWS would result in greater cumulative theoretical gains than Cooling Towers.

Table G-6. Estimated Annual Harvest Gains Due to Decreased I&E at IPEC (Millions)

	Fish Harvest
Current Configuration*	0.056
CWWS	0.029
Cooling Towers	0.031

Source: NERA calculations as explained in text
* Current Configuration harvest gains are relative to the regulatory baseline

4. Incremental Biological Impacts of Cooling Towers (Organisms and Age-1 Equivalents)

Table G-7 presents cumulative biological impacts for Cooling Towers relative to CWWS. The calculations show that under both discount rates, Cooling Towers provide greater cumulative biological benefits than CWWS if one assumes Cooling Towers can operate continuously.

Table G-7. Estimated Total Incremental Impacts for Continuously Operated Cooling Towers

Technology	Organisms	Age-1 Equivalent
Present Value (r = 3%)		
CWWS	2,776.0M	17.17M
Cooling Towers	3,465.7M	14.57M
Difference	+689.7M	-2.60M
Present Value (r = 7%)		
CWWS	1,494.0M	9.29M
Cooling Towers	1,802.5M	7.55M
Difference	+308.6M	-1.73M

Source: NERA calculation based on ASAAC (2013)

5. Cumulative Incremental Benefits of Cooling Towers

The estimated present values of cumulative benefits for the Cooling Towers and CWWS alternatives are shown in Table G-8. These results show that the theoretical cumulative benefits of Cooling Towers are smaller than CWWS even when Cooling Towers are assumed to operate continuously during the year. This result reflects the fact that CWWS can be permitted and constructed years before Cooling Towers and thus would generate additional years of theoretical benefits before Cooling Towers would be in place. Under both discount rates, we see that CWWS realizes greater fish harvest benefits.

Table G-8. Estimated Total Incremental Benefits for Continuously Operated Cooling Towers

Technology	Fish Harvest
Present Value (r = 3%)	
CWWS	0.192M
Cooling Towers	0.170M
Difference	-0.022M
Present Value (r = 7%)	
CWWS	0.103M
Cooling Towers	0.088M
Difference	-0.015M

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

C. Comparison of Incremental Costs and Biological Impacts (Organisms and Age-1 Equivalents)

Table G-9 summarizes the incremental costs and biological impacts for Cooling Towers if one assumes Cooling Towers can operate continuously. Cooling Towers provide incrementally greater organisms (eggs and larvae) benefits than CWWS, though at a high price per organism. Specifically, CWWS save organisms incremental to the current configuration at a cost of $0.06 per organism using a 3 percent discount rate, and $0.08 per organism using a 7 percent discount rate. Cooling Towers save organisms incremental to CWWS at a cost of $1.54 per organism using a 3 percent discount rate, and $2.06 per organism using a 7 percent discount rate. Cooling Towers save fewer age-1 equivalents than CWWS at a higher cost and are thus dominated.

Table G-9. Incremental Cost and Biological Impacts Comparison for Cooling Towers Relative to CWWS

Cooling Towers	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Incremental Cost (Million 2012$)	$1,061.1	$1,061.1
Incremental Benefits (Millions)	689.7	-2.60
Cost / Benefits	$1.54	Dominated
Present Value (r = 7%)		
Incremental Cost (Million 2012$)	$636.7	$636.7
Incremental Benefits (Millions)	308.6	-1.73
Cost / Benefits	$2.06	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Net costs may differ slightly from costs minus benefits because of rounding.
Source: Benefits from Table G-8, costs from Table G-2, and NERA calculations as explained in text

D. Comparison of Incremental Costs and Benefits

Table G-10 summarizes the incremental costs and benefits of Cooling Towers. Biological benefits are lower for Cooling Towers than CWWS at both discount rates. Because Cooling Towers yield *lower* biological benefits at substantially *higher* costs than CWWS, we conclude that Cooling Towers are "dominated" by the CWWS for these benefits metrics.

Table G-10. Incremental Cost and Benefit Comparison for Cooling Towers Relative to CWWS

Cooling Towers	Fish Harvest
Present Value (r = 3%)	
Incremental Cost (Million 2012$)	$1,061.1
Incremental Benefits (Millions)	-0.022
Cost / Benefits	Dominated
Present Value (r = 7%)	
Incremental Cost (Million 2012$)	$636.7
Incremental Benefits (Millions)	-0.015
Cost / Benefits	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. Net costs may differ slightly from costs minus benefits because of rounding.
Source: Benefits from Table G-8, costs from Table G-2, and NERA calculations as explained in text

E. Non-Incremental Analysis

Table G-11 shows the costs and organism and age-1 equivalent benefits of Cooling Towers relative to the current configuration at IPEC if one assumes Cooling Towers can operate continuously. The cost per additional organism is $0.36 at a 3 percent discount rate and $0.42 at a 7 percent discount rates. The cost per additional age-1 equivalent is $84.46 at a 3 percent discount rate and just over $100 at a 7 percent discount rate.

Table G-11. Costs and Biological Impacts of Cooling Towers Relative to Current Configuration

Cooling Towers	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Cost (Million 2012$)	$1,230.6	$1,230.6
Benefits (Millions)	3,465.7	14.57
Cost / Benefits	$0.36	$84.46
Present Value (r = 7%)		
Cost (Million 2012$)	$760.5	$760.5
Benefits (Millions)	1,802.5	7.55
Cost / Benefits	$0.42	$100.67

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

Table G-12 shows the costs and fish harvest benefits for Cooling Towers relative to the current configuration. The cost per marginal harvested fish is $7,244 at a 3 percent discount rate and $8,621 at a 7 percent discount rate. As explained elsewhere, we estimate a monetized value of a marginal harvested fish at approximately $67, meaning that the cost of saving each fish through the use of cooling towers is over 100 times the benefit of each fish.

Table G-12. Costs and Biological Impacts of Cooling Towers Relative to Current Configuration

Cooling Towers	Fish Harvest
Present Value (r = 3%)	
Cost (Million 2012$)	$1,230.6
Benefits (Millions)	0.170
Cost / Benefits	$7,243.85
Present Value (r = 7%)	
Cost (Million 2012$)	$760.5
Benefits (Millions)	0.088
Cost / Benefits	$8,620.95

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA calculations as explained in text

F. Sensitivity Analyses

We considered the sensitivity of the results to various uncertain parameters in the main report. Table G-13 below shows incremental costs and biological outcomes of continuously operated Cooling Towers in two "extreme" sensitivity cases. The assumptions used in the "All Favorable" (i.e., costs lower and benefits higher for the two CWIS) and "All Unfavorable" (i.e., costs higher and benefits lower for the two CWIS) cases are summarized in Table 34 of the main report.

In both "extreme" sensitivity cases, Cooling Towers have greater incremental costs and lower incremental gains in age-1 equivalents and fish harvest than CWWS. The cost per organism saved in the "All Favorable" cases is similar to the base case with continuous Cooling Towers operation. Cooling Towers have incremental organism *losses* in the "All Unfavorable" case (and are thus dominated by CWWS in this case). This supports the conclusion that Cooling Towers are dominated by CWWS even if Cooling Tower operation were not limited by emissions regulations.

Table G-13. Incremental Costs and Biological Outcomes of Cooling Towers with All Favorable Assumptions and All Unfavorable Assumptions

	Implications for I&E Mortality		Biological Benefits
Cooling Towers	Organisms	Age-1 Equivalents	Fish Harvest
Base Case			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$1,061.1	$1,061.1	$1,061.1
Incremental Benefits (Millions)	689.7	-2.60	-0.022
Cost / Benefits	$1.54	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$636.7	$636.7	$636.7
Incremental Benefits (Millions)	308.6	-1.73	-0.015
Cost / Benefits	$2.06	Dominated	Dominated
All-Favorable			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$790.3	$790.3	$790.3
Incremental Benefits (Millions)	441.4	-1.18	-0.004
Cost / Benefits	$1.79	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$491.6	$491.6	$491.6
Incremental Benefits (Millions)	213.3	-0.82	-0.004
Cost / Benefits	$2.31	Dominated	Dominated
All-Unfavorable			
Present Value (r = 3%)			
Incremental Cost (Million 2012$)	$1,410.4	$1,410.4	$1,410.4
Incremental Benefits (Millions)	-616.4	-8.79	-0.088
Cost / Benefits	Dominated	Dominated	Dominated
Present Value (r = 7%)			
Incremental Cost (Million 2012$)	$723.7	$723.7	$723.7
Incremental Benefits (Millions)	-443.2	-5.26	-0.053
Cost / Benefits	Dominated	Dominated	Dominated

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars. "Base" indicates that a value is unchanged from the base case.

Source: NERA calculations as explained in text

G. Conclusions

Cooling Towers would provide greater theoretical benefits if they could operate without the constraints of air permitting requirements. However, none of the major conclusions of the study would change if we assumed Cooling Towers could operate continuously. In particular:

1. Cooling Towers would have substantially greater costs than CWWS;

2. Cooling Towers would result in smaller theoretical benefits than CWWS; and

3. Thus, Cooling Towers would be "dominated" by CWWS.

H. References

ASA Analysis & Communication, Inc. (ASAAC). 2013. *Biological Input to "Wholly Disproportionate" Analysis of Cylindrical Wedgewire Screen and Closed Cycle Cooling Alternatives for Indian Point Energy Center*. December.

ENERCON Services. 2010. *Analysis of Closed-Loop Cooling Salinity Levels: Indian Point Units 2 & 3*. November 2010.

Tetra Tech. 2013. *Indian Point Closed-Cycle Cooling System Retrofit Evaluation*. Prepared for the New York State Department of Environmental Conservation. June 2013.

TRC. 2009. *Cooling Tower Impact Analysis for the Entergy Indian Point Energy Center*. September 1.

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STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollution Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations Inc.'s Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

**REBUTTAL TESTIMONY OF DAVID HARRISON, JR., PH.D.
IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY
NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.**

CLOSED CYCLE COOLING AND STATE ENVIRONMENAL QUALITY REVIEW

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

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March 28, 2014

TABLE OF CONTENTS

Page

I. INTRODUCTION

Q. Please state your name, current position, and business address.

A. My name is David Harrison, Jr. I am an economist and Senior Vice President at NERA Economic Consulting ("NERA"), an international firm of economists specializing in microeconomics, and am co-head of NERA's global environmental practice. My business address is 200 Clarendon Street, Boston, Massachusetts 02116.

Q. Are you the same David Harrison, Jr. who submitted prefiled direct testimony on February 28, 2014 as an expert witness for Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC (collectively, "Entergy") in support of their application for SPDES Permit Renewal (DEC No.: 3-5522-00011/00004, SPDES No.: NY-0004472) and a Water Quality Certification (DEC App. Nos. 3-5522-00011/00030 (IP2) and 3-5522-00105/00031 (IP3)) for Indian Point Units 2 and 3 (together, the "proceeding")?

A. Yes, I am.

Q. Please state the purpose of your prefiled rebuttal testimony.

A. The purpose of my rebuttal testimony is to respond to various criticisms offered by witnesses for the New York State Department of Environmental Conservation ("NYSDEC") Staff and Riverkeeper of my analyses of the alternatives being proposed—cylindrical wedgewire screens ("CWWS") and closed-cycle cooling towers—as the best technology available ("BTA") for reducing impingement and entrainment mortality at Indian Point Energy Center ("IPEC"), under both the "wholly disproportionate" test used by NYSDEC in selecting BTA pursuant to 6 N.Y.C.R.R. § 704.5, and under the State Environmental Quality Review Act ("SEQRA"). In reviewing these other parties' direct prefiled testimony and reports, it appears that certain witnesses have also offered testimony concerning the economic impacts of requiring interim (or fish protection) and/or permanent outages of IPEC, subjects which, I understand, the April 2014 adjudicatory hearings are not supposed to consider and as to which the time for submitting evidence has not yet come. I do not respond to this outages-related impacts evidence at this time, but intend (and fully reserve the right) to supplement my testimony and reports in this proceeding to address those issues at the appropriate phase of the proceeding, if necessary.

Q. Which witnesses' testimony does your rebuttal testimony address?

A. I have developed comments on the testimony of the following individuals: Sharon Brooks, Charles Nieder, Roy Jacobson, Jr., Leka P. Gjonaj, David Wheat, Thomas Paynter, Ronald Stannard, and Christopher Hogan, all testifying on behalf of NYSDEC Staff; Robert M. Fagan, testifying on behalf of Riverkeeper; and Christopher Russo, testifying on behalf of the City of New York.

Q. How is your rebuttal testimony organized?

A. I have organized my testimony according to the three broad subject areas that my reports and direct testimony have addressed in this stage of the proceeding.

First, I address the testimony related to my analysis of the proposed BTA alternatives under the "wholly disproportionate" step of New York's BTA test. My rebuttal testimony here specifically addresses the testimony of Mr. Nieder, Ms. Brooks and Mr. Jacobson, all from NYSDEC Staff.

Second, I address the testimony—or rather, the lack thereof—in response to my benefit-cost analysis of the proposed BTA alternatives under SEQRA, which relates to Mr. Nieder's, Ms. Brooks's and Mr. Jacobson's testimony. As discussed below, these witnesses' testimony does not specifically address the SEQRA benefit-cost analysis recounted in my testimony and report, *Benefits and Costs of Cylindrical Wedgewire Screens and Cooling Towers at IPEC* (NERA 2013b) (Entergy Ex. 296D), nor does it appear to discuss the importance of benefit-cost analysis to a proper SEQRA analysis or otherwise distinguish the SEQRA analysis from the analysis called for under the "wholly disproportionate" test. These witnesses' testimony does, however, make passing comments that relate to various aspects of benefit-cost analysis generally, and so I address these comments in the second part of my testimony.

Finally, I address testimony related to my analysis under SEQRA of the electricity market impacts that would result if IPEC were not available. My rebuttal testimony here addresses the testimonies and reports of Mr. Fagan, testifying on behalf of Riverkeeper, Mr. Christopher Russo, testifying on behalf of the City of New York, and Ms. Gjonaj, Mr. Wheat, and Dr. Paynter from the New York Department of Public Utilities ("NYSDPU") as well as Mr. Stannard and Mr. Hogan from NYSDEC, all of whom have testified on behalf of NYSDEC.

Q. Were there any portions of your analyses or particular conclusions which NYSDEC's and Riverkeeper's witnesses appear not to have challenged?

A. Yes, many of which I mention below in connection with specific issues. Broadly speaking, however, none of the foregoing witnesses appears to challenge (1) any particulars of the NERA December 2013 Benefit-Cost Report and its analysis of costs and benefits of cooling towers and CWWS for purposes of SEQRA, or my conclusions in that report; (2) the uncertainty analysis supporting the conclusion that the costs of cooling towers are "wholly disproportionate" to their environmental benefits for purposes of the

BTA determination; or (3) the reasonableness or accuracy of many of the individual cost and benefit components analyzed in the Wholly Disproportionate Report. Moreover, electricity system modeling results developed by NYSDEC's and Riverkeeper's witnesses appear to support my conclusions that New York State electricity expenditures and air emissions would be higher if IPEC were not available than under baseline conditions with IPEC in the electricity system.

Q. Have the criticisms of your analysis advanced by witnesses for NYSDEC Staff or Riverkeeper led you to reconsider either your analysis or the conclusions you have drawn from that analysis?

A. No. For the reasons detailed below, I stand by the analysis and conclusions I reported in my direct prefiled testimony and in the three reports incorporated by reference therein (Entergy Exs. 296D, 296E and 297).

II. REBUTTAL TESTIMONY REGARDING THE "WHOLLY DISPROPORTIONATE" STEP OF THE BTA DETERMINATION

Q. Based on your review of NYSDEC Staff's witnesses' testimony, what is your understanding of the information that NYSDEC Staff has considered to evaluate whether the costs of cooling towers are "wholly disproportionate" to the benefits for purposes of the BTA determination?

A. According to Mr. Nieder's, Mr. Jacobson's and Ms. Brooks's testimony, NYSDEC Staff does not believe it is appropriate to compare aggregate costs and benefits to determine whether costs are "wholly disproportionate" to the benefits. Instead, NYSDEC Staff compares what Messrs. Nieder and Jacobson term "proportional costs" to what they term "proportional environmental benefits." Proportional costs are defined as estimated annual costs divided by an estimate of Entergy's total annual revenues from operating IPEC, as follows:

$$\text{Proportional Cost} = \frac{\text{Annual Cost of Mitigative Technology}}{\text{Annual Gross Revenue of Facility}}$$

According to Mr. Nieder's report and testimony, the annual costs of cooling towers are equal to about 10.3 percent of IPEC gross annual revenue, based on information from the Tetra Tech report (see p. 17 of Nieder Report, Ex. A to Nieder Direct).

Proportional benefits are defined as the number of organisms protected under the proposed BTA alternative under consideration divided by the number of organisms at risk of impingement or entrainment mortality under baseline conditions:

$$\text{Proportional Benefit} = \frac{\text{Number of Organisms Protected by Technology}}{\text{Number of Organisms at Risk of Mortality}}$$

According to Mr. Nieder's report and testimony, the proportional benefits of cooling towers are a reduction in impingement mortality by 98.9 percent and entrainment by 96 percent (see p. 16 of Nieder Report, Ex. A to Nieder Direct). Mr. Nieder concludes, and Mr. Jacobson and Ms. Brooks concur in his conclusion, that cooling towers' proportional costs of 10.3 percent are not "wholly disproportionate" to their proportional benefits of 96 percent to 98.9 percent.

Q. **Is the approach used by NYSDEC Staff to compare costs and benefits for purposes of the BTA determination appropriate?**

A. No, it is not: it is inconsistent with both NYSDEC precedent and established modes of economic analysis.

Q. **How is NYSDEC Staff's approach inconsistent with NYSDEC precedent?**

A. As Ms. Brooks's testimony indicates, NYSDEC Staff incorporate a facility's revenue, meaning gross revenue, into the calculation of "proportional cost" because it "gives an indication of an entity's ability or capacity to respond to changing conditions," and is "an appropriate factor to employ in considering the cost of installing technology to comply with a statutory requirement" (Brooks Direct at p. 5, ll. 27-29). Similarly, Mr. Nieder states that annual revenue is estimated to determine "the revenue available for implementing BTA" (see p. 7 of Nieder Report, Ex. A to Nieder Direct). By considering revenue in this manner, NYSDEC Staff effectively makes the "wholly disproportionate" step of its BTA determination into an affordability test akin to the "reasonably-be-borne" standard adopted following the ruling of the U.S. Court of Appeals for the Second Circuit in *Riverkeeper, Inc. v. EPA*, 475 F.3d 83 (2d Cir. 2007), which the Interim Decision followed. But the Regional Commissioner's more recent November 28, 2012 decision in this proceeding explicitly abandons the use of the "reasonably-be-borne" standard in light of the Supreme Court's reversal of the Second Circuit's decision and signaled a clear return to the "wholly-disproportionate" test and the pre-*Riverkeeper* NYSDEC precedents of *Athens* and *Bowline*. Under those precedents, the relevant inquiry is whether "the *costs* [of the proposed BTA] are 'wholly disproportionate' to the environmental benefits to be gained [from the proposed BTA]" (Nov. 28, 2012 Decision at p. 6). NYSDEC Staff's current approach is inconsistent with that administrative precedent that the Regional Commissioner's decision explicitly reestablishes (Nov. 28, 2012 Decision at p. 7) which – while not a traditional benefit-cost analysis – still compares costs to society with benefits to society, in accordance with the proper economic approach to decision-making in this context.

Q. Even assuming for the sake of argument that the affordability of a proposed BTA alternative was an appropriate consideration, is it appropriate for NYSDEC Staff to base that consideration on Entergy's gross revenue from the IPEC facility?

A. No. Even assuming for the sake of argument that affordability were relevant to the "wholly disproportionate" test under the applicable standard (and as just discussed, it is not), the question whether a BTA alternative is affordable still depends on the amount of money that is actually available to be put toward that alternative. Just as household budgets are determined by take-home income rather than gross income, the relevant metric for determining "affordability" would be *net* revenue—after taking into account costs—rather than *gross* revenue, which is the metric used by NYSDEC Staff. Still, it cannot be overemphasized that, under the relevant NYSDEC precedents and in accordance with sound economic practice, whether a proposed BTA alternative is "affordable" is not the relevant inquiry.

Q. Why is NYSDEC Staff's approach inconsistent with economic principles?

A. NYSDEC Staff's comparison of what its witnesses define as "proportional costs" and "proportional benefits" does not provide any economically meaningful framework for comparing the actual costs and benefits of CWWS and cooling towers. As far as I am aware, no source in the economic literature or regulatory guidelines recommends such a method and, to my knowledge, no federal or New York state agency employs a similar method. The general pitfalls associated with using calculations of the ratios of costs to benefits as a basis for decision-making have been noted (see, for example, Boardman et al.2011 p. 464, EPA 2010 p. A-14, NYS 2008 p. 7). But the particular cost and benefit proportions used by NYSDEC Staff are completely arbitrary, and I can provide numerous examples to show why NYDEC Staff's approach here is highly illogical.

First, NYSDEC's "proportional benefits" ratio renders the number of organisms saved by cooling towers (or any other BTA alternative) essentially irrelevant. For example, assume that, compared to the current configuration, a proposed BTA alternative will protect 9 out of every 10 organisms that currently experience impingement or entrainment mortality. Assuming that there are 1 billion organisms at risk of such mortality, 900 million organisms would be protected, yielding a "proportional benefit" ratio of 90%. But assuming that there are only 1 million organisms at risk, 900,000 will be protected, yielding the same "proportional benefit" ratio of 90%. Thus, regardless whether 900 million or 900,000 organisms – only 1/1000th as many – are protected, NYSDEC Staff would use the same "proportional benefit" – 90% – for determining whether the costs of the technology are wholly disproportionate to the benefits.

Note too that this goes both ways: under DEC Staff's proposed wholly disproportionate test, the absolute cost of the project and the applicant's absolute revenues are also irrelevant. Continuing with the example above, it does not matter whether the cost of saving 900 million fish is $1 million or $1 billion; all that matters is the proportion of that cost in relation to the applicant's revenue. Thus, if it cost $1 billion to save the 900 million fish, DEC Staff would find that these costs are not wholly-disproportionate to the benefits for an applicant with $10 billion in revenue (because proportional costs are 10 percent), but would find them wholly disproportionate for an applicant with $100 million in revenue (because proportional costs are 1000 percent). A test that can produce such drastically different results *with the same costs and benefits* is useless as a basis for rational decision-making.

Second, it is not clear under NYSDEC Staff's approach when a comparison between the proportional cost and proportional benefit ratios will result in the determination that costs are "wholly disproportionate" to benefits, and the testimony of NYSDEC's witnesses sheds no light. Consider how much cooling towers would need to cost before their proportional cost could be deemed "wholly disproportionate" to a proportional benefit ratio of 96 to 99 percent. Because NYSDEC Staff defines proportional costs as the costs of the technology divided by the facility gross revenue, one might surmise that under Staff's approach, the cost requiring of cooling towers at IPEC still would not be "wholly disproportionate" to their expected environmental benefits, even if their costs were equal to *all* of IPEC's gross revenue, as proportional costs of 100 percent would still be roughly equivalent to proportional benefits of 96 to 99 percent. Yet that conclusion is itself inconsistent with NYSDEC Staff's determination, as Mr. Jacobson's testimony recounts, that the cost of implementing annual 32-week outages at IPEC *would* be "wholly disproportionate" to the benefits of such outages, even though proportional benefits (98 percent) exceeded proportional costs (62 percent) for that alternative, as was also true of cooling towers (see Jacobson Direct at p. 12, ll.12-13). From Mr. Jacobson's testimony it seems clear that a direct comparison of "proportional benefits" and "proportional costs" cannot be the basis for the "wholly disproportionate" analysis, because 62 is not disproportionately larger than 98. None of NYSDEC Staff's witnesses has attempted to explain this inconsistency or provide any guidance as to when the value of "proportional costs" become wholly-disproportionate to "proportional benefits." But if these metrics of costs and benefits are not being directly compared, it is not clear how they provide any useful information at all to inform the decision of whether the costs of a given alternative are "wholly disproportionate" to the benefits. The problem of course is that, as I have explained, the proportional cost and benefit ratios that NYSDEC Staff employ do not have any economically meaningful relationship to each other, and so supply no meaningful basis for comparison.

Finally, the approach taken by NYSDEC Staff does not take into account the value of what is being protected. As an initial matter, there does not appear to be any dispute that even if no entrainment were occurring whatsoever, most fish eggs and larvae would not live to become adult fish; biological experts involved in this case have indicated that the ratio for some species is only one in a million. *See* Barnthouse et al. (2008) at 12 (citing Barnthouse for the Electric Power Research Institute (2004), at 6-26). Yet DEC Staff's proposed analysis values a single egg just as much as a single adult fish. In deciding whether the cost of saving an organism is "wholly disproportionate" to the value of that organism, surely it matters whether the organism is an adult fish capable of being caught by commercial fisherman or anglers, or itself spawning, rather than an egg that is vastly more likely than not simply to die. This also matters because Mr. Nieder's own analysis demonstrates that CWWS will be more effective, on an annual basis, at preventing impingement than will closed cycle cooling. *See* p. 16 of Nieder Report, Ex. A to Nieder Direct. Because impingement affects older life stages of fish that are more likely to survive and provide benefits, DEC Staff's analysis, by ignoring life stages, arbitrarily undervalues the benefits provided by CWWS in comparison to cooling towers.

Likewise, in determining whether the costs of cooling towers (or any technology) are "wholly disproportionate" to their benefits, one may reasonably assume that it matters whether the organisms being saved are in fact valued by society, or the extent to which impingement and entrainment mortality experienced by the organisms in fact affects the ecosystem. Yet according to NYSDEC's methodology, the proportional benefits would appear to be the same regardless whether the organisms being protected are representatives of a critically-endangered species or are members of an abundant species deemed by biologists to be inconsequential (or indeed, even harmful) to the surrounding ecosystem.

Q. Does NYSDEC Staff's analysis properly account for the timing of costs and benefits from cooling towers?

A. No. NYSDEC Staff's analysis fails to account for the timing of costs and benefits. NYSDEC Staff, per Mr. Nieder, calculates annual costs on the assumption that the capital costs would be spread over 20 years. But we have assumed (and Staff witnesses do not challenge) that this proceeding will not end until 2018, after which there would be years spent in permitting proceedings and on completing final designs before construction begins. Construction and operating expenses will therefore be incurred not over the full 20 years of the renewal operating licenses, but instead during a much shorter period beginning sometime in the 2020s and running until expiration of the IPEC operating licenses in 2033 and 2035. NYSDEC Staff's calculations therefore understate the annual "proportional costs" of cooling towers.

In addition to understating the annual cost of cooling towers, Mr. Nieder's analysis overstates the annual benefits of cooling towers, for Staff's analysis does not account for the fact that annual costs of cooling towers would be incurred over a significantly longer timeframe than the annual benefits of cooling towers. Assuming this proceeding ends in 2018, the Tetra Tech Report implies that the towers described in that Report (the "Tetra Tech Alternative") may not be constructed until about 2026, which implies only seven to nine years of benefits at IP2 and IP3, respectively, before the expiration of their renewal operating licenses. Indeed, ENERCON estimated that construction of the circular hybrid towers described in ENERCON's 2003 and 2010 reports (the "Hybrid Tower Alternative") could take 12 to13 years, an estimate that Tetra Tech concluded was "not unreasonable" (*see* Tetra Tech 2013, Entergy Ex. 232), as a result of which the Hybrid Tower Alternative might provide only *three* years of benefits at IP2 and *five* years of benefits at IP3 before being decommissioned.

Accordingly, average annual benefits during the period in which the towers are being constructed and operated will be substantially lower than projected by Mr. Nieder.

All told, it is not only simpler, but economically more rational, to consider the total aggregate benefits and total aggregate costs of a project, as reported in the NERA 2013 Wholly Disproportionate Report (Entergy Ex. 297), rather than average annual costs and benefits. Consideration of aggregate costs and benefits not only corrects for the problems addressed above, it also appropriately accounts for the lack of benefits during the pendency of this proceeding and during any permitting, design and construction phases of a project.

Q. Focusing more specifically on Mr. Nieder's testimony, Mr. Nieder suggests (see Nieder Direct at p. 8, ll. 1-5, and p. 11, ll. 12-14) that reduced impingement and entrainment mortality of aquatic organisms is the only metric of environmental benefits relevant for the purpose of determining BTA. Do you agree with that?

A. No. Based on the information I have been provided to date, I understand that organisms comprise a large variety of aquatic life stages, from eggs and larvae to adult fish, and that these different life stages are not equal in terms of the theoretical benefits they would provide to the fishery. A single fish, for example, can be caught by commercial fishermen or recreational anglers, or may itself spawn. A single fish egg is exceedingly likely simply to die, with the vast majority of eggs contributing benefits only as a result of being eaten by something further up the food chain (and note that our analysis accounts for such "forage fish" effects in calculating theoretical biological benefits).

In determining the benefits of reduced impingement and entrainment mortality, it is therefore appropriate to distinguish mortality at different life stages to avoid treating all organisms the same. As noted in the NERA report, this point previously has been recognized by NYSDEC when it has noted the usefulness of converting early life stages to "juvenile equivalents," a metric that reflects life stage value, rather than total number of organisms (NERA 2013a, p. 25). The measure I used in my testimony and the report is "age-1 equivalents," which is similar to the metric of "juvenile equivalents."

Neither the organisms metric nor the age-1 equivalents metric distinguishes between different types of fish. In particular, these measures do not distinguish "game fish" (*i.e.*, fish caught by recreational and commercial fishermen) from other fish that do not have direct value to people. In addition, these metrics do not take into account that only a relatively small fraction of the marginal game fish made available to the fishery due to CWWS or cooling towers would be caught or harvested. For these reasons, it is useful to provide a measure of biological benefits based on additional fish harvest due to reduced impingement and entrainment mortality. I therefore also included additional fish harvest as a measure of theoretical biological benefits in my testimony and report.

Q. Were the estimates of fish harvest that you used in the NERA Report limited only to those fish that have direct use value to people?

A. No. Fish that do not have direct use value (including both non-harvested species and non-fished harvested species) are accounted for in the NERA analysis indirectly as forage fish—*i.e.*, fish that are available as food for game fish—through their contribution to greater numbers or weight of game fish. These calculations are based on well-established methodologies developed and accepted by biologists.

In addition, consistent with EPA guidelines, I qualitatively evaluated the potential benefits that would accrue from reductions in impingement and entrainment to those who do not make use of the fish resources, *e.g.*, the benefit one may receive from knowing that a particular species of fish in the Hudson River and the Atlantic Ocean continues to exist. These "non-use" benefits can be quantified only through stated preference surveys, which are both difficult and costly to perform and which often produce unreliable results. EPA guidelines recognize these difficulties and do not require that all categories of benefits be monetized or quantified, especially if it is expected that the likely cost of gathering the information necessary to do so will exceed the expected value of the additional information in the decision-making process; rather, EPA's guidance instructs that benefit categories should be assessed carefully to determine their expected significance. Here, the biological information on which I relied suggests that any non-use benefits accruing from the use of CWWS or cooling towers are unlikely to be significant, based on criteria from a well-regarded textbook in the economics literature. *See* Freeman (2003) at 156-157. In light of this evaluation, and taking into account the cost and potential unreliability of conducting the stated preference survey needed to quantify or monetize them, I instead analyzed non-use benefits on a qualitative rather than a quantitative basis, and I concluded that non-use benefits were unlikely to be significant in this case.

Q. Let's turn to some specific criticisms that NYSDEC Staff's witnesses had of your analysis. In his testimony, Mr. Nieder states that "NERA only estimated environmental benefits that would be gained by operating a closed-cycle cooling system under the assumption that for 87 percent of the year the installed closed-cycle cooling system would not be able to operate" (Nieder Direct at p. 13, ll. 9-12). Is that accurate?

A. No. In both the NERA Wholly Disproportionate Report (Entergy Exhibit 297) and the NERA Benefit-Cost Report (Entergy Exhibit 296D), benefit estimates are in fact also provided assuming a hypothetical scenario in which cooling towers could operate 100 percent of the time. These sensitivity analyses show much greater estimated benefits of cooling towers compared to the scenario in which cooling towers only operate roughly 13 percent of the time. However, even in this case, cooling towers have smaller aggregate benefits than CWWS—at much greater costs—because CWWS could be installed earlier and thus would provide greater benefits (by any metric) over more years than cooling towers. Thus, even in this case, CWWS would "dominate" cooling towers and cooling towers clearly would fail the "wholly disproportionate" test. Additionally, it worth noting that neither Mr. Nieder nor any other NYSDEC witness takes issue with my conclusions regarding the limited extent of benefits from cooling towers assuming that TRC is correct that air quality constraints will limit their operation to only 13 percent of the calendar year.

Q. Mr. Nieder claims that he could not evaluate CWWS as a BTA option because ENERCON and Entergy did not provide sufficient information regarding operation and maintenance ("O&M") costs (see Nieder Direct at p. 14, l. 22 to p. 15, l. 5). Is that a fair criticism?

A. No. The NERA Reports included quantified cost estimates for what are expected to be the most significant categories of CWWS costs. The additional O&M costs for CWWS—which would represent primarily the annual costs of making sure the screens were kept clear of debris—were not available, but it is inconceivable that O&M costs would change the bottom line result that cooling towers are much more expensive than CWWS. The NERA report estimates that total costs of CWWS would be $169.5 million and $123.8 million, while the total costs of cooling towers would be $1,056.6 million and $670.9 million, at 3 and 7 percent discount rates, respectively. The omitted costs of CWWS would need to be *5 to 7 times larger* than the quantified costs of CWWS to make the costs of CWWS comparable to the costs of cooling towers. Mr. Nieder provides no evidence that this is likely or even possible; to the contrary, his analysis of O&M costs – which in all likelihood greatly overstates them, as explained below – is that such costs would be *lower* than capital and other costs (only 40% of total costs). Thus, the conclusions that CWWS have lower costs and higher benefits than cooling towers, and thus that cooling towers are dominated by CWWS and fail the wholly disproportionate test, are not affected by the omitted costs noted in Mr. Nieder's testimony.

It is not always possible to quantify all categories of costs and benefits, and regulatory guidelines do not require all costs and benefits to be quantified (see, for example, EPA 2010, pp. 7-3 to 7-4). I note that the Tetra Tech Report, on which Mr. Nieder's proportional cost ratio calculation is based, excluded a number of construction and O&M cost items from its "budgetary cost estimate" for the Tetra Tech Alternative, including "[c]ondenser modifications," a "[c]ontinuous condenser cleaning system," and "[n]on-routine maintenance" (see Tetra Tech Report, June 2013, p. 23 (Entergy Ex. 232); Nieder Direct at p. 2, ll. 14-16). If Mr. Nieder can apply his interpretation of the "wholly disproportionate" analysis to the Tetra Tech Alternative despite these omitted cost categories, he can also apply it to CWWS.

Q. Does Mr. Nieder's estimate that O&M costs of roughly 40 percent of total costs (see Nieder Direct at p. 17, ll. 8-10) appear to be a reasonable estimate for CWWS at IPEC?

A. No. Based on my review of the specific data underlying Mr. Nieder's calculations, it appears that the average value he calculated of 40 percent is likely to substantially overstate the O&M costs that have been omitted from the NERA analysis of CWWS at IPEC for several reasons.

First, the estimated capital costs of CWWS at IPEC are significantly larger than every single data point provided, and the data show that plants with larger capital costs tend to have relatively lower O&M costs as a percentage of total costs. Indeed, according to Mr. Nieder's information, for the one project on Mr. Nieder's list that is somewhat comparable in size to IPEC—the Northport facility—O&M costs are only 8 percent of total costs. Entergy's proposed CWWS array is even larger and has greater capital and construction costs than the Northpoint facility, and therefore 8 percent may be viewed as a reasonable cap for 20 years of O&M costs at IPEC.

Second, Mr. Nieder uses 20 years of O&M costs in his calculations. But that timeframe ignores that, as the NERA Reports reasonably assumes, CWWS would begin operation in 2024. Because the 20-year renewal terms for Units 2 and 3 are scheduled to expire in 2033 and 2035, respectively, only 9 to 11 years of O&M costs at IPEC are relevant here, not 20 years. The corresponding ratio of O&M costs to total costs would thus be roughly half as large compared to plants with 20 years of O&M costs: even crediting Mr. Nieder's analysis of 40 percent for 20 years of O&M costs (which as just noted, ignores economies of scale), the O&M percentage would drop to 20 percent for an average of 10 years of O&M costs per unit.

Moreover, Mr. Nieder does not appear to discount future costs compared to present costs, as should be done for any valid comparison of present and future costs, and as is done in the NERA Reports using the U.S. OMB/EPA guidance of three and seven percent real annual discount rates. Of course, discounting future costs will lower the ratio of O&M costs as a percentage of total project costs.

Finally, I was not able to recreate the calculations of Mr. Nieder using the underlying studies, but the limited information available in these studies calls into question the applicability of Mr. Nieder's specific estimates to this context. For example, numerous O&M estimates used by Mr. Nieder appear to include electricity costs (e.g. World Trade, Port Jefferson, E.F. Barrett), which have not been omitted from the NERA analysis. If Mr. Nieder had more appropriately compared non-electricity O&M costs to total project costs, the resulting ratios would have been significantly smaller.

For all these reasons, the examples provided by Mr. Nieder suggest that the non-electricity O&M costs for CWWS at IPEC are likely to be substantially lower than 40 percent of total project costs.

Providing confirmation of my conclusion that Mr. Nieder is greatly overstating O&M costs as a percentage of total project costs, I understand that Mr. Beaver has testified that the principal O&M costs for CWWS will involve cleaning any fouling on the screens, which will only substantially occur during the summer months (and will be minimized by the use of anti-biofouling materials on the screens). Mr. Beaver also has testified that these activities can be conducted by dive teams, and Entergy's per-day cost for a dive team is $7,000 (see pp. 35-37 of Beaver Rebuttal Testimony). As a conservative estimate, even if Entergy were required to put a dive team in the water every day during the summer to address fouling, that would entail total costs of only $637,000 per year. In the context of a $223 million project, even without taking into account discounting to present values, approximately 10-12 years of such O&M costs ($6.37 million to $7.64 million) do not affect any of the conclusions I have reached in this proceeding.

Q. Do you agree with Mr. Nieder's conclusion (Nieder Direct at p. 7, ll. 1-21) that the methodologies used to make the "wholly disproportionate" determination for the Athens and Bowline plants are irrelevant to the current decision?

A. No. None of Mr. Nieder's explanations in support of this contention withstands scrutiny. First, Mr. Nieder argues that because neither the Athens nor the Bowline plant was operating at the time of the BTA decision, neither facility had a revenue stream to which benefits could be compared. But the simplistic calculations of gross revenue that Mr. Nieder undertakes for IPEC (*i.e.*, plant generation multiplied by an average electricity price) could just as easily have been performed for a proposed facility based on projections, which surely were available in support of the proposed projects. Second, Mr. Nieder implies that the BTA determinations at Athens and Bowline were fundamentally different because the issue at hand in both cases was selection of specific closed-closed cycle cooling technologies rather than whether closed-cycle cooling would be implemented at all. However, I am aware of no economic principles or regulatory guidance that distinguishes between these two situations, and Mr. Nieder presents no argument for why these situations should be treated differently. Finally, Mr. Nieder claims that the *Athens* and *Bowline* decisions are irrelevant here because only the most recent Decisions of the Commissioner control. But as already explained, the November 28, 2012 Decision of the Regional Director specifically "reestablish[ed] the administrative precedent that was in effect prior to the 'reasonably be borne' language of the (now reversed) Second Circuit decision" (p. 7). *Athens* and *Bowline* are the most relevant examples of this prior administrative precedent. I therefore conclude that the methodology used to make the BTA determination for Athens and Bowline is relevant to the BTA determination at IPEC; Mr. Nieder has provided no convincing evidence to the contrary.

Q. In his testimony, Mr. Nieder also refers to calculations with respect to the Hybrid Tower Alternative. Have you considered the effects on your results and conclusions of using the Hybrid Tower Alternative?

A. Yes.

Q. What are the major differences in your analysis if the Hybrid Tower Alternative is used as opposed to the Tetra Tech Alternative?

A. As shown in the 2013 Tetra Tech Report (p. 27, and reproduced in the table below), cooling tower cost estimates for the Hybrid Tower Alternative are at least as large as the corresponding estimates for the Tetra Tech Alternative for every cost category, and for certain categories costs are considerably higher. Most importantly for the purposes of my conclusions, the cooling tower cost estimate for the Hybrid Tower Alternative is significantly larger than the estimated costs of CWWS.

Summary Cost Comparison (millions of 2012 dollars)

Item	Tetra Tech	ENERCON
Capital Costs	$1,009.3	$1,273.4
Construction Outage	$537.9	$696.1
Maintenance	$35.5	$55.3
Parasitic Loss	$15.1	$28.8
Algonquin Pipeline Relocation	$14.8	$14.8
Summary Cost	**$1,612.6**	**$2,068.4**

Notes:
Reproduced from Tetra Tech (2013), p. 26.

A. ENERCON also projects a construction period for the Hybrid Tower Alternative of 12 to 13 years, which is significantly longer than the construction period of 7 to 9 years that Tetra Tech has forecasted for its Alternative. Tetra Tech witness Tim Havey stated in testimony that he did not disagree with ENERCON's estimate regarding the construction schedule: "[T]he overall time to completion estimate of 12 to 13 years was not unreasonable given the volume of blasting and spoils removal that would have to occur, and the limitations placed on construction activities by local ordinances and seasonal weather concerns" (Havey Direct at p. 9, ll. 18-21). A 12 to 13 year construction phase would imply that the benefits of cooling towers would not begin to accrue until roughly 2030. That leaves only 3 to 5 years of benefits for units 2 and 3, respectively, before the end of the relicensing period. The following table displays the theoretical biological impacts of the Hybrid Tower Alternative, with the theoretical biological impacts of CWWS included for purposes of comparison.

Cumulative Biological Impact of the Hybrid Tower Alternative: (cooling towers operate ~13 percent of the time)

Technology	Organisms	Age-1 Equivalent	Fish Harvest
Present Value (r = 3%)			
CWWS	2,776.0M	17.17M	0.192M
Cooling Towers	339.0M	0.51M	0.013M
Difference	-2,437.0M	-16.66M	-0.179M
Present Value (r = 7%)			
CWWS	1,494.0M	9.29M	0.103M
Cooling Towers	168.5M	0.25M	0.006M
Difference	-1,325.5M	-9.04M	-0.097M

Sources: NERA calculations based on ASAAC (2013), ENERCON (2010)

And the following table displays the same information for the hypothetical scenario in which cooling towers can operate 100 percent of the time.

Cumulative Biological Impact of the Hybrid Tower Alternative: (cooling towers operate 100 percent of the time)

Technology	Organisms	Age-1 Equivalent	Fish Harvest
Present Value (r = 3%)			
CWWS	2,776.0M	17.17M	0.192M
Cooling Towers	1,814.6M	7.59M	0.089M
Difference	-961.40M	-9.58M	-0.103M
Present Value (r = 7%)			
CWWS	1,494.0M	9.29M	0.103M
Cooling Towers	865.6M	3.61M	0.042M
Difference	-628.43M	-5.68M	-0.061M

Sources: NERA calculations based on ASAAC (2013), ENERCON (2010)

The tables displayed above show that due to the longer construction period forecast for the Hybrid Tower Alternative, the aggregate biological impacts are larger for CWWS than cooling towers using any metric of biological impacts. This remains true even in the hypothetical scenario in which cooling towers can operate 100 percent of the time.

Q. **When you analyze the Hybrid Tower Alternative, do any of your assessments change regarding the "dominance" of the CWWS alternative over the Cooling Towers alternative?**

A. Yes. In the appendices to the NERA Reports, I evaluated the costs and biological impacts of a hypothetical scenario in which cooling towers can operate 100 percent of the time, without regard for air quality regulations. Table G-9 of the NERA Wholly-Disproportionate Report shows that, with respect to the Tetra Tech Alternative and looking only at the "organisms" biological impacts metric (but not any other metric), there would be some incremental decrease in entrainment of organisms from use of the Tetra Tech Alternative, in comparison to CWWS. As shown above, however, when considering the Hybrid Tower Alternative, the incremental biological impacts of cooling towers (compared to CWWS) are negative for all metrics of biological impacts (i.e.

organisms, age-1 equivalents, fish harvest). In other words, even ignoring air quality constraints, CWWS would provide a greater aggregate reduction in impingement and entrainment of organisms than would the Hybrid Tower Alternative. Along with the result that the cost of cooling towers are higher than the costs of CWWS, the implication of negative incremental biological impacts is that CWWS "dominate" the Hybrid Tower Alternative across all scenarios, including in the hypothetical scenario in which cooling towers can operate 100 percent of the time. Of course, my conclusion that cooling towers are dominated by CWWS when they are forced to operate roughly 13 percent of the time due to air quality restrictions remains true when the Hybrid Tower Alternative is used, because the benefits of cooling towers under this scenario are even lower.

Q. Turning to the testimony of Sharon Brooks, is she correct in her criticism that NERA performs a "traditional cost-benefit analysis" that converts benefits to monetary values in order to apply to the "wholly disproportionate" test?

A. No. Ms. Brooks conflates two separate NERA reports: (1) the NERA Wholly Disproportionate Report (Entergy Ex. 297), conducted as part of the BTA determination; (2) the NERA 2013 Benefit-Cost Report (Entergy Ex. 296D), conducted in connection with SEQRA. In her testimony, Ms. Brooks defines the "NERA Report" as the Wholly Disproportionate Report (p. 6), but then proceeds to say that the NERA Report performs "a traditional cost-benefit analysis" that "converts the benefits of reducing impacts to a multitude of aquatic specifies and a very large ecosystem to one market or monetary value" (p. 7). These are incorrect characterizations of the NERA Wholly Disproportionate Report, which appears to be the only analysis about which Ms. Brooks comments in her testimony.

My analysis and conclusions related to the BTA determination are based solely on the NERA Wholly Disproportionate Report, which does not include a traditional cost-benefit analysis or any monetization of benefits, but instead relies on a methodology similar to that which NYSDEC has used to conduct "wholly disproportionate" analyses in the past, comparing costs to non-monetized benefits (organisms, age-1 equivalents, and harvested fish). For example, Table 24 in that report does not attempt to monetize the benefits of fish eggs and age-1 equivalents, but instead notes that closed-cycle cooling will reduce entrainment of all organisms (e.g., eggs) at a cost of about $2.37 per egg, and theoretically result in additional age-1 equivalents at a cost of nearly $1,500 per fish:

Table 24. Costs and Biological Impacts of Cooling Towers Relative to Current Configuration

Cooling Towers	Organisms	Age-1 Equivalents
Present Value (r = 3%)		
Cost (Million 2012$)	$1,056.6	$1,056.6
Benefits (Millions)	513.7	0.84
Cost / Benefits	$2.06	$1,265.19
Present Value (r = 7%)		
Cost (Million 2012$)	$670.9	$670.9
Benefits (Millions)	283.0	0.45
Cost / Benefits	$2.37	$1,489.73

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA 2013a

Table 25 then observes that the cost per theoretical additional harvested fish of installing closed cycle cooling is nearly $62,000 per fish:

Table 25. Costs and Biological Benefits of Cooling Towers Relative to Current Configuration

Cooling Towers	Fish Harvest
Present Value (r = 3%)	
Cost (Million 2012$)	$1,056.6
Benefits (Millions)	0.020
Cost / Benefits	$52,957.25
Present Value (r = 7%)	
Cost (Million 2012$)	$670.9
Benefits (Millions)	0.011
Cost / Benefits	$61,632.45

Note: All values are present values as of January 1, 2013 in millions of constant 2012 dollars.
Source: NERA 2013a

To assist the Tribunal in determining whether these costs per theoretical additional age-1 equivalent fish and harvested fish are "wholly disproportionate" to the benefits of such fish, I also provide evidence that recreational fisherman place a value on each fish caught of about $67 (NERA 2013a, p. 169). And while I conclude that $1,500 or $62,000 is a "wholly disproportionate" price to pay to produce a theoretical fish that anglers value only at $67, I did not opine – as one might expect in a simple "traditional cost-benefit analysis" – that any cost over $67 per fish is necessarily too high.

Q. In response to a question relating to your criticism of the use of IPEC revenue in the "wholly disproportionate" test, Ms. Brooks states that revenue is relevant because "it is an indicator of a company's ability to respond to changes in its operating environment, for instance its capacity to implement options necessary to continue to operate and succeed with its business plan" (p. 6, ll. 10-12). Do you agree?

A. No. It is important to point out at the outset that the question Ms. Brooks was asked misstates both the Wholly Disproportionate Report and my testimony. The question suggests that there is a statement in that Report which states that "facility revenue is irrelevant when assessing a company's ability to construct a BTA technology," and then asks Ms Brooks whether she agrees with "that statement." The actual statement on page E-3 is the following: "In accordance with economic principles, our assessments of costs do not include comparisons to IPEC revenues in terms of the 'wholly disproportionate' test." In other words, the wholly disproportionate test is not an affordability test, as I already explained. Nonetheless, facility revenue is used in my calculations of the costs of a technology to the extent revenue is lost during construction outages and as a result of parasitic and efficiency losses, consistent with DEC precedent.

III. REBUTTAL TESTIMONY REGARDING THE BENEFIT-COST ANALYSIS AS PART OF THE SEQRA DETERMINATION

Q. What is your understanding of the relationship between the BTA determination and the inquiry to be conducted under SEQRA?

A. I understand them to be two separate, independent inquiries. As previously discussed here and in my direct testimony, I understand that New York law requires that the "location, design, construction and capacity of cooling water intake structures . . . reflect the best technology available for minimizing adverse environmental impact," 6 N.Y.C.R.R. § 704.5, and prescribes a 4-part test for determining whether that is so, including consideration of whether the costs of practicable technologies are 'wholly disproportionate' to the environmental benefits they confer. SEQRA, on the other hand, requires New York State agencies, including NYSDEC, to consider the environmental impacts of the actions they contemplate, to "weigh and balance relevant environmental impacts with social, economic and other considerations," and to "avoid[] or minimize[] adverse environmental impacts to the maximum extent practicable," "consistent with social, economic and other essential considerations." 6 N.Y.C.R.R. § 617.11(d)(2), (5).

Q. Do the testimonies of Charles Nieder, Roy Jacobson, Jr. or Sharon Brooks address the NERA Benefit-Cost Report or SEQRA?

A. No, these witnesses' testimonies explicitly address only the NERA Wholly Disproportionate Report in connection with the BTA determination. Indeed, as NYSDEC Staff has operationalized the BTA determination and specifically its "wholly disproportionate" component as discussed above, NYSDEC Staff's analysis completely ignores numerous social, economic and other considerations that clearly are relevant to the SEQRA inquiry, such as impacts on consumer electricity prices.

For example, nowhere do Mr. Nieder, Mr. Jacobson or Ms. Brooks address the economic implications for New York consumers of requiring lengthy construction outages at IPEC during construction of cooling towers. Yet, the DPS witnesses sponsored by DEC Staff indicate that construction outages would have a large impact (on the order of $0.9-$1.6 billion) on New York electricity consumer expenditures. *See* Gjonaj and Wheat Exhibit 5 and Paynter Exhibit 2. This is precisely the kind of impact that can be taken into account under SEQRA, but that Mr. Nieder, Mr. Jacobson, and Ms. Brooks never address. I discuss these expenditure impacts in more detail in the next section of my rebuttal testimony.

All told, the DEC Staff witnesses never attempt to "weigh and balance" the mainly eggs and larvae that would be preserved by the competing BTA proposals, with the social costs and consumer price impacts of the proposals. Under SEQRA, is it worth imposing upwards of $2 billion in non-discounted costs on Entergy, and upwards of $1 billion in costs on New York consumers (let alone the adverse air quality, aesthetic, and other environmental impacts discussed by other witnesses), to achieve the incremental benefits offered by cooling towers over CWWS or the no-action alternative? No DEC Staff witness *ever* provides an opinion on this question under SEQRA, or actually addresses my conclusion (at page 75 in the Benefit-Cost Report) that cooling towers do not pass a social benefit-cost test "because their potential social costs are *far greater* than their potential social benefits" (emphasis added).

To the extent that comments made by Mr. Nieder, Ms. Brooks or Mr. Jacobson may have any relevance to the methodology used in the NERA Benefit-Cost Report, however indirect, I address them below.

Q. On that note, what is your response to Ms. Brooks's claim at page 6 of her testimony that economics as a field does not yet have the tools needed to value aquatic species?

A. This is an inaccurate statement, on which much of Ms. Brooks's testimony appears based. There is in fact a long history and an extensive literature in economics that has developed tools which allow economists to value aquatic species. These economic approaches have been relied upon by U.S. EPA and other regulatory agencies in valuing aquatic species. Indeed, the New York State Governor's Office of Regulatory Reform stated the following in its July 2008 Report entitled *Cost-Benefit Assessment in Rulemaking: A Guide for State Agencies*: "Health and environmental benefits can be monetized using the willingness-to-pay concept . . . where the amount an individual is willing to pay for a specific benefit is determined through either market data or opinion surveys." The analysis in the NERA Benefit-Cost Report employs these standard economic approaches (set forth in the relevant EPA and New York State guidelines) to estimate the value to society of theoretical changes in fish harvests.

Ms. Brooks goes on to criticize (on page 6 of her testimony) valuations of benefits that are "tied to a single market," that "reflect[] a single value for a single purpose" and that are "one dimensional" and do not "capture the essence" of a resource's "many contributions to the ecosystem." These concerns may be agreeable in the abstract, but to the extent her statements were intended as a criticism of my analysis, they are far off the mark. My analysis is not "tied to a single market," nor is it "one dimensional": in my SEQRA analysis, for example, I look at commercial fisheries; recreational fishing; indirect use benefits such as increased fishing equipment sales, increased property values, and increased ecotourism; and non-use benefits for persons who simply value knowing additional theoretical fish are there. For fish species that are not themselves caught by commercial and recreational fisherman, I analyzed their value as forage fish for species that are themselves caught. My reports make every effort to "capture the essence" of aquatic organisms' "many contributions to the ecosystem." In contrast, the DEC Staff's proposed analysis only simplistically asks what the comparative percentages of aquatic organisms and revenue are.

Q. Mr. Nieder and Ms. Brooks claim that monetary values cannot be applied to the environmental benefits of reduced impingement and entrainment of aquatic specifies at IPEC. Do you agree with that?

A. No. Monetary values can be applied to the environmental benefits of reduced impingement and entrainment of aquatic species at IPEC using the standard economic approach mentioned above. In particular, the social benefits resulting from cooling towers or CWWS at IPEC are the maximum amount of money that individuals as a group would pay voluntarily to obtain the environmental improvements, *i.e.*, the theoretical increases in various fish populations. To determine those values, consistent with EPA guidance and sound economics practice, I relied on information including (1) annual average *ex-vessel* commercial fish price data reported by the National Marine Fisheries Service ("NMFS") to quantify the theoretical benefits to commercial fish resource users and (2) a detailed, statistical meta-analysis that relies on various studies of recreational fishing habits to quantify the theoretical benefits to recreational fish resource users.

Further, Ms. Brooks claims (at page 6 of her prefiled direct testimony) that Staff's proposed BTA analysis "does not monetize the benefits to be had from installing and operating" a particular technology, and does not "convert the benefit of reducing impacts to a multitude of aquatic species and a very large ecosystem to one market or monetary value." However, Staff's approach is also assigning values to the benefits of technologies, by calculating "proportional benefits" and comparing them to "proportional costs," as explained above: under Staff's apparent approach, the implicit monetary value of a given percentage reduction in fish losses would vary according to whatever plant gross revenue happens to be. Compared to converting aquatic organisms to monetary terms using well accepted economic approaches employed by other regulators such as EPA, Staff's "proportional benefits" values are plainly more arbitrary, less transparent and less useful for the task of balancing economic considerations in a SEQRA proceeding.

Q. Do you have any response to explanations provided in Mr. Nieder's testimony (see Nieder Direct at p. 4, ll. 11-18) for why DEC did not assign monetary values to environmental benefits for BTA alternatives?

A. Yes. None of Mr. Nieder's apparent explanations for not developing monetary values withstands scrutiny. As I discuss in my direct testimony, in the NERA Benefit-Cost Report and in my previous answer, economists have developed well-established methods to provide monetary values for situations such as this in which a policy or project leads to aquatic ecological benefits. Mr. Nieder seems to indicate two major reasons for not monetizing benefits in his response to the question on p. 4. One reason seems to be based upon a quotation from the U.S. EPA that "97 percent of the I&E mortality losses at industrial facilities operating a CWIS include unharvested recreational and commercial fish and forage fish which do not have direct human use values" (Nieder Direct at p. 4, ll. 14-17). Mr. Nieder seems to imply that monetary values cannot be assigned to these unharvested recreational and commercial fish and forage fish, but that is not true. As explained in the previous section, fish that do not have direct use value (including both non-harvested species and non-fished harvested species) are accounted for in the NERA monetary benefits as indirect benefits through their contribution to greater numbers or weight of game fish, which means that 100 percent of the I&E gains are included in the monetary benefit estimates. The calculations of indirect biological benefits are based on well-established methodologies developed and accepted by biologists, and are consistent with the methods and guidelines of the U.S. EPA.

A second concern seems to be that non-use benefits "are qualitative in nature and simply cannot be monetized accurately." But the fact that some potential benefit categories are not monetized does not mean that monetary values should not be developed for the other categories. As I discussed earlier (see pp. 14-15), consistent with EPA guidelines on the role of qualitative assessments in a benefit-cost analysis, I considered non-use benefits from a qualitative perspective. Note that this response also addresses Ms. Brooks's testimony at page 8 in her prefiled direct testimony that my analysis "assum[es] everything can and must have a strictly monetary value . . . ." This statement is clearly incorrect, as my reports plainly acknowledge that some benefits cannot easily be quantified and therefore addresses those benefits on a qualitative basis.

Q. Is it conceivable that assigning monetary values to non-use benefits could affect the conclusions related to cooling towers?

A. No. It is important to note that my major conclusion regarding the cooling tower alternative—that its costs are wholly disproportionate to its benefits—does not depend upon the dollar value of non-use benefits, or, indeed, the dollar value of any other benefits. The biological information indicates that CWWS provides greater aggregate biological benefits than cooling towers, both because air quality limitations mean that cooling towers could only be operated on average 13 percent of the time over the course of the year and because CWWS would be in place sooner than cooling towers and thus would generate benefits for a longer period of time. Indeed, the timing difference means that CWWS provides greater aggregate biological benefits even if one assumes that cooling towers could operate 100 percent of the time. Thus, whatever non-use benefits might be calculated for cooling towers—and economic criteria indicate they are not likely to be important—would be greater for CWWS.

Q. Do you agree with Ms. Brooks (at page 7 of her direct testimony) that a traditional benefit-cost analysis is not relevant to whether cooling towers or CWWS should be installed at IPEC?

A. It depends on what she means by a "traditional cost-benefit analysis." I have never said that if the net benefits of a proposal are negative by even a single dollar, then the proposal should not be adopted, and I do not believe that New York law is so mechanical. At the same time, Section 617.11(d)(2) plainly states that an agency's SEQRA finding must "weigh and balance relevant environmental impacts with social, economic and other considerations," and New York's SEQRA Handbook notes that "in the findings which must be issued after a final EIS is completed, environmental impacts or benefits may be balanced with social and economic considerations" (NYSDEC 2010, p. 87). Comparing costs and benefits in monetary terms is the best method of weighing and balancing the economic impacts of CWWS or cooling towers that is useful to support decision-making in this context. In addition, this method has been used by EPA in its recent proposal related to Section 316(b) of the Clean Water Act (EPA 2011). By lumping together and criticizing all comparisons of costs and benefits as a "traditional cost-benefit analysis," Ms. Brooks limits DEC to only arbitrary means of weighing environmental and economic impacts, such as Staff's irrational comparison of benefit and revenue ratios.

Q. Is Ms. Brooks correct in claiming (at page 7 of her direct testimony) that the NERA Report "creates a static analysis of a moment conceptually frozen in time simply ignores or side-steps any representation of the actual environment: the Hudson River, its aquatic species and its ecosystems."?

A. No. The NERA analyses rely on biological modeling of the theoretical gains to the harvests of specific species if CWWS and cooling towers were in place at IPEC. Moreover, the expert biological assessments indicate that reducing impingement and entrainment at IPEC would not in fact increase fish populations or harvests, and would not have any significant effect on the aquatic ecosystem surrounding the plant. Ms Brooks presents no biological information to support her claim that the NERA report "fails to recognize the contribution of aquatic organisms to the ecosystem" (Brooks Direct at p. 7, l. 31, to p. 8 l. 1).

Indeed, it is especially ironic that Ms. Brooks criticizes my analysis on the basis that is supposedly "ignores or side-steps any representation of the actual environment: the Hudson River, its aquatic species, and its ecosystems" (Brooks Direct at p. 7, ll. 29-30). My analysis, of course, is highly specific to "the Hudson River, its aquatic species, and its ecosystems": it identifies the specific fish species that are impinged and entrained; considers the specific life stages of those species that are impinged or entrained; considers which of those species are directly fished by humans and which are of benefit only as forage fish; considers the commercial, recreational, indirect use, and non-use benefits of those specific species; acknowledges evidence that entrainment in the specific context of the Hudson River does not actually decrease fish populations in the River; and so forth.

It is DEC Staff's BTA analysis that "ignores or side-steps any representation of the actual environment: the Hudson River, its aquatic species, and its ecosystems." DEC Staff lumps all fish together and refuses to consider any differences among species, treating a valuable striped bass the same as a bay anchovy. DEC Staff also refuses to consider the particular life stages of fish that are impinged and entrained and the implications of those specific life stages in the ecosystem, treating the impingement of a juvenile fish the same as entrainment of a single egg. And, as explained amply elsewhere, DEC Staff assigns values to aquatic organisms that have no relation to species or life stage, because they are based on the irrelevant data point of facility revenue.

Q. What is your response to Ms. Brooks' contention, based on Boardman, et al. (2011), a textbook cited in the NERA report, that "cost-effectiveness analysis is a more appropriate choice because one is not able to monetize the most important impact"?

A. Ms. Brooks's argument fails for several reasons. First, Ms. Brooks has provided no information to indicate that the NERA benefits assessment "is not able to monetize the most important impact," as she claims. In addition, as shown by the cost-effectiveness undertaken in the NERA Wholly Disproportionate Report, the use of a cost-effectiveness analysis instead of a benefit-cost analysis does not change any of my conclusions. I have shown that the costs of closed cycle cooling greatly exceed those of CWWS, and CWWS provides greater aggregate benefits even assuming no air quality restrictions on use of cooling towers, meaning that CWWS dominates cooling towers even under a cost-effectiveness analysis.

Q. How do you respond to Ms. Brooks's claim that "accepting NERA's monetized value for the aquatic resources would permit an irretrievable commitment of natural resources to Entergy's cooling water intake structure?"

A. Ms. Brooks's statement ignores the trade-offs inherent in decision-making, including in this context. All economic development involves a commitment of natural resources; burning a single gallon of gasoline reflects "an irretrievable commitment of natural resources." Indeed, the construction of cooling towers would also constitute an "irretrievable commitment of natural resources" to Entergy's cooling water intake structure: it will, among other environmental impacts, impose visual impacts, affect air quality, result in permanent excavation of landscapes, and still result in the impingement and entrainment of some aquatic organisms (in fact, greater impingement than is seen with CWWS). Such unavoidable trade-offs are precisely why a SEQRA finding appropriately requires the weighing and balancing of environmental impacts with social, economic and other considerations. A benefit-cost analysis is the approach most well suited to account for the economic considerations associated with proposed options for reducing impingement and entrainment at IPEC's cooling water intake structures.

Q. Would any of your conclusions in the Benefit-Cost Analysis change if you were to use information on cooling towers from the 2010 ENERCON Report as opposed to the 2013 Tetra Tech report?

A. No. As discussed in the previous section, using the 2010 ENERCON Report, the estimated costs of cooling towers are larger for every category of costs and the estimated benefits of cooling towers are smaller compared to those calculated using the 2013 Tetra Tech Report. Therefore, the major conclusions that the costs of cooling towers are larger than the costs of CWWS and the benefits of cooling towers are smaller than the benefits of CWWS remain true when information from the 2010 ENERCON Report is used.

IV. REBUTTAL TESTIMONY REGARDING THE ELECTRICITY MARKET IMPACTS IF IPEC WERE NOT AVAILABLE AS PART OF THE SEQRA DETERMINATION

Q. Turning now to the analyses under SEQRA of the electricity market impacts that would result if IPEC were not available, could you indicate what impacts were considered in the testimony provided by witnesses for Riverkeeper, the NYSDEC and the City of New York and how those categories compare to those you evaluated?

A. The testimony (and accompanying reports) includes information on wholesale electricity and capacity prices, New York State consumer expenditures for energy and capacity, carbon dioxide and air emissions, electricity system reliability, and fuel diversity. This is the same set of impacts I considered.

Q. Could you provide an overview of the testimony of the various witnesses whose empirical results you comment on?

A. Yes. It is useful to organize the testimony in terms of the witnesses' affiliations, which include Synapse, the New York State Department of Public Service (NYSDPS), and Charles River Associates (CRA). Mr. Robert Fagan of Synapse provides testimony on behalf of Riverkeeper that includes information on wholesale electricity prices and emissions of CO_2, nitrogen oxides (NO_x), and sulfur dioxide (SO_2). The testimony is accompanied by a Synapse report, dated February 28, 2014. The NYSDPS is represented by two sets of testimony (and accompanying results tables) providing empirical results, one by Leka Gjonaj and David Wheat and a second by Dr. Thomas Paynter, as well as commentary by Ronald Stannard, and Christopher Hogan, all of which are provided on behalf of the NYSDEC. Together the DPS testimonies provide information on New York State consumer expenditures for wholesale electricity and capacity as well as emissions of CO_2, NO_x and SO_2. Christopher Russo of CRA provides information on wholesale electricity expenditures and capacity expenditures as well as emissions of CO_2, NO_x and SO_2. Mr. Russo's testimony is accompanied by a CRA report dated August 2, 2011.

Q. Have you developed a summary of the results provided in these various testimonies and reports for the impact categories that overlap with yours?

A. Yes. I wanted to provide a broad overview of the results across the four sets of testimonies/reports to provide an indication of similarities and differences in results among the various studies. I developed charts that summarize the modeling results for emissions and electricity prices and expenditures. I tried to make the results for the various studies as comparable as possible. Thus, I tried to put dollar expenditures in the same units (2012 dollars) and the emissions in the same units (short tons). In some cases, I had to make certain assumptions because the units were not specified. I also tried to include the same years in the comparisons. In my report and testimony, I developed estimates for the period from 2015 to 2019. The Synapse and CRA reports included overlapping years from 2016 to 2019, and thus I used that time period in the comparisons. The DPS values were provided for two years, 2016 and 2022, and I provide both of these years (although wholesale electricity and air emissions estimates were only provided for 2022). Certain DPS results also differed because they assumed that IPEC would be out for 42 weeks rather than over the course of the year, as assumed in the other studies.

Q. What general criteria did you use to determine the cases you used from the other testimonies and reports?

A. My report focuses on the impacts if IPEC were not available over the course of the entire year, roughly the situation if there were a construction outage or other major outage event. This does not include, for example, the effects of so-called "protection outages" (which I understand are not the subject of this hearing). My report also is careful to base impacts upon consistent "baseline" and "IPEC out" scenarios, including judgments about what changes might occur in the near term (e.g., 4-5 years) if IPEC were not available. Thus, I excluded cases based upon short outages (i.e., outages less than 42 weeks) and cases in which there were not clear connections between the "baseline" and "IPEC out" cases (and thus the impacts of "IPEC out" could not be separated out from other events—such as greater energy efficiency or larger amounts of renewables—that were not justified on the basis of market conditions). This latter issue relates to the potential problem of conflating the effects if IPEC were out of service with other changes that might be anticipated regardless of whether or not IPEC were available. For example, if one scenario predicts that there will be additional energy efficiency over time, the baseline as well as the "IPEC out" scenario should reflect that assumption and not just the "IPEC out" scenario. With this assumption in both scenarios, the difference (e.g., CO_2 emissions) would provide a valid measure of the *independent* impacts if IPEC were not available.

Q. With that background, could you identify the scenarios from the Synapse analysis you use as the basis for comparison with the NERA results?

A. Mr. Fagan presents ten scenarios that vary by IPEC status and outage type as well as by load assumptions, wind additions, solar additions and coal retirements, as shown in Table 3 of the Synapse report (p. 17). There are two basic divisions relating to the IPEC outage period, one set based upon various outages related to closed cycle cooling construction and related purposes, and one set based upon IPEC being fully out of service over the period from 2016 to 2025. Recognizing that it is necessary to compare scenarios with a consistent baseline, I developed information for four sets of comparisons between the baseline and an "IPEC out" case. Two of the cases involved what I understand is a "reference baseline" and two cases involve an alternative baseline with greater energy efficiency, wind and solar additions, and coal retirements; I label the second set the "renewables" case for ease of identification. For the first two sets, I used averages for the period overlapping with my estimates (2016-2019); for the third and fourth set, I calculated differences across two years (2017-2018) because Synapse assumed the outages for the two IPEC units would be divided among those two years.

Q. Could you identify the scenarios from the DPS analysis you use as the basis for comparison with the NERA results?

A. Yes. Mr. Gjonaj and Mr. Wheat of DPS were asked to evaluate scenarios defined by DEC, as reported in Exhibit_G-W-3. The most appropriate scenario for our comparison is labeled Run 1, which assumes 42-week construction outages for both IPEC units. They developed results for two years, 2016 and 2022, with the results for wholesale energy prices/expenditures only available for 2022. I present results for both years for capacity expenditure impacts and the 2022 results for emissions and wholesale energy prices/expenditures.

Q. Can you identify the CRA scenarios you used in your comparative analysis?

A. The CRA report includes cases in which IPEC would be out of service from 2016 to 2019, a period that overlaps with my modeling, and thus I used the average values for this period in the comparisons. CRA includes a single baseline and four "IPEC out" cases. None of the "IPEC out" cases is labeled as "most likely;" I used the CRA case closest to my estimates of what additional changes were likely to occur if IPEC were not available—the case he refers to as the "conventional thermal" case in which 500 MW of capacity are added both in the Lower Hudson Valley and New York City—as the basis for the CRA "IPEC out" case for the comparisons.

Q. Could you provide the table of results and summarize what it shows about the similarity and differences among impacts across the four sets of testimony and reports?

A. Table 1 and 2 provide this summary. Table 1 shows results related to electricity price and expenditure impacts, and the rightmost column of this table shows the average of the results from the other studies. The overall conclusion is that the four sets of price/expenditure impacts are very similar. Table 2 shows results for CO_2 emission impacts and NO_x emission impacts, and again the rightmost column shows the average of the results from the other studies. The CO_2 impacts are virtually identical across the four sets of results. Although the NO_x emission impacts vary across the various estimates, even they are quite similar. The NERA and Synapse results are somewhat larger (in terms of percentage impacts) than the DPS and CRA impacts.

Table 1. Wholesale Electricity and Capacity Price Impact Comparisons

	NERA	Synapse Base Case	Synapse Renewables Case	DPS	CRA LHV & NYC CC	Average Results
LMP Price Impacts (2012$/MWh)	3.56	2.68	1.82	1.64		2.05
Consumer Price Impacts (Billions 2012$)						
Wholesale Electricity	0.4			0.2	0.4	0.3
Capacity	1.4			1.4 / 0.7	1.2	1.1
Total	1.8			1.6 / 0.9	1.5	1.3

Note: NERA values represent average estimates for model years 2016-2019. NERA values are reported as average for region represented by NYCA Zones GHI to correspond with Synapse estimated values.
Synapse values represent average estimates for model years 2016-2019. Synapse values are reported for NYCA Zones GHI.
DPS LMP and wholesale electricity price estimates are provided for NYS in year 2022. We assume they were reported in nominal dollars so we convert to 2012 dollars.
DPS capacity price and total price estimates are provided for years 2016/2022. We assume they were reported in nominal dollars so we convert to 2012 dollars.
CRA values represent average estimates for model years 2016-2019. We adjust dollars from 2010 dollars to 2012 dollars.
Average results do not include NERA estimates.

Table 2. Air Emissions Impact Comparisons

	NERA	Synapse Base Case	Synapse Base Outage Case	Synapse Renewables Case	Synapse Renewables Outage Case	DPS	CRA LHV & NYC CC	Average Results
CO_2 Emissions Impacts (millions of short tons)	5.6	5.7	6.1	5.2	5.6	5.1		5.5
(as percent change)	15%	14%	15%	15%	17%	14%	15%	15%
NO_x Emissions Impacts (thousands of short tons)	3.1	2.7	2.8	1.6	1.7	1.5		2.1
(as percent change)	17%	15%	16%	13%	13%	7%	8%	12%

Note: NERA values represent average estimates for model years 2016-2019.
Synapse values represent average estimates for model years 2016-2019. Outage cases represent the total additional emissions during the two construction periods.
DPS values are reported for model year 2022, the only model year with construction outages that was modeled with GE MAPS.
CRA values represent average estimates for model years 2016-2019.
Average results do not include NERA estimates.

Q. Could you elaborate on the similarity of the electricity expenditure results?

A. Yes. Three modeling results estimate added electricity expenditures: NERA, DPS and CRA. The NERA estimates indicate that, on average over the 2016-2019 period, New York State consumers would pay about $1.8 billion per year more for electricity if IPEC were not available. The DPS provides comparable estimates for wholesale electricity for 2022 and estimates for capacity payments for 2016 and 2022. The DPS does not indicate whether the dollars are in nominal or real values; to be conservative, I presumed they are in nominal dollars and thus I discounted them back to 2012 dollars. The DPS energy and capacity expenditures would total $1.6 billion if the 2022 wholesale electricity value is added to the 2016 capacity value and $0.9 billion if the 2022 wholesale electricity value and 2022 capacity value are added. The CRA estimates are $0.4 billion for added energy expenditures and $1.2 billion for added capacity expenditures, with the total increase about $1.5 billion per year. The average of all of the other three sets of estimates (two DPS estimates and one CRA estimate) is $1.3 billion per year in added electricity expenditure to New York State consumers if IPEC were not available.

Q. How can you explain the similarity of the electricity expenditure results across these various studies?

A. The similarity in the results is not surprising because the models used for wholesale electricity price impacts (PROMOD for NERA, PROSYM for Synapse, and GE-MAPS for both DPS and CRA) are all production cost models that use broadly similar data bases, and the capacity price impacts are calculated using the methodology and data developed by New York State to model capacity prices. There are of course various differences in the assumptions used in the various modeling efforts, but my objective here is to provide a broad overview of the results, without getting into the many details in the modeling assumptions. From this broad perspective, it seems clear that all the modeling shows that New York State consumers would pay on the order of $1 billion or more in additional expenditures for electricity in a year in which IPEC were not available.

Q. How significant are these increases in expenditures?

A. It seems clear that having New York State electricity customers pay more than $1 billion is a significant impact under SEQRA. None of the other testimonies have rebutted the proposition that electricity customers would incur substantially greater expenditures for electricity if IPEC were not available.

Q. Could you comment on Mr. Hogan's statements on p. 8, ll. 3-16, of his direct testimony that "the modeling presented by DPS staff forecasts relatively minimal potential wholesale energy market impacts under various outage scenarios" and that "over the long-term, including under scenarios in which outages occur in 2022, potential impacts in [installed capacity] prices are forecast to be relatively minimal"?

A. Yes. With regard to wholesale energy market prices, Mr. Hogan compares the estimated price increase as a percentage of the base case price, noting that the modeling projects impacts "up to approximately 2% relative to a Base Case under construction outage scenarios." (p. 8) This Statewide comparison ignores the variation in impacts within the New York State; the Hudson Valley region would have a percentage increase that is almost twice as large as the state average. In addition, the impacts on expenditures related to electricity capacity payments are even greater than for wholesale electricity and thus much more significant to New York electricity consumers. Mr. Hogan acknowledges that the DPS modeling "forecasts potential large impacts on [installed capacity] prices in the short-term...") (p. 8, ll. 13-14). Thus, the 2% figure used by Mr. Hogan is a misleading indicator of impacts on New York consumers generally and consumers in the most affected regions in particular.

Moreover, in order to determine significance, it seems more appropriate to focus on the total dollar value increase in consumer expenditures that would occur, rather than a percentage impact. As noted in the table above, even under the DPS estimates—which are about half the estimates for the NERA and CRA modeling results—New York consumers would pay about $200 million more for wholesale electricity if IPEC were not available. In addition, the capacity expenditure increase forecast by DPS modeling for 2016 is about $1.4 billion. Mr. Hogan's argument that the 2022 impacts are "relatively minimal" may be relative to the value of $1.4 billion; but many would consider the added capacity expenditures estimated by DPS of $700 million to be large in an absolute sense. Note that even under the DPS modeling for 2022, the increase in expenditures for New York electricity consumers would be about $900 million, an amount that certainly could not be considered "minimal" in an absolute sense.

Q. Turning now to emissions, could you elaborate on the results for CO_2 emissions?

A. The results of the four modeming studies are remarkably similar for CO_2 emissions impacts. The NERA study estimates that CO_2 emissions would increase initially by about 5.6 million tons in a year in which IPEC was not available, or about 15 percent of baseline New York State emissions.

The Synapse study estimates that the increase would be between 5.2 million and 6.1 million tons (depending on the scenario), or about 14-17 percent of baseline CO_2 emissions. The DPS estimates that added CO_2 emissions would be 5.1 million tons, or about 14 percent greater than baseline. The CRA results are provided as percentage increases; the increase is 15 percent for the case used in these comparisons. The average of the other results is 5.5 million tons, or about 15 percent of baseline emissions.

Q. How significant are these impacts on CO_2 emissions?

A. As mentioned in the NERA report, the estimated CO_2 impacts are larger than the target reduction in New York State CO_2 emissions over this period under the Regional Greenhouse Gas Initiative (a decrease of 4.0 million tons by 2019 relative to the 2014 level).

Q. What about the statement of NYSDEC witness Ronald Stannard (at p. 4, ll. 8-10) that even with the presumed permanent retirement of IPEC, modeling projects cumulative CO_2 emission reductions in the regional CO_2 cap under RGGI?

A. This observation, though correct, does not provide any perspective on the significance of IPEC to meeting RGGI goals and reducing regional CO_2 emissions. Comparing the potential increases in CO_2 emissions if IPEC were not available to the RGGI goals provides an appropriate indication of the importance of IPEC to regional climate policy goals.

Q. Do all three of the other studies provide explicit information on the impacts on annual CO_2 emissions if IPEC were not available?

A. Both the DPS study and the CRA study provide explicit estimates, and thus I take their results directly from their documents. In contrast, in the case of Synapse, I had to go into the details of the Synapse report to determine the results and calculate the impacts. I did not see any explicit mention in either Mr. Fagan's testimony or the Synapse report of the impacts on CO_2 emissions if IPEC were not available.

Q. Could you elaborate on the results for NOx emissions?

A. The results for NO_x emissions vary more than the CO_2 results, although all studies show substantial increases, on the order of a 10 percent increase in New York State NO_x emissions, if IPEC were not available. The NERA modeling estimates an increase of about 3,100 tons or about a 17 percent increase. The Synapse scenarios range from 13 percent to 16 percent. DPS modeling indicates an increase of 7 percent, with the CRA estimate equal to 8 percent. The average for the other studies is an increase of 2,100 tons, or about 12 percent of baseline emissions. My understanding is that the differences are due primarily to different assumptions on coal unit availability, particularly with regard to the Danskammer facility (a portion of which is coal-fired). The NERA modeling assumes that Danskammer would be mothballed and not available in the baseline but would return to service if IPEC were not available, and I believe that the other analyses assume Danskammer would be available in both scenarios. The current owner of Danskammer recently has indicated an intention to resume operation, which, if the request were approved, would mean that Danskammer would be in the baseline and the NO_x impacts would be somewhat smaller than the NERA estimate. Note, however, that changing the status of Danskammer would affect other modeling results; in particular, I would expect the change to lead to greater energy and capacity price impacts (because a relatively low-cost facility would now be in the baseline and thus not available to replace part of IPEC generation and capacity).

Q. Could you comment on the significance of the potential increases in NO_x emissions?

A. As I mention in my report, as part of its State Implementation Plan (SIP) for the New York Metropolitan Area particulate matter (PM2.5) non-attainment area, New York aims to reduce annual NO_x emissions from relevant point sources by 1,100 tons between 2007 and 2017. The average estimate of the change in NO_x emissions if IPEC were not available is about 2,100 tons, which is almost twice the target reduction for point sources.

Q. What about the statement of Mr. Stannard on page 2 of his testimony that the NO_x emissions increase projected by the DPS of about 1,500 tons is less than 1 percent of the total emissions that DEC projected for the New York City non-attainment area in 2025?

A. I think a comparison with total emissions is less useful than a comparison of the reductions New York is intending to obtain from point sources. Presumably if IPEC generation were no longer available, New York would have to look for costly reductions from other sources. Even based on the relatively low DPS estimate of 1,500 tons, the State would need to obtain NO_x reductions that are greater than its current target reduction for relevant point sources.

Q. Could you comment on Mr. Hogan's characterization on p. 11, ll. 2-10, of his direct testimony of the nature of the air emission impacts forecast by the DPS modeling?

A. Yes. Mr. Hogan refers to Mr. Stannard's testimony, and thus my comments on Mr. Stannard's characterization of the air emission impacts is relevant to Mr. Hogan's comments as well that "the forecasted increases of SO_2 and NO_x appear to be relatively small" and "the forecasted increases in CO_2 emissions were already accounted for in recent revisions to the Regional Greenhouse Gas Initiative (RGGI) program." (p. 11, ll. 6-9). For the reasons I discussed earlier, I believe the potential increases in NO_x emissions are not necessarily "small" and that the appropriate criterion for evaluating the significance of CO_2 emissions impacts is not what is included in the RGGI modeling but rather what the potential increase in CO_2 emissions would be if IPEC generation were not available. As noted above, all estimates, including the modeling done by DPS, put the potential annual increase in CO_2 emissions at more than 5 million tons.

Q. Do you agree with Mr. Russo's description on pages 12-13 of his testimony on the factors that must be considered when analyzing the potential impacts of an extended outage or retirement on power system reliability?

A. Yes. As Mr. Russo notes, many aspects of system reliability would be affected if IPEC were not available, including resource adequacy, Locational Capacity Requirements (LCR) and voltage support. Resource adequacy measures the ability of the interconnected power system to meet demand with an acceptably low probability of an outage, with the metric typically expressed as Loss of Load Expectation (LOLE). The federally-mandated standard is an LOLE of 0.1, which roughly means that an outage would be expected one day every ten years. In addition to this state-wide measure, LCRs reflect the unique characteristics of New York's grid and currently specify that 86 percent of the New York City load must be met by in-City load and generation and that 105 percent of the load on Long Island must be met by load and generation on Long Island. I agree with Mr. Russo that these LCR requirements highlight the importance of the geographic location of supply resources. I also agree with Mr. Russo that IPEC provides significant voltage support to the New York electrical system that allows other sources of electricity to move from Update to the Southeast New York region and that this voltage support cannot be provided by reducing demand or adding transmission lines.

Q. Could you comment on Mr. Hogan's conclusion (at p. 8, ll. 23-26) that "[m]uch of Entergy's discussion [developed by NERA] about these potential impacts...is

generally in the context of the potential decommissioning or shut-down of Indian Point Units 2 and 3, which is not the subject of this proceeding and is therefore beyond the scope of the SEQR review"?

A. This is not an accurate characterization of the NERA electricity market modeling. As noted in the introduction to my Electricity System Impacts Report, the modeling assesses potential "impacts if a requirement to install cooling towers made IPEC unavailable to contribute to the electricity system, including the possibility of an extended outage due to blasting or other conditions." The empirical estimates in my report provide useful information for SEQR evaluations regarding the potential impacts on the electricity system if IPEC were not available for whatever reason, including a construction outage. Indeed, as I explained above, the estimates I develop for electricity price and expenditure impacts and air emissions impacts are similar to those developed by the DPS experts on behalf of the NYSDEC.

Q. Do you agree with Mr. Russo's statement in his testimony (p. 9, ll. 20-22) that "natural gas can be subject to sharp seasonal price spikes even during a period when prices otherwise are low as compared to historical levels"?

A. Yes. As Mr. Russo notes, significant natural gas price spikes occurred this winter and at several other times in recent years. As I discuss in my report (pp. 30-31) regarding the importance of fuel diversity, NYISO and other stakeholders in New York State have expressed concern about the State electricity system's heavy reliance on natural gas, particularly around New York City. Indeed, the State's consumption of natural gas for electricity generation more than doubled between 2004 and 2012. This reliance on natural gas can cause large swings in power prices for New York State consumers because of the significant volatility in natural gas prices. If IPEC were unavailable, including for a construction outage, New York State (and particularly areas around New York City) would become even more reliant on natural gas for electricity generation, and consumers would become even more exposed to large swings in their electricity bills.

Q. Does this conclude your testimony?

A. Yes.

V. REFERENCES

Boardman, Anthony, David Greenberg, Aidan Vining, and David Weimer ("Boardman et al."). 2011. *Cost-Benefit Analysis Concepts and Practice. 4th Ed.* Saddle River, NJ: Prentice Hall.

Barnthouse, Lawrence W. et al. 2008. *Entrainment and Impingement at IP2 and IP3: A Biological Impact Assessment.*

Barnthouse, Lawrence W. for the Electric Power Research Institute. 2004. *Extrapolating Impingement and Entrainment Losses to Equivalent Adults and Production Foregone.*

Beaver, Sam ("Beaver Testimony"). Prefiled Rebuttal Testimony of Sam Beaver in Support of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC and Entergy Nuclear Operations, Inc. March 2014.

Brooks, Sharon 2014 ("Brooks Testimony"). Direct Testimony of Sharon Brooks in the Matter of a Renewal and Modification of a SPDES Permit Pursuant to ECL Article 17 and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York Parts 704 and 750, et seq.

Freeman, A. Myrick III. 2003. The Measurement of Environmental and Resource Values Theory and Methods. 2nd Ed. Washington, D.C.: Resources for the Future.

Jacobson, Jr., Roy 2014 ("Jacobson Testimony"). Direct Testimony of Roy Jacobson, Jr. in the Matter of a Renewal and Modification of a SPDES Permit Pursuant to ECL Article 17 and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York Parts 704 and 750, et seq.

Matter of Renewal and Modification of a SPDES Permit by Entergy IP2 and Entergy IP3, Ruling of the Regional Director, November 28, 2012.

NERA Economic Consulting (NERA). 2013a. Wholly disproportionate assessment of cylindrical wedgewire screens and cooling towers at IPEC. December 2013.

NERA Economic Consulting (NERA). 2013b. Benefits and Costs of Cylindrical Wedgewire Screens and Cooling Towers. December 2013.

New York Governor's Office of Regulatory Reform. 2008. Cost-Benefit Assessment in Rulemaking: A Guide for State Agencies. July.

New York State Department of Environmental Conservation (NYSDEC). 2000. Athens Generating Company, LP – Interim Decision. June 2, 2000. **http://www.dec.ny.gov/hearings/10976.html**

New York State Department of Environmental Conservation (NYSDEC). 2002. Mirant Bowline, LLC – Decisions. March 19, 2002. **http://www.dec.ny.gov/hearings/11479.html**

New York State Department of Environmental Conservation (NYSDEC). 2010. *The SEQRA Handbook.* 3rd Ed.

Nieder, William C. 2014 ("Nieder Report"). Indian Point Energy Center Unit 2 and Unit 2 BTA Analysis Step Four of the BTA Procedure: The Wholly Disproportionate Test. February 28, 2014.

Nieder, William C. 2014 ("Nieder Testimony"). Direct Testimony of William Charles Nieder in the Matter of a Renewal and Modification of a SPDES Permit Pursuant to ECL Article 17 and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York Parts 704 and 750, et seq.

Tetra Tech. 2013. Indian Point Closed-Cycle Cooling System Retrofit Evaluation. Prepared for the New York State Department of Environmental Conservation. June 2013.

U.S. Environmental Protection Agency (EPA). 2010. *Guidelines for Preparing Economic Analyses.* Washington, DC: EPA, December.

U.S. Environmental Protection Agency (EPA). 2011. *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule*. March 28.

U.S. Federal Appeals Court, Second Circuit. 2007. *Riverkeeper, Inc. v. EPA*, 475 F.3d 83 (2007).

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

In the Matter of Entergy Nuclear Indian Point 2, LLC and Entergy Nuclear Indian Point 3, LLC For a State Pollutant Discharge Elimination System Permit Renewal and Modification	DEC No.: 3-5522-00011/00004 SPDES No.: NY-0004472
In the Matter of Entergy Nuclear Indian Point 2, LLC, Entergy Nuclear Indian Point 3, LLC, and Entergy Nuclear Operations, Inc. Joint Application for CWA § 401 Water Quality Certification	DEC App. Nos. 3-5522-00011/00030 (IP2) 3-5522-00105/00031 (IP3)

PREFILED REBUTTAL TESTIMONY OF DANIEL GESSLER, P.E., PH.D., D.WRE, IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

CLOSED CYCLE COOLING

ENTERGY NUCLEAR INDIAN POINT 2, LLC, ENTERGY NUCLEAR INDIAN POINT 3, LLC, AND ENTERGY NUCLEAR OPERATIONS, INC.

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PREFILED REBUTTAL TESTIMONY OF DANIEL GESSLER, P.E., PH.D., D.WRE
IN SUPPORT OF ENTERGY NUCLEAR INDIAN POINT 2, LLC,
ENTERGY NUCLEAR POINT 3, LLC AND ENTERGY NUCLEAR OPERATIONS, INC.

Q: Please identify yourself.

A: My name is Daniel Gessler. I am Vice President and Principal of Alden Research Laboratory, Inc. ("Alden"), with offices at 30 Shrewsbury Street, Holden Massachusetts; 9521 Willows Road NE, Redmond, Washington; 813 SW Alder St. Suite 410, Portland Oregon; and 2000 S. College Ave., Suite 300, Fort Collins, Colorado. My principal office is in Fort Collins.

Q: Are you the same Daniel Gessler who provided prefiled direct testimony on February 28, 2014 on behalf of Entergy in support of its application for renewal of State Pollutant Discharge Elimination System ("SPDES") Permit (DEC App. Nos. 3-5522-00011-00004 SPDES No. NY0004472) for Indian Point Units 2 and 3 and the corresponding issue in the associated Water Quality Certification ("WQC") proceeding, as it has been consolidated by this Tribunal (collectively, the "Proceedings")?

A: Yes.

Q: Please state the purpose of your prefiled rebuttal testimony.

A: The purpose of my prefiled rebuttal testimony is to address any aspects of the prefiled direct testimony submitted by NYSDEC Staff or Riverkeeper concerning Alden's analysis of the potential for recirculation of the exhaust from Tetra Tech's proposed ClearSky cooling towers, as they were described in the report prepared by Tetra Tech entitled *Indian Point Closed-Cycle Cooling System Retrofit Evaluation*, dated June 2013. I have reviewed the prefiled direct testimony of NYSDEC Staff's witnesses that addressed potential operational impacts associated with Tetra Tech's ClearSky towers, Messrs. Tim Havey and Eduardo Ortiz. I understand that Riverkeeper offered no testimony concerning operational impacts of closed-cycle cooling at IPEC.

Q: Did Messrs. Havey or Ortiz address Alden's analysis of recirculation associated with Tetra Tech's ClearSky configuration?

A: No. Mr. Havey does not mention recirculation of cooling tower exhaust or the computational fluid dynamic ("CFD") modeling performed by Alden of the Tetra Tech ClearSky towers. Mr. Ortiz asserts that "both cooling towers were sized for a proper allowance for recirculation ad determined by the vendor (SPX/Marley)" but that "[i]n order to better simulate the recirculation effects created by different wind conditions a more detailed analysis is required." Ortiz Direct at p. 11, l. 12-15. Neither Tetra Tech nor Hatch, however, appeared to have conducted that "more detailed analysis." As set forth in my prefiled direct testimony and in the report entitled, "*Computational Analysis of the Proposed Cooling Tower Installation at Indian Point Units 2 & 3*," dated November 8, 2013, Alden did perform CFD modeling for the two prevailing wind conditions at IPEC, which showed that recirculation resulted in as much as a 3°F increase in the entering wet bulb temperature. Importantly, while the Alden analysis was more detailed than any analysis presented by Tetra Tech or Hatch, a more complete analysis would be required for design purposes. Mr. Havey did not address Alden's analysis in his direct testimony. Although Mr. Ortiz states in his testimony that both towers were sized with an allowance for recirculation "as determined by the vendor (SPX/Marley)," he does not state whether SPX/Marley's "allowance for recirculation" was sufficient in light of Alden's analysis.

END OF TESTIMONY

Before the
New York State Department of Environmental Conservation

In the Matter of

Entergy Nuclear Indian Point 2, LLC
Entergy Nuclear Indian Point 3, LLC

DEC: 3-5522-00011/00004
SPDES: NY-0004472
DEC: 3-5522-00011/00030
DEC: 3-5522-00011/00031

February 28, 2014

Prepared Direct Testimony of:

Christopher J. Russo

Charles River Associates
200 Clarendon Street
Boston, MA 02116

On Behalf of:

The City of New York

Q. Would you please state your name, employer, and business address?

A. My name is Christopher Russo, and I am employed by Charles River Associates ("CRA"), a/k/a CRA International, Inc. My normal place of business is 200 Clarendon Street, Boston, Massachusetts 02116.

Q. What is your current position?

A. I am a Vice President in the Energy Practice at CRA. The primary focus of my consulting is in the areas of wholesale electricity market analysis, business strategy for the electricity industry, and strategic planning for energy market participants. I have advised clients on strategic issues in the energy industry, including quantitative analysis of wholesale energy markets, the impact of regulatory restructuring, planning under uncertain conditions, market power issues, and energy procurement.

Q. Could you briefly describe your education and professional experience?

A. Prior to joining CRA in 2007, I worked as an independent energy market consultant, supporting clients analyzing and modeling electricity markets in the United States and Europe. My work has focused on quantitative analysis of energy markets, advising clients on investments and planning in these markets, and advising clients on overall market strategy.

I have been particularly involved in the analysis of the power system in New York, directing work on behalf of public and private entities, including the New York Power Authority, the City of New York, and numerous private market participants.

I received my BS in Mechanical Engineering from Tufts University, and my MS in Technology & Policy from the Massachusetts Institute of Technology. My *curriculum vitae* is attached as Exhibit___[CJR-1].

Q. What is the scope of your testimony in this proceeding?

A. My testimony in this proceeding will focus on the potential environmental, electric system reliability, and economic consequences of an extended outage resulting from the retrofit of closed-cycle cooling, or "CCC," tower configurations for the Indian Point Energy Center, or "IPEC", and the potential effects of IPEC's retirement. My testimony discusses the wholesale energy market, system reliability and resource adequacy effects, and air emissions impacts, as well as the effect of IPEC's status on New York's electricity markets.

My testimony does not address whether IPEC should be required to install a CCC or implement some other solution in place of its existing once-through cooling system, or whether IPEC should be retired. It focuses instead on the potential effects of such decisions, and is offered to provide additional record support for an informed decision on such matters.

Q. Are you sponsoring any other Exhibits in connection with your testimony?

A. Yes. I offer Exhibit___[CJR-2], which is the Indian Point Energy Center Retirement Analysis that details the basis for many of the statements and conclusions presented in my testimony. I refer to this study throughout my testimony as the Retirement Report. I also offer Exhibit___[CJR-3], which presents certain historic locational marginal prices, or LMPs, of electricity in New York State. Finally, Exhibit___[CJR-4] presents historic monthly natural gas prices for the Transco Zone 6 delivery point.

Q. What interests does the City have in these proceedings?

A. The City has both direct and indirect interests in the outcome of this proceeding. As one of the largest electricity consumers in New York State, the City has a direct interest in how the Best Technology Available, or "BTA," ultimately selected for IPEC may affect system reliability and energy costs. The City also has developed, and is implementing, a comprehensive sustainability policy initiative that seeks, among other things, to reduce harmful air emissions. The City, therefore, also has a significant interest in how the BTA selected for IPEC may impact air emissions.

As to the indirect interest, the City has a desire to help ensure a reliable and affordable electricity supply for its residents and businesses, while minimizing environmental impact. The City's proximity to IPEC means that its residents and businesses are likely to experience the economic, reliability, and/or environmental impacts potentially associated with the BTA implemented pursuant to the outcome of this proceeding.

Q. Please continue.

A. For the purposes of this proceeding, the City has asked me to analyze and opine on the potential reliability, economic, and air emissions impacts associated with the CCCs proposed by the New York State Department of Environmental Conservation, or "DEC," as the potential BTA. I also considered the CCC configurations that Riverkeeper, Inc. had proposed as the BTA. I understand, however, that Riverkeeper recently decided to withdraw its support for those configurations.

As an outer bound on the potential impacts associated with the proposed CCCs, I also considered the possibility that the selected BTA ultimately may cause, or contribute to, IPEC retirement because that solution is not economic, or because engineering and/or permitting challenges turn out to be insurmountable. I concluded that this consideration was warranted, in part, based on my review of the "Response Document" that Entergy filed on December 13, 2013. That report comprehensively described the various challenges that Entergy perceives to constructing and operating the CCCs that were proposed by DEC and Riverkeeper.

The City takes no position regarding the specific technology that should be selected as the BTA to replace IPEC's existing cooling system, but believes that the selection of the BTA should recognize the potential adverse reliability, economic, and emissions impacts.

Q. Have you examined the potential reliability, economic, and emissions impacts that may result if IPEC suspends commercial operations?

A. Yes. I previously conducted the Retirement Report, which is attached as Exhibit___[CJR-2]. Commissioned by the New York City Department of Environmental Protection, the Retirement Report evaluated and discussed the potential impacts associated with the retirement of IPEC, but did not address the question of whether IPEC should retire.

The Retirement Report modeled the potential system reliability, economic, and air emissions impacts associated with a full retirement of IPEC under what we term a "base case," and also under various sensitivity scenarios looking at alternative possibilities. I also conducted a security-constrained production cost simulation of the New York Independent System Operator, Inc., or "NYISO," market and surrounding regions for the period 2011 through 2022, as further described in Section 4 of the Retirement Report.

Q. Can you briefly summarize the metrics you employed in your analysis?

A. Yes. I will summarize here the principal metrics that the Retirement Report used for the economic, reliability and environmental analyses.

With regards to projected economic effects, I provided two principal metrics. The first metric was the change in the cost of wholesale power that would be borne by load-serving entities such as utilities in New York State. This higher cost makes up a significant portion of consumers' bills and, therefore, would increase customer costs. The second metric consists of what I referred to as "contractual support," or economic subsidies, that would be required to construct several of the options that we analyzed in the Retirement Report if IPEC suspends or ceases operations. I elaborate further on this contractual support on pages 17 and 18 of this testimony. I note also that there are direct, indirect and induced economic benefits resulting from IPEC's status as a large employer and consumer of goods and services in the region. I have not quantified these effects.

From a reliability standpoint, I focused on the concept of resource adequacy for the New York power system. Sufficient resource adequacy, as measured by the Loss of Load Expectation, or LOLE, criterion, is only one of the conditions that needs to be met to ensure that a system is reliable, and is a necessary, but not the only, criterion to be fulfilled. Simply meeting a resource adequacy criterion (or a reserve margin, a coarser metric) is not enough to ensure that the New York power system is sufficiently reliable. However, for purposes of the Retirement Report, resource adequacy provides sufficient insight into the potential reliability impacts associated with an extended outage or retirement of IPEC to support the conclusions reached in that report.

With regards to emissions, my analysis focused on changes in air emissions, and most specifically on the increases in emissions of carbon dioxide and oxides of nitrogen that would result from replacement sources of energy.

Q. What were the key conclusions of the Retirement Report?

A. If IPEC is retired, wholesale energy and capacity prices will increase for consumers by varying amounts, depending on the scenario. The following four scenarios were examined in the Retirement Report.

1. In a scenario in which IPEC is retired and no new generation is installed, the total cost to New York State electric consumers would increase by an average of approximately 11.7%, or $2.2 billion.

2. In a scenario in which IPEC is retired and 500 megawatts of capacity is constructed at the IPEC site in the Lower Hudson Valley, or LHV, the total cost to New York State electric consumers would increase by an average of approximately 8.8%, or $1.7 billion.

3. In a scenario in which IPEC is retired, 500 megawatts of capacity is constructed at the IPEC site in the LHV, and an additional 500 megawatts of capacity is constructed in New York City in 2018, the total cost to New York

State electric consumers would increase by an average of approximately 7.8%, or $1.5 billion.

4. In a scenario in which IPEC is retired, a 1,000 megawatt high-voltage direct current transmission line to New York City is constructed, and a 500 megawatt offshore-wind farm interconnected to Brooklyn is constructed, the total cost to New York State electric consumers would increase by an average of approximately 8.7%, or $1.7 billion.

Under these four scenarios, the total cost to electric consumers in New York City would increase by an average of approximately 7.8% or $567 million, 5.7% or $411 million, 3.9% or $295 million, and 3.8% or $269 million, respectively. Given the impossibility of predicting the amount, location, and timing of generation that actually may be constructed in response to an IPEC retirement, the studied scenarios represent a range of potential impacts across the spectrum of likely outcomes.

Q. Did you update the analyses underlying the Retirement Report in support of this testimony?

A. No. However, as described below, I have reviewed key data inputs to determine that the analyses underlying the Retirement Report would not yield substantially different results if conducted again today, notwithstanding recent changes in certain aspects of the New York State power system. Thus, I confirmed that the Report's conclusions remain broadly applicable in both direction and magnitude.

Q. Please explain how you confirmed that the Retirement Report remains relevant today.

A. There are several different metrics by which we may evaluate the relevance of the Retirement Report's conclusions today. When considering reliability, economic and environmental effects, there are several key factors which play a major role in the conclusions. They include the composition of supply resources, the demand for electricity, market commodity prices, and the ability to transmit energy inter-regionally. Thus, the impacts of changes on the Retirement Report results can be expressed in terms of direction and magnitude. In addition to these technical and economic factors, changes in the regulatory approach to the system must also be considered.

The demand for electricity and composition of supply resources may be the most straightforward factor to analyze. The 2011 NYISO "Gold Book" was used as a data input for the Retirement Report. The 2011 Gold Book cites the 2013 baseline load as 162,787 gigawatt hours. Most recently, the NYISO issued the 2013 NYISO "Gold Book," which cites the 2013 baseline load as 163,856 gigawatt hours. This amounts to a difference of 0.7 percent between the predicted current year baseline loads specified in the 2011 and 2013 Gold Books.

Similarly, the 2011 Gold Book predicts a baseline load of 165,319 gigawatt hours for 2016, while the 2013 Gold Book predicts a baseline load of 166,804 gigawatt hours for 2016. This amounts to a difference of 0.9 percent between the 2016 baseline loads predicted by the 2011 and 2013 Gold Books.

Overall, the load forecast and installed capacity for New York have changed by only small amounts since the Retirement Report was completed, and there have been no major new transmission projects constructed that would increase inter-regional transfer. There have been some changes in the State's generation mix since 2011, such as the commissioning of the 512 megawatt Bayonne Energy Center with an electrical connection to Brooklyn, which was included in projections from the Retirement Report. Also, the 508 megawatt Danskammer power plant located in the LHV was forced to retire after it sustained damage from Hurricane Sandy in late 2012. The supply-demand balance in each region and the ability to transfer power from one region to another are major determinants of the prices and reliability of the system, and both of these factors have remained relatively stable since 2011. This relative stability allows us to reasonably conclude that the expected impacts associated with the loss of IPEC output would be similar to those we estimated in the Retirement Report.

With regards to commodity prices, the primary change since the Retirement Report was completed has been the continued general decrease in both the commodity price and delivered price of natural gas, driven largely by increased production from shale gas. This has several effects which I elaborate upon on pages 15 and 16 of my testimony. Briefly, although this downward trend in commodity prices has decreased the cost of wholesale power to consumers, it increases the contractual support needed to procure replacement generation. In addition, as we have seen this past winter, natural gas can be subject to sharp seasonal price spikes even during a period when prices otherwise are low as compared to historic levels.

Another notable change since the Retirement Report was completed was the decision to proceed with the New York Energy Highway. This publicly-funded effort proposes the construction of new generation and transmission infrastructure. The Energy Highway Blueprint includes generation options that are broadly similar to those considered in the Retirement Report. The construction of large new transmission projects could reduce the need for new power plants in the Lower Hudson Valley to replace IPEC's output, if that facility retires. Greater import capability into a zone can decrease the amount of installed capacity needed in that zone by allowing imported energy and capacity to assist in meeting reliability needs.

However, as noted below, transmission lines cannot fully replace all of the power system benefits that IPEC provides, most notably the voltage support that is needed to maintain electric system balance. In addition, there are other important factors to consider with regards to the relative value of generation and transmission. Alternating current, or AC, transmission, generally does not permit controllable flows, and so one megawatt of AC transmission is not a substitute for one megawatt of generation. Further, there must be sufficient generation available to supply power via transmission links, and the generation will not necessarily be available in the NYISO Zone in which that supply is produced.

RELIABILITY ISSUES

Q. Would the installation of a CCC interrupt IPEC operations?

A. Yes. My understanding is that one or both reactors would have to be shut down for a period of time during any CCC retrofit.

Q. Can IPEC be retrofitted with CCC or retired without jeopardizing the reliability of New York's power system?

A. In the short term, analyses from the NYISO and operational experience indicate that one reactor at a time could be taken out of service without compromising system reliability. This has been done periodically in the past to conduct refueling or other forms of maintenance. However, any such scheduled maintenance activity is generally undertaken in periods of non-peak electric demand, such as the spring and fall. Unless new sources of generation are constructed in a location and on a scale that could offset the simultaneous loss of both reactors, at least one IPEC reactor must always be online to ensure system resource adequacy and reliability. The retirement or extended outage of both IPEC reactors would immediately precipitate the need for replacement options and impose direct and indirect adverse effects on reliability that warrant careful consideration. Those reliability effects are the focus of this portion of my testimony.

Q. How much of NYC's electrical supply does IPEC contribute?

A. This cannot be accurately captured in a single number, and contracts alone do not provide a clear answer. When power is generated from power plants, it is not directed towards any specific location. Its output flows across the power network and affects the flows and power distribution across New York State and the broader region. In other words, electrons are fungible, and when electricity is supplied to the grid it flows according to the laws of physics, not according to the terms of contracts. While one can look at the total output of IPEC in terms of megawatts and compare it against demand or electric load, the actual power flows will vary greatly depending on system conditions at any given point in time.

Various entities in New York State contract for part of IPEC's output in the installed capacity market, but these are economic contracts and cannot be used reliably to analyze IPEC's actual contribution to resource adequacy or system stability. By the same token, we cannot draw any useful inferences regarding system reliability from the absence of such contracts with IPEC.

Q. What factors must be considered when analyzing the potential impacts of an extended outage or retirement of IPEC on power system reliability?

A. IPEC's retirement would affect numerous aspects of system reliability.

One such impact would be on resource adequacy. Broadly speaking, resource adequacy measures the ability of the interconnected power system to meet demand for electricity with an acceptably low probability of an outage. This metric of resource adequacy is typically expressed in terms of LOLE, and the federally-mandated standard is 0.1, which is defined roughly as one day in every ten years.

In addition to the overall resource adequacy for the State, the NYISO, along with the New York State Reliability Council, also set Locational Capacity Requirements, or LCRs, that reflect the unique characteristics of New York's grid. These LCRs currently specify that 86% of the load in New York City must be met by in-City load and generation, and that 105% of the load on Long Island must be met by load and generation present on Long Island.

The fact that LCRs are necessary in New York State demonstrates that the location of new generation must be considered when analyzing system reliability. Any analysis of system reliability that relies solely on the State's Installed Reserve Margin or otherwise fails to account for the geographic location of supply resources represents a gross oversimplification of the issue that will yield misleading results.

Q. What other reliability issues must be considered?

A. IPEC provides significant voltage support to New York's electrical system. Voltage support is critical for both maintaining system stability as well as maintaining transfer capability across interfaces; put differently, reactive power generation at IPEC allows the transfer of other sources of electricity (including thermal and renewable sources) from Upstate to the Southeast New York region. Voltage support cannot be provided solely by reducing demand through energy efficiency measures, or by the addition of transmission lines.

Q. What system reliability conclusions did the NYISO make regarding whether IPEC could be retired or undergo an extended outage?

A. The NYISO conducts a biennial review of system reliability called the Reliability Needs Assessment, or RNA. I reviewed the most recent RNA issued in 2012 , in which the NYISO analyzed the possibility of both IPEC units retiring and the resulting effect on system resource adequacy. In the 2012 RNA, the NYISO concluded that, in the NYCA or New York Control Area – which is coextensive with the State of New York – resource adequacy would fail to meet minimum standards upon the retirement of both reactors. The NYISO calculated that the LOLE would be 0.48 if both units are retired or out of service, which is significantly above the 0.1 standard that represents acceptable reliability. (Higher numbers indicate a greater probability of a load shedding event and thus lower reliability.)

ECONOMIC ISSUES

Q. What economic effect would the long-term outage of one reactor have on the market?

A. The long-term outage of one reactor would cause energy and capacity prices to rise. IPEC's supply is inframarginal in the market, and IPEC is one of the lower-cost producers of energy in the market. The net removal of approximately 1,000 megawatts of energy from the market would reduce supply and cause prices to rise. In the Retirement Report, I found that the retirement of IPEC and the construction of 1,000 megawatts of gas-fired capacity (which also is inframarginal) would cause prices to increase by an average of approximately 7.8%, or $1.5 billion, for electric consumers in New York State (Scenario #3 above).

Q. What economic effect might an extended outage have on IPEC operations?

A. IPEC, like many nuclear plants, is essentially a price-taker in energy markets where the marginal, and thus market-clearing, price is set by units with a higher short-run marginal cost. In current New York markets, such units are nearly always gas-fired and, accordingly, the cost of natural gas is the major component of the price of electricity.

New York State energy prices, through a combination of lower gas prices and decreased demand for electricity and energy efficiency improvements, are at very low levels relative to historic prices. Nuclear power plants have relatively high fixed costs, and relatively low variable costs, neither of which is affected by the cost of natural gas. In contrast, many thermal plants are sensitive to the cost of natural gas. In addition, installed capacity prices in the capacity zone where IPEC is located are also at low levels relative to historic prices. Further, the All Hours, On-Peak, and Off-Peak Locational Marginal Prices, or LMPs, for 2013 are lower than the equivalent prices for 2004 through 2008, and 2010, as demonstrated in Exhibit___[CJR-3]. From these facts, I can reasonably conclude that Entergy's profit from IPEC likely is lower now than it was in the past.

In addition, it is reasonable to assume that lost energy and capacity revenue from an extended construction-related outage of one IPEC unit, along with a significant capital expenditure to permit and construct the towers, could impact business decisions regarding continued operations of the IPEC reactors.

Q. What effects could current lower natural gas prices have on your conclusions?

A. There are at least two areas in which lower natural gas prices could have an effect on the conclusions of my analysis.

The first relates to the effect on Entergy's financials and its decisions regarding the short- and long-term operations of both IPEC reactors. As noted above, IPEC's units are fully inframarginal in New York markets, and are essentially price takers for both energy and capacity prices, where the marginal price that sets clearing prices in each hour of the day is set principally by gas-fired units. Of these two markets, IPEC derives the bulk of its revenue from the energy markets.

All else equal, the lower the price of natural gas, the lower the economic energy profit earned by IPEC (and by gas-fired units, generally). Lower profits combined with the prospect of an extended outage and large capital expenditures to modify its cooling system can reasonably be expected to impact Entergy's business decisions regarding operations at IPEC.

The second effect relates to how attractive the New York markets are to new merchant investors. As gas prices decrease, the potential revenue and profit for gas-fired generators decreases as well, making merchant entry less attractive for new investors and decreasing the likelihood that new plants will enter the market. This decrease in revenue and profit can be offset, in part, by changes in installed capacity prices.

Q. Did the Federal Energy Regulatory Commission recently determine that a new capacity zone should be created in New York State?

A. Yes. In 2013, the NYISO put forth a proposal to a create a new zone for installed capacity in the Lower Hudson Valley, currently termed the New Capacity Zone or NCZ. This new zone reflects the important role that supply in the LHV plays in serving load in New York City and Southeast New York State. The purpose, in large part, of the NCZ is to ensure that there is an additional financial incentive for power plant developers to enter the market. The Federal Energy Regulatory Commission recently approved the creation of the NCZ, which will go into effect on May 1, 2014.

Q. What effect would the NCZ have on your conclusions regarding potential economic impacts associated with an extended IPEC outage or retirement?

A. Upon IPEC's outage or retirement, there would be markedly less supply in the installed capacity market, causing prices to rise. In the Retirement Report, this effect was felt in the Rest of State or "ROS" zone, which comprises the whole of New York State except New York City and Long Island. When the NCZ is implemented, these effects would be concentrated on consumers in the NCZ, which incorporates the LHV, and also would impact New York City. I would expect to see a greater absolute change in prices spread over a smaller number of consumers because IPEC's load represents a much greater proportion of the LHV supply than the larger ROS supply. That is, customers in the LHV and New York City are likely to experience higher costs.

Q. What does it mean that "contractual support" would be required for new market entrants in the event of IPEC's retirement?

A. New York's energy markets are structured such that market revenues should provide sufficient financial incentive for private, non-governmental entities to enter the market and construct new generation. In practice, uncertain revenues from energy and capacity markets can make obtaining private equity and debt financing a challenge for some market participants.

As part of the Retirement Report, I analyzed hypothetical replacement options from an investor perspective. My analysis for a set of hypothetical alternatives to IPEC showed that New York State electricity markets were not fully remunerative to private investors, and that contractual support would be required to get these options built. The cost of these contracts would ultimately be incurred by whatever entity (and their customers) provided this support to new power plants, and so must be recognized as an incremental cost to consumers if IPEC is retired. In addition, the execution of power purchase agreements to support new generators normally has the effect of transferring price risk from the private sector to consumers.

As explained in the Retirement Report, power plants larger than roughly 500 megawatts would require contractual support to be constructed if IPEC were to retire. Given the fact that overall natural gas prices (and bases) have continued to decline since the Retirement Report was prepared, I would expect that the amount of contractual support required to support new generation projects would be larger now than what I calculated in the Retirement Report.

Q. What role can energy efficiency energy play in replacing IPEC's capacity?

A. Energy efficiency is an important component of New York's energy mix, and can be a component of meeting reliability standards.

Q. Did the analyses underlying the Retirement Report account for energy efficiency as part of the replacement supply?

A. Yes. Using the NYISO's base case Gold Book 2011 load forecast, my resource adequacy analysis in the Retirement Report indicated that resource adequacy standards would not be violated until 2020 if both reactors were retired. Adjusting the resource adequacy analysis to reflect historic rates of achievement for energy efficiency, as described below, indicated that resource adequacy standards would be violated upon the retirement of both reactors. In 2012, the NYISO's RNA also concluded that system reliability would be violated in 2016 upon the retirement of both reactors using the NYISO's base case load forecast, which incorporated the NYISO's base case energy efficiency targets.

In both cases, the NYISO's base case forecast includes forecasts of energy efficiency penetration. In 2011, the NYISO stated that New York had achieved 57% of its base case energy efficiency targets to that date, indicating that a degree of conservatism may be warranted when considering future achievement of energy efficiency targets. Accordingly, the extent to which energy efficiency reliably can offset a loss of IPEC capacity is uncertain.

Q. **What about renewable resources?**

A. Renewable resources are an important part of New York's energy infrastructure and can contribute replacement energy if IPEC's output is reduced. Renewable resources, however, must be "derated" or discounted to account for the fact that their output is intermittent and not fully predictable. The NYISO accounts for this in their analyses. Thus, for example, the NYISO would consider 2,000 megawatts of wind turbines installed at IPEC's site to represent approximately 200 megawatts of installed capacity, which would not be sufficient to replace the full contribution of IPEC to reliability and economic supply.

The location of renewable resources also is important. Many renewable resources are located far from load centers, generally, and from New York City and the Lower Hudson Valley, specifically. There must be sufficient transmission capacity to enable the delivery of renewable energy to loads. Existing transmission constraints currently limit the amount of renewable energy from Upstate facilities that may be delivered to the region now served by IPEC.

I note that there is one unique, potential resource that would provide effects atypical of many renewables. A private developer has received State approval to construct a 1,000 megawatt high voltage direct current transmission line between Quebec and New York City. If constructed, this line would deliver energy that is sourced predominantly from hydroelectric resources located in Canada. Both the hydroelectric output and energy transmission along the line would be controllable, meaning that this particular project would be more similar to baseload generation than the intermittent generation that is characteristic of most renewable resources. It is unclear at this time whether this project will be financed and constructed.

Q. Where would the replacement power come from during an extended CCC outage?

A. During an extended outage necessary to install CCC technology, or if IPEC were to be retired, it is likely that most or all replacement energy would come from gas-fired units in New York and surrounding region, as these plants nearly always provide the marginal supply in this region.

Q. Would increased gas generation make New York State affect the potential economic impact associated with retirement or extended outage of IPEC?

A. Yes. The price of electricity in NYISO markets is set by the marginal unit, or the last one "turned on" to meet the demand for electricity. The last unit turned on is nearly always a gas-fired unit in New York State. The primary determinant of marginal cost – and, therefore, the price such marginal units bid – is the cost of natural gas.

The cost of natural gas for power plants is a combination of two factors: the first is the commodity cost, often quoted as the price at Henry Hub, and the second is the "basis", or the difference between the Henry Hub and the point of delivery on the interstate pipeline system, such as the New York City Gate, or Transco Zone 6 delivery point. The basis is driven largely by demand for gas on the interstate pipeline system, and can be very volatile; relatively small changes in supply can yield very large changes in basis which, in turn, can yield significant changes in the cost of electricity.

The cold weather that affected much of the United States in January, 2014 has had an appreciable effect on demand for natural gas and, therefore, on natural gas prices. As demonstrated on Exhibit___[CJR-4], the average natural gas price for the Transco Zone 6 delivery point for January 2014 is the highest monthly average of the past 14 months, $107.98 higher than the January 2013 average. The January 2014 average price also indicates a $126.97 increase over the December 2013 average price. This increase in natural gas prices is largely a winter phenomenon, and the spikes we have seen in the past several months are the consequence of a colder-than-average winter.

One consequence of increased natural gas generation in New York State is obviously an increased need for natural gas supply. Given the dynamics of pipeline systems in which small changes in demand can result in large price changes, increased demand for gas may lead to more volatile pricing patterns in the future.

Q. What effect would the implementation of recommendations specified in the Energy Highway Blueprint have on your conclusions?

A. The New York Energy Highway is a State policy initiative to construct new transmission and generation in New York State. This initiative would be funded in large part by State agencies and utilities and, thus, ultimately by consumers. The final decision regarding which projects might be constructed has not been made.

With regards to transmission, energy in New York State generally flows from Upstate to the Southeast New York Region based on a complex interaction of system architecture elements and numerous factors. Blueprint projects that pertain to transmission generally seek to increase the flow of energy from Upstate to Southeast New York. Construction of these projects likely would decrease the need for power plants in the Lower Hudson Valley if IPEC were to retire. These projects also seek to alleviate congestion and thus lower prices into the Southeast New York region. Such price reductions would increase the "contractual support" or out-of-market payments that a developer would require to construct generation resources to replace IPEC.

Q. Would you summarize your conclusions regarding the potential economic impact of an extended IPEC outage, or retirement?

A. If IPEC retires, the cost of energy and capacity would increase to varying degrees throughout the State. Those increased costs ultimately would be paid by consumers. It does not appear likely that energy efficiency and/or renewable generation will be adequate to fully replace IPEC, if it retires. Consequently, new gas-fired generation would be needed. It is possible, however, that such generation could require some level of contractual support or other State intervention to be constructed, unless customers bear material energy and capacity price increases for a number of years.

ENVIRONMENTAL ISSUES

Q. Can you summarize the results of the environmental impact analysis presented in the Retirement Report?

A. If IPEC is retired, the emissions of carbon dioxide and oxides of nitrogen will increase. I analyzed the following four scenarios in the Retirement Report for New York State impacts.

1. In a scenario in which IPEC is retired and no new generation is installed, nitrogen oxide emissions will increase by an average of approximately 10.8%, and carbon dioxide emissions will increase by an average of approximately 12.2%.

2. In a scenario in which IPEC is retired and 500 megawatts of capacity is constructed at the IPEC site in the LHV, nitrogen oxide emissions will increase by an average of approximately 9%, and carbon dioxide emissions will increase by an average of approximately 13.1%.

3. In a scenario in which IPEC is retired, 500 megawatts of capacity is constructed at the IPEC site in the LHV, and an additional 500 megawatts of capacity is constructed in New York City in 2018, nitrogen oxide emissions will increase by an average of approximately 7.7%, and carbon dioxide emissions will increase by an average of approximately 13.8%.

4. In a scenario in which IPEC is retired, a 1,000 megawatt high-voltage direct current line to New York City is constructed, and a 500 megawatt offshore-wind farm interconnected to Brooklyn is constructed, nitrogen oxide emissions will increase by an average of approximately 5.3%, and carbon dioxide emissions will increase by an average of approximately 6.6%.

Under the four scenarios outlined above, nitrogen oxide and carbon dioxide air emissions will increase in New York City by an average of approximately 15.1% and 17.7%, 10.2% and 13.1%, 10% and 18%, and 5.1% and 7.6%, respectively.

Q. Please explain how an extended outage or shutdown at IPEC would affect air emissions.

A. Broadly speaking, an extended IPEC outage would increase emissions of carbon dioxide and oxides of nitrogen in two ways.

First, replacement sources of energy would have higher emissions rates. In this case, one must consider the marginal supply from existing generators and imports. The marginal fuel supplying incremental energy would principally be natural gas, from plants in New York State and PJM, a regional electric system that neighbors New York State, although imports from Quebec could increase marginally.

Natural gas, while considerably cleaner than coal, still emits significant amounts of carbon dioxide when combusted, and also emits some nitrogen oxides even if emission controls are installed. Of these two pollutants, oxides of nitrogen more directly affect consumers in the downstate region, as nitrogen is a local criteria pollutant, with localized health effects. In fact, nitrogen oxides are treated statewide as non-attainment contaminants because they are precursors to the formation of ozone, and New York City currently is designated as a severe non-attainment zone area for ozone. I note that such increased emissions also would include an incremental amount of particulate matter; New York City currently is a non-attainment area for fine (PM2.5) particulate matter, and New York County is a non-attainment area for filterable (PM10) particulate matter.

Examining the potential supply options in the Retirement Report, as well as those potential projects currently in the NYISO queue, all significant replacement options consist of thermal, gas-fired units. Replacement of IPEC's output with these units will increase air emissions. One possible exception to this is the 1,000 megawatt transmission line that may deliver Canadian renewable energy to New York City. Even if that project were to be constructed and operated, however, my analysis in the Retirement Report under the low-carbon scenario reflects the fact that air emissions still would increase if IPEC is not in operation, as the 1,000 megawatts would not fully replace IPEC's output.

Q. Would the emissions of sulfur dioxides also be increased if IPEC is retired or out of service for an extended period of time?

A. Yes, but such emissions are produced principally by coal-fired units and are not material in comparison to the emissions described above.

Q. What other environmental effects would an extended outage or retirement have?

A. In addition to emissions from replacement sources of power, I am not aware that any party has analyzed the emissions associated with construction of a CCC tower. As has been described by other parties in these proceedings, the construction activities that will be necessary to install a CCC tower are anticipated to include the blasting and removal of approximately two million cubic yards of spoils. Entergy estimates that, if trucks alone are used to remove the blasting spoils, hundreds of heavy truck trips would be required every day for three to four years. If barges instead are used to transport the spoils, the number of truck trips carrying spoils would be reduced, and supplemented with many barge trips each year. I have not attempted to quantify the overall effect of this activity, but note that it would be incremental to any air emissions effects from IPEC replacement power.

Finally, the daily transportation of workers and delivery of materials to IPEC would result in a level of additional emissions that, to my knowledge, similarly has not been estimated.

Q. Does this conclude your testimony?

A. Yes.