

International strategy for the WeAMEC (West Atlantic Marine Energy Center)

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CONTENT

1	INTRODUCTION	2
2	INTERNATIONAL SCENE OF MARINE RENEWABLE ENERGIES	4
3	THE INTERNATIONAL WEAMEC STRATEGY	5
3.1	Networks of basins and sea test sites	6
3.2	MRE technologies and innovative technological building blocks.....	8
3.3	Training networks through Research	9
3.4	Bio-colonisation and Corrosion.....	11
3.5	Smart monitoring of offshore structures	13
4	SYNTHESIS OF PARTNERSHIPS	15

1 Introduction

The international dimension plays a major role for the WeAMEC. Thus, partners have to get deeply involved in a collective strategy at this level.

The WeAMEC road map has been developed through a collaborative work from the regional actors coordinated by the CMI Office in 2013 - 2014:

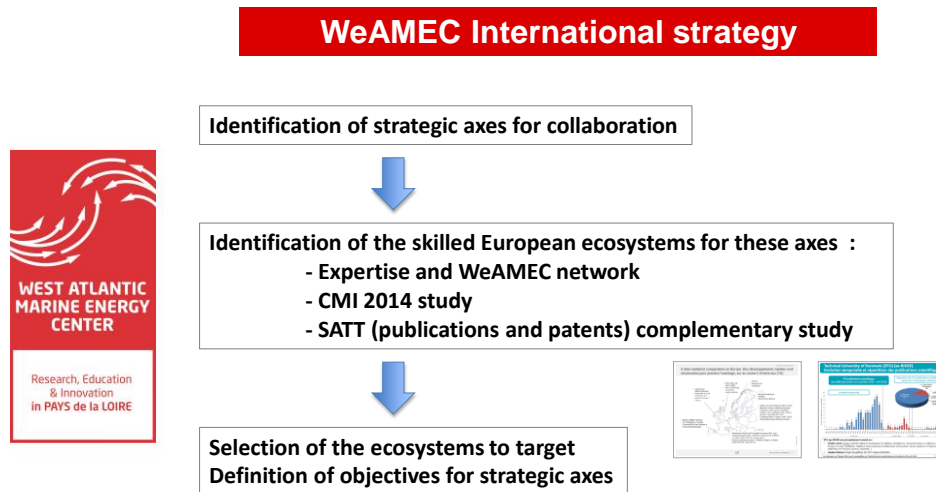
- Axis 1 : Develop fixed-structure wind power, especially in the extreme conditions (hard ground, strong swell, etc.) of the Atlantic coast area.
- Axis 2 : Accelerate the transition from fixed to floating offshore wind turbines.
- Axis 3 : Move ahead with less mature MRE technologies, such as tidal energy, ocean thermal energy conversion (OTEC) and wave energy.



- Axis 4 : Develop innovative technological building blocks for these different technologies.

The resulting roadmap lays out the following medium-term objectives:

The international strategy for the WeAMEC declines this roadmap at the international level. The development has been built on the following approach (Cf. below) during RIME (Research Innovation Test Facilities) WeAMEC meetings. First it identifies several themes of collaboration to strengthen in order to develop the themes of its roadmap including at European level. Then, competent ecosystems on these themes have been identified on the basis of the expertise of the members of the WeAMEC and on their network analysis and the 2014 CMI study and a complementary study conducted with the SATT (production of publication and patents). It results the selection of ecosystems for which should be strengthened partnerships and the definition of objectives of cooperation with each of them.



The international strategy of the WeAMEC has been presented and validated in the COMOP of September 16, 2016 then in the COPIIL of October 10, 2016.

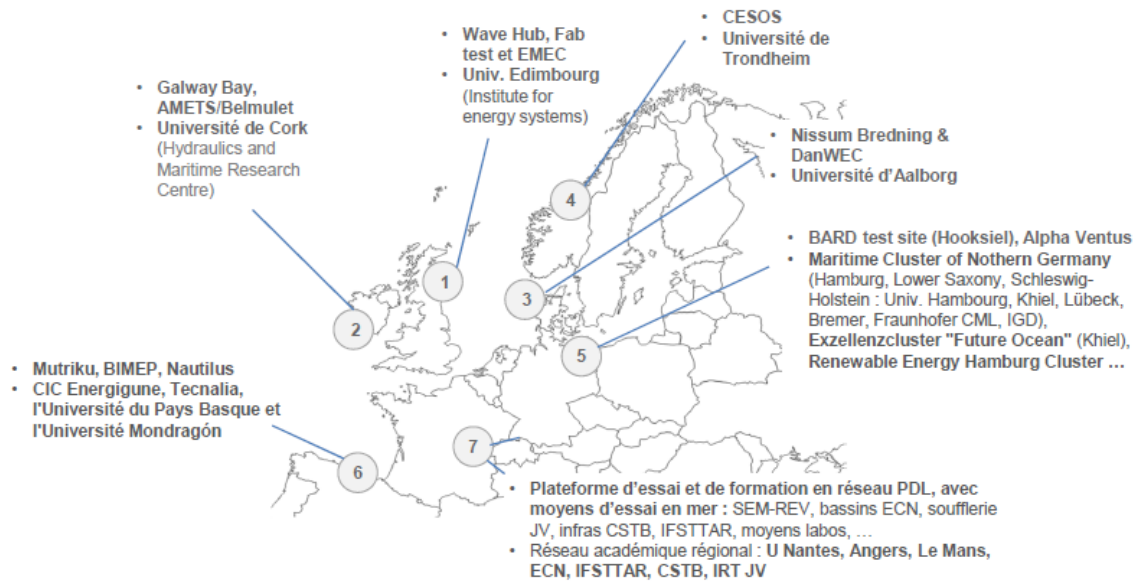
2 International scene of Marine Renewable Energies

Today Europe is undoubtedly leader in the development of marine renewable energy although recently some important initiatives have been launched in the United States or in Asia especially for offshore wind power.

Therefore it is logical that strategic partnerships target mainly Europe as significant funding opportunities exist for collaborative projects at European level.

During the phase of implementation of the WeAMEC a study of the forces at work in Europe was conducted by CMI cabinet and all regional partners.

The main conclusions of this study are recalled in Appendix 1. Six European ecosystems were identified during this study:



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A study was also conducted for the labelling of the SEMREV test site at the ANR with some of the same ecosystems especially for the sea test sites.



3 The international WeAMEC strategy

The international WeAMEC strategy must rest on themes of growth-generating developments relying on the pre-existing strengths of the ecosystem which should be strengthened. These themes were discussed at the Research and Innovation meetings of WeAMEC and are as follows:

- **Networks of basins and sea test sites ;**
- **The MRE technologies and innovative technological components ;**
- **Training networks through Research ;**
- **Bio-colonisation and corrosion ;**
- **Smart monitoring of offshore structures.**

Each of these themes are strong issues of the WeAMEC technology roadmap for which a check of existing partnerships as well as 5-year targets will now be described.

3.1 Networks of basins and sea test sites

Networks of basins and sea test sites allow to federate the means at European level and to propose European projects to offer for test framework. These projects are used to perform the tests on the best suited site to the technology and its level of maturity (type of testable technology on the site, electric power generated, more or less severe sea conditions...). This axis is carried mainly by ECN at international level with the wave basin and the towing tank and SEMREV sea test site.

An important project for structuring these networks already exists today. It's the MARINET 1 project [2011-2015] (which involved the ECN wave basin) and includes the following partners:

- + UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK - Ireland
- + AALBORG UNIVERSITET – Denmark
- + THE UNIVERSITY OF EDINBURGH - United Kingdom
- + FRAUNHOFER IWES GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV – Germany
- + WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE – Portugal

In total 28 sites are involved across Europe.

This project has been able to reference the wave basins of Central Nantes at European level. As a result ECN has obtained the largest number of tests among all partners of the project. In addition the insertion in this network and the opportunity to compete for new projects of the same type technical results were very rewarding and some international technology developers have returned to continue their tests at ECN in B2b collaborations.

Objectives 2020 :

The first objective is to propose to the European funding a project with the majority of MARINET 1 partners in a new unifying project called MARINET 2. It will also integrate the ECN/SEMREV sea test site (which is now operational) in the MARINET 2 project (which was not the case for MARINET 1).

The Second goal is to set up within 4 years two other projects of tests of technologies at sea in order to feed the load plan of SEMREV with technologies developed in other European countries. This will allow to develop the activity of the test site and capitalizing in feedback on relevant technologies developed at European level.

The third objective is to offer at a European level a 'network of excellence' structure involving key partners through a labelling ESFRI issued to the large European research structures.

This approach at the European level implies a network organisation at the french level which is under discussion (THEOREM project).



Situation in 2014 :

Structure of the network of European partners through the MARINET 1 project with test basins (with french Ifremer and ECN/basin level) and some test sites.

Results achieved since 2014 :

Several major results have been achieved in 2015 and 2016 for the integration of WeAMEC ecosystem test facilities in the European ocean test facilities particularly those of Ecole Centrale Nantes:

- 2016: MARINET 2 accepted for "The Grant Agreement preparation" (August 2016).
- 2016: 1 project of networking of test sites **assembled and funded**: FORESEA (ECN/SEMREV).
- 2016: one GIS long THEOREM (IFREMER/ECN) being structured. In parallel submission of the french consortium to the EU as part of the MARINERGY network. This proposal was classified "in emergence" in a first call in 2016 and is favorably positioned for a second call to come.

3.2 MRE technologies and innovative technological building blocks

MRE innovative technologies developments with fixed-structure and floating wind power and wave energy are carried out in a competitiveness way in terms of cost per kWh produced while adapting the technologies to the severe conditions of the Atlantic coast.

3.2.1 Wind power

FLOATGEN and OCEAGEN are the major projects respectively funded at the European and national level. It will test the first floating wind turbine off the French coast in 2017.

For this it will be necessary to finalize SEMREV test site equipment particularly for the electric infrastructure.

In this context it would be interesting to connect ecosystems that also have sea demonstrators to share skills as the **Norwegians of Trondheim**, the **Portuguese of the WavEC** and the **Scottish (University of Edinburgh / EMEC test site)** whose will deploy the first pilot farms in 2018 (see the objectives of the previous paragraph).

For floating wind power development WeAMEC has strong skills in hydrodynamic notably through the teams of the LHEEA of ECN but must seek to collaborate with organizations of the same level in aerodynamic modeling and characterization of the wind resource.

The University of Stuttgart which is a FLOATGEN partner has a strong business and recognized expertise on the modeling of the operation of the turbines (numerical modeling of aerodynamics, wind at sea measurements). The opportunity was taken to talk about measuring the wind on SEMREV especially from lidar.

Contacts also exist with The University of Kiel (capital of the Federal State (Land) of Schleswig-Holstein) for collaboration around the FINO platforms. One of the research projects promoters has been invited to speak at the FOWT'16 Symposium (Marseille) on this subject.

TU Darmstadt and **DTU Wind (ex-RISOE)** near Copenhagen could also be a privileged partner on this issue particularly on the aerodynamic modeling aspects parts.

3.2.2 Wave energy

For wave energy WeAMEC must work with ecosystems able to propose innovative concepts. This will allow to work on hydrodynamic design and testing at sea aspects. (see axis 1 of the international strategy of WeAMEC). The main ecosystems in this area are:

- **The University of Aalborg associated with the DANWeC test site** took part in the development of Wavedragon and today it has strong connections with the Wavestar and the Weptos projects.



- **The University of Edinburgh, associated with the EMEC test site**, is a historic player in wave energy built on the pioneering work of Stephen Salter (Wave Power, Nature, 1974) on the Salter's Duck. The Pelamis technology is the result of this University, as well as the Artemis digital hydraulic technology (acquired by Mitsubishi to develop a wind turbine generator).

Situation in 2014 :

- SEMREV test site to equip (underwater electrical connection hub).
- FLOATGEN project in preparation.

Objectives for 2020 :

- Complete the equipment of the **ECN/SEMREV site** with the underwater connection HUB.
- Participate in a demonstration project of a **floating wind turbine** on SEMREV.
- Participate in a project of development of a **wave energy converter**.
- Participate in two complementary projects on the **critical technological building blocks**: anchor, dynamic umbilicals, environmental observatory, and wind.

Results achieved 2014 :

- 2015 : design, acquisition and implementation of the Hub SEMREV. The test site is operational for testing demonstrators at sea.
- 2015 : integration of ECN / SEMREV in the FLOATGEN FP7 project (official 2015, 2014 eligible expenditure).
- 2016 : porting the "anchoring and monitoring system" WP of FLOATGEN by ECN.
- 2016 : H2020 OCEANERA-NET project validated by Europe.

3.3 Training networks through Research

Research training networks including at European level allow to establish a wide range in 'ITN' projects or curriculum ERASMUS. This axis is focused at the international level by the ECN, the University of Nantes and IFSTTAR.

Situation in 2014 :

Participation at OCEANET project (ITN project) by Ecole Centrale de Nantes and University of Nantes with the following partners:



- FRAUNHOFER IWES GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV - Germany
- UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK - Ireland
- WAVEC/OFFSHORE RENEWABLES - CENTRO DE ENERGIA OFFSHORE – Portugal

Objectives for 2020 training through the Research:

For the [2015-2020] period the objective is to get 2 new ITN projects.

Achieved results since 2014 :

- 2015: University of Nantes leader in a COST VoSHM network with post-doctoral fellows training.
- 2016 : Start of the H2020-MSCA-ITN-2015 « INFRASTAR »¹ project coordinated by IFSTTAR with University of Nantes as a partner (4 years project 1st may 2016). This project aims to develop generic knowledge for optimal management of generic concrete structures subject to fatigue with such application areas as bridges and wind turbines.
The recipient partners in this project are PHIMECA, AAU, COWI, BAM, GuD, EPFL, NEOSTRAIN, partners are EIFFAGE, SIEMENS, and BAST. 12 PhD are financed by INFRASTAR (3.5 M€) divided in 3 scientific work:
 - Monitoring and Auscultation (4 PhD)
 - Modeling of structures and actions (4 PhD)
 - Fiabiliste approach to decision making (4PhD)

This project puts a strong emphasis on training through Research. 3 weeks training will be organized, 3 industry days and a summer school will take place in France which has the ambition to sustain based on the LiRGc and the WEAMEC.

- 2016 : ITN in setting up on "reliability SHM". University of Nantes in collaboration with HERIOT WATT University (Glasgow).
- 2017 : Set Europeans laboratory in network in 2016 by preparing an ITN (Scotland, Germany, Ireland) on the topic of the effects of bio colonization on the safety of MRE structures. The call will open in September 2017.

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3.4 Bio-colonisation and Corrosion

The bio-colonisation and corrosion theme is a focus of strategic development of the WeAMEC ecosystem at internationally level notably supported by the University of Nantes. The Biocolmar platform is an important element of this strategy.

Outcome from the Oil & Gas, this problem appeared even stronger in the case of the EMR which must drastically reduce its costs including OPEX. It is the same on the fatigue and corrosion but to a lesser extent because these phenomena of degradation, easier to simulate in the laboratory, have already been investigated with well referenced influential factors. The international ecosystem is well known and the University of Edinburgh and the EMEC are key players, as the University of Cork and MAREI.

In Europe, especially within the INCORE program, laboratories are structured so as to (1) understand the issue (SAMS), (2) to measure in situ (U. Cork), (3) to model hydro-dynamiques effects (PML, U. Cork) and (4) to work on new protections (Catapult).

The PML (Plymouth Marine Laboratory) and SAMS (Scottish Association for Marine Science), associated to EMEC test site, are recent players on bio-settlement applied to systems at sea.

The University of Cork, within the MAREI consortium, develop protocols for image analysis with the University of Nantes and a database ULTIR, project co-funded by MAREI (Irish network) and Capacités (subsidiary of the University of Nantes) since December 2014 on the monitoring of **bio-colonisation**.

The University of Stuttgart has been one of the leaders of the ANR DFG WindSHM project in 2014, whereby the University of Nantes took a large part on the bio-colonisation part. The University of Nantes also mounted as FP7 Bioprotect project in 2013 on bio-colonisation with German partners.

Situation in 2014 :

- B to B collaboration Université Cork / Université Nantes.

Objectives for 2020 :

- Participation in a project on organic colonization funded at European level, particularly on understanding and characterization of bio-colonisation.

Results achieved since 2014 :



- 2015 : PhD funded by EDF, "Corrosion and marine fouling protection of Offshore facilities", in partnership with Marine Science Lab in Edinburgh..
- 2016 : Phase 1 of the TOCCME project (call H2020 EMPIR) accepted (environmental measures at sea).
- 2017 : Networking in 2016 of European laboratories in preparation of an ITN (Scotland, Germany, Ireland) Effect of bio-colonisation on the safety of structures EMR. The call will open in September 2017.



3.5 Smart monitoring of offshore structures

The axis of **smart monitoring of offshore structures** aims to reduce OPEX of EMR technology costs. This theme is held in the region including by the University of Nantes and by IFSTTAR and CEA Tech research organizations. Companies like KEOPS and VALOREM are also involved on this subject.

This eco-system on the SHM, visible by the host of the EWSHM2014 conference co-hosted by the University of Nantes with IFSTTAR and INRIA (450 delegates), is in the process of structuring to make it visible at the international level in the form of the PdL ECND GiS and supported by CPER means.

Aalborg University has expertise on the evaluation of the reliability of the oil & gas offshore systems, skill that has been applied to the wind power recently, including within the above-mentioned INFRASTAR ITN. Collaborations with the University of Nantes deal with this, both as a member of the Management Committee of the action COST YOU 1402: Quantifying the Added Value of Structural Health Monitoring.

The University of CORK has been the leader of the build of the ITN Waterr-Net submitted in 2014 then in 2015 which was intended to develop the fiabiliste approach (taking into account the uncertainties) for wind floating in the presence of modes of degradation (fatigue, bio-colonisation and corrosion) followed by monitoring. Furthermore, the University of Nantes participated, alongside the University of Cork, in the production of the FP7 2012 (1) Re-Wind, project intended to study a new type of fixed foundation for offshore wind turbines of future generation with a contribution to the integration of the spatial variability of the soil and optical fiber instrumentation of the metallic foundations to prevent failures and (2) i3wind including issues of integrated design of future concepts of offshore wind turbines (to the 20 MW) with a contribution on the integration of the spatial variability of ground, models of materials degradation and growth of the probabilistic Biofouling and Structural Health Monitoring by optical fiber composite materials. These two projects have not been selected.

The University of Trondheim (NTU) is a University with whom, as with Aalborg, close links have been established with the University of Nantes (invitations to thesis defenses) and first discussions took place within the COST YOU 1402 action.

The University of Stuttgart has been one of the leaders of the ANR DFG WindSHM project in 2014, whereby the University of Nantes took largely on the bio-colonisation aspect.



Situation 2014 :

- Start of monitoring mooring construction in the Floatgen framework (including C. SPRAUL thesis).
- Contacts with FINO (Schleswig Holstein, Germany).

Objectives 2020 :

To participate in two new European projects on the SHM of offshore structures. Particullary for one of them by using the complementary skills of the WeAMEC ecosystem (ONE/GEM, IFSTTAR, ICAM,...) in instrumentation of distributed fiber, and through the acquisition of an innovative high-frequency asking system in 2016 by IFSTTAR.

Results achieved since 2014 :

- 2015: project COST VO_SHM. Network and preparation of a H2020 roadmap is on going.
- 2016 : start of the ITN INFRASTAR project, coordinated by IFSTTAR.
- 2016: EETInet submitted - Interreg Atlantic AREA - Theme of the SHM of port areas.
- 2016: ITN in development on the theme of "reliability-SHM". University of Nantes in collaboration HERIOT WATT University (Glasgow).
- 2016: Setting up H2020 Project "Monitoring Offshore Concrete" (University of Nantes).

4 Synthesis of partnerships

Following the discussions in the RIME meetings, the 6 partnerships with the international ecosystems to focus on have validated in COMOP WeAMEC meeting. These six partners are involved in different levels in 5 themes structuring the international strategy of WeAMEC (test Sites, EMR technology, training through research, biocolonisation and SHM):

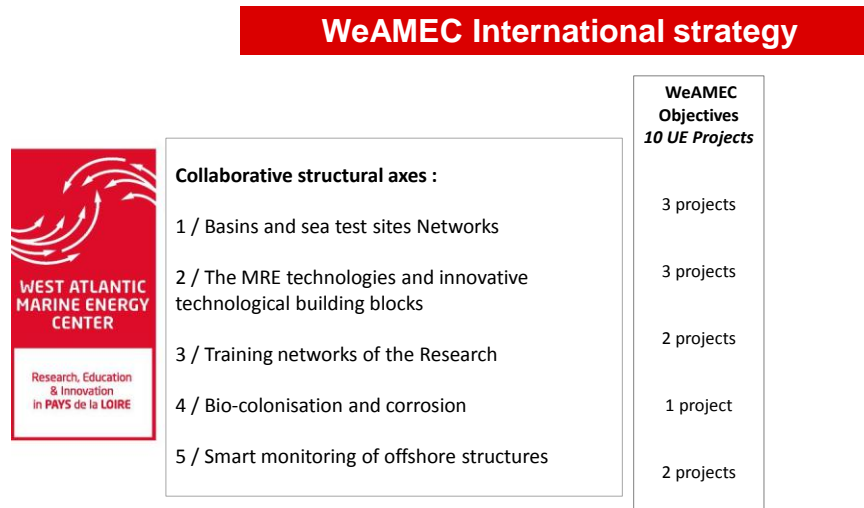
- Danemark : DTU Wind, Aalborg University and DanWEC
- Scotland: Edinburgh University associated EMEC and Flowave
- Germany: Fraunhofer IWES & IEE associated Kiel University, TU Darmstadt and Stuttgart University
- Ireland : MaREI (Marine Renewable Energy Ireland),incluant Cork University, NUI Galway, University college of Dublin, University College Cork / Beaufort Building (dontLiR / National Ocean Test Facility)
- Norway : SINTEF Group, including 7 institutes including MARINTEK and associated with NTNU / Trondheim
- Portugal : WavEC Offshore Renewables.
- USA : The Massachussets ecosystem including the NorthEastern University

Among the six entities identified in the CMI study 5 were used to build structuring partnerships. The Spanish test site of Basque country has been replaced by the WaveEC in Portugal, given the importance of this partner on the axis 'European federation of sea test sites'. For each country concerned, agencies and testing facilities have been grouped in coherence with the perimeter of WeAMEC (research laboratories, test facilities, sea test sites).

These six ecosystems are considered among the most dynamic in Europe. They are more specifically described in annex 2. A quantitative analysis of the patents and publications from these ecosystems conducted in 2016 with the SATT West confirms it.



Collaboration with these ecosystems on the 5 international strategic themes of the WeAMEC is presented in the figure below, with targets of projects by topic:



| PAGE 7
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This is in line with the WeAMEC convention which provides for the participation in 10 European projects over the [2015-2020] period.