

## Waterpower - Program 58

### Program Overview

#### Program Description

Climate change and the need for domestic energy sources present new opportunities for waterpower development and increased revenue from carbon credits and green energy power sales. Hydropower is challenged, however, by claims that it is not a renewable energy technology because of environmental concerns related to fish passage blockage, turbine mortality on downstream migrating fish, and potential greenhouse gas emissions. Through its Waterpower Program, the Electric Power Research Institute (EPRI) is the only central, industry-leveraged research organization that can cost-effectively address these issues and inform policy development.

The Waterpower Program assesses the potential, status, generation and environmental performance, and cost of waterpower technologies, including conventional hydropower and emerging technologies that use ocean, tidal, and in-stream energy. The program supports research on national and international issues of relevance to the waterpower industry, including technology development and optimization, resource assessment, fish passage and protection, environmental impact assessment and stewardship, and waterpower's relevance in creating a low-carbon future.

#### Research Value

This program helps the waterpower industry develop balanced, science-based strategies to optimize performance and safety, protect ecological resources, and allocate water to ensure continued cost-competitive hydropower operation while meeting other stakeholder and public needs. The program supports a public-private collaborative to develop the next generation of fish-friendly hydropower turbines and provides research and technical results that support recognition of hydropower as a renewable, domestic energy resource. Additional program research on emerging opportunities for marine energy technologies (ocean and tidal) allows interested parties to stay current with the latest technology developments while collaborating on innovative concepts for utility marine-energy electric applications and products. Critical motivation for this research is that the hydropower industry

- may lose designation as a renewable energy technology and be ineligible for renewable portfolio standards and reduction/elimination of carbon credits and power premiums,
- may face increased re-licensing costs,
- may be precluded from new development (at nonpowered existing dams and new dams), and
- may lose generation (revenues) as a result of stringent fish protection requirements, including high mitigation (fish passage and restoration) cost.

#### Approach

This program provides information, innovative mitigation technologies, and expert services to help the waterpower industry, government agencies, nongovernmental organizations, and the public effectively plan and manage waterpower development projects while also protecting environmental resources. The program delivers

- technical reports on critical waterpower industry issues, including resource potential, development needs (R&D, economic incentives, and regulatory enhancements), environmental production methods, and operation and maintenance of existing infrastructure;
- issue briefs that concisely review critical industry issues;

- conferences and workshops where waterpower industry issues and opportunities can be explored and discussed; and
- websites with the latest information on fish passage and protection and new ocean energy and hydrokinetic technology information

### Accomplishments

There is a newfound enthusiasm for what is usually been considered a mature technology. Generation-related research focuses on optimizing the performance and value of hydropower in a low-carbon future. Environment-related research focuses on maintaining EPRI's fish passage and protection reference manual and developing the next generation of environmentally enhanced ("fish-friendly") hydropower turbines. New research focuses on hydropower's contribution to greenhouse gas emissions and its relevance to global climate change. Program accomplishments include

- performance assessments and information on upstream and downstream fish passage technologies;
- assessment of waterpower's potential and its research, development, deployment, and demonstration needs;
- information resource documents on environmental protection, mitigation, and enhancement approaches;
- sound technical information to support federal and state endangered and threatened species listing assessments;
- advancement of fish-friendly turbine technology, including a \$1.2 million award from the U.S. Department of Energy (DOE) for field deployment and testing; and
- workshop and report/conference proceedings on hydropower in a low-carbon future and related new opportunities and challenges.

### Current Year Activities

Program R&D for 2010 will focus on continued development of the Alden/Concepts NREC fish-friendly turbine, year three of greenhouse gas research analysis, information summaries on key operational and maintenance (O&M) and performance optimization issues, and development of new information on hydropower pumped-storage development and opportunities. Specific efforts will include the following:

- Continued redesign (with DOE support) of the Alden/Concepts NREC advanced fish-friendly hydropower turbine in preparation for industry commercialization, field deployment, and testing
- Assessment of the greenhouse gas contribution of hydropower reservoirs in the United States
- Technology roundup analysis of key O&M issues, including plant performance optimization
- Analysis and documentation of best practices in the hydropower pumped-storage industry
- Continued assessment of waterpower growth opportunities and the R&D efforts required to attain them
- Expanded interest group activities in the area of hydropower, ocean, and tidal energy
- Ocean and hydrokinetic energy resource assessment updates and environmental impact analysis
- Examination of the role of waterpower relative to renewable portfolio standards and carbon dioxide costs or constraints, with deliverables including periodic intelligence reports, EPRI perspectives, and technical updates, presentations, and seminars
- Maintenance and updates of the EPRI Hydropower Fish Passage and Protection Manual
- Continued development of information on endangered and threatened species (e.g., American eel)

### Estimated 2010 Program Funding

\$0.75M

### Program Manager

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## Summary of Projects

Project Number	Project Title	Description
P58.001	Hydropower Technology	The Hydropower Technology project addresses hydro asset optimization and current hydro industry issues through a collaborative research forum offering seminars and workshops to address current industry hot topics, including a roundup report on a selected topic. Hydropower technology will also use epri.com Internet tools to share problems and proposed solutions and to extend the communication capabilities of the group.
P58.002	Fish Passage and Protection	State-of-the-art information on fish passage and protection at hydropower projects
P58.003	Advanced (Fish-Friendly) Hydropower Turbine Design Development	Engineering design; turbine model testing, including engineering and economic performance analysis; and field test plan development in preparation for future field deployment and demonstration of an advanced fish-friendly hydropower turbine.
P58.004	Valuation of the Environmental and Social Effects of Hydropower	Research examines the environmental and social effects of hydropower relative to other forms of power generation. Current focus is on resolving the issue of whether U.S. hydropower operations are a net contributor of GHG emissions. Initial research focuses on theoretical analyses, which may lead to future field sampling to gather empirical data to resolve the issue.

### P58.001 Hydropower Technology (063334)

#### Key Research Question

Many conventional hydropower plants face aging assets and workforce, with increasing demands on performance. At the same time, the value of these plants and their part in electric grid operations is increasing because of hydro's proven flexibility and response and in recognition of the renewable and low-carbon-emitting attributes of hydropower. Modernization issues include meeting environmental constraints, addressing CO<sub>2</sub> policy, and optimizing operating efficiency while delivering more precise control of plant output for regulation and ancillary services. Accreditation issues relate to qualifying for production tax and renewable energy credits, low-emitting and green power certificates, and other incentives for capacity expansions and efficiency improvements.

#### Approach

This project addresses current hydro industry issues through a collaborative forum offering updates on relevant R&D topics related to hydropower issues and opportunities plus workshops on current industry interests. The project aims to create a forum for members to discuss O&M issues with their peers and maintain an open dialogue with vendors regarding issues that are of mutual interest to the group. Reporting will depend on participation and the nature of the projects. A summary or roundup report from selected topics is planned. Participant meetings are held in conjunction with hydropower industry events such as the HydroVision, National Hydropower Association, and Waterpower conferences. As larger or more complex issues are identified, this project will address research needs in a collaborative structure, allowing reduced individual costs and broadening access to technical expertise.

## Impact

- Facilitating the exchange of information and sharing of best practices to position hydropower asset owners for a larger role as a nonemitting and renewable generation option
- Creating opportunities for collaborative R&D activities and sharing of experience with new technology applications for improved maintenance and operation in existing facilities and in optimizing plant operations
- Addressing current hydro industry technical issues through industry surveys, case studies, and an ongoing series of roundup summary reports
- Providing opportunities for interactions among peers to identify key issues in today's hydro industry and to pool resources to investigate and develop solutions of mutual benefit

## How to Apply Results

This project aims to improve O&M performance and help members revalue assets in existing hydropower facilities relative to new electricity market and system operator demands. The work addresses three application areas that present opportunities for hydropower in a carbon-constrained future: optimizing performance of existing assets, recognizing added value of assets in a carbon-constrained future, and qualifying incremental hydropower additions as low-impact and renewable generation.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Hydropower Technology Workshop:</b> The assembled package of the 2010 Hydropower Interest Group meeting will include results, presentations, future plans, discussion on selected workshop or summary topics, and summary materials.	10/01/10	Technical Resource
<b>Hydropower Summary Report:</b> EPRI will continue a series of topical reports that address hot issues in the hydropower industry (e.g., pumped storage), offering practical treatment of applications, field experience, and information from manufacturers or standards groups in a roundup report.	12/31/10	Technical Update

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Hydropower Roundup Report:</b> A one- to two-day workshop will cover a selected topic of interest to the Hydropower Interest Group. Candidate topics are obtained from advisor and interest group members.	12/31/11	Technical Update

## P58.002 Fish Passage and Protection (101904)

### Key Research Question

Protection of migratory and nonmigratory fish populations is an issue for most hydroelectric projects. Protection and passage requirements are expensive, reduce operating capacity, and limit development of the additional U.S. hydropower generation potential. Relevant information on design and operation of fish passage facilities is scattered, and many designs are untested or in need of further development.

### Approach

This project focuses on gathering new fish passage and protection information and maintaining EPRI's web-based fish passage and protection technical reference manual. This reference on technologies and

approaches for upstream and downstream fish passage will be revised as required by developments in research and application of technologies. Monitoring of professional literature and publications by resource agencies and Federal Energy Regulatory Commission (FERC) licensing results will support determination of the need for revised chapters. This project also investigates fish protection issues that are relevant to hydropower operation (e.g., American eels) and conducts research on development, optimization, and evaluation of fish passage technologies.

## Impact

Participation in this project provides the following benefits:

- Assistance and state-of-the-art technical information on all aspects of cost-effective approaches for fish passage and protection
- Contribution to the development of sound life-history technical information on fish and wildlife under consideration for federal and state listing as endangered or threatened species

## How to Apply Results

Hydroelectric project owners, operators, and stakeholders will use project information and technologies to analyze and plan environmental protection, mitigation, and enhancement alternatives during FERC relicensing of private investor-owned projects and during National Environmental Policy Act assessments conducted for federal projects.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Update of EPRI Fish Passage and Protection Manual:</b> Annual updates will be developed for EPRI's Fish Passage and Protection manual, a resource at <a href="http://www.epri.com">www.epri.com</a> for state-of-the-art knowledge on fish passage and protection at hydropower projects. Chapters for annual update are selected by EPRI program advisors.	12/31/10	Technical Update

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Update of EPRI Fish Passage and Protection Manual:</b> Annual updates will be developed for EPRI's Fish Passage and Protection manual, a resource on <a href="http://www.epri.com">www.epri.com</a> for state-of-the-art knowledge on fish passage and protection at hydropower projects. Chapters for annual update are selected by EPRI program advisors.	12/31/11	Technical Update

## P58.003 Advanced (Fish-Friendly) Hydropower Turbine Design Development (067514)

### Key Research Question

Development of environmentally enhanced, fish-friendly) hydropower turbines that cause minimal injury to passing fish offers an opportunity to maximize energy production while simultaneously providing a safe passage route for fish migrating or moving downstream. Fish-friendly turbines may also lead to development of additional U.S. waterpower energy resources, particularly at existing dams without hydroelectric power.

## Approach

This project redesigns the Alden/Concepts NREC advanced fish friendly hydropower turbine for installation and testing at a hydropower project. In 2009, EPRI was awarded a two-year, \$1.2 million research grant by the U.S. Department of Energy to complete the preliminary engineering design and model testing of this turbine. When this research is complete, the turbine will be ready for field deployment and testing. Research in 2010 will focus on physical model testing and refinement of the engineering design in accordance with test results. Annual workshops for the industry, government, and public will keep stakeholders informed on research progress and future deployment and field testing developments.

## Impact

- Fish passage survival and energy efficiency improvements through selection of optimized turbine system designs
- Advancement of hydropower as a component of renewable energy options

## How to Apply Results

The information will be used by hydroelectric project owners and operators in planning new hydropower developments as well as in upgrading existing projects with advanced hydropower turbine systems. Members are encouraged to attend workshops and meetings to obtain the results of the advanced hydropower turbine demonstration and the path for installing the technology.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Preliminary Engineering Design and Model Test Performance of the Alden/Concepts NREC Hydropower Turbine:</b> This report will present the final results of the two-year EPRI-DOE-Industry effort to complete the preliminary engineering design of the Alden/Concepts NREC turbine. The report will also present the results of the physical model testing performed by the turbine vendor. Model testing will examine both engineering and economic performance. Upon completion of this project, the turbine's design will be near 80% complete. The remaining design will be accomplished after a deployment site is selected.	12/31/10	Technical Report
<b>Advanced Turbine Workshop:</b> This workshop will review the technical progress in the development and deployment of all advanced hydropower turbines, including the EPRI-DOE effort to complete the preliminary engineering design of the Alden/Concepts NREC hydropower turbine. The workshop will be open to EPRI members, nonmembers, government agencies, academics, consultants, and nongovernmental organizations. Plans for field deployment and testing will be reviewed and discussed.	12/31/10	Workshop, Training, or Conference
<b>Field Evaluation Plan for Testing Fish Survival Through an Advanced Hydropower Turbine System (Fish-Friendly Turbine):</b> The field evaluation plan will specify the experimental procedures (e.g., species for testing, fish injection and collection locations, operating conditions, and variables for testing) for evaluating the turbine's performance when it is deployed.	12/31/10	Technical Report

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<p><b>Field Evaluation Plan for Testing Fish Survival Through an Advanced Hydropower Turbine System (Fish-Friendly Turbine): Plan Implementation:</b> In 2011, the site for testing of the advanced turbine is expected to be identified and installation of the turbine to be under way. The field evaluation plan for testing fish protection performance will be refined and implemented in accordance with the site-specific features of the hydropower plant (e.g., species for testing, fish injection and collection locations, operating conditions, and variables for testing).</p>	12/31/11	Technical Update
<p><b>Advanced Turbine Workshop:</b> This annual workshop for the industry, government, and public will update stakeholders on developments with advanced turbine development, deployment, and testing.</p>	12/31/11	Workshop, Training, or Conference
<p><b>Evaluation of Fish Survival Through an Advanced Hydropower Turbine System (Fish-Friendly Turbine):</b> This report will summarize the results of fish survival monitoring after passage through the fish-friendly hydropower turbine. Testing will be conducted at a field site where the advanced turbine is deployed (to be determined in 2010–2011).</p>	12/31/12	Technical Update

## P58.004 Valuation of the Environmental and Social Effects of Hydropower (067515)

### Key Research Question

Hydropower operations affect environmental (fish passage and protection, in-stream flows) and social (recreation, land use) values in a number of ways. A recent issue of concern, relative to hydropower's consideration as a renewable, non-carbon-emitting energy resource, is that hydropower reservoirs may be a source of greenhouse gas (GHG) emissions. This issue is of particular importance in tropical and possibly boreal regions, but the extent to which it is an issue in the temperate United States is not well understood. If hydropower is a contributor of GHGs, its value relative to renewable portfolio standards and production tax credits may be at risk.

### Approach

In 2008, EPRI began a three-year project to comprehensively examine the hydropower GHG emission issue for U.S. operations. In the first year, EPRI reviewed the available literature on GHG emissions from U.S. hydroelectric storage reservoirs. In 2009, EPRI examined the strengths and biases associated with available GHG measurement and modeling techniques. In 2010, EPRI will test existing techniques for measuring GHG emissions from reservoirs and develop a model framework for conducting a full GHG accounting of reservoir development and hydropower operations. Future-year research may involve empirical data collection via prototype laboratory and field studies.

### Impact

- Clarifying hydropower's role in a carbon-constrained future
- Providing information on the nature of hydropower as a domestic renewable energy resource

### How to Apply Results

The information from this project will be used by policymakers, hydroelectric project owners, project operators, and stakeholders (including the public) to better understand the relationship between hydropower operations and GHG emissions, support new hydropower production planning in a carbon-constrained future, and support generation pricing in accordance with carbon credit values.

## 2010 Products

Product Title & Description	Planned Completion Date	Product Type
<b>Experimental Protocols and Tools for Measuring Greenhouse Gas Emissions from Hydroelectric Reservoirs in the U.S.:</b> This technical update will review the available protocols for monitoring GHG emissions from hydroelectric reservoirs including the tools necessary. The report will also present a recommended protocol including potential sites in the U.S. for monitoring.	12/31/10	Technical Update

## Future Year Products

Product Title & Description	Planned Completion Date	Product Type
<b>Greenhouse Gas Emission Research from Hydropower Reservoirs: Year 3 Field Investigations:</b> In year three, EPRI will design a study that includes field investigations to fill gaps in the knowledge and understanding of hydropower operations and GHG emissions. The technical report will present the final results of the three-year EPRI research project.	12/31/11	Technical Report