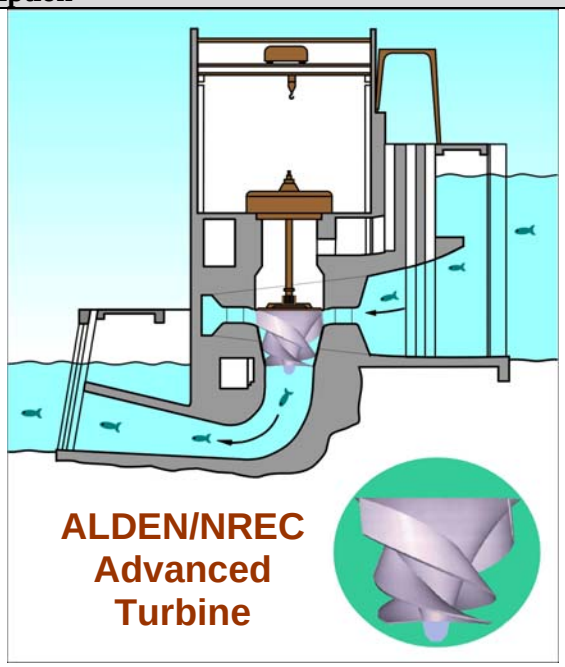
2.3.10 ADVANCED HYDROPOWER

Technology Description

Hydroelectric power generates no greenhouse gas. To the extent that existing hydropower can be maintained or expanded through advances in technology, it can continue to be an important part of a greenhouse gas emissions-free energy portfolio. Advanced hydropower is technology that produces hydroelectricity both efficiently and with improved environmental performance. Traditional hydropower may have environmental effects, such as fish mortality and changes to downstream water quality and quantity. The goal of advanced hydropower is to maximize the use of water for generation while improving environmental performance.



System Concepts

- Conventional hydropower projects use either impulse or reaction turbines to convert kinetic energy in flowing or falling water into turbine torque and power. Source water may be from free-flowing rivers, streams, or canals, or water released from upstream storage reservoirs.
- New environmental and biological criteria for turbine design and operation are being developed to help sustain hydropower's role as a clean, renewable energy source – and to enable upgrades of existing facilities and retrofits at existing dams.

Representative Technologies

- New turbine designs that improve survivability of fish that pass through the power plant.
- Autoventing turbines to increase dissolved oxygen in discharges downstream of dams.
- Reregulating and aerating weirs used to stabilize tailwater discharges and improve water quality.
- Adjustable-speed generators producing hydroelectricity over a wider range of heads and providing more uniform instream-flow releases without sacrificing generation opportunities.
- New assessment methods to balance instream-flow needs of fish with water for energy production and to optimize operation of reservoir systems.
- Advanced instrumentation and control systems that modify turbine operation to maximize environmental benefits and energy production.

Technology Status/Applications

- Hydropower provides about 78,000 MW of the nation's electrical-generating capability. This is about 80 percent of the electricity generated from renewable energy sources.
- Existing hydropower generation faces a combination of real and perceived environmental effects, regulatory pressures, and changes in energy economics (deregulation, etc.); potential hydropower resources are not being developed for similar reasons.
- Some new environmentally friendly technologies are being implemented
- DOE's Advanced Hydropower Turbine System (AHTS) program will be completing public-private partnerships with industry to demonstrate the feasibility of new turbine designs (e.g., aerating turbines at the Osage Dam, and a Minimum Gap Runner turbine at the Wanapum Dam).

Current Research, Development, and Demonstration

RD&D Goals

- By 2006, the completion of testing of hydroelectric turbine technology capable of reducing the rate of fish mortality to 2%, which would equal or better other methods of fish passage (e.g., spillways or fishways).
- Also in the near term, the goal is to complete the development of the Advanced Hydro Turbine Technology in support of maintaining hydroelectric generation capacity due for relicensing between 2010 and 2020.

RD&D Challenges

- Biological design criteria for new technology are limited by poor understanding of how fish respond to turbulent flows and other physical stresses inside turbines and downstream of dams.
- To affect public perception, field-testing will be needed to provide the evidence that fish survival through turbines is equal to or greater than survival in other passage routes around dams. Regulatory trends are shifting power plant operation from peaking to baseload, effectively reducing the energy value of hydroelectricity and reducing plant capacity factors; higher instream-flow requirements are reducing total energy production to protect downstream ecosystems, but scientific justification is weak.

RD&D Activities

- DOE's AHTS program constructed a test facility for pilot-scale testing of a new turbine design to evaluate hydraulic and biological performance; testing at this facility was completed in FY 2003.
- New biological design criteria to protect fish from shear and pressure have been developed in controlled laboratory experiments; computational fluid dynamics modeling and new sensor systems are producing new understanding of turbulence in turbines and draft tubes.
- Regional efforts by the Army Corps of Engineers and Bonneville Power Administration are producing solutions to some site-specific problems, especially in the Columbia River basin; but they are not addressing the national situation that is driven by market pressures and environmental regulation.
- Resource assessments of low-head and low-power resources were completed and analyzed.

Recent Progress

- TVA has demonstrated that improved turbine designs, equipment upgrades, and systems optimization can lead to significant economic and environmental benefits – energy production was increased approximately 12% while downstream fish resources were significantly improved.
- Field-testing of the Kaplan turbine Minimum Gap Runner design indicates that fish survival can be significantly increased, if conventional turbines are modified. The full complement of Minimum Gap Runner design features will be tested at the Wanapum Dam in FY 2005.

Commercialization and Deployment Activities

- Voith Siemens Hydro Power and the TVA have established a partnership to market environmentally friendly technology at hydropower facilities. Their products were developed in part by funding provided by DOE and the Corps of Engineers, as well as private sources.
- In a competitive solicitation, DOE accepted proposals for advanced turbine designs from Voith Siemens, Alstom, American Hydro, and General Electric Co., field verification and testing is underway with some of these designs to demonstrate improved environmental performance.
- Flash Technology is developing strobe lighting systems to force fish away from hydropower intakes and to avoid entrainment mortality in turbines. Implementation at more sites may allow improved environmental performance with reduced spillage.

Market Context

- Advanced hydropower products can be applied at more than 80% of existing hydropower projects (installed conventional capacity is now 78 GW); the potential market also includes 15-20 GW at existing dams (i.e., no new dams required for development) and more than 30 GW of undeveloped hydropower.
- Retrofitting advanced technology and optimizing system operations at existing facilities would lead to at least a 6% increase in energy output – if fully implemented, this would equate to 5 GW and 18,600 GWh of new, clean energy production.