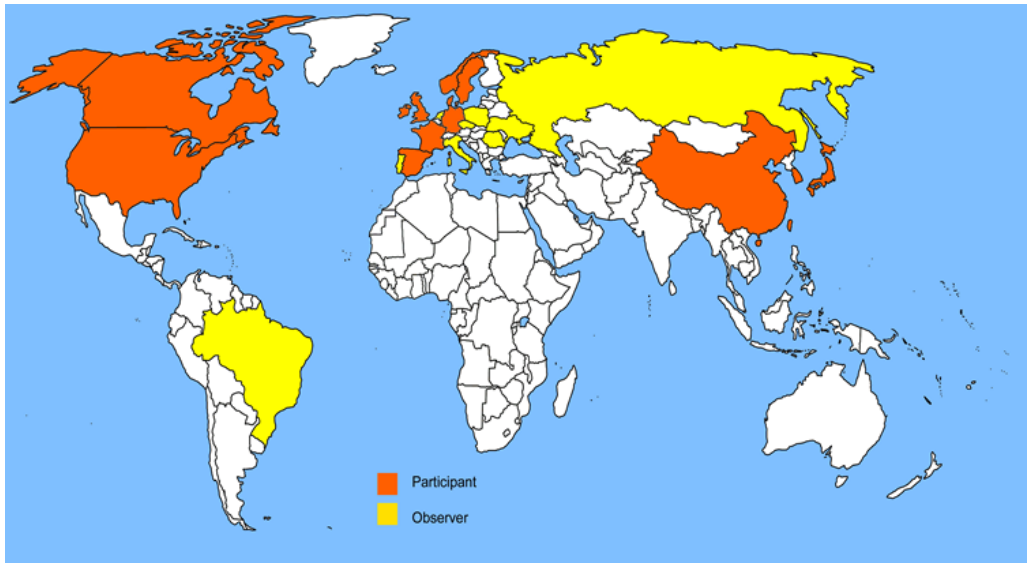
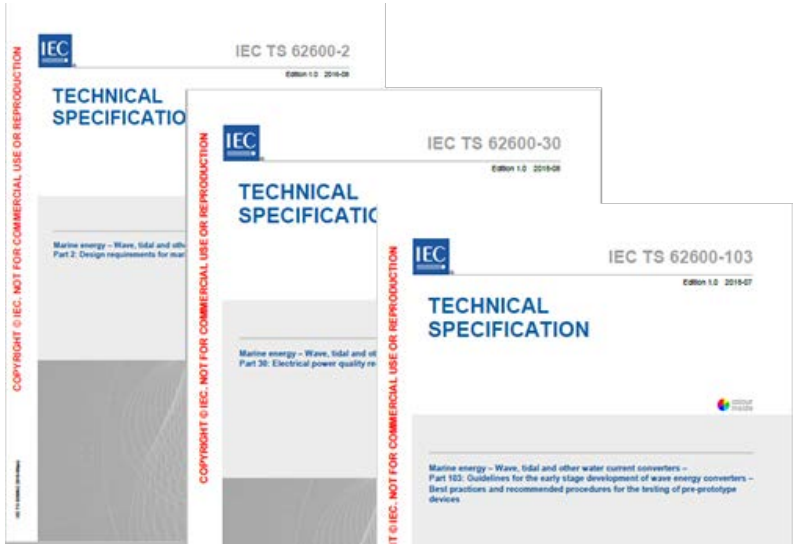




Standards Development, IEC TC 114 IEA-OES Annual Contribution

2.2.3.401

Marine and Hydrokinetics Program

Wednesday, October 9, 2019

Walt Musial

National Renewable Energy Laboratory

Project Overview

Project Summary

- Supports **standards development** and **research programs** under International Electrotechnical Commission (IEC) (www.iec.ch) and International Energy Agency (IEA) Ocean Energy Systems (OES) (https://www.ocean-energy-systems.org/).
- Only formal **international collaborations** in WPTO program.
- Internationally recognized standards are essential for **marine energy technology commercialization.**
- Nascent industry cannot sustain this activity without **DOE support.**

Project Objectives & Impact

- Accelerate commercialization of Marine Energy Technology
- Build confidence in the investment community for project financing
- Reduce technical risk by enabling predictable lifetimes and energy production
- Help regulators manage public safety by reducing failures
- Increase access to critical data and growth opportunities with international collaboration
- Enable DOE to construct a targeted and well-informed ocean energy research program
- Provide feedback to the U.S. industry on the status of international activities

Project Information

- **Project Principal Investigators**
  - Walt Musial
  - Arielle Cardinal
  - Bob Thresher
- **WPTO Lead**
  - Bill McShane
- **Project Partners/Subs**
  - The **IEC TC114 U.S. Technical Advisory Group** (TAG) has 43 active members from industry, academia, and national labs. In addition, the TAG collaborates with 27 countries participating on this effort.
  - The **Ocean Energy Systems** is an IEA Technology Collaboration Program which has 25 member countries.
- **Project Duration**
  - October 2009 - Present

Alignment with the Program

Marine and Hydrokinetics (MHK) Program Strategic Approaches

Data Sharing and Analysis

Foundational and Crosscutting R&D

Technology-Specific Design and Validation

Reducing Barriers to Testing

Alignment with the MHK Program

Data Sharing and Analysis

- Provide original research to assess and communicate potential MHK market opportunities, including those relevant for other maritime markets
- Aggregate and analyze data on MHK performance and technology advances, and maintain information sharing platforms to enable dissemination
- Support the early incorporation of manufacturing considerations/information into design processes
- Leverage expertise, technology, data, methods, and lessons from the international MHK community and other offshore scientific and industrial sectors

IEA and IEC participation:

- Leverages the Program's technical projects to gain higher access to technology, validation data, methods, and lessons from the international MHK and other scientific ocean-based communities (e.g., offshore wind, oil, and gas)
- Accelerates the uptake of new innovations
- Increases industry wide collaborations (e.g., between federal and state agencies and technology and project developers)
- Ensures that collected data can be accepted by U.S. regulatory authorities and harmonized internationally.

Alignment with the MHK Program

Technology-Specific Design and Validation

- Validate performance and reliability of systems by conducting in-water tests of industry-designed prototypes at multiple relevant scales
- Improve methods for safe and cost efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning of MHK technologies
- **Support the development and adoption of international standards for device performance and insurance certification**
- Evaluate current and potential future needs for MHK-specific IO&M infrastructure (vessels, port facilities, etc.) and possible approaches to bridge gaps

Technology Specific Benefits:

- Standards **improve methods** for safe and cost-efficient installation, grid integration, operations, monitoring, maintenance, and decommissioning of MHK technologies.
- Development and adoption of consensus-based international standards **raises confidence** in the technologies
- Enables third-party **warrantees** and certifications for MHK devices by increasing confidence in performance and safety
- Increases attractiveness of technology to **insurers and financiers**.

Alignment with the MHK Program

Reducing Barriers to Testing

- Enable access to world-class testing facilities that help accelerate the pace of technology development
- Work with agencies and other groups to ensure that existing data is well-utilized and identify potential improvements to regulatory processes and requirements
- Support additional scientific research as needed, focused on retiring or mitigating environmental risks and reducing costs and complexity of environmental monitoring
- Engage in relevant coastal planning processes to ensure that MHK development interests are equitably considered

How Standards Reduce Barriers to Testing Labs:

- Provides test centers with uniform guidance to conduct tests and issue globally recognized test reports.
- Facilitates mutual recognition among qualified test centers (e.g. IECRE Test Laboratories)
- Increases the value of reports by accredited test centers
- Gives regulators assurance that devices comply with industry best practices and will have a high probability of technical success.

Project Budget

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Project Budget FY17–FY19 Q1 & Q2 (October 2016 – March 2019)	
Costed	Costed	Costed	Total Costed	Total Authorized
$525K	$661K	$350K	$1,536K	$1,934K

- Project costs have been in line with plans.
- Funding has been relatively level with incremental increases to cover increased U.S. leadership, IECRE involvement, and larger number of active working groups (ad hoc groups, maintenance teams, and new working groups combined)
- Projects funds are generally split 80% for IEC TC114 work and 20% for IEA OES work
- NREL provides fixed stipends to supplement subject-matter experts' work. Balance of labor is either volunteered by SMEs or provided by their companies.

Management and Technical Approach - Background

IEC TC114

- U.S. TAG and DOE support was initiated in 2008.
- Work is ongoing with no planned end date.
- The standards task has been on track and there have been no significant delays.
- Regular meetings are held for the U.S. TAG, TC 114, and ME OMC.

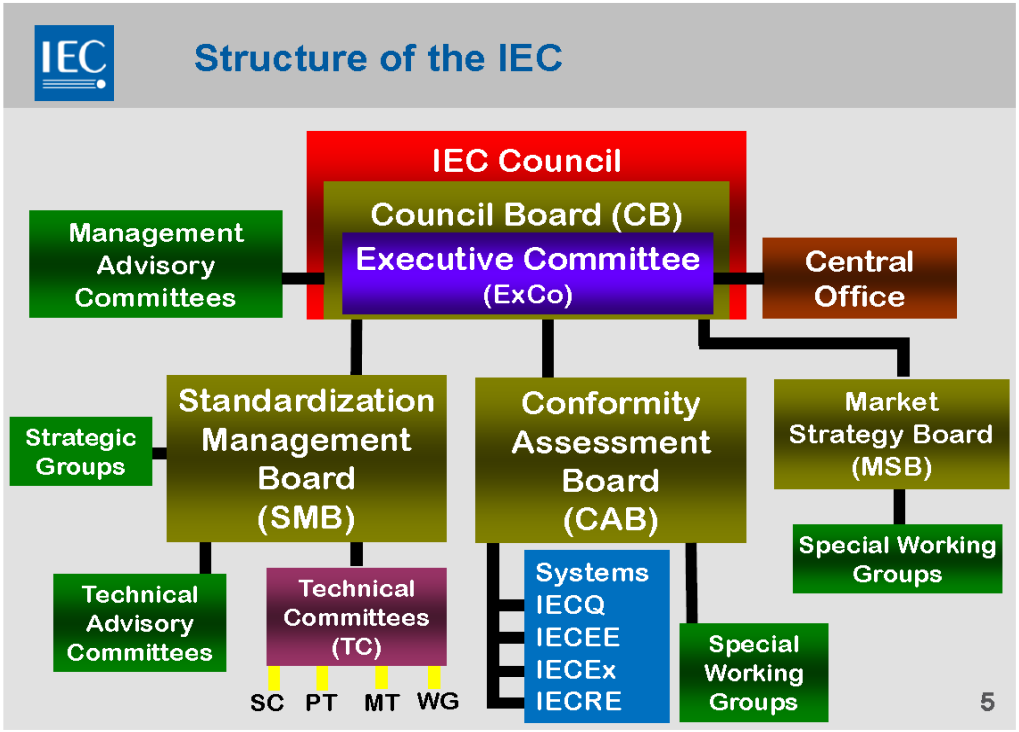
IEA OES

- U.S. participation initiated in 2005, and Task 4 and 5 started in 2011 and continuing participation is planned dependent on value to United States.
- Task 4 and 5 workshops have been held and reports have been made public on OES Website www.ocean-energy-systems.org. Future workshops to be held on a rotational basis and organized by selected countries depending on interest.

Management and Technical Approach – IEC TC114

IEC TC114

- Serve as Technical Administrator to manage U.S. TAG of TC-114, and interface with IEC and ANSI
- Maintain and manage subcontracts to support industry participation through stipends and ANSI dues (approx. $350k)
- Participate in and directly lead the development of international standards and certification processes related to Marine Energy
- Maintain strong international leadership through TC114 chairman, U.S. TC114 Delegation, and TAG Executive Committee



Management and Technical Approach – IEC TC114

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Chairman: **Jonathan Colby (U.S.)**
Secretary: Danny Peacock (U.K.)
Technical Officer: Anson Chiah (IEC)

U.S. Technical Advisor: Bill Staby
U.S. Deputy Technical Advisor: Phil Beauchamp
U.S. TAG Administrator: Arielle Cardinal

WG/PT	Title	Convener
MT62600-1	Terminology	Mohamed El-Hawary (CA) **Phil Beauchamp (US)**
MT62600-2	Design requirements for marine energy systems	**Eric Greene (US)**
MT62600-10	Assessment of mooring system for marine energy converters (MECs)	Ryan Nicoll (CA)
MT62600-100	Power performance assessment of electricity producing wave energy converters	Aaron MacNeill (CA)
MT62600-101	Wave energy resource assessment and characterization	Matt Foley (GB)
MT62600-200	Power performance assessment of electricity producing tidal energy converters	**Gabe Alsenas (US)**
MT62600-201	Tidal energy resource assessment and characterisation	Claire Cohen (GB) **Kevin Haas (US)**
PT62600-3	Measurement of mechanical loads	Anton Schaap (NL)
PT62600-4	Standard for establishing qualification of new technology	John Griffiths (GB)
PT62600-20	Guideline for design assessment of Ocean Thermal Energy Conversion (OTEC) system	Martin Brown (GB)
PT62600-202	Scale testing of tidal stream energy systems	**Martin Wosnik (US)**
PT62600-300	Power performance assessment of electricity producing river current energy converters	Sue Malloy (CA)
PT62600-301	River energy resource assessment and characterization	**Kevin Haas (US)**
AHG 3	Assessment of information received on IEC TS 62600-102: Wave Energy Converter power performance assessment at a second location using measured assessment data	Kim Nielsen (DK)
AHG 8	Proposal for a plan for the alignment of future work activities under the existing AHGs, PTs, and MTs	**Jonathan Colby (US)**
AHG 9	Assessment of information received on IEC TS 62600-103: Guidelines for the early-stage development of wave energy converters: Best practices and recommended procedures for the testing of pre-prototype scale devices	Brian Holmes (IE) **Johannes Spinneken (US)**
AHG 10	Assessment of information received on IEC TS 62600-30: Electrical power quality requirements for wave, tidal, and other water current energy converters	Mohamed El-Hawary (CA) Sara Armstrong (IE)
AHG 11	Assessment of information received on IEC TS 62600-40: Acoustic characterization of marine energy converters	**Brian Polagye (US)**

Management and Technical Approach – IEA OES

- **Disseminate information** and IEA-OES work products to U.S. stakeholders
- The United States served as **operating agent for Task 5** on information exchange
- Facilitate information exchange between countries and delegates by:
  - **Leveraging information** and coordinating efforts to ensure that investments are of the highest impact to advance the ocean energy sector
  - **Connecting international colleagues** with U.S. experts and vice versa
  - **Introducing new topics** for discussion that can benefit from international collaboration
- **Connect U.S. experts with international workshops** to fill ocean energy knowledge gaps with needed work products

End-User Engagement and Dissemination Strategy

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Partners, Subcontractors, and Collaborators

IEC TC114

- NREL manages approximately 25 subcontracts with subject matter experts for their contribution to TC114 and IECRE.
- 132 U.S. observing and participating members from government, academia, and industry; and 27 member countries.

IEA OES

The Ocean Energy Systems is an IEA Technology Collaboration Program which has 25 member countries

Participating and Observing IEA OES Countries

Communications and Technology Transfer

IEC TC114: NREL maintains a website (www.tc114.us) that details the activities of IEC TC114 and provides links to the purchase of all technical specifications.

The TAG TA and TC Chair present the status of TC114 activities at industry conferences and events throughout the year (e.g., METS, OTC, IMREC).

NREL organizes Quarterly TAG Teleconferences and annual face to face meeting

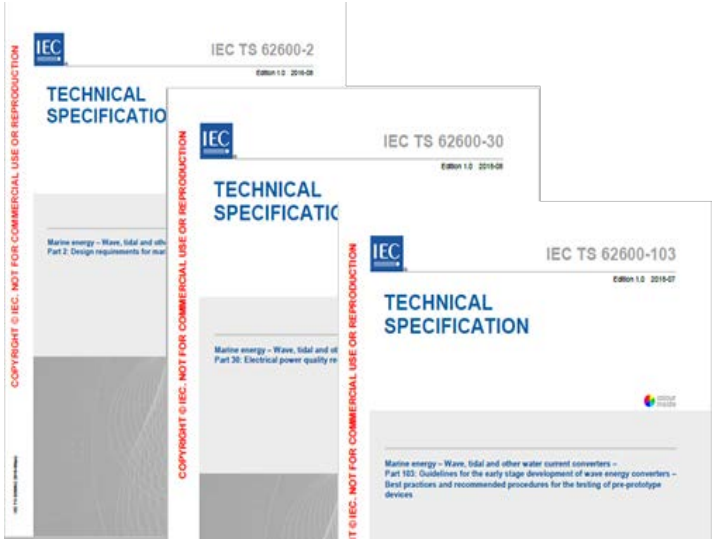
IEA OES: OES reports are published on the OES website at www.ocean-energy-systems.org

Quarterly briefings with the U.S. Marine Energy Council

Technical Accomplishments - IEC

IEC TC 114 and IECRE:

- Published 12 technical specifications to date with 2 more likely in 2019;
- Recruited U.S. subject matter experts and tracked staffing for all project teams and ad hoc groups (132 participating and observing members with 43 active U.S. TAG members);
- Successfully nominated U.S. TAG member Jonathan Colby to serve as IEC TC 114 and the IEC ME-OMC Chair;
- Successfully nominated U.S TAG member, Gabe Alsenas, to serve as treasurer of the IECRE;
- Successfully nominated 2 U.S. experts (**Carrie Schmaus and Nathan Tom**) to the IEC Young Professionals Programme, an international program designed to train the next generation of standards professionals;
- Designed, launched, and regularly updated the U.S. TAG website detailing the ongoing standards effort (www.tc114.us);
- Established and maintained liaisons with relevant industry groups;
- Contributed to the formation of the ME-OMC under IECRE and populated the group with U.S. members.



Technical Accomplishments IEA (Cont.)

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

TASK N°	TITLE	LEAD BY	STATUS
1	Review, Exchange and Dissemination of Information on Ocean Energy Systems	Portugal	Active
2	Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems	Denmark	Completed
3	Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids	Canada	Completed
4	Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems	United States	Active
5	The Exchange and Assessment of Ocean Energy Device Project Information and Experience	United States	Completed
6	Worldwide Web GIS Database for Ocean Energy	Germany	Active
7	Cost of Energy Assessment for Wave, Tidal, and OTEC at an International Level	UK	Active
8	Consenting Processes for Ocean Energy on OES Member Countries	Portugal	Active
9	International Ocean Energy Technology Roadmap	UK	Active
10	Wave Energy Converters Modelling Verification and Validation	Denmark	Active
11	Investigation and Evaluation of OTEC Resource	Japan	Active
12	Stage Gate Metrics International Framework for Ocean Energy	European Commission	Active
13	Tidal Energy Converters Modelling Verification and Validation	Singapore	Active
14	Assessment of Jobs Creation on Ocean Energy (Terms of Reference under preparation)		New activities under discussion
15	Ocean Energy in Insular Conditions		
16	Open Water Testing		

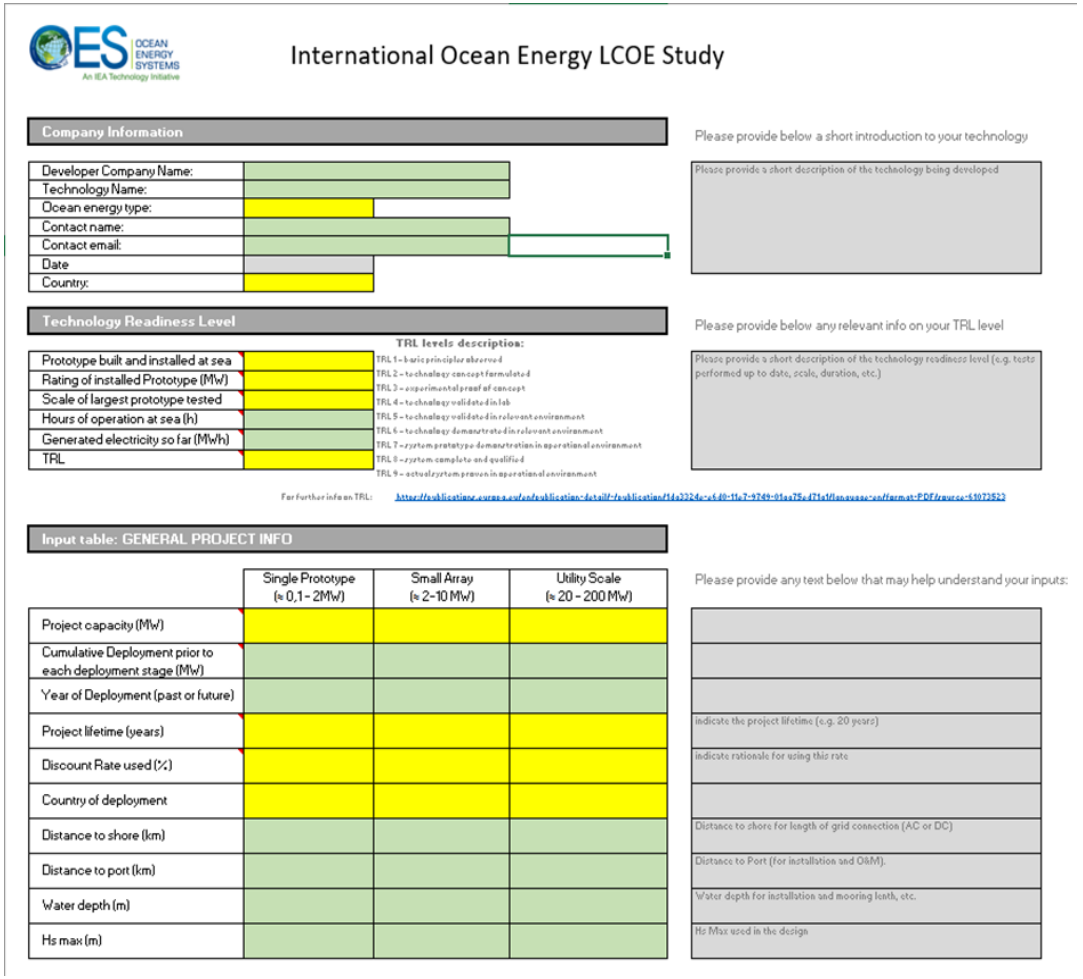
Technical Accomplishments IEA (Cont.)

- Task 7: NREL is representing the US for IEA's Ocean Energy Systems **Cost of Energy for Ocean Energy Technology** Report (End of 2019)

- Develop a standard methodology for Cost of Energy reporting globally.
  - Define Baseline Cost Estimates
  - Identify cost drivers
  - Predict future costs
  - Suggest future analysis activities

- Strengthens collaborations through data sharing, model development, and R&D prioritization.

Task 7



OCEAN ENERGY SYSTEMS
An IEA Technology Initiative

International Ocean Energy LCOE Study

Company Information

Developer Company Name:	
Technology Name:	
Ocean energy type:	
Contact name:	
Contact email:	
Date	
Country:	

Please provide below a short introduction to your technology

Please provide a short description of the technology being developed

Technology Readiness Level

Prototype built and installed at sea	
Rating of installed Prototype (MW)	
Scale of largest prototype tested	
Hours of operation at sea (h)	
Generated electricity so far (MWh)	
TRL	

TRL levels description:
TRL 1 – basic principles observed
TRL 2 – technology concept formulated
TRL 3 – experimental proof of concept
TRL 4 – technology validated in lab
TRL 5 – technology validated in relevant environment
TRL 6 – technology demonstrated in relevant environment
TRL 7 – system prototype demonstration in operational environment
TRL 8 – system complete and qualified
TRL 9 – actual system proven in operational environment

For further info on TRL: https://publications.europa.eu/en/publication-detail/-/publication/f4a2324e-e540-11e7-9749-01aa75ed71a1/language-en/format-PDF/source-61072522

Please provide below any relevant info on your TRL level

Please provide a short description of the technology readiness level (e.g. tests performed up to date, scale, duration, etc.)

Input table: GENERAL PROJECT INFO

	Single Prototype (≈ 0,1 - 2MW)	Small Array (≈ 2-10 MW)	Utility Scale (≈ 20 - 200 MW)
Project capacity (MW)			
Cumulative Deployment prior to each deployment stage (MW)			
Year of Deployment (past or future)			
Project lifetime (years)			
Discount Rate used (%)			
Country of deployment			
Distance to shore (km)			
Distance to port (km)			
Water depth (m)			
Hs max (m)			

Please provide any text below that may help understand your inputs:

indicate the project lifetime (e.g. 20 years)

indicate rationale for using this rate

Distance to shore for length of grid connection (AC or DC)

Distance to Port (for installation and O&M).

Water depth for installation and mooring kenth, etc.

Hs Max used in the design

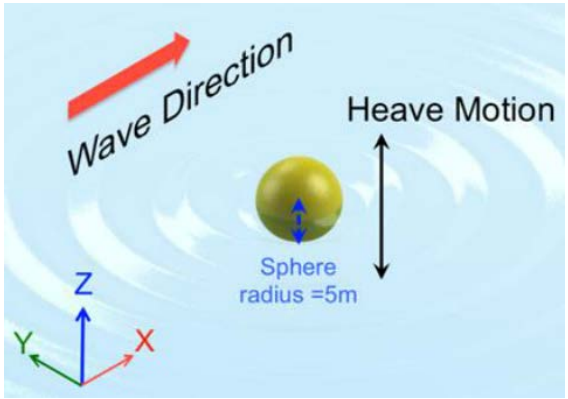
Technical Accomplishments -IEA (Cont.)

Support of International Collaboration:

– IEA OES Task 10 (WEC modeling verification & validation):

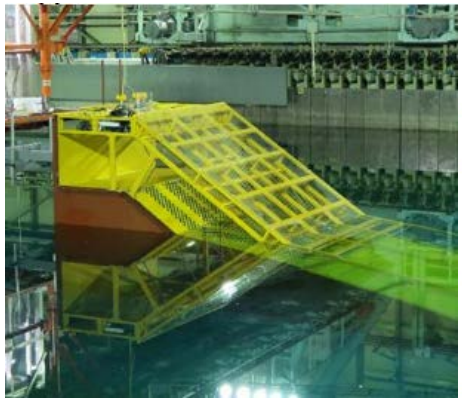
- The goals are to assess the accuracy of, and establish confidence in, the use of numerical WEC models, to determine a range of validity of existing computational modelling tools, to identify uncertainty related to simulation methodologies.

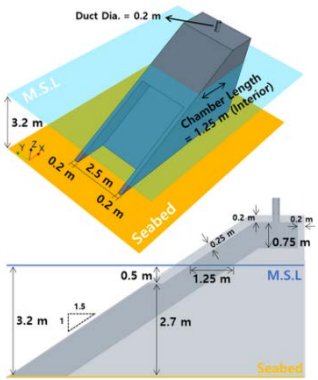
Phase I: Heaving sphere



Phase II: Model scale test article at Carderock wave basin

Phase III: OWC, test data from the KRISO ocean basin testing



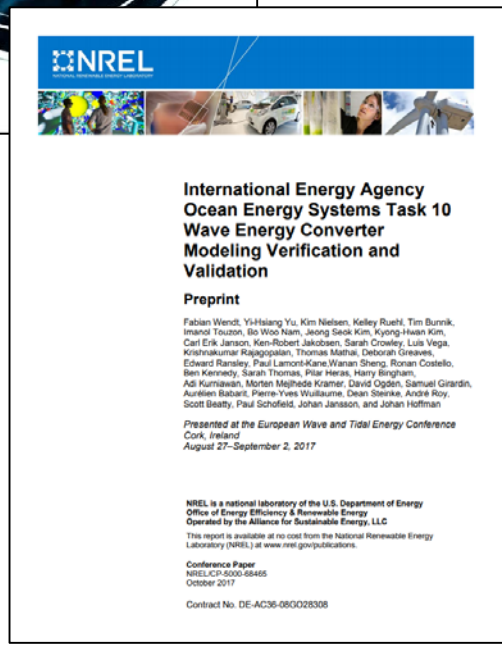


- Results from the first two phases have been presented at EWTEC2019 and the 3rd International Conference on Renewable Energies Offshore (**FY19 Q2 milestone**).

Technical Accomplishments - IEA (Cont.)

IEA-OES

- Organized and held four workshops over the period 2014–2016, one in each year (Open Ocean Test Facilities, Ocean Numerical Modeling, Designing for Reliability, and Ocean Energy Policy);
- Developed the work plan for two new OES tasks on ocean energy modeling codes, held three in-person workshops and published two conference papers;
- Facilitated information exchanges in IEA-OES ExCo meetings that led to cohosted workshops for development of stage-gate metrics for wave energy, and international participation in an instrumentation database community of practice;
- Initiated OES joint action and workshop series on MHK metrics;
- Currently participating in Tasks 7 and 10
- Published annual reports beginning in 2008 when the U.S. joined OES.



Future Work

FY19/Current Research

IEC TC114: Continue to manage day-to-day operations of U.S. TAG and U.S. Participation in IEC. Recruit subject-matter experts for new project teams. Organize and attend U.S. TAG and IEC TC114 Plenary Meetings. Work with Marine Energy Council and DOE to determine prioritization for standards work.

IEA OES: Provide coordination and logistical support; develop technical presentations for Executive Committee meetings and workshops; analyze and review OES reports and work products; and contribute to the OES country report and other OES reports for the United States.

Proposed Future Research

IEC TC114: Standards are evolving over time to identify critical needs of the end users and fill gaps. TC114 has identified the following priority standards:

- Cable Lay Guidelines and Procedures
- Design guidelines for subsea cables\cable networks and performance/reliability of connectors
- Design guidelines for marine energy system connection to distribution level grid including small scale/ community projects

IEA OES: Continuation of the wave energy converter simulation models benchmarking task and the LCOE assessment study as well as participation in international workshops on powering the blue economy using ocean energy systems.