MARINET

Marine Renewables Infrastructure Network

Partners

Ireland

University College Cork, HMRC (UCC_HMRC) Coordinator

Sustainable Energy Authority of Ireland (SEAI_OEDU)

Denmark

Aalborg Universitet (AAU)

Danmarks Tekniske Universitet (RISOE)

France

Ecole Centrale de Nantes (ECN)

Institut Français de Recherche Pour l'Exploitation de la Mer (IFREMER)

United Kingdom

National Renewable Energy Centre Ltd. (NAREC)

The University of Exeter (UNEXE)

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The University of Edinburgh (UEDIN)

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Plymouth University(PU)

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Stichting Tidal Testing Centre (TTC)

Stichting Energieonderzoek Centrum Nederland (ECNeth)

Germany

Fraunhofer-Gesellschaft Zur Foerderung Der Angewandten Forschung E.V (Fh_IWES)

Gottfried Wilhelm Leibniz Universität Hannover (LUH)

Universitaet Stuttgart (USTUTT)

Portugal

Wave Energy Centre - Centro de Energia das Ondas (WavEC)

Italy

Università degli Studi di Firenze (UNIFI-CRIACIV)

Università degli Studi di Firenze (UNIFI-PIN)

Università degli Studi della Tuscia (UNI_TUS)

Consiglio Nazionale delle Ricerche (CNR-INSEAN)

Brazil

Instituto de Pesquisas Tecnológicas do Estado de São Paulo S.A. (IPT)

Norway

Sintef Energi AS (SINTEF)

Norges Teknisk-Naturvitenskapelige Universitet (NTNU)

What is MaRINET?

MaRINET is a European Commission-funded network of world-class research centres that have come together in order to accelerate the development and commercial deployment of marine renewable energy technologies – wave, tidal and offshore-wind.

Through facilitating access and streamlining the testing process, these research centres aim to advance marine renewables R&D at all scales - from small-scale model and laboratory testing, through to prototype and open sea trials. In order to do this, the network partners are offering periods of Free-of-Charge access to their testing facilities and conducting joint activities in parallel to standardise testing, improve testing capabilities and enhance training & networking in the industry.

The numbers

- 4 year duration - from April 2011
- €11m total budget
- 12 countries
- 29 partner research centres
- 45 infrastructures
- 700 test-weeks available for appx. 300 projects

MaRINET Offers

- Periods of Free-of-Charge transnational access (TA) to research infrastructures:
  - 45 world class test facilities available - open to large and small companies, research groups etc.
  - Contribution towards users' travel and subsistence.
  - User workshops/networking events to aid R&D progression by promoting technology and enabling collaboration.
- Joint activity by partners in parallel with TA:
  - Adoption of common test standards. Facilitates direct comparison and streamlined progression of test devices from small-scale to larger-scale facilities.
  - Coordinated research to improve testing capabilities.
  - Networking & training in the form of staff exchanges and Free-of-Charge training courses

> MaRINET offers a unique opportunity to access these world-class European test facilities in order to validate and progress concepts at any stage of development, and to ultimately harness the untapped renewable energy resources that are abundant around the European coastline.
>
> This is a great opportunity to advance marine renewable research testing and commercial development for European companies and research groups.
>
> **Professor Tony Lewis**
> **The University College Cork in Ireland**

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youtube.com/channel/UCtQxAiX3XOIjRzbJ9v7kgpw

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MaRINET
Transnational Access

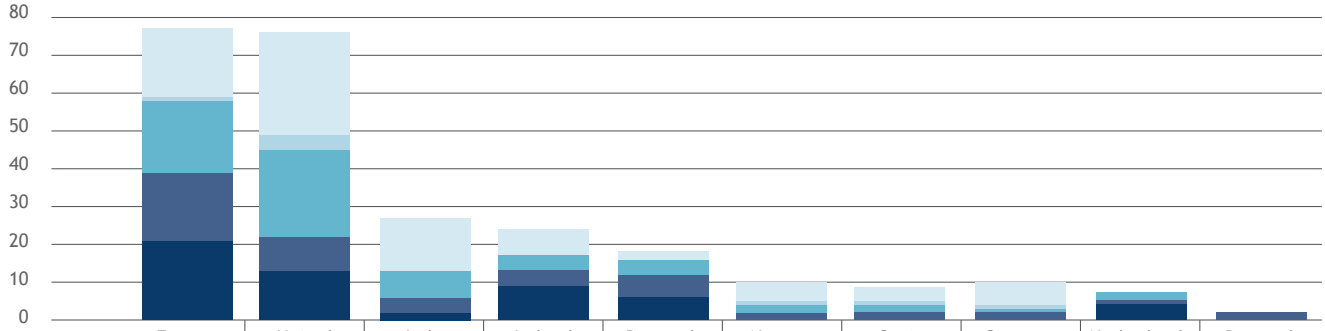
MaRINET is offering Free-of-Charge, EC-funded Access to Test Facilities: 45 state-of-the-art wave, tidal, offshore-wind & environmental data and cross-cutting facilities, with associated personnel and expertise.

A cornerstone of the MaRINET initiative is the offer of EC-funded transnational access for those who wish to conduct marine renewables testing at specialised facilities/infrastructures. Access is open to companies and research groups of any size who wished to test at facilities outside of their own country. Costs of accessing the facility are borne by the EC (through the 7th Framework Programme) for defined periods of access, and a contribution is made towards travel costs.

The suite of facilities that makes up the MaRINET network represents the highest quality of facilities in the marine renewable energy sector. The quality of the infrastructure not only depends upon the physical facilities but also includes the capability and experience of the staff. All of the staff at the infrastructures have extensive experience in the field of offshore renewable energy.

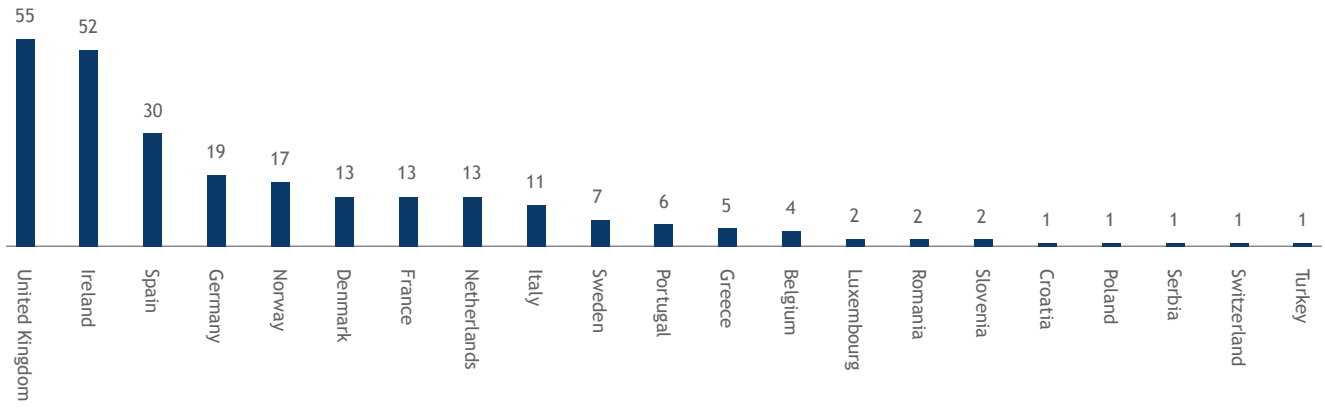
To date (September 2014) the MaRINET initiative has received more than 256 eligible proposals from 21 countries across Europe. A total of 659 equivalent weeks of access have been offered to the various projects.

Figure 1. Number of eligible applications received per country over the 5 calls



	France	United Kingdom	Italy	Ireland	Denmark	Norway	Spain	Germany	Netherlands	Portugal
Call 5	18	27	14	7	2	5	6	2	0	0
Call 4	1	4	0	0	0	1	1	0	0	0
Call 3	19	23	7	4	4	2	1	2	2	0
Call 2	18	9	4	4	6	2	2	1	1	2
Call 1	21	13	2	9	6	0	0	2	6	0

Figure 2: Statistics of eligible applications “from” countries for the 5 calls

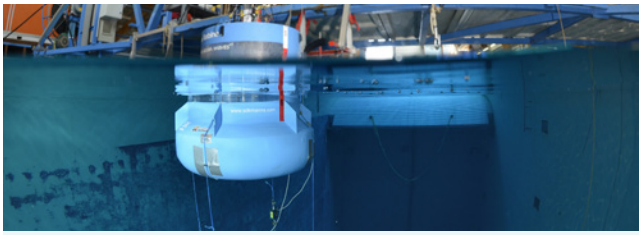


Success stories

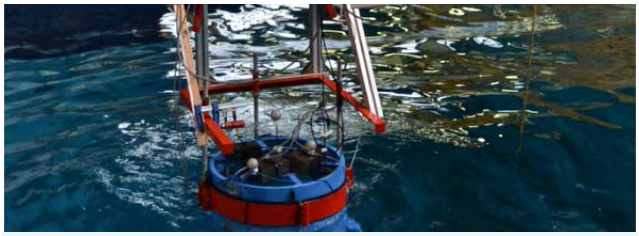
Sendekia was granted access to the large scale lab deep seawater wave tank at IFREMER, France

S.L. Sendekia is a Spanish company that has invented and patented a conversion system consisting of a water turbine working with an Oscillating Water Column (OWC). “SDK Wave Turbine” is able to take off power from hydraulic bidirectional oscillating movement. This means that the turbine is capable of generating electricity both on inflow and outflow. SDK Wave Turbine can be installed as a floating body, like a buoy, or fixed in a breakwater or a fixed offshore structure. The buoy is deployed with a simple four-wire mooring attached to an anchoring weight on the seabed. At the bottom of the buoy there is an opening that allows flow between the oscillating water column chamber and the sea through the turbine.

Through the MaRINET granted access, they could verify the operation of the device including the mooring system, the power take off and obtain the power matrix of their device. The buoy, mooring system, OWC, hydraulic turbine and mechanical system, demonstrated the potential of the technology which means that the technology can move to the next stage of development of testing in real sea medium scale site.



SDK WAVE TURBINE deployment in the deep seawater wave tank at IFREMER.

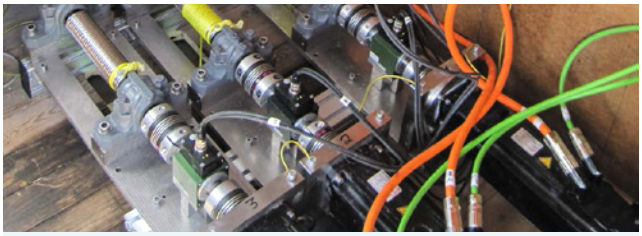


SDK WAVE TURBINE testing in the deep seawater wave tank at IFREMER.

Nemos was granted access to the medium scale Nissum Bredning test site at AAU, Denmark

The German company Nemos Gmbh has tested a 1:10 scale model of their wave energy converter at the Nissum Bredning test site. Through the MaRINET granted access they obtained efficiency data in natural seaways and validated the steering mechanisms and algorithms of self-aligning terminator wave energy converters in natural seas. Another aim of the work carried out was to get first predictions on the wear in the ropes and fouling effects. Data of forces in the foundations and ropes was also collected and processed. With the collected data, an improved cost prediction model can be set up with a refined economic efficiency model. The idea is to scale the 1:10 scale data to full scale and thereby get efficiency data for a full-scaled prototype which is among the next steps in the development process of the NEMOS wave energy converter taking the final step towards commercial deployment.

Nemos elongated buoy in operation at the medium test site in Nissum Bredning, Denmark.



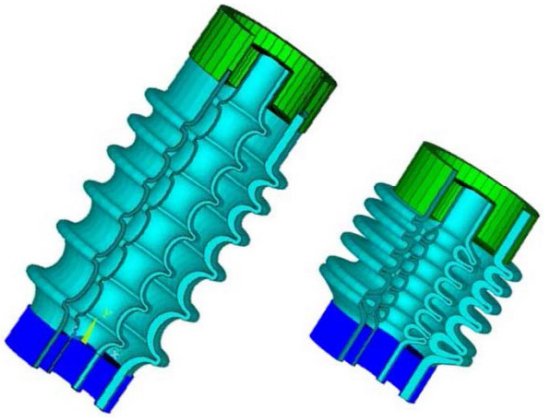
Nemos power take off system high above the water.

TfI Polymer Based Mooring System was granted access to the large scale Hydrodynamic and Ocean Engineering Tank at ECN, France.

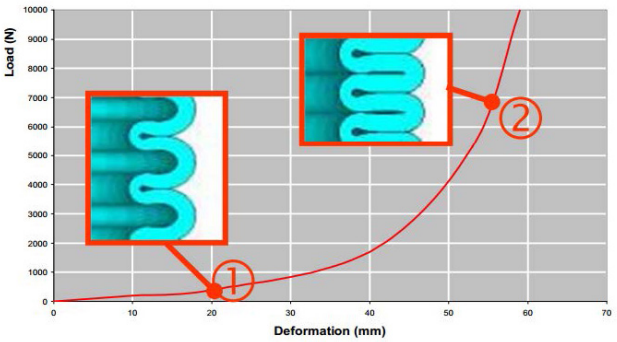
The Irish company Technology from Ideas have tested new mooring tethers containing elastomeric and thermoplastic mooring elements at the hydrodynamic and ocean engineering tank at ECN. Through the access granted, they could measure significant load reductions without any negative impact on the motion of the wave energy device using their mooring solution. Peak load reductions of 60% to 70% were seen across all sea states as well as significant reductions in impact loads. These reductions offer a step change in the loads seen by the mooring lines, the anchor systems and the device itself. The potential cost savings for operators is therefore very large. Because of the results obtained during the MaRINET access period, their manufacturing partners are now ready and able to deliver full scale components to the industry (wave energy, tidal, floating wind, navigation buoys, data buoys, platforms).

> I was impressed by the support given by the infrastructure staff, and the welcoming attitude towards our R&D activities. This opportunity (laboratory access through the MaRINET project) has boosted the development of our technology in a way we couldn't imagine otherwise.

Transnational access user group



The TfI elastomer tether mooring system was tested on the Wavebob scale device in the hydrodynamic and ocean engineering tank at ECN.



The TfI elastomer tether mooring system.

User Workshop

Participants of the 1st MaRINET User Workshop held in Rome.

The first User Workshop was organised in Rome from the 4th to the 7th of November 2013. The MaRINET User Workshops are meant to allow the development of a coherent network of researchers and developers in Europe working in the area of offshore renewable energy. These workshops allow true networking and research exchange to be undertaken between user groups who had been granted transnational access through MaRINET and researchers from the MaRINET network.

During the first workshop, eleven users were invited to present the research activity conducted during their period of access. Additionally, meetings were organised between users and Infrastructure Managers to discuss the various aspects of the Transnational Access programme with the objective of improving the process and facilitate a valuable access to research Infrastructures for a larger number of users.

A second user workshop will be held within the MaRINET project to once again provide an unique opportunity for interactions between researchers and practioners from the industrial sector.

Standardisation and Best Practice

Network partners are coordinating activities aimed at standardising best practices for wave, tidal, offshore wind energy and cross-cutting systems (common elements).

Due to the fact that marine renewables testing centres are not uniformly configured or constructed, standardisation is an important aspect to MaRINET. At present, there is no pan-European or worldwide consensus on appropriate test methodologies and practices.

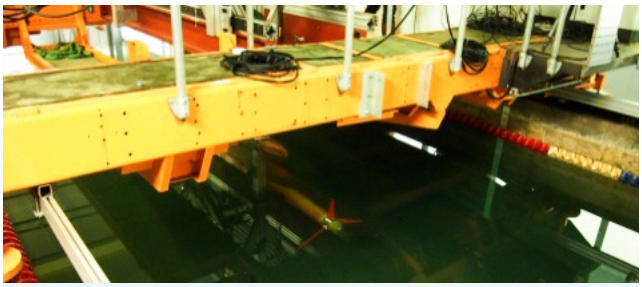
Reports and manuals have been compiled from all the information collected to encourage the standardisation of best practices. Some of them are already available online in Wiki format to encourage on-going use and continuing refinement.

Report topics include:

- Standardisation and harmonisation of simulations and resource data at all facilities and all scales.
- Model construction methods – full similarity and scalability between model and prototype.
- Instrumentation – standardisation for when upgrading is required.
- Data analysis methodology and presentation formats.
- Comparative testing – 'Round Robin' testing of a calibration model in MaRINET facilities to characterise and verify the performance behaviour of the various test facilities.

One of the highlights of the activities within this part of the project is the 'Round Robin' testing of a scale tidal device. The test tanks used in this testing program were: IFREMER's Re-Circulating Flume Tank at Boulogne Sur Mer, France; Strathclyde's Tow Tank, Glasgow, UK; and CNR INSEAN's Tow Tank and Re-circulating Flume Tank in Rome, Italy. IFREMER's scale tidal turbine, together with its on board instrumentation and data acquisition system was tested at these four facilities. The test program implemented at all facilities was the exact same, together with the range of flow velocities tested.

This 'Round Robin' testing program on tidal energy is the first of its type and will quantify the range of impacts different testing environments will have on the performance of the device being tested. This will enable the development of a test tank calibration factor which can then be implemented in order to bench mark the results from a specific testing site in order to undertake cross comparison between the performance of a device irrespective to the environment it is being tested within.



Round Robin testing at Strathclyde's Tow Tank, UK.

wiki.marinet.eu/index.php/Main_Page

Research to innovate and improve infrastructures, technologies and techniques

Joint research in the MaRINET Network is being carried out in order to innovate and improve infrastructures, technologies and techniques.

Offshore renewable energy research activities related to developing, testing and characterisation of wave, tidal and offshore-wind energy systems, from laboratory to full scale, has achieved world class quality at the individual infrastructures. Many problems in the field can be addressed with existing methods and technologies. However, the MaRINET network of leading institutions has identified several unsolved issues specific to offshore renewable energy technology testing that require further research.

One of them included full scale wind resource surveying. Offshore wind energy already provides a significant proportion of the existing renewable energy. With the political aim of achieving ever higher penetrations of renewable energy, due to public acceptance issues, much or even most of the new wind energy will be deployed offshore. To achieve much higher levels of offshore wind energy as economically as possible, it is imperative to have an as accurate as possible understanding of the offshore resource. A study reviewing the available measuring technologies for surveying the offshore wind resource was performed. Aspects such as accuracy, cost and maturity were covered with particular attention paid to how well the different technologies were covered by existing standards and best practices. Suggestions for improvements and additions were also given where appropriate.

The study ended in the production of a report dealing primarily with surface measurements able to provide data of sufficient accuracy to support a wind resource assessment. This includes traditional mast measurements and measurements from remote sensing devices (lidars, sodars and radars) placed above the water (on platforms), in the water (on buoys or ships) and scanning from the coast, with main focus on the ability of the sensors to measure mean wind speed and direction since this is the primary requirement for an estimate of the available wind resource.

Parallel measurements of the floating lidar and a fixed lidar installed on the Pont de Petroli, Badalona, Catalonia, Spain

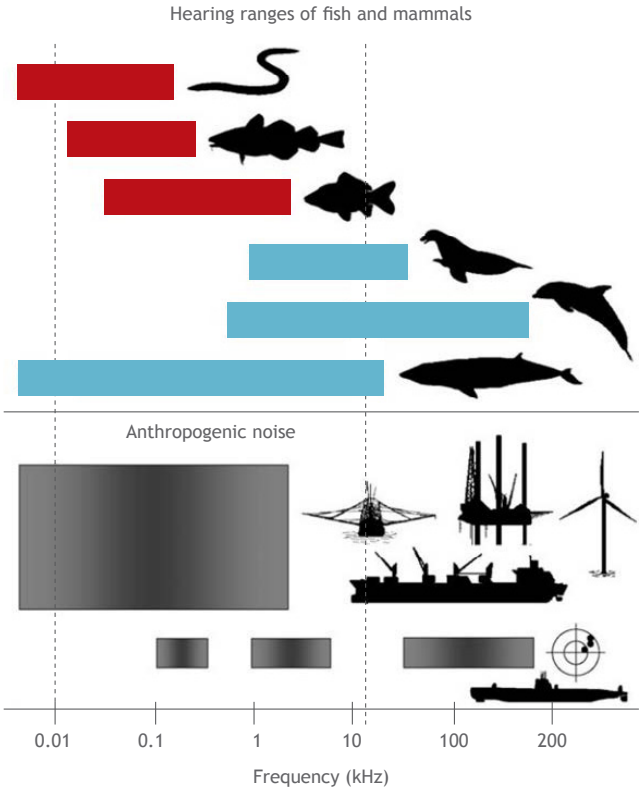
Offshore test of Fraunhofer IWES Wind Lidar Buoy next to FINO1 met. mast 45 km offshore, North Sea.

Investigations of the environmental issues of ocean energy

Another joint research highlight of the MaRINET project concerns investigations of the environmental issues associated with ocean energy. Marine renewable energy is an emerging sector with the first commercial scale devices currently under test at a few high-energy sites across Europe. At this early stage of the industry, the extent to which these technologies interact with the surrounding environment is largely unknown. Understanding these interactions is essential to the acceptance and commercial development of these technologies.

Marine renewable energy project developers must take environmental issues into consideration early in the design process, with the entire project lifecycle in mind (i.e. design, installation, operation, maintenance and decommissioning). By ensuring that monitoring is robust and of high quality, and is managed adaptively with regulatory input, the learning from these early-stage deployments could lead to better-informed risk assessments at the commercial licensing stage, and consequently to better informed, targeted and refined monitoring requirements for commercial deployments. This type of refinement would consequently introduce associated efficiencies, time saving for regulators, and cost reductions for all.

Some of the MaRINET partners looked deeper into the need for environmental monitoring, identifying the key environmental uncertainties surrounding offshore renewable energy development, and the legislative and research drivers for monitoring to address these unknowns. They also consider the techniques and protocols which have been developed for environmental monitoring to date, and summarise monitoring activities being undertaken at marine renewable energy test sites across Europe. New monitoring techniques being trialled at some of the MaRINET facilities are also detailed, and recommendations for developing a coordinated approach to environmental monitoring across Europe are provided in an extensive report.



Marine X-band radar system installed at EMEC electricity substation, UK.

WavEC monitoring buoy, Portugal.

MaRINET
Training

MaRINET provided training and education in the operations of research infrastructures, thus contributing to the development of the sector.

The short Free-of-Charge training courses are aimed at early-stage researchers and postgraduate students but are also open to all interested applicants from companies, research groups, educational institutions etc. The aim is to have an equal mix of early-stage researchers/students and industry attendees on each course.

8 short courses are offered:

- Experimental testing in wave tanks and flumes
- Monitoring of pilot plant and pilot zones
- Instrumentation of ocean devices
- Experimental modelling of electrical equipment
- Experimental modelling of air turbines
- Offshore wind measurement techniques
- Remote sensing in the offshore environment
- Experimental modelling of wind actions on offshore structures

All in all, the short courses had over 150 participations from over 15 countries.

Participants of the short course "Experimental testing in wave tanks and flumes" held in HMRC, University College Cork, Ireland.

Day trip to Ringaskiddy, Ireland, for the participants of the short course "Experimental testing in wave tanks and flumes".

Wind tunnel tour for the participants of the short course "Offshore wind measurement techniques" organized by UNIFI-CRIACIV and UNIFI-PIN, Italy.

Visit to the Mutriku OWC Plant as part of the short course "Laboratory-based development of electrical power conversion and control strategies for ocean energy devices" held at TECNALIA, Spain.

Visit to EMEC facilities for the participants of the short course "Environmental monitoring in wave and tidal test sites and pilot zones" held in Orkney, UK.

Visit to EMEC facilities for the participants of the short course "Environmental monitoring in wave and tidal test sites and pilot zones" held in Orkney, UK.

"It has been a very rewarding experience delivered by experimented and professional staff. I am very grateful to the short-course organizers.

Participant of one of the short-courses

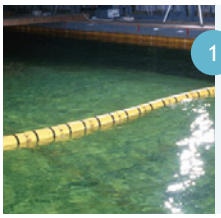
Structured Development Schedule

Over the years, devices have been developed in an ad-hoc fashion and as a result, many failures have occurred in the misguided rush to get full scale devices into the sea. This has resulted in significant investment losses, slow rate of technology development and credibility issues for the sector. In order to attempt a standardised approach to development, an international "Structured Development Schedule" has been produced. This concept, based on proven steps established by NASA and widely used by many engineering research establishments, has gained acceptance worldwide through the International Energy Agency's intergovernmental collaboration 'Ocean Energy Systems Implementing Assessment' (OES) and through the European FP7 project EQUIMAR, which developed the concept using Technology Readiness Levels and other metrics. It is now used as the main development and assessment method in the US and Europe.

Even though the MaRINET project has proven a great success, most of the technologies in the field of marine renewable energy still have important steps to take before they are ready for commercial deployment. It is therefore essential to still support this new industry, and national and European public funding is crucial in order to accelerate the commercialization of the sector and also to maintain the industrial leadership position that Europe has within this field.

> We need MaRINET in order to pursue the development towards the successful commercialisation of our technology!
>
> **A user group**

An outline of the Structured Development Schedule is given below:



1 *Phase One - Validation Model*
- *Fundamental Testing in regular waves in a laboratory*
- *Scale: 1:25 - 100*

2 *Phase Two - Validation and Design Model*
- *Testing in realistic sea conditions in a laboratoty*
- *Scale: 1:10 - 25*

3 *Phase Three - Process Model*
- *Testing in conditions representative of deployment site either in a laboratory or at sea*
- *Scale: 1:10 - 15 or 1:1 - 4*

4 *Phase Four - Prototype Model*
- *Large scale pilot at sea*
- *Scale: 1:1.25*

5 *Phase Five - Demonstration*
- *Pre-production Prototype*
- *Scale: 1:1 (Full scale)*

The MaRINET project provides access to infrastructures at each phase of the development in order to reduce late-stage technology failures due to unstructured development.

Range of infrastructures available through the MaRINET project, at each scale and in each focus-area.

	FOCUS AREA			
SCALE	**Wave Energy**	**Tidal Energy**	**Offshore-Wind Energy and Environmental Data**	**Cross-Cutting Areas e.g. Electrical/PTO/Materials etc.**
Small Scale Lab	**AAU** Wave Basin **QUB** Wave Basin **UCC-BEAUFORT** Wave Basin **UEDIN** Curved Wave Tank **UNI-STRATH** Kelvin Hydrodynamics Lab **UNIFI** Wave-Current Flume	**DTU** Current flume With Carriage **UNI-STRATH** Kelvin Hydrodynamics Lab **USTUTT** Laminar Wind Tunnel **UNIFI-CRIACIV** Boundary Layer Wind Tunnel **UNIFI-CRIACIV** Wave-Current Flume	**UNIFI-CRIACIV** Boundary Layer Wind Tunnel **UNI-STRATH** Kelvin Hydrodynamic Lab **USTUTT** Laminar Wind Tunnel	**SINTEF** Renewable Energy Lab - SmartGrids **TECNALIA** Electrical PTO Lab UCC-BEAUFORT Rotary Test Rig **USTUTT** Turbine Test Rigs **UNEXE** Dry Marine Component Test Facility
Large Scale Lab	**CNR-INSEAN** Wave Tank **ECN** Hydrodynamic and Ocean Engineering Tank **IFREMER** Deep Seawater Wave Tank **IFREMER** Wave-Current Circulation Tank **NAREC** Wave Flume **PU** Ocean Wave Basin **UEDIN** FloWave Test Tank	**CNR-INSEAN** Circulating Water Channel **IFREMER** Wave-Current Circulation Tank **PU** Ocean Wave Basin **UEDIN** FloWave Test Tank	**ECN** Hydrodynamic and Ocean Engineering Tank **PU** Ocean Wave Basin	**DTU** Mechanical Test Facilities **DTU** PowerLabDK **IFREMER** Materials in Marine Environment Laboratory **NAREC** CPTC Energy Link Labs **NAREC** Nautilus Rotary Test Rig
Medium Scale Site	**AAU** Nissum Bredning **EMEC** Real Sea Test Sites, Orkney (Wave) **SEAI-OEDU** Galway Bay	**EMEC** Real Sea Test Sites, Orkney (Tidal) **QUB** Portaferry Tidal Centre **TTC** Den Oever Tidal Site	**AAU** Nissum Bredning **QUB** Portaferry Tidal Test Centre **SEAI-OEDU** Wave Site Data Galway	**UNEXE** South West Mooring Test Facility
Large Scale Site	**EVE** Biscay Marine Energy Platform **SEAI-OEDU** Belmullet Test Site	No Infrastructure Currently Available	**DTU** Database of Wind Characteristics **DTU** Mobile Offshore Wind Measuring **DTU** National Wind Test Site **ECNETH** Database of Measurements on OWEZ **NTNU** Full Scale Wind Measurement Station **PU** HF Radar for offshore wave/current **SEAI-OEDU** Belmullet Test Site Data **USTUTT** Offshore Nacelle LiDAR	**EVE** Mutriku OWC Plant **FH-IWES** Offshore Field Test Facilities **WAVEC** OWC Pico

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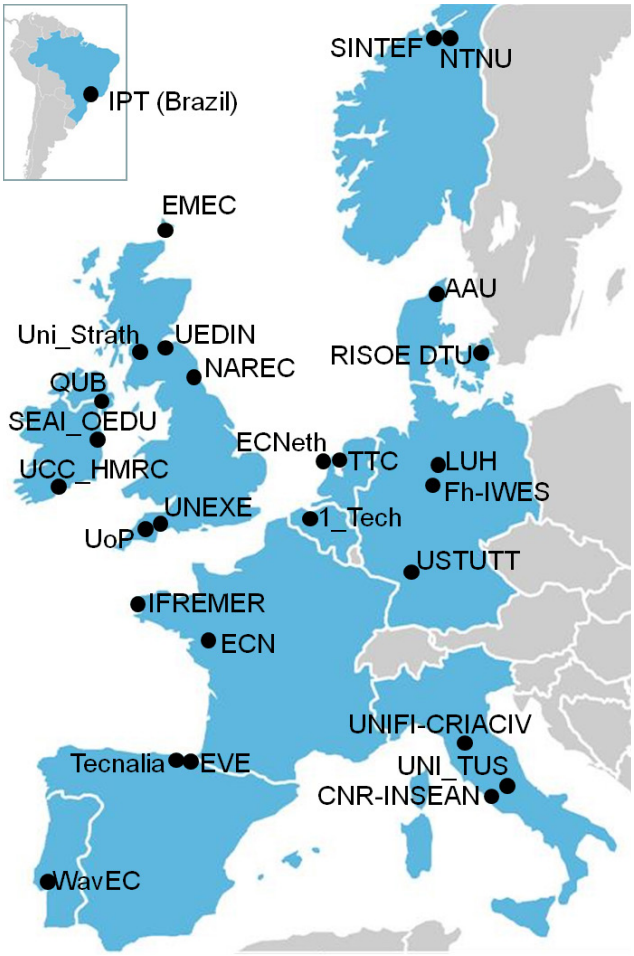
Further information:
www.marinet.eu



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Universitaet Stuttgart (USTUTT)

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Università degli Studi della Tuscia (UNI_TUS)

Consiglio Nazionale delle Ricerche (CNR-INSEAN)

Brazil

Instituto de Pesquisas Tecnológicas do Estado de São Paulo S.A. (IPT)

Norway

Sintef Energi AS (SINTEF)

Norges Teknisk-Naturvitenskapelige Universitet (NTNU)