ECONOMAR software tool for the economic analysis of marine projects

ECONOMAR is a bottom-up cost estimation and economic analysis tool that is linked to a database of industry cost rates that ensures a high level of confidence in the determination of the cost electricity from renewable technologies – wind, wave and tidal or ocean currents. The tool has been developed in-house by Oceanflow and used both as a teaching aid for post graduate students in marine renewable energy and on commercial projects ranging from land based wind farms to wave energy convertors (WECs) and tidal energy converters (TECs).

The three main elements of ECONOMAR are:

- Electricity production analysis
- Cost modelling
- Economic analysis

Electricity Production Analysis

Electricity production for WECs can be based on a first order estimate of conversion efficiency or a full stochastic analysis using transfer functions of the device performance derived from model tests or CFD in accordance with Reference 1. Energy production for wind turbines and TECs is based on realistic capacity factor estimates derived from published data while a more detailed prediction can be obtained using turbine efficiency linked to a resource assessment. In the case of TECs, ECONOMAR uses site specific tidal characteristics to build up an energy resource assessment for the lunar month in accordance with the recommendations of Reference 2. The actual electricity production from wind and tidal turbines depends upon the technology's baseline conversion efficiency and the control strategy for coping with flow variations. ECONOMAR allows for the efficiency of energy conversion taking into account the capabilities of the solution to cope with start-up, normal operation and excessive energy levels.

Cost Modelling

The cost modelling element of ECONOMAR supports the build-up of a detailed bottom-up CAPEX estimate which includes the following elements.

- **Structure:** This is the wave energy collector for a WEC project or the turbine support structure for a wind turbine or TEC project, including floating platform solutions where applicable. Rates for steel or reinforced concrete construction are included for different complexities of structure.
- **Power Take-off Machinery:** This element can vary significantly depending upon the selected solution and is based on historic data or user supplied input. It includes all of the necessary systems to turn the input renewable energy to stabilised electrical output.
- **Electricity export:** This covers the array interconnection solution, e.g. step-up transformers, export umbilicals, connectors and subsea breakers, field interconnector cables, main distribution substations (with or without their own support platforms), HV subsea cable export back to shore, onshore step-down transformers and grid connection breakers. The program selects appropriate cabling solutions to give acceptable losses in order to allow the user to test different array layouts and power export solutions.

- **Inshore assembly:** This covers the assembly of main components and includes the hiring-in of appropriate transportation and heavy lift equipment.
- **Foundations and moorings:** This covers only the material costs of the fixing solution, e.g. gravity bases, piles, mooring lines, anchors, etc. Overturning loads and first pass mooring loads are estimated by ECONOMAR based on Oceanflow's detailed appraisal of real installations using state of the art software OrcaFlex.
- **Foundation installation:** This covers the deployment of the foundation or mooring solution for the array. Charter rates for different classes of anchor handling, crane barge or work-over vessels are included in the database. Allowance for weather dependant downtime is included, as is the distance from the base port and mobilisation / demobilisation costs.
- **Installation deployment:** This covers the transportation of the turbine, WEC or TEC to the offshore deployment site and includes transportation vessel costs and hook-up costs taking into account the necessary vessels and installation procedures. If necessary Oceanflow can realistically model the transportation and installation process in order to assess handling loads, weather induced interruptions and sea fastening loads.
- **Project management, insurance and contingencies:** These are just some of the additional cost centres that go to make-up the total CAPEX estimate and are selected based on the level of maturity of the technology and the experience of deploying in similar environments.

Economic Analysis

The user's main interest is either the Levelised Cost of Electricity (LCoE) from the marine energy farm or the internal rate of return (IRR) on investment for a contracted energy sale scenario. Proper assessment of LCoE or IRR requires a realistic assessment of the revenue side of the equation which comes from the Electricity Production Analysis linked to agreed tariffs and subsidies. The cost side of the equation has to take into account the cost of financing the project and the operating expenditure (OPEX) on the project as well as the initial CAPEX and the end of life decommissioning costs and possible scrappage revenue. The effect of taxation on the enterprise can also be considered within ECONOMAR. The ratio of borrowing to equity investment and the inclusion of any capital grants can all be considered. Sensitivity assessments can be carried out in order to assess the risk of achieving the target LCoE or IRR.

Ref 1: **Assessment of Performance of Wave Energy Conversion Systems, EMEC 2009**

Ref 2: **Assessment of Performance of Tidal Energy Conversion Systems, EMEC 2009**