Although rivers are public resources, licenses can be obtained to dam rivers for the purpose of hydropower generation. The Federal Power Act (FPA) authorizes the Federal Energy Regulatory Commission (FERC) to issue hydropower licenses for non-federal projects. These licenses last for 30 to 50 years and usually place conditions on how the hydropower project should be operated.

FERC is led by a five-member Commission that oversees the generation of hydropower, as well as the interstate transportation of natural gas and electricity. On hydropower matters, the Commission is supported by the Office of Hydropower Licensing (OHL) and five regional offices.[1] OHL staff review and process license applications and make recommendations on hydropower licensing to the Commission, which ultimately decides whether to issue or deny licenses.

As of 1996, FERC had jurisdiction over about two-thirds of the nation's hydropower projects (1,633 out of 2,356 projects); the remaining third are federally owned.[2] Many of these projects were first licensed decades ago, without explicit attention to environmental impacts. Now, with the licenses of many projects near expiration (or already expired), relicensing provides an opportunity to assess and mitigate environmental impacts. As shown in Exhibit 1-1, over one-quarter of FERC's hydropower licenses expire between 1993 and 2010. Although the greatest number of licenses expired in 1993, many of these projects are still in the process of applying for a new license.

[1] The OHL is located in Washington, DC. Regional offices are located in Atlanta, Chicago, New York, Portland, and San Francisco.

[2] FERC has issued 1,016 licenses and 617 license exemptions for these projects. FERC issues exemptions for two types of projects: (1) small hydropower projects (five megawatts or less) that will be built at an existing dam; and (2) hydropower projects that will be constructed on an existing conduit, such as an irrigation canal. FERC, *Water Power: Use and Regulation of a Renewable Resource*, obtained from "www.ferc.fed.us/hydro/docs/waterpwr.htm" on 2/13/98.

Exhibit 1-1

LICENSES EXPIRING FROM 1993 TO 2010

Year	Number Of Licenses Expiring	Total Authorized Generating Capacity (MW)
1993	160	1,977
1994	3	267
1995	4	74
1996	7	38
1997	5	369
1998	6	168
1999	13	224
2000	36	631
2001	33	1,854
2002	13	471
2003	21	1,508
2004	26	935
2005	23	4,137
2006	17	2,634
2007	19	7,419
2008	10	1,344
2009	14	1,203
2010	9	1,058
Total	**419**	**26,311**

Source: FERC, *Relicense Forecast 1993-2010*, Office of Hydropower Licensing, December 1993.

Given the large number of licenses up for renewal, natural resource management agencies that participate in relicensing have a significant opportunity to ensure that FERC gives sufficient consideration to environmental quality when evaluating how the nation's waterways are used in the future. While hydropower was long considered environmentally benign relative to fossil fuel generation, concern has increased over its impact on river ecosystems and surrounding environments. For example, dams may flood terrestrial areas, impede the passage of fish, de-water segments of streams, and degrade water quality. These changes can greatly affect habitat for fish and wildlife species and human enjoyment of river resources.

PURPOSE OF THE REPORT

The purpose of this report is to help Fish and Wildlife Service (FWS) staff become more effective participants in the hydropower relicensing process through a better understanding of the economic analysis used to evaluate hydropower projects. In particular, the report offers information designed to help non-economists achieve the following goals:

- First, the report explains FERC's current economic approach, making key concepts clearer to non-economists.

- Next, the report reviews a number of potential methodological improvements to the economic analysis, explaining why such refinements are important and how they may influence the outcomes of the analysis.

- Finally, the report provides non-experts a basic foundation in resource economics. These concepts are essential to ensuring that the relicensing analysis integrates benefits associated with environmental improvements. We provide guidance to help FWS staff recognize applications of key valuation approaches, and instructions on how to structure basic screening analyses.

To the extent that FWS staff and other participants recognize and promote the suggested refinements, economic analysis of hydropower projects could be improved and play a more meaningful role in licensing decisions.

REPORT SUMMARY

A summary of findings and recommendations from our analysis of hydropower relicensing is provided below.

Legal and Regulatory Context for Hydropower Relicensing

Concerned that FERC's licensing process did not adequately consider environmental resources, Congress amended the FPA with the Electric Consumers Protection Act (ECPA) in 1986. By enacting ECPA, Congress clarified that FERC's relicensing decisions must reflect a balanced analysis of "developmental" and "non-developmental" values.[3] Chapter 2 describes the ECPA amendments and other FPA provisions most relevant to resource agencies. These are primarily captured under four sections of the FPA:

- **FPA Section 4(e)** establishes that FERC must give "equal consideration" to developmental and non-developmental values in its licensing decisions.

- **FPA Section 10(a)** requires FERC to consider resource management agency recommendations for ensuring that a project is best adapted to comprehensive plans for developmental and non-developmental resources.

- **FPA Section 10(j)** requires FERC to consider resource management agency recommendations pursuant to the Fish and Wildlife Coordination Act to protect, mitigate damages to, and enhance fish and wildlife resources.

[3] "Developmental" benefits of a project include power generation, water supply, flood control, irrigation, and river navigation. "Non-developmental" values of a waterway include fish and wildlife resources, recreational opportunities, and other aspects of environmental quality.

- **FPA Section 18** authorizes resource management agencies to prescribe upstream and downstream fishway passage requirements.

FERC's hydropower relicensing responsibilities are also driven by the National Environmental Policy Act (NEPA), which requires all federal agencies to evaluate the environmental impacts of their actions (or actions they permit). Federal agencies are directed to use the NEPA process to assess reasonable alternatives to proposed actions, avoid or minimize any possible adverse environmental effects, and identify practical means to restore and enhance environmental quality.

In addition, the hydropower relicensing process may be affected by federal statutes other than the FPA and NEPA, such as the Fish and Wildlife Coordination Act, the Endangered Species Act, and the Clean Water Act. These statutes often provide opportunities for resource agencies to intervene in the relicensing process and influence FERC's decisions. Along with these statutes, several court cases have affected how FERC interprets relevant legislation and implements the relicensing process. The collective impact of these court rulings has been to strengthen the role of resource agencies in the relicensing process and to assert the importance of considering the broader environmental impacts of hydropower projects.

Chapter 2 also provides an overview of how FERC implements the relicensing process. For each step of the process, we highlight the responsibilities of the applicant and FERC, as well as points where resource agencies, Indian tribes, and the public typically participate in the process.

FERC's Current Economic Methodology

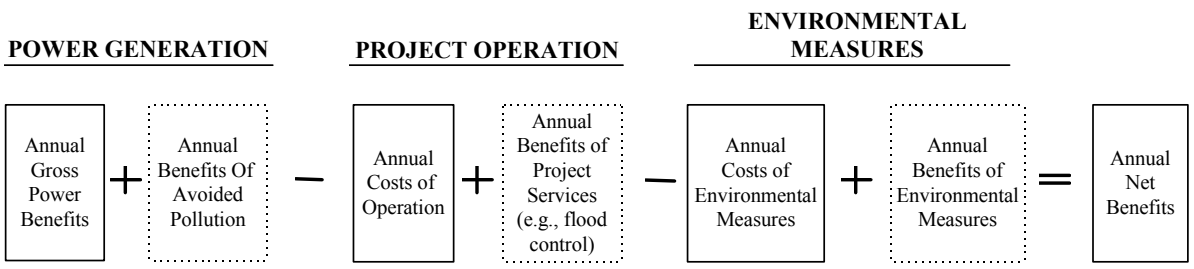
FERC's economic analysis of hydropower relicensing involves an assessment of the costs and benefits of operating a project under various proposed modes and conditions. Relicensing proposals can range from continuing operations as allowed under the existing license (referred to as the "no-action" alternative), to operating the dam under alternative conditions, to removing the dam. FERC is responsible for assessing the power and "non-power" values associated with these different alternatives to determine which option would give the greatest benefit to the public. FERC calculates the monetary value of a project's power by estimating the additional cost that would be incurred to replace the project's power with power from an alternative source. In contrast, "non-power" values, which include services provided by the river (e.g., fish and wildlife resources and recreation) and services provided by the project (e.g., water supply and flood control), are typically characterized in qualitative terms rather than assessed a dollar value that can be incorporated in net benefit estimates.

To evaluate the net benefits of different relicensing proposals, FERC focuses its economic analysis on six benefit and cost components associated with power generation, project

operation, and environmental measures (see Exhibit 1-2).[4] Typically, FERC quantifies three of these components (indicated by solid-line boxes) and incorporates them in its net benefit estimates. The others (indicated by dotted-line boxes) are either assessed qualitatively or quantified but left out of the net benefit calculation.

Exhibit 1-2

OVERVIEW OF FERC'S ECONOMIC METHODOLOGY*



* Solid-line box indicates quantified estimate. Dotted-line box indicates items either assessed qualitatively or quantified but left out of FERC's net benefit calcultaion.

The six benefit and cost components of FERC's economic methodology can be defined as follows:

1. **Annual Gross Power Benefits:** These benefits reflect the avoided cost of replacing a project's power generation with power generated from an alternative source.

2. **Annual Benefits Of Avoided Pollution:** Relative to alternative types of power generation, such as a coal-fired plant, hydropower production generates less air pollution. FERC generally recognizes this avoided pollution as a benefit of hydropower projects.

3. **Annual Costs of Operation:** This cost reflects past investment costs owed on the project, anticipated future investment costs, and current operation and maintenance (O&M) costs.

[4] Throughout the report, we use the term "environmental measures" to refer to actions that would protect, mitigate damages to, and/or enhance the environment. FERC refers to environmental actions as "enhancements" because FERC assumes that the baseline for analysis is the waterway's existing conditions. In contrast, resource agencies view a new environmental action as a "mitigation of resource losses" because they assume a "without the project" baseline (i.e., conditions that would prevail after the project is removed). We discuss baseline issues in more detail in Chapters 3 and 4.

4. **Annual Benefits Of Project Services:** Beyond power generation, hydroelectric projects may offer benefits such as flood control, water supply, irrigation, and river navigability.

5. **Annual Costs Of Environmental Measures:** Many licensing decisions introduce operating conditions designed to protect, mitigate damages to, or improve environmental quality. These changes may result in direct costs and/or reduced power values.

6. **Annual Benefits Of Environmental Measures:** Environmental measures can improve fish and wildlife resources, recreational opportunities, and other aspects of environmental quality.

Chapter 3 provides a more detailed description of how FERC evaluates each of these components.

Potential Refinements to FERC's Economic Methodology

Under FERC's current economic methodology, the non-power benefits of relicensing alternatives are rarely quantified or incorporated in net benefit estimates. For example, current relicensing analyses rarely examine economic values associated with river recreation. This shortcoming and other methodological problems may bias relicensing decisions against alternatives that include environmental measures. In Chapter 4, we discuss how incorporating non-power values into net benefit estimates would improve FERC's analysis of relicensing alternatives. This establishes the basis for a more complete examination of the analytic methods available for estimating non-power values in Chapters 5 and 6. We also recommend several changes to FERC's economic analysis, including refinements to FERC's assumed discount rate and baseline for analysis and a new approach for estimating avoided pollution benefits.

Finally, we identify several potential problems with FERC's current approach to estimating gross power benefits and the costs of operation. Although these problems do not bias FERC's analysis in any systematic way, refinements to FERC's approach could improve the accuracy of net benefit estimates.

Exhibit 1-3 summarizes our recommended refinements and notes their implications for net benefit estimates. Collectively, these recommendations are intended to improve the quality of FERC's net benefit estimates and expand the usefulness of FERC's economic analysis in relicensing decisions.

Exhibit 1-3

SUMMARY OF RECOMMENDED REFINEMENTS TO HYDROPOWER RELICENSING ECONOMIC METHODOLOGY

Component In Current Economic Methodology	Problem With Current Analysis	Recommendations	Implications of Recommendations
Benefits of Environmental Measures	**Environmental benefits** not quantified or included in net benefit estimates.	Estimate environmental benefits and include them in net benefit calculations.	Increases the net benefits of alternatives calling for environmental measures.
Basic Assumptions	**Discount rate** of ten percent is too high.	Use a lower discount rate. Based on discount rates applied by other federal agencies, two percent (lower bound) and seven percent (upper bound) may be appropriate.	Increases the value of benefits that occur further into the future (e.g., the recovery of an ecosystem).
	Baseline for analysis does not account for "without the project" conditions.	Use information on what conditions would be like without the project as a reference point to identify potential non-power benefits associated with the river resource.	Ensures that the potential public benefits of river restoration receive due consideration.
Gross Power Benefits	**Energy demand** may be overstated.	Use independent sources (rather than applicant estimates) to assess the region's energy demand and the need to replace power that may be lost due to decommissioning or new licensing conditions.	Reduces potential bias in energy demand projections.
	Fuels costs may be overstated; **heat rates** may be understated.	Fuel costs can change rapidly; update fuel cost data regularly. Assume higher (less efficient) heats rates for new generation facilities, in the range of 6,500-7,500 BTU/kWh.	Improves accuracy of gross power benefit estimates.
	Length of plant life may be understated.	Assume a longer plant life -- perhaps 30 years -- for new replacement generation facilities.	Reduces replacement costs, thereby reducing gross power benefits, and project net benefit.
	Least cost thermal alternative approach is less accurate than using market price information.	Market information on electricity prices is becoming increasingly available. Where possible, use market prices to evaluate replacement power costs.	Improves accuracy of gross power benefit estimates.
Costs of Operation	**Sunk costs** are improperly included.	Only forward-looking costs are relevant to relicensing decisions. Remove sunk costs (referred to as "net investment costs" in FERC's analysis) from the economic analysis.	Reduces the costs of operation, increasing project net benefit.
	Timing of capital costs is assumed to be the first year of a new license.	Capital investments may not all be scheduled for the first year of a new license. Capital costs should reflect the year in which they are expected to occur.	Reduces the costs of operation, increasing project net benefit.
	Future costs to relicense or decommission are not included.	Reflect the real costs of operation by incorporating project relicensing or decommissioning costs in the economic analysis.	Increases the costs of operation, decreasing project net benefit
Avoided Pollution Benefits	**Avoided pollution benefits** based on pollution control costs rather than impacts of pollution *not* controlled.	Base benefits on avoided health and environmental impacts of pollution released.	May reduce avoided pollution benefits. Provides a more defensible basis for estimating avoided pollution benefits.

Research Methods for Assessing Non-Power Values

The primary recommendation for improving FERC's current economic analysis is more rigorous integration of non-power values into net benefit calculations. A variety of analytic approaches exist for characterizing the non-power benefits relevant in hydropower relicensing. The guidance offered in this report is designed to attune non-economists at FWS to these analytic techniques and how they can be applied in a relicensing context.

First, a number of primary research methods are potentially applicable in assessing non-power benefits. While this report does not offer detailed instructions on implementing such analyses, it provides the conceptual basis for recognizing when they are applicable. Exhibit 1-4 summarizes potentially useful techniques. As shown, several techniques are most conducive to valuing the recreational and aesthetic benefits associated with improved river resources. These techniques include travel cost models and contingent valuation. A number of other analytic approaches are best suited to analyzing the benefits of current project services. For example, avoided cost and factor income approaches can be used to analyze the value of water supplied by the project. Likewise, property value models may be applicable when considering the broad socioeconomic value of reservoirs to local communities. In Chapter 5, we discuss these potential applications and review the analytic demands and limitations of the various primary valuation methods.

Exhibit 1-4

PRIMARY VALUATION METHODS AND POTENTIAL APPLICATIONS IN HYDROPOWER RELICENSING

Valuation Methods		Example Applications
Revealed Preference	Market Supply and Demand Models	Value changes in commercial fishing catch resulting from increased spawning of anadromous species
	Travel Cost Models	Value changes in recreational activity (e.g., increased rafting from enhanced river flows)
	Property Value Models	Evaluate effect of reservoir management on property values
Stated Preference	Contingent Valuation	Assess value of improved recreation (e.g., improved catch rates resulting from improved fish habitat) Assess non-use values associated with free-flowing rivers
Other	Avoided Cost Approach	Value municipal water supplied by project
	Factor Income Approach	Value irrigation water supplied by project
	Instream Flow Valuation	Value increments to instream flow on basis of willingness to pay for recreational and aesthetic uses

In addition to primary valuation methods, "benefits transfer" approaches are potentially useful in assessing non-power benefits. Benefits transfer involves the application of unit value estimates and models from existing studies to estimate benefits associated with resources at the hydropower site in question. While benefits transfer has a number of important uncertainties and limitations, it allows for estimation of non-power benefits without undertaking potentially expensive and time-consuming primary research. As a result, benefits transfer may be useful as a screening tool to target more extensive research and analysis or may be the sole analytic approach when more costly original research is not feasible.

To facilitate use of benefits transfer, Chapter 6 reviews existing value estimates and analytic approaches for a number of benefit categories frequently at issue in hydropower relicensing. Specifically, we review the following:

- Estimates of willingness to pay for recreational fishing opportunities and changes in the quality of recreational fisheries;
- Estimates of willingness to pay for whitewater recreation (e.g., rafting, kayaking);
- Estimates of the marginal value of increments to instream flow and methods for comparing instream flow benefits to the cost of foregone power generation; and
- Estimates of non-use value associated with dam removal and free-flowing rivers.

Finally, Chapter 7 provides four case studies that illustrate how integration of non-power values might influence relicensing decisions. The objective is to demonstrate both the primary research techniques discussed in Chapter 5, as well as the benefits transfer approaches discussed in Chapter 6. Two of the cases focus on methods for establishing instream flows that balance power and non-power interests. Another case contrasts dam removal costs with use and non-use benefits estimated through a contingent valuation survey. Finally, one of the cases compares dam removal costs with recreational fishing and rafting benefits.

STRUCTURE OF THE REPORT

This report is divided into six chapters and three appendices.

- Chapter 2 provides an overview of the federal legislation and court rulings governing hydropower relicensing and summarizes the major steps of the relicensing process itself.
- Chapter 3 describes FERC's current economic analysis of hydropower relicensing.
- Chapter 4 provides a critical assessment of FERC's economic methodology and recommends refinements.
- Chapter 5 describes the primary analytic methods available for valuing non-power benefits of different relicensing alternatives.
- Chapter 6 discusses how benefits transfer techniques can be applied to develop screening analyses of non-power benefits.

- Chapter 7 presents case studies that demonstrate how non-power benefits can be valued and integrated into relicensing decisions.

- Appendix A examines modeling approaches for estimating potential regional economic impacts of relicensing alternatives (i.e., changes in output and employment of regional businesses). While such impacts cannot be integrated into the net benefit calculation, FWS staff may want to understand the derivation and relevance of such estimates. Appendix B presents a list of acronyms used in the report. Appendix C provides a glossary of key terms.

Throughout the report, we use a "pointer" symbol (☞) to call attention to key issues of relevance to FWS staff and to guide the reader to other sections of the document that discuss important topics in more detail.