Support for International Standards Development, Marine and Hydrokinetic Renewable Energy in the United States

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Abstract

The development of the hydrokinetic renewable energy industry is in its early stage. It is important to have well-defined standards and technical specifications to maintain the stability of the industry. The United States has established a Technical Advisory Group (TAG) through the American National Standards Institute (ANSI). The TAG is working with all facets of the industry to support the development of International Electrotechnical Commission (IEC) standards and specifications. This paper will highlight the participation from individuals, industries, and government entities.

Keywords: hydrokinetic energy, international standards, US TAG

1. Introduction

The marine hydrokinetic energy community in the United States has determined that the development of standards is important to the industry. The standards will provide stability to the industry as it grows and reduce project risk that will attract more capital investment and financial backing. The U.S. Technical Advisory Group (TAG) is integrating the interests of system developers, researchers, utilities, and other stakeholders. This process is being done to support the international committee in the development of technical specifications to support the international community.

2. Technical Advisor Group (TAG)

2.1 United States National Committee (USNC)

USNC is the organizational arm of the American National Standards Institute (ANSI) supporting the U.S. interests in both International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) standards development. ANSI provides a forum for the development of both U.S. and international standards. The development of standards follows guideline established by ANSI. Access to the process and standards is maintained by ANSI.

2.2 TAG Membership

The TAG is important to support the development of the IEC Technical Specifications (TS). A TAG is formed when a proposed standard is issued by either the ISO or the IEC. Membership to the TAG is open to all individuals and interested parties. A representation of all aspects of the industry is important. Table 1 lists participating members and their affiliation, which is a good representation of the marine energy community.

Table 1 TAG Members

Person	Affiliation
Neil Rondorf (Head of Delegation)	SAIC (Science Applications International Corporation)
James E. Adamson	Marinus Power LLC
Dr. Aiman Alawa	Free Flow Energy
Dr. Madasamy Arockiasamy (PT62600-2)	Florida Atlantic University
Roger Bagbey	Inspired Systems
Philip Beauchamp (PT62600-1)	GE Global Research
Jonathan Colby (PT62600-200)	Verdant Power
Dean Corren	Verdant Power
Frederick Driscoll	National Renewable Energy Laboratory
Millard Firebaugh	Ocean Renewable Power Company
Kenneth E Gettman	National Electrical Manufacturers Association
David Goodwin	Science Applications International Corp
Eric Greene (PT62600-2)	Eric Greene Associates Inc.
Ron Hippe (WG-1)	Teledyne-RD Instruments

Person	Affiliation
Mike Leibowitz	National Electrical Manufacturers Association
Pukha Lenee-Bluhm (WG-1)	Oregon State University
Laurie Meyer	Lockheed Martin Corp
John Miller	University of Massachusetts Dartmouth
David Nedorostek	Minerals Management Services
Sean O'Neill (PT62600-1)	Ocean Renewable Energy Coalition
Dr. Robert Paasch (PT62600-2)	Oregon State University
Brian Polagye	University of Washington
Michael Raftery (62600-100)	Stevens Institute of Technology
Eric W. Schreiber	Royal Caribbean Cruises, Ltd.
Susan H. Skemp	Florida Atlantic University
Brennan T Smith	Oak Ridge National Laboratory
Charles E. Smith (Convener PT62600-2)	Petroleum Research Atlantic Canada
Bill Staby	Resolute Marine Energy, Inc.
Emil D. Tietje III (convener PT62600-100)	Science Applications International Corp

3. IEC TC114 Support

The TC114 TAG has been inclusive in its efforts to attract members. The goal is to seek representation from a broad range of stakeholders to provide well-rounded input into the IEC TS development.

4. Membership on the IEC Working Groups and Project Teams

4.1 General

TC114 has established one working group (WG) and four project teams (PT):

1. WG-1, "Wave and tidal energy resource characterization and assessment"
2. PT 62600-1, " Terminology"
3. PT 62600-2, "Design requirements for marine energy systems"
4. PT 62600-100, "The assessment of performance of wave energy converters in open sea"
5. PT 62600-200, "The assessment of performance of tidal energy converters"

4.2 WG-1 Resource Characterization

WG-1 is divided into two sub-working groups: one for wave and the other for tidal. The U.S. TAG has identified an expert for each sub group. The experts have attended working meetings and teleconferences.

4.2.1 Sub-Working Group 1.1, PT62600-3-1 Wave Resource

PT62600-3-1 is a technical specification for the determination of the wave resource at a particular location. The U.S. TAG nominated Pukha Lenee-Bluhm as an expert on the PT. Lenee-Bluhm has attended the meetings and teleconferences.

4.2.2 Sub-Working Group 1.2, PT62600-3-2 Tidal Resource

PT62600-3-2 is the technical specification for the determination of the tidal resource at a particular location. The U.S. TAG nominated Ron Hippe as an expert on the PT. Hippe has attended the meetings and teleconferences.

4.3 PT62600-1 Terminology

PT62600-1 will provide a common terminology for TC114. The U.S. TAG nominated the following experts to the PT:

Phil Beauchamp
Sean O'Neill

The PT issued its first Committee Draft in March 2010 and has started incorporating the comments. Beauchamp and O'Neill are working with U.S. subject matter experts (SMEs) on each PT to confirm terminology.

4.4 PT62600-2 Design

PT62600-2 a technical specification (TS) for the design of both wave and tidal energy converters. The TS will provide guidance for safe design, fabrication, and operation of the converters. Charles Smith is the convener for the PT. The U.S. TAG nominated the following to the PT:

Bob Paasch
Ye Li
Madasamy Arockiasamy

The first PT meeting was hosted by Smith at Florida Atlantic University.

The U.S. TAG has established a shadow committee with Yi as the chairman. The committee held a workshop during the Global Marine Renewable Energy Conference in Seattle. The workshop provided a forum to exchange ideas from:

1. Developers
2. Design firms
3. Research laboratories
4. Utilities

The information from the workshop was provided to the PT to assist in the development of the TS.

4.5 PT62600-100 Wave Energy Converter Performance

PT62600-100 is the TS for wave energy converter performance. David Tietje is the convener for the PT. The U.S. TAG nominated Mike Raftery as an expert to

the PT. The United States has attended and participated in the teleconferences as part of the writing of the TS. The PT held its October 2009 meeting in Seattle and was hosted by the United States. The PT issued a Committee Draft (CD) in June and is working on resolving comments. The U.S. TAG established a shadow committee after the CD was used. The committee will assist Raftery's continued work on the PT. The shadow committee provided input for the comments on the CD.

4.6 PT62600-200 Tidal Energy Converter Performance

PT62600-200 is a TS for tidal energy converter (TEC) performance. The U.S. TAG nominated Jonathan Colby as an expert to participate on the PT. Colby has attended the PT meetings and teleconferences. The United States will host the October 2010 PT meeting in New York.

The U.S. TAG has established a seven-member shadow committee to support Colby. The PT specification clauses have been assigned to members in the committee. This will provide the details needed for active participation in the PT meetings. Several topics have been identified to the Department of Energy (DOE) for additional research:

1. Power measure
2. Acoustic Doppler Current Profiler (ADCP) deployment location
3. Available operational time
4. Length measurement period
5. Wave and turbulence
6. Yawing and flow misalignment
7. Blockage and its affect on efficiency and the environment.

5. University Support

5.1 General

The development of standards requires continued research and development (R&D). R&D at universities is being used to:

1. Test and develop prototypes
2. Research environmental impacts
3. Design and building testing equipment

5.2 Oregon State University

Oregon State University has several programs that support the development of wave energy:

1. Prototype development of wave energy converters
2. Testing wave energy converters (WECs) at O. H. Hinsdale Wave Research Laboratory
3. Electrical magnetic frequency (EMF) studies on marine power cables.

Northwest National Marine Renewable Energy Center (NNMREC) is supporting the development of a Mobile Ocean Test Berth (MOTB). NNREC is a collaboration between Oregon State University and the University of Washington. The MOTB, shown in Figure 1, will be used to test wave energy converters at test sites.

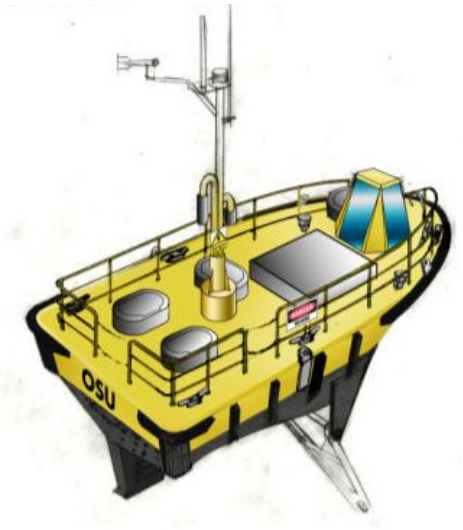

Figure 1 Mobile Ocean Test Berth Concept

The MOTB will be transported to test sites and moored near a deployed WEC. A power cable will connect the WEC to the MOTB. The MOTB will measure WEC power output plus any other parameters that a developer is interested in.

5.3 Maine Maritime Academy

Marine Maritime Academy (MMA) is working on model testing a tidal current turbine. This is leading to the development of a standard methodology. MMA is using the International Towing Tank Conference ITTC standards as guidance for their testing procedures at this time.

5.4 University of Washington

The University of Washington has several tidal energy programs:

1. Resource characterization with ADCP data
2. Evaluation of background noise
3. Environmental impact from tidal devices
4. Numerical modelling of rotor performance

NNMREC is supporting a test platform for tidal energy converters. The facility would be located off Marrowstone Island in Puget Sound.

5.5 New England Marine Renewable Energy Consortium (MREC)

MREC is a university and industrial consortium of

1. Massachusetts Institute of Technology
2. Woods Hole Oceanographic Institute
3. University of Massachusetts
4. University of New Hampshire
5. University of Rhode Island
6. Battelle Laboratory

7. Lockheed
8. National Grid
9. Alden Labs
10. Federal agencies
11. Local communities

The consortium is researching technology that is suitable for the New England area, which has a high energy use. Models are being developed that will include ocean renewables. The consortium concept will reduce R & D risks. A test facility between Martha's Vineyard and Nantucket is being developed, see Figure 2.

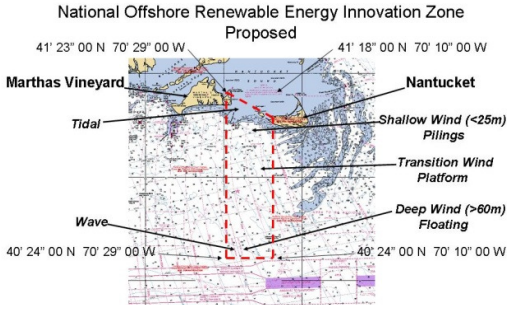

Figure 2 National Offshore Energy Innovation Zone

5.6 Florida Atlantic University

Florida Atlantic University is assisting in the development of ocean current and thermal energy. The Center for Ocean Energy Technology is conducting scientific and engineering research in the Florida Current off southeast Florida to determine ocean current and temperature profiles. Oceanographic research and assessment programs include:

1. Acoustic Doppler current profilers for continuous resource characterization data. Analysis underway
2. Ocean thermal energy conversion measurement for time series mapping of the temperature profile for the ocean thermal gradients offshore Ft. Lauderdale, Fla.
3. Environment effects assessment and analysis underway to include such areas as benthic habitat, acoustic, sea turtles and marine mammals
4. Prototype device (20kW) fabrication underway for ocean current test and evaluation. The three-phase 240-volt alternating current (VAC) system will provide a platform to fully test the offshore turbine.
5. Operational and testing requirements being developed to provide an evaluation platform capability for ocean current device developers

5.7 Stevens Institute of Technology

Stevens Institute of Technology is studying the effects of fully submerged, variable depth, tension leg platforms (TLP) on surface waves. Preliminary research indicates wave power density can be increased on the order of three times over the platform before wave-breaking criteria are exceeded. The TLP designs are intended for intermediate to deep water environments. Research goals include making wave energy viable in mild to moderate wave climates as found on the East Coast of the United States to reduce mooring costs, expand viable wave energy regions, and expand deployment and maintenance windows.

5.8 US Air Force Academy

A team of aerospace engineers are applying the principles of airplane lift to create a new wave-energy systems that is durable, extremely efficient, and can be placed anywhere in the ocean, regardless of depth. Computer and scale-model testing of the system suggest higher efficiencies than wind turbines. The system is designed to effectively cancel incoming waves, capturing their energy while flattening them out. This process has an added application as a storm-wave breaker.

5.9 University of Hawaii

The University of Hawaii has established the Hawaiian National Marine Renewable Energy Centre (HNMREC.) HNMREC is working to develop the Ocean Technology Energy Converter (OTEC) and wave energy solution in support of the state of Hawaii, the Hawaii Electric Company, and the Department of Defense.

6. Government Laboratories and Agencies

Laboratories are using their experience in wind energy to support the development of IEC technical specifications. The National Renewable Energy Laboratory (NREL) is the lead government lab for this effort and is being supported by:

1. Sandia National Laboratories (SNL)
2. Pacific Northwest National Laboratory (PNNL)
3. Oak Ridge National Laboratory (ORNL)
4. Minerals Management Services (MMS)
5. Federal Energy Regulation Commission (FERC)

The government is developing computer models to support the design of marine energy converters. The computers models will be designed to allow multiple design configurations of marine energy converters. The marine hydrokinetic Jobs and Economic Development Impact (JEDI) model will be one of the models used to validate the development of the technology.

7. Private Industry

7.1 Pacific Gas and Electric Company (PG&E) WaveConnect™

PG&E has funded studies to permit a test facility for wave energy converters. The facility will have:

1. Ability to test three or four WEC arrays
2. Marine power cables
3. Deployment techniques
4. Shore support infrastructure.
5. Connection to the grid

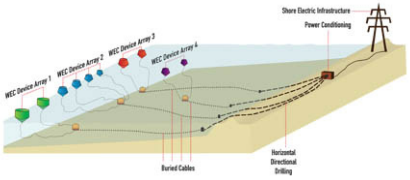

Figure 3 PG&E WaveConnect™

This will provide an opportunity for PG&E to evaluate different WECs and for WEC vendors to demonstrate array operations.

7.2 Snohomish County Public Utility District (PUD)

Snohomish, Wash., PUD is investigating the use of tidal power in the Puget Sound area. The pilot project will use horizontal-axis turbines. The turbines will be grid-connected. Snohomish PUD has been doing studies:

1. To estimate the available power
2. On the impact on the surrounding environment
3. On various test site characteristics and alternatives

7.3 Ocean Renewable Power Company (ORPC)

ORPC installed a marine turbine to the entrance of the Bay of Fundy. The turbine generator unit is a beta test device. The first grid-connected unit is planned for late 2011.

7.4 Verdant Power

Verdant completed test operation of an array of five full-scale 5-meter diameter 35kW Kinetic Hydropower System (KHPS) turbines at its Roosevelt Island Tidal Energy (RITE) project in New York's East River. These fourth generation units provided power with a water-to-wire efficiency of 35 percent to 40 percent over the tidal period. This experience led to Verdant's 56kW Gen5 design, which is aimed at long-term reliability and cost-effective manufacture. Verdant has developed the Gen5 composite rotor with support from DOE's NREL and Sandia National Lab. It is expected that the Gen5 system will be built and tested in 2010/2011 and will be used in arrays at Verdant's RITE project site and its Cornwall Ontario River Energy (CORE) project in the St. Lawrence River in Cornwall, Ontario, Canada.

7.5 Vortex Hydro Energy

The VIVACE (vortex induced vibration for aquatic clean energy) converter harnesses the horizontal hydrokinetic energy of ocean river currents as slow as 2 knots and converts them to electricity. VIVACE enhances flow-induced motions (VIV, proximity galloping, interference galloping, wake galloping, and galloping) using fish biomimetics such as surface roughness and passive fish tails. It is a truly three-dimensional device, as cylinders are distributed in all three-dimensions as in a school of fish formation. Power densities of 309 watts per cubic meter at 3 knots Basic research is conducted in the Marine Renewable Energy Lab of the University of Michigan. Product development is done by Vortex Hydro Energy. A 5kW river prototype will be launched in July-August 2010 in the St. Clair River. Funding is provided by the U.S. Navy, the Office of Naval Research, the National Science Foundation, Michigan Universities Commercialization Initiative, and other public and private sources.

7.6 Turner Hunt Ocean Renewable LLC

Turner Hunt Ocean Renewable LLC (THOR LLC) is developing a family of ocean current turbines for use off the southeastern United States in the Gulf Stream. THOR LLC is working with the MMS on a lease that would allow for the deployment of the company's scaled prototype off the east coast of Ft. Lauderdale, Fla., with future deployments as far north as Hatteras, N.C. THOR's ocean current turbine is completing testing and evaluation as a scale model in a unique ocean current simulator built by THOR. THOR's ocean current turbine provides near base load capacity factors using a proprietary power control protocol method of operation. It is estimated that the ocean current resource off the southeastern U.S. coast is capable of delivering over 60GW of renewable energy to anywhere on the eastern seaboard via undersea transmission at competitive prices.

7.7 Resolute Marine Energy (RME), Inc.

RME has been developing its wave energy converter technologies since 2006 with support from both the Department of Energy and the National Oceanic and Atmospheric Administration. Two WEC designs have shown promise through theoretical modelling and wave tank experiments. One WEC is an innovative variation of a traditional point absorber, and the other is a bottom-mounted hinged flap. RME is planning to conduct reduced-scale ocean tests of both designs in summer 2011.

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