WAVE ENERGY PRIZE

U.S. DEPARTMENT OF ENERGY

Technical Submission Requirements

This document serves as the **"Technical Submission"** noted in the Wave Energy Prize Rules. This document must be completed and submitted electronically via the Team only secured website (see instructions and required content below) by each competing Team in the Wave Energy Prize **by 5:00 PM ET, July 15, 2015** to be reviewed and judged for consideration as a Qualified Team.

Each question/request in the Technical Submission must be answered in English and the required supporting information must be included. The response for each question/request must strictly adhere to the following criteria:

- Written responses must be no more than 600 words; fields are limited in the pdf submission document to support this requirement.

- Requested drawings must be provided in PDF format and be no larger than 10 MB per file; all file names must include the Team name and date (e.g. teamname_questionnumber_filename_date.pdf); no more than five (5) drawings will be accepted per question as appropriate. All files must be of sufficient resolution so detail can be clearly seen. Descriptions of drawings must accompany each drawing and be clearly marked to indicate what question they refer. Please combine drawings into a single, multi-page PDF file per question when possible.

Technical Submission Content

The required content for answering each of the questions below is clearly provided in bold.
To help you craft your responses, a number of relevant aspects for consideration are also outlined.
The items listed for consideration are not required, but are provided as "thought starters" when completing the Technical Submission.

Please note, with the exception of Question 12, all these questions relate to your device concept at full scale.

1. General Description

At a conceptual level, why will your WEC device and technical approach deliver the necessary two-fold improvement in Annual Climate Capture Width per Characteristic Capital Expenditure required to be a candidate for winning the Wave Energy Prize?

(Please provide response below. 600 word limit)

2. WEC Device Configuration

Provide system level design drawings, descriptions of the drawings, and an overall description of the working principle of the proposed full scale WEC technology.

These drawings should be to scale and, at a minimum, include views in three orthogonal planes and one three-dimensional perspective view.

Drawings must include:

- **Key dimensions of WEC device**
- **Total device mass (with and without ballast) and displaced volume**
- **Location of water line on device in still water and static equilibrium in installed configuration**
- **Total surface area, both wetted and dry, of key device profiles (not components)**
- **Layout and key dimensions of mooring system and/or foundation**
- **Predominant wave propagation direction and orientation of device**

Description must include:

- **Description of overall working principle of the proposed full scale WEC technology (concept of operation)**
- **Description of all of the supplied WEC technology drawings**

When providing a thorough response to the above required information, consider the following aspects:

- WEC technology in operational condition system configuration
- Key subsystem drawings relevant to understand the function of the WEC technology
- Visualization of key system and component motions relevant to this WEC technology

(Please provide response below. 600 word limit)

3. Wave Energy Farm Configuration

Provide schematic wave farm drawings of a farm configuration of multiple devices, descriptions of the drawings and an overall description of the operating principle of a wave farm of the proposed WEC technology.

These drawings should be to scale and, at a minimum, include views in three orthogonal planes and one three-dimensional perspective view.

Drawings must include:

- **Key dimensions of wave energy farm**
- **Drawing of umbilical, interconnection, and grid connection**
- **Predominant wave propagation direction and orientation of devices**

Description must include:

- **Overall operating principle of a wave farm (written with supporting drawings)**
- **Description of all of the supplied wave farm drawings**

When providing a thorough response to the above required information, consider the following aspects:

- **Distribution of WEC devices in farm configuration considering**
- **Aspects of WEC farm configuration and design specific to this WEC technology including**
- **mooring system with shared mooring infrastructure and shared mooring points**
- **WEC device umbilical and shared interconnection and cable infrastructure**
- **WEC farm in survival condition system configuration**
- **Accessibility of individual WEC device in farm configuration**

(Please provide response below. 600 word limit)

4. Primary Power Absorption

Provide drawings and a description of the primary wave power conversion of the WEC technology. Description must include:

- **Power absorption mechanism that is utilized for the primary power conversion step**
- **Absolute or relative degrees-of-freedom (DOF) and/or modes of deformation and/or modes of operation that are utilized for the primary power conversion step**
- **Kinematic and dynamics description of the wave power absorption and conversion process**
- **Magnitude and dimension of key kinematic and dynamic physical quantities (e.g. stroke, velocity and force or volume flux and pressure difference, etc.)**
- **Approximate capture width**

Drawings should be to scale and, at a minimum, include views in three orthogonal planes and one three-dimensional perspective view.

Drawings must include:

- **Key dimensions of primary power conversion system**
- **Clear visualization of absolute or relative degrees-of-freedom (DOF) and/or modes of deformation and/or modes of operation that are utilized for the primary power conversion step**
- **Predominant wave propagation direction and orientation of device**

When providing a thorough response to the above required information, consider the following aspects:

- Load paths
- Power flow paths
- Types of materials used
- Approximate frequency bandwidth of efficient power absorption
- Any inherent system properties that provide differing fluid-primary system interaction in different sea conditions with benefit for energy absorption at different incident wave power levels
- Any forms of shape, mode, orientation variation or other system adaptation that are utilized in order to influence power absorption capabilities, power capture, and loading of the system in different sea conditions
- Technical solutions for the implementation of the adaptations identified in the previous bullet
- Loading on the device and mooring during operational, including stress, fatigue and wear
- Control considerations related to controlling power energy absorption and in order to maximize wave energy absorption and/or delivery
- Control considerations related to controlling primary fluid-system interaction in order to reduce structural and other loading
- Control considerations related to adaptive control of shape, mode, orientation, or other system adaptation
- Existence of end-stop requirements and the satisfaction of these requirements
- Maximal theoretical wave power absorption capability
- Structural loads,
- Reliability and redundancy inherent in the system

(Please provide response below. 600 word limit)

5. Secondary and Any Further Internal Power Conversion

Describe the secondary and any further internal power conversion of the wave energy converter.

Description must include:

- **Type of power forms used in the secondary and any further internal power conversion steps in the power conversion chain**
- **Key characteristics of the internal power conversions steps**
- **Magnitude and dimension of key kinematic and dynamic physical quantities (e.g. stroke, velocity and force or volume flux and pressure difference, etc.)**
- **Approximate power conversion efficiency of the secondary and any further internal power conversion steps**

When providing a thorough response to the above required information, consider the following aspects:

- Load paths
- Power flow paths
- Types of materials used
- Power conversion schemes
- Internal short-term energy storage possibilities and their implementation
- Any inherent system properties that provide differing fluid-primary system interaction in different sea conditions with benefit for energy absorption at different incident wave power levels,
- Any forms of internal power conversion adaptations that are utilized in order to influence power conversion capabilities and loading of the system in different sea conditions
- Technical solutions for the implementation of the adaptations identified in the previous bullet
- Internal loading in/on the power conversion chain and supporting structure, including stress, fatigue and wear.
- Control considerations of internal power conversion and effects to maximize wave energy absorption, internal energy conversion and/ or while reducing internal and/or final conversion power flows and loadings
- Existence of end-stop requirements and the satisfaction of these requirements
- Reliability and redundancy inherent in the system
- Inclusion of a drawing of the secondary and any further internal power conversion system; these could include:
    - Views in two orthogonal planes
    - Clear visualization of internal kinematic and dynamic, degrees-of-freedom (DOF) and/or modes of deformation and/or modes of operation that are utilized for the secondary and any further intermediate power conversion steps

(Please provide response below. 600 word limit)

6. Final Power Conversion Step to Deliver Electricity

Describe the final power conversion step including the delivery of electricity.

Description must include:

- **Type of pre-final power forms prior to conversion into electricity**
- **Key characteristics of the final power conversions step**
- **Approximate conversion efficiency of the final power conversions step**

When providing a thorough response to the above required information, consider the following aspects:

- Load paths
- Power flow paths
- Any forms of final power conversion adaptations that are utilized in order to influence power conversion capabilities and external or internal loading of the system in different sea conditions
- Technical solutions for the implementation of the adaptations identified in the previous bullet
- Internal loading in/on the final power conversion step and supporting structure, including structural stress, fatigue and wear
- Control considerations of the final power conversion step and effects to maximize final energy conversion and delivery and/ or while reducing internal and/or final conversion power flows and loading
- Existence of limitation requirements of power, force, motion, current, etc. and the satisfaction of these requirements
- Reliability and redundancy inherent in the system Power output conditioning
- Compliance with grid code

(Please provide response below. 600 word limit)

7. Device Load Bearing Structure

Provide drawings and a description of the load bearing structural design of the proposed WEC.

Description must include:

- **Specification of materials used in the structural load bearing mass and its proportion in the structural load bearing mass. Include internal, external and hydrodynamic loads**
- **Overall geometry**
- **Load/force flow path**

Drawings should be to scale and include views in three orthogonal planes and one three-dimensional perspective view.

Drawings must include:

- **Overall dimensions of WEC structure**
- **Identification of connection to mooring system and/or foundation to the structure**
- **Identification of connection points of power conversion system to the structure**
- **Identification of absolute and/or relative degrees-of-freedom (DOF) and/or modes of deformation and/or modes of operation, if applicable**
- **Dimensions of mooring system and/or foundation**
- **Predominant wave propagation direction and orientation of device**

When providing a thorough response to the above required information, consider the following aspects:

- External and internal loading of structure
- Key high stress locations
- Redundancy
- Manufacturing process
- Modularity
- Assembly

(Please provide response below. 600 word limit)

8. WEC Device and Farm Survival

Provide a description of the critical load cases and operational circumstances that are to be considered in the context of WEC device and farm survival.

Description must include:

- **Critical survival load cases**
- **Critical survival circumstances and strategies**
- **Design and/or operational measures taken to ensure device and farm survival**
- **WEC technology in survival condition system configuration with reference to previous drawing**

When providing a thorough response to the above required information, consider the following aspects:

- Observability of critical load cases of circumstances
- Loading on the device and mooring during extreme sea conditions (25/50/100 year storms) including structural stress, fatigue, and wear.
- Fail-safe design consideration
- Any inherent system properties that provide differing fluid-primary system interaction in different sea conditions with benefit for energy absorption in extreme and survival conditions
- Passive or active fast (wave time frame) or slow (sea state time frame) control
- Inherent system dynamics and wave-system interaction properties supporting survivability

(Please provide response below. 600 word limit)

9. Technology Production

Provide a description of the production process of the WEC technology and the balance of plant system components.

Description must include:

- **Key characteristics of production and manufacturing**
- **Key characteristic of supply chain considerations**

When providing a thorough response to the above required information, consider the following aspects:

- Production and manufacturing supply chain consideration
- Manufacturing, production and assembly process
- Required manufacturing activities at factory, at harbor, and on site
- Required production facility equipment and infrastructure
- Annual production volume

(Please provide response below. 600 word limit)

10. Transport, Assembly, Deployment and Installation

Provide a brief description of the deployment and installation process of the WEC technology, the wave farm and the balance of plant system components.

Description must include:

- **Key activities in sequential transport, assembly, deployment and installation process**

When providing a thorough response to the above required information, consider the following aspects:

- System and/or subsystem transportation to installation site
- Effort and duration of assembly process
- Effort and duration of deployment and installation process
- Required equipment and infrastructure detailing type and amount
- Possibility of implementing simultaneous installation

(Please provide response below. 600 word limit)

11. Device and Farm Maintenance

Provide a description of the operation and maintenance requirements and process of the proposed.

Description must include:

- **WEC technology in maintenance system configuration**
- **Key sub-systems that are expected to require planned maintenance**
- **Key sub-systems that are expected to require unplanned maintenance**

When providing a thorough response to the above required information, consider the following aspects:

- O&M strategy of WEC technology and wave farm infrastructure, e.g. cabling, mooring, substation, etc.
- Equipment and infrastructure required to implement maintenance procedures
- System, subsystem, and component repair and exchange requirements
- Consideration of monitorability, accessibility, maintainability
- Consideration of system modularity and ease of subsystem exchange
- Consideration of ease of partial operation

(Please provide response below. 600 word limit)

12. Scale Model Construction

Describe the steps you will take to ensure that any scale model(s) you construct for testing during the Wave Energy Prize correctly scales the relevant physics of your WEC device concept. Include consideration of Power Take Off, air compressibility, deformation, material type.

To investigate further the scaling of the physics of a model, the following paper (Section 2.1) is provided for your reference:

http://www.supergen-marine.org.uk/drupal/files/reports/WEC_tank_testing.pdf

Note: The above link is supplied to provide a reference regarding how to scale the physics of a WEC model. Its inclusion does not imply that the Wave Energy Prize administrators require its use during the scaling of a Team's model. All Teams are responsible for the design, scaling, and construction of their WEC models for the purpose of assessment and testing during the Wave Energy Prize.

(Please provide response below. 600 word limit)

13. Technology Risk

Provide descriptions of key technology risks.

Description must include:

- **Descriptions of the three key technology risks that you expect with respect to general technology operation and survival**
- **Descriptions of the three key technology risks that you expect with respect to achievement of high techno-economic performance and economic viability**
- **Assessment of each of the above risks and associated consequence**

When providing a thorough response to the above required information, consider the following aspects:

- Estimate for risk frequency
- Estimate for risk severity
- Corresponding risk management strategy for each of the risks within the general categories to avoid, transfer, mitigate, or accept risk

(Please provide response below. 600 word limit)

14. System acceptability

Provide descriptions of any acceptability issue of the WEC technology and related solution to resolve these issues.

Description must consider:

- **Lifecycle environmental acceptability**
- **Social acceptability - socio-economic impact and/or benefit**
- **Legal, regulatory, and certification acceptability**
- **Safety**
- **Risk Mitigation**
- **Insurability**
- **Market acceptability – investor, financier, operator, utility**

(Please provide response below. 600 word limit)

15. Characteristic Capital Expenditure

Provide information required to determine the Characteristic Capital Expenditure.

Description must include:

- **Maximum generator electrical power output**
- **Maximum generator torque/force**
- **Any torque/force/pressure transformation ratios in previous power conversion steps**
- **Maximal Power Take Off reaction torque/force/pressure on loadbearing structure**

Description must include for each material type:

- **Material type (e.g. steel)**
- **Related geometrically simplified (e.g. no stiffeners) surface area**
- **Grade of material (e.g. A36 steel, 6061-T6 Aluminum, etc.)**
- **Density**
- **Elastic modulus**
- **Yield stress**
- **Specific Manufactured Material Cost (CMMC) estimate ($/ton) and source information (e.g. quote)**

(Please provide response below. 600 word limit)