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Report to the Chairman, Committee on Energy and Commerce, House of Representatives

September 1988

ELECTRIC POWER

Issues Concerning Expansion of the Pacific Northwest-Southwest Intertie

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GAO

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Resources, Community, and
Economic Development Division

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September 14, 1988

The Honorable John Dingell
Chairman, Committee on Energy
and Commerce
House of Representatives

Dear Mr. Chairman:

In accordance with your request, this report provides our evaluation of issues concerning Bonneville Power Administration's plans to expand the Pacific Northwest-Southwest Intertie.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution until 30 days from the date of this letter. At that time we will provide copies of the report to the Secretary of Energy; the Administrator, Bonneville Power Administration; and the Director, Office of Management and Budget. We will also make copies available to other interested parties upon request.

This work was done under the direction of Keith O. Fultz, Senior Associate Director. Other major contributors are listed in appendix V.

Sincerely yours,

J. Dexter Peach

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

The Bonneville Power Administration and about 30 California utilities are planning to expand the alternating current portion of the electric power transmission intertie between the Pacific Northwest and California at a cost of $883 million. As agreed with the Chairman, House Committee on Energy and Commerce, GAO reviewed (1) Bonneville's economic justification for the addition, (2) the relationship of Canadian power imports to the intertie expansion, and (3) the potential for impacts on salmon and steelhead trout.

Background

Bonneville markets power from 30 federal dams and generating facilities and builds, owns, and operates 14,000 miles of high voltage transmission lines. The existing intertie has 5,200 megawatts (MW) of capacity, and Bonneville owns about 80 percent of the Northwest segment. The direct current portion of the intertie is being expanded by 1,100 MW, and the proposed alternating current addition would add another 1,600 MW.

In 1980 and 1983 GAO concluded that expanding the intertie would be highly beneficial. Consumers in California, the Northwest, and Canada could benefit from the resulting increases in power sales. GAO recommended that the Department of Energy and Bonneville facilitate cost-effective additions.

The salmon and steelhead trout of the Columbia River, vital natural resources, were severely depleted by construction and operation of the dams that Bonneville relies on to provide power. There are concerns that power operations associated with the expanded intertie will increase fish mortality and thereby thwart efforts by Northwest utilities, federal and state agencies, and interest groups to double the migratory fish runs.

Results in Brief

Efforts to expand the intertie have involved years of study, debate, and negotiation over a variety of complex economic, institutional, engineering and environmental issues. Resolving those issues has been difficult because of the diverse interests and potential impacts involving parties from California, the Northwest, and the federal government.

Although Bonneville expects the overall net economic benefits of the proposed addition to California, the Northwest, and Canada to be substantial, further analysis is needed to clarify the relationship between the economic justification for Bonneville's investment in more than

800 MW of the proposed 1,600 MW addition and noneconomic considerations. A separate determination of the economic benefits of the two 800 MW increments is needed since the first increment can be added by Bonneville with relatively little investment to the existing transmission system, while the second increment will require a new line and related facilities. This information could be particularly useful in any Bonneville decision on possible nonfederal utility participation in financing the intertie addition.

The addition could make increased sales of Canadian power possible. Canada is deciding whether to increase further its efforts to export power.

While Bonneville estimated that losses of salmon and steelhead trout related to intertie expansion would be under 3 percent, it made its estimates with a controversial computer model. Bonneville's estimates may be made more credible if Bonneville obtains an independent review of the model.

Principal Findings

Further Economic Analysis Needed

Bonneville estimated that the net economic benefit of the addition through 2030 would be $661 million and that its share would be $199 million. However, it projected that it would incur losses over the first 4 years and that about 18 years would be needed to recover its $327-million investment in financing the addition in the Northwest.

GAO asked whether a smaller addition would be more cost-effective. According to Bonneville, only minor modifications to existing facilities are needed to provide 800 MW in the Northwest. This would require a small portion of its $327-million investment. The second 800 MW requires more construction and the bulk of its investment. Bonneville did not estimate whether this increment alone would yield net benefits to it. Some further analysis would be needed to develop this estimate.

Bonneville officials said they did not analyze the segments separately because California utilities proposed a 1,600 MW addition. They said that their analysis shows that 1,600 MW is justified economically and that 800 MW is not a practical option because California utilities are unlikely

to agree on how to share less than 1,600 MW. This possibility is supported by a 1983 GAO review that found disputes among California utilities over access to the existing intertie.

Also, the 1,600 MW addition is expected to reduce intertie reliability problems. These problems have caused 30 power outages on the West Coast over the past 15 years and would be reduced by building the addition in a right-of-way separate from the existing alternating current lines, according to the Western Area Power Administration.

While the 1,600 MW addition may result in net economic benefits, as Bonneville points out, and may increase reliability, GAO nevertheless believes that Bonneville should disclose whether its proposed investment in the second 800 MW increment in the Northwest is economically justified.

Several nonfederal utilities have proposed to participate and receive ownership rights in the Northwest addition, but Bonneville states that if participants are added, they should be limited to the increment requiring new construction. This is because Bonneville and two other utilities already own the existing facilities that would be modified to provide the first 800 MW increment. GAO believes that analyzing the segments separately might offer added perspective for deciding whether nonfederal utilities should participate in the addition.

Effect of Expansion on Canadian Imports

Canada has traditionally made sales to California over the intertie. Bonneville estimated that Canada could receive $161 million (24 percent) of the net benefits and could further benefit if it decides to increase exports. Canada was considering whether to increase power exports but had not made a decision as of June 1988.

Impacts on Salmon and Steelhead Trout

Bonneville estimated losses related to intertie expansion at less than 3 percent for as many as 42 varieties of salmon and steelhead trout. It also estimated the losses would be more than offset by survival increases ranging from 2 to 70 percent if previously planned protective facilities were installed. In July 1988 the Congress passed legislation directing the Corps of Engineers to construct these facilities.

Bonneville performed its analysis of fish losses with a computer model that was controversial among those most familiar with its use. Bonneville had not completed the documentation needed for reviewing the

model. Yet, the Office of Management and Budget has proposed as a governmentwide standard that such documentation should be available so that results can be duplicated by independent experts. Also, National Bureau of Standards and Environmental Protection Agency officials told GAO that to help establish the credibility of Bonneville's analysis, the model should have been documented and reviewed by experts prior to its use.

Bonneville officials said that their results are reasonable, that the model has been reviewed previously by regional officials, and that there was not time to document the model and obtain a separate expert review. Bonneville, however, is now documenting the model and considering a contract proposal by Washington State University to review the model and Bonneville's analysis. GAO believes that documentation is important so that Bonneville's results can be duplicated and reviewed. Furthermore, GAO concluded that Bonneville could enhance credibility and reduce the controversy by obtaining an independent expert review.

Recommendations

GAO recommends that Bonneville's Administrator clarify Bonneville's economic analysis by providing a break out of Bonneville's costs and the sources and extent of revenues it expects for each 800 MW increment of the addition. Doing the analysis for each increment by using the same regionwide net benefits approach that Bonneville employed in its original analysis would be useful. We expect this information on each increment could, for example, help clarify the relationship between the economic basis for Bonneville's investment and noneconomic considerations and may also contribute to the decision about how much capacity Bonneville would pay for. GAO also recommends that Bonneville obtain an independent expert review of its fish-related modeling techniques.

Agency Comments

GAO discussed the facts and conclusions in this report with responsible agency officials, but at the request of the Chairman, House Committee on Energy and Commerce, did not obtain official agency comments on the report.

Contents

Tables

Figures

Abbreviations

AC	alternating current
BC Hydro	British Columbia Hydro and Power Authority
DC	direct current
DOD	Department of Defense
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
GAO	General Accounting Office
kV	kilovolt
MW	megawatts
OMB	Office of Management and Budget

Introduction

Three high-voltage transmission lines connect the electric power systems of the Pacific Northwest and California and are referred to as the Pacific Northwest-Pacific Southwest Intertie. The intertie consists of a direct current (DC) line and two alternating current (AC) lines with a combined capacity of 5,200 megawatts (MW).[1] The intertie facilitates the sale of power between the two regions, including seasonal power exchanges, and has also been used to transmit Canadian power to California utilities.

In the Northwest the AC intertie lines and accompanying facilities are owned by the Department of Energy's Bonneville Power Administration and two investor-owned utilities. Bonneville also owns the Northwest portion of the DC line and accompanying facilities and operates the entire Northwest portion of the intertie. The Southwest's transmission lines and accompanying facilities are jointly owned by California public and private utilities and the Department of Energy's Western Area Power Administration. The California portions are operated by Pacific Gas and Electric, Southern California Edison, and the Los Angeles Department of Water and Power.

Bonneville supplies about 50 percent of the power used in the Northwest. This power is generated at 30 hydroelectric dams constructed and operated by the U.S. Army Corps of Engineers and the Department of the Interior's Bureau of Reclamation. Bonneville sells electric power to utilities and industries in the Northwest and power in excess of Northwest needs over the intertie to California utilities. Bonneville's Administrator is legally required to set power rates to produce enough revenue to cover the agency's costs, which include a federal investment debt of about $8 billion and obligations to third parties of about $6 billion.

Bonneville's sales over the intertie are an important part of its revenues. In 1985 and 1986, for example, California utilities provided about $600 million in revenues to Bonneville. During the 1980s, California's purchases generally accounted for about 15 to 20 percent of Bonneville's revenues. Bonneville's revenues have been in about the $2-billion to $3-billion range since 1983.

[1] The DC line, with a capacity of 2,000 MW, connects the northern Oregon and southern California areas. The two AC lines, with about 3,200 MW of capacity, connect the Northwest with central California.

Intertie Expansion Efforts

The power sales made possible by the intertie have saved California consumers billions of dollars by replacing power that would have been produced by higher-cost oil and gas generators in California with power produced at lower-cost Northwest and Canadian hydroelectric facilities. These sales have also produced substantial financial benefits for Bonneville, other Northwest utilities, and Canadian utilities. In 1980 and 1983 reports, we recommended that the intertie be expanded and stated that, among other things, an expanded intertie offered significant benefits because increased surplus energy generated by hydropower was available in the Northwest, which could further displace oil and gas consumption by California utilities (see chap. 2).[2]

Efforts to increase the capacity of the intertie are now underway to further the benefits that have been realized thus far. Bonneville, Southern California Edison, and the Los Angeles Department of Water and Power are increasing the capacity of the DC intertie by 1,100 MW. The expansion is expected to be completed during 1988.

Plans are also proceeding for modifying existing AC facilities and constructing a third AC transmission line, which, in total, would add 1,600 MW of transmission capacity. Bonneville, Portland General Electric Company, and Pacific Power and Light Company own the existing facilities that will be modified and added to, to complete the 1,600 MW Northwest segment. Concurrently, California utilities are planning to increase the capacity of the southwest segment of the intertie by constructing a 340-mile AC line between the Oregon/California border and the San Francisco Bay area.

The estimated present value cost of expanding the AC portion of the intertie is about $880 million, according to Bonneville's April 1988 Final Environmental Impact Statement (EIS).[3] The estimated costs of the Northwest segment of the expansion are $327 million,[4] which Bonneville has proposed to finance. About 30 of California's public- and investor-

[2]Oil Savings From Greater Intertie Capacity Between the Pacific Northwest and California (EMD-80-100, Sept. 24, 1980) and Expanding the Pacific Northwest/Southwest Intertie—Benefits and Impediments (GAO/RCED-84-38, Nov. 4, 1983).

[3]"Intertie Development and Use Final Environmental Impact Statement," U.S. Department of Energy, Bonneville Power Administration (Apr. 1988).

[4]This is Bonneville's estimate of total present value of the transmission facilities in 1987 dollars.

owned utilities are expected to share costs of $557 million for the southwest segment. The Western Area Power Administration is also a participant. Bonneville estimates that the AC expansion will become operational in 1991.

Expansion Is Controversial

Plans to expand the intertie have been controversial. The existing intertie was constructed in the 1960s after much controversy over who would fund its development and who would receive its benefits. With regard to the current AC intertie expansion plans, a number of broad concerns have been raised by groups who will be affected by the expansion as currently planned. These groups include investor-owned and publicly owned utilities in California and the Northwest, as well as their respective customers. The concerns have included questions about how the costs and benefits of the planned expansion are allocated among various affected groups; the availability of power to be transmitted; the environmental impacts, particularly in the Northwest, of increased power generation; and access to the intertie. In our 1983 report we stated that utilities were hesitant to expand the intertie because of uncertainties, such as the availability of Northwest power for sale to California over the longer term and how benefits from intertie transactions would be shared among California utilities.

One particular concern, expressed by members of the Congress regarding the expansion plans for the Northwest AC segment, focuses on whether other utilities should participate in financing the expansion, resulting in their obtaining some form of ownership rights with assured access to transmission capacity on the intertie. Current utility access to intertie capacity is determined through Bonneville's application of its intertie access policy. This arrangement is expected to continue should Bonneville finance and operate the expansion.

Objectives, Scope, and Methodology

At the request of the Chairman, House Committee on Energy and Commerce, we examined Bonneville's plans to expand the Northwest segment of the AC intertie. As agreed in discussions with his office, we focused our examination in three general areas:

- Bonneville's analysis of the net economic benefits of expanding the AC portion of the intertie and, in particular, the economic justification for its planned financing of the northern segment of the AC transmission facilities;

- the relationship of future Canadian power imports to the expansion of the intertie; and
- the potential impact on salmon and steelhead trout of the Columbia River basin from increased hydropower plant operations or from the construction of additional hydropower facilities to provide electricity for expanded intertie sales.

Preceding and during the course of our work, a number of Bonneville activities were underway that directly related to our examination and were included in our scope of work to the extent possible. Among these were the development and completion in April 1988 of Bonneville's final environmental impact assessment for the expansion of the intertie (a draft of Bonneville's assessment was published in 1986); finalization of Bonneville's long-term intertie access policy in May 1988, which will guide the allocation of intertie capacity ultimately under Bonneville's control among those utilities requesting access; and a Bonneville study of nonfederal utility participation in the Northwest AC transmission line addition, completed in March 1988, which had been requested by members of the Congress.

For our examination of Bonneville's economic analysis of expanding the AC portion of the intertie, we reviewed Bonneville's cost-benefit analyses prepared for its draft and final environmental impact statements on intertie development and use and Bonneville's study of nonfederal participation in the intertie. We discussed specific aspects of these analyses with Bonneville officials and with representatives of the California Public Utilities Commission; the California Energy Commission; the Western Area Power Administration; the Pacific Northwest Electric Power and Conservation Planning Council, Direct Service Industries (which represents large industrial purchasers of Bonneville's power); and G.H. Bowers, Inc., of Seattle, a private consulting firm. We also obtained information on the economic impact of the AC expansion on California utilities from the Transmission Agency of Northern California, which represents some California public utilities involved in the California portion of the AC expansion, and Energy Associates of Atlanta, Georgia, a firm that analyzed the economic benefits of the AC expansion for California utilities.

Our examination in the area of Canadian power imports and its relationship to the intertie was based on studies and documents obtained from Bonneville and interviews with officials of Bonneville and British Columbia Hydro and Power Authority, a Canadian provincially owned electric utility.

Concerning the potential impacts of intertie expansion on salmon and steelhead trout, we reviewed Bonneville's environmental analyses and public comments on its analyses and held discussions with utility representatives and officials of fish and wildlife agencies. To determine current practices and methods for analyzing such environmental issues, we interviewed officials and obtained information from the National Bureau of Standards, the Environmental Protection Agency (including various environmental research laboratories), and the Energy Information Administration of the Department of Energy. We also interviewed officials and obtained documents from three organizations involved in environmental analysis: the Holcomb Research Institute, Butler University, Indianapolis, Indiana; Pepper, Hamilton, and Scheetz, Washington, D.C.; and Research and Evaluation Associates, Inc., Chapel Hill, North Carolina. We also held discussions with the U.S. Army Corps of Engineers officials and reviewed documents concerning the Corps' efforts to install facilities to minimize the impact on fish of operating the Corps dams on the Columbia River.

With regard to the potential for additional small hydropower plant development, we reviewed Bonneville's assessment of this issue as reported in its study of nonfederal participation in intertie expansion, obtained assessments of small hydropower development potential from the Northwest Power Planning Council and the Federal Energy Regulatory Commission, and identified steps planned by Bonneville and the Council to limit the future environmental impact of small hydropower plant development and operation. (Our results on this subject are reported in app. I.)

To obtain more general information about the areas included in our review and efforts to develop and use the intertie, we also held discussions with and obtained documents from officials of the Western Area Power Administration; the Public Power Council, an organization representing public utilities in the Northwest; the Pacific Northwest Utilities Conference Committee; Puget Sound Power and Light Company, a Northwest investor-owned utility; the Natural Resources Defense Council, the National Wildlife Federation; and the Northwest Conservation Act Coalition.

Our work was conducted between November 1987 and June 1988 in accordance with generally accepted government auditing standards. We discussed our findings with Bonneville officials and have included their views where appropriate. As requested, we did not obtain official agency comments on a draft of this report.

Further Analysis Would Clarify Bonneville's Economic Basis for AC Intertie Expansion

Utilities, power consumers, and concerned governmental agencies of the Pacific Northwest and Southwest and Canada are interested in the extent of net benefits[1] that could result from the proposed third AC transmission line and how those net benefits will be shared. Consumers in each area can expect lower electricity prices made possible by intertie sales. How these benefits are distributed is directly related to who owns the intertie and how its use is controlled. Bonneville assumed in the economic analysis for its environmental impact statement that it would finance the third AC intertie addition in the Northwest and control other utilities' use of, or access to, that portion. California utilities have already agreed on how they will share ownership and finance the proposed addition in that state.

Bonneville estimated the overall costs of the addition to be $883 million and the net benefits to range from a loss of $803 million to a gain of $5.6 billion for California, the Northwest, and Canada, with base case net benefits estimated as a gain of $661 million.[2] We found that Bonneville's net benefit estimates are sensitive to changes in California's forecasts of its electricity requirements—and that these forecasts have been changing in recent years. Further, we found that although Bonneville did estimate net benefits for a variety of situations that might occur, it did not estimate a most likely value for net benefits. We concluded that further analysis of the variability in the California market and the development of a most likely net benefits value would serve to clarify and add credibility to Bonneville's economic analysis. In response to our questions, Bonneville initiated work to address these matters.

Bonneville estimated that its costs for the 1,600 MW addition would be $327 million and that its share of net benefits would be $199 million. While the proposed addition is designed to provide 1,600 MW, it appears that the first 800 MW of capacity in the Northwest could be added for a relatively small portion of the costs needed for 1,600 MW. The net benefits of the second 800 MW increment have not been estimated separately, and we believe it is unclear whether the net benefits of this increment to Bonneville would be positive. An incremental analysis of the benefits to Bonneville would be beneficial because it would help clarify the relationship between the economic basis for Bonneville's investment and noneconomic considerations. This information may also be useful in

[1]Net benefits equal total benefits minus total costs. Specifically, in Bonneville's analysis this was measured as the savings from displacing high-cost power in California with cheaper power from the Northwest and Canada.

[2]All dollar figures in this chapter are net present values unless noted otherwise.

deciding whether to accept proposals by other Northwest utilities to participate and share in the costs of the addition in the Northwest.

GAO Has Supported Cost-Effective Intertie Expansion

In 1980, we analyzed three intertie addition alternatives and found that two of the three were justified. The additions we analyzed included a 360 MW DC upgrade, a 1,500 MW AC addition, and a 2,200 MW DC addition. Our economic analysis found strong support for the first two alternatives, which would have added 1,860 MW to what was a 4,100 MW intertie at that time. We made recommendations to the Secretary of Energy directed at facilitating these alternatives. We also recommended further study of the 2,200 MW DC addition because changes were taking place in the Southwest and Northwest that also could have made that line beneficial.

In our 1983 follow-up review, we concluded that the benefits we found in 1980 had greatly increased because additional energy over and above the Northwest's needs was available to be marketed to California. Although no agreements had been reached for constructing additional intertie capacity, the existing DC line was being upgraded by 400 MW. Bonneville had also initiated studies and met with interested California utilities concerning other intertie expansion alternatives. The alternatives receiving the most consideration were to upgrade the two existing AC lines by 400 MW and possibly by another 800 MW, build a third AC line of 1,500 MW to 1,800 MW, and build a second DC line.

While utilities in the Northwest and California agreed that a major addition would be beneficial, problems were hampering individual utility decisions to proceed with development. These problems included uncertainty over the quantity and cost of surplus power available in the Northwest, legal restrictions on Bonneville's sales of power outside the Northwest that were designed to protect Bonneville's regional customers, and disagreements between California municipal and investor-owned utilities about how access to the intertie by individual utilities would affect their shares of the benefits from expansion. We recommended that the Secretary of Energy and the Administrator of Bonneville take steps to facilitate the development of the most cost-effective intertie addition or additions.

Since our 1983 report, additions have been completed providing 3,200 MW of AC capacity and 2,200 MW of DC capacity for a total of 5,200 MW. Now an 1,100 MW expansion of the DC line is under construction, and the 1,600 MW AC addition is under consideration. In April 1987 Bonneville

began constructing the DC intertie expansion, which it expects to complete during 1988. Bonneville estimated the costs of the DC expansion to be $376 million and the base case net benefits of this project to be about $1 billion dollars through the year 2030.[3] Bonneville's analysis of the proposed AC intertie addition is the focus of this chapter.

The proposed 1,600 MW AC addition is composed of two parts—a California portion and a Northwest portion. The California portion is also composed of two parts:

- The California-Oregon Transmission Project would provide a third 500 kilovolt (kV) AC transmission path between southern Oregon and central California. The addition would occupy a right-of-way separate from the right-of-way that contains the two existing AC intertie lines. The addition would be composed of 170 miles of existing transmission line upgraded from 230 kV to 500 kV and approximately 170 miles of new 500 kV line constructed in California and 8 miles constructed in Oregon. This project is proposed by a consortium of most California utilities.
- The Los Banos-Gates Transmission Project would provide an 84-mile, 500 kV transmission path in California's San Joaquin Valley. This project is proposed by the Pacific Gas and Electric Company.

The Northwest portion of the addition is composed of modifications and additions to existing facilities owned by Bonneville, Pacific Power and Light, and Portland General Electric that would provide up to 800 MW of capacity. The second 800 MW of capacity would be provided by further modifications to existing facilities and construction of a new 500 kV transmission line in Oregon.

Further Evaluation of California's Electricity Forecasts Is Underway

The electricity requirements of California are a key factor in Bonneville's economic analysis of the third AC intertie. In general, the greater the demand by California for Northwest electricity, the greater the potential sales over the intertie and benefits to those involved. This intertie is expected to make significant net benefits possible by allowing

[3]At the direction of the Ninth Circuit Court of Appeals, Bonneville addressed this project in its April 1988 EIS.

the Northwest and Canada to transmit more nonfirm energy[4] produced at their hydroelectric plants to California than is now possible. In California, this power can displace more expensive power produced within the state by oil- and gas-fired generation plants. This intertie addition would also allow more energy to be sold during the daytime peak demand hours, when it is most valuable.

In Bonneville's draft EIS of October 1986, Bonneville estimated that the expanded intertie would produce a loss of $234 million through 2030. Subsequently, in its final EIS of April 1988, Bonneville estimated that the intertie would result in net benefits of about $661 million through 2030. More than 60 percent of the $900-million shift in Bonneville's net benefit estimate was due to a change in California's forecast of its electricity requirements.[5] Figure 2.1 shows the differences in the California load[6] forecasts that Bonneville used in its two estimates. Figure 2.2 illustrates the resulting nonfirm energy sales, which were projected to be made over the expanded intertie in the draft and final EISs.

Bonneville's Senior Assistant Administrator for Power Management explained that an important difference between the two forecasts resulted from a change in rates that Bonneville planned to charge California for power. He said the earlier forecast projected lower demand for Northwest power because of Californians' concern about what they perceived as relatively high prices for Bonneville's power. To address the concern, Bonneville developed a rate cap to limit the price California could be charged. As a result, he said, California considered this rate change, which caused California's subsequent forecast of an increased demand for Northwest power.

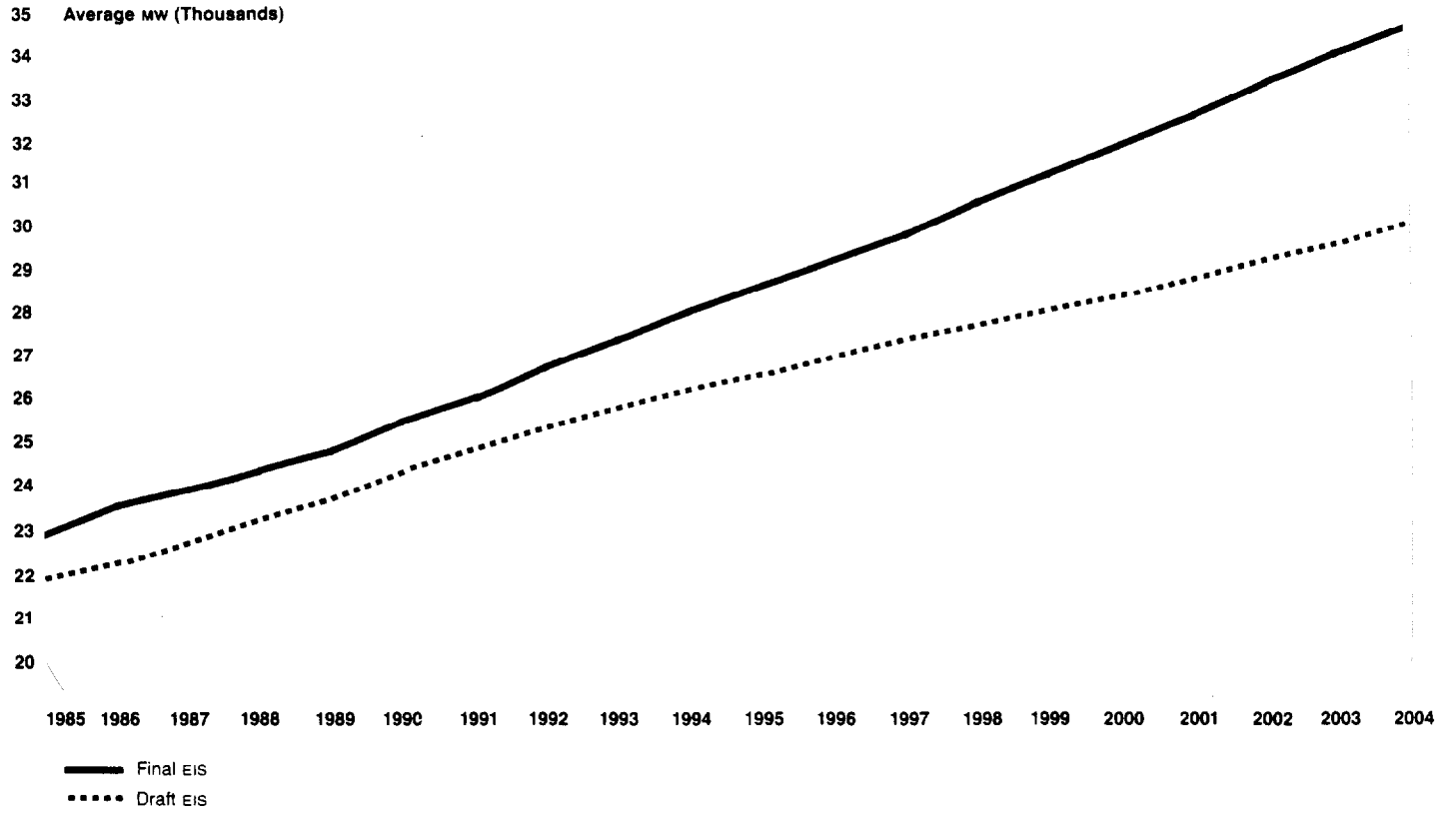
Bonneville efforts to account for variances in California's forecasts were not based on a historical analysis. Bonneville examined two alternative scenarios, of plus or minus 4,000 MW, to determine the net benefits that

[4]Because of the variability of the amount of water in any given year, the Pacific Northwest plans and builds power plants on a critical-water planning basis, which assumes that the hydroelectric system will produce no more energy than it did during the worst drought on record. The amount of energy generated under the critical water criterion is called "firm energy," which is continuously available on a guaranteed basis. When water flows are greater than critical, as they usually are, "nonfirm" energy is available. Nonfirm energy is not continuously available under guaranteed arrangements. Nonfirm energy that becomes surplus to the Northwest is available for export over the intertie.

[5]Other changes included revisions in the rates to be charged for electricity to reflect current Bonneville practice and increased energy sales resulting from changes in existing hydroelectric facility operations as well as more intertie electricity sold during peak demand periods in California.

[6]Load is a measure of required electricity.

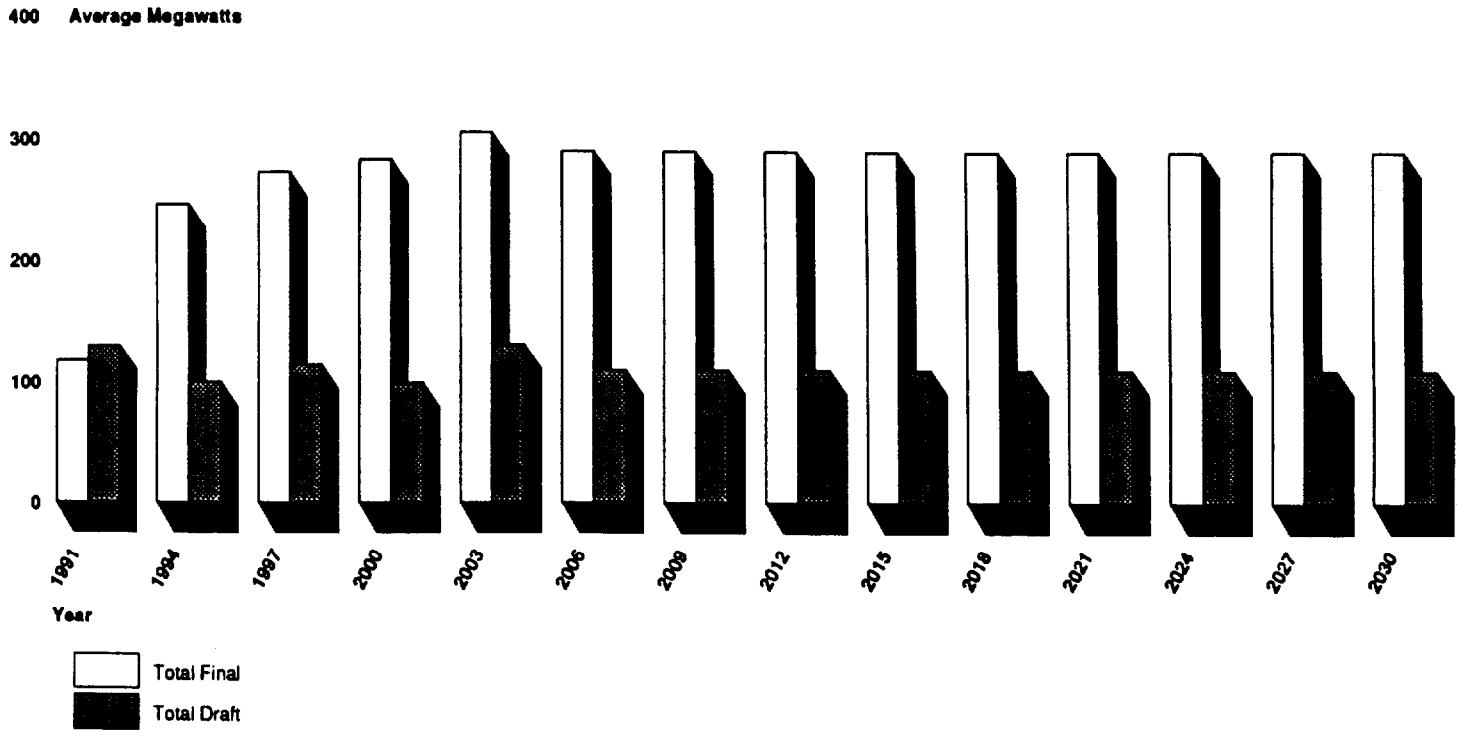
Figure 2.1: California Market Estimates Used by Bonneville Power Administration



might result if California's future loads varied from the forecast used in the final EIS. It did not base these two scenarios on an in-depth analysis to determine the most appropriate alternative scenarios. These scenarios provided net benefits of $824 million and $95 million, respectively.

We found some information that supports and some information that raises questions concerning Bonneville's choice of California load scenarios. In support of Bonneville's choice, the Northwest Power Planning Council recently concluded that Bonneville's minus 4,000 MW scenario roughly approximated a 1986 forecast of California loads prepared by the California Energy Commission. In addition, Bonneville officials have told us that more recent California Utility Commission load forecasts (1987) are higher than the load forecast Bonneville used in its final EIS. In another study, however, Energy Management Associates estimated

Figure 2.2: Nonfirm Energy in Final Versus Draft EIS



low, medium, and high California load forecasts to the year 2004.[7] Extending these Energy Management Associates forecasts to the year 2030 (the time period covered by Bonneville's analysis) showed a wider range of estimated California loads than Bonneville's plus or minus 4,000 MW range, i.e., loads averaging over 6,200 MW higher and 10,200 MW lower than Energy Management Associates' medium forecast.

Given the sensitivity of intertie net benefit results to California load forecasts and the change in estimates that occurred in an 18-month period, we questioned Bonneville officials about the need for further analysis of California load forecasts. Bonneville's Chief of Power Forecasting said he had considered evaluating historical changes in projections of California loads, reasons for these changes, and the accuracy of

[7]Energy Management Associates made these forecasts in a 1987 intertie study for the Transmission Agency of Northern California, prepared for the southern end of the intertie addition. Energy Management Associates' medium forecast was similar to that adopted by the California Energy Commission in 1986.

those forecasts that had been made, but questioned whether such an effort would improve Bonneville's treatment of uncertainty in the forecasts. The Chief also expressed his view that it would be very difficult to perform such an analysis.

According to Bonnevilie's Senior Assistant Administrator for Power Management, questions about the California load forecast are important. However, he also expressed serious doubts that Bonneville could reduce the uncertainty associated with California load forecasts through validation efforts. He said that while one could reasonably question Bonneville's plus or minus 4,000 MW scenarios, he does not expect that further examination of California loads will yield any different overall results. However, at our suggestion, Bonneville is now evaluating California load forecasts to better identify a range that reflects historical and likely variability in California load requirements.

A Most Likely Value for Net Benefits Is Being Identified

In its assessment of the net benefits of intertie expansion, Bonneville included analyses showing how changing the values of selected variables affected the overall results. For a small number of selected variables, Bonneville estimated the probabilities that specific values associated with these variables would occur and, using these probabilities, computed an expected value that was based on this small number of variables. Our work showed, however, that Bonneville did not estimate a most likely value (or, expected value) that was based on all sensitivity variables in this analysis.[8] The Senior Assistant Administrator for Power Management said that such an expected value is important and that this estimate is being developed.[9]

An important part of Bonneville's approach to analyzing the uncertainty of intertie net benefits involved assessing how changing the value of one variable at a time from its base case could affect the net benefits. Table 2.1 shows the results of this sensitivity analysis. As shown by examples in the table, Bonneville estimated regionwide net benefits ranging from −$388 million to almost $2.8 billion, depending on values assumed for selected variables.

[8]Estimated net benefits can take different values. The expected (or, most likely) value of net benefits equals a weighted average of these values, where the weights equal probabilities of these values.

[9]An expected value can control for the effects of uncertainty. By incorporating probabilities of different values occurring, such an estimate allows for an overall summary of these effects.

Table 2.1: Sensitivity Analysis of Net Benefits Through 2030

Dollars in millions

Assumption	Regionwide	Bonneville
Base case	$661	$199
California low gas prices	−388	−64
California high gas prices	1,963	847
California low load (-4,000 MW)	95	42
California high load (+4,000 MW)	824	418
Northwest low load	2,766	1,289
Northwest high load	−98	−76

Although Bonneville did not compute an expected value that was based on all of the sensitivity variables, it did control for uncertainty stemming from some of the variables it examined. For example, Bonneville computed expected values that were based on water uncertainty as a way to control for uncertainty in predicting future water conditions. It also assigned probabilities of occurrence to different California natural gas price and Northwest load scenarios to control for uncertainty in those variables. Table 2.2 shows these results.[10]

Table 2.2: Intertie Net Benefits Based on Different Natural Gas Prices and Northwest Load Scenarios

Dollars in millions

		Gas prices		
Northwest load		High (25-percent chance)	Medium (50-percent chance)	Low (25-percent chance)
High (25-percent chance)	Region	$1,179	$−98	$−803
	Bonneville	60	−76	−256
Medium (50-percent chance)	Region	1,963	661	−388
	Bonneville	847	199	−64
Low (25-percent chance)	Region	5,591	2,766	530
	Bonneville	3,100	1,289	559
Expected value (over Northwest load and gas prices)	**Region**	**$1,102**		
	Bonneville	**516**		

Note: Probabilities are in parentheses. Also, "region" refers to California, the Northwest, and Canada.

We noted, however, that Bonneville did not consider other likely scenarios that could affect the expected value of net benefits. For example, the Chief of Power Forecasting stated that load growth in the Northwest and California tends to be positively correlated. We subsequently found historical data on power consumption for the Northwest and California

[10]Bonneville assumed that the probability of a particular Northwest load occurring is unaffected by gas prices forecasted and vice versa. As explained later, this is not a realistic assumption.

that appeared to be positively related. Further, Bonneville data we reviewed indicated a positive relationship between natural gas prices and load growth. The Northwest Power Planning Council incorporated this relationship in its Northwest load forecasts. Similarly, DRI, a commercial forecasting company, projected higher forecasted demand for electricity in its high oil forecast and lower forecasted demand in its low oil forecast. (Tables 2.1 and 2.2 show the effects of changing gas prices on supply or cost of generating electricity in California, which, in turn, affect intertie demand and net benefits.)

According to Bonneville officials, although these scenarios are reasonable ones to consider, analyzing them could be expected to produce results within the range of cases that they had already considered. Nevertheless, we believe that including these combined events and their probabilities in the analysis would provide a more complete measure of expected value and would add credibility to Bonneville's analysis.

Because of the sensitivity of intertie net benefits to certain key variables and the range of plausible values that can be assigned to these variables, we discussed with Bonneville officials the importance of calculating an overall expected net benefit value for intertie expansion. Bonneville noted that the $661 million base case estimate was not an expected value based on all the variables in its analysis. The Senior Assistant Administrator for Power Management agreed that such an expected value was important, and Bonneville now is developing this estimate.

We also identified several other factors that appeared to be of some potential significance, but which would be difficult to quantify. (These are discussed in app. II.) In addition to the economic net benefits, Bonneville officials said other benefits would occur. For example, they said that the California utility agreements to share this intertie addition addressed long-standing disputes among California's investor-owned and publicly owned utilities about access limitations imposed by the intertie's California owners. Bonneville officials also said this addition would add to the reliability of the regional power system.

Bonneville officials also pointed out that a recent economic analysis of the intertie by the Northwest Power Planning Council was supportive of investment in the additional AC intertie.[11] The Council staff analysis was limited and focused on Northwest net benefits. The study concluded that

[11] Economic Analysis of the Proposed Intertie Expansion, Northwest Power Planning Council (May 17, 1988).

the 1,600 MW expansion could yield net benefits to the Northwest about $100 million greater than Bonneville estimated. (Bonneville's base case estimate was that the net benefits to the Northwest would be $307 million.) However, the study did not estimate the corresponding changes in net benefits to California and Canada.

Evaluating the Northwest Addition Incrementally Would Be Useful

We reviewed the potential for viewing the intertie addition incrementally as a basis for ensuring the cost-effectiveness of the proposal. Our 1980 report had reviewed intertie options incrementally, and our 1983 report identified an 800 MW AC upgrade as a possible alternative. We found that the construction of an 800 MW addition in California would be affected by reliability and institutional considerations. But we did find indications that an incremental review of Bonneville's investment in the Northwest portion of the project could be beneficial.

California

We found that an 800 MW addition was not considered for California in Western's EIS or two prior studies conducted by interested parties.[12] An 800 MW addition would be possible from an engineering perspective by upgrading or rebuilding the intertie in the existing AC intertie right-of-way or by reducing the proposed size of the transmission line in a separate corridor. We identified concerns related to reliability and institutional feasibility with these options.

The proposed 500 kV additions in California will provide for significant improvements in the reliability of intertie operations in addition to 1,600 MW of capacity, according to documents we reviewed. The current transmission system approaches the limits of reliable operation with the large power flows over the intertie in recent years. Since the existing two AC intertie lines occupy the same right-of-way, the likelihood of their simultaneous failure is greater than for lines following separate routes. During the past 15 years, the existing AC intertie has gone out of service 30 times, and on some occasions this has caused widespread power outages in California, Nevada, Oregon, and as far as Texas. On one occasion, over 5 million customers lost power, and on another occasion about 2.4 million lost power due to intertie-related disruptions, according to the Western Area Power Administration's EIS. Adding transmission capacity

[12]Final Environmental Impact Statement for the California-Oregon Transmission Project and the Los Banos-Gates Transmission Project, Western Area Power Administration and Transmission Agency of Northern California (Jan. 1988); Central Valley Project Transmission Upgrade Study, Western Area Power Administration (Mar. 1984); and The California-Oregon Transmission Project: Preferred Route Plan of Service and Power Systems Studies, Power Systems Studies Committee (Mar. 1987).

in a separate right-of-way significantly improves intertie reliability and is highly desirable, according to Western's EIS.

Upgrading the capacity of the existing AC intertie by 800 MW is comparable to the 1,600 MW AC alternative evaluated by Western in its EIS in that both would be upgrades of the AC intertie in the existing right-of-way. Our 1983 report stated that reliability was a concern in deciding whether to upgrade the existing system by 800 MW. In its November 1986 draft EIS, Western found that upgrading by 1,600 MW in the existing right-of-way would not meet the electric power industry's reliability criteria because of the increased potential for large blackouts. According to Western Area Power Administration's Deputy Manager in Sacramento, California, an 800 MW upgrade in the existing right-of-way would be unacceptable for the same reason, particularly with the 1,100 MW capacity of the DC expansion project added to the transmission system.

In 1983, we also reported that a disadvantage to upgrading the existing AC lines is that the existing AC intertie is hampered by "loop flow." Sometimes when power is scheduled to flow from the Northwest to California on the AC intertie, some of the power will not flow on the intertie, but rather will follow a circuitous path through other inland transmission lines in reaching California. In addition, sometimes when power is scheduled from the Rocky Mountain area over inland transmission lines, some of the power will not flow on the inland path, but rather will follow a path over the AC intertie in reaching its destination. This loop flow results from the interconnected operation of the western transmission system, and it reduces the effective carrying capacity of transmission lines. The systems that carry increased electricity on their lines and experience a loop flow problem may suffer from higher transmission losses, possible degradation of system reliability, and reduced capability to schedule power to or from other systems.

We also discussed an 800 MW alternative with Bonneville Power Administration officials, and they questioned the institutional feasibility of this alternative in California. Bonneville's Senior Assistant Administrator for Power Resources said that the 1,600 MW proposal originated with California utilities and that the amount provided was needed for California utilities to reach agreements on sharing additional intertie capacity. He expressed concern that a smaller intertie may not be a viable option; he could foresee no immediate way for agreements to be reached among California utilities to share a smaller intertie addition. Bonneville

also reported in its study of nonfederal participation that Southern California Edison Company, which would own about 20 percent of the California-Oregon Transmission Project, stated its view that either 1,600 MW will be constructed or there will be no increase in AC intertie capacity.

In 1983 we reported that issues between California's public and private utilities concerning access to the intertie and Northwest power have created considerable controversy and legal disputes. Public utilities have claimed that, through intertie agreements, private utilities have entered into anticompetitive practices that restrict access to Northwest power. We stated that these controversies hampered decisions on expansion and made intertie expansion uncertain. Bonneville's Senior Assistant Administrator stated that the agreement between California's public and private utilities to share this intertie addresses this issue.

Northwest

Bonneville evaluated the impact of the transmission system reinforcements and additions needed to match the 1,600 MW AC California proposal and did not evaluate AC alternatives of other sizes. The proposed 1,600 MW intertie addition in the Northwest can be viewed in two increments of about 800 MW each. The first 800 MW increment requires minor modifications to existing intertie facilities owned by Bonneville, Portland General Electric, and Pacific Power and Light, according to Bonneville's study of nonfederal utility participation. The study also states that the second 800 MW increment in the Northwest requires further modifications and construction of a new transmission line and related facilities.

Bonneville officials said they would need an engineering estimate to precisely identify the cost and amount of transmission capacity that facility modifications would make possible. The capacity amount could be somewhat less than 800 MW and perhaps as little as 500 MW, according to Bonneville's Director of Resource Planning. (We refer to 800 MW as the capacity of each segment since Bonneville's participation study identifies this amount.)

Though the net benefits of each increment had not been estimated separately, Bonneville officials indicated in our interviews that the cost of the first increment in the Northwest would likely be a small portion of the total cost. Bonneville's study states that the cost to provide the second 800 MW increment of capacity is about $267 million. Pudget Sound Power and Light commented that these costs appear inflated and include facilities not actually needed for the transmission capacity for

California imports. Bonneville responded that the price it proposed for nonfederal utility participation ($330 per kilovolt, based on costs of $267 million) reflects the actual costs of facilities required to achieve the incremental capacity plus a fair market value for existing facilities that supports the increase.

Bonneville, in addressing the development of the AC addition incrementally in its study of nonfederal utility participation, pointed out that the existing owners have ownership and contractual rights to the first 800 MW of additional capacity. Bonneville's view is that further nonfederal utility ownership in the Northwest should therefore be limited to the second 800 MW increment because the existing owners would otherwise be required to give up some of their current ownership and contractual rights. However, some nonfederal utilities do not agree with this proposed limitation.

Bonneville's EIS economic analysis reported its base case net benefits from the 1,600 MW addition to be $199 million, with losses occurring over the first 4 years of operation. Bonneville projected that it could recover its costs in about 18 years. Bonneville officials also said it was unclear whether the second 800 MW of capacity, if viewed incrementally, would yield net benefits. This suggests that while the net benefits of the first increment could be positive, it is unclear whether the net benefits of a second increment would also be positive.

We discussed performing an analysis of the intertie addition in 800 MW increments with Bonneville officials. They opposed this suggestion and stated that the 1,600 MW proposal was the option California utilities selected and that it may not be possible to reach agreements to share an 800 MW addition. They stated that their analysis shows that the full 1,600 MW of capacity is economically justified. We believe an incremental analysis of the net benefits to Bonneville would provide useful information. Since the construction costs appear to be concentrated on the second increment, it is important for Bonneville to quantify its net benefits from this increment to help clarify the relationship between economic and noneconomic considerations for its investment in the Northwest portion of the project. This information may also be valuable in getting a better understanding of the time frame in which the second 800 MW increment can be expected to begin producing benefits for Bonneville. In addition, depending on the extent of benefits to Bonneville from the second increment, this information may offer added perspective for deciding whether nonfederal utilities should participate in the Northwest addition.

Bonneville officials also expressed concern that their economic analysis of intertie benefits not be the basis for deciding the price that should be paid by nonfederal utilities for participation in the intertie. Bonneville's study suggests cost-based pricing for participation. It also states that Bonneville could consider value-based pricing and that whichever method is considered, it should appropriately compensate the current owners for their assets. We have not evaluated how the intertie should be priced for nonfederal participants and do not suggest that Bonneville's analysis of intertie benefits be used for this purpose.

Other Aspects of Bonneville's Analysis Could Be Clarified

We noted that Bonneville's analysis could be clarified in two other areas. The first involves Bonneville's assumption that the Northwest's two partially completed and currently "mothballed" nuclear power plants would become operational. In 1987 Bonneville estimated that there was only a 16-percent chance it would need these plants by the year 2000. The second involves the presentation of Bonneville's net benefit results using alternative discount rates.

Nuclear Power Plants and Intertie Net Benefits

In assessing the overall net benefits from an expanded intertie, Bonneville projected the power resources that would be developed, over time, to produce energy in the Northwest. Specifically, Bonneville projected that the Northwest's two uncompleted nuclear plants would produce power as soon as loads grow beyond the capacity of other less costly resources. One nuclear plant was assumed to begin producing power in 1999 and the second in 2004. However, in May 1987 Bonneville issued its final study of the region's two uncompleted nuclear power plants, which examined the economic, legal, contractual, and financial issues related to them.[13] In that study Bonneville found that there was about a 34-percent chance of needing one of the plants by the year 2000 and about a 16-percent chance of needing both plants.

It is not clear to what extent the inclusion of these two nuclear power plants affects Bonneville's net benefit estimates. Bonneville's analyses appear to show that the inclusion of the nuclear plants may contribute to the net benefits projected for the intertie. We noted that under certain of Bonneville's scenarios, intertie net benefits would decrease in amounts ranging from $180 million to $354 million as a result of replacing the power generated by the nuclear plants with power produced by

[13]WNP-1 and WNP-3 Study, 1987 Resource Strategy, Bonneville Power Administration (May 1987).

combustion turbines. However, Bonneville officials believed that inclusion of these nuclear plants had relatively little effect. They said it was unlikely that combustion turbines or other high-cost resources would replace the nuclear power plants. Yet, we also found that in the Northwest Power Planning Council's study of the intertie, the Council assumed that high-cost coal plants would be developed in the Northwest instead of the nuclear plants.

Discount Rate Used to Project Net Benefits

Bonneville's base case estimate of $661 million net benefits for intertie expansion is based, in part, on Bonneville's use of a 3-percent real discount rate (about an 8-percent nominal discount rate).[14] According to Bonneville's Chief of Power Forecasting, this rate was selected as an approximation of the cost of Department of Treasury borrowing. Bonneville also calculated intertie net benefits on the basis of a 7-percent real discount rate (a 12-percent nominal rate), which it characterized as an average discount rate for utilities. With this rate, intertie expansion net benefits were calculated as $265 million.

Considering the net benefits that would result from other discount rates can provide additional perspective. For example, a discount rate reflecting private sector financing costs, which may also be appropriate to consider since construction of electric power transmission facilities is normally a private sector activity, would be higher than a public sector rate and thus lower the intertie net benefits. We computed net benefits on the basis of (1) a 13.5-percent nominal rate, which, according to Energy Management Associates, approximates the discount rate for investor-owned utilities and (2) a 15-percent nominal rate.[15] Table 2.3 shows the effects that different discount rates have on the computation of net benefits.

[14]A real discount rate equals the nominal discount rate minus an inflation factor.

[15]According to the Office of Management and Budget (OMB), a real rate of 10-percent reflects private sector opportunity costs, which, with a 5-percent inflation premium added, equals 15 percent. Bonneville officials said that no utility would be subject to a discount rate as high as 10 percent. Nevertheless, the basis for OMB's rate is the rate of return on the next best investment alternative anywhere in the economy.

Table 2.3: Net Benefits Using Alternative Discount Rates

Dollars in Millions

Nominal discount rate (percent)	Net benefits
8.15	$661
12.0	265
13.5	189
15.0	137

As the table shows, net benefits are positive values in each case, but the discount rate selected for reviewing the investment can significantly affect the perspective on net benefits.

Conclusions

Bonneville's analyses show that forecasts of sales to California utilities are a key variable influencing the results. Bonneville's estimates of the net benefits of intertie expansion--varying from a loss of $234 million to a net benefit of $661 million—highlight the volatility of California load forecasts and their influence on the results. On the basis of our review of Bonneville's economic analysis, we believe additional analysis of the reasons for the changing California load forecasts could provide important insight and additional information on which to base intertie expansion decisions. We support the additional work Bonneville is performing in this area.

To ensure the continuing benefits estimated for this intertie expansion, there needs to be close cooperation between California and the Northwest. This is illustrated by the $900-million shift in intertie benefits resulting from the change in California's forecasts that Bonneville officials attributed, in part, to modification of their pricing policies. The differences in the forecasts indicate that realizing net benefits from the addition depends heavily on the sources from which California chooses to obtain power in the future, which in turn appears to depend heavily on the competitiveness of Bonneville's prices.

We also found that Bonneville performed limited analyses to show how combined changes in the values assigned certain variables included in its analysis would affect net benefits. For example, we noted that Bonneville did not assess the possible correlation between California and Northwest load growth forecasts and how they are affected by changing natural gas prices. Additional analyses along these lines could also contribute to estimating a most likely net benefit of expanding the intertie,

which we suggested Bonneville perform. We support Bonneville's current effort to develop this estimate.

Our review also raises a question about the economic justification for Bonneville's proposed investment in the full 1,600 MW of the intertie addition in the Northwest. It is unclear whether the second 800 MW increment of capacity would result in net benefits to Bonneville. To clarify this, Bonneville could perform an analysis of the benefits to it from each 800 MW increment of capacity. This is important to further disclose the economic justification for Bonneville's investment and clarify the relationship between Bonneville's economic justification for its investment and noneconomic considerations. We believe that at $327 million, Bonneville's investment is sufficient to warrant this further analysis. This information may also assist in addressing the appropriateness of participation or ownership by other Northwest utilities. As for California, however, we found evidence indicating that an 800 MW option is questionable, primarily because of reliability and institutional considerations.

Recommendation

We recommend that Bonneville's Administrator clarify Bonneville's economic analysis by providing a breakout of Bonneville's costs and the sources and extent of revenues it expects for each 800 MW increment of the addition. Doing the analysis for each using the same regionwide net benefits approach that Bonneville employed in its original analysis would be useful. We expect this information on each increment to help clarify the relationship between the economic basis for Bonneville's investment and noneconomic considerations, and it may also contribute to the decision about how much capacity Bonneville should pay for.

Intertie Expansion and Electricity Imports From British Columbia

British Columbia Hydro and Power Authority (BC Hydro), a Canadian, provincially owned electric utility, is the major Canadian exporter of electricity to Bonneville, Northwest utilities, and utilities in the Pacific Southwest (primarily California). BC Hydro's electricity exports are delivered over Bonneville transmission interconnections at the Washington/Canadian border and over the intertie from Oregon to California. The proposed activities to expand the transmission capability of the intertie (both the DC transmission line upgrade and the addition of the third AC transmission line) may offer opportunities for BC Hydro to increase sales of electricity to U.S. utilities. The extent to which BC Hydro realizes increased electricity sales, the nature and value of these sales, and the U.S. utilities that will purchase BC Hydro electricity will be influenced to a large degree by decisions regarding the extent to which the current intertie is expanded and whether and how utilities other than Bonneville will participate in the Northwest expansion efforts.

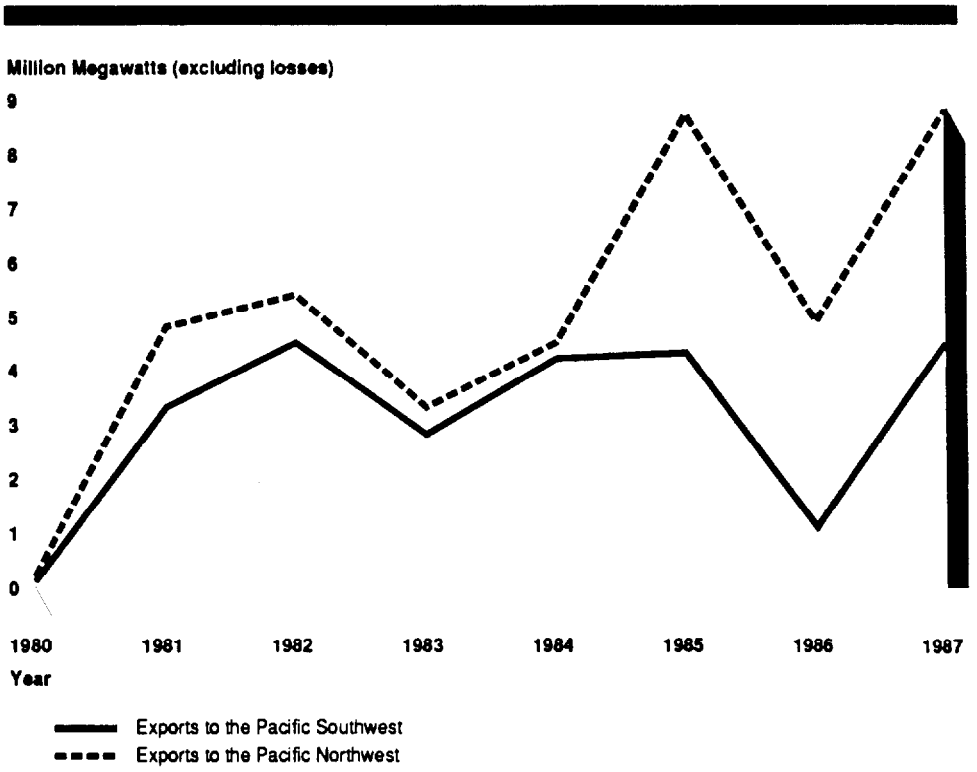
British Columbia Electricity Exports

BC Hydro electricity exports have, for the most part, been nonfirm energy in excess of its needs. Delivery of this energy to the U.S. has required access to Bonneville-operated transmission interconnections at the Washington and British Columbia border; to the Bonneville-operated federal transmission system in the Northwest for Northwest utility purchasers; and to the Bonneville-operated portion of the intertie for electricity sales to California and Southwest utility purchasers. (Fig. 3.1 shows the amount of electricity BC Hydro exported to the U.S. between 1980 and 1987.)

Prior to September 1984, Bonneville generally granted access, on the basis of market prices, to its portion of the intertie for the delivery of nonfederal power. This meant that utilities with the lowest prices at any given moment could gain access to the intertie until its capacity was reached. As electricity surpluses developed in the Northwest and British Columbia, requests for access to Bonneville's intertie capacity, in order to sell surplus electricity primarily to California utilities, exceeded the capacity. In response to this situation, Bonneville developed and implemented an interim access policy that identified how Bonneville would allocate available intertie transmission capacity.

In general, the policy provided that assured transmission would be provided for firm power sales by Bonneville and other Northwest utilities. Canada was excluded from making firm power sales over Bonneville's portion of the intertie. Any transmission capacity in excess of that needed for firm power sales was allocated first between Bonneville and

Figure 3.1: BC Hydro Electric Power Exports



other Northwest utilities; Canadian utilities could gain access only when the intertie was not otherwise filled.

While this policy provided a means for allocating intertie capacity, California utilities and agencies expressed concerns that Bonneville was preventing low-cost energy generated in the Northwest and Canada from reaching California. According to a BC Hydro official, Bonneville's access policy has caused BC Hydro to make sales at times when the value of electricity is less than it otherwise would charge. He cited an example in which BC Hydro was prevented from selling over the intertie to California utilities at a rate of 15 mills per kilowatthour, but did get transmission access for sales to Northwest utilities at a rate of 8 mills per kilowatthour.

In lawsuits filed by the Los Angeles Department of Water and Power and by the California Public Utilities Commission and the California Energy Resources Conservation and Development Commission, the federal court upheld Bonneville's access policy. The court found that Bonneville was authorized and obligated to give itself priority in use of

the intertie and to give other Northwest utilities priority over extra-regional utilities.

Expanded Intertie Expected to Benefit Canadian Utilities

According to Bonneville's economic analysis, expanding the capacity of the intertie is expected to result in significant benefits to Canadian utilities. In Bonneville's base case economic analysis, Canadian utilities were projected to realize 24 percent, or $161 million, of the benefits from constructing the third AC transmission line. Canadian utilities would also receive 19 percent, or $184 million, of the benefits expected from upgrading the existing DC transmission line.

In our discussions with a BC Hydro official, he agreed that expanding the intertie's capacity increases the potential for BC Hydro to make additional electricity sales to U.S. utilities. This official estimated that BC Hydro might be able to make sales averaging 400 MW to 500 MW over the third AC transmission line, if constructed. BC Hydro's 20-year resource plan for the period 1988 to 2007 commented that potential long-term markets for power exports from British Columbia are emerging in both the U.S. Pacific Northwest and the U.S. Pacific Southwest. A BC Hydro official told us that the provincial government is reexamining whether British Columbia should be attempting to increase its exports of power and that this policy is expected to be clarified later this year.[1] Thus, while an expanded intertie appears to afford an opportunity for Canadian utilities to increase electricity sales to U.S. utilities, British Columbia's provincial government has not yet decided what emphasis it will place on exports.

Transmission Access Important for Increasing Future Purchases From Canada

Utilities in both the Northwest and California have expressed interest in future purchases of BC Hydro power on a long-term basis. One factor in making long-term sales will be BC Hydro's access to the transmission system between BC Hydro and U.S. utilities. Bonneville has limited BC Hydro's previous access to the intertie, and its current policy, which was announced during April 1988, continues these limitations and also offers improved access in return for certain benefits. The nature of the transmission access question could also change depending on (1) whether nonfederal participation occurs in expanding the intertie and

[1] British Columbia also has significant undeveloped hydroelectric capacity on which it could rely should it decide to increase its power exports over the long run. A June 1987 report identified over 14,000 MW of undeveloped hydroelectric capacity in British Columbia. See Canadian Hydropower: Potential Resources and Implications for U.S. Industrial Competitiveness, Electricity Consumers Resource Council (June 1987).

(2) whether new nonfederal transmission interconnections will be constructed between the United States and British Columbia.

One potential project discussed between U.S. utility representatives and BC Hydro is the development of the Site C hydropower project on the Peace River in British Columbia. This project would represent a projected $1.7-billion investment in hydroelectricity and related transmission facilities[2] and could provide an estimated 480 MW for sale to U.S. utilities. Between June 1986 and January 1987, a joint study group, composed of representatives of BC Hydro, Bonneville, and several Northwest and California utilities studied the feasibility of this project. The study showed that the project was feasible but that completing the project would, among other things, require that Bonneville furnish transmission for the project's power, or that others provide transmission, from Canada to the Northwest and California.

For several years, Bonneville officials have told BC Hydro officials that firm power sales from Site C to California utilities would first require construction of the third AC transmission line and added benefits to Bonneville. According to the utilities' agreement to study Site C, it would also depend on Bonneville's implementation of its recently finalized long-term intertie access policy. In general, the long-term policy provides that first priority for access will be given to Bonneville to market federal power. Second priority will be given to Northwest utilities, third priority to U.S. utilities outside the Northwest, and fourth priority to Canadian utilities.[3]

The final access policy removes the requirement that the third AC transmission line be completed prior to providing Canadian utilities access for firm power sales. Bonneville officials have retained their position that they are willing to negotiate with BC Hydro officials for improved access to the intertie for certain considerations that would benefit U.S. utilities. One such benefit, according to Bonneville, would be additional power resources, which could result from increased coordination between BC Hydro and Bonneville in the operation of the Columbia River system.[4]

[2]October 1985 Canadian dollars.

[3]The proposed free-trade agreement between the United States and Canada would, if signed, modify Bonneville's intertie access policy so that BC Hydro would be afforded treatment no less favorable than the most favorable treatment afforded to U.S. utilities located outside the Pacific Northwest.

[4]As of July 1988, Bonneville was negotiating with BC Hydro concerning a power sale in return for coordination benefits as a 1-year experiment.

Thus, should intertie expansion take place with no nonfederal participation, Canadian utility access to the intertie would also be dependent on Canadian utility success in negotiating access with Bonneville.

Nonfederal participation in expanding the intertie, a possibility Bonneville is now examining, could change the nature of the transmission access question for Canadian utilities. Nonfederal participation in an expanded intertie could present Canadian utilities with new entities with which to negotiate intertie access and would likely offer Canadian utilities a different basis from which to negotiate. Even under this situation, however, Canadian utility access to the intertie also will be contingent upon obtaining access to the Bonneville-operated interconnections between the United States and British Columbia.

Another factor under consideration, which could affect Canadian utility access to U.S. electricity markets, is nonfederal transmission interconnections between the United States and BC Hydro. Recently, the Washington Water Power Company and Puget Sound Power and Light Company have expressed interest in building transmission lines connecting their systems directly to BC Hydro's. BC Hydro is interested, and, according to a BC Hydro official, a contract for the Washington Water Power project could be signed as early as the end of this summer. Puget Sound Power and Light is expected to apply for a federal permit to build its proposed transmission line in the near future.

Should nonfederal transmission interconnections be constructed, British Columbia utilities, for the first time, will be afforded an opportunity to negotiate with U.S. utilities rather than Bonneville for transmission access to U.S. electricity markets, at least in the Northwest. A Bonneville official told us, however, that Bonneville has intervened in regulatory proceedings on the Washington Water Power proposal and is likely to do so on the Puget Sound Power and Light proposal, because Bonneville anticipates potential transmission problems that could result from the proposed new lines.[5]

Summary

Significant financial benefits have been estimated to accrue to Canadian utilities from an expanded intertie. These benefits would result from an

[5]A permit is required of any person who proposes to construct and operate facilities at the borders of the U.S. for the purpose of importing or exporting electricity. The permit is designed not to regulate import trade, but to regulate and control the physical connection of U.S. territory to the territory of a foreign country. A permit is issued upon finding that the proposed interconnection is consistent with the public interest.

increasing level of electricity sales to U.S. utilities made possible by additional intertie capacity. The estimated benefits assume Bonneville's ownership of the expanded intertie in the Northwest. The question of nonfederal participation is now being considered, but has not been resolved. Should there be participation by nonfederal utilities, the nature and extent of benefits to both U.S. utilities and Canadian utilities could change.

Overall, the future role of Canadian electricity imports in the western United States focuses on the question of transmission access, specifically, on which entities control the use of transmission facilities important to Canadian utilities' ability to market electricity in the Northwest and Southwest. It appears that decisions affecting the Pacific Northwest-Southwest Intertie are key to shaping the future of Canadian electricity imports in that region. Among those key decisions are the extent of intertie expansion, whether expansion will involve nonfederal participation, and the implementation of Bonneville's long-term intertie access policy. Other pertinent decisions include those involving proposed nonfederal transmission interconnections with BC Hydro.

Impacts on Salmon and Steelhead Trout From Changes in Major Dam Operations

Operation of the hydroelectric power dams of the Columbia River system affects the survival of salmon and steelhead trout. During their spring migration to the ocean, juvenile salmon and steelhead must pass as many as nine large dams. At each dam, they may pass through the power-producing turbines, which kill 10 to 30 percent of the fish, according to the Northwest Power Planning Council. Cumulative losses can be significant—over 50 percent of those fish that must pass the most dams. The mortality rate of these fish is reduced when the fish flow past the dam in water that is being spilled (flowing over the dam), are physically directed past the turbines by bypass facilities,[1] or are collected and transported around the dams.

Some losses of salmon and steelhead trout—less than 3 percent for individual stocks,[2] according to Bonneville's estimate—could result from power operations associated with expanding both the DC and AC interties. Bonneville also estimated that installing additional bypass facilities will increase fish survival so that the losses are more than offset. During our review we found that the U.S. Army Corps of Engineers had not agreed to install bypass facilities at the Corps dams because the Corps was concerned that it was not obligated to do so and that some of the facilities would not be cost-justified. However, on July 19, 1988, the Congress passed the Energy and Water Development Appropriation Act of 1989, which directs the Corps to proceed with the bypass facilities. We also found that Bonneville is relying on these bypass facilities to be highly efficient, although high efficiency levels may not be achieved at every dam.

The analytical work supporting Bonneville's views is based on a computer model called FISHPASS. This computer model was originally developed by the Corps and simulates the survival of salmon and steelhead as they pass through the large Columbia River system dams. Environmental Protection Agency officials and other computer modeling experts told us that computer models related to biological situations, such as FISHPASS, should be reviewed by independent experts prior to use in significant environmental impact statements to provide evidence

[1]Bypass facilities assist the fish in migrating past the dams and are installed on five Columbia River system mainstem dams. The Council program calls for improvements to increase fish survival at three of these five, and the installation of bypass systems at four Corps dams and five public utility district dams.

[2]Stock refers to the varieties of salmon and steelhead that were identified in Bonneville's analysis by their spawning location within the Columbia River basin. About 100 stocks were identified in Bonneville's EIS.

about the credibility of the model, which will help increase the confidence of decisionmakers. We found that FISHPASS is controversial among various regional officials who have reviewed it. We also found that Bonneville did not have its proposed use of FISHPASS reviewed by independent experts prior to conducting its analysis, but now is considering whether to do so.

Protection and Enhancement of Salmon and Steelhead

In 1980 the Northwest Power Act (16 U.S.C. 839) directed that special efforts be made to protect, mitigate, and enhance fish and wildlife that had been adversely affected by the Columbia River system's hydroelectric dams—particularly the anadromous salmon and steelhead trout.[3] The construction of these dams was a major factor in the decline of some of these fish stocks to a point of near extinction. By 1980, the salmon and steelhead originating above the confluence of the Columbia and Snake rivers were being considered for inclusion on the national list of threatened and endangered species.

The 1980 act established the Northwest Power Planning Council, an interstate compact agency, to plan for regional power development and for enhancing and protecting the region's fish and wildlife resources. The Council has adopted a comprehensive fish and wildlife program and set an interim goal of doubling the annual fish migration to 5 million, but has not yet set the time frame for achieving this goal.[4] To enhance the priority accorded to the Council's efforts, the act and the Council have called for Bonneville to give fish equitable consideration with other project purposes in its decision-making.

Bonneville's Analysis of Impacts on Salmon and Steelhead

The effects of intertie expansion have caused concern for Bonneville, federal and state fish and wildlife agencies, local Indian tribes, and environmental interest groups because some of the changes may cause even more fish to be killed than with present operations. These fish have sport and commercial value, as well as cultural and religious value to the Indian tribes. An increase in power turbine operations (in order to supply the additional electricity for sales made possible by the larger intertie) will reduce the amount of water spilled and increase the flow of

[3]Anadromous fish spawn in freshwater rivers and streams. Their offspring migrate to the ocean to mature and return to the freshwater rivers and streams of their origin to spawn.

[4]GAO previously reported that federal, state, tribal, and utility interests were cooperating with the Council: Federal Electric Power: A Five-Year Status Report on the Pacific Northwest Power Act (GAO/RCED-87-6, Feb. 19, 1987).

water—and fish—through the turbines. To reduce the number of fish killed this way in hydropower operations, some owners and operators are installing dam bypass facilities.

Bonneville's analysis shows that the proportion of water spilled would generally decrease less than 6 percent, with several exceptions.[5] During low-water years, Bonneville officials said, there would be essentially no changes in operation or effects on salmon and steelhead. In very high-water years, Bonneville officials said, intertie operations would have some beneficial impact on fish by reducing the very high quantities of spill that cause fatal nitrogen supersaturation disease in juvenile fish.

Bonneville used the computer model FISHPASS to analyze how the changes in water spill and flow rates would affect juvenile fish mortality. This model simulates survival of fish as they pass through large Columbia River system dams. FISHPASS was developed by the Corps of Engineers and modified by Bonneville for use in its analysis. It has been used since 1984 to estimate the spill needed to achieve fish survival levels recommended by the Council and to assess the economic justification for constructing bypass facilities at Corps dams.

Bonneville concluded that the losses of salmon and steelhead it projected are not significant. This conclusion is conditioned on a comparison of the losses with the increased fish survival expected to result from improving and installing dam bypass facilities that will assist the fish in migrating past the dams. Bonneville decided that the significance of increased fish mortality resulting from the intertie should be evaluated in the context of the overall fish population trends. Increases in the fish populations are expected to result from implementing the Council's program. Should certain of the planned bypass facilities that were included as part of the Council's program not be installed, Bonneville concluded that it would consider the related losses significant because stocks now in a potentially critical condition could remain so or be placed in greater jeopardy.

Table 4.1 shows results from Bonneville's analyses. It includes the average range of additional losses of fish that are projected to occur as well as estimates of the improvements in fish survival that could occur if facilities are installed on the dams to assist migration. (Specific stocks

[5]Bonneville reported spill increases exceeding 6 percent as follows: Bonneville dam, 7.5 percent in June; The Dalles, 6.2 to 9.8 percent for May, June, and July; John Day 6.0 to 9.9 percent for May and June; Ice Harbor, 6.0 to 19.1 percent for June and July; and Lower Monumental, 6.9 to 19.7 percent for June and July.

dependent on improvements at certain dams are indicated in app. III. More specific information about maximum potential impacts is included in app. IV.)

Table 4.1: Forecasted Improvements and Potential Losses of Fish Stocks, April 1988

Originating pool and stock[a]	Number of stocks	Improvement forecasted for 2003 (Percent)	Average losses due to intertie (Percent)
Lower Granite			
Chinook yearling	11	22	0.1
Steelhead	3	6	No change
Lower Monumental			
Chinook yearling	1	17	0.1
Chinook subyearling	1	24	2.2 to 2.4
Steelhead	2	16	0.3 to 0.5
Wells			
Chinook yearling	2	38	1.5 to 1.6
Chinook subyearling	2	70	1.4 to 1.8
Steelhead	2	42	0.9 to 1.1
Sockeye	1	43	1.7 to 1.8
Rocky Reach			
Chinook yearling	1	41	0.1 to 0.9
Chinook subyearling	1	37	0.8 to 1.6
Steelhead	2	30	0.5 to 0.7
Rock Island			
Chinook yearlings	2	25	0.2 to 0.6
Chinook subyearling	1	41	0.5 to 0.8
Sockeye	1	32	0.8 to 1.0
McNary			
Chinook yearling	1	10	0.4
Steelhead	3	7	0.0 to 0.2
John Day			
Chinook yearling	1	5	0.3 to 0.8
Steelhead	2	5	0.6 to 0.8
The Dalles			
Chinook yearling	2	8	0.2 to 0.7
Total	**42**		

[a]The number of fish in the stocks identified above varies widely. Bonneville reported less than 20 returning adults of the Asotin Creek spring chinook that enter Lower Granite pool, while over 100,000 sockeye were reported as returning to the Okanogon River above Wells pool in 1985.

Source: Bonneville Power Administration.

The Corps Has Been Directed to Install Dam Bypass Facilities

The improvements in bypass facilities on mainstream Columbia River system dams recommended by the Northwest Power Planning Council are a centerpiece of its fisheries program. Historically depressed stocks of salmon and steelhead cannot otherwise be rehabilitated, according to the Council, and bypass facilities can cut losses in half during the migration of juvenile fish to the ocean. As for the decisions at hand, Bonneville's findings of no significant impact, reported in its EIS, rely on the completion of facilities at certain dams.

During our review we found that the installation of bypass facilities at Corps dams was in doubt until the Congress acted in July 1988. On Apr 5, 1988, the Corps decided that further work on installing bypass facilities at its dams should await the completion of a report discussing the Corps' responsibilities, the cost-effectiveness of bypass facilities, and regional cost-sharing possibilities.

Several specific events related directly to this decision. About 1 year earlier, in March 1987, the Corps' headquarters had requested justification for these facilities from its North Pacific Division and stated that "we are not convinced that the fish survivability goals you are attempting to achieve are justified, appropriate, or something the Corps must accomplish."[6] In September 1987 a cost-benefit study of the proposed facilities was submitted to Corps headquarters.[7] This study was based on an analysis using a modified version of the FISHPASS model to estimate fish survival and value. The study found that $52 million of improvements would be cost-effective at four Corps dams but that $105 million of improvements were not justified for the John Day, Lower Monumental, Bonneville, Ice Harbor, and The Dalles dams.[8] The study did not take into account considerations for species preservation, the

[6]Letter of March 26, 1987, from the Director of Civil Works, U.S. Army Corps of Engineers, to the Commander, U.S. Army Engineer Division, North Pacific.

[7]Juvenile Fish Bypass Goals, U.S. Army Corps of Engineers, North Pacific Division (Apr. 4, 1987).

[8]Bonneville's analyses focused on the improvements needed to avoid significant impacts from interti expansion (rather than the need for the improvements in general). Bonneville concluded that improvements are needed to avoid significant impacts at five Corps dams, including The Dalles, but not at Ice Harbor.

mitigation obligations of the Corps, or the cultural and religious significance of the fish to the Indians of the Northwest.[9]

An April 5, 1988, letter from Corps headquarters responding to the report again stated that the Corps' obligations in this area are not yet clearly defined and that a further study was needed. Corps officials said that the key unresolved question was whether the bypass facilities are justifiable to mitigate past fish losses caused by Corps dams or whether the Corps has made sufficient improvements ($470 million) in its dams so that the facilities proposed now are actually enhancements beyond mitigation. The Corps began a further review of this situation in May 1988 to determine whether a substantive study must be done and, if so, to help define the study scope. The results of this review were expected during July 1988.

Some members of the Northwest congressional delegation have expressed strong support for the completion of the dam bypass facilities. On July 19, 1988, the Congress passed the Energy and Water Development Appropriation Act of 1989, which directs the Corps to spend $18 million for design, testing, and construction of bypass facilities during fiscal year 1989.

Bypass Facility Efficiency Levels

In our 1987 report,[10] we noted problems with the effective operation of a bypass facility at the Bonneville dam. In 1982 the Corps completed a $23-million, state-of-the-art bypass system for Bonneville dam's second powerhouse. The expected fish passage rate was 85 percent, but the system had not exceeded 35 percent. The Corps' September 1987 report stated that the problems should continue to be investigated but that various additional improvement measures tested to date are not clearly cost-justified.

Because of this experience, we asked regional officials for their views about the possibility that the proposed bypass facilities may not reach the projected efficiency levels that Bonneville used in its analysis.

[9]Since the Corps' 1987 study was based on the FISHPASS computer model, we asked Corps and Bonneville officials for their views about the reasonableness of the results. The Corps' North Pacific Division responded that the best available modeling was used, but that its results were subject to question because of uncertainties concerning data used in the model. Bonneville responded that if the Corps' assumption about ocean survival were increased from 0.1 to 0.2 percent, this would double the benefit-cost ratios of the bypass facilities. This comment indicates that additional bypass facilities may be found justified, with changes in assumptions.

[10]GAO/RCED-87-6, Feb. 19, 1987.

Bonneville, Council, and Corps officials agreed that testing prior to construction will ensure that substantial expenditures will not be made for facilities that are less efficient than expected.

Corps officials and the Council's Executive Director, however, indicatec that the projected efficiencies of bypass facilities are not certain. The estimated efficiencies are engineering estimates based on existing systems, although the physical structure and hydrology of each dam is different. Bonneville officials added that research has shown that only Th Dalles has the potential for problems similar to those experienced at Bonneville dam, but that even a system with moderate efficiency at Th Dalles, combined with the existing facilities, would provide substantial fish protection.

Perspective on Bonneville's Use of FISHPASS

We identified practices currently used in government to ensure the cred ibility of models such as the FISHPASS model Bonneville used for its EIS analysis. We asked officials of the Environmental Protection Agency, the Energy Information Administration, and the National Bureau of Standards about such government standards and practices. We found n government wide standards, but the Office of Management and Budget (OMB) is developing a circular on the subject. We also found that established practices of the Environmental Protection Agency and requirements by the Energy Information Administration are used to ensure model completeness, reasonableness, and ability to yield competent results.

The procedures and practices of these agencies ensure that computer models are documented, model operation is consistent with the documentation, and the model assumptions and mathematical formulas are consistent with known facts and research results. Modeling experts we talked with said that complete model documentation should be available for important decisions. OMB's proposed circular would require documen tation sufficient for a competent professional from outside the agency t duplicate the agency's results. The proposed circular states that documentation should include a model specification; a summary of the purpose of the model, including its principals, structure, and assumptions; a complete mathematical statement of the model; a description of any data base used with the model; a description of the validation, verification, and audit record associated with the model; the results of using the model, including both the raw outputs and analysis based on those outputs; and a user's guide explaining how to run the model.

The Environmental Protection Agency and Energy Information Administration include reviews of models by independent experts prior to their use. According to the Director, Office of Environmental Processes and Effects Research, Environmental Protection Agency, it is particularly important that models concerning the environment that are used for major decisions be independently reviewed by a panel of competent experts because of the relatively high levels of uncertainty attached to models that involve situations related to biology, such as FISHPASS. The Chief, Mathematical Analysis Division, National Bureau of Standards, agreed that a professional peer review team should have reviewed the proposed use of this model.[11]

FISHPASS has been reviewed by regional officials in various contexts. For example, its use by the Corps for determining appropriate levels of spill at each dam has been reviewed by interested regional officials as part of the Northwest Power Planning Council program. The use and results of the model have also been reviewed by interested regional officials as part of Bonneville's development of its EIS. Yet, we found that Bonneville's use of FISHPASS is controversial among those most familiar with it and that it did not receive an independent expert review, as described above, prior to Bonneville's analysis. We also found that the documentation needed for such a review is not complete.

Bonneville officials responded that the time required for an independent, expert review was not possible within the time schedule for completing the analysis. In addition, they considered the reviews of FISHPASS by regional officials to be extensive and added that fishery groups were consulted in preparing for the analysis and that Bonneville's methods and results were explained to the fishery and environmental groups. Bonneville officials also said they were aware that model documentation should be complete but that time was not available to complete it earlier. As of July 1988 Bonneville was working to complete the documentation and planning to hire a contractor to review the model and address potential model improvements.

Comments on Bonneville's Analysis of Intertie Effects

Bonneville received numerous comments on its analysis of intertie impacts on salmon and steelhead, some of which raised concerns about the use of the FISHPASS model. A detailed criticism appeared in a brief filed by the state of Idaho in litigation regarding Bonneville's decision

[11]The cost of an independent peer review would range from $15,000 to $100,000, according to experts involved in the review of models.

not to prepare an environmental impact statement on the expansion of the DC intertie line. (That litigation was dismissed before the court hear the parties' arguments, after Bonneville prepared an environmental impact statement.) Our interviews with officials concerned with Bonneville's analysis and review of documentation brought out four major issues. These concern the adequacy of the model, the assumptions used and the interpretation of the results.

Issue 1: The underlying accuracy of FISHPASS is not known since it has not bee verified by a comparison of the results to actual conditions.

Discussion: Bonneville officials stated that FISHPASS was the most technically proficient model for this analysis, that no verified model was available, an that only a qualitative analysis could have been done otherwise. Corps and Northwest utilities officials commented that FISHPASS represents an improvement in the region's analytic capability and is the best method now available for performing such analyses.

Bonneville, Council, and fishery agency officials agreed that complete verification of this model is problematic because of the difficulties in selecting an appropriate verification method, its potential cost, and emphasis on other, higher priority fish program measures, although some officials thought some verification tests could be devised.

Environmental Protection Agency officials said that this condition is no unusual because of the difficulties, time, and expense required for verifying environmental models. They added that, consequently, it is particularly important that the model assumptions and logic reasonably depic the key environmental and biological relationships.

Issue 2: Since FISHPASS is not a life cycle model, it does not measure the cumulative impact of increased mortality on future fish generations.

Discussion: Bonneville officials said FISHPASS was at the state of the art in analyti capabilities when it was selected, and they did not use a life cycle model because the data required for using such a model were not available. Instead, Bonneville used FISHPASS to estimate relative changes in fish survival resulting from operations that support increased intertie sales for four different years: 1988, 1993, 1998, and 2003. Officials of fishery

agencies stated they are concerned because the analysis does not reveal that losses of even the small percentages identified by Bonneville will compound over the years, so that the long-term losses could be significant. The Columbia River Inter-Tribal Fish Commission[12] has illustrated that a small change may produce a large effect with the following observation: The Commission estimated that at current survival levels the Council's goal of doubling the fish runs could be reached by 2026. If survival could be improved by 2 percent per dam, the Commission estimates the runs could double 20 years sooner.

Fishery officials also stated that increased mortality in 2 or more adjacent years could result in a serious decline of some fish stocks. In addition, they suggested that an analysis focusing on the probability of relatively large losses of upriver stocks could provide added insights.

Some alternative models do exist. Bonneville stated, however, that acceptable alternative modeling capabilities were at least 3 to 4 years away as of January 1988. The Council's program includes an effort to improve the region's modeling capability.

Issue 3: FISHPASS contains judgments and assumptions about critical variables and their interaction that are uncertain and the subject of scientific disagreement.

Discussion: Bonneville performed sensitivity analyses to test the effect of changes in assumptions, including six factors associated with fish mortality, four changes in projected dam bypass facilities, and five changes in sales prices and electricity loads. Bonneville officials concluded that the results change very little for the assumptions tested, except that future survival is greatly affected by improvements in dam bypass facilities.

Fishery agency officials cited as a specific example that turbine mortality and reservoir mortality are treated as independent variables in FISHPASS. They said this may not be the case, since reservoir mortality is likely to increase after fish travel through the pounding of several turbines.

[12]The Commission represents the interests of four Northwest Indian tribes in the anadromous fish matters of the Columbia River basin. The four tribes have rights by treaty to take fish that pass their usual and accustomed fishing places.

Bonneville officials agreed that FISHPASS has limitations concerning reservoir and turbine mortality but that the sensitivity testing they performed accounts for this in their judgment. A "worst case" sensitivity analysis was not performed, according to the officials, because they had done extensive sensitivity testing and it was their judgment that combinations of worst case assumptions occurring together was remote. The Council concluded that while there are limitations in Bonneville's methodology, it is reasonable. Fisheries officials stated that the analysis could have addressed some combinations of the variables changing at the same time.

Issue 4: Bonneville has used FISHPASS to identify changes that are too small to measure.

Discussion: Regional utility officials commented that a 5-percent change in survival is within the natural variability of the ecosystem and that uncertainties in the data and assumptions provide variability beyond the range of accuracy Bonneville has attempted to achieve. They added that the small impacts were expected because the hydropower system is operated near its optimum level so that any changes would be minor. Fisheries and tribal officials, however, stated that losses of even one-half percent could be significant for stocks in critical condition.

EPA officials stated that because of our limited understanding of nature, biological models have error ranges that can be attributed to the unknown. They added that this condition, by itself, is not sufficient grounds to dismiss an environmental model. Bonneville officials said that their analysis of relative changes demands less precision than if they had attempted to make specific estimates of changes in fish populations and that the sensitivity analyses they performed provide confidence that their results are reasonable. In a January 1988 discussion document, Bonneville stated that this is a difficult and imprecise area of biological science and that the impacts shown by FISHPASS cannot be known with certainty or measured in real time. Bonneville also stated that it will use its authorities to ensure that any future, unanticipated impacts are promptly and fully addressed.

On the basis of the numerous comments Bonneville received on its initial analyses of potential intertie impacts, Bonneville made revisions to improve its analysis. Two major improvements were (1) an identification and analysis of the potential impacts on individual fish stocks and

(2) the addition of several analyses to address uncertainties associated with key assumptions, such as bypass facility completion and efficiency, reservoir mortality, turbine mortality, and the survival rate of transported fish. On January 25, 1988, the Chairman of the Northwest Power Planning Council commented that Bonneville's analytical methods were reasonable and that the Council was made more comfortable with Bonneville's acknowledgment that there are inherent limitations in Bonneville's analytical methods.

Bonneville's Senior Assistant Administrator said a better consensus on this analysis would have been desirable and that better, more generally accepted tools would have helped. Nevertheless, he said, Bonneville's results are reasonable and added that water is and will be spilled to ensure that migrating fish are protected. He also pointed out that the Northwest Power Planning Council supported Bonneville's analysis, that Bonneville is working to develop a consensus on appropriate analytic tools, and that those who question the analysis should trust that Bonneville will act responsibly.

Further Research and Settlement Discussions Underway

Bonneville has a continuing program to seek information about the adverse fisheries impact of power operations. For example, Bonneville is studying the effects of fish survival from changing river flows and reducing predators. This research is a portion of Bonneville's fishery efforts on which it spends an estimated $100 million per year. (See table 4.2.)

Table 4.2: Estimated Range of Annual Bonneville Fisheries Expenditures

Dollars in millions

Type of expense	Cost
Direct expenditures	$35 to 50
Interest expense and repayment of expenditures for capital improvements	35 to 50
Foregone power revenues to improve water flow and dam spill	40 to 100

Source: Bonneville Power Administration.

As of July 1988, Bonneville officials were considering a contract proposal by the University of Washington for a review of FISHPASS. The proposal contains important elements of model reviews as described by Environmental Protection Agency officials, such as (1) the biological basis for model assumptions, (2) the review of model documentation,

and (3) the evaluation of alternative models. These elements are important because they should provide information that enhances the degree of confidence in related decisions.[13]

A workshop of fishery biologists is proposed as part of the contract that is focused on criteria for assessing the significance of modeling results. This focus, however, would not contain the elements of the workshop approach currently in use by the Environmental Protection Agency, such as professional evaluations of (1) input values, (2) model assumptions, (3) scientific judgments made in formulating major model components, (4) the integration of model components, and (5) ensuring that th model coding is error-free. This last step should be performed with the same version of FISHPASS that Bonneville modified for use in its analyses.

Bonneville also has been conducting negotiations with interested regional parties for a long-term arrangement concerning additional volumes of water that would be spilled to assist the spring fish migration. These negotiations are related to a long-standing regional interest in increasing fish survival during the spring migration and also concern the DC expansion project. Should agreement be reached, Bonneville officials said it may limit litigation over Bonneville's intertie decisions.

Conclusions

The AC intertie project is expected to result in operational changes in Columbia River power facilities coincident with key activities recommended by the Council's program to restore the Columbia River system fish runs. By directing the installation of bypass facilities at the Corps dams, the Congress has authorized a centerpiece component of the Council's program that is perceived as critical to minimizing the impact of operating the Columbia River power system. Yet, the actual effectiveness of the proposed bypass facilities in improving migration survival will not be known until they are in operation. This is particularly true because of the high operating efficiencies projected and technical complexities in achieving expected results.

Bonneville's reliance on highly efficient dam bypass facilities that are not yet proven will require the continuing attention that Bonneville has stated it will provide. We endorse Bonneville's intention to keep a close

[13]A recent GAO report discussing the quality of modeling information for decision-making is DOD Simulations: Improved Assessment Procedures Would Increase the Credibility of Results (GAO/PEMD 88-3, Dec. 29, 1987).

watch over the fishery impacts of its actions. It will need to focus particular attention on valuable stocks that have been substantially depleted.

Bonneville's methodology for assessing fishery impacts associated with intertie expansion involved a detailed and complex assessment that was based on what it concluded were the best available computer modeling techniques and information. The analysis is detailed in that it identifies potential impacts on individual stocks of anadromous fish and considers conditions particular to their survival. By attempting to relate operational changes for producing electricity to fish mortality, Bonneville's assessment deals with a highly complex hydrological and biological situation.

While FISHPASS has been reviewed prior to Bonneville's use and by those commenting on Bonneville's analysis, its use is controversial among those most familiar with it. We found that Bonneville did not perform certain steps that experts recommended as a basis for helping to assure the credibility of such computer models. Specifically, the computer model documentation needed for reviewing the model and assuring that the results could be duplicated was not available, and the type of review suggested by National Bureau of Standards and EPA officials has not been performed.

Given the importance attached to fishery resources in the Northwest, the great extent of past losses, and the conflicts inherent in balancing power development and fish conservation efforts, it is appropriate that Bonneville's analysis has been carefully scrutinized and criticized for its weaknesses. We believe that an independent, expert review of FISHPASS, if performed earlier, would have taken advantage of an important opportunity to build credibility and a consensus for Bonneville's analytic approach and, if performed now, may contribute to resolving the controversy and the development of improved analytic tools for use in subsequent decisions. We therefore believe that the contract Bonneville is considering for an expert review of the FISHPASS model is appropriate, and we also believe that Bonneville would benefit from broadening the range of issues to be discussed in the workshop proposed under this contract to include those addressed by the Environmental Protection Agency's review process.

Recommendation

We recommend that Bonneville's Administrator contract for an independent review of FISHPASS and include the activities generally undertaken in Environmental Protection Agency reviews of models. The

Administrator may wish to consult with Environmental Protection Agency officials concerning the content and methods used in these reviews.

Potential for Additional Small Hydropower Plant Development

Should nonfederal utilities obtain additional ownership of the AC intertie, federal and state agencies and environmental organizations are concerned that power resource development could occur in the Northwest to serve California customers under certain circumstances. Among the resource development possibilities are new small hydropower plants that could have negative effects on salmon and steelhead. Although small hydropower plants could be developed, their numbers would depend on the amount of intertie capacity owned by nonfederal utilities limitations on the terms of ownership or intertie use, the extent to which other power resources supply electricity for California, and the economic and environmental viability of the hydropower projects.

Although regulatory controls are in place to address the environmental effects of small hydropower development, federal and state agency officials and representatives of environmental organizations and Indian tribes told us that these controls are insufficient to prevent important adverse impacts on anadromous fish. Consequently, Bonneville has adopted some additional controls limited to the Columbia River basin. The Pacific Northwest Power Planning Council is considering additional controls for the entire Northwest.

Views of Regional Officials on Small Hydropower Impacts

In 1981 the Northwest's fish and wildlife agencies and Indian tribes called for the Council to help limit additional hydroelectric development until it first considered its cumulative effects and appropriate mitigation. In 1982 the Council agreed with the concept of protecting some areas from future hydroelectric development and started studies to develop this concept. Recognizing that the environmental effects and related mitigation measures for small hydropower development are under the Federal Energy Regulatory Commission's (FERC) jurisdiction, we obtained the views of various regional officials about the need for further controls. Federal and state officials we talked with indicated that important adverse effects of hydroelectric projects cannot be prevented. Utility officials have said that FERC review requirements are sufficient for addressing environmental concerns. The following briefly summarizes their views.

- Oregon and Washington state officials told us that it is not possible to build a dam in anadromous fish areas without adverse impacts. One stated that up to a 5-percent mortality rate of certain species occurs even with the best of fish screens.
- National Marine Fisheries Service officials are also concerned. They told us that the technology has not been proven to effectively mitigate the

impacts of hydropower development on anadromous fish. Problems remain, particularly for downstream migration, and some proposed dams should not be built because irreversible losses will result. The Service recently made such a recommendation to FERC concerning two proposed dams on the Snake River.

- An official of the Northwest Power Planning Council told us that the technology is not available in many cases to effectively mitigate the impact of hydroelectric projects on anadromous fish and that small hydropower projects can cause flooding of spawning areas and thereby destroy them. The primary goal of the Council's protected areas program would be to protect the critical fish and wildlife habitat that remains. (See the following section for a discussion of this concept.)
- Utility representatives have said that the fair way to assess proposed hydropower projects is on a site-by-site basis and that the proposed protected areas program is not needed because existing FERC regulations provide ample safeguards for fish protection.

Many sites in the Pacific Northwest have small-scale hydropower development potential. Both FERC and the Council have been assessing the potential for these sites to be developed. In addition, Bonneville has estimated the amount of small hydropower development that could be related to additional nonfederal utility ownership of the Northwest segment of the AC intertie. These efforts are discussed in the following sections.

Northwest Power Planning Council Estimates

The Council has estimated future hydropower development potential in the Northwest as part of its preparations for considering a proposal to designate "protected areas." (See table I.1.) In this concept, which has been under development since 1982, portions of the Northwest's rivers would be designated as off limits to additional hydropower development. The goal of these designations would be to protect streams and wildlife habitat from damages caused by future hydropower development.

Table I.1: Northwest Power Planning Council Estimates of Hydropower Potential, May 1988

Area	Total projects	Total project capacity (megawatts)	Projects in anadromous fish areas	Project capacity (megawatts)
Columbia River basin	156	2,169	40	211
Outside the Columbia River basin	216	1,549	76	658
Total	**372**	**3,718**	**116**	**869**

Note: The Council's estimates were based on U.S. Army Corps of Engineers and FERC data.

If the Council adopts a proposal as described in its October 1987 issue paper, the 116 potential projects located in areas affecting steelhead and salmon would be designated as unsuitable for development. Within the Columbia basin, about 25 percent of the total river miles would be designated as protected areas. Outside the Columbia basin, about 27 percent of the Northwest's total river miles would be designated as protected areas.

The protected areas designations, as envisioned in the Council's issue paper, would establish standards to be applied by federal agencies in accordance with their current legal obligations. According to the proposal, Bonneville, FERC, the Corps of Engineers, the U.S. Bureau of Reclamation, and other federal agencies that manage, operate, and regulate hydroelectric facilities in the basin would have to act consistent with the restrictions or explain why this is not possible.

In April 1988 Bonneville adopted a program along the lines proposed by the Council but limited to the Columbia River basin. It decided to deny intertie access to new hydropower projects within "protected areas" of the basin. Bonneville may revise its program once the Council's proposed program is finalized.

Under the Electricity Consumers Protection Act of 1986, Council designations of protected areas appear to have significance in FERC's hydropower licensing proceedings. The act requires that FERC give consideration to comprehensive plans in the licensing of hydropower projects. The Council's staff considers its fish and wildlife program to be a comprehensive plan and interprets the 1986 act to mean that FERC would not license projects located in protected areas unless otherwise required to by law. We also interviewed FERC officials, who said they expected the Commission would consider the Council's program as comprehensive, which would include the provisions for protected areas, if they are adopted. But FERC staff said that the decision to license a new

project is based on a number of considerations, not just a comprehensive plan.

FERC Estimates

In November 1987 FERC identified 648 sites in the Pacific Northwest that would require new dams or diversions.[1] The hydropower capacity of these sites was reported as approximately 4,000 MW. Private developers had, in the past, submitted proposals for 532 of these sites, although some of these applications are no longer active. FERC's experience has indicated that less than 20 percent of all sites with preliminary permit applications advance to licensing and not all licensed projects are built.

FERC is also estimating the number of projects that appear economically viable. According to FERC's study coordinator, about 40 to 190 projects may be found to be economically viable under various assumptions. FERC's draft report states that these projects could be developed, if not privately, by local utilities, cooperatives, municipalities, or industries.

FERC's draft study states that if its licensing process operates properly, projects with nonmitigable significant impacts would not be developed, regardless of their economic attractiveness. This conclusion is based on the strengthened environmental review required by FERC prior to licensing and FERC's assumption that its coordination with federal and state agencies will ensure adequate protection.

In April 1988 we asked the Director of FERC's Portland, Oregon, office for a listing of applications for small hydropower projects that are currently on file with FERC for the states of Oregon, Washington, Idaho, and Montana. We combined this information with the Council's data base to identify which projects were planned in areas currently identified as having anadromous fish. (See table I.2).

[1]Public Utility Regulatory Policy Act Benefits at New Dams and Divisions, Draft Staff Report Evaluating Environmental and Economic Effects, FERC, Office of Hydropower Licensing (Nov. 1987). The Public Utility Regulatory Policies Act of 1978 contains provisions that encourage the development of renewable energy sources from power facilities that produce less than 80 megawatts. The act requires electric utilities to purchase power from such facilities under certain conditions and also provides tax credits, accelerated depreciation allowance for hydropower facilities, and exemptions from licensing for certain projects.

Table I.2: Hydropower Potential on the Basis of Applications on File With FERC

Area	Total projects	Average project capacity (MW)	Projects in anadromous fish areas	Average project capacity (MW)	Projects outside anadromous fish areas	Averag projec capacit (MW
Columbia River basin	62	547	27	77	35	46
Outside the Columbia River basin	114	1,046	54	313	60	73
Total	**176**	**1,593**	**81**	**390**	**95**	**1,20**

Bonneville's Estimates

As part of Bonneville's study of nonfederal utility participation in the intertie, congressional requesters asked Bonneville to address the concern that increased small hydropower development that is detrimental to the environment could result from nonfederal participation. In response, Bonneville identified the power transactions of interest to the utilities desiring ownership. On the basis of this information and other assumptions, Bonneville officials estimated that firm power transaction could increase about 1,000 MW and that the small hydropower contribution would be a maximum of 100 MW.[2] This would generally be equivalent to 15 to 20 small hydropower projects.

As Bonneville recognized, other resources could support California sale and future conditions could vary from those assumed. For example, (1) intertie capacity available for ownership by nonfederal utilities could differ from the 800 MW or 1,600 MW amounts analyzed by BPA, (2) Cana dian power availability could change, (3) and the quantity of power sol could differ from the amounts now indicated.

There is some disagreement with Bonneville's analysis. For example, public utility officials stated that power resource development will not differ substantially with or without nonfederal utility ownership. They stated that new power resources of the region will be built or acquired by nonfederal utilities consistent with regional resource development goals. In contrast, the National Resources Defense Council stated that Bonneville's analysis understates the potential for small hydropower development associated with nonfederal ownership and that added actions are needed. Bonneville officials told us that their estimate was

[2]The alternative sources of firm power Bonneville identified included Canadian power, completion o one of the region's two mothballed nuclear power plants, a coal-fired power plant, small hydropowe plants, and cogeneration. These estimates did not include the small hydropower potential that coulc be related to up to 229 MW of firm power sales by nonfederal utilities that Bonneville assumed wou be transmitted over its portion of the intertie.

based on judgment, that other amounts could possibly occur, and that numerous variables could affect such an estimate.

Observations

The future impact of new small hydropower development in the Northwest on anadromous fish could be dependent on the implementation of the protected areas policies of the Council and Bonneville. This would include the small hydropower potential related to nonfederal utility intertie ownership, and these policies could prevent additional adverse effects on salmon and steelhead by placing environmentally sensitive areas off limits to further development. In addition, the success of the Council's efforts will depend on the extent that its protected areas policy, if adopted, is reflected in licensing decisions made by the Federal Energy Regulatory Commission.

Factors Affecting Intertie Economics That Appear Difficult to Quantify

During our review, we identified several factors that could affect the net benefits of the intertie but are difficult to quantify. These include the potential for making firm sales beyond those Bonneville considered in its analysis, the use of market-based rates for electricity transmission over the intertie, and the net benefits of environmental effects. This appendix discusses these factors, since they appear to be of some significance.

Potential for Additional Firm Sales

The potential for firm sales is an issue of possible significance to the question of net benefits from added intertie capacity. Bonneville estimated net benefits if, in addition to nonfirm energy, more firm sales are made. Increased firm sales would allow California and the Northwest to defer investments in power plants. For example, Northwest utilities could send power over the intertie to help California utilities deal with peak demand. At off-peak hours, California power plants, not otherwise fully used, could produce power for return to the Northwest. This exchange could defer building some plants that might be used only for short peak periods each day.

Bonneville's estimate of firm sales is subject to considerable uncertainty A third AC intertie could make it easier to accommodate firm sales by Northwest utilities and Canada as well as nonfirm energy sales by Bonneville. Bonneville, however, is currently restricted by the Northwest Preference Act in the amount and type of firm sales that it can make outside the Northwest. However, these restrictions do not apply directly to other Northwest utilities.

In its analysis, Bonneville estimates net benefits of $990 million as a result of a 600 MW capacity sale.[1] Bonneville also assumes another 1,950 MW in new firm contracts, but does not attribute any of these sales to the third AC intertie. This assumption may result in an understatement of potential net benefits.

The Senior Assistant Administrator for Power Management agreed that negotiating these contracts would be facilitated by a third AC intertie. However, he noted that Bonneville was assuming that the 1,950 MW of firm contracts could be made possible by its proposed intertie access

[1]In a capacity sale, a utility buys rights to capacity to ensure its ability to meet peak demands. It may never call upon this capacity, but it pays dollars for these rights. If energy is delivered, it must send back an equivalent amount of energy during its off-peak hours. Other types of firm contracts include capacity-energy exchanges and seasonal exchanges. Capacity-energy exchanges are conducted under the same terms as capacity sales, except that no money ever changes hands. Unlike a capacity sale, a capacity-energy exchange involves a net import of energy to the selling utility.

policy. He also stated that Bonneville has not analyzed the full potential of Canadian sales that could be made possible by a third AC intertie because Canada has not recently committed itself on the amount of electricity it desires to sell in the Northwest and California (see ch. 3). In one of Bonneville's sensitivity analyses, Bonneville assumed a firm sale of 500 MW from Canada to California starting in 1991, with net benefits of $1.1 billion.

Market Pricing of Intertie Transmission

Another question of possible significance to net benefits relates to the pricing of access to the intertie. Under Bonneville's current access policy, intertie users are charged cost-based transmission rates, but this policy may not ration intertie use according to highest value.[2]

By establishing a competitive market for intertie access, market rates of transmission could lead to a mix of contracts that maximizes regionwide net benefits. Higher valued contracts would take precedence over lower valued contracts because holders of more valuable contracts would, in theory, be willing to pay a higher price for access than holders of less valuable contracts. Only by chance would cost-based rates duplicate such results.[3]

Bonneville is currently participating in an experiment to determine whether generation and transmission facilities can be used more efficiently through market pricing of transmission capacity and electricity.[4] Bonneville officials said there was merit to market-based transmission rates, but noted that strong objections had been encountered to Bonneville's recent suggestions to use such rates. The Senior Assistant Administrator for Power Management, however, noted that a market-based access price could possibly be included in contracts rather than in the transmission rates.

Environmental Effects

According to the Council, Bonneville conducted several case studies in 1983 and 1984 and found that estimating environmental costs and benefits was feasible. Environmental effects are analyzed in the EIS but are

[2]The models used in Bonneville's analysis do not determine the mix of contracts that maximizes net benefits. Instead, given assumptions about firm contracts negotiated over an intertie, Bonneville's System Analysis Model determines how much nonfirm power will be sold.

[3]If a third intertie was being operated below capacity, cost-of-recovery pricing of access could be equivalent to market pricing.

[4]This experiment is with the Western Systems Power Pool involving utilities in 10 states.

not included in calculating net benefits. Some of these effects, such as improvements in air quality in California, could have substantial economic value. On the other hand, effects pertaining to fish population and mortality, and their corresponding value, are uncertain, as pointed out in chapter 4.

Relationship of Fish Stocks and Bypass Improvements Needed for Avoiding Significant Impacts (Includes Both AC and DC Additions)

Dam needing improvements	Fish stocks dependent on improvements
Dalles	John Day Spring Chinook
	Umatilla Steelhead
	Deschutes Spring Chinook
	Warm Springs Spring Chinook
Lower Monumental	Tucannon River Spring Chinook
	Tucannon River Steelhead
	Lyons Ferry Fall Chinook
	Lyons Ferry Fall Steelhead
McNary	Same as Lower Monumental and also including all steelhead from McNary Pool and Yakima Spring Chinook
Little Goose	14 stocks of spring and summer chinook and steelhead spawning above Lower Granite Dam
Lower Granite	Same as Little Goose
The five mid-Columbia dams[a]	Mid-Columbia stocks above Rock Island Dam

[a]Priest Rapids and Wanapum, owned by Grant County Public Utility District; Rock Island and Rocky Reach, owned by Chelan County Public Utility District; and Wells, owned by Douglas County Public Utility District.

Source: Bonneville Power Administration.

Range of the Average and the Maximum Single-Year Relative Changes in Survival (Percentage for 1993, 1998, and 2003 for the AC and DC Additions)

	Chinook yearling		Chinook subyearling	
Pool	Range of average changes	Maximum increase/ decrease	Range of average changes	Maximu increas decreas
Wells	−1.2/−2.0	5/12	−0.7/−2.2	10/
Rocky Reach	0.1/−1.4	16/16	−0.7/−1.9	13
Rock Island	0.4/−1.4	15/14	−0.2/−1.0	7
Lower Granite	0/−0.1	1/1	−0.2/−0.4	1
Lower Monumental	−0.1/−1.7	6/8	−1.9/−2.9	4/
McNary	0.4/−1.4	9/11	−0.5/−1.0	3
John Day	0/−1.7	7/13	−1.2/−2.3	10/
The Dalles	0.2/−1.6	8/16	−0.4/−1.0	3
Bonneville	−0.1/−0.5	1/4	−0.1/−0.7	2
Total	**0/0.7**	**3/6**	**−0.5/−0.9**	**2**

	Steelhead		Sockeye	
Pool	Range of average changes	Maximum increase/ decrease	Range of average changes	Maximu increas decrea
Wells	−0.8/1.2	4/8	−1.6/−2.0	7/
Rocky Reach	−0.5/−0.9	3/6	0/0	0
Rock Island	0/0.7	6/8	−0.7/−1.3	10
Lower Granite	0/0	0/0	−0.2/−0.3	0
Lower Monumental	0/−1.0	5/9	0/0	0
McNary	0.3/−1.7	5/8	0/0	0
John Day	−0.3/−1.3	5/5	0/0	0
The Dalles	−0.2/−1.3	3/8	0/0	0
Bonneville	0/−0.6	1/4	0/0	0
Total	**−0.1/−0.4**	**1/3**	**−0.5/−0.7**	**2**

Note: Changes are relative to no interite additions and are based on the averages and maximums for the 40 simulations performed for each year of analysis.

Source: Bonneville Power Administration.

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