Diagrams from Publishable Summary

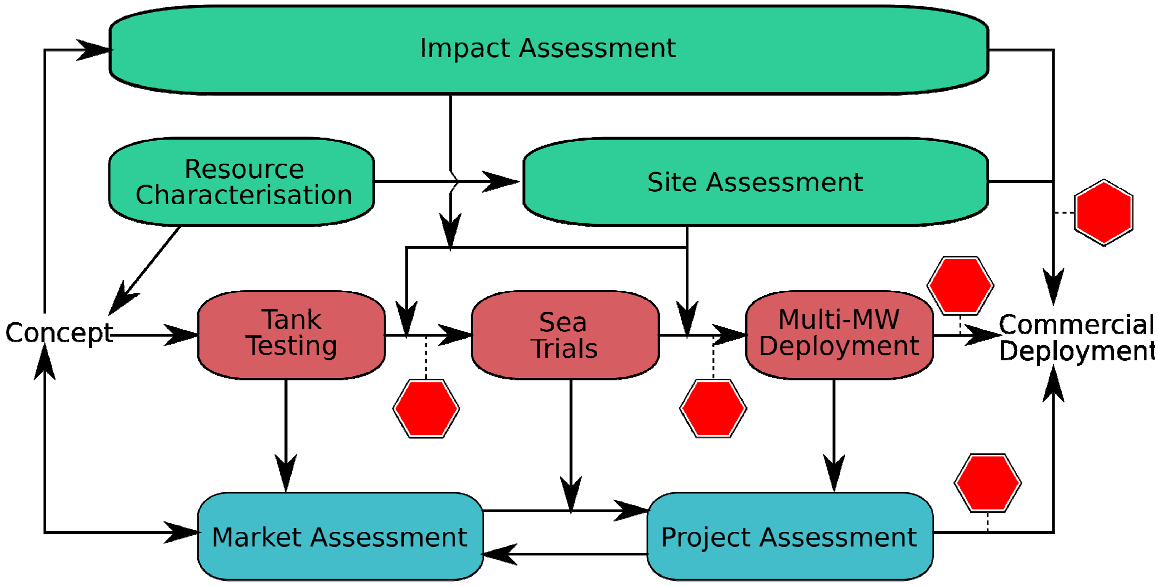

Figure 1 Project development flow-chart from initial concept to full-scale commercial deployment, showing environmental considerations (top), engineering assessment (middle) and economic assessment (bottom)

Table 1 The EquiMar protocol numbering system

I	Environmental	
I.A		Resource Assessment
I.B		Impact Assessment
II	Engineering	
II.A		Tank (controlled environment) Testing
II.B		Sea (uncontrolled environment) Trials
II.C		Large Scale (multi-MW) Deployment
III	Economic	
II.A		Project Assessment

Technology Readiness Level	TRL Definition	Description
TRL 1	Basic principles observed and reported	Scientific research beginning to be translated into applied R&D. Initial proposal of concept derived from observations of physical principles
TRL 2	Technology concept and/or application formulated	Paper and analytical studies of technology applied in marine environment
TRL 3	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated, including analytical studies and laboratory tests / tank tests to physically validate the analytical predictions. Parts of the system may be representatively tested, such as the use of discs instead of rotors, or orifice plates instead of air turbines
TRL 4	Component and/or system validation in laboratory environment	The basic technological components are integrated at the laboratory scale to establish that the pieces will work together. The outputs should be analyses of how the experimental test results differ from the expected system performance goals
TRL 5	Laboratory scale, similar system validation in relevant environment	System tested at laboratory scale in a range of relevant environments. The outputs should include behavioural studies and comparisons with analytical results.
TRL 6	Engineering/Pilot scales, similar (prototype) system validation in relevant environment	Engineering scale models tested in a relevant environment. Outputs should include a comparison between the predicted analytical results and the results from the trials
TRL 7	Full-scale, similar (prototype) system demonstrated in relevant environment	Demonstration of system operating in relevant environment, such as full scale prototype operating for a number of months and developing and improving operating procedures and settings
TRL 8	Actual system completed and qualified through test and demonstration	The technology has been proven to work in its final form and under expected conditions, such as with a full scale prototype in similar configuration to the final machine operating for a number of years to demonstrate continued operation and reliability
TRL 9	Actual system operated over the full range of expected conditions	The technology is in its final form and operated under the full range of operating conditions, in a multi-device array configuration

Table 2 Definitions and descriptions for the nine technology readiness levels

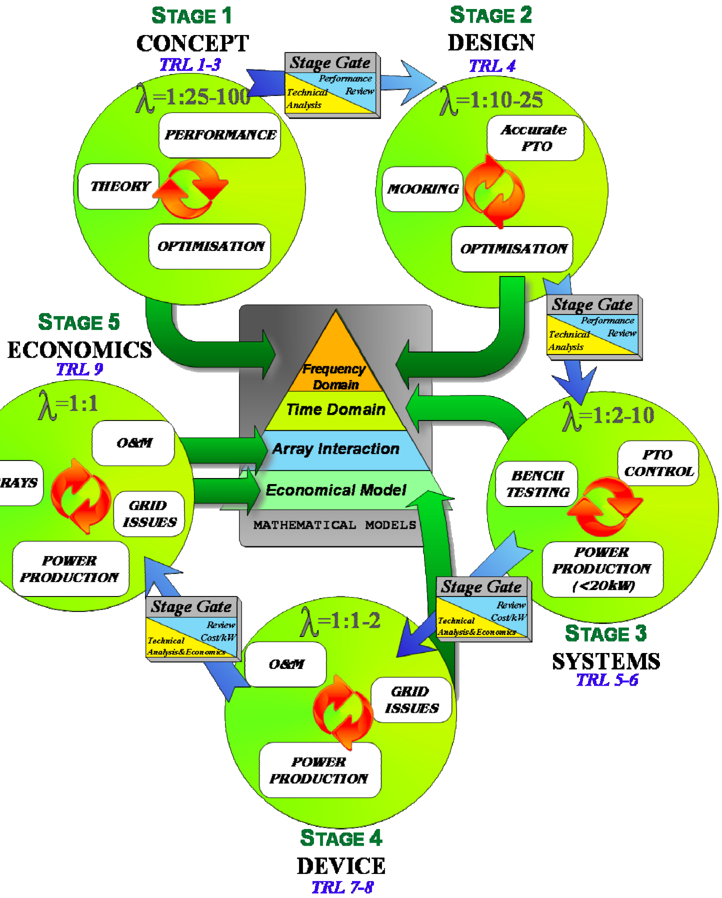

Figure 2 Engineering assessment of technology

Table 3: Specific Objectives of the Work Packages

WP	Objectives
1	- To analyse results from previous National, European and International activities in the field of pre-normative research for marine energy - To identify lessons learnt from other sectors, which can be applied to produce harmonised testing, and assessment of marine energy extraction devices. - To understand and take account of explicit stakeholders' needs and practical constraints for matching different system designs to various marine environments.
2	- To establish and apply methodologies which characterise the nature of the local sea states and of tidal levels and streams at device deployment locations, to underpin resource assessment at a site-specific scale. - To produce protocols which guide the industry in the use of physical and numerical methods for resource assessment allowing fair comparison between both sites and device types.
3	- To deliver common practices for the computational assessment of conceptual device performance; and procedures for undertaking tank testing of small prototype ocean energy devices.
4	- To establish standard monitoring approaches, best practice sea trial techniques and agreed analysis and presentation methodologies.
5	- To deliver protocols which provide guidance for developers - prior to deployment - on how to integrate their device designs into farms or arrays on a multi-megawatt scale - To provide standardized methods for assessing the performance of the arrays or farms as a whole.
6	- To develop a common framework regarding environmental impact assessment issues in order to produce Best Practice Protocols.
7	- To develop a framework for evaluating the long-term economic viability of marine energy technologies. - To review the main drivers of cost of electricity generated by marine energy farms - To develop methods for quantifying long-term cost-reduction of alternative generating technologies which evaluate cost drivers for civil engineering infrastructure for several device types, explore the relationship between device performance limitations and long-term revenue, and describe procedure for comparing technologies in terms of their scope for cost reduction - To evaluate influence of technology selection and deployment scale on economic viability.
8	A set of protocols for methods of assessment in five key areas of marine renewable development will be established. This WP will synthesise past knowledge, new research and the needs of the industry and government to produce: 1. A review of stakeholder perception of the requirement and content of protocols 2. Protocols for: (i) Physical environment assessment (wave and tidal), (ii) Device performance assessment (wave and tidal), (iii) System and component reliability assessment (generic for both technologies), (iv) Economic assessment (wave and tidal), (v) Environmental assessment (wave and tidal) 3. A critique of how these can be combined to provide an assessment of the suitability of different technologies matched to specific sites.
9	- To increase public awareness of Ocean Energy through the news media and to increase understanding of the benefits, environmental and economic impacts of this emerging industry. - To engage with the Ocean Energy Community. - To present the final project outcome, the EquiMar protocols, to the wider ocean energy community.

Diagrams from Description of Work Performed and Main Scientific and Technical Results

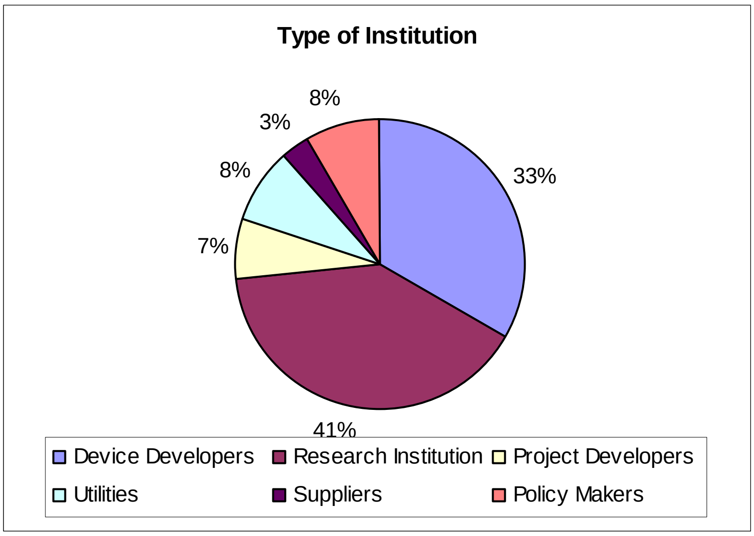

Figure 1 Distribution of responses to question A (type of organisation of the respondent)

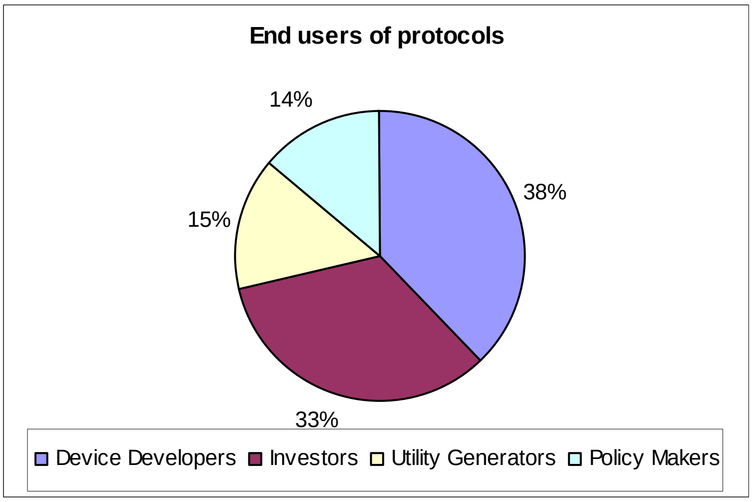

Figure 2 Distribution of responses to question 13 (end users of the protocols

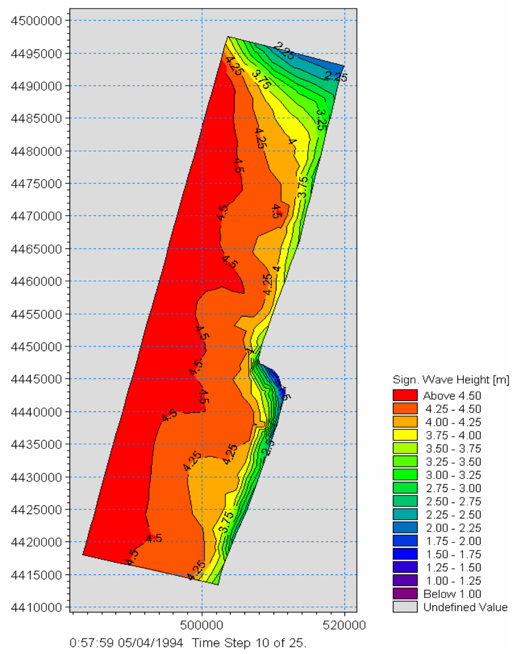

Figure 3 Wave modelling at Figueira da Foz, Portugal

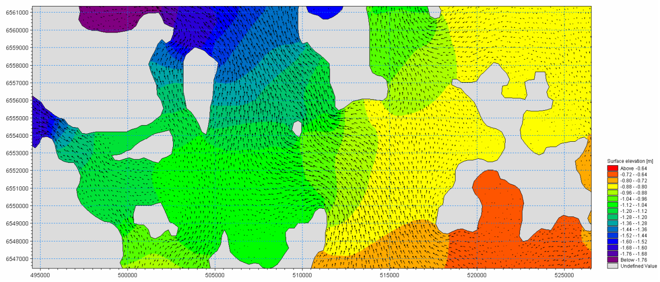

Figure 4 Tidal modelling for Orkney

Table 4 Resource assessment requirements

		Modelling	Measurement	Early: Resource Characterisation	Development: Engineering Design	Development: Site Assessment	Development: Operational Planning	Operation: Level of Resource	Operation: Ongoing Operation & Maintenance	Operation: Prediction & Tuning
Summary statistics		•	•	✓	✓	✓	✓	✓	✓	
Spectra	Directional	•	•		✓	✓		✓		✓
	Non-directional	•	•		✓	✓		✓	✓	✓
Elevation Time series	Directional		•		✓					✓
	Non-directional		•		✓					✓
Extremes		•			✓	✓				
Long-term temporal variation		•		✓		✓				
Mean and maximum currents		•	•	✓	✓	✓	✓		✓	✓
Tidal level		•	•	✓	✓	✓	✓		✓	
Wind (model input)		•	•	✓		✓	✓		✓	✓

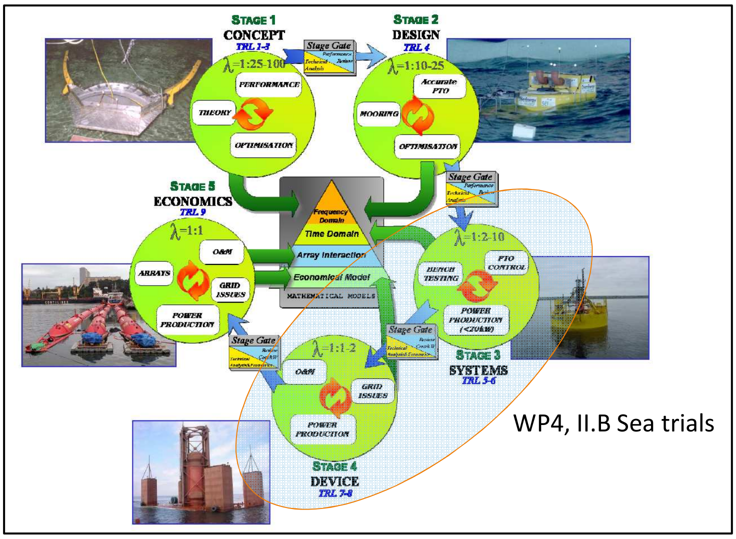

Figure 5 Structured Development Programme for a Wave Energy Device.

Figure 6 to accomplish the development process a device must progress through 3 phases

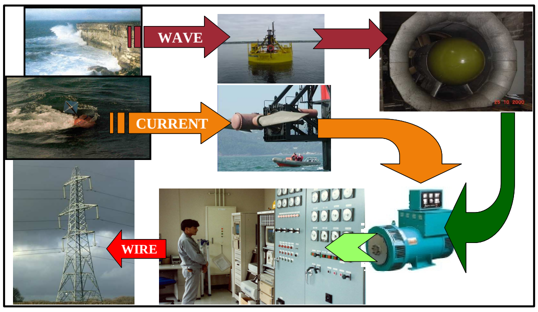

Figure 7 depicts the various energy conversion stages that occur in typical wave and tidal machines and clearly shows the multi-disciplinary nature of the two technologies

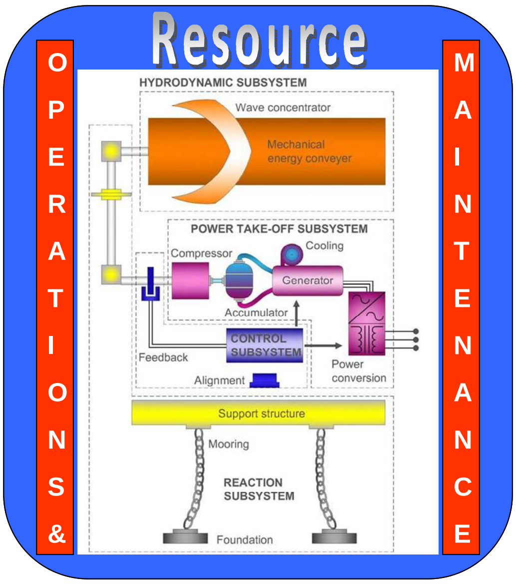

Figure 8 each type of converter, WEC or TEC, split into sub-systems representing each of the energy conversion phases

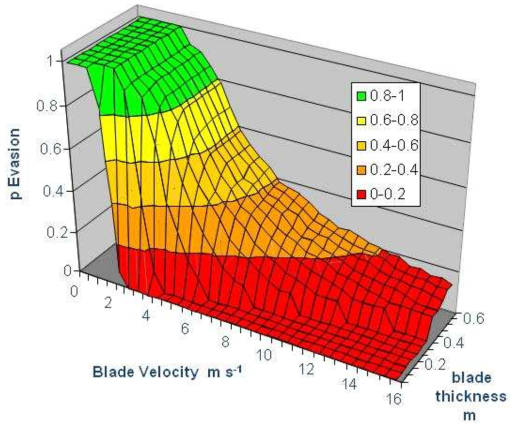

Fig. 9 – Fish collision with turbine blades: the probability of collision evasion for fish length 30 cm.

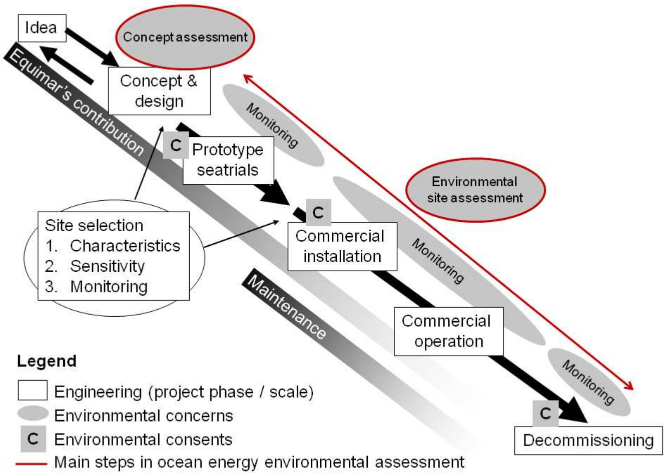

Fig. 10 – Scope and time line of the environmental assessment throughout wave and tidal project phases.

Fig 11 EquiMAR Workshop at ICOE 20010, Bilbao

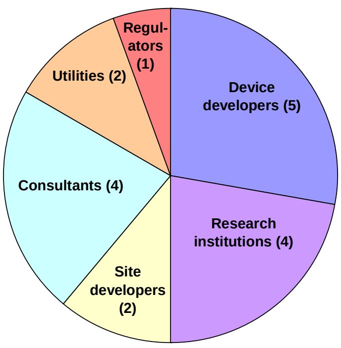

Fig 12 Stakeholders who responded to the questionnaire.

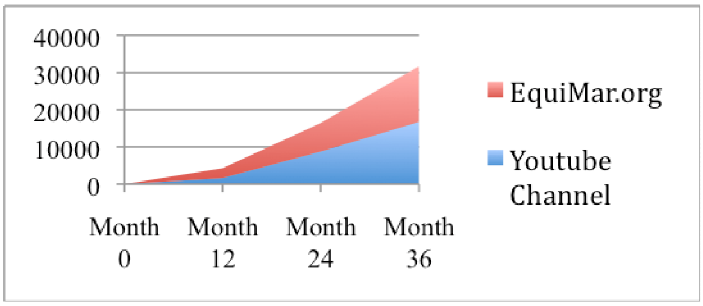

Table 2: Hits on the EquiMar.org and the YouTube Channel over the duration of the project.


UK & IRELAND

MEDIAWATCH

Seal of approval for tide power

Fig 13 BBC Wildlife Magazine September 2009