September 2009

Preliminary Costs and Benefits of California Draft Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling

Prepared for:

California Council for Environmental and Economic Balance

Prepared by:

NERA
Economic Consulting

Project Team

David Harrison, Jr., Ph.D., Project Director
Andrew Foss, Project Manager
Albert L. Nichols, Ph.D.
David Nagler
Samuel Grausz

NERA Economic Consulting
200 Clarendon Street, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501
www.nera.com

Acknowledgments

This report was prepared by NERA Economic Consulting ("NERA"), an international firm of consulting economists specializing in the application of economics to complex issues of business and public policy. For nearly half a century, NERA's economists have been creating strategies, studies, reports, expert testimony, and policy recommendations for government authorities and the world's leading law firms and corporations. NERA serves clients from more than 20 offices across North America, Europe, and Asia Pacific with a staff of more than 600 professionals highly trained in economics and related disciplines.

NERA has extensive experience in developing cost-benefit assessments related to the requirements of Section 316(b) of the Clean Water Act, having performed analyses for numerous electricity generating facilities—including nuclear and fossil fuel units on the Atlantic Ocean, the Hudson River, the Great Lakes and other water bodies—and having participated actively in the development and evaluation of the U.S. Environmental Protection Agency's 316(b) regulations. NERA personnel have presented the results of our cost-benefit assessments to numerous state and federal officials. Two members of the project team (Dr. Harrison and Dr. Nichols) were among the 33 environmental and resource economists (including several Nobel laureates) who submitted an *Amici Curiae* brief to the U.S. Supreme Court (in *Entergy Corporation v. Riverkeeper, Inc. et al.*) supporting the use of cost-benefit analysis in implementing 316(b) requirements.

The NERA study was directed by Dr. David Harrison and managed by Mr. Andrew Foss. The other members of the project team included Dr. Albert Nichols, Mr. David Nagler and Mr. Samuel Grausz. The project was supported by the California Council for Environmental and Economic Balance ("CCEEB"). Although we are grateful to CCEEB for their support, the report does not necessarily reflect the views or conclusions of CCEEB or its members. The study's authors alone are responsible for the report and any errors or omissions it may contain.

Contents

List of Figures

List of Tables

Executive Summary

On June 30, 2009, the California State Water Resources Control Board ("Water Board") issued a Draft Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling ("Draft Policy"). The Draft Policy would require electric generating facilities to reduce their intake of cooling water by installing closed cycle wet cooling systems or, under certain conditions, by demonstrating compliance via alternative means. This report provides information on the application of cost-benefit analysis to the Draft Policy. The information could be used by the Water Board in evaluating and further refining the policy. Specifically, the report draws on guidance from federal and California state agencies on methods that could be used to develop detailed cost-benefit assessments for the Draft Policy at the affected facilities. The report provides preliminary estimates of the Draft Policy's costs and benefits statewide. It also provides preliminary estimates of the Draft Policy's costs and benefits at a single facility (San Onofre Nuclear Generating Station, or "SONGS") to illustrate how the site-specific alternative provided in the Draft Policy could be implemented. The report also discusses some of the concerns expressed by the Water Board staff in the Draft Substitute Environmental Document ("Environmental Document") regarding the use of cost-benefit analysis in the context of regulating cooling water intake structures at electricity generating facilities.

A. Overview of Methods and Sources Used to Estimate Costs and Benefits

We used various sources of information to develop preliminary estimates of the costs and benefits of the Draft Policy statewide and at SONGS. Our primary source on cooling technology costs was the recent study by Tetra Tech for the California Ocean Protection Council on alternative cooling systems at California's coastal power plants (Tetra Tech 2008). In addition, we estimated the costs of replacing power lost during construction of the cooling towers and as a result of lower net generating capacities with the towers. We also estimated the costs associated with changes in emissions of carbon dioxide ("CO_2") based on projected allowance prices.

We based our benefits assessment on the methodology established by the U.S. Environmental Protection Agency ("EPA") for its Phase II Rule to reduce impingement and entrainment from large existing power plants under Section 316(b) of the Clean Water Act. Our primary sources on benefits were biological studies at SONGS and summary data in the Environmental Document on impingement and entrainment at California's other coastal power plants. We also relied on species-specific information on the commercial and recreational values of fish impinged and entrained. We used these values to express the potential benefits of the Draft Policy in dollar terms. We made several "conservative" assumptions in our cost-benefit analyses to avoid overstating the costs or understating the benefits of the Draft Policy. We also assessed whether the costs and benefits we did not monetize would likely affect our conclusions regarding net benefits (i.e., benefits minus costs) and whether the conclusions were sensitive to alternative discount rates used to calculate costs and benefits.

B. Preliminary Statewide Cost-Benefit Results

Table E-1 summarizes the results of our preliminary statewide cost-benefit analysis. The Draft Policy calls for a phased implementation of closed-cycle cooling systems, with requirements differing for facilities with different technologies and different locations; compliance dates range from 2011 to 2022. As a result, the costs and benefits for different facilities will be experienced in different years. We calculate present values based on annual costs and benefits in the compliance year and 20 subsequent years for each facility. Table E-1 shows these present values in millions of 2009 dollars as of January 1, 2009 based upon a real discount rate of 7 percent. The present values reflect the fact that several power plants would not have to comply with the Draft Policy until many years in the future (e.g., in 2022 for SONGS) and thus the present values as of January 1, 2009 are much lower than they would be if the same costs and benefits were incurred earlier.

The estimated present value of total costs across all affected power plants in California is approximately $3.12 billion, i.e., a total of about $3.12 billion would need to be set aside on January 1, 2009 to equal the discounted sum of all costs incurred in future years under the Draft Policy. The largest component is capital costs at about $1.5 billion, followed by energy penalty costs at $618 million and construction outage costs at $450 million. The estimated present value of total benefits across all affected power plants in California is about $34.2 million, i.e., the discounted sum of the benefits of the Draft Policy in future years would equal about $34.2 million. Entrainment gains account for about $26.7 million of the benefits and impingement gains account for the remaining $7.5 million in benefits.

As shown in Table E-1, the preliminary estimated present value of net costs (i.e., costs minus benefits) of the Draft Policy across all affected power plants is approximately $3.09 billion. These preliminary results indicate that the costs society would incur to install cooling towers on all affected would exceed the benefits society would gain by a factor of 91.

Table E-1. Preliminary statewide cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$1,503.6
Operating and Maintenance	$151.5
Construction Outage	$450.3
Energy Penalty	$617.7
Heat Rate Impact	$91.3
CO2 Emissions	$306.8
Total	$3,121.3
Benefits	
Impingement	$7.5
Entrainment	$26.7
Total	$34.2
Cost-Benefit Comparisons	
Net Costs	$3,087.2
Costs to Benefits Ratio	91

Note: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Statewide analysis does not include the costs of cooling tower retrofit at Encina, Portrero, Redondo Beach, or South Bay because Tetra Tech (2008) does not provide cost estimates for these facilities, but the analysis does include the benefits of reduced cooling water intake at these facilities.
Source: NERA calculations as explained in text

Guidelines on regulatory policymaking from the California Department of Water Resources ("DWR"), EPA, and U.S. Office of Management and Budget ("OMB") indicate that policies are economically justified only if their total benefits exceed their total costs (or non-monetized effects are likely to cover any gap in monetized costs and benefits). The large net costs of the Draft Policy suggest that it would not make economic sense to use society's scarce economic resources to retrofit all relevant California power facilities with cooling towers, based on these preliminary results. We determined that this preliminary conclusion would not change as a result of using different discount rates and taking into account unquantified factors.

A full cost-benefit analysis of the Draft Policy would include developing several additional assessments beyond the preliminary assessments provided in this report.

1. Expansion of technologies considered to include those other than closed-cycle wet cooling systems.

2. Assessments of the possible responses of facility owners to the Draft Policy requirements—including the possibility of premature closure or re-powering of certain facilities—and the implications for the statewide costs and benefits.

3. Assessments of the likely effects of the alternative compliance mechanisms on compliance at the various facilities and the implications for statewide costs and benefits.

4. Additional analyses of the implications of uncertainties in the cost and benefit estimates, including the possibilities of additional sensitivity analyses and Monte Carlo analyses.

C. Preliminary Site-Specific Cost-Benefit Results

The Draft Policy, as noted, would allow owners and operators of affected nuclear power plants and affected fossil fuel-fired power plants with a heat rate of 8,500 Btu/kWh or less to request alternative reduction targets from their Regional Water Board if they demonstrate that the costs of the Draft Policy for their power plants would be "wholly disproportionate" to the benefits. The Draft Policy does not provide specific guidelines on how the cost-benefit analysis should be performed, although it does indicate that costs should be measured in terms of cents per kWh and benefits should be measured in terms of "habitat production foregone," an estimate of habitat area production that is equivalent to the loss of entrained species. As discussed in the report, these measures of costs and benefits are not consistent with state or federal guidelines and raise conceptual and practical difficulties.

We performed a preliminary site-specific cost-benefit analysis of the Draft Policy for SONGS using the EPA's methodology for the Section 316(b) Phase II Rule. Table E-2 summarizes our results. The estimated present value of costs arising from implementing the Draft Policy at SONGS is about $1.7 billion, and the estimated present value of benefits is about $12 million. Thus, the estimated costs from implementing the Draft Policy at SONGS would exceed the estimated benefits by a factor of 145.

This analysis assumes that cooling towers would be installed at SONGS to comply with the Draft Policy. Although additional study would be necessary to assess the costs and benefits of alternative compliance mechanisms, our preliminary analysis indicates that requiring installation of cooling towers at SONGS would not be economically justified. It would be important to expand the cost-benefit assessment for SONGS to include evaluations of the costs and benefits of other technologies that could reduce impingement and entrainment. It would also be useful to develop additional analyses of the effects of uncertainties regarding costs and benefits, including the possibilities of additional sensitivity analyses and Monte Carlo analyses.

Table E-2. Preliminary SONGS cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$293.3
Operating and Maintenance	$12.5
Construction Outage	$776.6
Energy Penalty	$359.9
Heat Rate Impact	$0.0
CO2 Emissions	$299.0
Total	$1,741.4
Benefits	
Impingement	$3.6
Entrainment	$8.5
Total	$12.0
Cost-Benefit Comparisons	
Net Costs	$1,729.3
Costs to Benefits Ratio	145

Note: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

D. Responses to Concerns with the Use of Cost-Benefit Analysis

The Environmental Document alludes to three broad concerns with using cost-benefit analysis. The following are summaries of our characterizations and responses to the concerns.

§ *Benefit estimates are incomplete*. Contrary to what the Environmental Document suggests, indirect use benefits can be assessed by including trophic transfer, which estimates the impact of additional forage fish on the population of fish valued directly by anglers. More broadly, although all monetized benefit and cost estimates are invariably incomplete, the results can be used to develop meaningful conclusions. Benefits that cannot be monetized can be evaluated qualitatively to assess the impact they might have on the net benefits of the Draft Policy.

§ *Consistency in state policy across regions*. The Environmental Document appears to assume that consistency requires uniform technology choices. But consistency is more usefully defined as applying a consistent set of decision criteria and methods for evaluating costs and benefits across regions and facilities.

§ *Cost-benefit analysis is too burdensome for regional boards*. As our analyses show, much of the necessary information is available already. The level of the analysis also should be tailored to the magnitude of the decision (e.g., a small peaking unit warrants less effort than a large nuclear unit). Finally, it is important to put the costs of the analysis in perspective as they are generally a very small fraction of the costs of the regulation in question.

In summary, we believe that (1) benefit estimates are sufficiently complete to provide meaningful cost-benefit comparisons, (2) cost-benefit analysis provides a useful type of consistency in treating facilities across regions, and (3) cost-benefit analysis is not too burdensome in light of the potential societal gains and the substantial information that is available.

E. Preliminary Conclusions and Recommendations

Our preliminary economic assessment of the Draft Policy leads us to offer several preliminary conclusions and recommendations.

1. Cost-benefit analysis is an important means of clarifying “what is at stake” in terms of key decisions regarding the Draft Policy. Concerns raised against cost-benefit analysis—that it is too incomplete, that it leads to inconsistent regional decisions or that it is overly burdensome to regions—are not legitimate reasons to deny its use in informing the Water Board and regional boards making plant-specific decisions.

2. Preliminary cost-benefit results indicate that requiring all California generation units with once-through cooling to retrofit with cooling towers does not pass a cost-benefit test; the net costs would be very large—on the order of several billion dollars on a present value basis, after accounting for the phasing of the requirement—and nearly 100 times estimated benefits.

3. The preliminary statewide and site-specific cost-benefit assessments could be expanded in several respects. The cost-benefit analysis could include assessing the implications of potential responses of facility owners to the Draft Policy requirements—including the possibility of premature closure or re-powering of certain facilities—for the costs and benefits of the Draft Policy. The statewide cost-benefit assessment also could be expanded to include a wide range of potential alternatives to the Track 1 requirement, including different levels of potential control (which would translate into different likely technology choices at the various facilities).

4. The flexibility provisions in the Draft Policy should be retained and expanded. The policy should allow site-specific cost-benefit analyses for all power plants, including those with a heat rate above 8,500 Btu per kWh, to identify the most economically desirable means of reducing impingement and entrainment. The flexibility provided by phasing the policy in gradually to minimize disruptions to the state and regional electricity systems should be retained.

5. The policy should establish a clear methodology for performing site-specific cost-benefit analyses. The EPA methodology in the Phase II Rule—in conjunction with cost-benefit guidelines from EPA and OMB as well as the State—offers a good template for such a methodology. Our illustration suggests that much of the information needed to implement such a cost-benefit methodology for individual California facilities is already available.

I. Introduction and Overview

On June 30, 2009, the California State Water Resources Control Board ("Water Board") issued a Draft Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling ("Draft Policy"). The Draft Policy would require electric generating facilities to significantly reduce their intake of cooling water, or (under certain conditions) demonstrate compliance via alternative means. This report provides information on the application of cost-benefit analysis to the Draft Policy. The information could be used by the Water Board in evaluating and further refining the policy. Specifically, the report draws on guidance from federal and California state agencies to describe the methodologies that could be used to develop detailed cost-benefit assessments for the Draft Policy at the affected facilities. The report then provides estimates of the Draft Policy's costs and benefits statewide and at San Onofre Nuclear Generating Station ("SONGS"). The report also considers some of the complexities that are involved in developing cost-benefit analyses both of the overall state policy as well as some of the concerns that arise either in performing the analyses or using the results in regulatory decision-making.

A. Overview of the Draft Policy

The Draft Policy covers nineteen coastal electric generating facilities in California. The Draft Policy's "Track 1" compliance alternative requires that the facilities reduce their cooling water intake flow by 93 percent relative to their intake flow rate, which generally will require installation of closed-cycle cooling systems such as cooling towers. Under some conditions, as described below, certain facilities could demonstrate compliance through less significant reductions. Regardless of the compliance mechanism used, the Draft Policy requires that facilities achieve final compliance over a time period ranging from one year after the effective date of the Policy to the year 2022. The policy also imposes various interim requirements before final compliance is achieved.

The following are the specific means by which facilities could comply with the policy without directly satisfying the Track 1 requirement:

§ *Track 2 option.* The proposed policy identifies a less stringent Track 2 alternative that is available if an owner/operator demonstrates to the Regional Board that compliance with Track 1 is "not feasible," though the policy does not appear to identify specific criteria for determining the feasibility of Track 1. Track 2 provides only a relatively small reduction in the reduction burden faced by facilities, lessening the required reduction in intake flow by 10 percent (i.e., from 93 percent to 83 percent reduction).

§ *Nuclear safety consideration.* The proposed policy provides for other requirements to be set if an owner/operator demonstrates that compliance would result in a conflict with a safety requirement set by the Nuclear Regulatory Commission ("NRC"). It does not provide specific guidelines for evaluating compliance of alternative technologies with NRC requirements.

§ *Site-specific "wholly disproportionate" demonstration.* The proposed policy provides that facilities with heat rates of 8,500 BTU per KWh or lower, as well as both California nuclear facilities, can request the establishment of an alternative, less stringent requirements if the Regional Water Board determines that the costs to comply with Track 1 or Track 2 are "wholly disproportionate to the environmental benefits to be gained."

The inclusion of the third flexibility mechanism highlights the importance of cost-benefit analysis to proposals as significant and far-reaching as the Draft Policy. Indeed, as described below, economists have developed detailed methodologies over many years to evaluate the costs and benefits of fish-protection alternatives at electric generating facilities. This report provides preliminary information on the costs and benefits of the Draft Policy statewide and at SONGS. The information is provided in advance of the Draft Policy's implementation so that the Water Board could use it to evaluate and refine the policy.

B. Regulatory Context

1. Federal Context

The principal federal statute underlying regulation of fish losses at generation stations and other facilities is Section 316(b) of the Clean Water Act. In recent years the U.S. Environmental Protection Agency ("EPA") has developed various regulations to reduce impingement and entrainment under Section 316(b). In July 2004 EPA promulgated its Phase II regulations under Section 316(b). These regulations established performance standards for existing generation stations requiring them to reduce impingement by 80 to 95 percent and reduce entrainment by 60 to 90 percent relative to the calculation baseline (assuming no controls in place). In its Phase II regulations, EPA identified various mechanisms to achieve compliance with regulatory requirements. One compliance mechanism involved site-specific cost-benefit analysis of fish protection alternatives to determine whether the costs of meeting proposed performance standards were "significantly greater" than the benefits.

Several aspects of the Phase II regulations, including the use of cost-benefit analysis, became the subject of litigation. In January 2007, the U.S. Court of Appeals for the Second Circuit ruled that cost-benefit analysis was not permissible under Section 316(b) of the Clean Water Act. In response to this ruling, EPA suspended its Phase II regulations in July 2007. In the *Entergy Corporation v. Riverkeeper, Inc. et al.* case decided in April 2009, the U.S. Supreme Court overturned the Second Circuit decision and ruled that cost-benefit analysis was permissible under Section 316(b). The EPA is now developing new Phase II regulations to implement Section 316(b) in light of this decision. In the meantime, EPA has instructed state issuers of NPDES permits—the Regional Water Quality Control Boards (Regional Water Boards) in the case of California—to use Best Professional Judgment ("BPJ") in determining permit requirements.

2. California Context

The Draft Policy provides a proposed framework and guidelines for BPJ in enforcing Section 316(b). The Draft Policy states that it is intended to "address an ongoing, critical impact to the State's waters that remains unaddressed" and to provide "a concise, statewide policy" to avoid "the statute's inconsistent application among the Regional Water Boards."

In addition to implementing Section 316(b) of the Clean Water Act, the Draft Policy also implements water quality legislation in California, most notably the Porter-Cologne Water Quality Control Act ("Porter-Cologne"). Porter-Cologne, enacted in 1969, establishes the nine Regional Water Boards and the single state Water Board. It grants the Regional Water Boards authority to regulate waste discharges that "could affect water quality." Specifically in regards to coastal facilities that withdraw water for industrial purposes, Porter-Cologne requires "new or expanded facilities" to use "the best available site, design, technology, and mitigation measures feasible…to minimize the intake and mortality of all forms of marine life."

C. Study Objectives

The overall objective of this study is to provide information to the Water Board on the application of cost-benefit analysis to the Draft Policy. It provides this information in three ways:

- The study describes the methodologies that could be used to develop complete cost-benefit assessments for California facilities, drawing on guidance from state and federal agencies.
- The study provides preliminary information on costs and benefits of the closed-cycle cooling requirement statewide.
- The study provides preliminary information on the costs and benefits of the closed-cycle cooling requirement at SONGS.

D. Outline of This Report

The remainder of this report is structured as follows:

- Chapter II provides an overview of the methodologies that economists have developed to evaluate the costs and benefits of fish-protection alternatives.
- Chapter III outlines the data and methodology we used to estimate the statewide costs and benefits of installing cooling towers at California's coastal power plants to comply with the Draft Policy.
- Chapter IV outlines the data and methodology we used to estimate the costs and benefits of installing cooling towers at SONGS to comply with the Draft Policy.
- Chapter V presents our preliminary conclusions and recommendations.

II. Cost-Benefit Analysis Methodology

Cost-benefit analysis is a well-established tool for providing information to decision-makers faced with the task of determining whether a proposed action (e.g., a policy or project) should be undertaken. This chapter provides an overview of the methodologies that economists have developed to evaluate the costs and benefits of fish-protection alternatives. These methodologies could be used to develop complete benefit-cost assessments for the Draft Policy.

A. Background

Cost-benefit analysis involves systematic enumeration of the costs and benefits that would accrue to members of society if a particular project were undertaken. Cost-benefit analysis provides an *ex ante* perspective; a project is evaluated in advance to aid in deciding in what form it should be undertaken and, indeed, whether the project should be undertaken at all. As the Office of Management and Budget (OMB 2003) notes:

> A good regulatory analysis is designed to inform the public and other parts of the Government (as well as the agency conducting the analysis) of the effects of alternative actions. Regulatory analysis sometimes will show that a proposed action is misguided, but it can also demonstrate that well-conceived actions are reasonable and justified.

Benefit-cost analysis is a primary tool used for regulatory analysis. Where all benefits and costs can be quantified and expressed in monetary units, benefit-cost analysis provides decision makers with a clear indication of the most efficient alternative, that is, the alternative that generates the largest net benefits to society. The California Department of Water Resources ("DWR"), in its *Economic Analysis Guidebook*, notes:

> Benefit-cost analysis determines whether the direct social benefits of a proposed project or plan outweigh its social costs over the analysis period. Such a comparison can be displayed as either the quotient of benefits divided by costs (the benefit/cost ratio), the difference between benefits and costs (net benefits), or both. A project is economically justified if the present value of its benefits exceeds the present value of its costs over the life of the project. (DWR 2008, p. ix)

The rationale for undertaking a cost-benefit analysis of a particular decision—such as the decision on additional fish protection measures at generating stations in California—is to allow society's resources to be put to their most valuable use. In choosing among alternatives, the basic cost-benefit principle is to select the alternative that produces the greatest net benefits (i.e., benefits minus costs) to society. It is possible that all project alternatives produce negative net benefits (i.e., positive net costs). In that case, the higher value alternative is to "do nothing," which at least produces a net benefit of $0.

The California DWR provides the following summary of decision criteria in cost-benefit analysis.

> Benefit-cost analysis is the primary method used to determine if a project is economically justified. A project is justified when:
>
> - estimated total benefits exceed total estimated economic costs;
> - each separable purpose (for example, water supply, hydropower, flood damage reduction, ecosystem restoration, etc.) provides benefits at least equal to its costs;
> - the scale of development provides maximum net benefits (in other words, there are no smaller or larger projects which provide greater net benefits); and
> - there are no more-economical means of accomplishing the same purpose. (DWR 2008, p. 13).

Every president since Jimmy Carter has required that federal agencies estimate the costs and benefits of major rules for review by the OMB. As part of that review process, OMB has developed guidelines for conducting cost-benefit analysis (OMB 2003). The U.S. EPA also has issued its own guidance for such analyses, most recently in 2000 in its *Guidelines for Preparing Economic Analyses* (EPA 2000). As part of the Phase II regulations promulgated by the U.S. EPA under Section 316(b) of the Clean Water Act, the U.S. EPA issued various case studies evaluating the costs and benefits of alternative technologies to protect fish. In January 2008, the DWR issued the latest edition of its *Economic Analysis Guidebook*. The following sections draw on these resources—as well as applied experience in developing cost-benefit analyses of fish-protection alternatives—to summarize the basic methodology that could be used to develop a cost-benefit analysis of the Draft Policy.

B. Overview of Cost-Benefit Analysis Steps

We divide the overall process into the following seven steps:

1. determine baseline conditions;
2. identify relevant technology and operational alternatives;
3. develop cost estimates;
4. develop benefit estimates;
5. perform cost-benefit comparisons;
6. consider the implications of costs and benefits that are not monetized; and
7. perform uncertainty analysis.

The sections below summarize each step.

1. Determine Baseline Conditions

Determining baseline conditions is an important first step in performing a cost-benefit analysis. As EPA notes in its *Guidelines*,

> An economic analysis of a policy or regulation compares "the world with the policy or regulation" (the policy scenario) with "the world absent the policy or regulation" (the baseline scenario). Impacts of policies or regulations are measured by the resulting differences between these two scenarios. EPA 2000, p. 21

Note that this analytic baseline may not be the same as the "compliance baseline" used to measure percentage reductions for purposes of determining whether a facility meets a standard. Whereas a compliance baseline may specify certain uniform assumptions, such as full flow or no protective measures, the analytic baseline should reflect the situation as it is, using average flows and incorporating the effects of any existing protective measures.

2. Identify Technology and Operational Alternatives

A cost-benefit analysis begins with identification of the alternatives to be evaluated. Most existing power plants use once-through cooling systems, whereby water is withdrawn from a body of water (e.g., river, lake, or ocean), used to cool the facility, and then discharged back to the water body. Fish losses can result from two general phenomena:

§ *Impingement* occurs when fish (generally small species or juveniles of larger species) are drawn against the cooling water intake structure, and some of them suffer mortality.

§ *Entrainment* occurs when eggs or larvae are drawn into the plant's cooling system, where some of them suffer mortality.

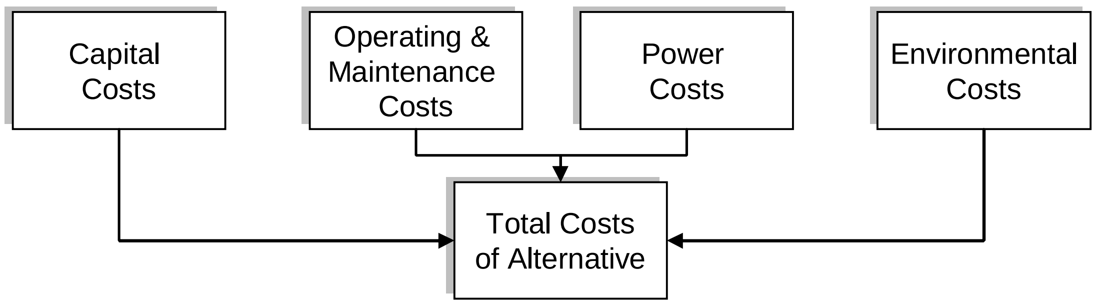
A range of technologies and operating procedures can reduce impingement and entrainment. One general approach that addresses both impingement and entrainment is to reduce the amount of water taken in by the plant. Conversion to closed-cycle cooling, as required by Track 1 of the Draft Policy, is generally regarded as the technology capable of achieving the highest level of control, with reductions of 90 percent or more from baseline levels possible. However, it also is typically the most costly option. Smaller reductions in flow can be achieved with other alternatives. To specifically address impingement, various types of screens and other devices (e.g., sound and light sources) can reduce mortality.

Economists conducting a cost-benefit analysis work with engineers and fishery biologists to identify a range of technically feasible and realistic alternatives for evaluation, including variations in intensity and combinations of measures as appropriate. Some technologies might not be technically feasible at a given plant and these can be eliminated from the cost-benefit analysis. In general, however, considering all feasible alternatives is important to ensuring that the most cost-beneficial alternative is identified.

3. Develop Cost Estimates

Figure 1 summarizes four general categories of costs that are typically relevant to fish-protection alternatives.

Figure 1. General categories of costs



As the figure demonstrates, costs of fish protection alternatives include up-front capital costs for purchase and construction of equipment, ongoing operation and maintenance costs, costs due to lost power, and environmental costs.

a. Capital Costs

Overnight capital costs are engineering estimates of the cost of installing the necessary structures and modifications using current prices for materials, equipment and labor, and assuming the modifications can be completed immediately (i.e., "overnight"). These cost estimates are necessarily site-specific. As described below, engineering estimates are used to determine the time period over which the overnight costs will be distributed.

b. Operating and Maintenance Costs

Operating and maintenance ("O&M") costs include annual labor costs, component replacement costs, and other costs incurred in upkeep of fish-protection equipment. In some cases, a technology may replace previous equipment or operational measures, partially offsetting the O&M costs of the technology itself.

c. Power Costs

Fish-protection alternatives at generating facilities can introduce power losses in two potential stages: (1) during a one-time event resulting from the need to shut down the plant during some portion of the construction period; and (2) on an ongoing basis due to the electricity required by equipment or reductions in gross output associated, for example, with lower cooling water flows that raise operating temperatures and reduce the efficiency of generation. Lost output must be made up by increased generation at other facilities, which would have higher marginal operating costs. (In some cases, reduced potential output can be offset through increased fuel consumption.) The cost of replacement power varies with time of year and time of day, with the highest costs during peak demand periods when even high-cost plants must operate to meet demand. As a result, it is important to specify what time of year a construction outage would be most likely to occur. Often it is necessary to model the operation of the regional electrical system to predict the likely sources of replacement power in future years.

The net cost of replacement power is the difference between the marginal costs of running those other plants more intensively and the savings (if any) from reducing output from the plant at which the fish-protection alternative is installed For some technological alternatives, replacement power costs can constitute a large fraction of total costs. Other technologies involve minimal or no replacement power costs. Closed-cycle cooling, as required by Track 1 of the Draft Policy, typically requires significant power costs.

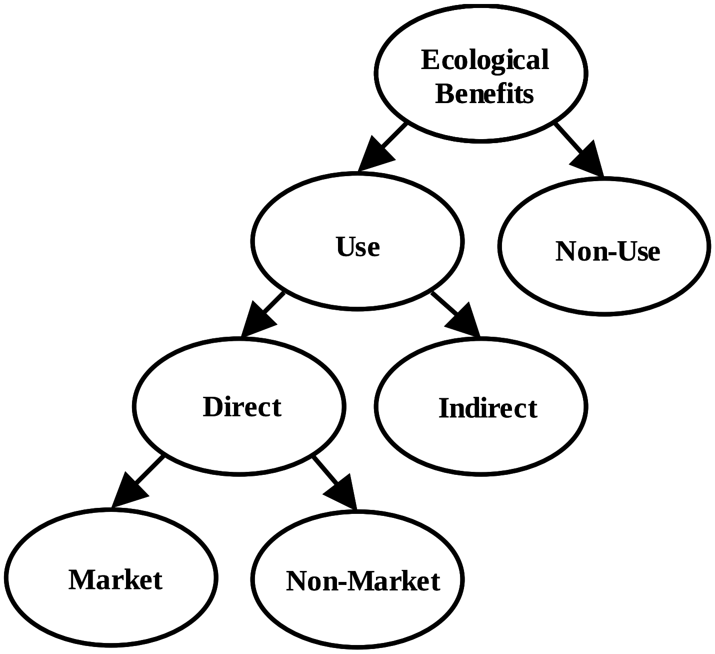
d. Environmental Costs

Air emissions from replacement power are the primary source of environmental costs due to fish-protection alternatives. If air emissions, such as SO_2 and, eventually, CO_2, are subject to a cap-and-trade system, the market value of the allowances associated with those emissions provides the appropriate cost measure. For other pollutants, estimates of marginal damages can be used. There also may be other types of potential external effects, such as aesthetic effects associated with tall cooling towers. For the most part such aesthetic effects are very difficult to quantify, but it is important to identify them for completeness.

4. Develop Benefit Estimates

The EPA *Guidelines* provide a summary of the benefit categories relevant to an assessment of ecological benefits, the broad category relevant to Section 316(b) analyses. Figure 2, reproduced from the *Guidelines*, provides a way of organizing the relevant benefit categories based on how they are experienced.

Figure 2. Benefit classification scheme from EPA *Guidelines*



Source: EPA (2000)

The figure divides ecological benefits into two major categories: use benefits and non-use benefits:

- *Use benefits* are those associated with actual use of the resource—such as fishing or various water-related activities. Use benefits can be further subdivided into direct and indirect benefits. Indirect benefits and direct benefits may be classified as market or non-market.

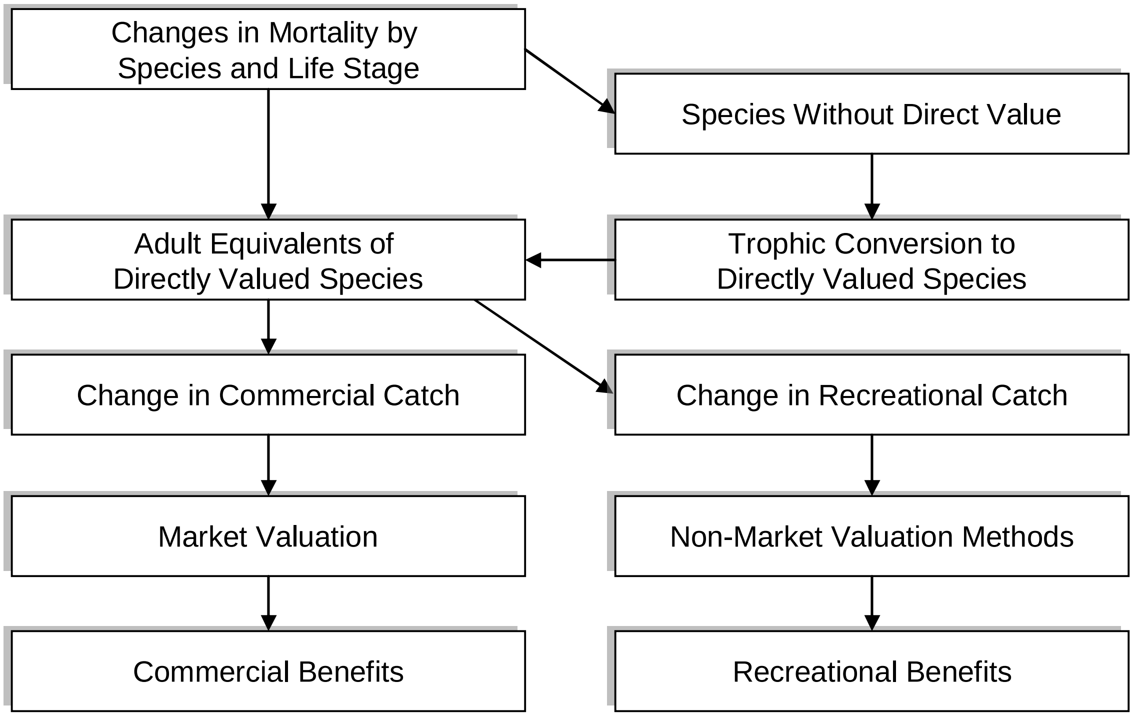
- *Non-use benefits*, in contrast, accrue to individuals who do not use the resource either directly or indirectly, but nonetheless place a value on preventing its impairment.

We discuss each type of benefit in the following sections.

a. Use Benefits from Increases in Catch

The primary benefit from fish-protection controls is to reduce fish mortality. The primary use value that members of society receive from reduced fish mortality is from increased fish catches. In the "direct" category, some species of fish are caught commercially ("market" effect) or recreationally ("non-market" effect). In the "indirect" category, other species are not caught, but rather serve as forage for species that are valued commercially or recreationally; it is important to include the benefits from increased numbers of forage fish in the total benefits. Figure 3 summarizes the steps involved in valuing increased fish catches.

Figure 3. Summary of steps in calculating monetized benefits



The process starts with estimates of the reductions in fish mortality for a given technology, broken down by species and life stage. For species that are caught commercially or recreationally, the next step is to estimate how losses translate to adult-equivalent fish, accounting for the fact that at each life stage, only a fraction survive to the next stage. Thus, for example, out of hundreds of thousands of eggs, only one may survive to adulthood. These biological calculations are critical to develop sensible benefit estimates, because it is increases in adult-equivalent fish that lead to benefits to commercial and recreational anglers.

For species that are not caught commercially or recreationally, the usual approach is to use trophic conversion factors to account for the fact that more forage biomass leads to more potential commercial and recreational fish catch. These calculations mean that all affected organisms are included in the benefit calculations, either directly or indirectly. The final step before valuation is to estimate what fractions of adult-equivalent fish species are caught and how that catch is divided between commercial and recreational fisheries.

b. Other Potential Use Benefits

In addition to fishing, EPA has identified a variety of other use benefits that may be relevant in some cases. Some of these categories are captured by the fishing-related measures. Many of these are in effect subcategories of commercial or recreational fishing—e.g., commercial bait, commercial and recreational shell fishing, and subsistence fishing. Others, such as food chain support, are addressed by an analysis of forage species. EPA also has identified various potential use values that are not addressed by analyses of commercial and recreational fishing. Such benefits include non-fishing activities (such as bird watching, viewing, or boating). Typically these other benefits cannot be quantified reliably but they can be evaluated on a qualitative basis, which is important for completeness. In most cases, they are not relevant to the kinds of modest changes in fish populations generally found in analyses of cooling systems at electric generating stations.

c. Non-Use Benefits

Non-use benefits are benefits that are not associated with any direct use by either individuals or society. These benefits arise if individuals 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 classic example of a non-use value is that many individuals may be willing to pay to preserve the Grand Canyon from being dammed even though they have never visited it and do not expect to do so in the future. Unfortunately, the only way to estimate non-use values is to use stated preference methods that involve surveying individuals and eliciting their preferences, rather than inferring those values from actual behavior. Such methods are expensive and difficult to apply well.

Recognizing these problems, EPA's Phase II rules for Section 316(b) cost-benefit analyses provide criteria for determining whether potential non-use benefits are likely to be significant. The Phase II rules recommend that studies consider the "magnitude and character of ecological impacts implied by the results of the impingement and entrainment mortality study and any other relevant information" (69 FR 41648). They suggest considering whether substantial harm is done to one of the following:

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 water body or watershed.

Cost-benefit analysis of fish-protection alternatives involves consideration of whether the alternatives would substantially mitigate any negative impacts of the generating facility on these three factors, and thus whether non-use benefits are likely to be significant.

5. Perform Cost-Benefit Comparisons

The standard objective in cost-benefit analysis is to provide information that would allow a decision maker to choose the alternative that maximizes net benefits (benefits minus costs). Because benefit and cost streams rarely are constant across time, they must be put in terms of their present value—discounted—before net benefits are computed. Guidelines from OMB and EPA provide guidance on the choice of an appropriate discount rate, including recommendations that analysts compute costs and benefits using different plausible discount rates to determine the sensitivity of the results to this choice.

Recognizing that the baseline (typically a "no-action" alternative), by definition, has zero net benefits (because all benefits and costs are measured relative to the baseline), alternatives with costs that exceed benefits would be rejected based upon the standard cost-benefit criterion. If there are multiple alternatives with positive net benefits, then the one with the largest net benefits should be chosen. This assessment requires comparing incremental benefits and costs of moving to more stringent alternatives. Thus, even if a relatively stringent alternative has positive net benefits, it should not be chosen if its incremental costs (relative to a less stringent alternative) exceed its incremental benefits.

The basic cost-benefit results are supplemented with a qualitative assessment of non-quantified factors and a quantitative assessment of uncertainties. The following sections describe these elements.

6. Consider the Implications of Non-monetized Costs and Benefits

In evaluating the quantitative results, it is useful to also consider whether costs or benefits that were not monetized are likely to be large enough to reverse tentative conclusions based on the quantified effects. In some cases, it may be clear that quantifying the effect would reinforce the tentative conclusion. For example, if net benefits are positive, taking into account an omitted benefit would increase already positive net benefits. Conversely, if net benefits are negative, then quantifying an omitted cost would make the alternative even more unattractive. In other cases, however, it will be necessary to reach some judgment about the likely magnitude of the non-quantified cost or benefit relative to the quantified net benefits.

7. Perform Uncertainty Analyses

In most cost-benefit analyses there are uncertainties about various elements of the quantitative results. These uncertainties generally come from several sources, including the biological and engineering estimates that provide many of the inputs to the analysis as well as from the economic parameters used in the analysis. Such uncertainties are inevitable, as the EPA *Guidelines* recognize: "[t]he issue for the analyst is not how to avoid uncertainty, but how to account for it and present useful conclusions to those making policy decisions" (EPA 2000, p. 27).

A common means of evaluating uncertainty is through sensitivity analyses that vary the values of key parameters over plausible ranges to see their impacts on results. These analyses are helpful, though they have two major limitations: (1) the number of sensitivity analyses can easily become unwieldy, especially if they include varying the values of multiple parameters simultaneously, and (2) it can be hard to interpret the results when some sensitivity analyses point to one conclusion while others point in a different one. Nonetheless, a sufficiently broad sensitivity analysis can often provide important information on the robustness of the conclusions drawn from the primary benefit-cost results. We provide the results of a limited set of sensitivity analyses in this report.

Monte Carlo analysis provides additional refinement of uncertainties, generating not just a range of possible outcomes, but also a formalized mechanism for estimating the likelihoods of different outcomes. It requires assigning probabilities to alternative assumptions and parameter values. Each trial of a Monte Carlo analysis involves using a computer simulation to sample from each of the probability distributions of parameter values, and then computing the resulting net benefits. Typically, hundreds or thousands of trials are run, from which a probability distribution of the outcomes is constructed. Because of the limited time and resources available for the analyses described in this report, we have not conducted Monte Carlo simulations.

III. Preliminary Statewide Costs and Benefits

This chapter provides the results of our preliminary assessment of the costs and benefits of retrofitting California's coastal power plants with closed-cycle cooling systems to comply with Track 1 of the Draft Policy. We also provide overviews of the data and methodology. Additional information is provided in attachments.

A. Draft Policy Implementation Schedule

Our cost-benefit analysis incorporates assumptions regarding the timing of the Draft Policy's implementation. The Draft Policy provides a schedule identifying a specific year by which each facility must achieve compliance. As indicated in Table 1, the schedule uses a staggered implementation scheme that we understand is intended, in part, to avoid potential electric system reliability concerns. We assume that each facility schedules closed-cycle cooling installation so that the retrofit is complete at the end of the facility's final compliance year. We assume that the fish-protection benefits are accrued and the ongoing costs (operating and maintenance, power, and air emissions) are incurred beginning in the year after the final compliance year.

Table 1. Draft Policy's closed-cycle implementation years

Facility	Year
Alamitos	2020
Contra Costa	2017
Diablo Canyon	2021
El Segundo	2015
Encina	2017
Harbor	2017
Haynes	2015
Huntington Beach	2020
Mandalay	2020
Morro Bay	2015
Moss Landing	2017
Ormond Beach	2020
Pittsburg	2017
Potrero	2011
Redondo	2020
SONGS	2022
Scattergood	2017
South Bay	2012

Source: Draft Policy

To aggregate values across time, we use a consistent, real (net of inflation) discount rate of 7 percent, as recommended by OMB. All present values are as of January 1, 2009, which has the effect of reducing the costs and benefit values substantially compared to a case in which the values were calculated as of the various facilities' compliance years. Note that discounting the values to a later starting date would scale costs and benefits up by equal proportions and thus would not affect whether results show net costs or net benefits.

B. Preliminary Statewide Social Costs of Cooling Tower Retrofits

We consider the major cost categories discussed in the above chapter. Our cost evaluation has the following four components:

1. construction costs;
2. operating and maintenance costs;
3. power costs; and
4. air emissions costs.

1. Construction Costs

We use engineering estimates of the costs of obtaining and installing the necessary structures and equipment as well as the recurring costs of operating and maintaining the equipment from Tetra Tech (2008).

Table 2 displays capital cost estimates. The first column displays the "overnight" cost as provided in the Tetra Tech report. The second column displays the present value of the costs for each of the facilities, based upon the compliance dates for the various facilities. Note that the large differences between the present values and the overnight costs reflect the effects of discounting all costs to January 1, 2009.

Table 2. Preliminary statewide capital cost estimates

Facility	"Overnight"	PV
Alamitos	$209.8	$99.7
Contra Costa	$98.5	$57.3
Diablo Canyon	$895.2	$397.5
El Segundo	$78.4	$52.2
Harbor	$26.5	$15.4
Haynes	$151.5	$100.9
Huntington Beach	$132.4	$62.9
Mandalay	$55.1	$26.2
Morro Bay	$89.0	$59.3
Moss Landing	$269.1	$156.6
Ormond Beach	$132.4	$62.9
Pittsburg	$125.0	$72.8
SONGS	$593.3	$246.2
Scattergood	$161.0	$93.7
Total	$3,017.2	$1,503.6

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: Tetra Tech (2008) and NERA calculations as explained in text

2. Operating and Maintenance Costs

Operating and maintenance costs are displayed in Table 3. The first column provides Tetra Tech's annual O&M cost estimates; the second column provides the resulting present value estimates, based upon assumptions regarding the compliance dates and the retirement dates for the various facilities.

Table 3. Preliminary statewide O&M cost estimates

Facility	Annual	PV
Alamitos	$2.1	$10.6
Contra Costa	$0.5	$3.1
Diablo Canyon	$9.1	$42.8
El Segundo	$0.4	$2.8
Harbor	$0.1	$0.6
Haynes	$1.9	$13.4
Huntington Beach	$0.9	$4.5
Mandalay	$0.3	$1.5
Morro Bay	$1.0	$7.1
Moss Landing	$2.6	$16.0
Ormond Beach	$0.7	$3.5
Pittsburg	$0.5	$3.1
SONGS	$8.4	$36.9
Scattergood	$0.9	$5.5
Total	$29.4	$151.5

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: Tetra Tech (2008) and NERA calculations as explained in text

3. Power Costs

As the previous chapter notes, fish-protection alternatives can increase costs related to power generation both during possible outage periods for technology installation and due to ongoing losses in generating efficiency.

a. Outage Power Costs

We rely on Tetra Tech (2008) for information on lost power due to outages. For four affected facilities (Diablo Canyon and SONGS, the two nuclear facilities, plus Haynes and Moss Landing), Tetra Tech provides estimates of the lost output (MWh) that the outage would cause. Table 4 displays this information. For the other facilities, Tetra Tech assumes that closed-cycle cooling installation would not require any incremental outage.

Table 4. Output loss due to facility outage

Facility	Output Loss (MWh)
Diablo Canyon	10,091,030
Haynes	175,000
Moss Landing	75,342
SONGS	8,261,443

Source: Tetra Tech (2008)

To estimate the social cost of the replacement power, we used year-specific price projections for California wholesale generation from the Energy Information Administration ("EIA") Annual Energy Outlook ("AEO") 2009. Table 5 displays the EIA AEO 2009 estimates of California wholesale electricity generation price and the price of natural gas to the California electricity sector.

Table 5. Energy price forecasts

	Electricity ($/MWh)	Natural gas ($/MMBtu)
2015	$64.79	$6.09
2016	$65.24	$6.37
2017	$65.92	$6.62
2018	$66.48	$6.87
2019	$67.14	$7.14
2020	$67.99	$7.42
2021	$68.79	$7.65
2022	$68.52	$7.54
2023	$70.64	$7.09
2024	$70.38	$7.07
2025	$69.97	$7.17
2026	$70.82	$7.35
2027	$71.26	$7.62
2028	$72.40	$7.95
2029	$73.31	$8.18
2030	$74.06	$8.44
2031	$74.06	$8.44
2032	$74.06	$8.44
2033	$74.06	$8.44
2034	$74.06	$8.44
2035	$74.06	$8.44
2036	$74.06	$8.44
2037	$74.06	$8.44
2038	$74.06	$8.44
2039	$74.06	$8.44
2040	$74.06	$8.44
2041	$74.06	$8.44
2042	$74.06	$8.44
2043	$74.06	$8.44

Notes: All dollar values are in 2009 dollars.
Source: EIA (2009) through 2030; assumed constant in real terms from 2031-2043

The outage costs also reflect cost savings (negative costs) that would occur because the affected facilities may avoid certain operating costs (e.g., fuel) during the outage. For the nuclear facilities, we use Tetra Tech's estimate of the cost savings; for the natural gas-fired facilities, we use the facility heat rates in conjunction with the natural gas price estimates described below to measure fuel savings.

Table 6 displays the present value of the outage-related power costs for the four affected facilities, both in each facility's outage year and on a present-value basis (taking into account each facility's outage date). The costs for the natural gas facilities are much lower than those for the nuclear facilities. This is because the gas facilities' outage times are significantly lower (as estimated by Tetra Tech) and their outage-related fuel savings are greater.

Table 6. Preliminary statewide outage-related power costs

Facility	Outage Year	PV
Diablo Canyon	$573.1	$254.5
Moss Landing	$2.6	$1.7
Haynes	$0.7	$0.4
SONGS	$466.9	$193.8
Total		$450.3

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: Tetra Tech (2008) and NERA calculations as explained in text

b. Ongoing Power Costs

We also use Tetra Tech information to develop estimates of the ongoing power losses due to closed-cycle cooling, with distinct methodologies for the natural gas and nuclear facilities. Both methodologies also draw on energy price forecasts developed for California by the EIA in Table 5 above.

The following sections describe how we evaluate ongoing power costs at natural gas and nuclear facilities.

i. Ongoing Power Costs at Natural Gas Facilities

As the Tetra Tech report describes, natural gas-fired facilities could potentially respond in two ways to the efficiency reduction caused by closed-cycle cooling: (1) increasing their natural gas consumption; or (2) decreasing their net electrical output. Some facilities may face engineering or other constraints that would the flexibility of their response; in practice, many would likely use a combination of the two approaches. Tetra Tech assumes, because of data limitations, that all gas-fired facilities use the first approach—they increase their natural gas consumption leaving net electrical output unchanged. We adopt the same assumption, and use the Tetra Tech report to estimate the physical increase in natural gas consumption that would result from closed-cycle cooling. Table 7 provides these estimates.

Table 7. Ongoing increase in natural gas consumption due to closed-cycle cooling

Facility	Gas Consumption (MMBTU / Year)
Alamitos	336,190
Contra Costa	15,116
El Segundo	94,693
Harbor	17,098
Haynes	353,513
Huntington Beach	199,496
Mandalay	28,666
Moss Landing	557,365
Ormond Beach	103,732
Pittsburg	36,855
Scattergood	255,071

Source: Tetra Tech (2008)

To estimate the resulting social costs for each facility, we multiply the increase in fuel consumption by the cost of natural gas to California's electricity sector (as provided above).

ii. Ongoing Power Costs at Nuclear Facilities

Tetra Tech provides estimates of the annual ongoing reduction in net electrical output at the nuclear facilities due to closed-cycle cooling (923,988 MWh for Diablo Canyon and 952,784 MWh for SONGS). We use EIA's California wholesale electricity price forecast to estimate the social costs of replacing these output losses.

iii. Summary of Ongoing Power Costs

Table 8 displays our present value estimates of ongoing power costs at all of the affected facilities.

Table 8. Preliminary statewide ongoing power costs

Facility	PV
Alamitos	$13.3
Contra Costa	$0.7
Diablo Canyon	$313.7
El Segundo	$4.9
Harbor	$0.8
Haynes	$18.5
Huntington Beach	$7.9
Mandalay	$1.1
Morro Bay	N/A
Moss Landing	$26.2
Ormond Beach	$4.1
Pittsburg	$1.7
SONGS	$304.0
Scattergood	$12.0
Total	$709.0

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
N/A is not available (Tetra Tech 2008 does not provide information for Morro Bay).
Source: NERA calculations as explained in text

4. Air Emissions Costs

Retrofitting facilities with closed-cycle cooling could lead to changes in air emissions in three ways:

1. Facility outages for installation would require replacement power, which would generate changes in emissions;

2. On an ongoing basis, some affected facilities would increase their fuel (i.e., natural gas) consumption per unit of energy generated; and

3. On an ongoing basis, some affected facilities would reduce their net electrical output, leading to additional emissions from replacement power.

Attachment A provides a description of the methodology that we use to quantify and value changes in air emissions. Replacement power would likely come primarily from natural gas-fired facilities, and the ongoing increase in fuel consumption would involve increased natural gas exclusively. Thus, we focus on nitrogen oxides (“NO_x”) and carbon dioxide (“CO_2”) the two major emissions associated with natural gas combustion.

a. NO_x Emissions

NO_x emissions are related to a variety of adverse health impacts primarily as a result of the formation of small particulate matter. These effects include premature death as well as some respiratory diseases requiring hospitalization. If emissions are subject to a cap-and-trade program, the social costs of emissions would be equal to the expected allowance prices. We have not attempted to quantify costs related to NO_x emissions for the purposes of this preliminary study. Doing so would increase the costs of the Draft Policy.

b. CO_2 Emissions

The social costs of CO_2 emissions depend upon whether emissions are regulated under a cap-and-trade program. If no cap-and-trade program is in place, the social costs would include the potential effects related to climate change. If a cap-and-trade program is in place, the social costs of emissions would be based upon the likely future allowance prices. For purposes of this preliminary study, we presume that a federal cap-and-trade program would be in place. Attachment A explains how we estimate the increases (tons) of CO_2 emissions resulting from the closed-cycle cooling installation, as well as how we value the increases using forecasted CO_2 allowance prices developed by the EIA.

Table 9 displays our estimates of the air emissions costs of closed-cycle cooling implementation, which are based upon statewide changes in CO_2 emissions if the Draft Policy were in place.

Table 9. Preliminary statewide CO_2 emissions costs

Facility	PV
Alamitos	$4.4
Contra Costa	$0.2
Diablo Canyon	$145.8
El Segundo	$1.5
Harbor	$0.2
Haynes	$5.5
Huntington Beach	$2.6
Mandalay	$0.4
Morro Bay	N/A
Moss Landing	$8.1
Ormond Beach	$1.4
Pittsburg	$0.5
SONGS	$132.5
Scattergood	$3.7
Total	$306.8

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
N/A is not available (Tetra Tech 2008 does not provide information for Morro Bay).
Source: NERA calculations as explained in text

5. Total Costs

Table 10 summarizes the preliminary social costs of the statewide closed-cycle cooling implementation for each affected facility.

Table 10. Summary of preliminary state costs

Facility	Capital	O&M	Power	Air Emissions	Total
Alamitos	$99.7	$10.6	$13.3	$4.4	$127.9
Contra Costa	$57.3	$3.1	$0.7	$0.2	$61.4
Diablo Canyon	$397.5	$42.8	$568.2	$145.8	$1,154.3
El Segundo	$52.2	$2.8	$4.9	$1.5	$61.5
Harbor	$15.4	$0.6	$0.8	$0.2	$17.1
Haynes	$100.9	$13.4	$18.9	$5.5	$138.7
Huntington Beach	$62.9	$4.5	$7.9	$2.6	$77.9
Mandalay	$26.2	$1.5	$1.1	$0.4	$29.2
Morro Bay	$59.3	$7.1	N/A	N/A	$66.4
Moss Landing	$156.6	$16.0	$28.0	$8.1	$208.7
Ormond Beach	$62.9	$3.5	$4.1	$1.4	$71.9
Pittsburg	$72.8	$3.1	$1.7	$0.5	$78.1
SONGS	$246.2	$36.9	$497.7	$132.5	$913.4
Scattergood	$93.7	$5.5	$12.0	$3.7	$115.0
Total	$1,503.6	$151.5	$1,159.3	$306.8	$3,121.3

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
N/A is not available (Tetra Tech 2008 does not provide energy penalty information for Morro Bay).
Source: NERA calculations as explained in text

C. Preliminary Statewide Benefits of Cooling Tower Retrofits

We use the methodology described in Chapter II to quantify the environmental benefits of the Draft Policy statewide and then monetize them (i.e., express them in dollar terms). As shown in Figure 2 in Chapter II, the potential environmental benefits of a policy can be divided into four categories: (1) market direct use; (2) non-market direct use; (3) indirect use; and (4) non-use.

Market direct use benefits include the value that commercial anglers would place on increased catch due to retrofitting the facilities with closed-cycle cooling. Non-market use benefits include the value that recreational anglers would place on the increased catch they experience. Indirect use benefits relate to the value that commercial and recreational anglers would place on larger stocks of game species due to increased forage species. These benefits are indirect in the sense that the forage species do not have recreational or commercial value by themselves, but they provide indirect benefits because they are consumed by game species that society directly values. Non-use benefits relate to the preservation or enhancement of environmental resources or services that society does not directly use but may still value, such as threatened and endangered species and ecosystem viability.

We begin this section by summarizing available information on impingement and entrainment at coastal power plants in California. We then describe how we estimated the increases in fishery yields from reducing cooling water intake under the Draft Policy. Next we describe how we estimated the value to society of the increases in fishery yields. This calculation generates estimates of the market use, non-market use, and indirect use benefits of the policy statewide.

We consider non-use benefits using the criteria established in the EPA Phase II Rules. As discussed in Chapter II, non-use benefits are benefits that are not associated with any direct use by either individuals or society. The EPA Phase II Rules under Section 316(b) of the Clean Water Act indicate that non-use benefits are unlikely to be significant unless the cooling water intake causes substantial harm to (1) threatened and endangered species; (2) important species; or (3) the maintenance of ecosystem structure and function. The EPA also notes, however, that non-use benefits that cannot be easily explained to the public should not be monetized, as the stated preference surveys used to value the benefits would not be accurate. Attachment B provides preliminary assessments of whether any of these three criteria is likely to apply with regard to cooling water intake at coastal power plants statewide. We conclude from these preliminary assessments that non-use benefits are not likely to be significant.

1. Baseline Impingement and Entrainment

The Environmental Document provides information on baseline impingement and entrainment at the coastal power plants covered by the Draft Policy. The Environmental Document includes data on impingement count and weight during normal operations (i.e., neglecting periodic heat treatments that cause additional impingements) based on their average actual flow between 2000 and 2005. Impingement data are not available for two facilities—Contra Costa and Pittsburg. Of the facilities for which data are available, impingement varies by a factor of over 500 as measured by count or approximately 40 as measured by weight.

Table 11 summarizes the baseline impingement data for each facility. We used these data to develop rough estimates of the potential statewide benefits of reducing impingement.

Table 11. Statewide baseline impingement

Facility	Count	Weight (lb)
Alamitos	52,106	2,249
Contra Costa	-	-
Diablo Canyon	4,821	710
El Segundo	2,396	751
Encina	138,932	5,806
Harbor	10,666	3,498
Haynes	17,838	390
Huntington Beach	26,666	1,487
Mandalay	67,733	2,553
Morro Bay	32,763	1,313
Moss Landing	293,883	4,466
Ormond Beach	13,534	3,112
Pittsburg	-	-
Potrero	106,182	2,371
Redondo	2,366	848
SONGS	1,322,490	28,094
Scattergood	92,829	9,185
South Bay	242,401	751

Note: "-" denotes that impingement data are not available.
Values are based on average actual flow between 2000 and 2005.
Unit-specific values have been summed.
Source: Water Board (2009), p. 31

The Environmental Document includes data on larval entrainment at the coastal power plants based on their average actual flow between 2000 and 2005. As shown in Table 12, larval entrainment also varies considerably across the power plants. Data on egg entrainment at the power plants are not provided for any facilities in the Environmental Document. We used the data in Table 11 to develop rough estimates of the potential statewide benefits or reducing entrainment, including both egg and larval entrainment.

Table 12. Statewide baseline larval entrainment

Facility	Larval Count
Alamitos	2,954,339,708
Contra Costa	95,110,000
Diablo Canyon	1,596,971,533
El Segundo	238,676,079
Encina	3,627,641,744
Harbor	85,429,045
Haynes	3,649,208,392
Huntington Beach	104,316,376
Mandalay	129,172,964
Morro Bay	318,873,127
Moss Landing	729,729,115
Ormond Beach	32,126,547
Pittsburg	175,230,000
Potrero	252,788,154
Redondo	373,757,257
SONGS	6,817,570,834
Scattergood	365,258,133
South Bay	1,667,044,144

Note: The higher of the two entrainment measurements in the Environmental Document (average larval concentration or study results) is used to avoid understating benefits.
Values are based on average actual flow between 2000 and 2005.
Unit-specific values have been summed.

Source: Water Board (2009), p. 31

2. Statewide Benefits

We developed preliminary benefit estimates of the Draft Policy for SONGS based on species-specific information on impingement and entrainment, direct and indirect fishery impacts, and commercial and recreational values. Similar data are not available for the other facilities. We scaled up the impingement and entrainment benefits for SONGS to the state as a whole using the impingement weight data and entrainment data on individual facilities above. Table 13 shows the results of our preliminary benefits assessments for the Draft Policy statewide. Details regarding the calculations behind these results are provided in Attachment B.

Table 13. Preliminary statewide benefits

Effect	Present Value
Impingement	$7.5
Entrainment	$26.7
Total	$34.2

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

D. Preliminary Statewide Cost-Benefit Assessment

This section compares the estimated costs of statewide implementation of closed-cycle cooling to the estimated statewide benefits. We discuss the effects of costs and benefits that are omitted from the monetary evaluations and calculate the sensitivity of the results to the discount rate.

1. Cost-Benefit Comparisons

Table 14 shows present values of costs, benefits, and net costs (i.e., costs minus benefits) in millions of 2009 dollars as of January 1, 2009 based upon a real discount rate of 7 percent. The present values reflect the compliance dates for the various facilities, which range from 2011 to 2022. Plants with later compliance dates have lower present values, all else equal, because costs and benefits are discounted for fewer years.

The estimated present value of total costs across all affected power plants in California is about $3.12 billion, i.e., a total of about $3.12 billion would need to be set aside on January 1, 2009 to equal the discounted sum of all costs incurred in future years under the Draft Policy. The largest component is capital costs at about $1.5 billion, followed by energy penalty costs at $618 million and construction outage costs at $450 million. The estimated present value of total benefits across all affected power plants in California is about $34.2 million, i.e., the discounted sum of the benefits of the Draft Policy in future years would equal about $34.2 million as of January 1, 2009. Entrainment gains account for about $26.7 million of the benefits and impingement gains account for the remaining $7.5 million in benefits.

The estimated present value of net costs (i.e., costs minus benefits) of the Draft Policy across all affected power plants is approximately $3.09 billion. These results indicate that the costs society would incur to install cooling towers on all affected would exceed the benefits society would gain by a factor of 91.

Table 14. Preliminary statewide cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$1,503.6
Operating and Maintenance	$151.5
Construction Outage	$450.3
Energy Penalty	$617.7
Heat Rate Impact	$91.3
CO2 Emissions	$306.8
Total	$3,121.3
Benefits	
Impingement	$7.5
Entrainment	$26.7
Total	$34.2
Cost-Benefit Comparisons	
Net Costs	$3,087.2
Costs to Benefits Ratio	91

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Statewide analysis does not include the costs of cooling tower retrofit at Encina, Portrero, Redondo Beach, or South Bay because Tetra Tech (2008) does not provide cost estimates for these facilities, but the analysis does include the benefits of reduced cooling water intake at these facilities.
Source: NERA calculations as explained in text

2. Effects of Non-Quantified Costs and Benefits

The basic steps in the cost-benefit analysis presented above include identifying the proposed action, determining its effects, valuing the positive effects (benefits) and negative effects (costs) to the extent feasible in dollar terms, and calculating the net costs or net benefits. It is also important to consider the potential effects that are not estimated in monetary terms. Both the U.S. EPA and OMB recommend describing omitted effects qualitatively and evaluating the implications of omitting these factors when presenting the overall results. EPA notes:

> … following a net benefit calculation, there should be a presentation and evaluation of all benefits and costs that can only be quantified but not valued, as well as all benefits and costs that can be only qualitatively described (EPA 2000, p. 177).

Similarly, OMB states:

> A complete regulatory analysis includes a discussion of non-quantified as well as quantified benefits and costs. A non-quantified outcome is a benefit or cost that has not been quantified or monetized in the analysis. When there are important non-monetary values at stake, you should also identify them in your analysis so policymakers can compare them with the monetary benefits and costs. When your analysis is complete, you should present a summary of the benefit and cost

> estimates for each alternative, including the qualitative and non-monetized factors affected by the rule, so that readers can evaluate them (OMB 2003, p. 3).

Here we briefly discuss the omitted costs and benefits qualitatively and consider their effects on the overall results. At the end of this section we summarize the conservative assumptions we made to avoid overstating the net costs of fish protection alternatives.

a. Qualitative Assessments of Non-Quantified Costs

Our analysis excludes several types of social costs that may result from implementation of closed-cycle cooling at the affected facilities:

- *PM_{10} emissions due to cooling tower equipment.* The Tetra Tech report states that cooling towers would directly emit particulate matter (PM_{10}). We do not include the social costs of these emissions.

- *Additional impingement and entrainment at other generating stations*. We do not include the social costs of any additional impingement and entrainment at generating stations that would make up for lost output at the affected facilities due to construction outages and energy penalties.

- *Local adverse impacts*. We do not include the social costs of any adverse impacts on local areas, such as noise and aesthetic effects, from construction of closed-cycle cooling at the facilities.

Incorporating these non-quantified costs would be expected to cause our overall net cost estimates to increase.

b. Qualitative Assessments of Non-Quantified Benefits

Our benefits assessment considers the relevant benefit categories described both in the EPA *Guidelines* (EPA 2000) and in the Section 316(b) regional benefits analyses for Phase II and Phase III facilities. We quantified and monetized the relevant and significant benefits categories. Several other benefit components included in these two sets of documents are not included in the benefits assessment because, as discussed below, we judged them either to be irrelevant or unlikely to be significant relative to the benefits that are quantified.

- *Non-market direct use benefits*. Our estimates cover all non-market direct use benefits identified by EPA in its Section 316(b) Phase II case studies with the exception of "near-water recreation direct viewing." Such benefits are likely to be zero or near zero because there is no reason to expect that marginal changes in fish abundance would affect the viewing experience on the California coast.

- *Non-market indirect use benefits*. EPA's category of non-market indirect use benefits includes a large number of subcategories. Most of these subcategories are covered implicitly by our inclusion of indirect benefits associate with trophic transfer from forage species and game species to California halibut. The other subcategories appear to be irrelevant in this case. There is no reason to believe that a small change in the fish populations would have any material impact on such categories of potential indirect use benefits as scientific research, TV shows or books on nature, or bird watching.

§ *Non-use benefits*. None of the three non-use criteria in the EPA Phase II Rule appears to hold for impingement and entrainment statewide, so non-use benefits are likely not significant.

We conclude that the benefits we have quantified include the major benefit categories relevant to evaluation of the fish protection alternatives at the facilities. The other benefit components discussed above that are not quantified are not likely to be significant. None of these non-quantified benefit categories, individually or collectively, would be large enough to reverse the conclusion that the costs of retrofitting California's coastal power plants with closed-cycle cooling would exceed the benefits.

3. Conservative Assumptions

Our conservative assumptions to avoid overstating the net costs of fish protection alternatives include the following:

§ *Immediate and recurring benefits*. We assumed that the benefits of reduced impingement and entrainment in terms of larger fish populations would occur immediately, when in fact it would take time for the early life stages entrained at the facilities and the juvenile fish impinged to grow up into harvestable fish.

§ *Assignment of additional biomass to highly valued species.* We assigned all the additional biomass in the ecosystem from both forage species and game species, after accounting for trophic transfer, to a highly valued predator species: California halibut. In fact, some of the additional biomass would be consumed by other species of less value to fisheries.

§ *High recreational fish values.* We used the highest recreational values for each species based on the literature we reviewed. We also inflated these values to account for catch-and-release.

§ *No additional costs to commercial fisheries.* We estimated the market use benefits as the increase in revenue to commercial fisheries, neglecting the potential increase in their costs. This assumption would tend to overstate the market use benefits.

4. Sensitivity Analysis

The statewide results are based upon the set of assumptions and parameters described in this chapter. As noted in Chapter II, it is useful to determine the sensitivity of the cost-benefit results to various parameters and assumptions.

For this preliminary assessment, we have developed estimates of the sensitivity of the results to alternative discount rates. The following are the net costs of the Draft Policy using discount rates of 3 percent, 7 percent (the base case), and 10 percent.

Table 15. Preliminary statewide net costs under alternative discount rates

Discount rate	Present Value
3%	$6,293.4
7% (base case)	$3,087.2
10%	$1,903.5

Notes: All dollar values are millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

A lower discount rate leads to a higher estimate of net costs. This result may seem counterintuitive, as one normally expects a project with up-front capital costs and benefits that extend over many years to look more favorable with a lower discount rate. The result here reflects the fact that costs are so much greater than benefits that a lower discount rate increases the present value of the costs by more than it increases the present value of the benefits, despite the fact that costs generally occur earlier in the projection period than benefits.

The higher discount rate leads to a lower estimate of net costs since it causes the present value of costs to decrease by a larger magnitude than the present value of benefits. It does not, however, change the conclusion that the Draft Policy would yield large net costs.

E. Possible Additional Statewide Cost-Benefit Analyses

These preliminary statewide results suggest that requiring cooling towers on all relevant facilities would not pass a cost-benefit test. This conclusion is robust with respect to alternative discount rates and with respect to likely costs and benefits that are not included in the analysis (including conservative assumptions).

A complete cost-benefit analysis of the Draft Policy would include consideration of two additional analyses:

1. expansion of technologies to include those other than closed-cycle cooling; and

2. consideration of the likely facility owner responses to the Draft Policy and the implications of these responses on statewide costs and benefits.

The following sections provide summaries of these potential additional analyses. (It would also be useful to expand the analyses of uncertainty to include other sensitivity analyses and Monte Carlo analyses.)

1. Cost-Benefit Assessments of Additional Technologies

The Environment Report notes that other technologies are available to reduce impingement and entrainment at California facilities. A complete cost-benefit analysis would include developing estimates of the costs and benefits of these other technologies.

Cost-benefit analyses should include a reasonably full set of feasible control alternatives and provide information on the effects of each alternative. Including all feasible alternatives is important both for completeness and for providing the basis for assessing the incremental benefits and incremental benefits of increasingly expensive alternatives. The following is from the EPA Guidelines.

> Present the incremental benefits, costs and net benefits of moving from one regulatory alternative to more stringent ones. . . . This should include a discussion of incremental changes in quantified and qualitatively described benefits and costs.

In the context of 316(b) cost-benefit assessments, three types of potential fish protection alternatives could be considered.

1. *Technological alternatives.* These alternatives include the addition of various technologies to the existing cooling water intake structure. Typical examples include various types of screen modifications, sound deterrent systems and relocation of the intake to an offshore position.

2. *Flow reduction alternatives.* These alternatives include reducing cooling water flow. Retrofit of a facility with closed-cycle cooling is only one example of this approach. Others include the installation of variable speed pumps to reduce water intake and modification of an outage schedule to reduce annual impingement and entrainment.

3. *Restoration alternatives.* These alternatives include methods to offset entrainment/impingement losses. Examples include habitat restoration (e.g., wetland restoration, submerged aquatic vegetation, removals of barriers to fish migration) and stocking.

Providing a range of feasible alternatives (i.e., those that could be implemented technically) would allow the cost-benefit analysis to identify any “low hanging fruit,” i.e., technologies that could be added that would obtain the majority of the potential fish protection benefits at relatively small costs.

We also note that the proposal requires that if less stringent controls are approved, “any difference in impacts to marine life…shall be fully mitigated.” However, mitigation would constitute another alternative for reducing net losses. As a result, it should be subject to the same type of test to see if its cost is “grossly disproportionate” to its benefits. There is no basis for assuming that the cost of mitigation will necessarily bear any reasonable relationship to its costs.

2. Effects of Facility Owner Decisions on Costs and Benefits

The statewide cost-benefit analysis in this chapter assumes that the Draft Policy would lead to retrofit of all affected units to closed-cycle cooling. However, the ultimate costs and benefits of the Draft Policy would depend upon how individual facility owners would respond to these requirements. In particular, the overall costs and benefits would change if some owners decided to retire or re-power their units prematurely rather than retrofit them with closed cycle cooling.

The Environmental Report addresses the possibility of electricity market effects, although it does not provide estimates of the likely changes due to the Draft Policy. The Environmental Report states that 43 of the 54 generating units covered by the Draft Policy are 30 years or older, and it speculates that it may be more economical for their owners to re-power these older units rather than install cooling towers or to shut them down and replace the power lost from other sources. The Environment Report (p. 110) cites an estimate that overall costs of a statewide policy to replace all once-through cooling units could range from $100 million to $11 billion.

If the Draft Policy would result in re-powering (or premature retirement/replacement) of some facilities, the calculations of the overall benefits and costs would be affected. Both sets of estimates would need to take into account the effects of shifts in electricity generation. It is important to note that imposing cooling intake requirements that lead to changes in the electricity system (e.g., premature retirement or re-powering) would not be costless.

The first step in considering these alternatives to retrofitting cooling systems would be to compare their costs to those of retrofitting to see what decisions plant owners are likely to make. Such a comparison would require estimating the net costs of re-powering or shutting down a plant. In the case of re-powering or replacement, there would be substantial capital costs but presumably also some ongoing savings from a more efficient repowered unit. All of the other cost components would have to be evaluated as well. For plant shutdown, the cost from the owner's perspective would be the lost operating profits (revenues minus variable costs, including fuel) plus any costs of shutdown per se (possibly including site clean-up).

Once the least-cost alternative from the facility's owner's perspective was determined, its social costs and benefits could be evaluated using the same types of methods used here.

IV. Preliminary Site-Specific Cost-Benefit Analysis

This chapter outlines the data and methodology we used to develop preliminary estimates of the costs and benefits of installing cooling towers at San Onofre Nuclear Generating Station (“SONGS”) to comply with the Draft Policy.

A. Overview of the Facility

SONGS is located on the coast of the Pacific Ocean approximately 2.5 miles southeast of San Clemente, California. The facility has two active nuclear-fueled generating units (Units 2 and 3) each with a dependable capacity rating of 1,127 MW (Water Board 2009, p. 35). SONGS had an average capacity factor of 83 percent between 2001 and 2006 (Water Board 2009, p. 35). Each unit uses once-through cooling technology and withdraws approximately 1,200 million gallons a day. SONGS has an offshore intake system with a velocity cap, which significantly reduces impingement. It also has a fish return system to further reduce impingement.

B. Preliminary Social Costs for SONGS

This section describes our preliminary estimates of the social costs of installation of closed-cycle cooling at SONGS. The basic methods are generally similar to those used for the statewide assessment, although we use engineering estimates from the recent site-specific study developed by ENERCON (2009) instead of Tetra Tech’s (2008) statewide assessment. Table 16 provides a summary comparison of ENERCON’s engineering estimates with those developed by Tetra Tech for SONGS. As described below in the following subsections, there are important differences between the two sets of estimates.

Table 16. Comparison of ENERCON and Tetra Tech SONGS engineering estimates

	ENERCON	Tetra Tech	Ratio
Construction Costs ($m)	$615	$593	1.04
Annual O&M ($m)	$3	$8	0.34
Outage Output Loss (1000 MWh)	33,116	8,261	4.01
Ongoing Ann'l Output Loss (1000 MWh)	1,128	953	1.18

Notes: All dollar values are in millions of 2009 dollars. The “Ratio” column indicates the ratio of the ENERCON estimate to the Tetra Tech estimate.
Source: ENERCON (2009) and Tetra Tech (2008).

1. Construction Costs

ENERCON’s “overnight” capital cost estimate for SONGS is approximately $615 million. This estimate is 4 percent higher than Tetra Tech’s estimate. On a present value basis assuming a five-year construction period ending in 2023, the ENERCON estimate is approximately $293 million.

2. Operating and Maintenance Costs

ENERCON's annual O&M cost estimate is approximately $3 million. This estimate is 66 percent lower than Tetra Tech's estimate. The ENERCON estimate leads to an overall present value for O&M costs of about $12 million.

3. Power Costs

We value the power costs of SONGS output losses during the closed-cycle construction outage and on an ongoing basis using the same methodologies as were used for the nuclear facilities in the statewide assessment.

a. Outage Costs

For the outage cost, we use ENERCON's engineering estimate of output losses due the outage (approximately 33 million MWh, three times larger than Tetra Tech's estimate) in conjunction with the electricity price and timing assumptions described in Chapter III. The present value outage costs are approximately $777 million with the ENERCON estimate.

b. Ongoing Power Costs

ENERCON estimates ongoing output losses at SONGS of about 1.1 million MWh, about 18 percent greater than Tetra Tech's estimate. The present value of ongoing power losses is about $360 million using ENERCON's estimate.

4. Air Emissions Costs

Increased air emissions due to closed-cycle cooling implementation at SONGS would arise due to the need for replacement power during the construction outage and on an ongoing basis. Using the methodologies described in Chapter III and Attachment A, we estimate that the present value of carbon dioxide costs at SONGS is approximately $299 million.

5. Total Costs

Table 17 summarizes our overall estimates of the social cost of closed-cycle cooling implementation at SONGS.

Table 17. Preliminary SONGS costs

Capital	$293.3
O&M	$12.5
Power	$1,136.6
Air emissions	$299.0
Total	$1,741.4

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: ENERCON (2009) and NERA calculations as explained in text

C. Preliminary Social Benefits for SONGS

We use the methodology described in Chapter II to quantify the environmental benefits of the Draft Policy at SONGS and then monetize them (i.e., express them in dollar terms) to the extent feasible. Details on our calculations appear in Attachment B. We used species-specific information on baseline impingement and entrainment at SONGS to develop rough estimates of the societal benefits of installing cooling towers. Information on baseline losses at SONGS was provided in Chapter III. Baseline impingement at SONGS appears above in Table 11, and baseline larval entrainment at SONGS appears in Table 12. We also considered egg entrainment at SONGS so that our benefit assessment would be as comprehensive as possible.

The estimated benefits from the reduction in impingement and entrainment due to installation of closed-cycle cooling are summarized in Table 18. We conclude that non-use benefits are likely not significant, as discussed in Attachment B.

Table 18. Preliminary SONGS benefits

Effect	Present Value
Impingement	$3.6
Entrainment	$8.5
Total	$12.0

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

D. Preliminary Cost-Benefit Assessments for SONGS

1. Cost-Benefit Comparisons

Table 19 summarizes the results of our preliminary site-specific cost-benefit analysis. The estimated present value of costs as of January 1, 2009 from implementing the Draft Policy at SONGS is about $1.7 billion, and the estimated present value of benefits is about $12 million. Thus, the estimated costs from implementing the Draft Policy at SONGS would exceed the estimated benefits by a factor of 145 Although there is no economic test to determine whether a particular costs is “wholly disproportionate,” to a particular benefit, we are aware of no economic principle that would justify incurring $1.7 billion in social costs to obtain about $12 million in social benefits—for a net cost of about $1.7 billion—which reflects these preliminary results.

Table 19. Preliminary SONGS cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$293.3
Operating and Maintenance	$12.5
Construction Outage	$776.6
Energy Penalty	$359.9
Heat Rate Impact	$0.0
CO2 Emissions	$299.0
Total	$1,741.4
Benefits	
Impingement	$3.6
Entrainment	$8.5
Total	$12.0
Cost-Benefit Comparisons	
Net Costs	$1,729.3
Costs to Benefits Ratio	145

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

An alternative reference date for present value calculations is 2022, the year by which SONGS would have to comply with the Draft Policy. The estimated present value of net costs for SONGS as of January 1, 2022 is $4.2 billion.

2. Non-Quantified Costs and Benefits

All of the non-quantified benefits and costs identified in Chapter III for the statewide analysis would also apply to this analysis. We conclude that none of the non-quantified benefits categories would, individually or collectively, change the conclusion that the costs of closed-cycle cooling at SONGS would far outweigh its benefits.

Similarly, all of the conservative assumptions (i.e., assumptions that tend to understate net costs) identified in Chapter III for the statewide analysis apply to this SONGS analysis as well. As noted above, relaxing these assumptions would lead to increases in the net costs.

3. Sensitivity Analysis

These site-specific results are based upon the set of assumptions and parameters described in this chapter. As noted in Chapter II, it is useful to determine the sensitivity of the cost-benefit results to various parameters and assumptions.

For this preliminary assessment, we have developed estimates of the sensitivity of the results to alternative discount rates. The following are the net costs for SONGS using discount rates of 3 percent, 7 percent (the base case), and 10 percent.

Table 20. Preliminary SONGS net costs under alternative discount rates

Discount rate	Present Value
3%	$3,117.6
7% (base case)	$1,729.3
10%	$1,153.9

Notes: All dollar values are in millions of 2009 dollars
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

A lower discount rate leads to a higher estimate of net costs. As discussed above in the context of the statewide results, this result may seem counterintuitive; it reflects the fact that costs are so much greater than benefits that a lower discount rate increases the present value of the costs by more than it increases the present value of the benefits, despite the fact that costs generally occur earlier in the projection period than benefits.

The higher discount rate leads to a lower estimate of net costs since it causes the present value of costs to decrease by a larger magnitude than the present value of benefits. It does not, however, change the conclusion that a SONGS closed-cycle cooling retrofit would yield large net costs.

E. Additional Site-Specific Cost-Benefit Analyses

These preliminary results suggest that the costs of retrofitting SONGS with closed-cycle cooling would be "wholly disproportionate" to the benefits. These results are robust with respect to different discount rates and to considerations of unquantified costs and benefits. We note, however, that these results are preliminary, based upon readily available data.

As with the statewide policy, it would be important to extend the cost-benefit analysis to include the effects of technologies other than closed-cycle cooling. Thus, it would be important in any site-specific analysis to include the full range of potential technologies, including technological alternatives, flow reduction alternatives and restoration alternatives. The Draft Policy seems to acknowledge the importance of such analyses for nuclear units but appears to deny the use of a site-specific assessment for the majority of non-nuclear units.

1. Site-Specific Studies for Nuclear Units

The Draft Policy anticipates the importance of developing more detailed assessments for the two nuclear units. In the implementation provisions, the Draft Policy proposes that the owners of SONGS and the other affected nuclear unit (Diablo Canyon) conduct special studies for submission to the Water Board.

The studies outlined in the Draft Policy should include additional information that could be used for cost-benefit assessments. The following are some specific recommendations.

1. The special studies should consider not only alternatives to meet the requirements of the Draft Policy, but also a broad range of alternatives that could achieve various levels of fish protection.

2. The assessments should include evaluations of the full social costs and full social benefits of these technology alternatives.

3. The method used in the special studies should be based upon sound economic principles as reflected in State and Federal guidelines and the technical literature.

2. Site-Specific Studies for Other Units

As discussed earlier, the proposed policy allows a subset of plants to obtain alternative standards if they can demonstrate that the costs of complying with the rule are “grossly disproportionate” to the benefits. This provision, however, is limited to nuclear units and the small number of fossil-fired units with heat rates of 8,500 Btu/kWh of less. Most fossil units affected by the Draft Policy would be excluded with this cutoff. We can see no economic reason why the “wholly disproportionate” demonstration should not be available to all affected plants.

3. Site-Specific Costs and Benefits

In addition, it would be desirable to modify the “wholly disproportionate” demonstration in the Draft Policy to focus more sharply on economic costs and benefits. For example, the proposal states that compliance costs should be reported on an amortized basis expressed in dollars per megawatt hour. This measure, however, does not account for the scale of the plant—how many megawatts it produces and hence what its ***total*** costs will be. Expressing costs in these terms but stating environmental measures in terms of totals makes it impossible to make meaningful comparisons.

The proposal also focuses on a measure of benefits—habitat production foregone, measured in acres—that cannot be compared usefully to costs because it provides no information on the dollar value that society places on reducing impingement and entrainment losses. The proposal also calls for reporting various other measures, but provides no guidance as to how they can be used to compute a measure of benefits to see if the costs are “grossly disproportionate” to the benefits.

4. Summary of Site-Specific Recommendation

In summary, we recommend that the Draft Policy be modified to extend to all plants the right of plant owners to make a “grossly disproportionate” demonstration and that the owners be directed to submit quantified and monetized estimates wherever possible, following guidelines from EPA or state agencies. These assessments could include the possibilities of re-powering and retirement of the facility.

V. Preliminary Conclusions and Recommendations

This chapter provides a summary of our assessments of the costs and benefits of the Draft Policy and its application to a particular site. We also address some concerns with cost-benefit analysis. We end with a summary of conclusions and recommendations.

A. Preliminary Statewide Cost-Benefit Results

Table 21 summarizes the results of our preliminary statewide cost-benefit analysis. The Draft Policy calls for a phased implementation of closed-cycle cooling systems, with requirements differing for facilities with different technologies and different locations; compliance dates range from 2011 to 2022. As a result, the costs and benefits for different facilities will be experienced in different years. Table 21 shows present values in millions of 2009 dollars as of January 1, 2009 based upon a real discount rate of 7 percent.

The estimated present value of total costs across all affected power plants in California is approximately $3.12 billion, i.e., a total of about $3.12 billion would need to be set aside on January 1, 2009 to equal the discounted sum of all costs incurred in future years under the Draft Policy. The largest component is capital costs at about $1.5 billion, followed by energy penalty costs at $618 million and construction outage costs at $450 million. The estimated present value of total benefits across all affected power plants in California is about $34.2 million, i.e., the discounted sum of the benefits of the Draft Policy in future years would equal about $34.2 million. Entrainment gains account for about $26.7 million of the benefits and impingement gains account for the remaining $7.5 million in benefits.

As shown in Table 21, the estimated present value of net costs (i.e., costs minus benefits) of the Draft Policy across all affected power plants is approximately $3.09 billion. These results indicate that the costs society would incur to install cooling towers on all affected would exceed the benefits society would gain by a factor of 91.

Table 21. Preliminary statewide cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$1,503.6
Operating and Maintenance	$151.5
Construction Outage	$450.3
Energy Penalty	$617.7
Heat Rate Impact	$91.3
CO2 Emissions	$306.8
Total	$3,121.3
Benefits	
Impingement	$7.5
Entrainment	$26.7
Total	$34.2
Cost-Benefit Comparisons	
Net Costs	$3,087.2
Costs to Benefits Ratio	91

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Statewide analysis does not include the costs of cooling tower retrofit at Encina, Portrero, Redondo Beach, or South Bay because Tetra Tech (2008) does not provide cost estimates for these facilities, but the analysis does include the benefits of reduced cooling water intake at these facilities.
Source: NERA calculations as explained in text

Guidelines on regulatory policymaking from the DWR, EPA, and OMB indicate that policies are economically justified only if their total benefits exceed their total costs (or non-monetized effects are likely to cover any gap in monetized costs and benefits). The large net costs of the Draft Policy suggest that it would not make economic sense to use society's scarce economic resources to retrofit all relevant California power facilities with cooling towers. We determined that this conclusion would not change as a result of using different discount rates and taking into account unquantified factors.

A full cost-benefit analysis of the Draft Policy would include developing two additional assessments beyond the preliminary assessments provided in this report:

1. Expansion of technologies considered to include those other than closed-cycle wet cooling systems.

2. Assessments of the possible responses of facility owners to the Draft Policy requirements—including the possibility of premature closure or re-powering of certain facilities—and the implications for the statewide costs and benefits.

3. Assessments of the likely effects of the alternative compliance mechanisms on compliance at the various facilities and the implications for statewide costs and benefits.

4. Additional analyses of the implications of uncertainties in the cost and benefit estimates, including the possibilities of additional sensitivity analyses and Monte Carlo analyses.

B. Preliminary Site-Specific Cost-Benefit Results

The Draft Policy, as noted, would allow owners and operators of affected nuclear power plants and affected fossil fuel-fired power plants with a heat rate of 8,500 Btu/kWh or less to request alternative reduction targets from their Regional Water Board if they demonstrate that the costs of the Draft Policy for their power plants would be "wholly disproportionate" to the benefits. The Draft Policy does not provide specific guidelines on how the cost-benefit analysis should be performed, although it does indicate that costs should be measured in terms of cents per kWh and benefits should be measured in terms of "habitat production foregone," an estimate of habitat area production that is equivalent to the loss of all entrained species. As discussed in the report, these measures of costs and benefits are not consistent with state or federal guidelines and raise a number of conceptual and practical difficulties.

We performed a preliminary site-specific cost-benefit analysis of the Draft Policy for SONGS using the EPA's methodology for the Section 316(b) Phase II Rule. Table 22 summarizes our results. The estimated present value of costs arising from implementing the Draft Policy at SONGS is about $1.7 billion, and the estimated present value of benefits is about $12 million. Thus, the estimated costs from implementing the Draft Policy at SONGS would exceed the estimated benefits by a factor of 145.

This analysis assumes that cooling towers would be installed at SONGS to comply with the Draft Policy. Although additional study would be necessary to assess the costs and benefits of alternative compliance mechanisms, our preliminary analysis indicates that requiring installation of cooling towers at SONGS would not be economically justified. It would be important to expand the cost-benefit assessment for SONGS to include evaluations of the costs and benefits of other technologies that could reduce impingement and entrainment.

Table 22. Preliminary SONGS cost-benefit analysis: summary results

	Present Value
Costs	
Capital	$293.3
Operating and Maintenance	$12.5
Construction Outage	$776.6
Energy Penalty	$359.9
Heat Rate Impact	$0.0
CO2 Emissions	$299.0
Total	$1,741.4
Benefits	
Impingement	$3.6
Entrainment	$8.5
Total	$12.0
Cost-Benefit Comparisons	
Net Costs	$1,729.3
Costs to Benefits Ratio	145

Notes: All dollar values are in millions of 2009 dollars.
Present values are as of January 1, 2009 based on a real annual discount rate of 7 percent.
Source: NERA calculations as explained in text

C. Addressing Concerns with Cost-Benefit Assessments

In this section we address several broader potential concerns about applying cost-benefit analysis to regulating cooling water intakes at California generating units.

1. Incomplete benefit estimates

Perhaps the most common and important underlying concern regarding the use of cost-benefit analysis in environmental decisions is that benefit estimates inevitably will be incomplete, which may lead to a bias against concluding that a given technology (e.g., closed-cycle cooling) has benefits greater than costs. Indeed, the Environmental Report seems to echo this concern in its reporting of the EPA Phase II cost-benefit analysis.

> Notably, the Phase II cost-benefit analysis was limited to direct use benefits, i.e., commercially and recreationally important species for which reasonable market data was [sic] available. Because the analyzed species typically comprise less than two percent of the impinged and entrained organisms, the Phase II cost-benefit analysis did not monetize more than 98 percent of the impacted fish and shellfish. Environment Report, p. 80.

This characterization of benefits assessments is misleading. In the original EPA document, the 98 percent figure was calculated by dividing the number of adult fish that anglers would have landed by the total number age-1 adult equivalent fish lost to entrainment or impingement from facilities covered by the proposed Phase II rule for Section 316(b) (EPA 2004, Chapters A9 and C3). However, forage fish (which account for the bulk of the “other” 98 percent) are counted indirectly because their contribution to the mass of fish species valued directly is included through trophic transfer calculations, such as those we used in our assessments in Chapters III and IV. Thus, those forage fish are valued indirectly. Thus, it is not accurate to claim that benefit assessments ignore the vast majority of organisms affected by cooling water intake structures. Rather, the benefit assessments value these gains in terms of the appropriate criterion for benefits—the amount that households (in this case, commercial and recreational anglers) would be willing to pay for the increases in game fish catch made possible by the additional forage fish.

It is true that EPA's case studies of cost-benefit analyses did not quantify non-use benefits. Complete benefit estimates should include non-use benefits, but only where there is reason to believe that they are material, as noted above in Chapter II (and discussed in Chapters III and IV in the context of specific statewide and site-specific benefit estimates). There are unlikely to be material non-use benefits associated with reducing losses resulting from cooling water intakes unless the losses are so large as to endanger the continued survival of a specifies in a region. The information developed in our preliminary non-use assessments suggests that non-use benefits are not likely to be significant with regard to the Draft Policy.

Non-use benefits are an example of a more general issue. It is generally impossible to quantify all benefits (or costs). As we discussed in Chapter II, it is important to review excluded benefits and costs to see if they are likely to make a material difference in the results of the cost-benefit analysis. Guidelines from both OMB and EPA recommend such qualitative evaluation, which we performed in our analyses of plant-specific and state-wide costs and benefits.

2. Benefit-Cost Analysis and Consistency in State Policy

The Environmental Report emphasizes the importance of developing a coordinated policy, expressing concern that allowing all facilities to use a site-specific cost-benefit analysis would compromise coordination:

> Alternative 2 [allowing all facilities to use a cost-benefit test to determine appropriate requirements] would permit any OTC facility to use the wholly disproportionate test and request alternative performance standards. This alternative would likely encourage most facilities, if not all, to opt for this compliance strategy rather than following Track 1 or Track 2. The end result would be a BPT, case-by case permitting process that would return the full burden of implementing S316(b) to the Regional Water Boards and negate any benefits that a coordinated statewide policy would offer. Environment Report, p. 80.

The concern that site-specific determinations would compromise coordination appears to be based upon a presumption that "coordination" means requiring the same technology at virtually all facilities, regardless of costs or environmental benefits. An alternative view of "coordination" is that coordination means that all facilities are subject to the same set of cost-benefit criteria (rather than the same compliance requirements). The Draft Policy could coordinate policy by developing a common set of criteria and procedures to be applied.

A "one-size-fits-all" technology requirement seems particularly inappropriate for intake-structure requirements in California because of the enormous differences among facilities in terms of the costs and benefits of a given technology. The information presented in Chapter III indicates that the cost of retrofitting various facilities with closed cycle cooling varies enormously across the different facilities. Similarly, the reductions in entrainment and impingement differ greatly among the facilities, as does the implication of these reductions for benefits. A coordinated policy that applied consistent criteria across decisions would necessarily lead to selecting a range of technologies depending on the characteristics of the different plants and their local environments.

3. Resource Burden of Preparing Cost-Benefit Analyses

The Environment Document expresses concern that allowing a site-specific cost-benefit assessment for all the affected facilities would be too burdensome to the Regional Water Boards, as indicated in the quote above. The core of this objection—that preparing a cost-benefit analysis is overly costly and burdensome—is a common one. This concern is misplaced for several reasons.

1. *Much of the necessary data are likely to be available already*. Much of the information required to develop estimates of costs and benefits already exists as a result of the substantial efforts that have been made over the years. Indeed, as we showed in Chapters III and IV, it is possible to do rough cost-benefit analyses using information developed the Water Board for other purposes.

2. *Tailoring scope of analysis to the case in question.* The appropriate scope and detail of the analysis depends on the scale of the decision. For example, the level of effort devoted to analyzing a large plant should, all else equal, be substantially larger than the effort for a small plant because the scale of costs and benefits would be greater.

3. *Small costs relative to costs at stake.* The costs of doing even a comprehensive cost-benefit analysis are usually small relative to the cost of retrofitting a facility with closed-cycle cooling. The information presented in the Environmental Report puts the *annualized* cost of retrofit for the affected facilities at $586.6 million per year (p. 110). In comparison to these substantial costs, the incremental costs of site-specific cost-benefit analyses are likely to be very small.

In sum, resources to evaluate the costs and benefits of technology alternatives at individual facilities are likely to be resources well spent, avoiding spending large amounts to achieve small benefits. Over time, the resource requirements are likely to be reduced, as Regional Boards develop familiarity with the methodologies and their application. Indeed, the Draft Policy could hasten this process by providing guidance and examples of cost-benefit analysis (as we have done in a preliminary way in Chapter IV of this report).

D. Preliminary Conclusions and Recommendations

Our economic assessment of the Draft Policy leads us to offer several conclusions and recommendations.

1. Cost-benefit analysis is an important means of clarifying “what is at stake” in terms of key decisions regarding the Draft Policy. Concerns raised against cost-benefit analysis—that it is too incomplete, that it leads to inconsistent regional decisions or that it is overly burdensome to regions—are not legitimate reasons to deny its use in informing the Water Board.

2. Cost-benefit results indicate that requiring all California generation units with once-through cooling to retrofit with cooling towers does not pass a cost-benefit test; the net costs would be very large—on the order of several billion dollars on a present value basis, after accounting for the phasing of the requirement—and nearly 100 times estimated benefits.

3. The statewide cost-benefit assessment could be expanded in several respects. The cost-benefit analysis could include assessing the implications of potential responses of facility owners to the Draft Policy requirements—including the possibility of premature closure or re-powering of certain facilities—for the costs and benefits of the Draft Policy. The statewide cost-benefit assessment also could be expanded to include a wide range of potential alternatives to the Track 1 requirement, including different levels of potential control (which would translate into different likely technology choices at the various facilities).

4. The flexibility provisions in the Draft Policy should be retained and expanded. The policy should allow site-specific cost-benefit analyses for all power plants, including those with a heat rate above 8,500 Btu per kWh, to identify the most economically desirable means of reducing impingement and entrainment. The flexibility provided by phasing the policy in gradually to minimize disruptions to the state and regional electricity systems should be retained.

5. The policy should establish a clear methodology for performing site-specific cost-benefit analyses. The EPA methodology in the Phase II Rules—in conjunction with cost-benefit guidelines from EPA and OMB as well as the State—offers a good template for such a methodology. Our illustration suggests that much of the information needed to implement such a cost-benefit methodology for individual California facilities is already available.

References

Boardman, Anthony, David H. Greenberg, Aidan Vining, and David L. Weimer. 2001. *Cost-Benefit Analysis: Concepts and Practice*. 2nd ed. Upper Saddle River, NJ: Prentice Hall.

California Department of Water Resources ("DWR"). 2008. *Economic Analysis Guidebook*. Sacramento, CA: DWR, January.

California ISO ("CAISO"). 2008. *Impacts on Electric System Reliability from Restrictions on Once-Through Cooling in California*. Sacramento, CA: CAISO, November 25.

California State Water Board ("Water Board"). 2009. *Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling: Draft Substitute Environmental Document*. Sacramento, CA: Water Board, July.

ENERCON Services, Inc ("ENERCON"). 2009. *Feasibility Study for Installation of Cooling Towers at San Onofre Nuclear Generating Station*. Draft. Prepared for Southern California Edison Company. Kennesaw, GA: ENERCON, September 18.

Electric Power Research Institute ("EPRI"). 2007. *Assessment of Once-Through Cooling System Impacts to California Coastal Fish and Fisheries*. Palo Alto, CA: EPRI, December.

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

ICF Jones & Stokes, Global Energy Decisions, and Matt Trask ("ICF Jones & Stokes"). 2008. *Electricity Grid Reliability Impacts from Regulation of Once-Through Cooling in California*. Sacramento, CA: ICF Jones & Stokes, April.

Johnston, Robert J. et al. 2006. "What determines willingness to pay per fish? A meta-analysis of recreational fishing values." *Marine Resource Economics*. 21:1-32.

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

Office of Management and Budget ("OMB"). 2003. *Circular A-4 to the Heads of Executive Agencies and Establishments Regarding Regulatory Analysis*. Washington, DC: OMB, September 17.

Southern California Edison ("SCE"). 2008. *Comprehensive Demonstration Study for Southern California Edison's San Onofre Nuclear Generating Station*. Palo Alto, CA: SCE, January.

Southern California Edison ("SCE"). 2001. *Marine Mammal Protection Act: Small Take Permit Application*. San Clemente, CA: SCE, February 12.

Tetra Tech. 2008. *California's Coastal Power Plants: Alternative Cooling System Analysis*. Report prepared for the California Ocean Protection Council. Golden, CO: Tetra Tech, February.

U.S. Environmental Protection Agency ("EPA"). 2000. *Guidelines for Preparing Economic Analyses*. Washington, DC: EPA, September.

U.S. Environmental Protection Agency ("EPA"). 2004a. "National Pollution Discharge Elimination System-Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities; Final Rule." Washington, DC: EPA, July 9. (69 Federal Register 41576).

U.S. Environmental Protection Agency ("EPA"). 2004b. *Regional Analysis Document for the Final Section 316(b) Phase II Existing Facilities Rule*. Washington, DC: EPA, February.

Attachment A. Preliminary Air Emissions Cost Estimates

This attachment provides information on how we estimate the social costs of the increases in air emissions due to the closed-cycle cooling implementation. As described in the main report, three types of air emissions impacts would result from closed-cycle cooling installation:

1. Facility outages for cooling-tower retrofits require replacement power, which generates emissions;

2. On an ongoing basis, some affected facilities could increase their fuel (i.e., natural gas) consumption per unit of energy generated; and

3. On an ongoing basis, some affected facilities could reduce their net electrical output, leading to additional emissions from replacement power.

As described below, the marginal source of power (i.e., the power that would replace incremental output reductions) in California is typically natural gas-fired. The increases in fuel consumption at affected facilities would entirely involve natural gas. Thus, while emissions from replacement power could potentially include a variety of pollutants, including carbon dioxide ("CO_2"), nitrogen oxides ("NO_X"), sulfur dioxide ("SO_2"), carbon monoxide, and mercury, the major air emissions of interest to this analysis are the pollutants associated with natural gas: NO_X and CO_2.

Elevated ambient concentrations of fine particles formed from emissions of NO_X and other air pollutants have been linked in various studies to a wide range of health effects. We have not developed estimates of the increases in NO_X emissions that the closed-cycle implementation would cause. Incorporating the NO_X costs would increase the overall cost estimates; excluding NO_X costs is thus a "conservative" assumption.

We thus focus our air emissions cost estimation on increased emissions of CO_2. The following sections describe how we estimate the changes in CO_2 emissions (i.e., tons) due to the closed-cycle cooling implementation. We then explain how we value the social costs of these emissions increases.

A. Air Emissions Increases due to Construction Outages

The reductions in output due to the construction outages would require replacement power from the electric system's "marginal" generating source, typically the lowest-cost source that is available to provide additional generation. Identifying the precise generating units that would increase generation in response to the outages would require detailed electricity market modeling. However, natural gas is virtually always the marginal fuel in California (see, e.g., California Energy Commission 2005). We therefore assume that replacement power would come from natural gas-fired facilities.

The output reductions from the natural gas-fired facilities (assumed to occur only during the construction outages of Haynes and Moss Landing) could be replaced by output from higher-cost and less efficient gas facilities with higher emission rates, since generating units are typically dispatched in order of their cost. To the extent that this occurred, the outages at the natural gas facilities would lead to net increases in emissions. Because information is not available on the precise sources of replacement power, however, we conservatively assume that the replacement power is of equal efficiency to the lost power and thus there is no net increase in emissions.

For replacement power for the nuclear facility outages, we assume that the replacement generation source is a new combined-cycle generating unit (with a heat rate of 7,196 btu/KWh based on EIA's (2009a) current modeling assumptions). In practice, replacement natural gas power could come from less efficient generation, and thus this assumption understates actual emissions increases. We estimate replacement emissions by multiplying the amount of replacement power needed (Table 4) by the heat rate of the replacement facility and the CO_2 content of natural gas (117 pounds/mmbtu).

B. Carbon Dioxide Emission Increases due to Ongoing Heat Rate Impacts

We assume (based on the Tetra Tech 2008) that all of the natural gas facilities affected increase their fuel consumption in order to maintain the same level of net electrical output despite the increases in heat rates brought on by closed-cycle cooling. Table 7 above displays Tetra Tech's estimate of the annual increase in fuel usage.

We multiply the estimate of the increase in natural gas consumption by the carbon content of natural gas to determine the increase in CO_2 emissions.

C. Carbon Dioxide Emission Increases due to Ongoing Power Losses for Nuclear Units

Closed-cycle cooling would cause the two nuclear facilities to produce less electricity than they otherwise would. We use Tetra Tech's (2008) estimate of the net output loss at each nuclear facility in conjunction with the assumed combined-cycle marginal emissions rate described above to estimate the increase in CO_2 emissions due to the nuclear output loss.

D. Valuation of Increased Air Emissions

As noted above, closed-cycle cooling installation would lead to increased emissions of several different pollutants. Increases in NO_X emissions could be significant, though we do not have enough information to estimate the social costs of these emissions. Increases in sulfur dioxide, mercury, and other pollutants would likely be less significant; we also do not attempt to quantify these. This section explains how we estimate the social costs of increased emissions of CO_2.

1. Overview of Valuation Methodology

For emissions that are subject to a cap-and-trade program (or are expected to be subject to a cap-and-trade program), the market price of allowances provides the appropriate measure of social costs. Under a cap-and-trade program, an increase in emissions at a given facility or group of facilities would not lead to an overall increase in emissions from covered facilities because the cap would continue to be binding. Instead, other facilities would reduce emissions, and they would incur some costs to do so. The facilities undertaking emission reductions would be those facilities that could reduce emissions at a cost closest to the market allowance price for emissions. Facilities that could reduce emissions at a lower cost than the market price already would have done so, rather than paying the market price for those emissions; facilities that could only reduce emissions at a higher cost than the market price would prefer to pay the market price for those emissions. Thus, assuming an efficient market, the allowance price for emissions will equal the cost of reducing emissions by an additional small amount (i.e., the marginal cost of emission reductions).

2. Potential CO_2 Cap-and-Trade Legislation

Many observers expect the federal government to establish a cap-and-trade program for greenhouse gas ("GHG") emissions over the next several years. As a result, we estimate the social costs of CO_2 emissions using a forecasted allowance price for a potential federal cap-and-trade program.

There are, of course, uncertainties regarding any prediction of future legislation. Moreover, despite widespread agreement that a federal program will be established, there is much less agreement (and thus much greater uncertainty) about its specific elements. These design elements include the stringency of the program and the timing of required emissions reductions, scope of program coverage, free allocation of emission allowances, and rules regarding offset credits. To value the social costs of increased CO_2 emissions, we use the allowance price forecast from a recent EIA analysis of the Waxman-Markey bill (EIA 2009b). This forecast is provided in the middle column of Table A-1.

E. Overall Social Costs of Increases in CO2 Emissions

Table A-1 shows the expected total annual increases in CO_2 emissions due to the Draft Policy. It also displays the allowance price forecast used to value the social costs of the emissions and the resulting cost estimates.

Table A-1. Social costs of increased CO_2 emissions

	Emissions (1000 tons)	Cost ($/ton)	Total Costs ($m)
2015	0	$24.76	$0.0
2016	26	$26.00	$0.7
2017	26	$27.30	$0.7
2018	78	$28.66	$2.2
2019	78	$30.10	$2.3
2020	78	$31.60	$2.5
2021	4,365	$33.18	$144.8
2022	3,984	$34.84	$138.8
2023	907	$36.58	$33.2
2024	907	$38.41	$34.8
2025	907	$40.33	$36.6
2026	907	$42.35	$38.4
2027	907	$44.47	$40.3
2028	907	$46.69	$42.3
2029	907	$49.03	$44.5
2030	907	$51.48	$46.7
2031	907	$51.48	$46.7
2032	907	$51.48	$46.7
2033	907	$51.48	$46.7
2034	907	$51.48	$46.7
2035	907	$51.48	$46.7
2036	881	$51.48	$45.3
2037	881	$51.48	$45.3
2038	829	$51.48	$42.7
2039	829	$51.48	$42.7
2040	829	$51.48	$42.7
2041	790	$51.48	$40.7
2042	401	$51.48	$20.6
2043	0	$51.48	$0.0

Notes: All dollar values are in 2009 dollars.
Costs expressed in short tons.
Per-ton CO_2 cost uses 2030 value for subsequent years.
Source: EIA (2009b) and NERA calculations as explained in text

F. Attachment References

California Energy Commission. 2005. Planning for California's Future Transmission Grid: Review of Transmission System, Strategic Benefits, Planning Issues, and Policy Recommendations. CEC-500-2005-132. August.

U.S. Energy Information Administration ("EIA"). 2009a. *Assumptions to the Annual Energy Outlook 2009*. Washington, DC: EIA, March.

U.S. Energy Information Administration ("EIA"). 2009b. *Energy Market and Economic Impacts of H.R. 2454, the American Clean Energy and Security Act of 2009*. Washington, DC: EIA, August.

Attachment B: Preliminary Benefit Estimates

This attachment provides details on our data and methodology for estimating the potential benefits of reduced impingement and entrainment due to installation of closed-cycle cooling at SONGS. The Comprehensive Demonstration Study ("CDS") for SONGS (SCE 2008) gives data on baseline impingement and entrainment at the facility based on biweekly biological sampling between March 2006 and May 2007. We combined this biological data with information in the California case study for the EPA Section 316(b) Phase III Rule (EPA 2006) and economic information to estimate the value of increased yields to commercial and recreational fisheries. We estimated the statewide benefits using the SONGS benefits and scaling factors derived from the statewide impingement data above in Table 11 and entrainment data above in Table 12.

A. Species Categories

We identified species to model for our benefits assessment and then scaled up our benefit estimates to account for other species so that our benefits estimates would be comprehensive. The species we identified to model were those most commonly impinged and entrained at SONGS and those with available parameters to convert from raw biological information to age-1 adult equivalents and fishery yield impacts.

Table B-1 shows the ten species we modeled, along with their categories. Game species are defined as species of value to commercial and / or recreational anglers. Forage species are defined as species of no value to commercial or recreational anglers. As discussed further below, we estimated the increase in direct fishery yields for game species. We did not estimate the increase in direct fishery yields for forage species, because these species are not harvested to any significant degree by commercial or recreational anglers. Forage species provide indirect benefits to society, however, because they are consumed by predator species of value to commercial and / or recreational anglers. The calculation of indirect benefits accounts for trophic transfer (i.e., the fraction of biomass that is transferred from prey species to predator species). California halibut is the assumed predator species for this analysis. It is not impinged or entrained to any significant degree at SONGS, so it is not in the direct impingement and entrainment analysis.

Table B-1. Species categories

Species	Category
Queenfish	Game
Croakers	Game
Pacific electric ray	Game
Pacific sardine	Game
Sargo	Game
Anchovies	Game
Topsmelt	Game
Jacksmelt	Game
Blennies	Forage
Crabs	Game
California halibut	Predator

Notes: "Croakers" includes black croaker, spotfin croaker, white croaker, and yellowfin croaker.
"Anchovies" includes Northern anchovy, deepbody anchovy, slough anchovy, and generic anchovies.
"Blennies" includes rockpool blenny and mussel blenny.
"Crabs" includes brown rock crab, Cancer crab, flat porcelain crab, graceful crab, hairy rock crab, Northern kelp crab, sh
crab, striped shore crab, tubercular pear crab, and Xantus swimming crab.
Source: EPA (2006)

B. Baseline Impacts

1. Impingement Data

Table B-2 shows baseline impingement at SONGS. The ten modeled species collectively account for 92 percent of total impingement at SONGS by count and 82 percent by weight.

Table B-2. SONGS baseline impingement

Species	Count	Weight (lbs)
Queenfish	712,937	7,919
Croakers	19,071	7,527
Pacific electric ray	184	3,278
Pacific sardine	107,466	2,804
Sargo	2,087	985
Anchovies	428,121	1,224
Topsmelt	10,556	690
Jacksmelt	4,038	660
Blennies	2,850	24
Crabs	70,437	708
Other Species	113,269	5,742
Total	1,471,016	31,559

Note: Impingement data include losses due to heat treatments.
Source: SCE (2008), pp. 5-10 – 5-13

2. Entrainment Data

The CDS gives data on entrainment of eggs and larvae at SONGS in two locations: in the plant and offshore. The offshore sampling has larger entrainment counts for both eggs and larvae than the in-plant sampling. Because the larval entrainment data for SONGS in the Environmental Document shown above in Table 12 are from offshore sampling, we used the larval count from offshore sampling for the sake of consistency.

We based our egg entrainment analysis, however, on the in-plant sampling rather than the offshore sampling. A much larger percentage of eggs in the in-plant sampling were identified by species (47 percent) than in the offshore sample (14 percent), and so using the in-plant sampling gives us more accurate benefit values. We scaled up the egg entrainment data from the in-plant sampling to account for the larger number of eggs entrained in the offshore sampling, so as not to understate the benefits of reducing entrainment at SONGS.

Table B-3 presents the egg entrainment data from in-plant sampling, our scaled-up estimates of egg entrainment to account for the difference in total egg count between in-plant and offshore sampling, and the larval entrainment data from offshore sampling. The ten modeled species collectively account for 43 percent of egg entrainment and 78 percent of larval entrainment.

Table B-3. SONGS baseline entrainment

Species	Egg Count In-Plant	Egg Count Offshore	Larvae Count Offshore
Queenfish	-	-	154,626,272
Croakers	346,845,518	464,611,114	410,273,552
Pacific electric ray	-	-	-
Pacific sardine	3,074,004	4,117,731	2,166,884
Sargo	-	-	491,914
Anchovies	11,157,637,827	14,946,027,195	4,354,602,367
Topsmelt	126,018	168,805	-
Jacksmelt	123,482,424	165,408,816	1,907,731
Blennies	2,398,747	3,213,201	413,982,657
Crabs	-	-	22,194,515
Other Species	15,366,461,565	20,583,886,662	1,499,283,034
Total	27,000,026,103	36,167,433,525	6,859,528,926

Note: "-" denotes no entrainment; see text on scaling of in-plant egg count to estimate offshore egg count.
Source: SCE (2008), pp. 4-15, 4-23 – 4-24, and 4-26

3. Age-1 Adult Equivalents

The benefits assessment relies on estimates of age-1 adult equivalents impinged and entrained. For impingement, we used the number of impinged individuals in Table B-2 as estimates of the number of impinged age-1 adult equivalents. For entrainment, we used species-specific parameters in the California case study for the EPA Section 316(b) Phase III Rule (EPA 2006) to convert eggs and larvae into age-1 adult equivalents. Our estimates are shown in Table B-4.

Table B-4. SONGS baseline age-1 adult equivalents

Species	Impingement	Egg Entrainment	Larval Entrainment
Queenfish	712,937	-	103,753
Croakers	19,071	235,396	275,290
Pacific electric ray	184	-	-
Pacific sardine	107,466	7,396	21,355
Sargo	2,087	-	123
Anchovies	428,121	823,310	354,090
Topsmelt	10,556	051	-
Jacksmelt	4,038	49,877	849
Blennies	2,850	44,691	6,076,677
Crabs	70,437	-	1,492

Note: "-" denotes no entrainment.
Source: NERA calculations based on EPA (2006)

C. Increase in Fish Populations

We assume that installation of closed-cycle cooling at SONGS would reduce cooling water flow by 95 percent, and that impingement and entrainment would also decrease by 95 percent uniformly across species. Our estimation of increased fish populations involves multiplying the baseline losses of age-1 adult equivalents in Table B-4 by 95 percent.

Our estimation of increased fish populations also accounts for the lower-than-normal capacity factor at SONGS in 2006, when the biological sampling took place (Water Board 2009, p. 34, 50). We increased the baseline losses in age-1 adult equivalents in Table B-4 by 22 percent so that our estimates would reflect typical operating conditions at SONGS.

Table B-5 shows our estimates of additional age-1 adult equivalents from installing closed-cycle cooling at SONGS.

Table B-5. SONGS increase in age-1 adult equivalents

Species	Impingement	Egg Entrainment	Larval Entrainment
Queenfish	827,688	-	120,452
Croakers	22,141	273,285	319,599
Pacific electric ray	214	-	-
Pacific sardine	124,763	8,586	24,792
Sargo	2,423	-	142
Anchovies	497,030	955,826	411,083
Topsmelt	12,255	059	-
Jacksmelt	4,688	57,905	986
Blennies	3,309	51,885	7,054,754
Crabs	81,774	-	1,733

Note: "-" denotes no entrainment.
Source: NERA calculations based on EPA (2006)

D. Increase in Direct Fishery Yield

Direct fishery yield is the total weight of commercial and recreational harvests for each species. As noted above, only game species have direct fishery yield benefits, because only game species are harvested by commercial and / or recreational anglers. Forage species do not have direct fishery yield benefits, because they are not harvested by commercial or recreational anglers.

Table B-6 presents the estimated potential increase in direct fishery yield from installing closed-cycle cooling at SONGS.

Table B-6. SONGS increase in direct fishery yield (lbs)

Species	Impingement	Egg Entrainment	Larval Entrainment
Queenfish	48,240	-	8,195
Croakers	1,290	18,593	21,744
Pacific electric ray	53	-	-
Pacific sardine	64	1	2
Sargo	485	-	31
Anchovies	808	1,500	645
Topsmelt	289	6	-
Jacksmelt	111	5,602	95
Blennies	x	x	x
Crabs	821	-	-

Notes: "-" denotes no entrainment.
"x" denotes that the species is a forage species without commercial or recreational fishery.
Source: NERA calculations based on EPA (2006)

E. Increases in Indirect Fishery Yield

Installing closed-cycle cooling at SONGS would not only provide benefits to the commercial and recreational anglers who harvest the species impinged and entrained. It would also provide indirect benefits to the commercial and recreational anglers who harvest predator species that consume the species impinged and entrained at the facility. California halibut is the assumed predator species for this analysis.

Table B-7 shows estimated indirect fishery yield benefits from installing closed-cycle cooling at SONGS. These estimates derive from the increases in age-1 adult equivalents in Table B-5 and indirect fishery yield conversion factors from EPA (2006). EPA (2006) estimates indirect fishery yield benefits only for forage species, but we estimated it for all species (including game species) to be conservative.

Table B-7. SONGS increases in indirect fishery yield (lbs)

Effect	Yield (lbs)
Impingement	7,041
Entrainment	2,123
Total	9,164

Source: EPA (2006) and NERA calculations as explained in text.

F. Valuation of Increased Fishery Yield

1. Commercial and Recreational Shares

The increases in fishery yield would accrue to commercial and recreational anglers. We used Southern California data on the weights of commercial and recreational harvests to allocate the increases in fishery yield to commercial and recreational fisheries. Table B-8 presents the commercial and recreational shares for each species.

Table B-8. Commercial and recreational shares for SONGS modeled species

Species	Commercial	Recreational
Queenfish	0%	100%
Croakers	22%	78%
Pacific electric ray	100%	0%
Pacific sardine	100%	0%
Sargo	0%	100%
Anchovies	100%	0%
Topsmelt	0%	100%
Jacksmelt	1%	99%
Blennies	x	x
Crabs	100%	0%
California halibut	17%	83%

Notes: "x" denotes that the species is a forage fish without commercial or recreational fishery.
Sources: California Department of Fish and Game (2009) and Pacific States Marine Recreational Fisheries Monitoring (2009)

2. Commercial Fish Values

The marginal social benefit of an extra pound of fish caught commercially is the market price of that species minus the incremental costs of catching it. We assume that the potential increases in commercial harvest from reduced impingement and entrainment at SONGS are too small to affect market prices. To the extent that prices would be driven down by increased supply, our commercial benefit estimates are too high. We further assume that commercial anglers incur no incremental cost to harvest the additional fish from reduced impingement and entrainment at SONGS. We thus assume that the additional revenue to commercial fisheries measures the market use benefits of reduced impingement and entrainment at SONGS.

The relevant commercial price is the price at the dock (i.e., the ex-vessel price). As the fish move along the distribution chain to consumers, their value rises, but that rise in value reflects value added at those other stages, not the value of increasing the catch, and is offset by costs incurred at those stages (e.g., fuel and labor to transport the fish from dock to distributor to retail outlet).

Table B-9 shows the ex-vessel commercial values for each species.

Table B-9. Commercial values for SONGS modeled species

Species	$ / lb
Queenfish	$0.74
Croakers	$0.74
Pacific electric ray	$3.15
Pacific sardine	$0.05
Sargo	$0.69
Anchovies	$0.05
Topsmelt	-
Jacksmelt	$0.30
Blennies	x
Crabs	$1.29
California halibut	$5.68

Notes: All dollar values are in 2009 dollars.
"-" denotes that the species is a game species without commercial fishery.
"x" denotes that the species is a forage fish without commercial or recreational fishery.
Sources: California Department of Fish and Game (2009)

3. Recreational Fish Values

Fish caught recreationally do not have a market price. However, economists have developed techniques for estimating the value recreational anglers place on their catch based on "hedonic" methods that look at the tradeoffs that anglers make between going to sites with higher catches and the costs of getting to those sites (primarily travel costs, including the value people place on time lost to travel) (Freeman 2003). The travel costs themselves are not counted as benefits, as the value they represent to anglers is offset by the cost to the angler of the travel. However, using statistical techniques economists can estimate how much surplus anglers receive. There are two basic variants of inferring demand for increased catch (or changes in other characteristics of sites) from data on observed travel behavior. One is called the "Travel Cost Method" ("TCM") and the other is the "Random Utility Model" ("RUM") (Freeman 2003).

Rather than conduct original TCM or RUM studies, policy analyses usually use existing studies to estimate values that can be applied in similar conditions. This approach, called "benefits transfer," may employ one of several different methods, depending on the data and resources available. According to the USEPA *Guidelines*:

> [A]nalysts will [often] need to look for estimates available from existing sources, and apply these values to the policy case using benefit transfer techniques (USEPA 2000, p. 95).

Although USEPA endorses meta-analysis as the most desirable method of combining results from multiple studies (via a formal statistical analysis) for purposes of benefit transfer, such analyses can be difficult and time-consuming to conduct, in part because published studies often do not include some key information needed to conduct a meta-analysis. In such cases, the study either must be dropped or the additional information must be obtained from the study's author(s).

Here we adopt a simpler strategy that estimates benefits using results from several studies that have generated estimates for the relevant species and water body (the California coast). Johnston et al. (2006) provide a useful summary of estimates of the marginal value of catching an additional fish from 48 different studies. Many of these studies developed separate estimates for different species or groupings of species, yielding a total of more than 120 study-species pairs. Using information from the studies, supplemented with information obtained directly from the studies' authors where necessary, Johnston et al. converted all of the estimates to constant 2003 dollars per fish caught at the margin. These values represent the average willingness to pay of recreational anglers in the study to catch another fish, averaged across sites. We have converted these results to 2009 dollars.

Table B-10 summarizes the data we used on recreational fishing values. We reviewed marginal recreational values for California in Johnston et al. (2006). We converted these values per fish to values per pound using average fish weights calculated from landings data in RecFIN (2009). The values then represent what recreational anglers would be willing to pay per additional pound of fish caught. Since recreational anglers often release the fish they catch back into the water body, the values had to be adjusted again to represent what recreational anglers would be willing to pay per additional pound of fish caught and kept. RecFIN (2009) provides information on the number of fish caught to the number of fish kept.

Table B-10. Recreational values for SONGS modeled species

Species	$ / Fish	Caught / Kept	Avg Wt (lbs)	$ / lb
Queenfish	$0.53	1.48	0.12	$6.83
Croakers	$4.14	2.27	0.59	$15.98
Pacific electric ray	-	-	-	-
Pacific sardine	$0.53	2.19	0.11	$10.32
Sargo	$4.14	1.45	0.73	$8.25
Anchovies	$0.53	1.61	0.04	$22.10
Topsmelt	$4.47	2.42	0.34	$31.97
Jacksmelt	$4.47	1.98	0.35	$25.42
Blennies	x	x	x	x
Crabs	-	-	-	-
California halibut	$10.23	4.87	3.46	$14.38

Notes: All dollar values are in 2009 dollars.
"-" denotes that the species is a game species without recreational fishery.
"x" denotes that the species is a forage fish without commercial or recreational fishery.
Sources: Johnston et al. (2006) and Pacific States Marine Recreational Fisheries Monitoring (2009)

Table B-11 presents our preliminary estimates of the annual benefits of installing closed-cycle cooling at SONGS. We multiplied the increases in direct and indirect yield by commercial and recreational shares and commercial and recreational values per pound. We scaled up the benefits to account for other species than those identified in Table B-1. We used the estimated annual benefits in Table B-11 to calculate the present values of benefits shown in the main report.

Table B-11. Preliminary SONGS annual benefits

	Commercial	Recreational	Commercial + Recreational
Direct Fishery Yield			
Impingement			
Modeled Species	$1,532	$361,020	$362,552
Other Species	$341	$80,293	$80,634
Total	$1,872	$441,313	$443,186
Entrainment			
Modeled Species	$5,620	$607,842	$613,462
Other Species	$7,423	$640,910	$648,333
Total	$13,043	$1,248,752	$1,261,795
Impingement + Entrainment			
Modeled Species	$7,151	$968,862	$976,014
Other Species	$7,764	$721,203	$728,967
Total	$14,915	$1,690,065	$1,704,981
Indirect Fishery Yield			
Impingement			
Modeled Species	$6,658	$84,399	$91,056
Other Species	$1,481	$18,771	$20,252
Total	$8,138	$103,170	$111,308
Entrainment			
Modeled Species	$2,008	$25,450	$27,458
Other Species	$2,117	$26,835	$28,951
Total	$4,124	$52,285	$56,409
Impingement + Entrainment			
Modeled Species	$8,665	$109,849	$118,514
Other Species	$3,598	$45,605	$49,203
Total	$12,263	$155,454	$167,717
Direct + Indirect Fishery Yield			
Impingement			
Modeled Species	$8,189	$445,419	$453,608
Other Species	$1,821	$99,064	$100,886
Total	$10,011	$544,483	$554,494
Entrainment			
Modeled Species	$7,627	$633,292	$640,920
Other Species	$9,540	$667,744	$677,284
Total	$17,167	$1,301,037	$1,318,204
Impingement + Entrainment			
Modeled Species	$15,817	$1,078,711	$1,094,528
Other Species	$11,361	$766,809	$778,170
Total	$27,178	$1,845,520	$1,872,698

Note: All dollar values are in 2009 dollars.
Source: NERA calculations as explained in text

G. Potential for Non-Use Benefits Statewide

This section briefly assesses whether retrofitting California's coastal electric generating facilities with closed-cycle cooling is likely to lead to significant non-use benefits. The concept of non-use benefits and the criteria that EPA has developed to assess their likely significance are described in Chapter II of the report.

1. Threatened and Endangered Species

The Environmental Document (p. 34) notes that endangered fish species have been impinged at California's coastal power plants. However, the Environmental Document does not provide data on entrainment or impingement of threatened and endangered fish species at individual facilities or across the state. The Environmental Document (pp. 73-74) does provide data on impingements of two threatened species of sea turtle: Green Turtles and Loggerhead Turtles. Fifty Green Turtles and six Loggerhead Turtles were impinged across the state between 1982 and 2006. Not all these impinged sea turtles suffer mortality, however. Five of the fifty impinged Green Turtles were dead at the time of impingement, and the affected facilities have equipment and procedures in place to return sea turtles and other large organisms unharmed to the ocean when they are impinged alive.

The Environmental Document (pp. 73-74) also provides data on impingements of marine marines that are not threatened or endangered but are protected under the Marine Mammal Protection Act. As in the case of sea turtles, not all these impinged marine mammals suffer mortality. Many of them were dead at the time of impingement, and the affected facilities have equipment and procedures in place to return marine mammals and other large organisms unharmed to the ocean when they are impinged alive (SCE 2001). Moreover, the impingement numbers for these marine mammals are well below the thresholds for population impacts (NMFS 2008).

In light of the low impingement rates cited in the Environmental Document and the mitigation measures already in place to return large organisms unharmed to the ocean when they are impinged alive, our preliminary conclusion is that the first EPA criterion for assessing the significance of non-use benefits is not met.

2. Other Important Species

EPRI (2007) examines the impacts of once-through cooling at California's coastal electric generating facilities on the populations of various fish species. It concludes "there is no evidence from previous Section 316(b) studies or information presented in the Draft California Policy that OTC [once-through cooling] has caused, or is at present causing, significant adverse effects on California coastal fish populations" (EPRI 2007, p. 4-2). Switching to closed-cycle cooling therefore "may result in no measurable benefit to California fish populations" (EPRI 2007, p. 5-2). Thus, our preliminary conclusion is that the second EPA criterion for assessing the significance of non-use benefits is not met.

3. Ecosystem Maintenance

Following EPRI (2007), our preliminary conclusion is that cooling water intake at affected facilities does not pose substantial harm to the maintenance of community structure and function in their local water bodies, and thus the third EPA criterion for assessing the significance of non-use benefits is not met.

4. Non-use Summary

Our preliminary overall conclusion is that none of the three EPA criteria for assessing the significance of non-use benefits is met statewide, and thus any non-use benefits from reducing impingement and entrainment at affected facilities are likely not significant.

H. Potential for Non-Use Benefits at SONGS

Below we assess whether any of the three criteria holds for cooling water intake at SONGS.

1. Threatened and Endangered Species

The SONGS CDS indicated no impingement or entrainment of threatened and endangered fish species (SCE 2008). The Environmental Document (pp. 73-74) provides data on impingement of threatened sea turtles at SONGS as well as impingement of protected marine mammals, but as noted above, many of these large organisms were dead when they were impinged, and many of those that are alive when they are impinged are returned unharmed to the ocean (SCE 2001). Our preliminary conclusion is that the first EPA criterion for assessing the significance of non-use benefits is not met.

2. Other Important Species

Following EPRI (2007), our preliminary conclusion is that cooling water intake at SONGS does not pose substantial harm to other important species, and thus the second EPA criterion for assessing the significance of non-use benefits is not met.

3. Ecosystem Maintenance

Following EPRI (2007), our preliminary conclusion is that cooling water intake at SONGS does not pose substantial harm to the maintenance of community structure and function in their local water bodies, and thus the third EPA criterion for assessing the significance of non-use benefits is not met.

4. Non-use Summary

Our preliminary overall conclusion is that none of the three EPA criteria for assessing the significance of non-use benefits is met at SONGS, and thus any non-use benefits from reducing impingement and entrainment at SONGS are likely not significant.

I. Attachment References

California Department of Fish and Game ("CA DFG"). 2008. *California Commercial Landings for 2007*. Sacramento, CA: CA DFG, August 5.

California State Water Board ("Water Board"). 2009. *Water Quality Control Policy on the Use of Coastal and Estuarine Waters for Power Plant Cooling: Draft Substitute Environmental Document*. Sacramento, CA: Water Board, July.

Caretta et al. ("NMFS"). 2008. NOAA Technical Memorandum NMFS: U.S. Pacific Marine Mammal Stock Assessments 2008. La Jolla, CA: NMFS.

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

Johnston, Robert J. et al. 2006. "What determines willingness to pay per fish? A meta-analysis of recreational fishing values." *Marine Resource Economics*. 21:1-32.

Pacific States Recreational Fishery Information Network ("RecFIN"). 2009. Pacific States Marine Recreational Fisheries Monitoring. http://www.recfin.org/.

Southern California Edison ("SCE"). 2001. *San Onofre Nuclear Generating Station Small Take Exemption Permit Application*. San Clemente, CA: SCE, February 12.

Southern California Edison ("SCE"). 2008. *Comprehensive Demonstration Study for Southern California Edison's San Onofre Nuclear Generating Station*. Palo Alto, CA: SCE, January.

U.S. Environmental Protection Agency ("EPA"). 2000. *Guidelines for Preparing Economic Analyses*. Washington, DC: EPA, September.

U.S. Environmental Protection Agency ("EPA"). 2006. *Regional Benefits Assessment for the Proposed Section 316(b) Rule for Phase III Facilities*. Washington, DC: USEPA, November.

NERA
Economic Consulting

NERA Economic Consulting
200 Clarendon Street, 11th Floor
Boston, Massachusetts 02116
Tel: +1 617 927 4500
Fax: +1 617 927 4501
www.nera.com