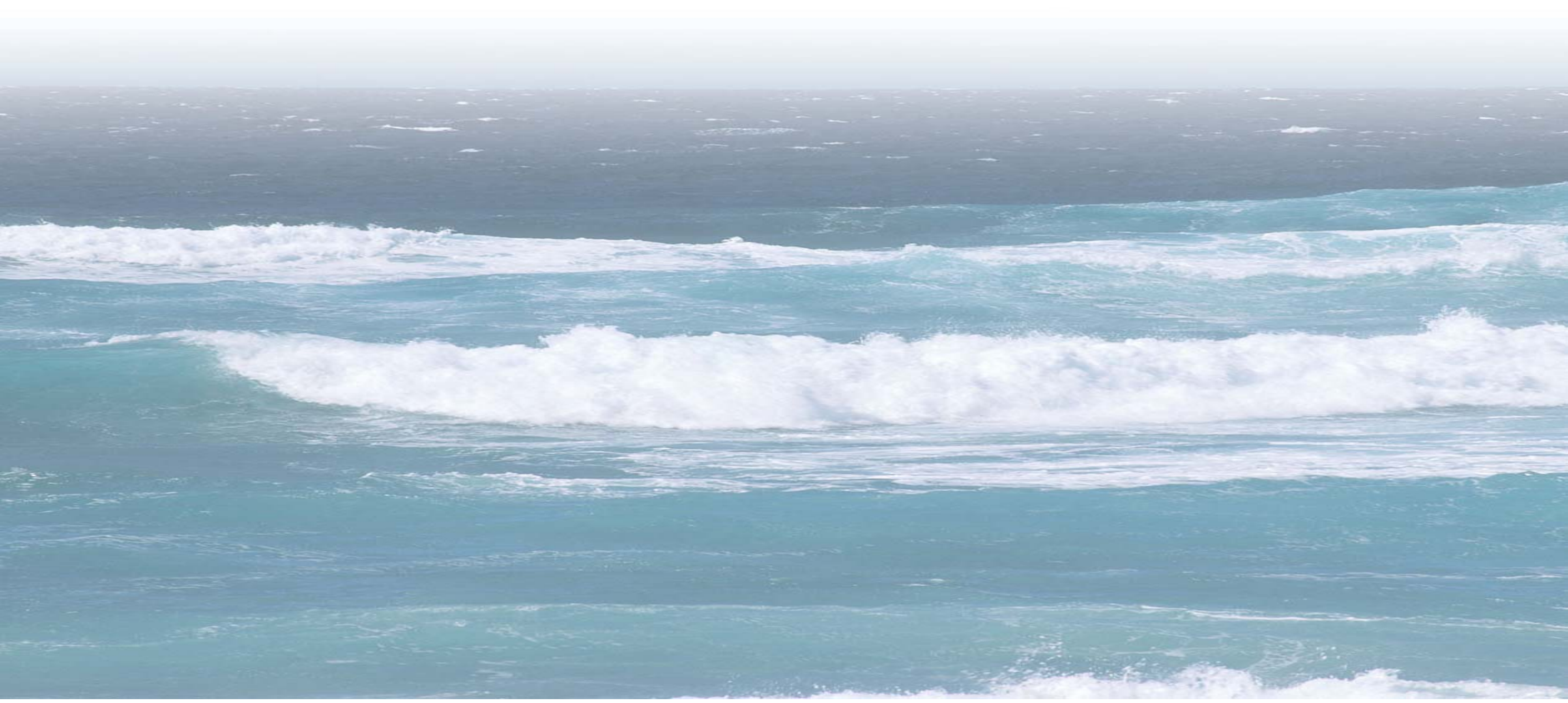
Methodology for Conceptual Level Design of Offshore Wave Power Plants



Report: E2I EPRI WP 005 - US
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1. Introduction and Summary

The purpose of this document is to describe the methodology E2I EPRI will use to accomplish the conceptual level design of offshore wave power plants (both a 1,500 MWh per year pilot plant and a 300,000 MWh per year commercial plant) Depending on the selected wave energy conversion (WEC) device technology, the pilot plant might vary in size as individual units might yield more then 1,500MWh per year.

Previously published documents describe the methodologies E2I EPRI will use to estimate the annual power production (Reference 1) and the cost of the plant and the cost of electricity produced (Reference 2).

2. Offshore Wave Power Plant System Outline

An offshore wave power system can be broken down into a number of generic subsystems. The list below provides a high-level outline:

1) Wave Energy Conversion (WEC) Device Subsystem

> Absorber Structure – All structural components that are directly responsible for absorption of energy from ocean waves such as capture chamber, counter reacting mass, etc
>
> Power Take Off - Equipment required to convert the slow oscillating movement of the prime mover (mechanical motion of buoy, oscillating air flow in OWC, water pressure in overtopping system or linear generator) into electricity.

2) Mooring – all equipment required for holding the WEC device in place

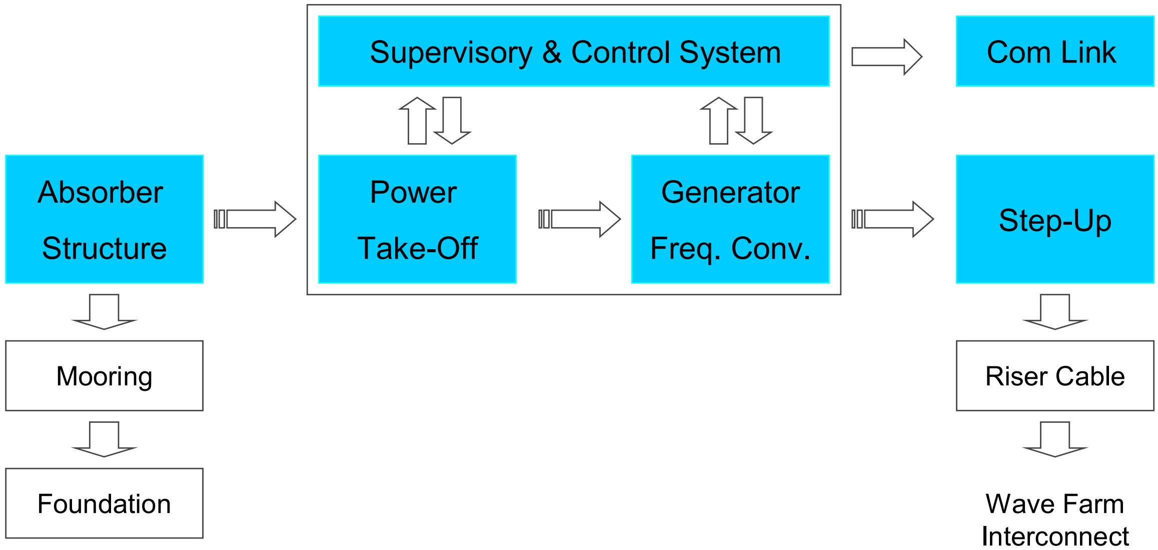
3) Electrical Interconnection – All cables required to interconnect the individual units to a common offshore interconnection point

4) Grid Interconnection – All cabling switchgear and infrastructure required for connecting the offshore common offshore interconnection point to a nearby grid interconnection point

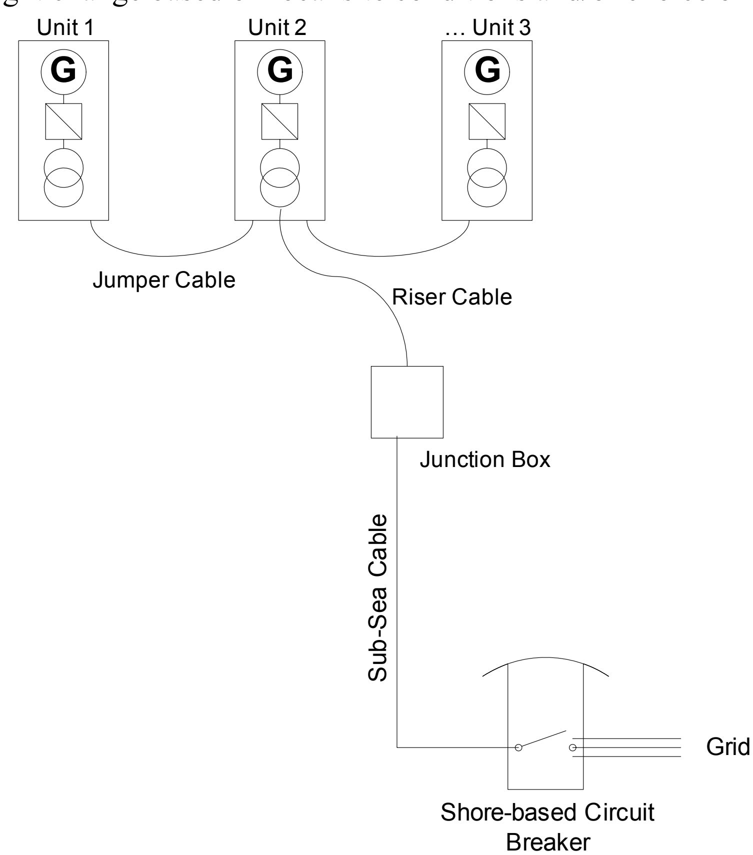
5) Remote Communication, Command and Control - the equipment that enables key measurements of system performance and remote diagnostic and other functions to be carried out.

6) Infrastructure Components – Contains additional Infrstructure components required for an operational power plant such as on-shore buildings, special purpose barges etc.

The following diagrams outlines the different device components in a typical offshore wave power plant and their dynamic interactions.



The following chart shows the likely electrical setup of the system. This design concept might change based on local site conditions and/or choice of technology.



3. Methodology Outline

The methodology that E2I EPRI will use to develop realistic conceptual reference designs follows a process to reduce cost uncertainties and to form a solid foundation for further detailed design efforts.

The process consists of the following steps:

1. Create project plans for each site outlining the process from initial site assessment activities through deployment and operation, including realistic timetables, resource requirements etc.

2. Establish cost parameters for each site, taking into consideration realistic site constraints such as available equipment, distance to shore, grid interconnection, available port infrastructure, weather windows etc.

3. Based on site specific wave data, estimate the annual power production of the device in its location. The methodology to be used is described in Reference 1.

4. Develop the capital cost and cost of electricity estimate for both a 1,500 MWh per year pilot plant and a 300,000 MWh per year commercial plant using the methodology described in Reference 2.

Wherever possible the methodology will use parametric models, which will enable EPRI/E2I to carry out basic cost optimization, evaluate alternative wave farm configurations and identify critical economic parameters.

Driving consideration for the pilot and the commercial plants are slightly different in that:

- The pilot plant design is driven by providing a least-initial cost option. This might lead to the selection of a site in closer proximity to shore and existing infrastructure, where the wave climate is not ideal in order to lower capitals expenditures. Leveraging of existing easements in place such as an existing sewage outfall, local support to provide infrastructure components etc. will be a key driver in the system design.

- The commercial power plant is driven by overall economic considerations in order to yield the lowest cost of generated electricity ($/kWh). This might lead to the placement of the wave farm further offshore in order to maximize power generated, leading to a more favorable economic balance.

4. Project Outline

The process, tasks and associated timeframes required for the a Phase III Construction and a Phase IV Operation will be outlined in form of a project plan. This will assist in the establishment of clear resource requirements and associated cost centers. These project plans will vary depending on site and device selection, but could include some of the following elements with associated constraints:

- Procurement
- Fabrication
- Assembly
- Transit between fabrication/assembly site and Coastal staging site
- Installation of moorings and transmission cable
- Testing and Commissioning
- Deployment of WEC Device
- Operation and Maintenance Activities
- Weather windows
- Operation & Maintenance

All elements of the lifecycle cost of this plant will be considered except of decommissioning. Decommissioning will have only have a minimal impact on the levelized cost of electricity as the cost are incurred at the end of the project cycle.

This project plan will vary depending on site and technology specific considerations. Where possible, driving assumptions will be used from the manufacturer and if these raise concerns, E2I EPRI will come up with its own assumptions based on related projects.

5. Cost Centers

Generic cost centers were previously identified in the cost assessment methodology report (Reference 2). These cost centers are used as a basis in coming up with total capital requirements and O&M cost. Depending on the specific site and device selection made by the individual states, changes will be made where necessary in order to accommodate for different requirements. Where possible, such cost will be taken from the manufacturer and cross checked with local estimates to reduce uncertainties. The cost estimates will be modeled parametrically where it makes sense in order to provide a means to evaluate different configuration options. A key focus area will be on the reduction of cost uncertainties as the experience gained by the E2I EPRI project team showed clearly that cost uncertainties are significant in this early stage industry and there is a need to reduce these uncertainties to a point where reasonable cost predictions are possible.

6. Standards and Assumptions

Offshore operational conditions are harsh and require specialized equipment to carry out operation. Cost of these operations can become a dominant factor in the overall economic picture. The pictures below are shown to provide an understanding of the potential challenges and safety issues such an offshore installation is facing.

Illustration: Cable laying vessel

Illustration: Winter conditions on the US west coast – an operators view

No accepted standards exist for the construction, operation and maintenance of offshore wave power plants. Related standards are found in the offshore oil & gas industry, that has a significant amount of experience in this field and developed standards for stationary offshore installations.

Costs for mobilizing and operating offshore equipment such as offshore handler tugs will be estimated based on related offshore projects. Costing data will be verified where possible by local offshore operators that have experience with similar projects. Operational weather windows will be estimated based on local wave data and cross checked with local operators.

Grid Interconnection standards and common practices will be adopted from the electric power industry. IEEE 1547 is likely the applicable standard to interconnect the offshore wave power plant with the electric grid and will be used for this study.

Standards for Performance and cost analysis have been previously established by the E2I/EPRI team (Reference1 and Reference2).

7. References

1. E2I EPRI WP US 001 "Guidelines for Preliminary Estimation of Power production by Offshore Wave Energy Conversion Devices" George Hagerman and Roger Bedard, December, 2003

2. E2I EPRI WP US 002 "Cost of Electricity Assessment Methodology for Offshore Wave Energy Power Plants" Mirko Previsic and Roger Bedard, March 2004