



The Future of Waterpower: 23,000 MW+ by 2025

Douglas A. Dixon, Ph.D.
Senior Project Manager
EESI Briefing
June 8, 2007

Acknowledgements

- Vision of Dave Youlen & Linda Church-Ciocci (NHA)
- Hard work of Mike Bahleda & Mary Ann Adonizio
- Previous efforts of many from DOE National Labs (Doug Hall and Mike Sale), EPRI (Roger Bedard), and industry including the innovators of the emerging waterpower technologies
- Review, comment, and critique of many in the Waterpower Industry



Presentation in a Nutshell

- **Waterpower** Components:
 - Conventional hydropower
 - Ocean energy (waves)
 - Hydrokinetic (instream turbines)
- Available resource = 85,000 to 95,000 MW
- Realizable capacity gains by 2025 = 23,000 MW
- Potential efficiency gains conservatively estimated to be 2 to 5% (5,300 to 14,000 GWH or ~3,100 MW)
- Achievement dependent upon RDD&D and economic incentives + **regulatory enhancement**
- Advanced Water Energy Initiative Program proposed

Background

- Concern over canceled DOE hydropower research program:
 - Significant unfinished advanced turbine technology & system optimization research
- No federal funding for emerging water technologies
- **DESPITE EPACK 2005 mandate**
- Success of other renewable technology sectors in securing federal funding support for RDD&D
- No consolidated data or information resource to make the case that a significant, renewable, domestic, and low carbon emitting waterpower energy resource exists
- NHA President, Dave Youlen (Brookfield Power) outreach to emerging water energy interests & EPRI for collaboration and technical support

Energy Policy Act of 2005

Hydropower – The Secretary shall conduct a program of research, development, demonstration, and commercial application for cost competitive technologies that enable the development of new and incremental hydropower capacity, adding to the diversity of energy supply of the United States, including (i) fish friendly large turbines and (ii) advanced technologies to enhance environmental performance and yield greater energy efficiency

Miscellaneous Projects - ...conduct [RDD&D] for (i) ocean energy, including wave energy ... and (iv) hydrokinetic hydro turbines



OBJECTIVE:

**Characterize the current
waterpower industry,
assess the U.S.
resource, estimate
potential that can be
realized and document
the R&D and economic
incentives that could
contribute to its
achievement**

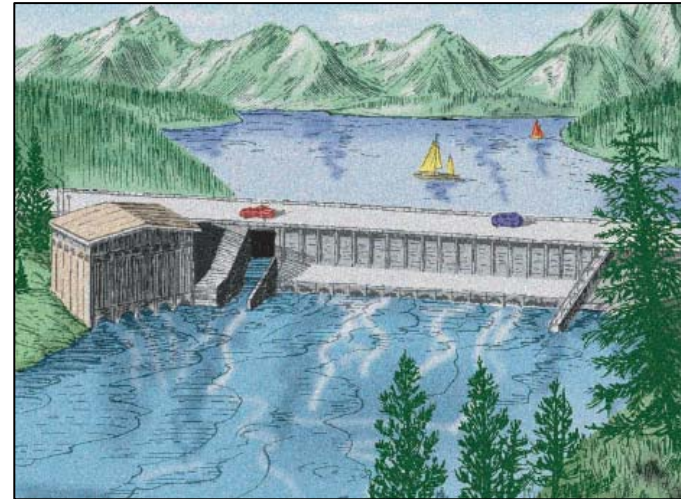
Approach

- Characterize waterpower energy sector and reviewed state-of-technology
- Gathered resource assessments (DOE, EPRI, BOR, COE, other)
- Estimated potential capacity additions & efficiency gains
- Reviewed types & importance of economic incentives
- Identified key RDD&D needs & required funding to be accomplished by a public-private **Advanced Water Energy Initiative Program**



What is the Resource?

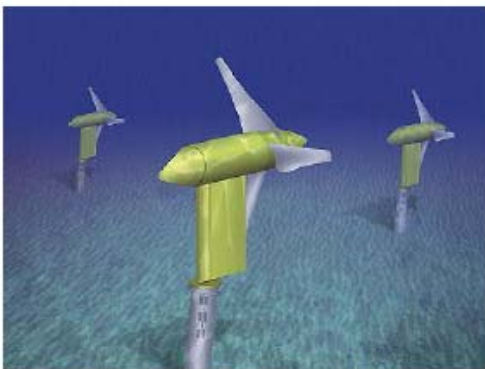
- Capacity additions at existing hydro
- Efficiency improvements at existing hydro
- New capacity at non-powered dams
- New conventional development
- Un-dammed moving water [hydrokinetic] (instream, tidal, ocean current, constructed waterways)
- Waves



New Emerging Waterpower Technologies

Hydrokinetic Turbines

- Horizontal axis turbines (like wind turbines)
- Vertical axis turbines
- Venturi devices
- Oscillating devices



Wave Energy Technologies

- Articulating or attenuator (Pelamis)
- Point absorber
- Over topping devices
- Oscillating water column



Waterpower Resource Assessment

- Conventional hydro (low power to large hydro = 62,300 MW):
 - Capacity gains at large & small hydro = 4,300 MW
 - New small (<30 MW) and low (<1 MW) hydro = 58,000 MW
 - New hydro at existing dams = (16,700 MW included above)
 - [Efficiency gains (4%) = 3,100 MW]
- Hydrokinetic = 12,800 MW (tidal only assessed for 5 states, ocean current not assessed)
- Wave Energy = 10,000 to 20,000 MW
- Pump storage not assessed
- **TOTAL = 85,100 - 95,100 MW**



Waterpower Realization (Conservative)

Technology	Potential	By 2010	By 2025
Conventional hydropower	62,300	525	10,000
Capacity gains at existing hydro	4,300	375	2,300
New small & low power hydro	58,000	125	2,700
New hydro at existing dams	(16,700)	25	5,000
Hydrokinetic	12,800	115	3,000
Ocean Wave energy	10,000 - 20,000	84	10,000
TOTAL	85,100 - 95,100	724	23,000

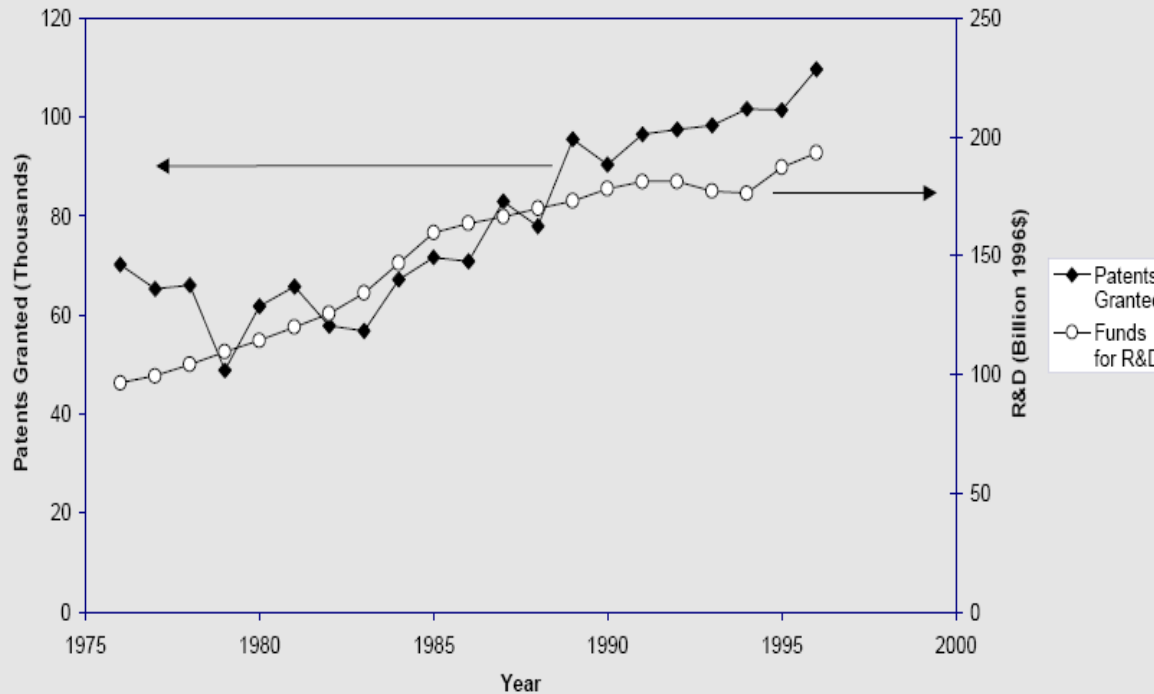
How Do We Get There?

- Research, Development, Deployment & Demonstration (RDD&D):
 - Environmental protection/performance
 - Efficiency improvements
 - New technology development & testing
- Economic incentives (PTCs/Clean Renewable Energy Bonds)



Importance of RDD&D Funding

Figure 2. Total U.S. patents granted and total U.S. investments in R&D.

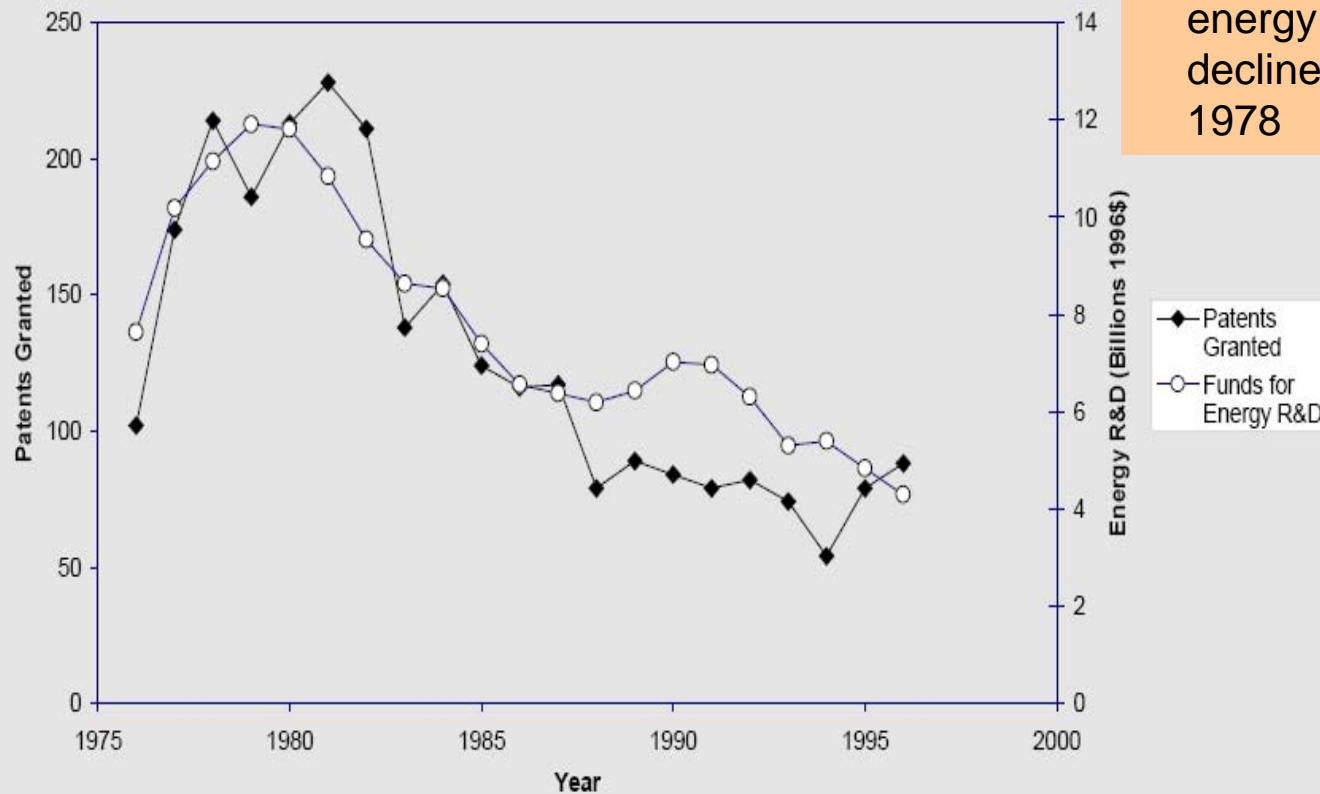


Total U.S. investments in R&D include both public and private R&D. Dollar values in this paper, unless otherwise noted, have been converted from current to constant 1996\$ using the GDP Chain-type Price Index (<http://www.bea.doc.gov/bea/dn/0898nip3/table3.htm>).

Source: Robert Margolis (Princeton) & Daniel Kammen (UC Berkeley)

Importance of Energy R&D Funding

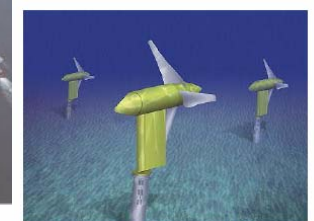
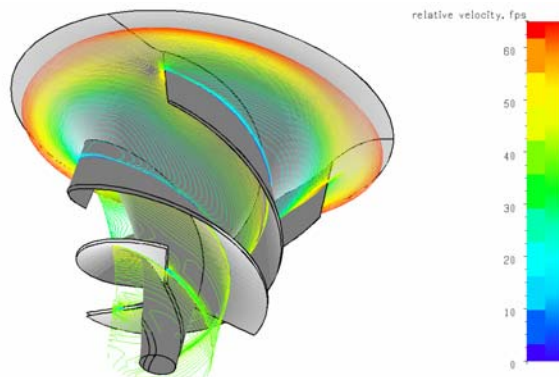
Figure 3. U.S. energy technology patents and total U.S. energy R&D.



Recent GAO Report (December 2006): U.S. energy R&D funding has declined by >85% since 1978

Exciting Technology Development

- Wave energy devices (Europe, Hawaii, Oregon)
- Hydrokinetic devices (RITE Project, SF Project)
- Conventional hydropower (not a mature technology)!



Advanced Hydropower Turbines: Wanapum Project Minimum Gap Runner

Grant County Public Utility District:

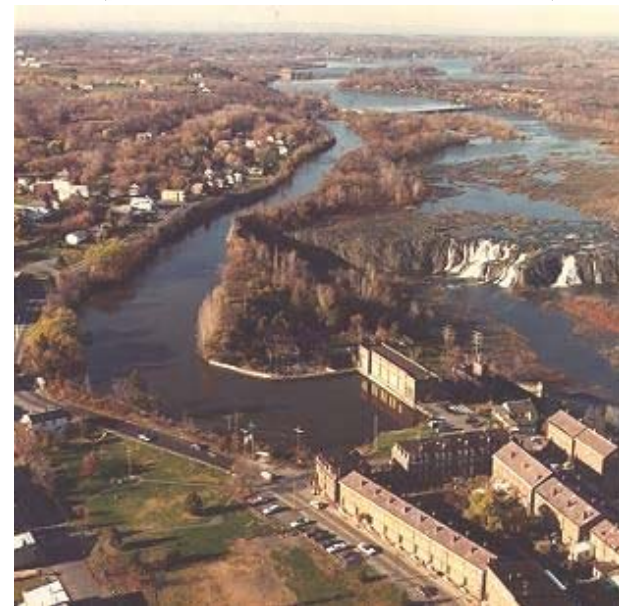
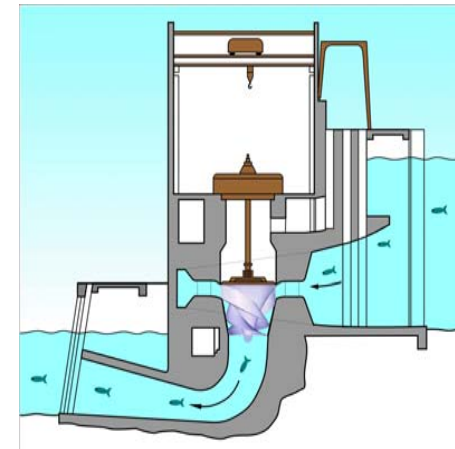
- 2005 – first installation & testing
 - Increased capacity & efficiency (**14%**)
 - Improved fish passage survival (**98%**) with additional gains possible
- 10 units replaced by 2012 (will pay for themselves in ~ 5 years)



Alden/Concepts NREC Turbine

- Pilot scale tests found fish survival ~93 to 100%
- Current EPRI Research:
 - Double power density (re-design scroll case & runner)
 - International participation (Electricité de France)
- Brookfield Power test installation: School Street Project, Albany, NY (~2009-2012)

Have resource agency support to examine fish passage through a turbine!



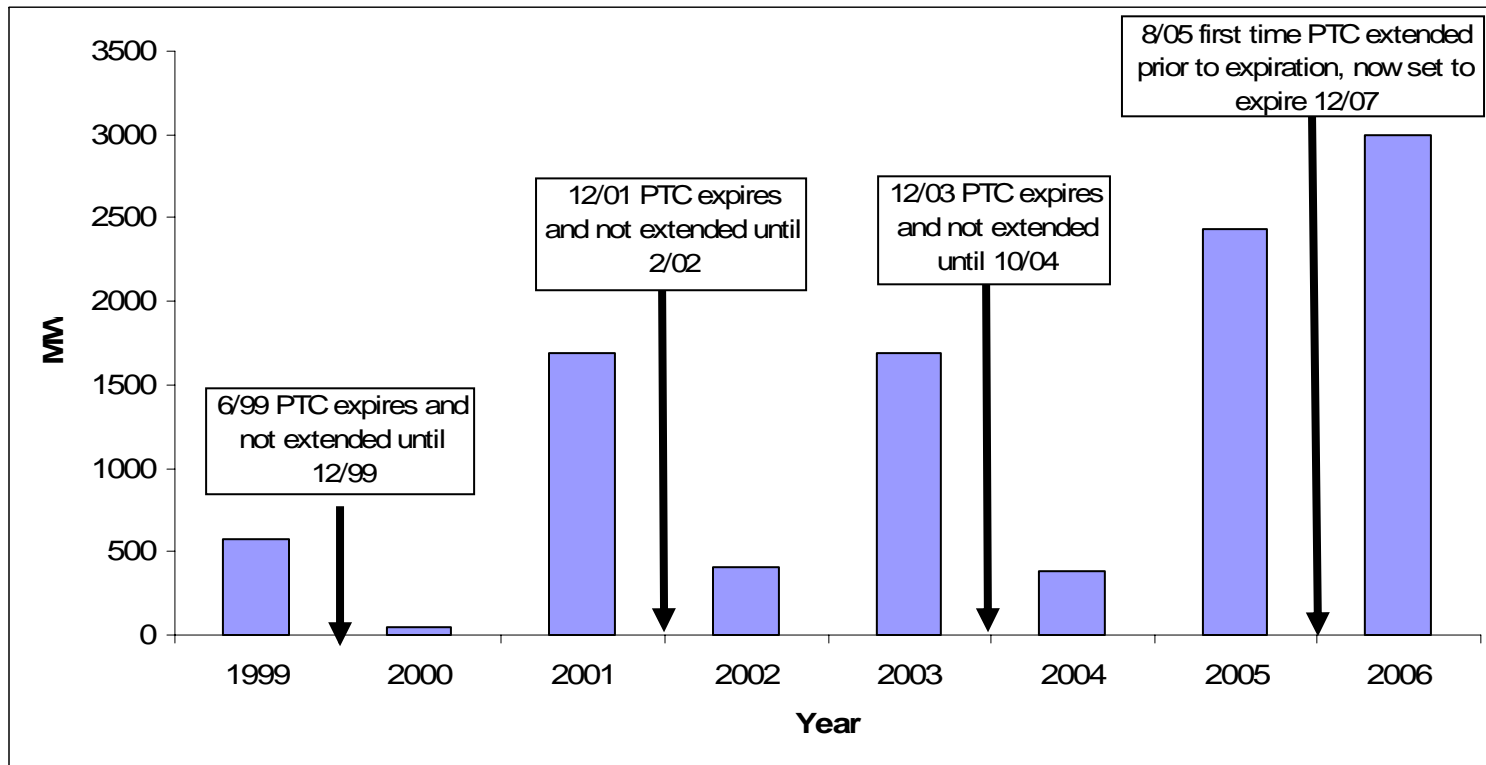
Advanced Water Energy Initiative (AWEI)

Public (DOE)- Private Collaborative:

- Waterpower Realization Committee – guidance & oversight
- Water Performance Initiatives – RDD&D to improve efficiency and environmental performance of conventional hydropower
- Waterpower Technology Development – RDD&D for hydrokinetic & ocean wave energy development
- Annual funding commitment of \$38 million



Wind Energy Development & PTCs



EPRI Report: Assessment of Waterpower Potential and Development Needs

Report 1014762, March 2007:

- Overview of the waterpower industry
- Waterpower potential
- Technology development needs (RDD&D, economic incentives, and regulatory issues)
- Achievable capacity and efficiency gains
- Waterpower's relevance to U.S. energy needs including other renewables



THANK YOU!

Douglas A. Dixon
Senior Project manager
804-642-1025 (Virginia Office)
ddixon@epri.com

Tom Key
Program manager – Hydro &
Renewables
865-218-8082 (Knoxville, TN)
tkey@epri.com

Roger Bedard
Ocean Energy Technology
Leader
650-855-2131 (Palo Alto, CA)
rbedard@epri.com

www.epri.com

Together...Shaping the Future
of Electricity