Engineering testing of marine energy devices

An introduction to engineering testing of marine renewables devices, by Andrew Mill, Chief Executive of the New and Renewable Energy Centre (NaREC)

At what stage should a product be released to market? An interesting question and one that could have many possible answers, depending on the nature of product and its customers. In the energy industries, where new products are brought forward all the time, customers often need to have confidence about performance, reliability and safety. This requires product developers to provide evidence of these points, a process that often involves testing.

Testing essentially involves comparing actual performance with expected performance against a set of criteria or standards. It may be done in the early stages of product development and designed to meet R&D objectives, but in many cases, should also be a continuous process linked to business development. Testing is, in fact, applied to many areas of business activity, from market testing and product testing through to testing business strategies. And of course, the efficacy of product testing is closely related to other business areas.

Testing marine renewables

In marine renewables, we are now seeing the development of generation products that are the basis of a new industry. Like other industries in the past, stakeholders in marine renewables face a number of uncertainties that need to be addressed for the industry to develop. For example, to raise required levels of finance, product developers must demonstrate commitment to minimising technical risks across the whole product life cycle. Other stakeholders have different requirements, as illustrated in Figure 1.

Figure 1: Requirements of stakeholders in the contexts of marine renewables technology development and project development. (Note this is for illustration only and not definitive.)

Stakeholder(s)		Requirement
Device developers	Including technical partners and advisors, ranging from academic institutions to design consultants.	Coherent and common design standards and guidelines.
Project developers	Companies intending to construct commercial scheme (e.g. farms) comprising multiple devices.	Evidence of device performance and survivability with quantified technical risks.
Manufacturing and service companies	Including materials suppliers, component manufacturers/suppliers, fabricators, installation contractors, operation and maintenance contractors.	Clear instructions on required methods and procedures to meet needs of other stakeholders in performance, survivability, reliability and environmental impacts.

Stakeholder(s)		Requirement
Investors in device development	Including private investors, grant agencies, venture capitalists.	Criteria for technology assessment including IP protection and development strategies.
Insurance companies	Including brokers and underwriters	Evidence of survivability, reliability and safety in design, production, installation and operation, with appropriate control of risks.
Power utilities	Grid and distribution network operators and asset owners. Electricity supply companies.	Evidence of quality of supply and compliance with grid codes. Evidence of expected performance as input to PPA.
Consenting authorities	Including Crown Estate, DTI, DEFRA and others.	Assessment of environmental impacts in both temporary (construction/ installation) and operational phases. Evidence of appropriate controls and monitoring.
Regulatory and advisory bodies, statutory consultees	Including HSE, MCA, SEPA, English Nature, SNH, CCW, RSPB and others.	Details of safety, health and environmental concerns and impacts as they affect particular regulatory areas.
Other users of marine environment	Including shipping and fishing industries and leisure users.	Details of extent of impacts on current activities (if any) and arrangements for control and monitoring.

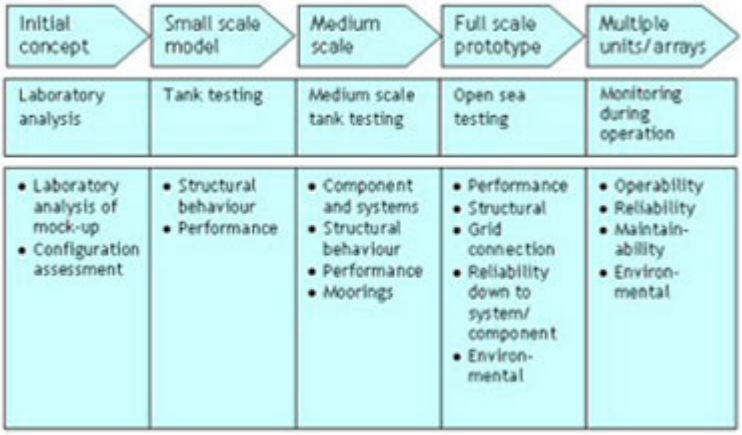
Standardisation and certification are routes to addressing some of these stakeholders' requirements. Testing against standards/specifications is also important. Given the range of technology options for marine renewables, something that is particularly important is the development of standard testing methodologies that allow devices to be compared. Industry recognition of this need and participation in standards development is essential for the methodologies to be adopted and strike a fair balance between product developers' and other stakeholders' requirements.

Stages of testing

In the early stages of device development, the principle function of testing is to help the designer confirm the actual performance of the device in different conditions and gather engineering data that are otherwise difficult to obtain. But as well as having engineering significance, early test results are needed to give confidence that it is worthwhile investing funds to continue development activities. As development proceeds, developers will need to raise funds from different sources and potential investors have different criteria for investment. Previous test results may meet these criteria, or the criteria could require further tests.

Different types of testing are appropriate at each stage of device development. As a design is developed, it will be necessary to consider not just the overall device, but also 'drill-down' into sub-systems and components (particularly where these are critical to overall performance, reliability or survivability). Figure 2 illustrates the type of testing that may be appropriate at each stage. Note that this picture shows just the physical testing aspect of device development; many other activities (including analysis, modelling/simulation, conceptual design and detailed design) are necessary too.

Figure 2: Stages of physical testing in marine renewables technology development



When test results have been obtained at a certain stage of development, the conclusion may be to proceed with the next stage or re-design the product (in part or whole) to improve its behaviour. Since the effectiveness of improvements will themselves need testing, the testing process is likely to be iterative. It is important that testing is well planned in order to control its inherent costs and risks. It is usually cheaper in both time and materials to test at small scales before committing to full scale devices (although some things cannot be tested properly at small scale for technical reasons). Also, the risks of deploying at large scale cannot be properly assessed until small scale tests are complete. Effective use of funds and avoidance of unnecessary risks are likely to be amongst investors' criteria.

There are different motivations for testing in later stages of development. Having proven that a concept works at full scale, testing may be orientated more towards proof of reliability and/or design optimisation. For instance, investors and insurers may expect run times of between 20,000 and 40,000 hours to give evidence of performance longevity (these testing times being typical for other generation equipment e.g. gas turbines), with independent validation of results. Engineering verification and/or certification is also likely to be required, with standards similar to those already available for wind turbines (e.g. the IEC 61400 standards series) and other generation plant and equipment.

Current status and facilities

At present, the priorities for testing marine renewables are to prove device concepts and progressively improve device designs. The New and Renewable Energy Centre in Blyth, Northumberland and the European Marine Energy Centre on Orkney, Scotland, offer facilities for testing devices at different stages of development, and wave tanks are also available at several universities in the UK (including the University of Edinburgh, Queen's University Belfast and Lancaster University) and elsewhere (e.g. Ecole Centrale de Nantes, France). Standards are also being developed by several parties, including a project under the Marine Energy Challenge to develop guidelines on the application of existing standards/design codes to marine renewables devices.

Summary

- In general, testing is needed to provide evidence and give confidence about performance, reliability and safety
- Stakeholders in marine renewables face a number of uncertainties, some of which can be addressed by testing, standardisation and certification
- In the early stages of device development, testing is needed to confirm actual performance and gain investor confidence
- It is important that testing is planned in order to properly control costs and risks
- The current priorities in testing marine renewables are to prove device concepts and progressively improve device designs. The UK has a range of facilities applicable to this