MARINE AND HYDROKINETIC ENERGY TECHNOLOGY: FINDING THE PATH TO COMMERCIALIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

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December 3, 2009

MARINE AND HYDROKINETIC ENERGY TECHNOLOGY: FINDING THE PATH TO COMMERCIALIZATION

THURSDAY, DECEMBER 3, 2009

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
COMMITTEE ON SCIENCE AND TECHNOLOGY
Washington, DC.

The Subcommittee met, pursuant to call, at 10:00 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Brian Baird [Chairman of the Subcommittee] presiding.

BART GORDON, TENNESSEE
CHAIRMAN

RALPH M. HALL, TEXAS
RANKING MEMBER

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COMMITTEE ON SCIENCE AND TECHNOLOGY

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Committee on Science and Technology
Subcommittee on Energy and Environment

Hearing on

Marine and Hydrokinetic Energy Technology: Finding a Path to Commercialization

Thursday, December 3, 2009
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Witness List

Mr. Jacques Beaudry-Losique
Deputy Assistant Secretary for Renewable Energy
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy (DOE)

Mr. Roger Bedard
Ocean Energy Leader
Electric Power Research Institute (EPRI)

Mr. James Dehlsen
Founder and Chairman
Ecomerit Technologies, LLC

Mr. Craig Collar
Senior Manager
Energy Resource Development
Snohomish County Public Utility District

Ms. Gia Schneider
Chief Executive Officer
Natel Energy, Inc.

HEARING CHARTER

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT
U.S. HOUSE OF REPRESENTATIVES

Marine and Hydrokinetic Energy Technology: Finding the Path to Commercialization

THURSDAY, DECEMBER 3, 2009
10:00 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

PURPOSE

On Thursday, December 3, the Subcommittee on Energy and Environment will hold a hearing entitled, *"Marine and Hydrokinetic Energy Technology: Finding the Path to Commercialization."* The purpose of the hearing is to explore the role of the Federal government and industry in developing technologies related to marine and hydrokinetic energy generation.

Similar to wind technologies of a few decades ago, interest in marine and hydrokinetic (MHK) technologies is increasing around the world. Also, as with the emergence of wind technologies of the 1970s, MHK technologies of today need a considerable amount of RD&D before commercialization. These technologies include wave, current (tidal, ocean and river), ocean thermal energy generation devices and related environmental monitoring technologies. There are a variety of energy conversion technologies and companies active in this field, and some MHK devices being demonstrated, primarily outside of the United States.

WITNESSES

- **Mr. Jacques Beaudry-Losique,** Deputy Assistant Secretary for Renewable Energy, U.S. Department of Energy
- **Mr. Roger Bedard,** Ocean Energy Leader, Electric Power Research Institute
- **Mr. Jim Dehlsen,** Founder & Chairman, Ecomerit Technologies, LLC
- **Mr. Craig W. Collar, P.E.,** Senior Manager for Energy Resource Development at Snohomish County Public Utility District
- **Ms. Gia Schneider,** Chief Executive Officer of Natel Energy, Inc.

BACKGROUND

The marine and hydrokinetic (MHK) renewable energy industry is relatively new, yet some of its technologies have roots from the growing wind industry. Experts in the industry expect that MHK technologies will follow a similar path as wind turbines. Significant achievement in efficiency enhancements and cost reductions during the past 30 years in the wind industry are transferable to MHK technologies. Similarly, the Electric Power Research Institute (EPRI) predicts that cost reduction forecasts for the MHK industry will follow a similar path as wind technologies, but not without overcoming some significant hurdles.

Studies have estimated that approximately 10 percent of U.S. national electricity demand may be met through river in-stream sites, tidal in-stream sites, and wave generation. This estimate includes approximately 140 TWh/yr from tidal and in-stream river technologies and 260 TWh/yr from wave generated electricity.[1] This does not include ocean thermal energy, ocean currents or other distributed generation in man-made water systems.

MHK generation could be important as it would meet the demand for coastal regions of the U.S. Coastal regions are home to 53 percent of the population of the U.S. despite comprising only 17 percent of the land in the country. 23 of the 25 most

[1] Electric Power Research Institute, "North American Ocean Energy Status." March, 2007.

populous counties are located in coastal regions and the 10 fastest growing counties are in coastal states—California, Florida, and Texas.[2]

Technologies and Industry Activity

Various MHK technologies can be used to harness energy from three major sources: currents (tidal, ocean and river), waves, and stored ocean thermal energy.

Current (tidal, ocean and river) Energy Technologies

There are several different energy technologies being used to harness the energy found in currents. Ocean currents of the world are untapped reservoirs of energy linked to winds and surface heating processes. The Gulf Stream is an example of an ocean current. Tides, another form of currents, are controlled primarily by the moon. As the tides rise and fall twice each day, they create strong tidal currents in coastal locations with fairly narrow passages. Examples include San Francisco's Golden Gate, the Tacoma Narrows in Washington's Puget Sound, and coastal areas of Alaska and Maine. Tidal in-stream energy conversion (TISEC) devices harness the kinetic energy of moving water and do not require a dam or impoundment of any type. Additionally, in-stream river technologies can be used in any kind of free flowing water, such as rivers or man-made canals.

Conversion devices used to harness energy from tidal currents are similar to those used for river currents, the major differences being that river currents are unidirectional and contain fresh water. Different kinds of currents turn turbines- either *horizontal* (axis of rotation is horizontal with respect to the ground, and parallel to the flow of water) or *vertical* (axis of rotation is perpendicular to the flow of water). The kinetic motion of the water turns the blades of the rotor, which then drives a mechanical generator. The systems used to harness energy from tidal and river currents are similar to those used in wind energy applications. These similarities lead many experts to believe that the development time for TISEC and in-stream river current conversion technologies may be less than other MHK technologies, such as wave energy conversion or ocean thermal energy conversion (OTEC) technologies.

Electricity generated from tidal currents has an estimated cost for a utility and municipal generator ranging from 4 cents/kWh to 12 cents/kWh, depending on power density.[3] Additional cost reductions will be achieved through economies of scale and improved engineering.[4] Despite the similarities between in-stream river devices and in-stream tidal devices, the former has no reliable studies regarding the cost of electricity. Research regarding the cost of electricity for river devices would help to expand the industry.

Companies across the country are developing devices to harness energy from currents. Verdant Power, established in 2000 and based in New York, has three different projects. Its longest running project is the Roosevelt Island Tidal Energy (RITE) Project operated in New York City's East River. In 2005, the Federal Energy Regulatory Commission (FERC) issued a special Declaratory Order allowing Verdant Power to produce and deliver electricity to end users during the testing phase of the RITE Project. The first federally licensed, in-stream hydrokinetic power plant, developed by Hydro Green Energy, was deployed on the Mississippi River in Hastings, Minnesota and began operating commercially on August 20, 2009. This project was approved in December 2008 by FERC. Pre-installation environmental testing has occurred since February 2009. The turbine has a nameplate capacity of 100 kW and its expected output is 35 kW. A second more efficient turbine is scheduled to come online in spring 2010.

Wave Energy Technologies

Wave energy conversion technologies use the motion of waves to generate mechanical energy that can be converted to electricity. There are many different devices in the testing, development, pre-commercial and commercial stages. While all systems operate under the same general concept of generating electricity through wave energy, they differ in design and method of electricity conversion components. Some of the most common technologies include: attenuators or linear absorbers, pitching/surging/heaving/sway (PSHS) devices, oscillating water columns, overtopping terminators, point absorbers, and submerged pressure differentials.

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[2] National Ocean and Atmospheric Administration, "Population Trends Along the Coastal United States". September 2004.

[3] This is the relationship between the density of the seawater (in kilograms per cubic meter) and the instantaneous speed or velocity of the stream (in meters per second).

[4] Electric Power Research Institute. "North America Tidal In-Stream Energy Conversion Technology Feasibility Study". June 11, 2006.

The Electric Power Research Institute (EPRI) states that the cost of electricity for electricity generated through wave energy conversion devices can range from 11.1 cents/kWh in parts of California to 39.1 cents/kWh in Maine. Wave technology is at approximately the same stage of development as wind technology 20 years ago, just starting its emergence as a commercial technology. At the beginning of wind power commercialization, the cost of electricity was over 20 cents/kWh. For each doubling of cumulative installed capacity, the cost of electricity from wind energy decreased by roughly18 percent. The cost of electricity is now around 6 cents/kWh (in 2006$). EPRI predicts that many MHK technologies will follow this same path.[5]

Despite the cost of wave energy generation several companies are pursing demonstration projects. Ocean Power Technologies (OPT) founded in 1994 and headquartered in Pennington, NJ has tested and is now deploying its PowerBuoy worldwide. In 2007, PNGC Power signed a funding agreement for OPT to develop a 150 kW PowerBuoy off the coast of Reedsport, Oregon. This project received $2 million in support from DOE in 2008. The first PowerBuoy is expected to be deployed in 2010. Pacific Gas & Electric Company (PG&E) is also looking at wave energy devices. They will be developing a testing center similar to the Wave Hub (discussed below) and has been awarded a cost sharing grant of 1.2 million by DOE for this project. The California Public Utility Commission is also contributing 4.8 million. The proposed WaveConnect project, to be located in Humboldt County, will be able to test up to four wave technologies at one time. PG&E was granted its FERC preliminary permit in March of 2008 and is planning to apply for its pilot plant license with the FERC in spring 2010.[6]

Ocean Thermal Energy Conversion Technologies

Ocean thermal energy conversion (OTEC) is an energy technology that converts solar radiation in the ocean to electric power. OTEC systems use the ocean's natural thermal gradient—the ocean's layers of water have different temperatures—to drive a powerproducing cycle. More than 70 percent of the Earth's surface is covered with oceans. This makes them the world's largest solar energy collector and energy storage system. On an average day, 60 million square kilometers (23 million square miles) of tropical seas absorb an amount of solar radiation equal in heat content to about 250 billion barrels of oil. A fraction of this stored energy can be converted to electricity with OTEC technologies.

The three types of systems used for OTEC are closed-cycle, open-cycle, and hybrid, which employ features from both closed and open-cycle systems. *Closed-cycle* utilizes a fluid with a low boiling point that is vaporized by warm surface seawater in a heat exchanger. The vapor turns a turbo-generator, and is then run though a second heat exchanger containing cold deep-seawater. This condenses the vapor back to the liquid form and it is then recycled through the system. *Open-cycle* technologies use warm seawater that boils when placed in a low-pressure container. The steam from the boiling water drives a low-pressure turbine that is attached to a generator. It is then condensed back to a liquid. *Hybrid* systems involve warm seawater which enters a vacuum chamber where it is flash-evaporated into steam, similar to the open-cycle evaporation process. The steam vaporizes a low-boiling-point fluid (in a closed-cycle loop) that drives a turbine to produce electricity.

Even though OTEC systems have no fuel costs, the high initial cost of building a facility makes OTEC generated electricity more expensive than conventional alternatives. Existing OTEC systems have a low overall efficiency, but there is reason to believe that subsequent technology advances and an expanded body of research based on off-shore oil and gas industry can make OTEC technologies cost-effective. Lockheed Martin Corporation reports that one of the key challenges facing OTEC is creating an economically viable plant. This situation is due to the non-linear scale-up of major OTEC subsystems—increasing the output power by a factor of ten increases the plant capital costs by factor three. The resulting cost of electricity from the first 100 MW commercial facility is calculated to be approximately 21 to 25 cents/kWh. These rates are competitive today in such locations as Hawaii and Guam. However, this number does not take into account several factors such as production and investment credits and decreased costs of future plants which further lower the cost.

OTEC systems currently are restricted to experimental and demonstration units. Island communities which currently rely on expensive, imported fossil fuels for electrical generation are the most promising market for OTEC. DOE originally funded research in OTEC in 1980 and has recently awarded two grants to Lockheed Martin

[5] Electric Power Research Institute. "North American Ocean Energy Status". March 2007.

[6] Electric Power Research Institute. "Offshore Ocean Wave Energy: A Summer 2009 Technology and Market Assessment Update," July 21, 2009.

Corporation totaling $1,000,000. The funding will help develop and describe designs, performance, and life-cycle costs for both the near shore and offshore OTEC baseline cost figures. Additionally, funding will go towards the development of a GIS-based dataset and software tool to assess the maximum extractable energy potential globally using OTEC technologies. The U.S. Navy has expressed considerable interest in OTEC. In September of this year the U.S. Naval Facilities Engineering Command (NAVFAC) recently awarded Lockheed Martin an $8.12 million contract to further the OTEC technology development.

International Activities

Many countries are developing MHK energy technologies. Brazil, Canada, the Netherlands, Italy, China, Sweden, Mexico, Germany, Australia, Portugal, India, Ireland, Japan, Denmark, Greece, New Zealand and many others are all operating MHK energy devices at the various scales of testing and commercialization. For example, South Korea deployed their first commercial tidal power plant in May of this year. It is estimated that this device will power approximately 430 households annually, and by 2013 it will have up to 90,000 kW of capacity and supply electricity to 46,000 houses. South Korea is also developing an additional 254 kW tidal power plant in Sihwa, which is scheduled to be completed by the end of next year.

The United Kingdom (UK) has made efforts to develop MHK energy technology. It has established specific funding streams and centers for development and testing of MHK technologies. The UK's marine energy goal is to have 2 GW of installed capacity by 2020. The Government is also developing a Marine Action Plan that is expected to be published by spring 2010. The Marine Renewables Proving Fund was established by the UK Government to provide up to $32.8 million in grants for the testing and demonstration of pre-commercial wave and tidal stream technologies. They also have established the Marine Renewables Deployment Fund, which will support technologies as they move from development to deployment. Additionally, three device testing centers have been established with a combined funding of up to $56.6 million from the UK Government. They are:

- *New and Renewable Energy Centre (NaREC):* The UK Government appropriated $14.5 million to build on and utilize existing infrastructure to provide an open access facility for marine developers to test and prove designs/components onshore. This facility includes complete in-house prototype development facilities for wave technology, including a wave tank, mechanical and electrical design engineering and procurement, electrical engineering consultancy and support for power conversion and drive train development, complete system testing from marine environment to grid connection, resource and feasibility assessment and consultancy, market analysis and research, and project management, funding, and investment coordination.
- *European Marine Energy Centre (EMEC):* EMEC was established following a recommendation by the House of Commons Committee on Science and Technology in 2002. The UK will provide $11.9 million as part of a renewable energy strategy for their in-sea stage testing facilities—the only multi-berth, purpose-built, open-sea testing facilities in the world. The Edinburgh-based Pelamis Wave Power technology has generated electricity to the national grid from its deep water floating device at EMEC's wave test site. After being tested, the Pelamis was deployed and connected to the Portuguese grid in the fall of 2008, but is currently not in operation. Verdant Power, Ocean Power Technologies and Columbia Power Technologies, as well as other MHK energy developers based in the United States have tested their technologies or interacted with EMEC's testing facilities and staff. EMEC is linked with a range of different developers and devices, as well as academic institutions and regulatory bodies. EMEC aims to ensure that different devices are monitored in a consistent way, using the best available methods. Furthermore, the dissemination of monitoring information can be carried out throughout the industry, regulatory bodies and their advisors, as appropriate.
- *The Wave Hub:* Due to be built in 2010, the Wave Hub is a $62 million project in which a collection of wave energy conversion devices will be connected to the national grid through high voltage sub-sea cables. It will be the UK's first offshore facility for the demonstration of wave energy generation devices.

Barriers to Generation in the United States

Despite the fact that the U.S. has significant MHK resources and several companies interested in the technology, more investment and greater attention has been paid to these technologies in Europe. The U.S. MHK industry is behind Europe and this could be because of a variety of interconnected financial, regulatory, and environmental barriers.

While cost remains one of the largest barriers, it is estimated that with appropriate pilot and commercial scale demonstration of MHK technologies, the cost of MHK generated electricity will quickly decrease over time. Getting from pilot to commercial scale requires investment in small-scale systems which are not yet proven technologies. It is already difficult to finance new renewable projects with the existing state and federal incentives. MHK projects have an additional set of unique environmental and regulatory barriers which add to the cost of installation and project uncertainty which investors find risky. As a result, developers are put in the position of needing to push for large commercial technologies to drive costs down, but will not do so until a technology is demonstrated and proven commercially viable.

Project finances are heavily dependent upon the pace of the regulatory permitting process. This regulatory permitting process can be costly, lengthy, and complex, and is a very significant barrier to MHK development in the United States (not the focus of this hearing). This process includes activities such as lease and revenue negotiations, submittal of plans and operations concerning the demonstration site assessment, construction and operations requirements, environmental and safety monitoring and inspections. Generally, many of these qualifications have not changed for over a half century and were developed for traditional hydropower plants or for oil and gas projects, not for demonstration MHK activities. Although earlier this year the FERC and Mineral Management Service (MMS) established a less complex permitting, licensing, leasing framework, and pilot project approval process, there are still upwards of 20 other federal, state, and local regulatory agencies which oversee MHK projects.

Part of the complex net of regulatory barriers for MHK devices are the environmental impact requirements needed for permits and licenses. Baseline data collections and significant monitoring of individual sites are needed to fully understand the impacts of MHK devices on the environment. Although environmental issues are expected to be minor for small numbers of units, one factor to be considered is whether large numbers of units will have more significant impacts on the environment. Techniques or models are needed to predict the cumulative effects of multiple units in order to guide deployment and monitoring.[7] A system of management practices, known as "adaptive management," is being used to identify potential environmental impacts, monitor these impacts, and compare them against quantified environmental performance goals. Adaptive management is particularly valuable in the early stages of technology development. In addition to site-specific research, collaborative research that is shared across industry groups and federal agencies is being discussed as a way to meet environmental requirements. Participants in a workshop convened by the DOE agreed that a facility, like the UK's EMEC, would be useful in carrying out environmental studies and making results publicly available.

Department of Energy Marine and Hydrokinetic Activities

The U.S. became involved in marine renewable energy research in 1974 when the Hawaii State Legislature established the Natural Energy Laboratory of Hawaii Authority. The Laboratory became one of the world's leading test facilities for OTEC technologies, but work there was discontinued in 2000. In 1980, two laws were enacted to promote the commercial development of OTEC technology: the Ocean Thermal Energy Conversion Act, (P.L. 96–320), later modified by P.L. 98–623, and the Ocean Thermal Energy Conversion Research, Development, and Demonstration Act, P.L. 96–310.

The Congress did not act on MHK technology 2005 (P.L. 109–58). Included in section 931(a)(2)(E) was a broad authorization for research, development, demonstration, and commercial application programs for ocean energy, including wave energy. That authorization contained no further instructions on how to structure a MHK program and expires after FY 2010. Then as part of the Energy Independence and Security Act of 2007 (EISA, P.L. 110–140) the Marine Renewable Energy Research and Development Act of 2007 was authorized. This directed the DOE to support RD&D and commercial application programs for MHK renewable energy technologies, including tidal flow and ocean thermal energy conversion technologies, and authorized DOE to provide grants to higher education institutions for establishment of national centers for marine renewable energy research, development, and demonstration. This research received an authorization of appropriations for $50,000,000 annually from 2008 to 2012. Additionally, DOE is required to submit

[7] Fisheries. Volume 32 Number 4. "Potential Impacts of Hydrokinetic and Wave Energy Conversion Technologies on Aquatic Environments". April 2007.

a report in June of 2009 to Congress that addresses the potential environmental impacts of MHK technologies—the report has not been submitted as of yet.

Since the 2007 EISA authorization DOE has established a portfolio of RD&D activities within the Wind and Hydropower program in the Office of Energy Efficiency and Renewable Energy. The DOE has received $10, $40 and $50 million over the last three years for all of the programs water activities, this includes traditional hydropower. The MHK activities have received a small amount of funding and the program has issued a variety of small awards to fulfill its statutory obligations. The two national centers were awarded $1.25 million each for up to 5 years: Northwest National Marine Renewable Energy Center, a partnership between Oregon State University and the University of Washington; and the National Marine Renewable Energy Center of Hawaii. DOE's program priorities for their solicitations include systems deployment, testing and validation; cost reduction and system performance/reliability; understanding environmental effects; resource modeling; and development evaluation and performance standards.

Although DOE has made significant efforts to conduct MHK RD&D, it is not clear if DOE is able to meet the needs of the industry under the current structure of the program. This hearing seeks to address the following questions: (1) Should MHK activities be removed from the larger Wind and Hydropower program and become its own technology program? (2) How could test facilities or specific grants help deploy more MHK devices into the actual demonstrate sites? and (3) How can the DOE, working with other federal agencies, help overcome environmental and regulatory barriers through better practices and improved technologies?

Chairman BAIRD. Good morning, everyone, and welcome to our hearing on Marine and Hydrokinetic Energy Technology: Finding a Path to Commercialization.

In today's hearing we will explore the role of the Federal Government and industry in developing technologies related to marine and hydrokinetic energy generation. These technologies include devices which harness energy from waves, tidal, ocean and river currents, and ocean thermal gradients. Development of related environmental monitoring technologies is critical for appropriate implementation of these emerging technologies.

Studies have estimated that approximately 10 percent of U.S. national electric demand may be met through energy generation from river in-stream sites, tidal in-stream sites and wave generation. This projection does not include ocean thermal energy, ocean currents or other distributed energy generation from manmade water systems. While there is a huge potential for energy from these technologies in the United States, the U.K. has been referred to as the world leader in ocean energy development by the International Energy Agency (IEA) and the Electric Power Research Institute (EPRI). The world-renowned testing facilities of the European Marine Energy Centre are at the forefront of technology development, and are the premier test bed and information center for policymakers, academia and U.S. companies with new technologies.

The United States became involved in marine renewable energy research in 1974 and enacted two laws on ocean thermal energy in 1980. The Congress did not authorize significant research on these technologies until the Energy Independence and Security Act (EISA) of 2007. Since then DOE has built up a modest portfolio of marine energy R&D activities within the Wind and Hydropower program of the Office of Energy Efficiency and Renewable Energy. This program has received a small amount of funding and issued a variety of small awards to fulfill its statutory obligations.

In my own home state of Washington, DOE has funded OpenHydro, a tidal technology developer based in Ireland and selected by the Snohomish County Public Utility District to design and install a tidal energy pilot plant in Admiralty Inlet. I am glad we have a representative of Snohomish here with us today so we can hear about this project, which is expected to begin operation as early as 2011 and produce up to one megawatt of energy—enough to power roughly 700 homes.

With few exceptions, marine and hydrokinetic technologies will need to be competitive in the marketplace if they are to be widely deployed. Therefore, I am especially interested to hear from our witnesses about the current and projected costs of electricity generated from marine and hydrokinetic technologies and how a more robust federal program might help in bringing these costs down.

With that, I would like to thank our excellent panel of witnesses, who we will hear from a moment.

[The prepared statement of Chairman Baird follows:]

PREPARED STATEMENT OF CHAIRMAN BRIAN BAIRD

In today's hearing we will explore the role of the Federal government and industry in developing technologies related to marine and hydrokinetic energy generation.

These technologies include devices which harness energy from waves, tidal, ocean and river currents, and ocean thermal gradients. Development of related environmental monitoring technologies is critical for appropriate implementation of these emerging technologies.

Studies have estimated that approximately 10 percent of U.S. national electricity demand may be met through energy generation from river in-stream sites, tidal in-stream sites, and wave generation. This projection does not include ocean thermal energy, ocean currents or other distributed energy generation from man-made water systems.

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The world renowned testing facilities of the European Marine Energy Centre are at the forefront of technology development, and are the premier test bed and information center for policymakers, academia, and U.S. companies with new technologies.

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With that, I'd like to thank this excellent panel of witnesses for appearing before the Subcommittee this morning, and I yield to our distinguished Ranking Member, Mr. Inglis, for his opening remarks.

Chairman BAIRD. At this point I recognize the distinguished Ranking Member, Mr. Inglis, for his opening remarks.

Mr. INGLIS. Thank you, Mr. Chairman, and thank you for holding this hearing.

This is a timely hearing. This year we have held hearings on solar, wind and biomass energy sources. Hydropower contributes more renewable energy to the U.S. electrical grid than all these other renewable sources combined. Depending on rainfall and water storage, conventional hydropower accounts for 6 to 9 percent, that is 6 to 9 percent of the total U.S. electrical supply.

Today we have the opportunity to explore ways to increase the contribution from hydropower through unconventional water sources. Marine-based hydropower represents a significant source of unused energy. South Carolina has a coastline of nearly 200 miles and considerable tidal resources around the Sea Islands. Technologies that can take advantage of the waves, currents, temperature differences and tides can turn our abundant coastal and tidal zones into energy generators.

As we will hear from our witnesses, these technologies will face a number of challenges related to environmental conditions and competition with recreational and commercial activities. I am confident, though, that we can manage all these challenges to utilize this large potential energy source. Microhydro represents a great opportunity for distributed electricity generation in streams and rivers, irrigation canals and other bodies of water previously not considered powerful enough for power generation. Hydropower installations of 1 megawatt or less can be deployed across the country, easing the burden on our electrical grid and increasing the security of electricity users around the country.

I am looking forward to hearing from our witnesses today on the current state of these technologies, what we need to move forward and what role the government should play in removing barriers to development and installation.

Thank you again, Mr. Chairman, and I yield back.

[The prepared statement of Mr. Inglis follows:]

PREPARED STATEMENT OF REPRESENTATIVE BOB INGLIS

Good morning and thank you for holding this hearing, Mr. Chairman.

This is a timely hearing, Mr. Chairman. This year, we have held hearings on solar, wind, and biomass energy sources. Hydropower contributes more renewable energy to the U.S. electrical grid than all of these other renewable sources, combined. Depending on rainfall and water storage, conventional hydropower accounts for 6–9% of the total U.S. electricity supply. Today we have the opportunity to explore ways to increase the contribution from hydropwer through unconventional water sources.

Marine based hydropower represents a significant source of unused energy. South Carolina alone has a coastline of nearly 200 miles and considerable tidal resources around the Sea Islands. Technologies that can take advantage of the waves, currents, temperature differences, and tides can turn our abundant coastal and tidal zones into energy generators. As we'll hear from our witnesses, these technologies will face a number of challenges related to environmental conditions and competition with recreational and commercial activities. I am confident that we can manage all of these challenges to utilize this large potential energy source.

Microhydro represents a great opportunity for distributed electricity generation in streams and rivers, irrigation canals, and other bodies of water previously not considered powerful enough for power generation. Hydropower installations of I megawatt or less can be deployed across the country easing the burden on our electrical grid and increasing the security of electricity users across the country.

I am looking forward to hearing from our witnesses today on the current state of these technologies, what we need to move forward, and what role the government should play in removing barriers to development and installation. Thank you again, Mr. Chairman, and I yield back.

[The prepared statement of Mr. Costello follows:]

PREPARED STATEMENT OF REPRESENTATIVE JERRY F. COSTELLO

Good Morning. Thank you, Mr. Chairman, for holding today's hearing to examine the future of marine and hydrokinetic energy technology (MHT) research and development (R&D) efforts.

MHT may become an efficient source of renewable energy in the future, and many U.S. companies have expressed interest in researching and developing technologies to harness energy from major sources of water. However, MHT remains years away from being a commercial source of energy because of several barriers, such as regulations and high costs.

I am interested in hearing from our witnesses what steps they believe are necessary to move these projects to the demonstration phase and if there is a greater burden from the current regulatory system or if the financial barriers to developing large-scale markets is overly restrictive. I would like to know how this Subcommittee can help overcome these burdens to move this research forward.

Finally, several of our international partners, in particular South Korea and the United Kingdom, have made substantial investments and developed large-scale demonstration projects in MHT. I am interested in hearing how U.S. research efforts can work with their international partners to learn from these demonstration projects.

I welcome our panel of witnesses, and I look forward to their testimony. Thank you again, Mr. Chairman.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Good morning, Mr. Chairman and Ranking Member.

Thank you for holding today's hearing on marine and hydrokinetic technologies and finding a pathway for their commercialization.

Today we have an opportunity to discuss what could potentially be one of our greatest untapped renewable energy resources, water. Where there is moving water, there is an enormous potential for power.

The possibility of utilizing the hydrokinetic energy our Nation's vast coastlines possess is more than promising. Estimates suggest that the amount of energy that could feasibly be captured from U.S. waves, tides and river currents is enough to power over 67 million homes. As we search to find viable and sustainable renewable energy technology, we must consider the great potential hydrokinetic technologies promise to yield.

My state of Texas has a solid industrial base for design, fabrication and installation of marine structures. Texas also has a trained workforce of divers and undersea technicians that would be easily employable in a marine power industry for installation and maintenance of these power facilities. The Gulf Coast including the complete Texas coastline has a strong potential for development. My district, which encompasses Dallas, Texas certainly has industry that could help marine and hydrokinetic power move forward.

Although we can not, at the present, move completely away from finite resources for fuel, we should begin to research and employ renewable technology. Additionally, we must make a thoughtful transition to clean renewable energy in a manner that would sustain the competitiveness of crucial energy intensive industries that not only provide our Country with jobs but also provide the world with products. As we choose which energy resources to develop we must carefully weigh all of their impacts.

Today's witnesses are of some of the top experts in the fields of Marine and Hydrokinetic Energy. They have provided much thought to this topic. I am keenly interested to hearing your opinions on how we can provide a cost-effective environmentally safe method to deploy these technologies.

Mr. Chairman, I want to welcome today's witnesses. Thank you, and I yield back the balance of my time.

Chairman BAIRD. I thank you, Mr. Inglis. We have been joined by Dr. Ehlers and also by Mr. Smith from Nebraska. I am always glad to see someone from Nebraska here at a tidal energy thing. It shows that the concerns about global warming must be real if we are planning on tidal energy in Nebraska. We have got problems on our hands. But good to see you, Mr. Smith. Thank you. He is an excellent Member of this committee. I am glad to have him here.

With this, we will hear from our witnesses. Mr. Jacques Beaudry-Losique is the Deputy Assistant Secretary for Renewable Energy at the Office of Energy Efficiency and Renewable Energy for the U.S. Department of Energy. Mr. Roger Bedard is the Ocean Energy Leader for the Electric Power Research Institute. Mr. James Dehlsen is the Founder and Chairman of Ecomerit Technologies LLC. Ms. Gia Schneider is the Chief Executive Officer of Natel Energy. Did I skip somebody? Oh, okay. I am sorry. And we are hoping Mr. Inslee will be here to introduce Mr. Collar but I get the pleasant duty of doing that. From my home state, Mr. Craig Collar is the Senior Manager of Energy Resource Development for Snohomish County PUD, or Snopud, as they sometimes call it, but I think Snohomish PUD is a better deal. A beautiful county and great tidal resources there if we can figure out how to harness them. So we have an outstanding panel of witnesses, and as our witnesses know, you will have five minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. When you have completed your spoken testimony, we will begin with questions. Each member of our panel will have five minutes to question witnesses. With that, we look forward to your testimony. Thank you again for being here.

Mr. Beaudry-Losique.

STATEMENTS OF JACQUES BEAUDRY-LOSIQUE, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. BEAUDRY-LOSIQUE. Chairman Baird, Ranking Member Inglis and Subcommittee Members, it is a pleasure to testify this morning. Thank you for your leadership in bringing these important marine and hydrokinetic energy technologies to the attention of the American public. The Department of Energy shares your belief that these technologies have significant potential to contribute to the Nation's future supply of clean, cost-effective renewable energy.

Studies conducted by the University of Washington, Virginia Tech and the Electric Power Research Institute estimate approximately 400 terawatt-hours per year can be extracted from marine and hydrokinetic technologies in this country, excluding ocean thermal systems. This is enough electricity to power cleanly approximately 36 million average American homes.

The Department of Energy's Office of Energy Efficiency and Renewable Energy allocated a substantial portion of its Congressional appropriations for water power toward the support of marine and hydrokinetics projects. In fiscal year 2008, $9.1 million supported 14 marine and hydrokinetic projects. In fiscal year 2009, funding more than tripled to $31.3 million, which supported a total of 41 separate projects. And in fiscal year 2010 we expect approximately $35 million to support marine and hydrokinetics projects.

The Department provides needed research and development funding for the industry, which is still at a relatively early stage of development and includes many small firms. Only one commercial project is currently operating in the United States, a 100-kilowatt in-river turbine on the Mississippi River in Hastings, Minnesota. Therefore, much of the work the Department funds focuses on two major priorities: one, assessing the Nation's resources, and two, determining baseline potential future costs of energy through analysis and testing of device performance and reliability, and the extent to which there are environmental impacts associated with these technologies.

In order to monitor this developing industry, the Department recently created an online database for devices under development. This database provides detailed information about the testing and deployment of these technologies around the world, even though the majority of development is occurring in Europe, North America, Japan and South Korea. The database currently tracks 149 companies working on 123 devices, which demonstrates that no firm industry consensus exists as to which technology will perform most efficiently. In fact, technology selection is highly dependent upon regional factors.

We segment the marine and hydrokinetic industry into three major categories: one, wave energy, two, currents such as ocean, tidal and river; and three, ocean thermal energy conversion, or OTEC. In the first case, the United States has experienced significant growth in the wave energy industry in the last decade and there are currently more than a dozen domestic companies and developers in existence. The size of the domestic resources encourage the development of this technology, particularly in the Pacific Northwest.

Second, the Department is committed to working with industry to develop ocean, tidal and river current technologies. For example, the Department recently made awards to develop the first drive train uniquely designed for large ocean current design devices and for a pylon-based mooring system to increase efficiency of in-river turbines. The Department also funds a number of projects in one of the most promising areas in the country for development of tidal energy: the Puget Sound in Washington the State. For the past year, DOE and the Snohomish County Public Utility District have jointly funded an initial survey siting and permitting work necessary for the construction and installation of up to three turbines at a tidal energy pilot in the Admiralty Inlet west of Whidbey Island.

Third, ocean thermal energy conversion systems use the ocean's natural temperature to generate power. OTEC could produce significant amounts of alternative energy for tropical island communities that rely heavily on imported fuels. The Department is currently assessing OTEC lifecycle costs, testing and manufacturing methods for coldwater pipes, developing a national resource assessment, and evaluating specific environmental impacts associated with large water intake systems.

Furthermore, to help achieve program objectives, the Department created and currently utilizes National Marine Renewable Energy Centers. The centers are public private partnerships with the goals of promoting research, development and deployment of marine energy technologies. In 2009, two centers were formally established, one at the University of Hawaii and the other as a partnership between the University of Washington and Oregon State University. The Department is pleased with the progress that has taken place at the centers since their recent inception. As an aside, next week

I will visit the Pacific Northwest National Laboratory's Sequim Marine Research Facilities, which work in partnership with the centers.

Finally, to enable market development, the Department collaborates with the International Electrotechnical Commission to develop codes and standards for all three groups of emerging technologies, as well as with the International Energy Agency to create a worldwide database of environmental research and best monitoring practices for these technologies.

Looking to the future, the Department is currently developing an industry roadmap. This effort will identify the various barriers that limit progress and highlight the technology developments, policies and other activities necessary to overcome these barriers. The first step is essential to ensure that marine and hydrokinetic power can become another significant resource to the Nation's clean energy portfolio in the long term.

So thank you again for the opportunity to appear before you today to discuss these important issues, and I am looking forward to answering any questions.

[The prepared statement of Mr. Beaudry-Losique follows:]

PREPARED STATEMENT OF BEAUDRY-LOSIQUE

Chairman Baird, Ranking Member Inglis, Members of the Committee, thank you for the opportunity to appear before you today to discuss the U.S. Department of Energy's Water Power Program and its activities related to marine and hydrokinetic energy generation technologies.

The global marine and hydrokinetic industry consists of energy extraction technologies that utilize the motion of waves, the currents of tides, oceans, and rivers, and the thermal gradients present in equatorial oceans. The Department of Energy (DOE) believes that marine and hydrokinetic energy technologies have significant potential to contribute to the nation's future supply of clean, cost-effective, renewable energy. In its March 2007 *Assessment of Waterpower Potential and Development Needs,* the Electric Power Research Institute (EPRI) conservatively indicated that marine and hydrokinetic power (exclusive of ocean thermal energy resources) could provide an additional 23,000 megawatts (MW) of capacity by 2025 and nearly 100,000 MW by 2050. In a more recent 2009 study appearing in HydroReview, collaborating authors from the University of Washington, the Virginia Tech Advanced Research Institute, and EPRI refined earlier estimates to conclude that resources could conservatively yield a total of 51,000 MW of extractable energy.[1] This estimate is the equivalent of 34 conventional coal-fired power plants.[2] The Department is currently developing predictive cost and performance models to assess the near- and mid-term economic potential for developing these resources.

According to recent industry studies,[3] potential ocean thermal energy conversion (OTEC) resources may be even larger.[4] However, it is necessary to note that preliminary estimates of extractable U.S. resources are just estimates of technical potential that do not equate to economically recoverable energy. There still remains an industry need for detailed, comprehensive resource assessments and validation of the costs for recovering this energy, which the Department is currently supporting through its programs.

The marine and hydrokinetic energy industry is still at a relatively early stage of development with less than a half dozen small commercial projects installed

[1] Bedard, Roger. George Hagerman. Brian Polagye. Mirko Previsic. "Ocean Wave and In-Stream "Hydrokinetic" Energy Resources of the United States." Forthcoming publication in HydroReview. 2009.

[2] Figures are based on the assumptions of an average coal plant with 500 MW of capacity, operating with a 90% capacity factor, and the average marine and hydrokinetic plant operating with a 30% capacity factor.

[3] Nihous, Gérard. "An Order-of-Magnitude Estimate of Ocean Thermal Energy Conversion Resources." Journal of Energy Resources Technology. December 2005. Vol. 127. p 328; Nihous, Gérard. "A Preliminary Assessment of Ocean Thermal Energy Conversion Resources." Journal of Energy Resources Technology. March 2007. Vol. 129. p. 17.

[4] Estimates are between 3,000,000–5,000,000 MW for global installed capacity.

worldwide and only one operating in the U.S., a river hydrokinetic project in Hastings, Minnesota. Much of the work being funded through the Department is, therefore, focused on evaluating the size, location and specific characteristics of the Nation's off-shore ocean and river energy resources, establishing baseline cost, performance and reliability data for a variety of devices, and assessing the environmental impacts associated with various technologies.

As part of our comprehensive effort to evaluate marine and hydrokinetic energy, the Department also funds targeted, innovative research and development projects with industry partners and the National Laboratories to address the near-term technical challenges to device development and deployment, helping to generate reliable, validated performance data and identify key cost drivers and reduction opportunities. The Department leverages its extensive expertise in technology development to identify and fund research in areas where industry currently lacks either the capabilities or financial resources.

Technology Overview

In order to monitor this developing industry, the Department has recently created an online database for marine and hydrokinetic devices that provides detailed information about the different technologies and deployment activities occurring around the world. There are currently dozens of unique device designs, and no firm industry consensus as to which technologies will perform the most efficiently and effectively. The database can present a snapshot of projects in a given region, assess the progress of a certain technology type, or provide a comprehensive view of the entire marine and hydrokinetic energy industry.[5] Based on information collected for this database, the following is an overview of the different types of marine and hydrokinetic technologies being developed around the world.

Wave Energy Technologies

Wave energy can be harvested from offshore, near shore, and shore-based environments through a number of engineering approaches. While there is currently no international consensus on nomenclature for wave energy devices, the Department is working with the Intergovernmental Panel on Climate Change and the International Electrotechnical Commission on standards to better define terminology. Major technology types are listed below.

- *Attenuators:* linear, jointed structures aligned parallel to the direction of the oncoming wave. Attenuators capture wave energy from the relative motion of their jointed parts as the wave passes along them.
- *Point absorbers:* floating structures that captures energy through mechanical motion as they rise and fall with the waves at or near the water surface.
- *Oscillating wave surge converters:* near shore designs that derive power from the back and forth movement of wave surge. These devices often function as pumps, using pistons to drive water through submerged or land based turbines.
- *Oscillating water columns:* channel waves into a partially submerged hollow chamber. The rise and fall of water within the structure pressurizes the chamber's air column and forces air through a turbine at high velocities.
- *Overtopping devices:* a category of floating or shore-based structures that are partially submerged, and funnel waves over the top of the structure into an elevated reservoir. Water then runs out of the reservoir through a turbine.
- A variety of fully submerged devices are under development that capture energy from the pressure differential induced within a device from passing waves. Such pressure difference can be used to drive a fluid pump to create mechanical energy.

Wave energy currently represents the largest sector of the marine and hydrokinetic industry both nationally and globally. The U.S. has experienced significant growth in the number of wave technology developers in the last decade, and there are now more than a dozen operating throughout the country, with the majority developing point absorber technologies.[6] However, the United Kingdom still leads countries in the total number of wave technology developers, as well as the number of technologies in the latter stages of development. To date, the U.K. is the

[5] The database can be accessed at *http://windandhydro.energy.gov/*.

[6] "Marine and Hydrokinetic Technology Database." Wind & Hydropower Technologies Program. (Online, 6/19/2009, *http://www1.eere.energy.gov/windandhydro/hydrokinetic/default.aspx*).

only country in which a company's commercialized wave technology has been sold to a publicly traded utility.

Current-Based Energy Technologies

Technologies designed to capture the energy from moving ocean, tidal, or river currents represent a smaller sector of the marine and hydrokinetic industry, but can be considered more mature relative to wave technologies due to the mechanical similarities hydrokinetic turbines share with wind turbines. One of the main technological differences between tidal current devices and those designed to capture energy from ocean or river currents is the need for tidal devices to be either bi-directional or change their orientation with the ebb and flow of the tides. Generally, current-based technologies can be divided into three categories: axial flow turbines, cross flow turbines, and reciprocating devices.

- *Axial or horizontal axis turbines:* typically consist of three or more blades mounted on a horizontal shaft to form a rotor that is oriented toward the direction of the flow. The kinetic motion of the water current creates lift on the blades causing the rotor to turn driving a mechanical generator. Axial flow turbines can also utilize a shroud to protect and accelerate water past the blades.
- *Cross flow turbines:* typically have two or three blades mounted along a vertical shaft to form a rotor. These devices can extract multi-directional flows without the need to orient to the direction of the flow. The kinetic motion of the water current creates lift on the blades causing the rotor to turn driving a mechanical generator.
- *Reciprocating devices:* generate electricity through an oscillating motion caused by the lift and drag forces of the water stream (similar to the tail motion of a fish or marine mammal like a whale or dolphin). Mechanical energy from this oscillation feeds into a power conversion system.

Although the roots of the modern current technology sector can be found in the U.S., developers of current-based technologies in the U.K. were quick to develop and deploy axial flow turbines during the late 1990s and early 2000s to take advantage of the strong tidal flows located in U.K. waters. The first grid-connected axial flow turbine, known as "Seaflow," was installed in May of 2003 on the North Devon Coast in the U.K. Most of the technology development in this sector is focused on axial flow turbines and is occurring in the U.K., U.S., Ireland, Canada, Norway, Australia and New Zealand. With the exception of two companies that are currently developing cross flow turbines, all development of current-based technology in the U.S. has focused on axial flow turbines.

Ocean Thermal Energy Technologies

Ocean thermal energy conversion (OTEC) systems use the ocean's natural thermal gradient to drive a power-producing cycle. Temperature differences between warm surface waters and colder deep waters need to differ by about 20 °C (36 °F) for OTEC devices to produce significant amounts of power.

The technology's lack of widespread development is due in part to high upfront capital costs, which has delayed the financing of a permanent, continuously operating OTEC plant. However, OTEC technologies could potentially produce significant amounts of alternative energy for tropical island communities that rely heavily on imported fuels. Most research and development to date has taken place in the U.S., Japan, Taiwan, and India.

Tidal Energy Case Study: Puget Sound

As one of the most promising areas in the country for the development of tidal energy, the Puget Sound in Washington State is currently home to a number of projects being funded by the Department. For the past year, the Department and the Snohomish County Public Utility District (SnoPUD) have jointly funded the initial survey, siting and permitting work necessary for the construction and installation of up to three turbines at a tidal energy pilot plant in the Admiralty Inlet, west of Whidbey Island. It was recently announced that the turbines will be designed and constructed by OpenHydro, a company specializing in shrouded, horizontal-axis turbines. SnoPUD will also be working with the Department and the Pacific Northwest National Laboratory over the coming year to determine the types of aquatic species present in the Admiralty Inlet, and will further determine both baseline levels of background noise as well as the acoustic impacts that hydrokinetic turbines could have on these species. Finally, as part of an ongoing project between the Department and the Northwest National Marine Renewable Energy Center to develop integrated instrumentation packages to collect environmental data, researchers at the

University of Washington have deployed state-of-the-art equipment at the potential SnoPUD site to evaluate water quality, flow characteristics, substrate composition and sedimentation rates.

Overview of the Water Power Program

The primary objective of the Department's marine and hydrokinetic energy activities is to evaluate the potential contribution that each of the aforementioned technologies can make to the nation's energy supply, through the development of accurate resource assessments, performance profiles, and lifecycle costs. Once the potential of the various technologies is better understood, the Department can make more targeted strategic decisions about which portfolio of research and development projects to support, based on the most promising marine and hydrokinetic technologies.

Resource Assessments

The Department is currently funding five separate resource assessments to quantify potential technically extractable marine and hydrokinetic energy by resource type and location. These include assessments for wave, tidal, ocean current, river current, and ocean thermal energy potential. The data generated by these projects will help stakeholders assess the potential contribution to the U.S. renewable energy portfolio and prioritize the level of investment for each resource type. Two assessments (wave and tidal) are scheduled to be completed by the end of fiscal year 2010. The other three assessments were only recently awarded in September through the Department's competitive solicitation process and are thus still in the process of negotiating contracts for the data collection. The Department aims to have each of those three assessments completed within one calendar year of project initiation.

Siting Issues and Environmental Impacts

The Department is also working to understand the environmental and navigational impacts of marine and hydrokinetic energy technologies and to find ways to mitigate any adverse impacts. DOE is using this information to identify best siting practices for marine and hydrokinetic technologies and to create mitigation strategies to address these impacts. DOE is also working with other government organizations to develop best practices for ensuring the process of siting and permitting is effective and efficient.

Under a cost-share contract with the Department's Bonneville Power Administration (BPA) and funds from certain BPA customer utilities and Washington State organizations, Golder Associates has been developing the "Integrated Decision Support System (IDSS)" for location, assessment, and optimization of in-stream tidal power development in Washington State. The IDSS is a computing platform to identify and analyze potential environmental, navigation, and fisheries issues and conflicts related to siting. The platform will be a multi-user, web-based geographic information system and tidal simulation model database, including power estimation tools. The IDSS is intended to provide siting decision-makers the information they need to make sound siting decisions.

In addition, the Department conducts targeted research into the impacts of marine and hydrokinetic technologies on ocean habitats and individual wildlife populations, including fish and marine mammals. This research includes studies how different types of hydrokinetic turbines can harm or change the behavior of fish, investigates the impacts of extracting energy from an ocean system on sedimentation rates, and tests a limited range marine mammal acoustic-deterrent system at an open water location.

Technology Performance and Cost Modeling

To determine the economic feasibility of harnessing the Nation's marine and hydrokinetic energy resources, the Department is supporting the development of numerical predictive cost and performance models as well as technology development projects in each area to generate real-life data to support and validate the models.

Although certain marine and hydrokinetic energy devices have been developed and deployed as pilot-scale demonstration projects, very few have operated continually for significant periods of time. As a result, the efficiency, reliability, survivability, and cost of the various devices types are not well quantified.

To validate, refine, and improve these models, the Department is also partnering with industry to develop and deploy individual marine and hydrokinetic devices that will generate the real-world data necessary to inform accurate analyses of device cost, performance, and environmental impacts. Partnering with industry will directly reduce the time required to develop projects, and will provide critical data on device performance and reliability. The Department's efforts include support for in-water testing and development projects, as well as work to design devices, sub-systems, and components.

Specific industry-led technology design and development projects include:

- Siting studies and the design of a grid-connected test berth being developed by Pacific Gas & Electric Company for multiple wave energy devices;
- Construction and demonstration of an oscillating water column device (called the Ocean Wave Energy Converter) by Concepts ETI, Inc.;
- Development and installation of a tidal energy device in the Puget Sound by Snohomish County Public Utility District;
- Demonstration of advanced composite cold water pipes for ocean thermal energy conversion devices by Lockheed Martin;
- Design and testing of a 2.5 MW Aquantis Current Plane ocean current turbine, intended for eventual deployment off the coast of southeastern Florida, by Dehlsen Associates, LLC;
- Optimization, demonstration, and validation of an intermediate-scale wave buoy from Columbia Power Technologies, Inc. in preparation for a full-scale ocean deployment;
- Scale-up of a previously tested power-buoy from Ocean Power Technologies, which will increase the power extraction rate, increase survivability, and reduce operation and maintenance costs;
- A Cooperative Research and Development Agreement with Verdant Power to improve and refine the company's tidal turbine rotor;
- Design and validation of an innovative floating support structure from Principal Power Inc. that combines wave and wind energy power take-off mechanisms to defray the mooring and installation costs associated with higher power output;
- Design and testing of an easily replicable, modifiable mooring system for fast-water tidal energy devices by Ocean Renewable Power Company, LLC; and
- Design, testing, and deployment in the Mississippi River of a pylon-based mooring structure for in-river turbine current technology from Free Flow Power Corporation.

In addition to the above projects that are focused on developing specific devices and technologies, the Department also funds the development of models, tools, and materials that can be widely used by the entire industry to optimize performance, predict loads, minimize failures, and reduce costs. The Department also maintains a database of all U.S. facilities capable of conducting hydrodynamic testing of marine and hydrokinetic devices, and is developing a program to aid developers in testing and validating initial sub-scale device designs.

Budget and Funding for Specific Technologies

The Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) has allocated a substantial portion of its Congressional appropriation for Water Power toward the support of marine and hydrokinetic projects. In fiscal year 2008, $9.05 million supported marine and hydrokinetic projects, while $31.3 million in fiscal year 2009 funding supported these projects. Some projects utilizing these funds are technology-specific while others are cross-cutting in nature. The Department plans to continue to provide financial support for marine and hydrokinetic projects as appropriate and according to Congressional appropriations and guidance.

In fiscal years 2008 and 2009, the Department awarded approximately $5.8 million to five separate projects focused specifically on wave energy development. These projects included a resource assessment, the design and siting of a grid-connected open-water device testing berth, engineering and testing an intermediate scale oscillating water column device, and two projects to build and test next generation point absorbing buoys.

During the past two years, the Water Power Program awarded approximately $4.5 million to six tidal energy-specific projects. These include a U.S. tidal energy resources assessment, the testing of new environmental monitoring equipment for tidal projects, surveys of aquatic species in the Admiralty Inlet, engineering design and construction approvals for a pilot tidal plant, and projects to design more efficient tidal turbine rotors and more reliable mooring systems.

In the area of ocean-current energy, the Program awarded $1.9 million across three ocean-current-specific projects, including the development of the first drive-train uniquely designed for large ocean current devices, a U.S. resource assessment, and the development of environmental survey methodologies for potential projects located off the southeast coast of Florida.

For river-current technologies, the Program awarded approximately $1.3 million to two river-current-specific projects, including the development of a pylon-based mooring system designed to reduce device installation and maintenance times and increase efficiency, and a nationwide assessment of in-stream hydrokinetic resources.

The Department awarded approximately $2.6 million in fiscal year 2008 and fiscal year 2009 to four projects focused on OTEC. These projects include a specific evaluation of the environmental impacts associated with the water intake systems, the validation and testing of a new manufacturing method for OTEC cold-water pipes, a resource assessment, and an assessment of the lifecycle costs of OTEC devices. In August 2009, the Navy also announced that it would award over $8 million to Lockheed Martin for OTEC component and subsystem design and testing. That project will be able to build upon the research currently being conducted by DOE, and collaboration between our two agencies will continue to ensure that there are no duplicated efforts.

The Department is developing lifecycle cost and performance profiles for different marine and hydrokinetic energy device classes, including wave, tidal, ocean current, in-stream hydrokinetic, and ocean thermal energy conversion. These profiles are informed by baseline representative commercial project development data from specific sites. The baseline cost of energy data will allow the Department to characterize and evaluate competing device classes and to identify the key drivers affecting the cost of marine and hydrokinetic energy. Verification of these data will also help the Department prioritize research and development efforts in a manner that assists and complements the industry's efforts.

National Marine Renewable Energy Centers

One of the mechanisms for achieving Departmental objectives has been to create and utilize National Marine Renewable Energy Centers (NMRECs), where a wide variety of work can be conducted. In 2009, two NMRECs were formally established—one at the University of Hawaii, and another as a partnership between the University of Washington and Oregon State University (known as the Northwest NMREC). The Centers are public-private partnerships between the universities, private companies, non-profits and governmental organizations, all with the goals of promoting research, development and deployment of marine energy technologies.

The work at the Northwest NMREC is primarily focused on wave and tidal research, with Oregon State focusing on wave technology applications and the University of Washington concentrating on tidal technology. Projects currently underway include:

- development of advanced wave forecasting technologies;
- creation of models used to optimize the placement and spacing of wave devices;
- site selection and design for an open water test berth for wave energy devices; and
- development of integrated instrumentation packages to collect environmental data.

Projects at the NMREC in Hawaii are focused on both wave and ocean thermal energy conversion technologies, and include:

- validation of wave forecasting models using real-time data;
- upgrades to wave tank facilities to accommodate device testing by developers;
- identification and testing of environmentally friendly material coatings; and
- modification of a submersible transport and recovery vessel able to deploy large instrumentation packages.

The Department is pleased with the progress that has taken place at the Centers over the short one year period since inception. During the past month, the programs at both Centers were critiqued by a panel of independent experts as part of an EERE-mandated peer review for all marine and hydrokinetic projects. Peer Reviews are rigorous, formal, and documented evaluation processes that use objective criteria and qualified, independent reviewers to evaluate the technical, scientific or business merit, and the productivity and management effectiveness of programs and projects. The results of the peer review for the Department's marine and hydrokinetic technology program will be made publicly available within the next three months.

Because of the significant research and development work occurring outside the U.S., establishing and maintaining collaborative efforts with the international community has also been extremely important. Currently, representatives for the Department are leading work on Annex IV of the International Energy Agency's Implementing Agreement on Ocean Energy Systems. The goal of this international collaboration is to assess worldwide research on the environmental effects and monitoring efforts for ocean wave, tidal, and current energy systems and will result in a global, publicly-available database of information, studies and best monitoring practices.

The need for international metrics to determine technology readiness levels and performance is also paramount, and so the Department is engaged with the International Electrotechnical Commission (IEC) to facilitate the development of relevant industry standards, provide consistency and predictability to their development, and to better represent U.S. interests. The IEC is based out of Geneva, Switzerland and is actively supported by 76 member countries in its efforts to prepare and publish international standards for all electrical, electronic and related technologies. Because of their technical expertise, the National Renewable Energy Laboratory (NREL) and Science Applications International Corporation (SAIC) were jointly selected to represent the Department on the U.S. Technical Advisory Group to the committee and to support the participation of key U.S. industry technical experts in the four relevant standards development working groups of the IEC.

Strategic Program Planning

Looking to the future, the Department is supporting the marine and hydrokinetic energy sector in developing a unified industry vision and roadmap. This effort will detail the various technical, non-technical and market barriers that limit progress and highlight the technology developments, policies, and other activities necessary to overcome such barriers. Based on industry consensus, NREL was selected to lead the project to develop this roadmap on behalf of the Department, with work scheduled for completion by the end of fiscal year 2010.

The Department has also convened several workshops with members of the marine and hydrokinetic industry in order to better align the Department's efforts with the needs of industry stakeholders before a formal roadmap is completed. The first of these meetings, hosted by the Department and EPRI, was held in October 2008, and the resulting report is publicly available at *http://oceanenergy.epri.com/oceanenergy.html#briefings.*[7]

The development of a marine and hydrokinetic industry roadmap directly supports DOE's ongoing internal efforts to develop a detailed Multi-Year Program Plan for the Water Power Program. All of the resource and technology characterization work currently underway is a crucial part in developing such a plan. As an industry roadmap is developed and ocean energy resources are accurately characterized, the program will be able to more efficiently prioritize future efforts, and tackle the barriers to technology development and deployment that it is best suited to address. The Multi-Year Program Plan for the Water Power Program is scheduled to be completed and made publicly available by May 2010.

The Department currently coordinates and leads an ad hoc advisory committee to the Interagency Working Group on Ocean Partnerships (the Joint Subcommittee on Ocean Science and Technology) focused on marine and hydrokinetic issues, which includes the Federal Energy Regulatory Commission, Minerals Management Service (MMS), National Oceanic and Atmospheric Administration (NOAA), U.S. Navy, U.S. Coast Guard, Fish and Wildlife Service, National Park Service, Environmental Protection Agency, and the U.S. Army Corps of Engineers.

DOE is providing support to the National Park Service in their development of a report titled, "Marine and Hydrokinetic Energy Technologies and Recreation: A Guide to Concepts and Methods," which will focus on potential impacts to recreation from marine and hydrokinetic technologies, and suggest ways in which those impacts can be studied and mitigated.

The Department is collaborating closely with NOAA to develop an integrated permitting process for OTEC demonstration projects, which DOE has authority over, and OTEC pilot projects, which are to be regulated by NOAA. The Navy is also very involved in this process, based on their high levels of technical knowledge and experience with OTEC research.

The Department also participates in the West Coast Governors Association's Ocean Energy Action team and worked with MMS to organize its 2008 Alternative

[7] Prioritized Research, Development, Deployment and Demonstration (RDD&D) Needs: Marine and Other Hydrokinetic Renewable Energy. EPRI, Palo Alto, CA 2008. *www.epri.com/oceamemergy/*

Energy Workshop. Finally, the Program helps to shape the Department's position on national marine spatial planning efforts currently underway at the Federal level, and continually works to ensure that there is due consideration of marine and hydrokinetic energy technologies in all discussions and decisions.

As stated previously, the marine and hydrokinetic industry is at a relatively early stage of development and maturity when compared to other renewable energy technologies, but the Department believes this industry can play a substantial role in the portfolio of clean, cost-effective, domestic energy that our Nation is dedicated to developing. To this end, DOE is committed to evaluating the realistic potential of the various resources and energy generation technologies and focusing Departmental efforts in the most efficient and effective areas. DOE has made key investments in this nascent industry and will continue to do so. Furthermore, DOE is uniquely positioned to aid in the development of marine and hydrokinetic technologies through continued support and collaboration with industry stakeholders, international partners and other non-governmental organizations. Most importantly, DOE's continued involvement will help speed the deployment of these technologies, just as the Department's commitment to wind energy has helped that industry to rapidly develop in recent years.

Thank you again for the opportunity to appear before you today to discuss these important issues. I am happy to answer any questions.

BIOGRAPHY FOR JACQUES BEAUDRY-LOSIQUE

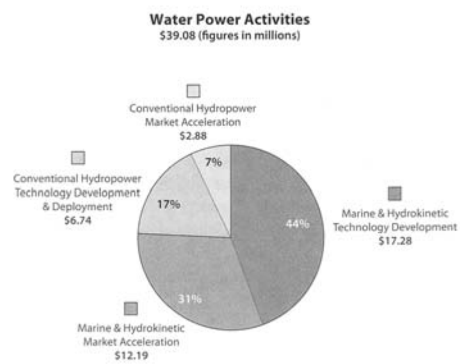
Jacques Beaudry-Losique was appointed in December 2008 as the Deputy Assistant Secretary for Renewable Energy of the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE). EERE works to strengthen the United States' energy security, environmental quality, and economic vitality in public-private partnerships. In this role, he oversees a portfolio of more than $750 million of Renewable and Clean Energy programs, including wind, water power, solar, biomass, geothermal and fuel cell technologies.

Previously, Mr. Beaudry-Losique served as the Program Manager of DOE's Office of Biomass Program. Over two years, Mr. Beaudry-Losique built what is now recognized as the largest and most advanced biofuels deployment program in the world. He was instrumental in accelerating the Office of Biomass deployment activities to support Presidential and Congressional goals. Among numerous milestones, his office initiated major programs to launch a cellulosic biofuels industry, including an investment of up to $272 million in four major cellulosic ethanol projects in 2007 and another investment of up to $240 million in nine 10% cellulosic biofuels demonstration projects in 2008. Jacques' office also played a leadership role in helping industry address environmental sustainability issues and supply chain bottlenecks such as the "ethanol blend wall."

Mr. Beaudry-Losique initially joined the Department as the Program Manager of the Industrial Technologies Program in June 2005, serving in that capacity until reappointed to the Office of Biomass Program in December 2006. He brought to the Office extensive experience in executive management, business development and commercial negotiations.

Prior to joining DOE, he worked in numerous senior management roles in the private sector. As the business development leader of General Electric Power Systems investment activities, he was responsible for the placement of equity investments into strategic energy technology companies. Prior to that, he held senior management roles with Aspen Technologies, a leading engineering and supply chain software company with strong ties to MIT. Mr. Beaudry-Losique also has many years of experience as a management consultant with McKinsey and Company.

Mr. Beaudry-Losique holds a Bachelor of Science degree in chemical engineering from the University of Montreal and a Master of Science degree in Industrial Engineering and Engineering Management from Stanford University. As a recipient of a Canadian Science Foundation Fellowship, he attended the MIT Sloan School of Management, where he received a master's degree in management in 1992.



Chairman BAIRD. Thank you very much.

Before we proceed to Mr. Bedard, I want to briefly note that our colleague, Representative Inslee from my home State of Washington, has joined us. Mr. Inslee has introduced legislation pertinent to this topic, and without objection, I would like to ask my colleagues that Mr. Inslee be allowed to join us on the dais. Hearing no objection, thank you for joining us, Mr. Inslee.

With that, we will proceed to Mr. Bedard.

STATEMENT OF ROGER BEDARD, OCEAN ENERGY LEADER, ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

Mr. BEDARD. Thank you, Chairman Baird, Ranking Member Inglis and Members of the Committee, again, my name is Roger Bedard. I am the Ocean Energy Leader at the Electric Power Research Institute, a collaborative, nonprofit R&D organization. I appreciate the opportunity to provide testimony to this Committee on marine and hydrokinetic, or MHK, technology, and the pathway to commercialization.

In 2004, we initiated wave energy technical and economic feasibility studies. In 2006, we followed that up with tidal hydrokinetic feasibility studies, and in 2008 with river hydrokinetic studies in the State of Alaska. Our studies have resulted in a substantial momentum, nationwide momentum towards adding MHK technologies to our national portfolio of energy supply alternatives. One measure of this momentum is the number of preliminary permits filed to the Federal Energy Regulatory Commission (FERC) by private investors that reference the EPRI studies.

I will focus my comments today on four key points. First, the wave and tidal hydrokinetic energy resource available to generate electricity in the United States is significant. Second, the technology to convert these resources to electricity is emerging and ready for testing in the ocean. Third, wave and tidal hydrokinetic energy can be cost competitive with other renewable technologies in the future. And fourth, significant challenges remain to finding the pathway to commercialization of MHK technologies.

Our studies indicate the total recoverable ocean wave and tidal energy resource could enable electricity generation on the order of about 10 percent of the present electricity consumption, and that turns out to be about 400 kilowatt-hours per year. The most significant of these resources is wave energy and the locations with the most economically viable wave energy resources are Hawaii and the Pacific Northwest. It is important to understand, though, that many factors may limit the use of this technology, including electrical transmission capabilities, environmental concerns and societal considerations.

There are many technology companies at various stages of development. The development cycle for these technologies is typically five to ten years. While there are now many companies ready for prototype testing in the ocean, only a few have reached that stage of development.

As wind technology was beginning to emerge into the commercial marketplace, the wholesale cost of electricity was in excess of 30 cents per kilowatt-hour. That is in 2009 dollars with no government financial incentives. Technology improvements and learning through production has cut that cost to about seven cents per kilowatt-hour today. Our studies indicate that MHK technology will enter the marketplace at a lower entry cost than wind energy did and will progress down a similar learning curve. The key reason for that is the high power density of the MHK resource compared to, say, the wind or solar resources.

On the other side of that coin is a challenge. The challenge for the industry is to develop cost-effective deployment and operational maintenance technology given the remoteness, and at times, hostility, of the operating environment.

We believe that a robust electrical system in the future will have a diversified portfolio of energy supply alternatives. Our Nation has investigated all known electricity supply alternatives except for one: the ocean. Our oceans are a public resource accommodating multiple uses including marine life, fishing, shipping and recreation. Ocean energy could work in harmony with those other users and provide renewable energy for the overall good of our society.

It will take a sustained evolutionary effort over the next 20 years to perfect MHK energy technology. We need to build the capability in this country to design, analyze, fabricate, test and deploy these emerging technologies.

In the area of testing and test facilities, currently the U.S. marine energy industry is challenged by the lack of proper and standardized infrastructure to deploy devices in the ocean. We are starting to make progress. The Northwest National Marine Research Center, led by Oregon State University and University of Washington, will provide ocean energy conversion system test berths for developers to perform ocean testing. The Pacific Gas and Electric Company (PG&E) is developing a pre-commercial demonstration test facility known as WaveConnect for full system testing of arrays or farms of these devices.

Long-term and consistent government funding support through this high-risk research, development and demonstration period is essential for building a globally competitive commercial U.S. industry. The idea of harnessing the vast power of the earth's oceans has fascinated and tantalized humans for centuries. Today we may be on the cusp of realizing these potential MHK technology options that we expect will prove tremendously valuable to our Nation in a carbon-constrained future. Thank you.

[The statement of Bedard follows:]

PREPARED STATEMENT OF ROGER BEDARD

Thank you, Chairman Baird, Ranking Member Mr. Inglis and Members of the Committee

I am Roger Bedard, Ocean Energy Leader for the Electric Power Research Institute (EPRI), a non-profit, collaborative R&D organization. EPRI has principal locations in Palo Alto, California, Charlotte, North Carolina, and Knoxville, Tennessee. EPRI appreciates the opportunity to provide testimony to the Energy and Environment Subcommittee on the topic of "Marine and Hydrokinetic (MHK) Technologies; Finding the Pathway to Commercialization."

In 2004, EPRI initiated technical and economic feasibility studies of ocean wave energy. We followed these studies with tidal hydrokinetic studies in 2006 and river hydrokinetic studies in Alaska in 2008. These studies have resulted in a substantial nationwide momentum towards adding MHK technologies to our national portfolio of energy supply alternatives. One measure of this momentum is the large number of preliminary permit applications filed by industry with the Federal Energy Regulatory Commission for the development of MHK power generation projects which reference the EPRI studies.

I will focus my comments today on four key points:

- First, the wave and tidal hydrokinetic energy resource available to the U.S. which can be converted to electricity is significant;
- Second, the technology to convert those resources to electricity is emerging and is ready for testing in the ocean;
- Third, wave and tidal hydrokinetic energy can be cost competitive with other renewable technologies in the future; and
- Fourth, significant challenges remain to finding the pathway to commercialization of MHK energy technologies.

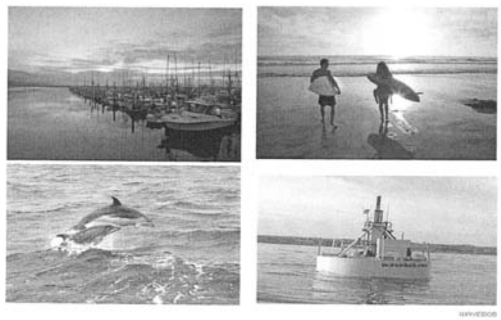
The key message that I hope you will take away from my testimony is that MHK energy is a renewable resource that we as a nation should seriously consider as an addition to our national portfolio of energy supply alternatives and that this consideration requires Government support and incentives as it has with other energy technologies in the past.

Background

The idea of harnessing the vast power of Earth's oceans has fascinated and tantalized humans for centuries. Today, we may be on the cusp of realizing this potential and enabling that to happen in the U.S. is within your jurisdiction.

Marine and hydrokinetic (MHK) technologies is a term used by the U.S. Congress to describe the conversion of ocean wave potential and kinetic energy, in-stream tidal, open-ocean and river current kinetic energy, and ocean thermal energy conversion It excludes offshore marine wind kinetic energy, does not mention ocean salinity gradient energy and should not be confused with conventional hydropower using a dam, impoundment or diversionary structure.

EPRI believes that a robust electricity system of the future will be a balanced and diversified portfolio of energy supply alternatives. Our nation has investigated many if not all known electricity supply alternatives (including space-based power; i.e., photovoltaic panels in orbit beaming power to large antennas on Earth) except for one; our oceans (with two exceptions, a large ocean thermal energy conversion program in the 1980s and a more modest open-ocean current program in the 1970s). Our oceans are a public resource held in trust and accommodating multiple users; fisherman make their living from the ocean, commercial shipping navigates the oceans to deliver goods, recreational boaters, surfers and those who just walk on the beach enjoy the ocean and whales and other living creatures make the ocean their home. Ocean energy could be one of those users working in harmony with other users and providing renewable energy for the overall good of our society.



Some of the Benefits of Marine and Hydrokinetic Energy

The advantages of ocean energy are numerous. First and foremost is a potential for costs that are competitive or lower than that of other renewable technologies. EPRI studies indicate that the high power density (kW/m2 for currents and kW/m of wave crest length for wave) of the MHK resource results in smaller and stronger energy conversion machines lower in capital cost than for other renewable technologies. The remoteness and at times, hostility of the ocean environment, however, results in higher deployment, operation and maintenance cost, but on balance, the cost of electricity can be comparable or lower than that with other renewable technologies. Other benefits include: (1) providing a new, environmentally friendly, renewable energy source for meeting load growth and legislated Renewable Portfolio Standard requirements; (2) easily assimilated into the grid (because of the predictability of the resource), (3) easing transmission constraints (since a large percentage of our population lives near the coast) with minimal, if any, aesthetic concerns; (4) reducing dependence on imported energy supplies and increasing national energy security; (5) reducing the risk of future fossil fuel price volatility; (6) reducing emissions of greenhouse gases as compared to fossil fuel-based generation; and (7) stimulating local job creation and economic development by using an indigenous resource.

Existing industries in the U.S. such as ship building are looking for opportunities to diversify, grow, and compete. These industries provide a trained workforce and institutional knowledge that will benefit ocean renewable energy technologies while helping to re-vitalize their own sectors.

The economic opportunities are significant. A relatively minor investment today could stimulate a worldwide industry generating billions of dollars of economic output and employing thousands of people while using an abundant and clean natural resource.

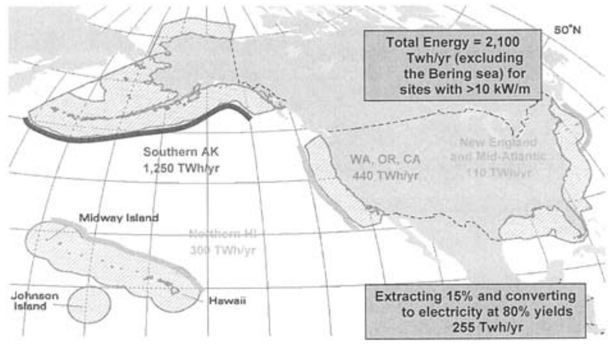
EPRI's Experience

EPRI's ocean energy experience is with wave and in-stream tidal and river hydrokinetic energy. In 2004, we initiated system definition technical and economic feasibility studies of ocean wave energy. At that time, the DOE was only able to provide in-kind services support to the EPRI efforts from the wind technology program at the National Renewable Energy Laboratory (NREL), which had an off shore component addressing related technical, environmental and regulatory issues. Under the leadership of Dr. Robert Thresher, Director of the National Wind Technology Center, NREL has provided valuable in-kind services and we continue working together today. EPRI followed the 2004–2005 wave energy studies in 2006–2007 with tidal in-stream studies and in 2008–2009 with river in-stream studies in Alaska (over 50 reports are available on our public website *www.epri.com/oceanenergy/*). The EPRI studies have resulted in a substantial nationwide momentum. One measure of this momentum is the large number of preliminary permit applications filed with the Federal Energy Regulatory Commission by industry for the development of MHK power generation projects in the U.S.

The Ocean Wave and In-Stream Tidal Currents, Open Ocean Currents and River Currents Hydrokinetic Energy Resource

Available Ocean Wave Energy Resource

EPRI has estimated the U.S. wave energy resource using decades of measurements by NOAA and Scripps data buoys. We estimate the available wave energy resource to be about 2,100 TWh/yr (for all state coastlines with an average annual wave power flux > 10 kW/m). This energy is divided regionally as follows:



Practical Ocean Wave Energy Electrical Energy Potential

The amount of that available wave energy that can be converted into electrical energy is not known given the uncertainties of societal, device spacing, conflicts of sea space and environmental limits.

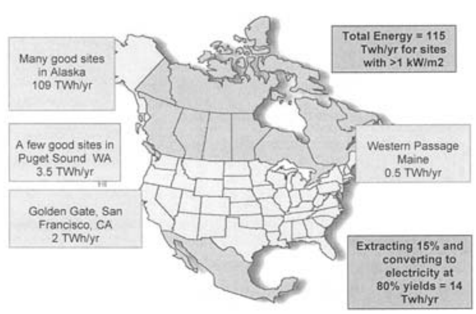
A preliminary estimate can be made by assuming absorption of 15% of the total available wave energy resource, a power train conversion efficiency of 90% and a plant availability of 90%. The electricity produced using this assumption is about 255 TWh/yr or equal to an average annual power of about 30 GW. The rated power is about 90 GW given a typical capacity factor of 33%. This amount of energy is comparable to the total energy generation from all conventional hydro power, or about 6.5% of current U.S. electricity consumption. This is significant.

Early wave plants must be built-out in phases with environmental monitoring and an adaptively managed process to larger size plants so that the cumulative effects of these larger plants stay within societal limits of acceptability

EPRI, teamed with NREL and Virginia Tech, has received grant funding from the DOE to perform a rigorous evaluation of the nation's available ocean wave energy resource and practical electrical energy generation potential. This work is scheduled for completion in 2010.

Available In-Stream Tidal Currents Hydrokinetic Energy Resource

Tidal in-stream hydrokinetic energy resources are not as well understood as wave energy resources. Economically viable hydrokinetic tidal energy sites typically occur in narrow passageways between oceans and large estuaries or bays. EPRI has studied many but not all potential U.S. tidal energy sites. The tidal energy resource at a single transect for those sites evaluated by EPRI to date is estimated at 115 TWh/yr with 6 TWh/yr at sites in the continental U.S. and the remaining 109 TWh/yr in Alaska. Tidal hydrokinetic energy resources may be locally important resources for the following regions in the lower 48 states; Maine, New York, San Francisco and Washington's Puget Sound.



The 115 TWh/yr estimate excludes sites with annual average power densities less than 1 kW/m2. If in-stream energy conversion device technology is economical at power densities less than 1 kW/m2, then the available resource in the lower 48 states could be much larger. These estimates should be considered as the lower bound of the tidal hydrokinetic resource because not all the U.S. tidal sites with potential have been evaluated.

The amount of the available tidal hydrokinetic energy resource that can be converted to electrical energy is not known given the uncertainties in societal, physical, ecological and environmental limits. We understand how to estimate the kinetic energy resource across a particular transect at a particular site, however, we have learned that this estimate is a poor predictor of both the maximum possible level of extraction for that site as well as the environmental impacts of extracting kinetic energy from that site. From a purely physical standpoint, depending on the limitations of seabed space within the high-velocity transects and the requirement to maintain adequate navigation clearance, the number of turbines that could be sited within a constrained channel is known given a maximum packing fraction for turbines. However, this could be limited to even lower levels of extraction by the ecological implications of changing the tidal regime by extracting kinetic energy from the flow. There is a self-limiting point at which it will not be economic to add additional turbines to an array since extraction reduces the available kinetic energy. It is unclear whether the available space, social and environmental pressures, or economics will pose the most stringent limits on resource extraction.

Furthermore, our current understanding of how extracting hydrokinetic energy at one site would affect the availability of hydrokinetic energy at another site within the same estuary or bay is insufficient to perform a resource estimate for an entire bay system.

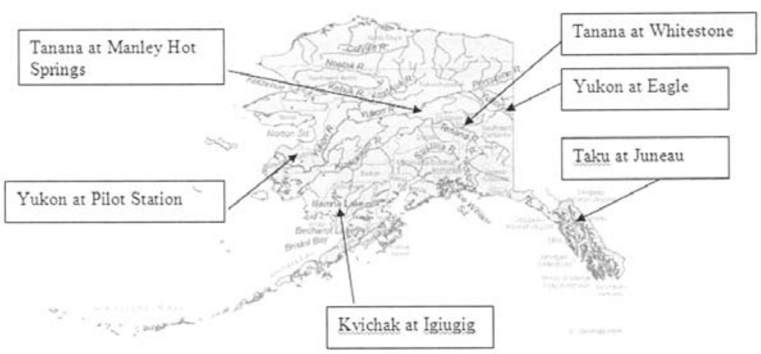
A conservative assessment of the deployment potential can be made by assuming absorption of 15% of the total available tidal hydrokinetic resource at a single transect of a tidal passageway (serving as a conservative proxy for the limiting factors discussed above), a power train efficiency of 90%, and a plant availability of 90%. The electricity produced using this assumption for the sites studied by EPRI is about 14 TWh/yr. This corresponds to an average annual power of 1,600 MW and a rated power of about 4,800 MW given a typical capacity factor of 33%. These estimates should be considered as the lower bound of the tidal hydrokinetic resource because not all the U.S. tidal sites with potential have been evaluated.

Georgia Tech has received grant funding from the DOE to perform an assessment of the energy production potential from tidal streams in the U.S. This work is scheduled for completion in 2010.

Available In-Stream River Current Hydrokinetic Energy Resource and Practical In-Stream River Current Hydrokinetic Electrical Energy Potential

A study carried out by New York University (NYU) graduate students in 1986, using a set of assumptions which were stated to be conservative, reported that about 110 TWh/year (average power of 12,500 MW) could be extracted from rivers using in-stream hydrokinetic energy conversion and that the majority of the nation's river hydrokinetic energy resource is in the Pacific Northwest and Alaska. Significant rivers in the continental U.S. are illustrated below

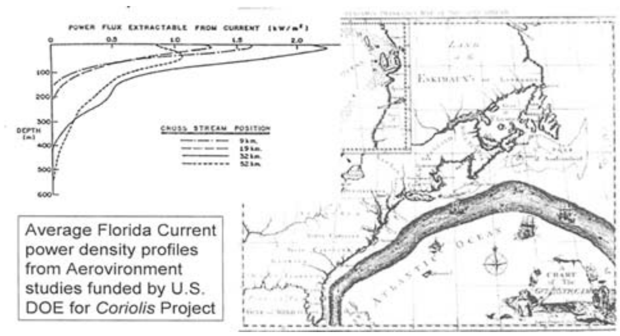
System definition and feasibility studies performed by EPRI in 2008-2009 showed that river in-stream hydrokinetic energy may be a feasible resource option for remote village electrification. EPRI surveyed six sites shown in the figure below and performed system definition and techno-economic feasibility studies for the three sites shown in yellow. Two pilot projects (Yukon River at Eagle and Kvichak River at Iguigig) are now underway at remote villages in Alaska, one funded by the Denali Commission and the other funded by the State of Alaska Renewable Energy Fund.



EPRI, teamed with NREL and the Universities of Alaska at Anchorage and Fairbanks, was recently selected by the FY2009 DOE Waterpower program for negotiation leading to award to assess the nation's river in-stream hydrokinetic resources and was also recently selected to perform desktop and laboratory flume studies that will produce information needed to determine the potential for injury and mortality of fish that encounter hydrokinetic turbines of various designs. Behavioral patterns will also be investigated to assess the potential for disruptions in the upstream and downstream movements of fish.

Available Open Ocean Current Resource and Practical Ocean Current Electrical Energy Potential

The primary open-ocean current resource available to the U.S. is located about 30 km off the shores of Southern Florida. The total available resource is not known, however, both Aeroviroment in the 1970s and recently Florida Atlantic University have estimated a practically recoverable electrical energy of 50 TWh/yr and an average annual power of about 10 GW (a capacity factor of 57%). Other ocean currents are typically located too far from shore or are too slow in current speed to provide for practical or economical transmission of power to load centers.



Average Florida Current power density profiles from Aerovironment studies funded by U.S. DOE for *Coriolis* Project

Georgia Tech was recently selected by the FY2009 DOE Waterpower program for negotiation leading to award to assess the nation's open-ocean hydrokinetic resources.

Resource Summary

Research by EPRI suggests that ocean wave and in-stream tidal hydrokinetic energy resource is location specific and that the total electrical energy production potential is equal to about 10% of the present U.S. electricity consumption (or about 400 Twh/yr). The most significant of these resources is wave energy and the locations in the U.S. with the most economically viable wave energy resource are Hawaii, Alaska and the Pacific Northwest (as far south as Point Conception which is just north of Santa Barbara, California).

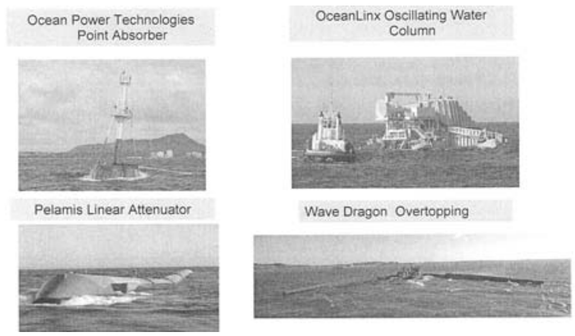
While this preliminary assessment provides a good first order indication of the resource potential, it is important to understand that many factors, such as electrical transmission capabilities, economic viability, environmental concerns and socio-economic considerations may impose additional limits onto these resources that may substantially alter full development potential. Given the present technical, environmental and economic uncertainties, it is important to pursue all MHK resources in a sensible and strategic manner.

Status of Ocean Wave and In-Stream Tidal, Open Ocean and River Current Energy Conversion Technology

Ocean Wave Energy Conversion Technologies

Today's wave energy conversion technologies are the result of many years of testing, modeling and development by many developer organizations. Total capacity deployed to date is about 4 MW worldwide, and most of the devices are engineering prototypes. The first shore-based grid-connected wave power unit was a system built into the coastline of the Island of Islay in Scotland in 2000. In 2003, WaveDragon of Denmark was the first offshore grid-connected wave power unit and was deployed in a protected bay due to its subscale design. The following year (2004), Pelamis of the U.K. was the first full-scale, offshore, grid-connected wave power unit deployed in open seas at the European Marine Energy Center (EMEC) in the U.K. Based on successful testing at EMEC, the first commercial sale of an offshore wave power plant was announced by Pelamis Wavepower in May 2005 and the first 2.25 MW of that plant was deployed off the coast of Portugal in 2008. Unfortunately, the primary project investor, Brown and Babcock, recently declared bankruptcy and the project is now on hold pending further investment capital.

A number of demonstration projects are ongoing and planned in the U.K, Ireland, Spain, Portugal, China, Japan, Australia, Canada, and the United States. If these early demonstration projects prove successful, medium-size wave farms up to 30-50 MW in capacity could be deployed within the next five to eight years.

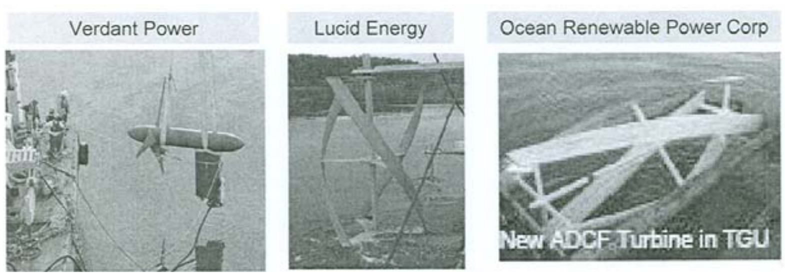


(a) PowerBuoy, courtesy of Ocean Power Technology, (b) OWC, courtesy of OceanLinx (c) Pelamis, courtesy of Pelamis Wave Power, and (d) WaveDragon, courtesy of WaveDragon,

Tidal In-Stream Energy Conversion Technologies

Today's tidal in-stream energy conversion technologies, much like wave energy technologies, are the result of many years of testing, modeling and development by many developer organizations. Total capacity deployed to date is about 3 MW worldwide, and most of the devices are engineering prototypes. The first grid-connected power units were built and installed in the U.K. and Norway.

A number of demonstration projects are ongoing and planned in the U.K, Norway, Sweden, France, Italy Korea, New Zealand, Canada, and the United States. The first commercial in-stream tidal power plant has yet to be realized.



(a) East River Roosevelt Island Tidal Project Axial Turbine courtesy Verdant Power, (b) Gorlov Vertical Turbine courtesy Lucid Energy and (c) Cross Flow Turbine courtesy Ocean Renewable Power Corp

River In-Stream Energy Conversion Technologies

Today's river in-stream energy conversion technologies are scaled down versions of larger tidal water turbines. Unlike wind turbines where the cost has come down as the sizes get larger, river in-stream developers hope to achieve cost reductions through high volume production of small machines, typically constrained in size due to river depth limitations and navigation requirements.

Two river in-stream turbines have been deployed in the U.S.; a 5 kW hydrokinetic turbine in the Yukon River in Alaska and a 40 kW hydrokinetic turbine deployed downstream of the hydro potential turbines at a conventional hydroelectric dam in Hastings, Minnesota.

Open Ocean Current Energy Conversion Technologies

Today's open-ocean current energy conversion technologies are similar to tidal and river in-stream technologies but with the potential of being very large in size due to the depths of the ocean. The 1970s Coriolis water turbine design diameter was 170 meters.

The first commercial in-stream open-ocean power plant has yet to be realized.

Energy Conversion Summary

There are many technology developers with different conceptual MHK energy conversion devices and those devices are at various stages of development. The time period for a MHK technology to progress from a conceptual level to deployment of a long-term full-scale prototype tested in the ocean is typically on the order of 5 to 10 years. The technology is still in its emerging stage; like where wind technology was approximately 15 to 20 years ago. It is too early to know which technology will turn out to be the most cost-effective, reliable, and environmentally sound, but it is likely that many different MHK technologies will play a role in our energy future.

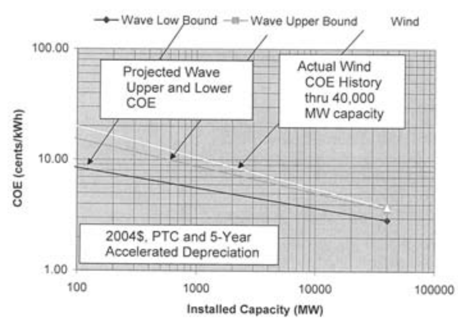
Of the many technology developers (greater than 50 each for wave and marine water turbine hydrokinetic machines), only a few dozen have progressed to rigorous subscale laboratory tow or wave-tank model testing. Only two dozen have advanced to short-term (days to months) subscale tests in the ocean. Even fewer have progressed to long-term (>1 year) testing of a full-scale prototype systems in the ocean. Pre commercial "pilot demonstration power plants" are needed to address critical concerns about reliability, maintainability, environmental issues and costs.

Status of MHK Power Projects and their Economic Competitiveness

Today, a large number of small companies, backed by government organizations, private industry, utilities, and venture capital, are leading the commercialization of technologies to generate electricity from ocean wave and tidal, river and open-ocean current resources. A small number of companies are leading the commercialization of ocean thermal gradient (and salinity gradient) energy technologies.

Over two decades ago, wind technology was beginning its emergence into the commercial marketplace at a busbar cost of electricity (CoE) in excess of 20 cents/kWhr (in 2004$ with production credits and 5-year accelerated depreciation). The historical wind technology CoE as a function of cumulative production thru 40,000 MW of cumulative production capacity deployed through 2004 is shown in the figure below. Wind technology experienced an 82% learning curve (i.e., the cost has reduced by 18% for each doubling of cumulative installed capacity). Over 1,500 MW of wind has now been installed worldwide. EPRI studies performed in 2004/2005 project indicate that wave energy will enter the market place at a lower entry cost than wind energy did and will progress down a learning curve that is similar to that of wind energy. The wave energy industry has the advantage of higher power densities compared to wind energy and therefore should have lower capital cost. The challenge to the wave energy industry will be to develop cost effective deployment and high reliability operation and maintenance technologies with low costs. Otherwise, the cost of deploying and operating these machines in a remote, and sometimes, hostile environment will outweigh the initial capital cost advantages and the CoE may not be competitive with other options.

The CoE is now approximately 7 cents/kWhr (in 2009$ with no incentives) for an average 30% capacity factor wind plant. Today, MHK technology status can be compared to wind 15 to 20 years ago; close to starting its emergence as a commercial technology.



Government Support of Marine and Hydrokinetic Research, Development and Demonstration (RD&D) and Commercialization

The European Union (UK, Ireland, Denmark, Norway, Sweden, France, Spain, and Portugal) is leading the development and commercialization of emerging marine and hydrokinetic energy technologies. Their support to accelerate this development includes:

- Supporting the technology developers with funding
- Funding subscale and full scale test facilities

- Establishing goals for commercialization
- Developing roadmaps that point out the pathways to meet these goals
- Providing financial incentives necessary to meet those goals

The Europeans have a 10 year head start on us in developing MHK technology.

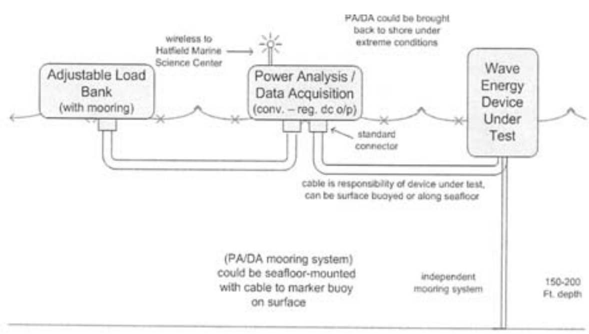
Other nations are also starting to engage in MHK energy. In Canada for example, EPRI performed in-stream tidal system definition and feasibility studies in the Bay of Fundy (Nova Scotia and New Brunswick). Our 2006 studies resulted in an immediate announcement by Nova Scotia Power for a multi million dollar tidal pilot demonstration project in the Minas Passage. This project is now funded at $70 million and the first of three large scale (1 MW class) machines has been deployed. Two other tidal machines as well as the submerged transmission cable will be deployed in 2010.

In the U.S., DOE manages a Waterpower RD&D program which began in FY2008 at $10 million, increased to $40 million in FY2009 and to $50 million in FY2010. This DOE program is funding many projects, including some of the EPRI work already discussed, but I will limit my testimony to one managed by universities and two managed by utilities which address a critical need; the need to test this new technology. Currently, the U.S. marine energy industry is challenged by the lack of proper and standardized infrastructure to deploy and test wave energy conversion devices in the ocean. Testing of these new devices needs to be done at scales that vary from small scale devices in subscale test facilities, to full scale ocean testing of prototype machines and to demonstration testing of pilot power plants. We are starting to make progress and sustaining this progress with long-term and consistent support is essential for building a globally competitive U.S. industry.

(1). The Northwest National Marine Renewable Energy Center (NNMREC) is a DOE-funded partnership between Oregon State University (OSU) the University of Washington (UW) and the National Renewable Energy Lab (NREL). The University partition of responsibilities is as follows:

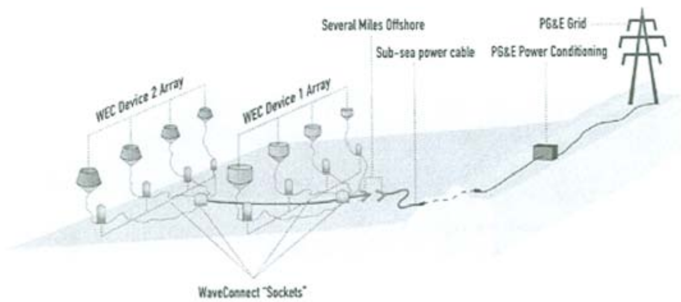
- OSU is responsible for wave energy research and development.
- UW is responsible for in-stream tidal energy research and development.
- Both universities collaborate on research, education, outreach, and engagement.

The NNMREC at OSU will provide wave energy conversion system developers with test berths to perform ocean testing, demonstration and advancement of subscale and full-scale devices. The first phase ocean test berths will be "mobile", with future plans to include both mobile and grid connected capabilities. The mobile ocean test berths (MOTBs) will consist of a power analysis and data acquisition (PADA) device and an adjustable load bank to simulate the utility grid as illustrated below



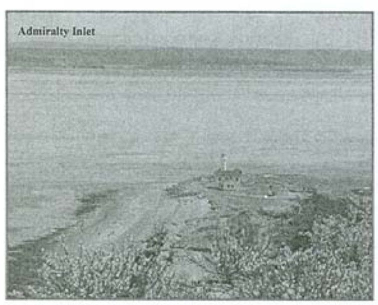
(2) Pacific Gas and Electric (PG&E) WaveConnect—PG&E is the largest investor owned utility in the country and its service territory includes about 600 miles of high wave energy coastline. PG&E seeks to complete final design, stakeholder outreach and permitting of two 5 MW pilot ocean wave demonstration plants in this current phase of the project. The next phase of the project will include building an undersea electrical grid connection several miles offshore. This "offshore electrical cable and socket" will connect wave energy converters from multiple vendors to the PG&E electrical grid (similar to the U.K. Wave Hub funded by the UK government) and provide for testing and evaluation of the devices for commercial deployment.

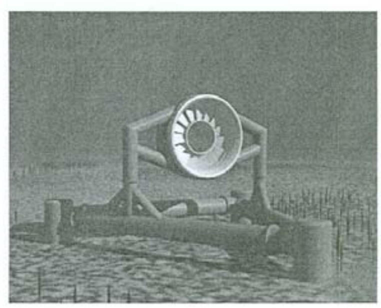
The current final design and permitting phase of the project is supported through PG&E ratepayer funding (80%) and by the DOE (20%). A greater level of Federal Government support may be needed once the project enters into the construction phase.



(3) Snohomish County Public Utility District No 1 (SnoPUD) Admiralty Inlet Tidal Power Demonstration Project—SnoPUD is located near Seattle, Washington, and is the second largest publicly-owned utility in the Pacific Northwest, and the twelfth largest in the United States in terms of customers served. The PUD has a rapidly growing service load and is required by the Washington State Renewable Portfolio Standard (RPS) to supply 15% of its load from new, renewable energy resources by 2020. As a result of these factors, approximately 140 MW of renewable energy resources needs to be added each year, on average, for the next twelve years. The PUD believes that tidal hydrokinetic energy from the Puget Sound estuary has the potential to contribute significantly toward meeting this challenge, but also believes in-water testing is required to address uncertainties in performance, cost and environmental effects.

The PUD is partnering with OpenHydro of Ireland to conduct the deployment, demonstration and testing of tidal in-stream energy conversion technology in the Admiralty Inlet region of the Puget Sound. The PUD currently envisions a ?1 MW pilot plant consisting of two to three OpenHydro turbines. The PUD envisions plant construction beginning in 2011. This project is currently supported at less than 50% by the DOE and may need greater Federal funding in the construction phase.





Conclusions

EPRI estimates the recoverable potential to provide electricity from ocean wave and in-stream tidal hydrokinetic resources to be about 10% of today's electric consumption in the U.S. The technology to convert those resources to electricity, albeit in its infancy, is available today for prototype and pilot demonstration testing and evaluation. Initial studies suggest that given sufficient deployment scale, these technologies will be commercially competitive with other forms of renewable power generation. However, significant technical, economic, operational, environmental and regulatory barriers remain to be addressed in order to progress this emerging industry to commercial development.

It is critical for the success of this industry to gain a full understanding of all life cycle-related issues over the coming years to pave the way for larger scale commercial deployments. Such understanding can only be gained in a practical way from the deployment of prototype and pilot demonstration systems in the ocean. Currently, the U.S. marine energy industry is challenged by the lack of proper and standardized infrastructure to deploy and test wave energy conversion devices in the ocean. We are starting to make progress and sustaining this progress with long-term and consistent support is essential for building a globally competitive U.S. industry.

Successful deployment of prototype and pilot demonstration systems will not only address technology and economic related issues, but will also provide confidence to regulators, the general public and investors. Both market push (RD&D) and market pull mechanisms (economic incentives to encourage deployment) will be required to successfully move this technology sector forward and develop the capacity to harness energy from the ocean.

It is very unlikely that any of this early stage development will be funded by the private sector because the risk of failure is too high. When an ocean energy development company can test a prototype scale machine that shows promising performance, reliability and cost, then the private sector investors may be interested. Even at that point, the private sector will not want to assume all of the financial risk and exposure to fully fund the first demonstration projects, or the first commercial projects, so some sort of support for these early commercial projects will be essential to get the industry started.

In retrospect, it is interesting to note that there are currently only two major U.S. companies selling large utility scale wind turbines in the United States, out of about a dozen that attempted to develop wind systems over the past 30 years. On the other hand, there are six major global companies now selling wind turbines in the United States, and several smaller foreign companies. Long term and consistent support through the high risk research and development period and though demonstration is essential for building a globally competitive U.S. MHK industry and commercializing it. It should also be noted that the Europeans already have a 10 year head start on developing MHK technology.

The eventual level of MHK power capacity in the U.S. will be strongly dependent on enabling actions and policies that support the development of the industry.

The establishment of national MHK deployment and timeline goals and the research, development and demonstration pathways or roadmap to success will assist in fully developing this potential. The funding needed to implement the roadmap and achieve the goals will be a significant higher than current levels, but within historical percentages for government agencies and private industry. Given the long technology development and deployment lead times inherent in capital intensive industries like energy, investment and policy decisions cannot be delayed without risk of losing opportunities for technology options that we expect will prove tremendously valuable to our nation in a carbon-constrained future.

Thank You

Roger Bedard
EPRI Ocean Energy Leader
November 29, 2009

BIOGRAPHY FOR ROGER BEDARD

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Roger Bedard

Roger Bedard is Ocean Energy Leader in the Renewable program area of the Generation Sector at the Electric Power Research Institute (EPRI). He has over 40 years of experience developing and leading technology research, development, and demonstration projects. His current research activities focus on collaborative ocean energy feasibility studies and demonstration projects.

Mr. Bedard joined the Client Relations department of EPRI in 1997. He was responsible for developing new clients in the federal and state government and internationally.

Before joining EPRI, Mr. Bedard was Vice President at Alstom Robotics where he managed custom robotic projects for nuclear waste cleanup. Previously he was a Program Manager at NASA Jet Propulsion Laboratory where he managed the Mars Rover research and development program, U.S. Army sponsored unmanned land vehicle technology programs, and U.S. DOE sponsored point focus distributed receiver solar thermal electric technology programs. Before that, he worked at Acurex where he managed solid rocket propulsion, torsion meter and point focus distributed receiver solar thermal electric technology programs. As an active duty Air Force Officer at the Air Force Rocket Propulsion Laboratory, he managed solid rocket propulsion technology programs.

Mr. Bedard received a BS degree in mechanical engineering from the University of Rhode Island, an MS degree in mechanical engineering from the University of Southern California, and an Electrical Engineering degree from the National Technical Institute of Electronics. He is a graduate of the NASA Senior Management Education Program and a distinguished graduate of the Air Force Officers Training School.

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Chairman BAIRD. Thank you.
Mr. Dehlsen.

STATEMENT OF JAMES G.P. DEHLSEN, FOUNDER AND CHAIRMAN, ECOMERIT TECHNOLOGIES, LLC

Mr. DEHLSEN. Thank you, Chairman Baird, Ranking Member Mr. Inglis and Members of the Subcommittee, my name is Jim Dehlsen.

My work has been in renewable energy technology since 1980, mainly focused on wind turbine design, manufacturing and helping to build the industry. The companies I formed and led are today America's two wind turbine manufacturers of utility-scale power generation: the wind division of General Electric with roots going back to Zond Systems, which I established in 1980, and the second formed in 2001, Clipper Windpower. I can state from this experience that both of these turbine manufacturers would not exist today had it not been for the enlightened U.S. energy policy stemming back to the oil embargo in the 1970s. Since 1999 I have also been engaged in marine renewable energy and recently formed Ecomerit Technologies with my son Brent to advance electric power systems based on wave and ocean currents. My wife tells me I flunked retirement.

I have been asked to address three items: advancing marine renewable energy as a separate program from hydropower, the expected time for marine energy to reach commercial readiness and large-scale deployment, and the DOE industry partnership in wind technology and implications for marine renewable energy.

First, hydropower and hydrokinetic have little in common. The basis for establishing a marine hydrokinetic program separate from hydropower is based not only on major differences in requirements for offshore marine versus land-based system deployment and operation, but also on very different technical, financial and technology maturity characteristics. These two hydros have little in common. Advances in the new marine technology will be far more robust and will occur more quickly and with marine hydrokinetic programs apart from, and not under, the federal hydropower program.

Second, the cost of energy and deployment. For a decade I have engaged in an effort to advance utility-scale power generation technology for both wave energy and ocean currents. Based on our engineering, we are targeting a cost of energy for both technologies in the range of 10 to 12 cents per kilowatt-hour by 2015, a level that should enable early commercialization, provided the U.S. government implements an effective program of incentives that supports marine renewables more tangibly and consistently than the federal support for wind energy. We are suspecting early systems to be megawatt sized. Therefore, meaningful rates of deployment, several thousand megawatts per year, should come in the 2015 to 2020 time frame in line with a forecast potential of 23 gigawatts by 2025, which was a recent estimate by the CORE. While this appears quite accelerated when compared to the history of wind, solar and other renewable energy technologies, it must also be viewed in light of the advanced know-how which is brought forward from marine engineering and shipbuilding, offshore oil, submersible vehicles, knowledge we now have on structural loads and control systems of wind turbines, the advanced numerical model design tools and fabrication know-how of large composite structures. This substantially reduces development costs and timelines.

Furthermore, the urgency that is now upon us from climate change and energy security is driving development of marine renewable energy not just in America but Europe as well, now with several years' lead, so we can expect a fast and competitive pace of technology advancement.

Learning from wind power: The U.S. renewable energy experience shows that in a government-industry partnership, the fundamental factor for success is a sustained federal commitment in the face of change, such as global price fluctuations or shifting national priorities that come with each Administration or political appointee. Perhaps the hardest public policy lesson that has come out of the American wind effort has been the repeated crippling effect on the industry from discontinuity in government support. The United States was in a clear leading position in wind power in the early 1980s due to early support which gave birth to the industry. Government support ended later that decade in the United States and the wind industry virtually collapsed. A series of on-again, off-again programs followed. While the U.S. wind industry continued in a struggle for survival, strong European Union support stimulated rapid growth throughout the continent. Today the European companies enjoy the lion's share of the industry, creating several hundred thousand jobs, generating upwards of $40 billion a year and growing at 20 percent plus annually. Now we are seeing massive support for wind energy in China, which has initiated 10 separate 10,000-megawatt regions representing $200 billion in industrial activity fully supported by the central government.

While America had the foresight and made the investment to launch the wind industry, discontinuity in support has allowed other nations to capture a major share of the long-term industry and industry benefits. We must not let this happen with marine renewables. Government support should be implemented quickly and sufficiently to sustain this emerging industry until it reaches industrial scale. Thank you.

[The statement of Mr. Dehlsen follows:]

PPREPARED STATEMENT OF JAMES G.P. DEHLSEON

Mr. Chairman and members of the Subcommittee, it is my pleasure to appear before you today to discuss the role that the government can play in advancing marine-based renewable energy technologies to meet a significant part of the nation's future electricity supply.

I am Founder and Chairman of Ecomerit Technologies, which has a focus on developing reliable, competitively priced, utility-scale ocean current and wave-powered electricity generating systems. We are also actively developing and investing in other sustainability-related technologies. We are located in Carpinteria, California.

Ecomerit Technologies represents my third entry in developing industrial-scale renewable energy technology. In 1980, I established Zond Systems, Inc., which pioneered wind power technologies leading to three generations of advanced wind turbines, and grew to become one of the largest global companies in wind turbine manufacturing, project development and plant operation. Acquisition of this technology and manufacturing formed the basis for GE's entry into the wind energy industry in 2002. As of last year, GE had produced over 10,000 turbines with worldwide deployment.

I also founded Clipper Windpower in 2001 with my son, Brent, and serve as Chairman of the Board. Clipper manufactures a new generation wind turbine, the 2.5 MW Liberty -the largest turbine produced in the U.S. -which received the Department of Energy's 2007 Outstanding Research and Development Partnership Award for its contribution toward industry advancements. Clipper is now in development on a 10 MW offshore turbine -the world's largest -planned for introduction in 2012/2013. In its lifetime, one of these 10 MW turbines will have the equivalent electricity generation of about 2 million barrels of oil.

It is important to note that the breakthrough wind energy technologies developed by Zond and Clipper were made possible by DOE/NREL grant funding and technical support, and this support also accounts for a substantial part of the technological innovation that has led to the success of the present $40 billion per year global wind industry.

Key Elements for Success in Marine Hydrokinetic Technology (MHK)

Drawing on my three decades in developing and commercializing renewable energy technologies, it is clear to me that marine hydrokinetic power can now play a significant role in adding to our national energy security, our economic development, and meeting our environmental goals. However, as with wind and solar energy, it will take a serious, robust and sustained partnership between the federal government and technology developers in a number of areas, including:

- Technology advancement, verification and acceptance through support for research, development and deployment;
- Clear, timely, predictable, and workable regulatory framework for siting and permitting of marine renewable projects;
- Clear, timely, and predictable incentive regime structure that facilitates rapid advancement of technology deployment;
- Close federal agency coordination and benefiting from lessons learned here and abroad in both wind and hydrokinetic power technology development and deployment; and
- The development of standards and certifications to provide confidence to customers and the financial markets.

Marine Renewables Overview

Today's emerging marine renewables industry includes technologies with the potential to convert the power of wave, tidal and constant ocean currents into utility-scale electricity supply.

The U.S. is blessed with abundant marine renewable resources on our extensive coastlines. According to the Electric Power Research Institute, the commercially available U.S. wave energy potential, alone, is roughly equal to 6.5% of the nation's entire generating portfolio. That is approximately the amount of electricity being produced by all traditional hydroelectric dams in the U.S. Another example is the Gulf Stream, just 15 miles off the coast of Florida, which has a constant flow equal to 50 times all the rivers of the planet and presents an opportunity to adapt much of the mature technology developed for wind power to provide thousands of megawatts of clean baseload power to the eastern seaboard states. Clearly, marine renewable energy can play a significant role in expanding our homeland energy supply and the power needs of our marine-related military facilities around the world.

Federal commitment to creating a robust U.S. marine renewables energy industry will advance our national economic goals by creating high-quality employment in coastal communities, long-term production in shipyards, development of fleets of vessels for deployment and servicing, and strengthening the thousands of businesses that make up the U.S. industrial supply chain. The establishment and nurturing of a U.S.-based marine renewable industry would secure our nation's place in developing offshore renewable energy technologies thereby ensuring that the United States is an exporter, not an importer, of these technologies.

Federal Support and Industry Partnership

The formation and growth of a U.S.-based marine renewables industry is not a given. It is essential to understand that marine renewables face significant challenges before they can become a meaningful part of the nation's power supply. These challenges include the current limited federal support, lack of adequate regulatory framework, and the need for closer government agency cooperation.

At the same time, there is the opportunity for accelerated growth of a U.S. marine renewables industry by adopting the "lessons learned" and building on the successes of wind and solar development programs both in the U.S. and Europe.

I strongly support the current action in Congress that would address these issues head-on and with a strong sense of urgency. Specifically, I support the pending marine and hydrokinetic program reauthorization which would establish the following program parameters:

$250 million/five-year authorization of:

- Research, Development, Demonstration & Deployment (RDD&D)/separate program line for water power
- Device verification
- Five-year accelerated depreciation

I believe that this program could have a comparable success and payback to the nation as experienced with U.S. programs in support of wind power and solar energy technologies.

One of the key issues I would like to stress today is the need for a serious, sustained federal effort to develop, demonstrate, and deploy marine hydrokinetic technologies to economically help meet its needs for energy security and CO_2 reduction and for gaining a global leadership position in the marine renewable energy sector and benefit from the major industrial opportunity that it presents.

The federal technology programs, particularly those at DOE, have over their 30-year history directly enabled the development and commercialization of new energy technologies such as geothermal, solar, biomass and wind. The Department's management -political and career -and the technical experts at headquarters and the national laboratories, can take much of the credit for helping to create today's global renewable industries. They closely collaborated with the emerging industry players to understand, and then mitigate risk; they requested the funds necessary to research, develop and demonstrate new technologies; they shared the pride when technology achieved commercial success and gritted through the setbacks along the way; and they promoted the new technologies, within the government, as well as with the nation's utilities, and their consumers. They helped launch major industrial activity and large-scale renewable power generation.

The U.S. renewable energy experiences shows that in a government/industry partnership, the most fundamental factor in success is a sustained federal commitment in the face of changing or uncontrollable events, such as global oil price fluctuations or shifting national priorities that come with each new administration or political appointee.

I share two examples:

In the 1990's, the DOE/NREL support for wind energy technology development and verification was highly effective and led to much larger and more efficient turbines. During that time, my company, Zond, developed three generations of turbines, greatly aided by technical and grant support from DOE/NREL. This enabled Zond's growth to a leading position in the industry, and eventually GE acquired the technology and manufacturing for its entry into wind energy. By 2008, GE had produced over 10,000 turbines, placing it among the top global wind turbine companies. The $32 million in DOE/NREL grant support has leveraged well in excess of $15 billion in direct economic activity.

In 2001, we launched Clipper Windpower to produce a new generation turbine based on advanced powertrain architecture and controls. In the same year, DOE/NREL solicited wind turbine technology proposals, and with good fortune, Clipper was selected for a $9 million matching grant. This was followed by over $150 million in private equity funding for the 2.5 MW Liberty turbine, which we started manufacturing in 2006. Clipper now has 800 employees, and there are 375 turbines deployed in 17 projects across the U.S., totaling 938 MW of generating capacity. This success would not have been possible without the DOE/NREL's assistance, from design to development, from demonstration to deployment, and yielding the "most advanced and efficient wind turbine in the industry" (DOE 2006 Report). Our DOE/NREL partnership again resulted in significant new manufacturing activity, created jobs, added to the Federal and State tax base, and helped grow the U.S. renewable power industry.

But there is the other side of the coin. Clipper Wind was also seeking to partner with DOE/NREL to develop offshore wind technology when the offshore wind program was suddenly terminated in 2006, significantly shifting the early offshore wind technology lead to Europe. With this, Clipper had to revert to overseas for support, where government incentive structures for technology development were robust and consistent. Today, we are engineering the 10 MW Offshore Wind Turbine in Blythe, England, where production is planned to start in 2013.

The UK now leads the world in offshore operating wind turbine capacity, and the European Union has accelerated their offshore wind program, expected to exceed

$150 billion by 2020. They have set goals of 20% from renewable energy deployment in 2020, which now includes offshore wind, wave, and tidal currents. This is supported by robust technology development grants and energy pricing mechanisms. UK offshore renewable energy produces roughly double the revenue compared to U.S. energy pricing.

China has installed its first offshore turbines, and its land-based turbine deployment is expected to be the highest for any nation by 2010 and beyond.

Hydropower and Hydrokinetic Have Little in Common

The basis for establishing a marine hydrokinetic program, separate from hydropower, is based not only on major differences in requirements for offshore/marine vs. land-based system deployment and operation, but also very different technical, financial, and technology maturity characteristics. Traditional hydropower technology has remained relatively static for decades. These two hydros have little in common. Advances in the new marine technology will be far more robust, and progress will occur more quickly with the marine hydrokinetic program apart from, and not subsumed under, the federal hydropower program.

Technology Verification Program

I firmly support the Congressional language that would establish a technology verification effort to increase marine-based power experience and to build and operate enough candidate devices to obtain statistically significant operating and maintenance data. The technology verification program for wave, tidal, and current energy systems is the bridge to commercial deployment of marine renewable energy devices. This program is modeled on DOE's successful wind turbine verification program of the 1990's, which lead to invaluable experience on siting, permitting and operations. In particular, the program significantly increased data collection to address the uncertainty regarding impacts of the then-emerging wind industry. A similar effort directed towards marine-based renewable energy technologies would also enhance DOE's ability to effectively manage an increased level of funding in a timely manner and with clear results.

Government Coordination

DOE should also work closely with other federal agencies that have an interest in marine renewables, particularly with the Department of Defense, the Department of Commerce (NOAA), and those agencies that have regulatory authority and can provide incentives.

Since 2002, DOD has provided funding for the development of marine renewable technologies. DOD facilities also offer a market for marine renewable products and services, particularly to reduce dependence on imported fossil fuels, which can be extraordinarily costly when supplied to DOD and remote bases.

The lack of a clear, timely, and predictable regulatory regime deters not only private investors in the technology, but also testing and near-term deployment funding. Federal agencies with regulatory authority or concerns related to marine renewables should work together to streamline deployment of MHK projects. The recent announcement by the Federal Energy Regulatory Commission that it has signed a Memorandum of Understanding (MOU) with nine federal agencies to streamline the siting of transmission lines provides an excellent model that should be applied to the marine renewable energy sector. Federal agencies should also coordinate with states that are either investing in this technology or will play a role in permitting and siting projects, including Maine, New York, Florida, California, Oregon, Washington, and Hawaii.

Cost of Energy and Deployment

Since 1998, I have engaged in an effort to advance utility-scale power generation technology for both wave energy and ocean currents. Based on this engineering, we are targeting a cost of energy for both technologies in the range of $0.10 to $0.12/kWh by 2015, a level that should enable commercialization, provided the U.S. government implements an effective program of incentives for research, development, and deployment, that supports marine renewables more tangibly and consistently than the federal support for wind energy. Meaningful rates of deployment (several gigawatts/year) should come in the 2015 2020 timeframe in line with the forecast potential of 23 GW by 2025.[1]

[1] American Council on Renewable Energy (ACORE), "The Outlook on Renewable Energy in America, Volume II: Joint Summary Report", March 2007; ACORE: Hydropower Industry Outlook, presentation to "Renewable Energy in America: Phase II Market Forecasts and Policy Requirements," November 29–30, 2006.

While this appears quite accelerated when compared to the history of wind, solar, and other renewable energy technologies, it must also be viewed in light of the advanced know-how, which is brought forward from marine engineering in shipbuilding, offshore oil, submersible vehicles, knowledge we now have of structural loads and control systems of wind turbines, the advanced numerical model design tools, and fabrication of large composite structures. This substantially reduces development costs and timeline. Furthermore, the urgency that is now upon us from climate change and energy security is driving development of marine renewable energy not just in America, but Europe as well. So we can expect a fast and competitive pace in technology advancement.

Learning from Wind Power Policy

The U.S. renewable energy experiences shows that in a government/industry partnership, the fundamental success factor is a sustained federal commitment in the face of changing or uncontrollable events, such as global oil price fluctuations or shifting national priorities that come with each new administration or political appointee.

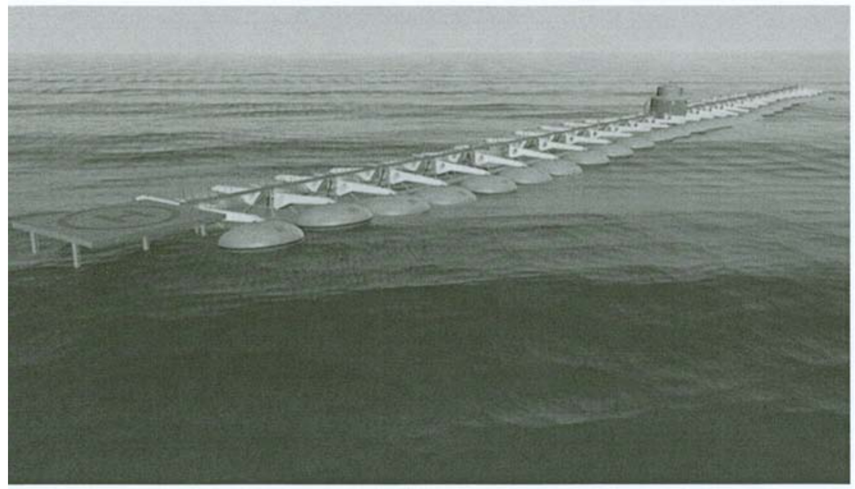
Perhaps the hardest public policy lesson that has come out of the American wind effort has been the repeated crippling effect, on the industry, from discontinuity in government support. The U.S. was in a clear leading position in wind power in the early 1980's due to the U.S. government's investment in renewable energy technologies, which started during the oil embargo in the 1970's. By the mid-1980's, government support ended and the U.S. wind industry virtually collapsed. A series of on again, off again programs followed. While the U.S. wind sector continued in its struggle for survival, strong European Union support stimulated rapid growth throughout the continent. Today, European companies enjoy the lion's share of the industry and have created several hundred thousand jobs, with a global wind industry generating upwards of $40 billion per year and growing at 20% annually. We are now seeing massive support for wind energy in China, which has initiated ten 10,000 megawatt regions representing$200 billion in industrial activity fully supported by the Central Government.

While America had the foresight and made the investment to launch the wind industry, discontinuity in federal support has allowed other nations to capture a major share of the long-term industry/energy benefits. We must not let this happen with marine renewables; government policy should be implemented quickly and sufficiently to sustain this emerging industry until it reaches industrial scale.

Summary

In summary, marine renewables offer enormous potential to stimulate our economy, address our environmental issues, and to provide an indigenous source of clean, renewable energy. I urge the Subcommittee to support a serious and sustainable federal investment to stimulate the continued development and ultimate deployment of U.S.-based marine renewables at home and around the world.

Thank you again for the opportunity to appear before you today and I am happy to take your questions.



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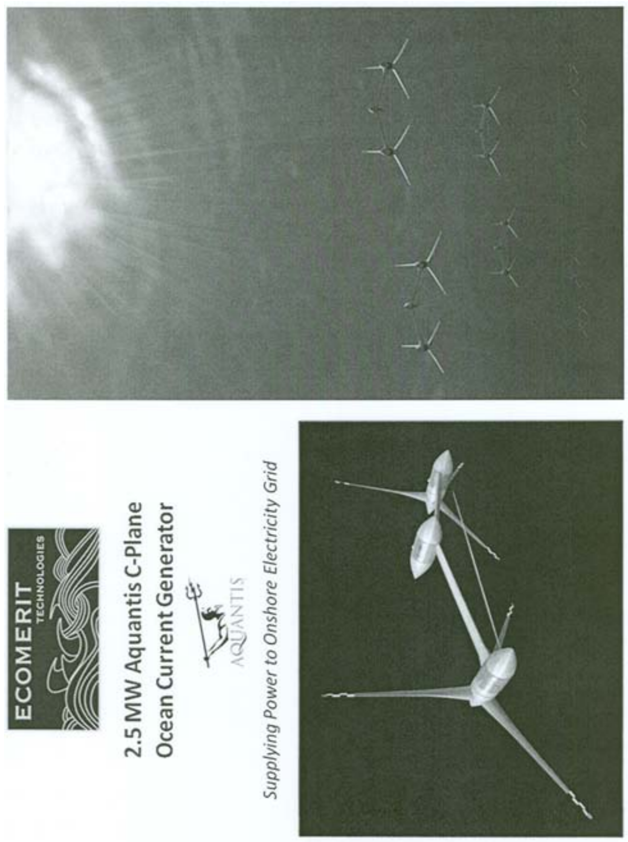


BIOGRAPHY FOR JAMES G.P. DEHLSEN

James G.P. Dehlsen James G.P. Dehlsen, recognized as a pioneer and world leader in wind power and renewable energy, co-founded Clipper Windpower, Inc., in 2001 where he serves as Chairman of the Board of Directors. Clipper developed the breakthrough 2.5 MW Liberty wind turbine. Manufacturing started in 2007 and in 2008, 289 turbines were produced, representing 722 MW and 8% of the U.S. market. Clipper is in development on a 10 MW offshore turbine planned for testing in 2011.

Mr. Dehlsen founded Zond Corporation in 1980 and served as its CEO and Chairman of the Board. Zond pioneered wind power technology, growing rapidly to become one of the largest global companies in wind turbine manufacturing, wind power project development and plant operation. With its acquisition by Enron Corporation in 2000, Mr. Dehlsen ended his Zond tenure. In 2002, General Electric purchased the wind business and technology for its entry into wind energy and is now a global leader in the industry.

Recognition for his work in the wind industry includes the Lifetime Achievement Award by the American Wind Energy Association, and the Danish Medal of Honor conferred by His Royal Highness, Prince Henrik of Denmark. He was inducted into the Environmental Hall of Fame as a leading environmentalist and "Father of American Wind Energy." Mr. Dehlsen has served as an advisor to the Department of Energy's Wind Program, testified at the first U.S. Senate hearings on global warming, and has served as a delegate to the Conference on Climate Change in Kyoto, Japan. Mr. Dehlsen has eight patents and seven patents pending.

Chairman BAIRD. Mr. Collar.

STATEMENT OF CRAIG W. COLLAR, P.E., SENIOR MANAGER FOR ENERGY RESOURCE DEVELOPMENT AT SNOHOMISH PUBLIC UTILITY DISTRICT

Mr. COLLAR. Good morning. Thank you, Mr. Chairman, Ranking Member Inglis and Members of the Committee. Again, I am Craig Collar from Snohomish County Public Utility District. Snohomish PUD is of course located in Washington State just north of Seattle. We are the 12th largest public utility in the country and we certainly appreciate the opportunity to provide testimony on this important topic today.

As you are all aware, the marine energy industry really today is in its infancy, and as a result there is very little data available relative to the viability of marine energy moving forward. In our view, the best way to close that data gap is by the responsible deployment and close monitoring of commercial-scale turbines at appropriately selected sites. In fact, that is the very purpose and objective of our project in the Puget Sound. Our project is already recognized as one of the leading efforts in the country. We have an extremely strong project team. It includes the University of Washington, the Northwest National Marine Renewable Energy Center, EPRI, two national labs, and of course, the Department of Energy. In working with our partners, we have selected Admiralty Inlet as the most appropriate site for our project, and as you can see from the chart, Admiralty Inlet is the main entrance to Puget Sound, and it is important to note, it is a very large body of water. It is nearly three and a half miles across.

In terms of tidal technology, we have selected OpenHydro as our partner for the project. OpenHydro is an Irish company. They have licensed tidal turbine technology that was developed here in the United States, and they are one of the few companies in the world to have already deployed and tested large-scale tidal energy devices and generated some data and learning from those. In fact, one was deployed last month in the Bay of Fundy up in Nova Scotia. The turbines utilized for our project will be very similar to those for that project and in fact are similar to the ones shown in the picture that you seen on the screen. I will also take this opportunity to note that the rotor on this turbine rotates at a very low speed, only in the range of 10 to 20 RPM.

Now, we intend that our demonstration project will consist of two to three of these OpenHydro turbines connected to the electric grid. The project will overall be a very limited scale relative to the size of Admiralty Inlet. In fact, it represents less than five 100ths of a single percent of the cross-section of Admiralty Inlet. This figure shows to scale what a tidal turbine in a cross-section of Admiralty Inlet would look like. It is also important to note that Admiralty Inlet is the main shipping channel in and out of Puget Sound, so all commercial traffic, military traffic, naval traffic all goes through Admiralty Inlet. So by any standard and definition, Admiralty Inlet is a working waterway.

Lastly, this figure depicts a bird's eye view of two turbines to scale in Admiralty Inlet. It might be hard to make out but the two small black dots that black arrow is pointing to, that is how large these commercial-scale turbines would be in Admiralty Inlet.

To date our project has been granted approximately $2.5 million in mostly federal funding and primarily from the Department of Energy. So the Department of Energy support both currently and ongoing will be absolutely critical to our project.

With respect to environmental considerations, one of the benefits of working with OpenHydro is they have actual data from deployments of these devices elsewhere in the world, primarily in Europe, and in fact, their projects have been continuously videotaped since 2006 and to date there are absolutely no interactions with fish or marine mammals and the turbines while the turbines are operating.

In terms of permitting, we are utilizing the FERC pilot process for our permitting effort. This process was developed by FERC specifically to facilitate the licensing of small, short-term, removable and carefully monitored projects just like ours while reducing the baseline study burden, thereby facilitating getting these projects into the water so we can gather data.

Over the past three years we have conducted nearly 100 formal project communications meetings with over 50 various and different stakeholder groups, importantly including of course tribal governments and resource agencies. Now, one of the key challenges that we face with resource agencies in particular is balancing the small size and scope of our project with the level of baseline information necessary to support permitting. It is clearly recognized that if those requirements are too burdensome, pilot projects like ours will never be able to advance into the water and progress in the United States will essentially be at a standstill.

Now, we believe that some resource agencies perceive that their existing regulatory accountability really precludes their support of a pilot process-type approach. For instance, the National Marine Fisheres Service feels they have little latitude to accept anything less than very detailed and rigorous baseline studies in order to support their analysis. Well, in fact, we are conducting in the neighborhood of $1 million of pre-installation and baseline studies just for our small research and development project and to date National Marine Fisheries has been reluctant to state really with any certainty that even that will be sufficient. Because these studies represent a very significant cost in advance of any certainty of actually getting a license for the project, it is very easy to see how this could easily prevent even leading research and development projects like ours from moving forward.

So in conclusion, it seems clear that so long as key resource agencies are not enabled to effectively balance the facilitation of renewable energy with their existing responsibilities, the advancement of renewable energy in this country is unlikely to progress at a pace sufficient to meet our energy and environmental challenges.

Well, thank you again for the opportunity to appear before you today. I certainly would be happy to answer any questions.

[The prepared statement of Mr. Collar follows:]

PREPARED STATEMENT OF CRAIG W. COLLAR, P.E.

Thank you Mr. Chairman, Ranking Member Inglis, and Members of the Committee for the opportunity to appear before you to provide testimony on this important topic. I am Craig Collar, Senior Manager of Energy Resource Development for the Snohomish County Public Utility District. Snohomish PUD is located in Washington State just north of Seattle and serves approximately 318,000 electric customers and nearly 20,000 water customers. Our service territory covers over 2,200 square miles, including both Snohomish County and Camano Island.

Introduction

Snohomish PUD is the twelfth largest publically owned utility in the nation and is located on the shores of the Puget Sound estuary. We believe there is significant potential to generate clean, renewable, environmentally benign, and cost effective energy from tidal flows at selected sites in the Puget Sound, and that successful tidal energy demonstration in the Sound may enable significant commercial development in the Sound and elsewhere resulting in important benefits for both the northwest region and the country. In order to meet the demands of a growing service load, as well as a state renewable portfolio standard, Snohomish is conducting exceptionally aggressive conservation and energy efficiency programs. Additionally, in just the past few years, Snohomish PUD has acquired the highest percentage of wind energy of any utility in the Northwest and is actively pursuing geothermal energy as well as solar, biomass and other clean resources. We believe that tidal energy also has the potential to contribute significantly as part of a richly diversified clean energy portfolio, but that in-water testing is required to address associated uncertainties in performance, cost, and environmental effects. Snohomish has made significant progress towards the deployment of such an in-water testing program, but while many barriers to this research and development effort have been overcome, substantial challenges remain to the successful deployment of tidal energy technology in our region.

The marine energy industry today remains in its infancy; even in the United Kingdom which has largely led the world in marine energy development and testing, marine energy projects are limited to a small handful of fairly recent efforts. As a result, little data relative to the technical, economic, and environmental viability of ocean energy generation has yet been established. Our view is that the most effective way to address this data gap is via the responsible deployment, testing and monitoring of utility-scale ocean energy devices at appropriately selected sites—this in fact is the objective of the Snohomish PUD Puget Sound Tidal Energy Demonstration Project. The data from this project will inform Snohomish PUD's potential development of other sites in and around Puget Sound, as well as provide important information for other marine energy developers in the nation.

Snohomish PUD Puget Sound Tidal Energy Demonstration Project

The purpose of the Snohomish tidal project is to gather data by conducting the deployment, demonstration, and testing of tidal energy conversion technology in the Puget Sound. The project is recognized as one of the leading marine energy efforts in the country, has substantial support in the region, and has built an exceptionally strong project team. Snohomish PUD, in partnership with the U.S. Department of Energy (DOE), the University of Washington (UW), the Northwest National Marine Renewable Energy Center (NNMREC), and the Electric Power Research Institute (EPRI) has conducted a thorough evaluation of potential tidal energy sites in the Puget Sound, and has selected Admiralty Inlet (Figure 1) as the most appropriate location to establish a demonstration project.

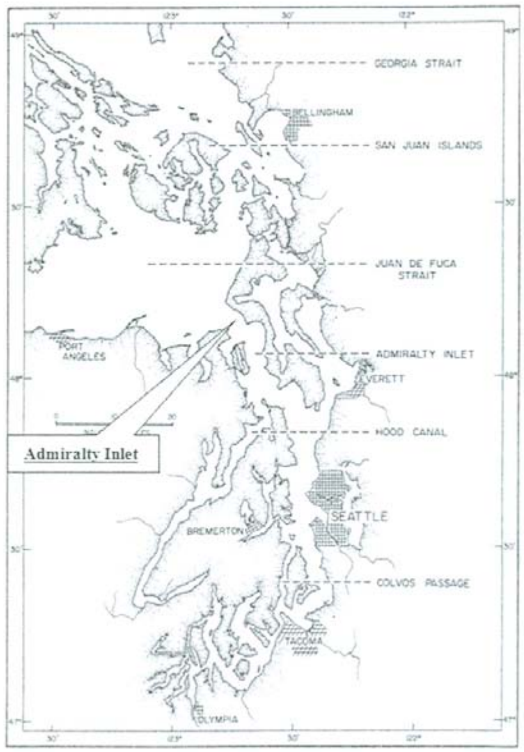


Figure 1: Puget Sound and Admiralty Inlet

Snohomish PUD and its partners have conducted an extensive suite of studies both to establish the suitability of the Admiralty Site for tidal energy generation, as well as to characterize important environmental characteristics of the site. To date these activities have included:

- Acoustic Doppler current profiling and tidal current modeling
- Detailed bathymetry measurements and geotechnical evaluation of the seabed
- Remotely operated vehicle videography of the seabed
- Water quality measurements
- Background acoustics measurements
- Multiple hydro-acoustic surveys to determine the presence, location, and abundance of fish and other marine life
- Passive acoustic monitoring to detect marine mammal echolocation/vocalization
- Passive monitoring for acoustically tagged fish and marine mammals
- Southern Resident Killer Whale (SRKW) observation, tracking, and behavior assessment
- Tidal energy conversion technology assessment and selection
- Preliminary plant design and grid interconnection study
- Navigation, fishing and social considerations

Snohomish PUD engaged with over 30 tidal energy technology developers worldwide as part of its assessment and selection program. This effort included visits with the leading technology developers in the U.S., Europe, and Canada, as well as to the European Marine Energy Center (EMEC) in the Orkney Islands, Scotland.

Following a detailed evaluation process Snohomish PUD selected OpenHydro as its technology partner for the demonstration plant. OpenHydro is an Irish energy technology company whose business is the design and manufacture of marine turbines for generating renewable energy from tidal currents. The OpenHydro turbine technology was developed in the United States in the early 1990's and the rights were subsequently licensed by OpenHydro in 2004. During 2006 OpenHydro completed the installation of the first tidal turbine at EMEC. This installation, mounted on a surface piercing testing rig, is shown in Figure 2.

Figure 2: OpenHydro Research and Development Installation

In May 2008 OpenHydro successfully completed the connection of the test structure to the electricity distribution network, making OpenHydro the first company to deliver tidal stream power to the UK national grid. Since that time OpenHydro has successfully deployed two additional turbines on completely submerged gravity bases; one at EMEC and one in November 2009 in the Bay of Fundy, Nova Scotia. The turbines utilized for the Puget Sound demonstration plant will also be deployed on completely submerged gravity foundations (as shown below in Figure 3) similar to those used for the EMEC and Bay of Fundy efforts.

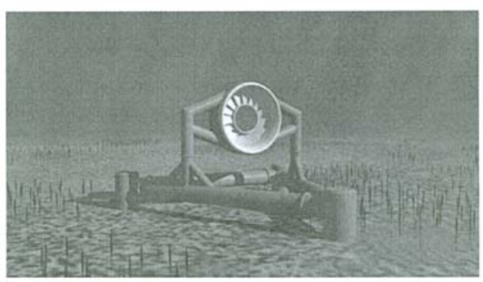


Figure 3: OpenHydro Turbine Gravity Foundation Installation

Snohomish envisions that the demonstration plant will consist of one or two OpenHydro turbines as large as 16 meters in diameter located about 1 kilometer offshore in approximately 60 meters of water depth. Power would be transferred to the electric grid on Whidbey Island via a seabed cable. The cable deployment will utilize horizontal directional drilling so as to avoid disturbing nearshore habitats. No anchor placements, pilings, or surface-piercing structures would be involved with the turbine installations or cable. In fact, both the turbines and their foundations are specifically designed to be completely removable for scheduled maintenance or other needs. The project would be of very limited scale relative to Admiralty Inlet, representing less than 0.05% of the Inlet's cross-section. The small scale and temporary nature of the project significantly diminish the likelihood of adverse environmental effects. Likewise, the water depth at the site and its location outside of the shipping channel mitigates navigational concerns. Figure 4 depicts a tidal turbine to scale in a cross-section of Admiralty Inlet.

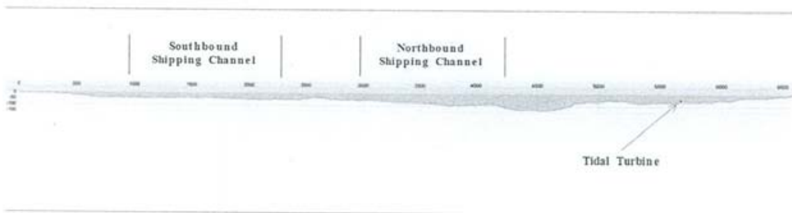


Figure 4: Scale Depiction of one Tidal Turbine Deployed in Admiralty Inlet

The OpenHydro turbine consists of a horizontal axis rotor with a single moving part and power take-off through a direct drive, permanent magnet generator. It is principally comprised of the rotor and the stator; there is no requirement for a gearbox. The design incorporates several key features to avoid or minimize environmental risk:

- No requirement for oil/grease lubrication.
- Rotor blade tips are retained within the outer housing.
- Slow rotational speed.
- Ability for the rotor to be stopped quickly and remotely
- Cavitation prevented by design at specified deployment depth.
- Deployment method and gravity base design eliminate need for drilling or piling operations, as well as facilitate potential relocation and complete removal of both the foundation/base and the turbine.

To date, the Snohomish PUD project has been granted approximately $2.5 million in funding to support technical design and environmental study efforts. Funding has been provided by the Bonneville Power Administration, energy and water federal appropriations, and most substantially by the Department of Energy's (DOE) Advanced Water Power Projects program. Specifically, Snohomish PUD has received two separate grants from the DOE to support project design and environmental studies, and has developed partnerships with numerous entities to carry out this work. In addition to the previously mentioned UW, NNMREC, and EPRI partnerships, Pacific Northwest National Laboratory and the National Renewable Energy Laboratory are also on the Snohomish team.

Snohomish PUD is also collaborating with the U.S. Navy's Puget Sound KHPS Project, which is being conducted with Verdant Power. The KHPS project plans for a test deployment of Verdant Power turbines for a period of approximately one year. The proposed Navy project is located approximately six miles south of the Snohomish PUD project location as shown in Figure 5 below. The Navy has chosen the southernmost of the two potential sites indicated for their project.

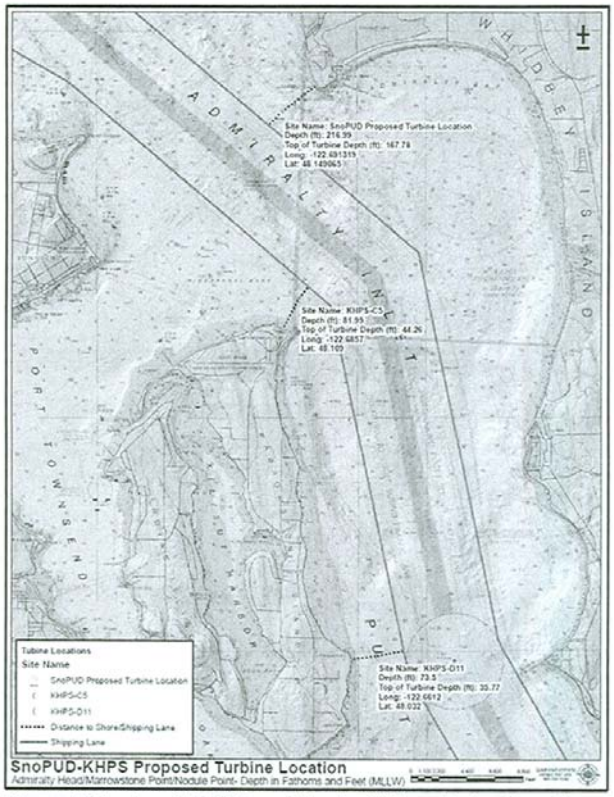


Figure 5: Snohomish PUD and Verdant/Navy Project Locations

The KHPS project will be interconnected to facilities at Naval Magazine Indian Island and will consistent of 3–6 Verdant Power turbines as shown in Figure 6. Snohomish PUD and the Navy have conducted some joint studies to share and reduce overall costs, and we are actively working to share information and collaborate in developing project operations and monitoring plans.

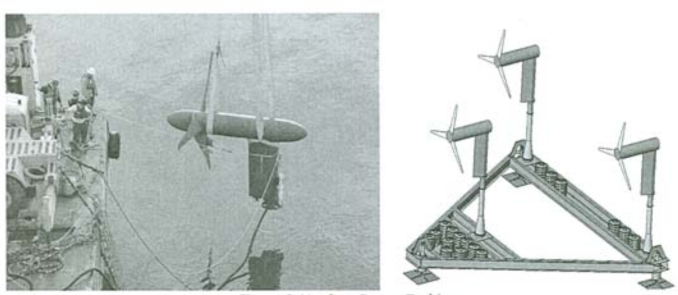


Figure 6: Verdant Power Turbines

In addition to the Snohomish and Navy projects, there is also consideration being given to the potential establishment of a National Tidal Energy Facility (NTEF) in the Puget Sound. This facility would utilize the infrastructure that will remain at the KHPS project after the Verdant turbines have been removed, and would provide a characterized, permitted site for test and demonstration of tidal energy systems.

The NTEF would be device-independent and would provide consistent, comparable performance data for a range of tidal energy devices and systems. The NTEF would provide developers with a permitted test site so that their resources can be better focused on technology development and not on permitting actions. Because the Snohomish and KHPS projects will both be in progress prior to the potential development of the NTEF, the data (technical, environmental, social, etc.) generated by these earlier projects should inform the ultimate design, utility and viability of developing the NTEF in the Puget Sound.

Outside the Puget Sound, Oregon State University (OSU), as a NNMREC partner, is working primarily to advance the wave energy industry. This includes improved wave energy forecasting for both offshore and near shore locations, device and array optimization methods and models, environmental effects evaluation, and the development of a mobile test berth for full scale wave device testing. Testing and evaluation will identify best practices for maintenance and quality control of wave energy systems and refine wave energy power measurements. The State of Oregon has invested significantly in wave energy including the formation of the Oregon Wave Energy Trust and designation of State capital funds to OSU as direct investment in the development of the NNMREC.

Environmental Considerations and Studies

While they are limited in scope, existing data and assessments regarding currently operating and proposed tidal projects are notable in that they document no substantial or unanticipated environmental risk. Scotland's Orkney Islands (where EMEC and the OpenHydro turbine are located) represent a very ecologically diverse and productive marine ecosystem which is home to a number of fish and marine mammal species. Fish and shellfish species include: mackerel, herring, haddock, cod, monkfish, several flat fish species, lobster, crab, and scallops. Marine mammal species include: otters, seals, minke whale, harbor porpoise, white-sided dolphin, common dolphin, killer whale, and pilot whale. Leatherback turtles also regularly visit Scottish waters between August and November. Operation of the EMEC OpenHydro turbine installation has been continuously videotaped while in operation since 2006 and to date no marine life incidents have been recorded. Review of the videotape data indicates that fish and marine mammals avoid and do not interact with the device while it is rotating, but as might be expected some fish species do aggregate downstream of the turbine at tidal current velocities too low for the turbine to rotate (Figure 7).

Figure 7: Fish Aggregation – OpenHydro Turbine (not rotating)

During periods of tidal current velocity energetic enough to turn the turbine's rotor the fish have been observed to leave the area rather than expend energy to maintain position against the flow of the tidal currents. It is also important to note that the flow dynamics of the turbine are such that the device will not "entrain" fish in any conventional hydropower turbine sense, but rather fish or other objects in the tidal flow would be drawn through the center opening or around the outside of the device. The previously noted OpenHydro installation in the Bay of Fundy was recently evaluated in a comprehensive Environmental Assessment report to Canadian federal and provincial governments; the likely effects of the project were found to be limited in scope and duration. While these and similar assessments do not by themselves document a lack of environmental effects for the Admiralty Inlet Pilot Project, Snohomish PUD believes they provide important context that must be considered in developing study plans and environmental analyses. Admiralty Inlet supports or includes designated critical habitat for eight ESA-listed species managed by the National Marine Fisheries Service (and two managed by the US Fish and

Wildlife Service) and supports a wealth of unlisted marine resources as well. As is the case for the entirety of Puget Sound, Admiralty Inlet is designated as Essential Fish Habitat for a number of species and includes several Habitat Areas of Particular Concern. It is important to note that Admiralty Inlet also includes a major shipping lane utilized by essentially all commercial and military traffic in and out of Puget Sound, substantial shoreline development, and a busy ferry route operating directly to the south of the project site.

Snohomish PUD is conducting environmental analyses by assessing potential mechanisms of effect for the species known or believed to occur in the project area based on existing information and a suite of pre-installation studies. Snohomish is also developing a significant monitoring effort to determine if unacceptable impacts occur or are likely to occur. An approach focused on monitoring enables direct evaluation of the primary unanswered question of how marine life will interact with the turbines. The NNMREC has been a key partner in the design and execution of project pre-installation studies conducted so far. An instrumentation platform designed by the University of Washington Applied Physics Laboratory to facilitate the study of tidal sites is shown in Figure 8. This platform is currently deployed on the seabed at the project site and has already delivered important information during the several months that it has been in service.

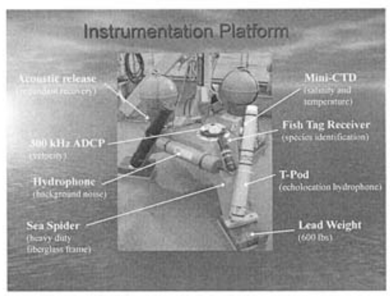


Figure 7: Tidal Project Studies Instrumentation Platform

Because there is not yet any subsea cable run to the deployment site, the platform must be retrieved and redeployed approximately every three months to download collected data and replace batteries. While pre-installation studies have essentially been completely developed and are underway, development of studies intended to monitor the project once it is operating continues. Potential project effects identified by Snohomish include modifying local habitat by adding new structure, blade strike or collision and similar "near field" effects, altered behavior patterns of some marine mammals or fish, modification of the acoustic or hydrodynamic environment, and the accumulation of derelict fishing gear. The goal of Snohomish's proposed monitoring efforts is to detect and describe in detail the potential for interactions between the project and marine species.

The specific objectives of Snohomish's proposed monitoring efforts are:

- Assess near-turbine presence and distribution of marine species;
- Assess near-turbine fish behavior;
- Identify near-turbine species composition;
- Evaluate the Project's acoustic signature;
- Evaluate the Project's effects on hydrodynamics; and
- Monitor and remove derelict gear.
- Evaluate potential effects of construction, decommissioning, or maintenance on aquatic species and water quality.

To address these objectives, Snohomish proposes to pursue the following monitoring efforts:

- Near-turbine monitoring and identification of aquatic species;
- Acoustic monitoring;
- Hydrodynamic effects monitoring;
- Derelict gear monitoring and removal; and
- Construction monitoring.

Snohomish believes the methods described below represent the best current practices for evaluating presence, distribution, and behavior of mobile marine species. At the same time, both hydrokinetic and hydroacoustic technologies are evolving at a rapid pace that makes it likely there will be significant technological advances and new information regarding hydrokinetic turbines during the course of pre-installation licensing efforts for the project. As a result, there is an expectation that changes will occur over time and will be addressed through an adaptive management program.

Numerous technical hurdles will need to be considered and addressed as part of the successful implementation of the monitoring plan. Chief among these are a complex of questions related to selection, placement, deployment, and retrieval of monitoring gear. For example, many of the sonar transducers and cameras envisioned in the monitoring plan will require periodic maintenance, whether scheduled (e.g., lens cleaning) or unscheduled (e.g., flooded casings). Servicing this equipment likely will require bringing it to the surface, which presents substantial challenges related to physical and electrical connections with data and power cables, subsequent redeployment of the gear, correct orientation and calibration of redeployed equipment, and similar issues. Snohomish will pursue a continuing dialogue with technology providers as to potential methods of addressing and testing each of these issues; however it is important to note that no method to address these challenges is currently identified, which may substantially affect Snohomish's monitoring abilities and technology decisions.

Snohomish believes that many of the technical issues described above, as well as data interpretation associated with the monitoring effort, will warrant review and discussion by a technical working group. This group would oversee and evaluate results of pre-installation and monitoring studies. These results would be used in combination with an understanding of the ecosystem and information from other relevant sources to make adjustments to study methods as appropriate, and to manage aspects of the project operation in a manner that avoids or minimizes unexpected or undesirable impacts on resources. The adaptive management process allows for immediate action where necessary to address a critical adverse effect of the project should any occur. Snohomish envisions this as a consensus-based group that would include representatives from federal and state resource agencies, tribal governments, and other appropriate stakeholders. It would administer key topics related to the project, including:

- Consideration of results from pre-installation studies and monitoring efforts and subsequent adjustments to study methods as appropriate.
- Development of monitoring thresholds for inclusion in Project license conditioning.
- Evaluation or initiation of potential mitigation or impact avoidance measures.

Snohomish believes that the environmental monitoring plan represents a critical and particularly challenging element of the overall project. Close collaboration with tribes, agencies, and other stakeholders; technical support from NNMREC and the Pacific Northwest National Lab; and the ongoing and strong support from the DOE's Advanced Water Power Projects program will all be important to the success of the effort.

Permitting Process, Consultation and Outreach

Snohomish PUD is utilizing the Federal Energy Regulatory Commission (FERC) Hydrokinetic Pilot Plant Licensing Process (Pilot Process) for the Admiralty Inlet project. The Pilot Process was proposed by FERC in late 2007 specifically to facilitate the licensing of small (rated capacity of less than 5 megawatts), short-term, removable, and carefully-monitored projects intended to test marine energy technologies, sites, or both. FERC recognized that there are a number of barriers to realizing the potential of these new technologies but that the primary barrier may be that they are as yet unproven, and that more data was necessary prior to any large scale commercial deployments. The purpose of the Pilot Process is to provide a means of testing new technology, including interconnection with the electric grid. The process aims to minimize both the up-front baseline study burden and the risk of adverse environmental effects by requiring a rigorous project operations monitoring effort, as well as project shutdown and removal if significant adverse environmental effects occur and cannot be mitigated.

Snohomish was issued a preliminary permit from FERC for the Admiralty Inlet site on March 9, 2007, though as early as July of 2006 Snohomish had informed key stakeholders (tribes, state agencies, federal agencies, NGO's, communities, etc.) of its intention to pursue tidal energy exploration in the Puget Sound. An initial project meeting was held with numerous stakeholders (tribes, state agencies, federal agencies, NGOs) on February 23, 2007 to formally introduce the project, answer questions, and discuss the consultation approach going forward. During the approximately two and one-half years since this initial meeting Snohomish has conducted nearly 90 formal project communication meetings with various stakeholders. These have included formal consultation meetings, community town hall meetings, conference presentations, NGO meetings, and more. Groups who have been engaged through these efforts have included:

- Washington Department of Ecology
- Washington Department of Fish and Wildlife
- Washington Department of Natural Resources
- Washington Governor's Office of Regulatory Assistance
- Washington Department of Community, Trade, and Economic Development
- Washington State Attorney General's Office
- Washington Energy Facility Site Evaluation Council
- U.S. Department of Energy
- U.S. Navy Region Northwest
- Naval Station Everett
- Naval Magazine Indian Island
- Federal Energy Regulatory Commission
- National Marine Fisheries Service
- U.S. Army Corps of Engineers
- U.S. Department of Fish and Wildlife
- U.S. Environmental Protection Agency
- U.S. National Park Service
- U.S. Coast Guard
- Puget Sound Pilots
- American Waterways Operators
- Puget Sound Harbor Safety Committee
- Washington State Ferries
- Federal Ocean Research and Resources Advisory Panel
- Puget Sound Partnership
- Tulalip Tribes of Washington
- Suquamish Tribe
- Skagit River System Cooperative
- Pacific Northwest National Laboratories
- The National Renewable Energy Lab
- The University of Washington
- Washington State University Energy Extension
- Seattle Pacific University
- People for Puget Sound
- The Orca Network
- The Whale Museum
- The Sea Mammal Research Unit
- Beam Reach Marine Science and Sustainability School
- Northwest Straits Conservation Alliance
- Fort Casey State Park
- Ebey's Landing National Historic Preserve
- Puget Sound Anglers
- Regional county Marine Resources Committees
- Regional city councils
- Numerous local community and service groups

As indicated by this level of engagement, Snohomish considers stakeholder outreach and consultation to be a critical element of project success, and believes that these efforts have been invaluable in keeping stakeholders informed and in maintaining open lines of communication for feedback and dialogue. Additionally and where practical, Snohomish has collaborated with regional stakeholders and marine experts to design and carry out certain studies. As one example, Beam Reach Marine Science and Sustainability School, the Whale Museum, and the Orca Network, all strong regional stewards for killer whales in Puget Sound, worked with Snohomish to design the project's Marine Mammal Study Plan and are currently conducting the study in partnership with the Sea Mammal Research Unit. The Sea Mammal Research Unit is associated with the University of St. Andrews in Scotland, and is currently engaged with efforts to study sea mammal interactions with tidal turbines at projects in the UK.

As required by FERC, Snohomish submitted a pre-application document (PAD) for the project in January 2008. The information provided in the PAD is intended to enable stakeholders interested in participating in the licensing process to become familiar with the project before any formal licensing procedure is initiated and assists these participants in identifying potential resource issues. The Snohomish PAD consisted of over 600 pages of information related to the project and project site and drew upon more than 700 different information sources to compile. As part of the PAD development effort, Snohomish reached out to 20 Indian tribes and organizations, 11 federal agencies, 9 state agencies, 13 Washington ports, 9 counties, 5 municipalities, and 49 non-governmental organizations representing environmental, recreation, and business interests.

With respect to formal permitting requirements, the following is a list of the potential regulatory authorizations, licenses, permits, or regulatory approvals that may ultimately be required prior to constructing and operating a hydrokinetic project within Washington State waters:

- License from the Federal Energy Regulatory Commission.
- Clean Water Act Section 401 Water Quality Certification from the Washington Department of Ecology.
- Marine Mammal Protection Act incidental take permit from the National Marine Fisheries Service.
- Endangered Species Act (ESA) compliance through ESA Section 7 consultation with the National Marine Fisheries Service and U.S. Fish and Wildlife Service.
- Essential Fish Habitat Program review from the National Marine Fisheries Service pursuant to the Magnuson-Stevens Fishery Conservation and Management Act.
- National Historic Preservation Act Section 106 compliance through consultation with the Washington State Historic Preservation Officer, as well as the Tribal Historic Preservation Officer of any affected federally recognized Indian tribe.
- Migratory Bird Treaty Act permit from U.S. Fish and Wildlife Service.
- Clean Water Act Section 404 permit from the U.S. Army Corps of Engineers.
- Rivers and Harbors Act Section 10 permit from U.S. Army Corps of Engineers.
- U.S. Coast Guard review for navigation impacts under the Ports and Waterways Safety Act and Coast Guard and Maritime Transportation Act of 2006.
- Water right for a non-consumptive appropriation of waters of the State.
- Hydraulic Project Approval from Washington Department of Fish and Wildlife.
- Aquatic land lease from Washington Department of Natural Resources.
- National Marine Sanctuary permit (for projects located in National Marine Sanctuaries—will not apply to Admiralty Inlet).
- Minerals Management Services (MMS) lease or right-of-way for projects located on the federal Outer Continental Shelf (OCS). If a portion of the project is located outside of waters of Washington State (or Oregon State) on the federal OCS, then authorization from the MMS may be required. (Will not apply to Puget Sound)
- Coastal Zone Management Act (CZMA) Consistency Certification from Washington Department of Ecology. Under Washington's CZMA program, activities that require federal approval and affect any land use, water use or natural resource of the State's coastal zone must comply with the enforceable policies within the six laws identified in the CZMA program document. The six laws are:
  - *the Shoreline Management Act (including local government shoreline master programs);*

- ○ *the State Environmental Policy Act;*
- ○ *the Clean Water Act;*
- ○ *the Clean Air Act;*
- ○ *the Energy Facility Site Evaluation Council; and*
- ○ *the Ocean Resource Management Act.*

A key challenge faced by Snohomish and project stakeholders, particularly resource agencies, is balancing the small size and scope of the Admiralty Inlet Pilot Project with the level of baseline information necessary to evaluate the project and satisfy permitting requirements. As noted earlier, the FERC Pilot Process minimizes the baseline study burden so as to facilitate the deployment and rigorous testing of these new technologies, thereby generating the data necessary to fill existing information gaps. FERC and others recognized that if baseline information requirements are too burdensome, pilot projects will never advance into the water and progress in the U.S. will be at a standstill. We agree with the position of FERC that any incremental additional risk represented by the Pilot Process approach is more than adequately contained by the stringent safeguards within the Pilot Process license, i.e. the license only applies to small, temporary, closely monitored facilities which are required to be shut down and/or removed if significant adverse environmental effects occur and cannot be mitigated.

Some resource agencies, however, perceive that their existing regulatory accountability precludes their full support of the FERC Pilot Process. For example, we understand that National Marine Fisheries Service (NMFS) generally supports the appropriate development of hydrokinetic projects in United States waters. Nonetheless, given the presence of endangered salmon and killer whales in Puget Sound, NMFS feels that they have little latitude to accept anything less than extremely detailed and rigorous studies in order to support their environmental analysis. While Snohomish has conducted or committed to approximately $1 million in pre-installation and baseline studies (the data from which will add to the already very substantial body of environmental information available for the Admiralty Inlet site) for the pilot project, NMFS is reluctant to state with any certainty that this baseline information is sufficient. Given that these studies necessarily incur significant cost prior to any certainty of actually receiving a plant license, it is not difficult to see how the study burden could easily prevent even small research and development projects like the proposed Admiralty Inlet effort from going forward. It seems clear that so long as key resource agencies are not enabled to effectively balance the proactive facilitation of renewable energy efforts with their existing responsibilities, the progress of renewable energy in the U.S. will advance at a pace unlikely to meaningfully address our country's energy and environmental challenges.

Thank you again for the opportunity to appear before you today to discuss this important topic. I would be happy to answer any questions.

BIOGRAPHY FOR CRAIG W. COLLAR, P.E.

Mr. Collar has 25 years of operations and program/project leadership experience spanning a variety of technical and general management assignments. Mr. Collar has been accountable for all business results (safety, quality, energy/environmental, production, cost, asset management, capital projects, human resource development) for several major manufacturing departments (up to $60 million annual operating budget) including the leadership of groups of up to 170 team members in the production of a variety of consumer products. Mr. Collar also has multi-year experience leading the overall operation and maintenance of a 50 MW cogeneration facility as well as that for a naval submarine nuclear propulsion plant.

Experience

- **Senior Manager-Energy Resource Development,** Snohomish County Public Utility District No. 1, Everett, WA. (2006–Present).
- **Engineering and Operations Management,** Kimberly-Clark Corporation, Fullerton, CA & Everett, WA. (1990–2006).
- **Nuclear Submarine Officer,** U.S. Navy, San Diego, CA (1985–1990).

Education and Certification

- **Master of Business Administration,** Colorado State University, Fort Collins, CO.

- **Bachelor of Science in Mechanical Engineering,** Montana State University, Bozeman, MT.
- **EAN/Six Sigma and Strategic Organizational Leadership Certificates,** Villanova University, Villanova. PA.
- **Global Management Certificate,** Thunderbird—The Garvin School of International Management, Glendale, AZ.
- **Utility Executive Leadership Certificate,** Willamette University, Salem, OR.
- **U.S. Naval Officer Nuclear Power Training,** Orlando, FL and Idaho Falls, ID (a one-year graduate level program).
- **Registered Professional Mechanical Engineer.**

Chairman BAIRD. Thank you.
Ms. Schneider.

STATEMENT OF GIA D. SCHNEIDER, CO-FOUNDER AND CEO, NATEL ENERGY, INC.

Ms. SCHNEIDER. Thanks very much, Chairman Baird, Ranking Member Inglis and members of the committee.

I am founder and CEO of a company called Natel Energy and we are commercializing a new low-head hydropower technology that has the potential to cut the turbine plus generator costs of developing low-head projects by as much as 50 percent, and at the same time, we look to enable safe downstream fish passage.

Low head is a term of art used in the hydropower industry to generally reference the amount of drop that you have available to generate energy at any particular site, and when we say low head, our particular focus is on sites that have greater than five feet but less than 20 feet of drop. The reason why we feel this is a really interesting place to focus is that there is actually quite a large amount of potential in low head in this country. According to a DOE study that was done back in 2004 that categorized separately low-head versus high-head potential in the country, there are about 71 gigawatts of remaining undeveloped low-head potential in this country, and in comparison, that represents less than two percent of the total that has been developed. There are about 73 gigawatts total, and about 71 remain to be developed. That study actually did not even quantify an additional important source of low-head hydropower that exists within our existing manmade structure like irrigation districts, conduits and canals. There are thousands of miles of these existing canals, primarily in the western United States. These canals all have thousands of existing drop structures. Those drop structures were built specifically to dissipate energy to help make sure that the water velocities in those canals remained within the operating constraints of the canals. That is the place where we could actually, in a pretty straightforward fashion, if we had effective technology, retrofit those sites to capture energy and bring that energy onto the grid.

The technical challenge is that, you know, the amount of power than you can generate at any given site is defined by the amount of head and the amount of flow. And the particular technical challenge that has prevented the development of low head in this country so far is that the technology that exists today is just very expensive. When you get down to heads that are less than 20 feet, the design constraints mean that using conventional technology just becomes way too expensive to develop these sites and so that is where we focus most of our innovation.

There also are environmental concerns that have to be addressed, and just because you have a site that has a small amount of power output or is low head in nature does not necessarily mean that that these sites are low impact, so therefore, responsible siting is absolutely a factor. This is actually where we think manmade conduits and canals could play a really interesting role going forward because in a lot of those settings you could incur very minimal incremental environmental impact to develop those sites. Many of those low existing drops are close to roads, close to transmission lines, doesn't require getting major new transmission infrastructure to be able to bring this power online.

When you move out of existing canals and move into streams, your environmental issues absolutely do go up. So when we look at the 40,000 existing low dams in this country, most of which also don't produce power, we have to start to look much more closely at environmental issues with respect to fish passage and water flow level fluctuations. This is also an area where development of monitoring technology and tools and R&D support into quantifying the environmental impact of putting low-head hydropower on these existing structures would be very valuable. Beyond that, when you start to look at putting multiple installations in series, multiple low-head installations in series looking at multiple low-head dams on a particular river or stream, the combined impact of those installations also has to be evaluated, and that is another very important area for focus for environmental impact study and research.

So what are some of the ways to catalyze innovation in this space? Well, we actually have received DOE phase I SBIR grants in the latest stimulus bill funding round and we will use that to focus on optimizing blade design in our turbines going forward. This kind of support is absolutely critical. The technology that we are developing is actually coming in at an entry cost point that is pretty cost-competitive already. Right now we look at about eight cents a kilowatt-hour, so we are already, you know, well within the range of where we can start to actually develop sites today. At the same time, we think we can get that down to about five cents a kilowatt-hour. And further support from the DOE, further grant support to look at R&D specifically into components to make this technology and technology such as ours most cost-effective would be greatly used.

I think the bigger barrier is actually coming on the environmental side. In the conduit and in manmade canal systems area, the challenges are a lot less from the environmental side and the environmental impacts are ones in which, as least certainly as we are finding talking to irrigation districts, we can start to get a handle on a lot of that. But as we look to move into streams, the studies that need to be done to effectively go through the licensing process to make sure that sites are chosen responsibly and to provide the data that is necessary in the licensing process becomes a lot more great, the burden becomes much greater. And so this is an area where we think additional funding through the DOE or through other programs that could focus on helping to collect standardized environmental impact assessment data and make that data available would be very useful.

Finally, as private companies such as ourselves and other companies in this space, in the hydrokinetic and also in marine technology space as well, a lot of us are spending a fair amount of our own dollars doing a lot of these kinds of environmental assessments and so some form of incentive in the form of perhaps a tax credit could be very useful. It would help us. We are going to go forward. We have—we make the business cases through our investors to invest in this technology as they look forward to the role that these kinds of technologies could play in addressing our clean energy future. We are gathering private support, but at the same time, if we could recoup some sort of return or some sort of offset for that investment that we are making on our own, that would be helpful in itself.

In summary, a little bit different from the focus from the rest of the panelz: Our focus is specifically to talk about low-head potential. We believe low-head hydropower is actually the low-hanging fruit, one of the true low-hanging fruit renewable energy opportunities in this country where we can bring, distribute renewable baseload power online relatively quickly. Thanks very much.

[The prepared statement of Ms. Schneider follows:]

PREPARED STATEMENT OF GIA D. SCHNEIDER

Introduction

Good morning Chairman Gordon, Ranking Member Hall, and members of the Committee and Subcommittee. My name is Gia Schneider and I am a co-founder and the chairman and CEO of Natel Energy, Inc. I greatly appreciate the opportunity to share Natel Energy's story with the Committee, and to discuss the roles of the federal government and private industry in developing technologies suitable for low head hydropower energy generation.

Natel Energy Background

Natel Energy, Inc. is a California and Texas-based company that is commercializing a new hydropower technology called the Linear Hydroengine or SLH, which could cut the cost of low-head turbines by as much as 50%. Our mission is to maximize the use of existing water infrastructure in the U.S. to bring on-line cost-effective, distributed, baseload, renewable energy from low head hydropower sources with minimal negative environmental impacts. Indeed, in certain cases, we believe the potential exists to implement projects that both deliver renewable energy and create positive environmental co-benefits. For example, we are evaluating the potential to incorporate renewable energy into low dams in the Midwest whose primary purpose is to create wetlands that trap nutrient pollutants which are a primary cause of the dead zone in the Gulf of Mexico. If we can successfully incorporate low head hydropower generation into some of these projects, we could create an additional revenue source for Midwest farmers, bring new renewable energy onto the grid, and reduce nutrient pollution.

A patent on Natel Energy's core technology was recently approved by the U.S. Patent Office under application number 11/695,358. Natel's technology can be packaged into both low head and hydrokinetic configurations. We have chosen to focus on the low head market for several reasons. First, the economics of low head settings tend to be more favorable than hydrokinetic ones simply because the energy density is greater where a site has even a small amount of head. Second, there are numerous settings in the U.S. where existing low head infrastructure could be retrofitted to capture energy that is currently wasted. These opportunities include low drops and diversion dams in irrigation canals, water treatment plant outfalls and the approximately 40,000 existing dams less than 25 feet tall in the U.S., the majority of which do not produce power. Many of these sites with existing infrastructure are relatively close to roads and transmission lines; and would incur minimal additional environmental impact by virtue of being developed.

In-line with our focus on low head potential in existing infrastructure, our first pilot commercial project is with an irrigation district called the Buckeye Water Conservation and Drainage District in Arizona. The project is near the town of Buckeye, which is west of Phoenix, Arizona. We entered into a joint development agreement with the irrigation district in 2008, and filed for a FERC Exemption from Licensing in early 2009. The project received the FERC Exemption in September 2009; and installation has commenced this week. We hope to be online and generating electricity next month in January 2010.

We have had discussions with more than 10 other irrigation districts and several municipal water treatment facilities with promising sites totaling over 100 MW of potential capacity. We are in the process of working with them to evaluate their sites to identify those with the best overall economics. I will discuss the potential we see for low head hydropower development in this space in the next section, but suffice it to say that we believe that 100 MW is just the start—there are over 800 irrigation districts in the U.S.

Natel Energy has been funded to-date by its founders, and by several committed seed investors. We are in the process of raising a Series B round of funding, which we hope to close in the first quarter of 2010. In addition, we are proud to have recently been awarded an ARRA Phase 1 SBIR grant from the Department of Energy.

Natel Energy is an early-stage company that has its roots in my family's, in particular my father Dan Schneider's long-standing vision of environmentally friendly hydropower playing a significant role in mitigating the impacts of climate change while securing our nation's future energy needs. My father first thought of the SLH concept in the first energy crisis in the 1970's and was able to build early, small prototypes that showed promising efficiency results when tested in laboratory settings; a hydraulic efficiency of 80% was demonstrated at tests conducted at the University of California, Davis hydraulics laboratory in 1979. He then went on to build larger units, using those early alpha designs, and install them in field settings. The longest running alpha field unit ran for approximately 2 years. While the results from those early efforts were promising, the economic rationale to invest in further development disappeared when the energy crisis ended, and my father wound down his efforts in the early 1980's.

My brother, Abe, and I grew up tinkering with the early prototypes and that planted a seed which would later grow. Both of us went on to college at the Massachusetts Institute of Technology. I was a chemical engineering major, but decided to work in the energy space after school, working for Accenture in their energy practice, then Constellation Power, and then helping start the energy and carbon trading businesses at the investment bank Credit Suisse. My brother received both a bachelors and a masters degree in mechanical engineering from MIT and went on to establish himself in product design and development, with both large firms like Timken, where he worked in Advanced Product Development; and small, innovative startups such as the Google-funded high altitude wind company, Makani Power. Several years ago, in 2005, my father, Abe and I decided that our current energy crisis was here to stay, and that we wanted to put our respective talents to work to help solve America's clean energy challenge and that led to the start of Natel Energy. We, and the entire Natel team, feel blessed to work in a field which gives each of us great personal satisfaction and are committed to the cause of delivering new, clean energy technologies to America.

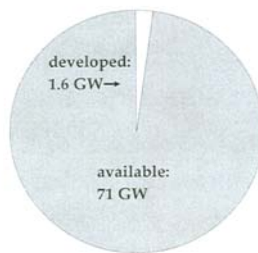
Low Head Hydropower Potential, Technology Challenges and Costs

The potential for new low head hydropower development in the U.S. is quite substantial. The last study done by the Department of Energy that made a clear distinction between low head and high head potential was completed in 2004 and estimated the total developable low head resource at 71 GWa.[1]

The potential is significant, and yet less than 2 GWa of low head hydropower has been developed in the U.S. to date. In addition, none of the DOE's analysis includes the low head potential that exists in the thousands of non-stream low head flows, such as low irrigation drop structures. Natel estimates that there is between 1 and 5 GW of low head potential that could be harnessed at low, irrigation drop structures. Many of these structures are built specifically to dissipate energy to keep water velocities within the structural requirements of the irrigation canals.

[1] GWa is the annual mean power which is a measure of the magnitude of a water energy resource's potential power producing capability equal to the statistical mean of the rate at which energy is produced over the course of 1 year. GWa can be converted to GW of installed capacity by dividing by the capacity factor, which on average is 50% for the U.S. hydropower resource. See DOE study DOE/ID–11111 titled "Water Energy Resources of the United States with Emphasis on Low Head/Low Power Resources" for further details.

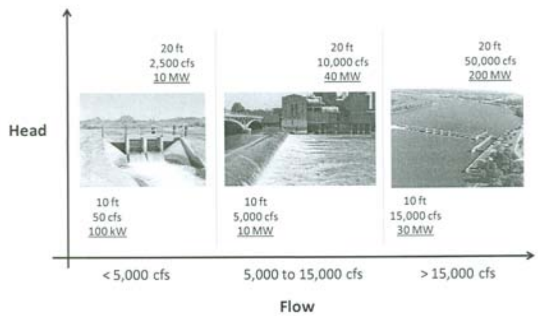
U.S. Low Head Hydropower Potential in GWa (DOE/ID-11111, 2004)



Before delving further, I would like to lay out several terms commonly used, but not necessarily with common definitions, in hydropower. Hydropower is most commonly described in several ways as follows:

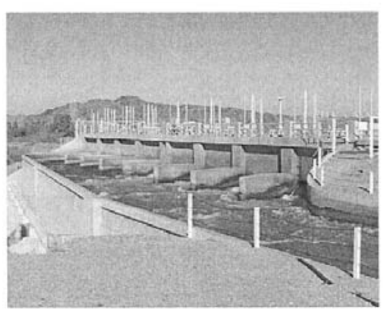
- Power generation potential—large, small, micro
    - Large generally refers to projects greater than 30 MW in size, though sometimes the lower end is stretched down to 10 MW
    - Small generally refers to projects anywhere between 100 kW and 10MW, though sometimes the upper end is stretched to 30 MW
    - Micro generally refers to projects less than 100 kW in size
- Head available—high, medium, low, hydrokinetic
    - High head generally refers to projects with large dams that are over 500 feet tall
    - Medium head generally refers to projects with between 30 and several hundred feet of drop
    - Low head generally refers to projects with less than 20 feet of drop, though some definitions move the low head upper limit to 30 feet
    - Hydrokinetic generally refers to projects where there is no head, and instead the energy is generated solely from the velocity of the water flow. This is analogous to the way wind turbines operate.
- Type of technology—conventional, unconventional
    - Conventional technology generally comes in two types—impulse and reaction turbines. Some common names of impulse turbines are Pelton and Crossflow; common names of reaction turbines are Kaplan, Francis, propeller, bulb, and pit.
    - Unconventional technology is a catchall bucket for a number of new turbine designs primarily aimed at hydrokinetic, marine and low head settings.

This creates a confusing landscape of terms, as they are not mutually exclusive. However, this can be somewhat simplified by remembering that for all sites, hydropower generation potential is defined by two variables—head and flow. Sites with either large flows or high head will generally create substantial amounts of power. Sites with both low head and low flows will generate small amounts of power. The below diagram illustrates the range of potential power across a hypothetical low head sites with 10 and 20 feet of head and varying amounts of flow. The photos illustrate the kinds of low head sites that would generally fall into the flow ranges described.



Some additional low head sites are shown below for further reference.

Maricopa-Stanfield Irrigation District Drop Structure; 100 cfs; 10 feet head; 200 kW potential



Gila Gravity Canal Headworks; 2,200 cfs max flow; 14 feet head; 2.4 to 5.9 MW potential

U.S. Low Head Hydropower Potential

As mentioned above, the potential for low head hydropower in the U.S. is significant. There is no one data source that details all aspects of the low head hydropower potential, but there are several good sources of data. The U.S. Department of Energy has conducted several studies of the hydropower potential in the U.S. with the most recent studies in 2004 and 2006.[2] The 2004 report specifically identified low head potential separately from high head; but does not appear to capture low head potential in man-made channels such as irrigation districts. The 2006 report

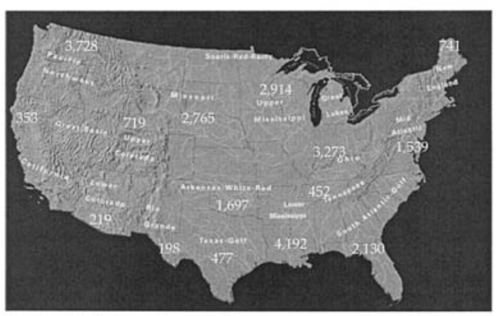
[2] 2004 DOE Report: *http://hydropower.inel.gov/resourceassessment/pdfs/03-11111.pdf,* 2006 DOE Report: http://hydropower.inel.gov/resourceassessment/pdfs/main__report__appendix__a__final.pdf

dropped the categorization by head, keeping only categorization by rated power potential. However, the underlying data for the 2006 report can be queried directly through a tool developed by the Idaho National Laboratory called the Virtual Hydropower Prospector.[3] In addition to the DOE studies, there is a National Inventory of Dams, which seeks to identify and catalogue all existing dams in the U.S.[4] The Department of Interior, U.S. Army Corps of Engineers and the Department of Energy published a report in 2007 on the hydropower potential at existing federal facilities.[5] Also in 2007, the electric Power Research Institute published a report assessing the waterpower potential of the U.S. and development needs.[6]

Based on data from these sources, the overall estimated 71 GWa of low head hydropower potential in the U.S. can further be described as follows. In the below table, low head refers to sites less than 30 feet tall; low power refers to sites with less than 1 MW of potential. All numbers in the table below are in MWa.

Annual Mean Power	Total	Developed	Excluded	Available
Total Power	289,741	35,430	88,761	165,550
Total Low Head Power	96,566	1,634	24,134	70,798
Low Head/High Power	72,022	1,173	21,400	49,449
Low Head/Low Power	24,544	461	2,734	21,349
Total High Head Power	193,175	33,796	64,627	94,752
High Head/High Power	157,772	33,423	55,464	68,885
High Head/Low Power	35,403	373	9,163	25,867

The site specific data underlying the 2004 DOE report can be further analyzed using the Virtual Hydropower Prospector to specifically screen for sites between 5 and 20 feet of head that are not in wilderness or other excluded areas. This identifies a total of 33.5 GWa of potential across 24,000 sites distributed as shown below.



The equivalent dataset underlying the 2006 DOE report, which applies a project development model to the potential to identify developable projects, can be analyzed in a similar fashion. From this dataset, only sites with between 5 and 20 feet of a head that are not in wilderness or other excluded areas, and that are less than 1 mile both from roads and from some portion of the power transmission infrastructure were selected. This identifies a total of 8 GWa of potential across 10,100 sites distributed as shown below.

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[3] Virtual Hydropower Prospector: *http://hydropower.inel.gov/prospector/index.shtml*

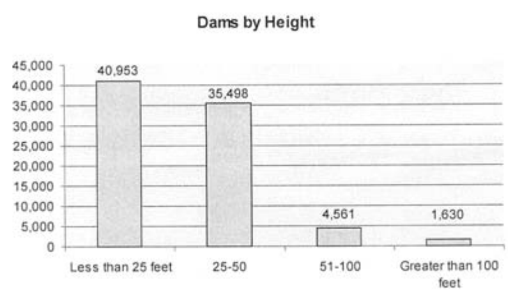
[4] National Inventory on Dams: *https://rsgis.crrel.usace.army.mil/apex/f?p=397:1:1280766746874154*

[5] DOI/USACE/DOE Report: *http://www.usbr.gov/power/data/1834/Sec1834*_EPA.pdf

[6] EPRI Report: *http://mydocs.epri.com/docs/public/000000000001014762.pdf*

As mentioned previously, neither of these datasets appear to capture the low head potential in man-made channels and conduits. The only study I have seen to date specifically focused on the potential in man-made irrigation canals was done by Navigant in California.[7] They identified 255 MW of potential hydropower in man-made channels and conduits in California. It is interesting to note that the Navigant study identified more hydro potential in man-made channels and conduits in California than in in-stream settings in California based on the screened 2006 DOE data shown above.

The final data set for analyzing low head potential in the U.S. is to look at existing structures identified in the National Inventory on Dams. According to the NID, there are over 40,000 existing dams in the U.S. less than 25 feet tall. Less than 3% of existing dams in the U.S. generate hydropower and the majority of those power-producing dams are medium to high head.



Technology Challenges

The technological challenge of generating electricity from water at low head settings comes from the fact described above that power is a function of head and flow. At low heads, the only way to scale to larger power output is to be able to pass larger volumes of water. Overcoming this hurdle, while keeping costs low and minimizing environmental impacts, has been the technological barrier to much development of low head hydropower resources in general.

Environmental Concerns

The environmental concerns for low head hydropower are driven by the characteristics of the site. Low head hydropower projects developed in existing, man-made channels or conduits with existing low drops or diversion structures will tend to have low incremental environmental impacts. Projects at existing low dams in stream settings will tend to higher potential impacts than projects in man-made conduits, though the magnitude of the impact will vary again depending on the setting. Arguably, putting power generation on existing structures such as locks and dams, provided that the installations do not interfere with transport and recreational uses, is another minimal impact kind of project.

[7] Navigant Report on Small Hydro in California: *http://www.energy.ca.gov/2006publications/CEC-500-2006-065/CEC-500-2006-065.PDF*

The environmental concerns that projects in river settings will need to address include:

- Fish passage
- Water flow modifications, if any
- Impacts from any required civil works construction
- Disturbed riverbank habitat

However, I believe that low head hydropower projects also have the potential in certain cases to help address certain environmental concerns such as nutrient pollution and sediment loading. Indeed, some existing research indicates that low dams spread across a watershed can mitigate flooding from runoff of large intense storms and can also sequester significant amounts of nitrogen and phosphorus. A study completed in 2004 of a system of 26 low dams across the Red River Basin in south central Manitoba showed significant and consistent retention of nitrogen and phosphorous in the small ponds and wetlands created by the dams over the four years of study. More research needs to be done to better understand how to truly manage our watersheds to deliver water for human consumption, for agriculture, for healthy ecosystems, for power production, and for recreational uses. However, another tool in the waterpower development toolbox that enables cost-effective low head hydropower development will have great use in many settings that do not have a high degree of environmental sensitivity.

Costs

A major factor inhibiting the development of America's hydropower resources on man-made conduit or water conveyance systems and existing low head, non-powered dams has been the high cost of available turbomachinery. Conventional low-head waterpower technology, such as Kaplan turbines and similar devices (bulb, tube, and even propeller turbines) has proven to be too costly for widespread market adoption. For example, several recent surveys of low-head hydropower plants built with Kaplan turbines have reported values of over $2,800/kW for the electromechanical equipment alone, given a 100 kW turbine operating with 3 meters of head (Singal 2008, Ogayar 2009).[8] [9] Natel's own survey of a variety of quotes from Kaplan turbine manufacturers indicates that the real market prices might be even higher. A surface fit following the same methodology disclosed by Ogayar, but using turbine quotes compiled from a range of feasibility studies conducted for low head sites, results in a predicted price of roughly $4,200/kW for a 100 kW Kaplan turbine at 3 meters of head.[10] Unfortunately for prospective low-head waterpower project developers, these numbers represent only the electromechanical equipment component of initial capital cost, covering the turbine runner, wicket gates, draft tube, generator, control system, and switchgear. Often, civil works and other project costs might equal or exceed the electromechanical component, leading to total installed costs which require extremely high capacity factors, high electricity prices, or both, to justify plant investment.

One of the primary reasons for the high cost of conventional turbomachinery is the complex blade shape of conventional turbine runners. According to the Electric Power Research Institute, the cost of a Kaplan runner may exceed 50% of the electromechanical component cost.[11] This is an indication of the complexity and fine manufacturing precision by which Kaplan turbine runners are characterized, but also is indicative of an opportunity for innovation in reducing an important barrier to low head hydropower development: cost.

For comparative purposes, the table below describes the economics for a 1 MW site with 10 feet of head using current conventional turbine costs, Natel's current SLH cost; and Natel's projected SLH cost at full-scale commercial operation. For the purposes of this comparison, all non-electromechanical costs are assumed to remain the same and are set at $1.48M—this would cover civil works, permitting, interconnect, etc. In addition, the capacity factor is assumed to be the same in all three cases and is set to 65%. For clear illustrative purposes, the payback time period is

[8] Ogayar, B., P.G. Vidal. Cost determination of the electro-mechanical equipmentof a small hydro-power plant. Renewable Energy 2009;34:6–13.

[9] Singal, S.K., R.P. Saini. Analytical approach for development of correlations for cost of canal-based SHP schemes. Renewable Energy 2008;33:2549–2258.

[10] Turbine quotes compiled from feasibility studies including: *http://library.wrds.uwyo.edu/ims/Park.html;T3http://www.yorkshiredales.org.uk/hydro-power*__feasibilty__study__july2009;T3http://mydocs.epri.com/docs/public/TR-112350-V2.pdf

[11] Gray, D. Hydro Life Extension Modernization Guides Volume 2: Hydromechanical Equipment, TR–112350–V2 Final Report, August 2000. EPRI.

calculated using a 10 ¢/kWh power price with no project leverage and no incentives (no Production Tax Credit or renewable energy credits).

	Conventional Turbine	Natel SLH Cost Today	Natel SLH Cost @ Commercial Scale
Turbine Package Cost per kW	$3,000	$1,700	$1,000
Total installed cost	$4.48 million	$3.18 million	$2.48 million
Levelized cost of electricity	8.6 ¢/kWh	6.6 ¢/kWh	5.5 ¢/kWh
Payback time	19 years	11 years	7 years

The purpose of the above table is simply to highlight that there is room for innovation in low head waterpower technology, and that innovation, if successful at lowering costs while keeping environmental impacts low, will enable the addition of significant new renewable generation to the grid. We have developed one new technology and there are a number of other companies working hard to innovate in the low head, marine and hydrokinetic space as well.

Areas where federal support would useful

The following kinds of federal support would help to reduce costs and transition our technology, and other innovative waterpower technologies more quickly into the market:

- RDD&D guidance and funding support to help reduce some of the costs of demonstrating and scaling up new low head waterpower technologies;
- Specific grant funds and research focused on better understanding the environmental issues for low head projects, particularly in river settings;
- Testing facilities for measuring the environmental and operational performance of new waterpower technologies;
- Tax credits or other incentives for companies investing in studies or monitoring programs that gather environmental performance data at installed new waterpower technology power projects;
- Beyond the immediate RDD&D needs:
    - *A long term extension of the Production Tax Credit (PTC) and Clean Renewable Energy Bond (CREB) programs would foster investment in retrofitting the many existing low head, non-power structures to produce new, distributed, baseload, renewable energy, by encouraging private sector investment and providing low cost financing to public entities such as most irrigation districts;*
    - *Section 45 Production Tax Credit parity for all low head hydropower, hydrokinetic, marine and other innovative water power technologies;*
    - *Inclusion of all low head hydropower, hydrokinetic, marine and other innovative water power technologies at existing, non-powered dams in a federal Renewable Energy Portfolio Standard (RPS).*

Closing

I would like to thank the Committee again for inviting me to testify and for its attention to the issues before the Committee. It has been a pleasure to appear before the Committee today and Natel Energy stands ready to work with the Committee in the future as needed. America is in a position to lead the world in clean energy technology development, but only by taking decisive action we will catch and surpass our international counterparts in waterpower technology development. In so doing, we, and many other innovative companies like us, will create new manufacturing and power sector jobs and help pave the way towards a clean, secure energy future for America while tackling the environmental issues we face as a country in an increasingly competitive world.

Thank you for your time.

Contact Information

If the members of the Committee or their staff would like additional information, please do not hesitate to contact Natel Energy at your convenience. Contact information is found below.

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BIOGRAPHY FOR GIA D. SCHNEIDER

Gia Schneider is the acting CEO of Natel Energy, Inc., which is commercializing a new, low-head hydropower technology that will cut the non-civil works cost of developing low head projects by as much as 50%. She is also a partner at EKO Asset Management and has extensive experience in the renewable energy and climate sectors. Previously, she worked in the Energy Trading Group at Credit Suisse where she helped start the carbon emissions desk. Prior to Credit Suisse, she worked in the Strategy Group at Constellation, a leading power generation company, and as a consultant with Accenture where she developed and implemented trading and risk management solutions for the utility industry. Gia received her bachelor of science degree in chemical engineering from the Massachusetts Institute of Technology. She has a long standing interest in climate change, sustainable development and renewable energy.

DISCUSSION

Chairman BAIRD. Thank you very much, Ms. Schneider. Excellent testimony, not surprising, given the backgrounds of the distinguished witnesses. I will recognize myself for five minutes and then we will proceed in alternating order. We have been joined by Mr. Davis, Mr. Tonko and previously—oh, there he is, the number one expert on wave energy in the U.S. Congress, Mr. Rohrabacher. I say that because he is our surf advocate. I hear that Bilbray is a better surfer, however. But he is very passionate about the ocean.

THE PROBLEM OF OUTSOURCED MANUFACTURING AND TEST BEDS

A number of questions come up, more than I could possibly cover in five minutes but I will start with a few. One of the issues is, it is very troubling. Mr. Dehlsen, you talked about it, and Mr. Bedard, you alluded to it. I am so frustrated to see U.S.-developed technology consistently, the initial technology, developed here and then capitalized and engineered elsewhere, then manufactured elsewhere. We are seeing it here again apparently. One of the limitations in addition to some of the environmental issues that Mr. Collar and Ms. Schneider mentioned, it seems to me that the test beds right now are elsewhere. We don't have yet, that I know of in place on either coast, a reliable place where if I am a manufacturer of some equipment I can say okay, I am going to work with FERC and DOE, we are going to ship it out there, drop it in the water and see what it does. What is being done to do that, Mr. Bedard? You talked about some potential facilities. What is being done and how is the government helping with that at the federal level and what can we do better?

Mr. BEDARD. What is being done is that just last year—I am sorry. I will take that back. The fiscal year 2008 appropriation initiated some national marine energy centers, specifically Oregon State University on wave, University of Washington on tidal, University of Hawaii on both OTEC and wave, and Florida Atlantic University, I believe, received—is receiving an earmark on ocean currents. So this country, we are just starting. Europeans are 10 years in front of us. Their governments have established test facilities that have been in place now for more than five years. So we have started. What we need is, as I said, consistent, long-term, sustained support to these test facilities so that developers do have places to go and put their machines into the water and develop the technology as step one. And then once that prototype gets developed, we then need to have systems test facilities, much like PG&E and Snohomish are doing, with a fully integrated grid connected array of systems.

PACE OF TEST BED DEVELOPMENT

Chairman BAIRD. When we will have these test beds ready to go?

Mr. BEDARD. In a number of years. It is really uncertain because of the regulatory issues associated with—we have to even permit these test beds and so there is uncertainty in terms of when—there are literally dozens of regulatory agencies that have to be dealt with.

Chairman BAIRD. Okay. That is very helpful. That is consistent with the concerns of Mr. Collar.

KEYS TO EXPEDITING PROJECTS

Mr. Collar, let me follow up on that regulatory issue because it seems that the test bed issue—as I have read your testimony and listened to you, it seems that this test bed issue is central. Mr. Dehlsen talked about the reliability of funding. You know, this annual extension of the production tax credit is not going to cut it. We need a sustainable, predictable situation including tax incentives. But this regulatory environment issue is very, very central. Talk to us a little bit about what you think we ought to do, Mr. Collar.

Mr. COLLAR. It really is one of the key challenges to moving these kinds of projects forward, and I think a lot of it is because really again that lack of data. It is very much a chicken or the egg kind of a situation. It is difficult to get projects like this permitted because there is no data and you can't get the data because you can't get the project permitted to get it into the water to generate that information. So I think again it is finding ways to strike that balance within the agencies between the facilitation of renewable energy and fully meeting their existing responsibilities and accountability. You know, one of the ways that we seek to do that with our project is via the very small, contained scale of the project. We wouldn't advocate nor would anyone else that we are aware of, you know, the installation of many, many turbines in a place like Admiralty Inlet before we first installed one or two and learned from those devices. But until we do that and until we can do that in a reasonable way in terms of both cost and resources and effort, it is going to be very difficult to move beyond that stage.

So I think one of the things is to come to grips or gain good alignment with the agencies around, you know, what is an appropriate amount of risk to take with some of these early projects? But the experts that we talked to in the Puget Sound would say the risk of our project is almost vanishingly small but it is not zero, and I think that sometimes the agencies really have discomfort until they can really see zero risk.

SPECIES SAFETY

Chairman BAIRD. Are you dealing with ESA (Endangered Species Act) issues? I mean, is this—the question for me is, so what is the problem, you know, given the model you talked about and the tiny scale, and I understand the baseline data. I am proud to be a scientist and happy to be on this Committee, but what is it you are—I have been told you have to have at least a year of baseline data before you put something in the water. Is that accurate?

Mr. COLLAR. At least a year. There certainly has been pressure to have much more than that, and it is also a degree of to what level of detail the data needs to be.

Chairman BAIRD. What is the specific concern? Is it that we just don't know what the concern is because we haven't done it yet or are we saying well, we are expecting salmon or sturgeon or ground fish, or what is the story?

Mr. COLLAR. The most specific and the largest concerns in Puget Sound, Admiralty Inlet in particular, are the effects of installations like this on ESA-listed species, particularly orca and salmon. Those are the key species. So really, that is the question that we are grappling with now is, what is the right degree of information in terms of the currents' behavior or abundance of salmon species and orca in Admiralty Inlet? And of course, there is a lot of information, historical information available relative to those questions, so it is really, how much more do you need before you can go forward with a project like the one we propose?

TURBINE DESIGN

Chairman BAIRD. Ms. Schneider, I grew up in canal country, western Colorado. It was irrigated and we used to boogie board on those canals. It was pretty dangerous. Periodically one of our friends would disappear. It was kind of a bad deal. But it seems to me that there is a lot of potential for this. Have you actually got—is this just a more efficient turbine design? I don't remember seeing in your testimony a picture. Maybe it is proprietary and you don't want to share with us lest we branch out in new career paths.

Ms. SCHNEIDER. No, no, no.

Chairman BAIRD. What does this look like?

Ms. SCHNEIDER. It actually doesn't look like any kind of conventional rotary turbine that you have seen. The technical term for it would be called a two-stage fully flooded impulse turbine.

Chairman BAIRD. Oh, yeah, I knew that.

Ms. SCHNEIDER. So it is a new turbine. It is a new turbine design, and the specific aspects of it are, basically it has very simple blades which kind of allows us to drive down costs. So cost of manufacture is a lot lower than conventional reaction turbines, the other conventional technology, and at the same time the generating side is fairly—the generator interface is fairly efficient because it actually has what is called a high specificity, without getting into too much technical terms.

Chairman BAIRD. Vern will explain all this later to us.

Ms. SCHNEIDER. But, I mean, we have an installation that is going forward actually with an irrigation district in Arizona. We just started installation at the beginning of this week so we have been through the FERC exemption process, received the FERC exemption in September, and that should be online and generating electricity hopefully in January.

Chairman BAIRD. That is exciting. Thank you.

I recognize Mr. Inglis for five minutes.

Mr. INGLIS. Thank you, Mr. Chairman.

I found it interesting, Ms. Schneider and Mr. Collar both spent some time discussing the impact on species. It is worth paying some attention to that. It is also worth paying attention to if you consider the ocean acidification problem related to the incumbent fuels, the tradeoffs in life, and we might should put pedal to the metal and—"might should", that is the way we say it down in South Carolina.

Chairman BAIRD. That is right good.

Mr. INGLIS. So it is interesting that both of you spent considerable time trying to allay those concerns but if you compare it to the other concerns, it is really rather small so pedal to the metal.

COMBINING WAVE AND WIND TECHNOLOGIES

Mr. Dehlsen, we are the happy beneficiaries of all your work. I didn't realize we had you to thank, but I thank you for having—General Electric is in our district, makes wind turbines, and there are 1,500 engineers and 1,500 production people, some which work on wind, some on gas turbines, but—so you are the father of that and we thank you. So for any of you, what do you think about the possibility of combining wave barges with wind barges such that you get a two-fer out of the lines, I guess, running back to shore? Is this possible?

Mr. DEHLSEN. We are looking at that actually for projects in the U.K. Clipper Windpower is currently in advanced engineering 10-megawatt offshore wind turbine for deployment in U.K. waters, and we believe that for every turbine that goes in, we could probably deploy three wave devices of the type that we are in design on. Those are each four and a half megawatts, so for every 10 megawatts' worth of infrastructure that you are putting in, you pick up another thirteen and a half megawatts of wave energy. We think it is quite a nice way to bring down the cost of energy by combining the two technologies.

Mr. INGLIS. In part what you are doing in some of those designs is using the weight of the apparatus, right, as the tide drops to move turbines or something so that you basically end up getting the benefit from the weight of all the stuff you got up on doing the wind. Is that—have I got that right? Is that one of the designs?

Mr. DEHLSEN. There are designs like that. Ours is one where between the turbines, which are centered on about 1,200 meters, you would accommodate three of what we call a centipod wave generator, which are very long barges there, about 650 feet long and have 56 pods on each side so they are fully exposed to the wave front and can yaw into the wave front. It is quite an unusual design actually.

Mr. INGLIS. So you use the motion through that barge apparatus to create the energy?

Mr. DEHLSEN. That is right, through the pods moving up and down while the barge itself, and it is really not a barge. It is a lattice, open lattice structure that allows the wave to pass through it, and as the wave passes through it causes the pods go up and down, drive hydraulic fluid through to drive a hydroelectric system.

Mr. INGLIS. Yeah, interesting.

Mr. Bedard.

Mr. BEDARD. There is also another benefit in addition to the cost two-foe that you mentioned, and that is the fact that you have two resources that have variability to them and you put those two together and you get less variability. There are less number of hours with no resource available when you have a hybrid wind-wave system than either a single wind or wave system. I tried to sell one of our EPRI feasibility studies a couple of years ago on that very topic and was told by all of the state energy agency and utility potential clients that I tried to sell that I was 25 years ahead of my time.

Mr. INGLIS. Yes. Of course, the thing that I hope that you are prophetic there and maybe ahead of your time but hopefully people will catch up with you is that it is economics that will drive this. If it is economically viable, then it will be deployed. I learned a great new definition of sustainability from an entrepreneur in Spartanburg, South Carolina, who recycles PET (Polyethylene-terephthalate) to make bottles again. He says the definition of sustainability is making a profit, and I think that is a very good definition. If you can make a profit, it is sustainable. If you can't, it is not, and so that is what we need to be focused on is figuring out how you can get two-fers or three-fers and so it makes sense economically.

Thanks, Mr. Chairman.

Chairman BAIRD. Thank you.

I recognize—who is on deck? Mr. Davis was next in line.

COMPARING ECONOMIC COSTS AND BENEFITS OF ENERGY TECHNOLOGIES

Mr. DAVIS. As we engage in this debate that we have had for some time on all different types of sources of energy and we continue to find new sources that we believe will be alternatives and renewables and less expensive, oftentimes we don't compare the cost of the current methods of producing energy and our cleaning up maybe some of those pollutants that we have such as coal or look at natural gas or look at other sources. We seem to get a great deal of excitement about sources of energy that may or may not produce an abundance or at least close to the same amount of energy for a similar cost as what we produce today. So I think that as we engage in these conversations, the hearing we are having today is certainly good for us, this Nation to be having these hearings. But I would like to hear more from each of you. When you take a kilowatt being produced today, what would it cost for the same and how quickly can this be put online to where we can start using this to benefit economically and job creation? How quick can this happen, how soon can we expect to see benefits from this and how costly will it be compared to what we produce today? That is basically my comment that I want to make. Can anyone answer that question?

Mr. BEAUDRY-LOSIQUE. Thank you for the question. I would say it is fairly important for us to always consider a balanced portfolio of technologies, some of those being near term and being able to deploy and make a difference. We are working on some of those, technologies. For example, at DOE like land-based wind, for example, and some elements of solar technologies. So it is important to not neglect longer-term very large sources of energy that could also make a difference 10 or 20 years from now. I believe this is one of the roles of government. Some of these resources could include offshore wind and some of these marine and hydrokinetic resources, and I think the question is, how do we strike the right balance with near-term technologies that can make a difference and long-term, very large-scale sorts of technologies? And I mentioned a couple here. And also how do you compare these technologies to the cost of existing technology? Will that improve versus existing technology? Are we chasing technology that will never be competitive? And I would say we are currently going through a strategic planning exercise at DOE to address precisely that question and see if we can optimize or improve our portfolio of technology while we strive to do so.

Mr. DAVIS. I have a situation in Kingston, Tennessee, that perhaps everyone in this room or certainly if you watched TV in the last year would be aware that there was a huge ash spill at the Kingston steam plant. We are told it will probably cost close to $1 billion plus for that cleanup that will go on the bills of almost 8 million users in the Tennessee Valley to help pay for that cost. That is a substantial amount of money that we have deferred for the last 30 or 40 years. And so as we engage in this debate, it is my hope that we look at every situation, alternatives, renewables and others, about whether or not this will help us get away from that situation. I asked the TVA officials and others if we were to take that billion dollars and build a solar farm in Tennessee, what percentage of the energy being produced at the steam plant could we produce with that billion-dollar investment, and I am told somewhere between 12 to 25 percent of energy that would be a renewable source. So as we engage—the reason I ask the question and made the comment is, as we engage in the conversation, it seems that we from time to time don't look at the actual total cost of what the cost would be to us 10 years, 20, 30 years or 40 years down the road. I hope as we engage in this debate as we continue to have hearings here and in other committees in the House that we become a little bit more focused on the proposals we are making and how successful they would be or is this just a new concept or idea that may or may never work.

Thank you all, and thanks, Mr. Chairman, for having the hearing.

Chairman BAIRD. Thank you, Mr. Davis.

Mr. Ehlers.

HYDROKINETIC POTENTIAL IN THE GREAT LAKES

Mr. EHLERS. Being from Michigan, are there any opportunities for hydrokinetic energy in Lake Michigan or some of the other Great Lakes? We are talking about putting wind energy in the middle of the lake far enough from shore so no one can see it but visible enough so boats won't run into it. Are there any hydrokinetic energy possibilities in the Great Lakes or is it just not worth the trouble? Mr. Bedard?

Mr. BEDARD. Yes, most probably. We have not studied it but most probably just from the basic understanding there is not a hydrokinetic potential in the Great Lakes. For wave energy one needs to have a long distance of ocean, a long fetch of ocean where the winds blow across that to build up the waves, and the Great Lakes are big but they are just not as big as the Pacific Ocean, and certainly there is no tidal energy, there is no current flow. Now, there are potential locations where the lakes flow when the water flows out of the lakes like they do I know in upstate New York, for using hydrokinetic energy. I wouldn't look in the lake but I would like where the water flows out of the lake.

LOW HEAD HYDROPOWER

Mr. EHLERS. Thank you.

I also want to mention this is really solar energy, and we might as well identify the source correctly. I think solar has immense possibilities in many different manifestations. When you mention solar, people automatically think of photoelectric cells and things like that but there are tremendous opportunities created by the wind, and this is just another manifestation of that. You talked about low head. How big is a low head? When you say low head, I immediately think of a submerged restroom but I don't think that is what you are talking about. How big a head is low head?

Ms. SCHNEIDER. Well, low head in the context that we are focused on, it would be a drop across a structure that is less than 20 feet, but in general greater than five, and the reason for the cut-off is five is just when we run economic analysis on a number of sites, once you get below five feet it just is very, very hard.

OTHER PROMISING TECHNOLOGIES

Mr. EHLERS. And a lot of effort appears to be going into developing appropriate turbines for this. Is that the best way to get energy, or can you just anchor something, the generator to the ocean bottom and the up-and-down motion of the waves? Is there any possibility of somehow extracting energy from the up-and-down motion of the waves rather than the lateral motion? Any comment on that? Mr. Bedard?

Mr. BEDARD. Yes, there are many different ways to convert either the potential or kinetic energy in waves. Many of the devices do work by using totally the potential energy, the up-and-down motion of a floating buoy that is then reacted either to the bottom or to a reactionary plate which is submerged in the water column, so yes, many devices work through the up-and-down motion of the waves.

Mr. EHLERS. And which appears to be most promising at this point?

Mr. BEDARD. We are not far enough along in the technology to know which of the different energy conversion devices will turn out to be most cost-effective in the future. Wind has obviously gotten there. You look at the wind machines. They are all open rotor, three-bladed, you know, machines on a mono pile. With wave energy, we are just not there yet. We need to test and evaluate the different energy conversion devices first.

Mr. EHLERS. Thank you very much. Yield back.

Chairman BAIRD. Mr. Ehlers, thank you.

Mr. Tonko.

LESSONS FROM VERDANT POWER IN NEW YORK STATE

Mr. TONKO. Thank you, Mr. Chair, and good morning to our panelists, and Mr. Bedard, thank you for mentioning the turbulent flow of waters in upstate New York. That is part of my district area.

Prior to arriving here as a freshman this year in Congress, I served as president and CEO of NYSERDA, New York State Energy Research and Development Authority, which as you know has this demonstration project, had the demonstration project along the East River along the island of Manhattan with Verdant Power's project, and they did disassemble that project for improvements and sent it over to the Colorado lab of DOE, and I believe we are back up and running, or not. Okay. We are supposed to be. But anyhow, I just want to know what Snohomish—perhaps Mr. Collar or Mr. Bedard or whomever on the panel might address your comments to what might have been learned from Verdant Power's project in that East River demonstration.

Mr. COLLAR. Certainly. I think there are a number of things. First of all, you really have to applaud Verdant, I think, for the effort, really blazing the trail here in a lot of ways for efforts like ours. So, I mean, a couple of things that were learned were in terms of deployment methodology in relatively shallow water. Folks might assume that this would be a relatively simple and straightforward evolution. It is not. It is very difficult even in places like the East River, so there is some learning there obviously in terms of the robustness and the design of the turbines themselves and the blades in particular. You know, you are going to have some failures like that along the road so, you know, learning from those and sharing that learning through efforts like the DOE's programs is important and has occurred. And then lastly, I think we also learned a fair bit in terms of monitoring technologies for monitoring the interaction of fish and marine life with turbines like the Verdant turbines, specifically in that case using the BiosSonics hydroacoustic technology. There were some parts of that that worked really well and there were some parts that we would choose to do differently in the future, so those would probably be the top three things that I would point out.

Mr. TONKO. As I understand it, it was not just the blades of that design but also the assembly, the assemblage of the blades that had to be improved on.

Mr. Bedard, were you going to comment on that?

Mr. BEDARD. I was going to add, sir, that Verdant completed their experimental phase about six months ago and they took the six units out. They got lots of good environmental data. They have now filed a draft license application with FERC to go to the next phase, which is installation of 30 of the units, about one megawatt of rated power, and so they will be in the regulatory process now for another year or two years before they hopefully get the license to install their next generation of turbine in that same location between Roosevelt Island and Queens in about two more years.

Mr. TONKO. And it was interesting to see what that meant to the Roosevelt Island population with some of the power that was exchanged for them. It is hoped that as much as 1,100 kilowatts worth of power could be utilized in kinetic format in New York State, so it is rather encouraging to see the promise that it holds. And in terms of the PUD plan here with Snohomish, just how—what are your plans to interconnect the tidal project to the main grid?

Mr. COLLAR. They actually intend to connect on Whidbey Island, which is adjacent to our site. Specifically we are working with Seattle Pacific University. In fact, their marine science lab is right on the shores where we would interconnect, so currently we are in dialog with them about rebuilding their marine science lab into one facility that can both serve their educational purposes as well as our need for onshore infrastructure and provide them with a pretty neat educational opportunity to leverage the results of our project to fulfill their mission.

Mr. TONKO. Thank you. Thank you very much.

Chairman BAIRD. Mr. Rohrabacher.

Mr. ROHRABACHER. Thank you very much, Mr. Chairman, and I am sorry I missed the first three witnesses. And Mr. Bedard, I remember JPL and—

Mr. BEDARD. Yes, sir, I worked on Mars Rover back in the late 1980s.

COST COMPETITIVENESS OF MHK TECHNOLOGIES

Mr. ROHRABACHER. I remember visiting you there once, I believe.

I don't think the question about cost was answered correctly, fully. I would like to—obviously if we are developing an energy resource that has to be of competitive cost in some way or it is just—we are just playing games here, so we are going to create technology in order to create technology when it is going to be integrated into an energy system that has other factors as well that cost. How will this—once we develop these technologies that you are talking about, how competitive will it be as compared to other sources of electricity?

Mr. DEHLSEN. The technologies we are working on I believe can be in the 10- to 12-per-kilowatt-hour range, and we are pretty confident on those numbers. It is really a function of how much steel goes into the machine versus how much power you can generate. Yes, you have cost for mooring and that sort of thing but that is the main driver, and—

Mr. ROHRABACHER. How would that be interpreted in terms of, oil would have to come to a certain barrel price in order to permit the electricity to be—for you to be competitive with electricity. What would that be?

Mr. DEHLSEN. Well, carbon fuels are in the range of about four to seven cents per kilowatt-hour but that is without counting the external costs.

Mr. ROHRABACHER. Right.

Mr. DEHLSEN. So if you give credit for that, which is a point that came up earlier, these technologies would be competitive.

IMPACTS ON SCENIC VIEWS

Mr. ROHRABACHER. Okay. One of the things that I have noticed, seeing that I live along the coast and I spent a lot of time in the water, that—and although that is the case, I have also been supportive of offshore oil and gas development, that wealthy people tend to live near water and they tend not to want to have their view disturbed and their view is more important than energy for the people. Would your alternatives create a view problem for people?

Mr. DEHLSEN. Certainly wind provides a very strong visual impact but what I think I have been saying anyway is that people now are starting to understand that there are priorities beyond the view aspect.

Mr. ROHRABACHER. I would hope so. You know, I would really hope that some of the people who are the most—have really enjoyed the fruits and benefits of our society would be a little bit more considerate of everybody else rather than just worrying about their view, seeing that we have about a trillion dollars worth of energy in terms of oil and gas that we should be utilizing offshore, but I would hate to see situations like great alternatives in the future—look, 100 years from now whether it is 10 years from now or 100 years from now, the type of ideas you are going to bring up are things that mankind is going to have to depend upon and you may be exploring an area that is really 100 years from now we may get vast amounts of energy from what you are doing and might be dependent upon that far more than we are on oil and gas.

Mr. DEHLSEN. I would hope so.

Mr. ROHRABACHER. I would hope so. That is correct. So Mr. Chairman, thank you for your leadership in this. I see this as a visionary approach which I think that we should be exploring and I wish you all success.

Chairman BAIRD. Thank you for your observations and insights.

Mr. Inslee is recognized. Thanks for joining us today, Mr. Inslee.

PROGRESS TO DATE AND THE POWER DENSITY OF MHK

Mr. INSLEE. Thank you, and thanks, Mr. Chairman, for holding this hearing. This is something we are looking in the future and I appreciate your willingness to explore this. It is something that hasn't totally arrived commercially and your willingness to do this I am very appreciative of. I am also appreciative of Mr. Ehlers' insight that all this is solar power except nuclear and engineered geothermal. I think that is a great insight. He is the only other Congressman that I have heard share that other than this one, so thanks, Mr. Ehlers.

Mr. Collar, welcome, and Mr. Dehlsen, I want to thank you for being the personification of what I view as a dynamic here which basically is following wind into the water as far as the dynamic, the economic dynamic. You are the absolute personification of that. You may not remember but you and I spoke a couple years ago when I was writing a book and you told me an interesting story about Clipper Wind and the development of wind power about a bolt that broke. Do you want to share that? It is kind of a metaphor for what we are talking about here. Do you remember the story?

Mr. DEHLSEN. Well, I remember one in the very beginning of wind power and it was the first wind conference in Palm Springs, and there was a lot of excitement around a machine that Bendix had put out that was a Darius machine. It looked like a big egg beater. Everybody had gathered out there to watch the machine perform. A bolt gave out and fortunately it could have decapitated the whole crowd, but that was one of the, kind of the early lessons on structures and how these things have to really have pretty rigorous kind of engineering.

Mr. INSLEE. Well, I appreciate the story, and the reason is, is despite that failure, the industry is now very commercially viable and robust and is the most dynamic thing in the energy industry probably right now, and I sense that that is the kind of experience we are going to have in the hydrokinetic field. You said something that was interesting, that you were optimistic about this, and maybe it was you or Mr. Bedard, I am not sure, that the density of energy associated with water as compared to wind may give this industry a faster up tick than wind. Do you want to elaborate on that, whichever one of you was that said that?

Mr. BEDARD. That was myself, Mr. Inslee, and the point I was making was that the fact that the power density of the hydrokinetic resource is much, much greater than that for wind and solar. That allows smaller machines with less material and capital cost—there is a potential capital cost advantage of a hydrokinetic machine, say, compared to a wind or solar machine but there is another side to that coin, and the other side is that it is operating in a very remote, hostile environment so the challenge to the marine hydrokinetic industry is going to be to develop the deployment technology and the operation and maintenance technology that will allow the total lifecycle cost to be less than or competitive to other renewable sources.

2009 STIMULUS FUNDING FOR MHK

Mr. INSLEE. Thank you.

Mr. Beaudry-Losique, I am sorry, I don't know if that is the correct pronunciation, we are so far a little bit disappointed in the stimulus funding. We haven't seen any of the stimulus funding dedicated to this particular industry. Do you have any insights on that? Do we have some hope in that regard?

Mr. BEAUDRY-LOSIQUE. I would say the Recovery Act mandates are fairly specific. Their focus was on creating jobs that would have short-term impact. Regarding the allocation to the water budget, we felt that traditional hydro projects could be put in operation fairly shortly and that there was no truly immediate device that was ready to go at a commercial scale for marine hydrokinetics and that our R&D budget for hydrokinetics is fairly plentiful right now, and we have what we need.

THE IMPORTANCE OF CONSISTENT FEDERAL SUPPORT

Mr. INSLEE. Well, we will continue to kind of provide you some additional resources, and I am appreciative of the vision that the

Department has shown and hope it will continue. One of the things, I have introduced a bill and we are looking forward to reintroduction of a bill that would establish a dedicated department really for this particular technology and hydrokinetic. I think it would helpful in focusing, and the reason I note that is, I think almost all of the witnesses talked about the importance of stability in federal policy of a long-term federal commitment that is not dependent on the personnel that happens to sit in a particular chair for three or four years, it is not dependent on who the majority is in Congress but it is a long-term federal commitment, and I think the establishment of an office would go a long way to helping in that regard and I look forward to talking to Members and the Chair about that. I hope we can advance that. Thank you very much.

Chairman BAIRD. Thank you, Mr. Inslee, and thank you for your many years of leadership on not only this particular form of energy but the whole issue of alternative energy and your book, which you brought with you. What is the title of that book, Mr. Inslee?

Mr. INSLEE. Well, I appreciate your efforts, but I don't know if I can put you in the five percent plan for marketing, Mr. Chair. I appreciate that.

Chairman BAIRD. Mr. Inslee wrote an outstanding book, *Apollo's Fire,* and it is an outstanding compendium, a bit dated because the transitions are happening so fast, but very few Members of Congress know as much about this topic as Mr. Inslee, and thank you for your leadership on that.

Mr. INSLEE. If I can note, though, I just want to note, Mr. Dehlsen was one of the most interesting people I met in the production of this book and I remember very specifically getting to talk to him about this story, and Mr. Dehlsen, I want to thank you for your leadership now on multiple technologies. We really appreciate it.

Chairman BAIRD. Are there any other members that are wishing for me to plug their book? I would be happy to at this point.

PERMITTING AND REGULATORY STRUCTURE

Let me follow up. I would like to do a brief second round. We may have some votes coming up. Mr. Beaudry-Losique, we have heard a lot about this issue of permitting and regulatory structure. Has your operation sat down with MMS (minerals management service) and the other regulatory bodies and said how can we work together, what changes do you need, how do we make those changes happen, and if you haven't, can we do that?

Mr. BEAUDRY-LOSIQUE. We are working with other agencies on a lot of our different renewable technologies. I would say this is a problem that is not unique to marine and hydrokinetics. It is shared by offshore wind. It is shared to some extent with solar deployment on BLM (Bureau of Land Management) lands. It is shared by on-land wind as well. So we have had numerous discussions with the Department of Interior, with FERC, within the Department of Interior. We are working specifically with MMS, which has a lot of the jurisdiction offshore for speeding up permitting both for offshore wind and for marine and hydrokinetics technology. We hope to have a memorandum of understanding in place with them shortly. But I would completely agree with my fellow panel participants that this is a very serious issue and that we are putting a lot of resources against it. Furthermore, we are doing a lot of the environmental studies to help pre-permit these marine research energy centers so we can have test beds to plug in small-scale marine devices fairly quickly, and that is part of our funding is actually to establish that pre-permitting that would help speed up testing these technologies.

Chairman BAIRD. I have done a lot of work on the permitting issue back home because we have a lot of water and a lot of endangered species where I live, and one of the things that really seems to help is to get all the agencies in a room with the consumers of the agency services, i.e., the permit applicants, and then try to see if you can't come up with some standardized permit structures. You know, back home it is not the first time a dolphin has ever been put—I don't mean a swimming dolphin, I mean the things you moor a boat to—it is not the first time we have put one of those in the Columbia River over the last couple of centuries, and yet there was a long process where each time you had to do a brand-new EIS (environmental impact statement) as if nobody had ever done it. So they have now got streamlined mechanisms for that. So my question would be, has there been a meeting, a conjoined meeting of your operation within DOE, the tidal hydro side, with the multiple regulatory agencies, with the applicants together to say let us figure out how to do this, come up with some target timelines, some reasonable expectations for baseline and then follow-up data, et cetera, particularly as we try to set up this test bed? Has that happened yet?

Mr. BEAUDRY-LOSIQUE. I would say it is fair to say that there has been a series of bilateral discussions with key agencies and it is definitely in our work plan, for example, with DOE and MMS, to get all the agencies in the same room in a working group with applicants to help determine what are the best intervention points to speed up the permitting process but this meeting has not occurred yet.

Chairman BAIRD. Okay. I will ask the witnesses, would that make sense to have a meeting like that? Would that be helpful to you?

Mr. COLLAR. I think from our perspective, it certainly would be very helpful. I think it is a logical next step. It is something we have not done to this point and I can see where it could be pretty useful, yes.

Mr. DEHLSEN. At approximately the same stage in wind going back in the early 1980s, what was done in a number of counties was to designate zones, and so rather than each time a developer having to go through the process, just approving a zone would be extremely helpful.

Chairman BAIRD. Okay. Mr. Bedard?

Mr. BEDARD. I am fortunate enough, Chairman Baird, to work for a technology organization and I don't have to get into the permitting. In fact, when I had my three children and needed a larger house, I even avoided adding a room on and going through the permitting process. I just bought a new house. So I don't like to deal with the pain.

Chairman BAIRD. Ms. Schneider, I mean, I know your issues are somewhat separate but perhaps you have some insights.

Ms. SCHNEIDER. I mean, in the sense of creating, especially as you look to low-head applications in streams, it is the same general concept that applies in terms of gathering standardized information and then feeding that into a streamlined process with FERC, not just the resource agencies but also then moving on to FERC. One of the things—and we certainly actually had a reasonably good path, I guess, through the process on this first project but that is also because we put a lot of effort in front in talking to all the stakeholders involved.

Chairman BAIRD. Shifting topic a bit, you know, Dr. Ehlers called much of this solar power. I believe some of it is lunar power as well, is it not?

Mr. DEHLSEN. Yes.

Chairman BAIRD. Puget Sound I guess would be, the Admiralty Inlet source, a fair bit of lunar power. That is a lead-in actually to a more substantive question, which is, Dr. Bedard, you talked about wave energy being the most promising. We have got a lot of big waves off our coast, and I am glad to see that has been recognized, but it seems to me the more predictable source is tidal flow and we know when it is going to happen, we know it is velocity. You know, when I scuba dive up in that area, man, you literally start it to the minute in some of these dives because if you are not out of that water when that tide changes, you have got a real problem up there. So we know to the minute, and that is not the case with wind, it is not the case with even solar in many cases and it is a real problem up in the Northwest as we try to integrate grid with unpredictable sources. Yet tidal is probably more predictable than wind. What is your take on that? Yeah, I think it is clearly more predictable than wind, probably more predictable than wave as well.

Mr. BEDARD. It certainly is. As a matter of fact, one can predict the tidal speeds centuries in advance because they are totally dependent upon the relative location of the earth-moon-sun system. With waves, it is also a good situation in that the waves are created from storms in the Pacific Northwest off Japan, the Gulf of Alaska, so we know three days in advance before the waves are going to hit the beaches. Mr. Rohrabacher, who is a surfer, would know that the maverick competition at Half Moon Bay, they call in the expert surfers one day in advance before the biggest waves are going to hit. So that definitely—the predictability is definitely an advantage. When I said that wave is the most significant, in the lower 48 states, there is only maybe a handful or a dozen or so really good tidal sites. Most of—the ocean energy in our country is in the State of Alaska. They have by far the most wave and tidal resources.

Chairman BAIRD. We have got, I mean actually a little bit north of us but off Vancouver Island there are some hellacious—and Point Defiance.

Mr. BEDARD. Absolutely.

Chairman BAIRD. I almost said whitewater kayaked. I sea kayaked there and it is like whitewater kayaking at times, pretty exciting.

Mr. DEHLSEN. I would like to offer another source of energy and that is the rotation of the planet and the Coriolis effect, which drives the Gulf Stream, and the energy resource off of the southeastern United States by the Gulf Stream is quite enormous. It is equal to about 50 times the rivers of the planet and it flows 12 to 15 miles off the coast of Florida, which doesn't have much else in the way of renewable energy, geothermal, et cetera. So that is a very important one, and the technology for doing that is very much like what you see coming out of wind power. So that is the area we are focusing on actually, that and wave power.

Chairman BAIRD. Thank you. One last comment. I drove by San Francisco Bay a while back and saw all those ships moored way up the bay there, they are permanently moored there. And I thought, Archimedes tells us there is an awful lot of weight being lifted every day and lowered back down every day and lifted every day. It is too bad we can't attach that to some kind of generator, and maybe somebody can figure it out.

Mr. Inglis.

Mr. INGLIS. Thank you, Mr. Chairman.

Dr. Ehlers, do you have—

Mr. EHLERS. A quick comment.

Mr. INGLIS. Sure.

Chairman BAIRD. I am going to get a lecture on Archimedes here.

Mr. EHLERS. No, except that apparently there is no historical evidence that he ran through the streets naked shouting "Eureka."

Chairman BAIRD. That was my favorite part.

ENERGY PRODUCTION FROM THE GULF STREAM

Mr. EHLERS. I know. It is most everyone's favorite part.

No, I was just going to comment on the Gulf Stream. I am very afraid of tampering with the Gulf Stream because we don't know how stable it is, and it would be disastrous for Europe if our attempts to extract energy from it somehow interfered with the flow of the Gulf Stream, and I have no idea what—you know, I just don't know what the tipping point is and I am not sure anyone knows, so I just wanted to toss that in.

Mr. DEHLSEN. Can I respond to that?

Chairman BAIRD. I will tell you what. Let me recognize Mr. Inglis for his five minutes and Dr. Ehlers will get his shot, unless Mr. Inglis wants to hear about the Gulf Stream.

Mr. INGLIS. That would be great. I would be happy for you to answer that question.

Mr. DEHLSEN. We had the University of Delaware do a study in that topic and their conclusion was that at 10,000 megawatts it was essentially within the noise of natural variability, so effectively you could extract that from the Gulf Stream, say, off of Florida, and really have no impact on that circulation pattern. That is a very important topic to be aware of.

Mr. INGLIS. And just two observations. One is, you know, as a guy that is into sailing, I think that the scene of being able to see wind turbines off shore is like looking at sailboats, and for the well-heeled that Dana was speaking of that don't like their view interrupted, I think they need to rethink that and just imagine that that is a beautiful sailboat out there. In fact, maybe we could put some colorful sort of spinnaker kind of sails on them or ribbons and make them look more like sailboats. I think they are really beautiful, particularly when you think about how they are out there producing no emissions. It is a rather beautiful scene. You should invite people over to see out of your window what we are doing out there, it seems to me.

The other thing is, since we are plugging, and I am not plugging a book, I am plugging a bill. I mentioned earlier Carlos Gutierrez' definition of sustainability that is making a profit. The challenge that we hear from this witness table a lot in transportation fuels is that incumbent fuel there being petroleum doesn't have all the costs in. If the costs were all in and a proper cost accounting, even for the simple thing of the defense expenditures associated with protecting that supply line, even if that were only attributed to the price of petroleum, then a lot of what we hear from that witness table would become economically viable. What we are hearing today is that this wave energy, tidal energy could become viable if the costs were in on coal, the dominant incumbent technology. If all the costs were in there, wow, you would be in business. So these ideas would not be ideas, they would be actually being deployed and being developed. So I have got a bill that does that. It is 15 pages compared to cap and trade, which is a 1,200-page monstrosity, and so it is 15 pages of a simple concept, a revenue-neutral tax swap, reduce payroll taxes, impose a tax on emissions, make it border adjustable so it is removed on export, imposed on import, and it is pretty exciting. Fifteen pages gets the job done. And it would change the economics and make it so what we hear from that table would suddenly become viable and fit with Carlos Gutierrez' definition of sustainability. If you can make a profit, it is sustainable; if you can't, it is not. But when the incumbent technologies get to hide the cost with negative externalities that are not internalized, there is a market distortion and especially conservatives should rise up and say we can't tolerate market distortions because we believe in the power of markets and we believe in the power of free enterprise.

Thank you, Mr. Chairman, for that opportunity to plug my bill as well as a book.

Chairman BAIRD. I fully support your bill, and the only drawback is that it sinks less carbon in the text of the bill than does the competing cap-and-trade model, but I think it is a much more elegant and likely to succeed strategy than the cap-and-trade model. The key point, though, to make this technology work, you have got to purely value carbon in some fashion and I think yours is a better way to do it, frankly.

Dr. Ehlers.

Mr. EHLERS. Thank you. Very briefly, I totally agree with the comments of Mr. Inglis, and it is certainly a more intelligent approach to take to the cap and trade, simply add a tax and give the money back to the people in a different way. I also commend Mr. Inglis on his comments about the view and I decided after your discussion of how beautiful they are that you obviously could improve your salary by selling real estate. You have a real talent there for making property look good. With that, I yield back.

THERMAL ENERGY POTENTIAL IN THE OCEANS

Chairman BAIRD. One final topic. The bells imply that we have a vote. We have not talked about thermal potential within the oceans, and I wonder if any of you would like to chat about that briefly. It may not be within your purview but possibly Mr. Beaudry-Losique could talk a little bit about the thermal potential energy because I understand it is fairly significant.

Mr. BEAUDRY-LOSIQUE. We agree that the potential of ocean thermal is fairly enormous. However, because of the relatively low difference in temperature between the top and the bottom of the ocean, we need still fairly large-scale device, enormous devices with very high capital cost. So we are going to spend the next year or two to try to validate the economics of OTEC and try to—and work also with the Navy on that topic and try to determine what is going to be the ultimate potential of driving that cost down. That will drive where would it best fit: a tropical island or for more mainstream applications.

Chairman BAIRD. Does anyone else wish to comment on that?

Mr. DEHLSEN. Yes. With the Gulf Stream application, the machine that we are developing is one that can also—other than generating electricity, you can generate high-pressure water to shore and use that water for reverse osmosis desalinization because if you are drawing the water off of depths, you pick up about a 20-degree differential. So central cooling of Miami, for example, is a possibility. And the energy payback on that is enormous. If you combine the residual electricity that you could generate off of the reverse osmosis flow that remains plus the central cooling, it really helps significantly the economics of that technology.

Chairman BAIRD. Maybe some low-head hydro applications there as well.

CLOSING

I want to thank our witnesses for very, very fascinating work and in all of your case lifetime of contribution to this important issue. As always, the record of this hearing will remain open for two weeks for additional statements from the members and for answers to any of the follow-up questions the Committee may ask of the witnesses. I would like personally to maybe follow up with some of you about the idea of a joint meeting with some of the regulators, some of the applicants and the research side so we can possibly get this thing moving a little bit faster and maybe a lot bit faster, and with that, the witnesses are thanked for their time. My colleagues, thank you for your input as always and thanks to the staff, and the hearing is now adjourned. Thank you very much.

[Whereupon, at 11:31 a.m., the Subcommittee was adjourned.]

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