Brussels, 13 April 2018

COST 016/18

DECISION

Subject: **Memorandum of Understanding for the implementation of the COST Action "A pan-European Network for Marine Renewable Energy" (WECANet) CA17105**

The COST Member Countries and/or the COST Cooperating State will find attached the Memorandum of Understanding for the COST Action A pan-European Network for Marine Renewable Energy approved by the Committee of Senior Officials through written procedure on 13 April 2018.

COST
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

MEMORANDUM OF UNDERSTANDING

For the implementation of a COST Action designated as

COST Action CA17105
A PAN-EUROPEAN NETWORK FOR MARINE RENEWABLE ENERGY (WECANet)

The COST Member Countries and/or the COST Cooperating State, accepting the present Memorandum of Understanding (MoU) wish to undertake joint activities of mutual interest and declare their common intention to participate in the COST Action (the Action), referred to above and described in the Technical Annex of this MoU.

The Action will be carried out in accordance with the set of COST Implementation Rules approved by the Committee of Senior Officials (CSO), or any new document amending or replacing them:

a. “Rules for Participation in and Implementation of COST Activities” (COST 132/14 REV2);
b. “COST Action Proposal Submission, Evaluation, Selection and Approval” (COST 133/14 REV);
c. “COST Action Management, Monitoring and Final Assessment” (COST 134/14 REV2);
d. “COST International Cooperation and Specific Organisations Participation” (COST 135/14 REV).

The main aim and objective of the Action is to The main aim and objective of the Action is to tackle the current research and techno-economic challenges, bottlenecks and barriers which the marine renewable (wave) energy sector is facing today. For the large-scale deployment of these technologies, an interdisciplinary approach is necessary, by bringing together many different involved stakeholders.. This will be achieved through the specific objectives detailed in the Technical Annex.

The economic dimension of the activities carried out under the Action has been estimated, on the basis of information available during the planning of the Action, at EUR 96 million in 2017.

The MoU will enter into force once at least seven (7) COST Member Countries and/or COST Cooperating State have accepted it, and the corresponding Management Committee Members have been appointed, as described in the CSO Decision COST 134/14 REV2.

The COST Action will start from the date of the first Management Committee meeting and shall be implemented for a period of four (4) years, unless an extension is approved by the CSO following the procedure described in the CSO Decision COST 134/14 REV2.

TECHNICAL ANNEX

OVERVIEW

Summary

The pressure of **climate change** and the growing energy demand has increased interest in marine renewable energy resources, such as wave energy which can be harvested through Wave Energy Converter (WECs) Arrays.

However, the wave energy industry is currently at a **significant juncture in its development**, facing a number of challenges which require that research re-focusses onto a **techno-economic perspective**, where the economics considers the full life-cycle costs of the technology. It also requires development of WECs suitable for **niche markets**, because in Europe there are inequalities regarding wave energy resources, wave energy companies, national programmes and investments. As a result, in Europe there are **leading** and **non-leading** countries in wave energy technology. The sector also needs to increase confidence of potential investors by **reducing (non-)technological risks.** This can be achieved through an **interdisciplinary approach** by involving engineers, economists, environmental scientists, legislation and policy experts etc. Consequently, the wave energy sector needs to receive the **necessary attention** compared to other more advanced and commercial ocean energy technologies (e.g. tidal and offshore wind).

The formation of the **first pan-European Network** on an interdisciplinary marine wave energy approach will contribute to large-scale **WEC A**rray deployment by dealing with the current bottlenecks. The **WECANet** Action aims at a collaborative approach, as it provides a strong networking platform that also creates the space for dialogue between all stakeholders in wave energy. WECANet's main target is the equal research, collaboration and funding opportunities for all researchers and professionals, regardless of age, gender and location.

Areas of Expertise Relevant for the Action	**Keywords**
● Civil engineering: Fluid mechanics, hydraulic-, turbo-, and piston engines ● Environmental engineering: Ocean engineering, sea vessels ● Environmental engineering: Renewable and alternative energy sources (theoretical aspects) ● Electrical engineering, electronic engineering, Information engineering: Energy aspects of electrical and electronic engineering ● Environmental engineering: Maritime and hydraulic engineering	● Marine renewable energy ● energy devices, floating, moored, fixed ● ocean waves ● renewable energy resources ● climate change

Specific Objectives

To achieve the main objective described in this MoU, the following specific objectives shall be accomplished:

Research Coordination

● To offer the necessary focus on wave energy, this Action aims at facilitating the necessary integrated interdisciplinary approach for marine wave renewable energy in Europe through intensive and effective networking based on a strong techno-economic focus, on collaboration between the participating stakeholders, and on exchange of existing knowledge in Europe.

● To enable technology and pave the way for reducing costs, key points for commercialization of wave energy. Research needs to re-focus onto a techno-economic perspective, where the economics considers the full life-cycle costs of the technology. This Action will bring together stakeholders and increase their understanding of the economic perspective.

● To focus on niche EU markets for wave energy technology. This Action focuses on the European case and acknowledges that if wave energy can be demonstrated for small niche technologies then this can progress to the development and deployment of larger and more powerful devices suitable for large-scale energy production.

● To improve risk management practices and to establish (environmental) impact mitigation measures in order to increase confidence for potential investors. This COST Action will approach these issues from a

technical (e.g. hydrodynamics), but also from an environmental, a legislative, political and socio-economic point of view.
● To encourage decision/policy makers to take up new interdisciplinary knowledge that addresses correlation between multi-layer uncertainties and large-scale WEC array or farm deployment, and to raise awareness of energy users and end-users of wave energy R&D and gain their direct support.

Capacity Building
● To provide a platform and forum for efficient networking, exchange of information and communication between stakeholders, and for identification of strategic research needed to deal with challenges and knowledge gaps for promoting deployment and commercialization of wave energy and for advancing the sector. This will enable the necessary interdisciplinary approach.
● To support interdisciplinary education (e.g. through STSMs, Training Schools) and involvement of ECIs (engineers, environmental scientists, economists, etc.) that will better reflect the interconnection of the large number of different aspects (and thus project layers) faced from design to implementation of wave energy deployment.
● To promote and enhance cooperation amongst research institutes and organisations involved in the follow-up of completed and existing, as well as the set-up of new European and (inter)national collaborative projects. This objective aims at opening the gates for future collaboration opportunities with strategic international partners, in strong project consortia.
● To create equal opportunities and support the Action participants in achieving national and European funding through research support to ECIs, PhD students and young professionals. This objective aims to overcome inequalities between countries that are leaders and non-leaders in wave energy, or for countries deeply affected by the economic crisis.
● To carefully balance the gender representation and organise strong participation of women, given the existing inequalities in the sector. This objective will also focus on actively encouraging female participants to take on leadership roles within funding applications for (inter)national research and innovation projects.
● To focus on the dissemination of the Action activities through events for both expert and non-expert audiences, and through creating a website to act as an information gate for many different stakeholders. Open-access joint publications and results' presentations in scientific international and national journals, conferences, workshops, info-days are Action targets.
● To encourage decision/policy makers to take up new interdisciplinary knowledge that addresses correlation between multi-layer uncertainties and large-scale WEC array or farm deployment, and to raise awareness of energy users and end-users of wave energy R&D and gain their direct support.

TECHNICAL ANNEX

1. S&T EXCELLENCE

1.1. CHALLENGE

1.1.1. DESCRIPTION OF THE CHALLENGE (MAIN AIM)

The growing energy demand, the need to reduce greenhouse gas emissions under the pressure of **climate change**, and the shrinking reserves of fossil fuels have all increased the interest in renewable energy. An example of a marine renewable energy resource with high potential, is energy from waves which is harvested through Wave Energy Converters (WECs), devices that convert the kinetic and/or potential energy of waves into electricity. The efficient exploitation of wave energy will require deployment of large numbers of WECs at specific sea sites, arranged in WEC arrays or farms.

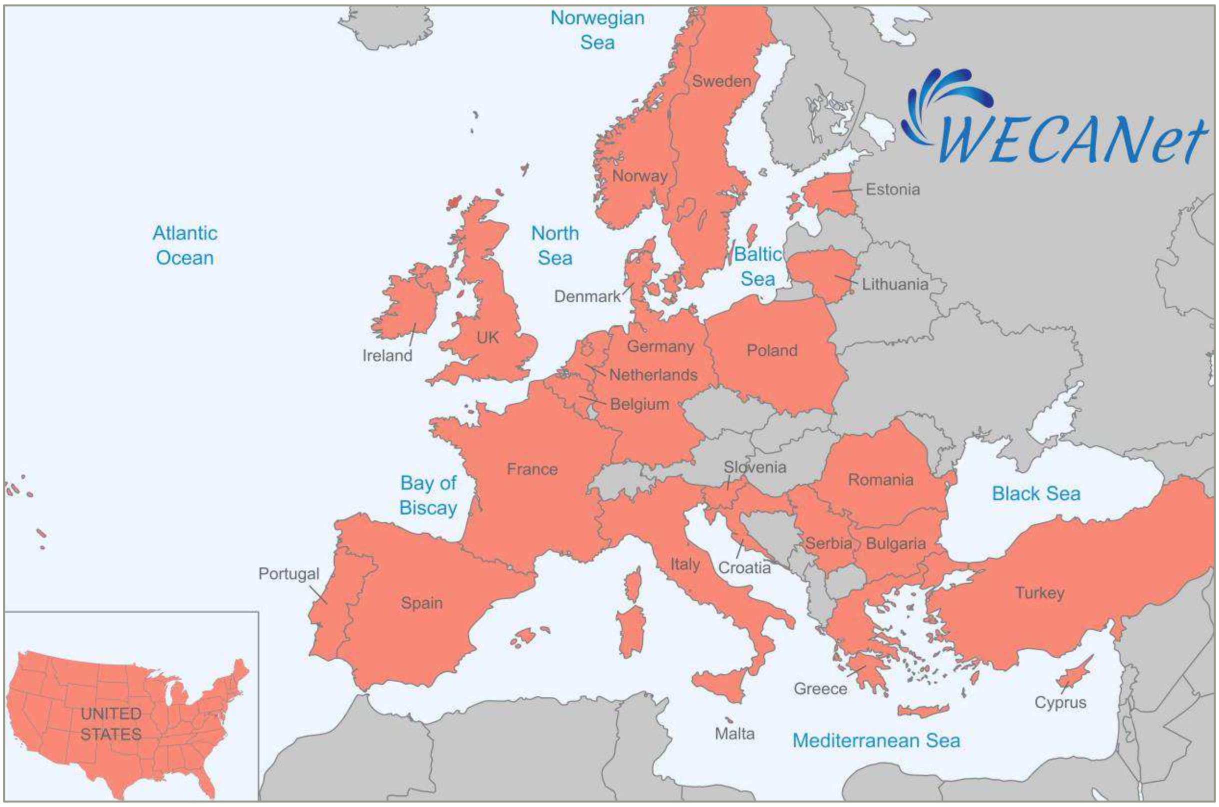


*Figure 1: This COST Action is an initiative by participants from **COST Countries** (in colour), which border open high-energetic oceans, and/or smaller low(er)-energetic seas. Exploitation of the available wave energy potential in Europe requires a **tailored approach, which is the target of this Action**.*

However, the wave energy industry is currently at a **significant juncture in its development**. Over the last 10 years, there has been significant investment in the development of WECs, but little concrete progress appears to have been made. Whilst the commercial development of wave energy is not a direct research challenge, it is important that research undertaken supports the wave energy industry in reaching commercialization, otherwise wave energy is in **danger** of becoming irrelevant.

A review of the current state of wave energy, indicates that a large number of researchers work on the prediction of the hydrodynamic performance of WECs, as well as on the structural loads that they are likely to experience. In addition, there is a significant amount of research supporting the optimal design and control of WECs from a power performance perspective. Nevertheless, looking at the abandonment of recent WEC prototypes, it was typically not the power performance that was an issue, but engineering details such as the performance of structural elements of the WECs, as well as the complexity of offshore operations which create major **challenges** regarding large-scale deployment. In addition, solving survivability issues of WECs that operate mainly in 'hostile' high-energetic wave climates, as well as minimizing the **'cost of energy'** are key elements for the commercialization of wave energy. Effectively, research needs to re-focus onto a techno-economic perspective, where the economics considers the full life-cycle costs of the technology.

Whilst some of this research may be done in the laboratory or using computer modelling, it will also require the deployment of prototypes both to help identify the key issues, as well as to investigate potential solutions. It is suggested that for practical and economic reasons these prototypes should be relatively small, but necessarily, fully-operational devices. This means the research focus, at least in the short- to medium-term needs to move from large-scale wave energy exploitation (and thus mainstream technologies developed for areas of more energetic wave conditions, which pursue device commonality through design consensus) to the **challenge** of developing WECs and tailored practices suitable for **niche markets**. However, in Europe, wave technologies and companies operating in the sector come from the countries which are currently considered as **leaders** in ocean technology, namely the United Kingdom, Denmark, Norway, Sweden, Ireland, Finland, Portugal [Magagna & Uihlein, 2015]. In terms of national programmes or investments, the same countries are leading in the ranking. It can be observed that countries along the Atlantic Arc are those with a larger market or energy resource or investments since the European seas (e.g. the Mediterranean) offer less of a resource. Hence, there is a need for a focus on the research and technological **challenges** that take into account the wave energy potential inequalities between European countries bordering open high-energetic oceans and those bordering smaller low(er)-energetic seas (Fig. 1). This has the potential to become an interesting niche positioning for the local industries of these countries. This is not to argue that research should be defined by commercial requirements, but recognises that if wave energy can be **demonstrated** for small niche technologies then this can progress to the development and deployment of larger and more powerful devices suitable for large-scale energy production.

Another major **challenge** is reducing the uncertainties related to the above research and technological issues, as well as mitigate possible environmental impacts, in which an interdisciplinary approach plays a significant role. In the different layers of the project design, a large number of experts are involved (from engineers, to biologists and economists) and success will only be achieved with the required degree of inter-relation and communication. Adopting a **holistic approach** and taking into account the main cost-drivers and impacts of wave energy projects, will lead to **reducing risks** in costs for potential investors. In other words, one of the main challenges is to increase reliability of wave energy projects and, thus, **increase confidence of potential investors**.

An additional **challenge** that the wave energy sector is facing today, is the comparison often made to other "ocean renewable energy" sectors and, in the worst case, its inclusion to a wider-scope group of "ocean energy" technologies (tidal, offshore wind, floating photovoltaics, etc.). Due to the fundamental differences between these technologies, and the challenges they are facing (as they are all emerging technologies), generalising under the common lens of "ocean energy" creates additional **dangers** for wave energy. For instance, **fundamental differences between wave and tidal** energy converters, including how they interact with the natural environment, as well as the different tools employed for their study, design and deployment, require separate treatment of these technologies. In other words, an "ocean energy" approach, instead of a "wave energy" approach does not ensure the necessary attention and the "in-depth" analysis which is crucial for wave energy development. On the contrary, it creates a larger gap between wave energy and the other technologies, than actually bridging it. This gap is illustrated in the recent findings by the European Environmental Agency [EEA, 2017] where it is clear that wave energy investments and consumption are the lowest (yet with highest future expectations), compared to other renewable energy industries, especially tidal and offshore wind. Moreover, as mentioned in the previous paragraph, for the European case there is a need to distinguish between wave energy exploitation in the ocean and the seas due to differences in the intensity of wave energy resources. This is an additional reason why the **"ocean energy" approach is not suitable**.

Another **challenge**, directly related to the **COST Missions and Policy**, is dealing with bottlenecks that prevent the efficient use of human resources for European science. These bottlenecks are related to:

- **Lack of efficient networking and communication**. Research often does not have the expected impact on industry, policy- and decision-makers, and this creates further technological bottlenecks and research valorisation barriers. This is partly the result of lack of communication, lack of an interdisciplinary approach and of insufficient flow of information between the involved stakeholders.
- **Lack of access to high-level, state-of-the-art research facilities and infrastructures** (e.g. for numerical and experimental modelling of WECs) for talented and creative researchers and ECIs (Early Career Investigators), especially from ITCs (Inclusiveness Target Countries), from non-leading countries in wave energy, and from countries deeply affected by the recent economic crisis.
- **Researcher age**. Wave energy is an emerging sector and still limited in terms of involved human resources compared to other energy sectors, and thus senior researchers stand often in the spot light. As a result, ECIs compared to their senior colleagues, have often limited access to strategic networking opportunities where they can contact important stakeholders. This leads to less opportunities for collaboration with strategic international partners, which makes them and their research less attractive for future strong project consortia and for receiving national and European funding.
- **Location** in terms of inequalities of available wave energy resources across Europe, which results in **lack of effective collaborations** involving more countries than the current **leaders** in wave energy investments and in European and national funding (see previous paragraph on niche markets). As a result, researchers based in countries that are **non-leaders** in wave energy have also less opportunities.
- **Gender**, given the existing inequalities in all engineering sectors, and in particular in wave energy.

1.1.2. RELEVANCE AND TIMELINESS

Addressing climate change requires a globally coordinated, long-term response across all involved sectors. The 2015 Paris Agreement provides the framework for limiting global warming. Article 194 of the Lisbon Treaty on the Functioning of the European Union (-*EU energy policy is aimed at promoting the development of new and renewable forms of energy*-) is the legal basis and sets objectives of Renewable Energy in the European. The existing Renewable Energy Directive (Directive 2009/28/EC, repealing Directives 2001/77/EC and 2003/30/EC), established that a mandatory 20% share of European energy consumption must come from renewable energy sources by 2020. **Looking towards the future**, Europe has started preparing for the period beyond 2020, in order to provide early policy clarity on the post-2020 regime for investors. Renewable energy plays a key part in the Commission's long-term strategy as outlined in its 'Energy Roadmap 2050' (COM(2011) 0885). The decarbonisation scenarios for the energy sector proposed in the roadmap point to a renewable energy share of at least 30% by 2030. However, the roadmap also suggests that the growth of renewable energy will slacken after 2020 **unless there is further intervention**. On 30 November 2016, the Commission published a legislative package entitled 'Clean energy for all Europeans' (COM(2016) 0860) as part of the broader Energy Union strategy (COM(2015) 0080). It includes a revised Renewable Energy Directive to make Europe a global leader in renewable energy and to ensure that the target of at least a 27% share of renewables in the total amount of energy consumed in Europe by 2030 is met. **Supporting policies:** Making electricity infrastructure fit for the large-scale deployment of renewables is among the primary goals of the Energy Union strategy (Fact Sheets 2017, 5.7.1- Energy Policy), and is further supported in the 'Energy Roadmap 2050' and the 'Energy Infrastructure Package' (5.7.2-Internal Energy Market). The promotion and development of new-generation renewable technologies is also one of the key elements of the Strategic Energy Technology Plan or SET-Plan (5.7.1- Energy Policy). On 20 January 2014, the Commission set out an action plan to support the development of ocean energy, including that generated by waves, tidal power, thermal energy conversion and salinity gradient power (in its communication entitled 'Blue Energy: Action needed to deliver on the potential of ocean energy in European seas and oceans by 2020 and beyond' (COM(2014) 0008)). This 'Blue Energy' action plan guides further development of the ocean energy sector. Its completion in the period 2014-2017 should help the industrialisation of the sector, so that it can provide cost-effective, low-carbon electricity as well as new jobs and economic growth for the European economy. At the regional level, several regions have included marine technology as a policy priority aligned with the "Blue Growth" European priority and the sub-priority of "Blue Renewable Energy". "Blue Growth" is the long term strategy defined by the European Union in 2012 to support sustainable growth in the marine and maritime sectors. It is the maritime contribution to achieve the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth whereby seas and oceans are identified as key drivers for the European economy with potential for innovation and growth. Common goals are best served through a **coordinated and inclusive approach**. Although today the ocean energy sector is relatively small, it could expand to contribute to economic growth and job creation in Europe. The sector could also contribute to the EU's 2050 greenhouse gas reduction ambitions **if the right conditions are put in place now**. Ocean energy should, in the medium to long term, be able to achieve the necessary critical mass for its commercialisation and become another European industrial success story.

Necessary cooperation mechanisms: The Renewable Energy Directive **promotes cooperation amongst European Countries** to help them meet their renewable energy targets, through joint renewable energy projects and joint renewable energy support schemes. This COST Action is then **built upon** all the above mentioned **European targets**.

1.2. OBJECTIVES

1.2.1. RESEARCH COORDINATION OBJECTIVES

A strong networking platform organised in a **S.M.A.R.T.** way that focuses on the current **challenges, bottlenecks and barriers** as identified in Section 1.1.1, will accelerate the current development of wave energy research and of the wave energy industry. This is the main drive for creating this COST Action. The **primary Research Coordination Objectives (i – v)** of this COST Action are presented below:

i) To offer the necessary focus on wave energy: one of the main objectives of this COST Action is to facilitate the necessary integrated interdisciplinary approach for marine wave renewable energy in Europe through intensive and effective networking based on a strong techno-economic focus, and on collaboration between the participating stakeholders. Also a target of this COST Action is the exchange of existing knowledge in Europe, regarding not only research but also practical or field experience by e.g. closing the gap in between researchers, policy makers and industrial partners. These **specific** targets are **achievable** only through a COST Action dedicated to the wave energy sector and its efforts to remain **relevant** based on **measurable** progress indicators. This is a critical **time** for the sector, and today **this COST Action is more necessary than ever** as illustrated in Section 1.1.

ii) To enable technology and pave the way for a positive economic perspective: installation practices and procedures are currently sub-optimal in terms of safety, practicality and cost. In line with the supply chain, the array development is a key factor for both reaching optimal size of installation and attracting the energy sector. Optimization of O&M is also necessary. In addition, and in order to achieve the sector engagement it is essential to achieve a grade of commonality that will enable the supply chain, allowing companies to improve their R&D results in a subsequent stage. Consequently, research needs to re-focus onto a techno-economic perspective, where the economics considers the full life-cycle costs of the technology. **This COST Action aims to bring together stakeholders and increase their understanding of the economic perspective**, in order to contribute to achieving this goal.

iii) To focus on niche European markets for wave energy technology. The need for reaching the quoted grade of commonality will lead to a design consensus required at this stage of the wave energy market. However, in a future mature market, the transition from commonality to freedom of design has the ability to promote the mature market by supporting the generation of tailor-made solutions for each application or site suitable for niche markets in Europe. **This COST Action focuses on the European case** and acknowledges that if wave energy can be **demonstrated for small niche technologies then this can progress** to the development and deployment of larger and more powerful devices suitable for large-scale energy production.

v) To improve risk management practices and to establish (environmental) impact mitigation measures in order to increase confidence for potential investors. This can be achieved through exploring and supporting e.g. new business models for facilitating risk-sharing under the appropriate political framework, and through adopting a holistic approach for wave energy. This pathway, will allow setting up the next generation of systems capable of reducing the ratio cost – performance (ORE, 2015). Moreover, more realistic and flexible environmental legislation [MacGillivray et al. 2013] in accordance with the level of wave energy development will contribute to the sector progress. This COST Action will tackle these issues as a large number of the participants investigate the possible (environmental) impact of WEC arrays/farms, from a technical (e.g. hydrodynamics), but also from an environmental, a legislative, political and socio-economic point of view. Another pathway for reducing uncertainties has directly to do with the numerical and experimental modelling at the design level of WECs or WEC arrays. As currently there is no full-scale and very limited small-scale data available for WEC arrays, the hydrodynamic numerical models currently employed in the sector are lacking validation. **This COST Action focuses on improving risk management practices, establishing impact mitigation measures and increasing the reliability of wave energy models** through core Action activities.

In **Section 3.1.1** a number of **secondary objectives** are defined within the Working Groups descriptions and how these secondary objectives will be organised in order to achieve the primary Research Coordination and Capacity-Building Objectives, while generating measurable Action outcomes.

1.2.2. CAPACITY-BUILDING OBJECTIVES

This COST Action provides the necessary opportunities for researchers and other professionals involved in the wave energy sector to meet and cooperate. The **primary Capacity-Building Objectives (1-8)** of this Action are **fully based on the COST Mission** and are presented below:

1) To provide a platform and forum for efficient **networking**, **exchange of information** and identification of **strategic research** needed to deal with challenges and knowledge gaps for promoting deployment and commercialization of WEC arrays and advancing the sector. It is of great importance that the participants share feedback from completed or running research and demonstration projects and experiences from the **'lessons learnt'**, but also that talented European researchers of all ages and gender can present new research plans and ideas. Through networking between researchers, industrial partners, policy- and decision makers and other wave energy stakeholders, the necessary communication, interdisciplinary approach and flow of information between the involved stakeholders will be achieved. These networking activities also have the aim to reach out to new participants and extend WECANet in order to include as many as possible wave energy stakeholders.

2) To support interdisciplinary education and involvement of ECIs (engineers, environmental scientists, economists, etc.) that will better reflect the interconnection of the large number of different issues (and thus project layers) faced from design to implementation of wave energy deployment. This will be achieved through Short Term Scientific Missions (STSMs) and Training Schools that will, for example, bring ECIs and many Action participants who have no access to research facilities, in contact with state-of-the-art infrastructures owned by several other Action participants. A large number of Early Career Investigators (50%) are already committed in this Action, as well as many infrastructure owners.

3) To promote and enhance cooperation amongst the participating research institutes and organisations involved in the follow-up of completed and existing, as well as the set-up of new European and (inter)national collaborative projects (e.g. within European Programmes open to all researchers: HORIZON2020, HYDRALAB+, MaRINET2, etc.). These collaborations often include joint doctoral research where international experts are directly or indirectly involved, commercial projects with a strong open-access research aspect, etc. This objective aims to open the gates for future collaboration opportunities with strategic international partners and in strong project consortia, which is of great importance for ECIs and young professionals in terms of research and innovation valorisation.

4) To provide support to the participants for achieving national and European funding through research support to ECIs, PhD students and young professionals, e.g. by organising STSMs. This objective aims to overcome inequalities between countries that are leaders and non-leaders in wave energy, or even for Inclusiveness Target Countries (ITCs, which have already a strong representation in WECANet (50%)) and countries deeply affected by the economic crisis, and thus offer equal opportunities to the involved researchers in terms of applying for and obtaining national and European funding.

5) To carefully balance the gender representation. WECANet has already organised strong participation of women (29%), given the existing inequalities in the sector. In order to encourage further female participation, the Action has established dedicated teams both from the academic and the private engineering sector, with expertise in gender inclusiveness policies, female entrepreneurship and leadership, and active in women engineering associations. This objective will also focus on actively encouraging female participants to take on leadership roles within funding applications for (inter)national research and innovation projects. The Main Proposer of the Action is a female Early Career Investigator, and many female participants are committed to undertake key roles in the achievement of this objective.

6) To focus on the dissemination of the COST Action activities through events, Training Schools for both expert and non-expert audiences, and through creating a website for this COST Action to act as an information gate for many different stakeholders. Dissemination of the Action outcomes will be realised through open-access joint publications and joint results' presentations in scientific international and national journals, conferences, workshops, info-days, etc.

7) To encourage decision/policy makers to take up new interdisciplinary knowledge that addresses correlation between multi-layer uncertainties and large-scale WEC array deployment, and **to raise awareness** of energy users and end-users of wave energy R&D and gain their direct support.

In **Sections 2.2** (specification of impacts) and **3.1.1** (Working Groups) more information is provided. Most of the objectives will be achieved not only over the duration of this COST Action but they will also continue after the COST Action is completed. There is a continuous need for dealing with the challenges which the wave energy sector faces throughout both the European and beyond and this need will be met through the network of researchers and stakeholders that will evolve through this COST Action.

1.3. PROGRESS BEYOND THE STATE-OF-THE-ART AND INNOVATION POTENTIAL

1.3.1. DESCRIPTION OF THE STATE-OF-THE-ART

Early estimations of the global wave energy resources [Isaacs & Schmitt, 1980] have indicated the great potential of wave energy, which is today estimated (Fig. 2) at about 3.7 TW [Pecher & Kofoed, 2017; Mørk et al., 2010]. From Fig.2, **it is clear that Europe includes both high- and low-energetic seas**.

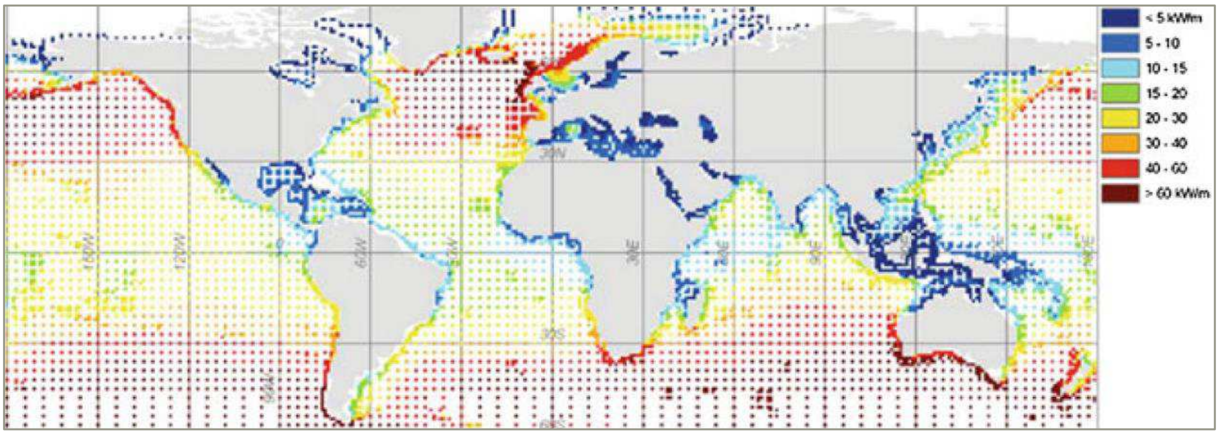


Figure 2. Annual global gross theoretical wave power for all WorldWaves grid points [Mørk et al., 2010].

The efficient exploitation of wave energy will require deployment of large numbers of WECs at specific sea sites, arranged in WEC arrays which will then be grouped together in larger WEC farms. As development continues in WEC technology there is an increasing interest in investigating how WECs interact with one another, and with the environment. The understanding of interactions between WECs is vital to support WEC array and farm design as commercialisation of WEC technologies progresses. Nowadays, many researchers investigate the performance of WEC arrays/farm [Folley, 2016] and WEC interaction [Stratigaki et al. 2014; Rawlinson, et al. 2010], but also their possible impact (environmental, socio-economic, on marine ecosystems etc.) [Tsani & Koundouri, 2016; Pistocchi et al., 2017].

Key findings for the EU and its Member States (recent report by EEA, 2017) show that today, Renewable Energy Sources (RES) have become a major contributor to the energy transition occurring in Europe. In 2015, renewable energy accounted for the majority (77 %) of new European generating capacity for the eighth consecutive year, which has already resulted in Green House Gas (GHG) emissions reductions in the European electricity sector. Key findings for RES in a global perspective, illustrate that global investments in renewables have shown steady growth for more than a decade. This led to a doubling of global renewable electricity capacity between 2005 and 2015. During this time, RES capacity increased across most parts of the world. According to the IEA Renewable Power Generation 2015 scenario [IEA, 2015], Ocean Energy Technologies, including those based on wave energy, will be **part of the energy mix** in 2025. According to the IRENA 2014 report, global installed wave power capacity could reach ~500 GWe, however based on Bloomberg findings and expectations by the Ocean Energy Europe (OEE), development targets for WECs have reduced in the past years, while the IEA (2015) report also states that currently the technology development and projects are not on track compared to what was initially foreseen, and that the **wave energy sector is lagging compared to tidal and offshore wind**.

Regarding utilization of wave energy for electricity production, the current state is that the technologies are not yet mature [Pecher & Kofoed, 2017] which **proves the importance of a COST Action dedicated to the wave energy sector**. A number of full scale demonstration projects exists, but these are generally still in the R&D phase (in which Europe is a world leader), with some of them expected to become operational by 2020. Currently there are 21 active wave energy projects installed in the seas worldwide [European Commission Joint Research Centre (JRC), 2014], while a number of array projects are moving forward (in Australia, in Scotland and in Portugal). CAPEX, O&M and LCoE figures for WECs are still estimations [JRC, 2014], however, **efforts** to reduce costs through optimization of structures, operation, control, economic approach etc. are expected to reduce the **'cost of energy'** to a level which at least is comparable with other more mature RES technologies (such as tidal and offshore wind).

1.3.2. PROGRESS BEYOND THE STATE-OF-THE-ART

In the context of **efforts to reduce the 'cost of energy'**, this COST Action aims to advance the field of wave energy utilization in order to overcome the main barriers and needs the sector is facing (see Section 1.1.1 and [MacGillivray et al. 2013]).

This Action will deal in detail and in-depth with these challenges. In Fig. 2 the inequalities in wave energy potential across Europe are depicted, which reveals the necessity for developing WECs, and research and project practices suitable for niche European markets, yet respecting a degree of consensus in the whole process which is also necessary for achieving large-scale commercialisation. Fig. 1 shows that many European countries border open high-energetic oceans, and/or smaller low(er)-energetic seas. Specifically, the different European study cases and sites in this COST Action target the Atlantic Ocean, the North Sea, the Baltic Sea, the Black Sea, the Aegean Sea, the Mediterranean Sea, the Adriatic Sea, the Tyrrhenian Sea, the Norwegian Sea, while for the USA more oceans/sea areas are involved. These sites do not only differentiate in terms of wave conditions, but also in terms of bathymetry (e.g. underwater cliffs should be avoided which create constraints for WEC installation, moorings and cable laying); in terms of ecosystems and environmental permissions (e.g. exclusion zones for rare seabed life, migration routes, archaeology, abandoned munitions) and in terms of country economic policy and renewable energy targets, etc. All these different factors affecting wave energy will be **tackled in this COST Action** based also on the specific study cases and characteristics for each country.

All Working Groups of this Action are based on innovative interdisciplinary approaches. An example refers to numerical and experimental modelling techniques, for which this Action has dedicated Working Groups to deal with core issues and knowledge gaps. For instance, a large number of researchers develop numerical models, yet there is a need for an understanding of the pros and cons of each method and their ranges of applicability. Significant improvements in modelling will lead to reducing part of the uncertainties related to wave energy projects, which is currently one of the important barriers.

More than 100 experts have joined forces and initiated this COST Action, all of them being very familiar with the local wave and coastal conditions of their countries, as well as with the local environmental, policy, legislative and financial situation, which are all crucial for the design and deployment of wave energy projects. This **COST Action is unique** as it includes as many as possible stakeholders, it adopts an interdisciplinary approach and it ensures a strong research base.

1.3.3. INNOVATION IN TACKLING THE CHALLENGE

The Action´s innovation potential lies in three major areas situated within its key objectives:

a) The forging of a **new pan-European Network for marine renewable energy with focus on Wave Energy** that will sustain beyond the duration of the Action and its funding cycle: recent questions focus on how to best integrate the different study and design layers involved in wave energy technologies. In part, the challenge lies in the differences of the distribution of the wave energy potential (Fig. 2) in space but also in time. Thus, the primary innovation capability - apart from its scientific impetus - can be found in how the network itself has been assembled, combining researchers and wider stakeholders that work on significant wave energy design phases from many countries around the shores of Europe (Fig.1).

b) The advancement of **inter- and multidisciplinary concepts** and methodologies for research, with particular attention paid to e.g. numerical and experimental modelling using experiences and practices from different engineering disciplines (e.g. combining the knowledge of naval architects on floating bodies with the knowledge of: coastal engineers on coastal processes, electrical and mechanical engineers on Power-Take-Off (PTO) systems, structural, chemical and material engineers on structural aspects of the WECs and mathematicians on mathematical models, etc.). Moreover this COST Action aims to combine different sciences (e.g. engineering with economics, environmental sciences, biology and ecology, policy, law, social sciences) as wave energy research has suffered from a lack of conceptual integration with necessary considerations, at different project levels.

c) Increased actor involvement: To establish a forum and network for discussion and communication between stakeholders and researchers active in wave energy. Most large seas in Europe border on several countries and therefore require concept practices that can be applied for groups of countries. To achieve this, scholars from different countries must be able to collaborate. Among these countries, not only are institutional contexts different but also economic circumstances. Networking will serve to develop approaches for wave energy that are applicable for Europe (and beyond). Practical experiences of stakeholders involved will support contextual issues in the debate.

1.4. ADDED VALUE OF NETWORKING

1.4.1. IN RELATION TO THE CHALLENGE

The **added value of networking** is already provided through Section 1.2, where the role of this COST Action to deal with the current bottlenecks through its primary objectives is described in detail. The formation of the first pan-European network on an integrated marine wave energy approach attends to the challenge of achieving large-scale array and farm deployment by dealing with the current bottlenecks through a **transdisciplinary lens**. This Action targets the forging of a collaborative approach, as it provides a broad range of network features and activities that not only facilitate scientific meetings and written output, but also creates the space for dialogue between all stakeholders in wave energy.

Furthermore, it raises public awareness and supports interaction and broader civil society engagement through public info-days and outreach initiatives. WECANet offers an inclusive space that connects stakeholder nodes cross-cutting local, national, regional and global scales, and across a variety of thematic areas. This COST Action also ensures how its findings can be communicated to significant state, private sector and civil society stakeholders in a timely and efficient manner through its networking tools. Additionally, it pools together diverse sub-disciplines and core forms of expertise cross-cutting the environmental, social and economic dimensions of wave energy projects. These interdisciplinary mixes include all the different areas of expertise mentioned in Section 3.3 (“WECANet Network as a whole”). Ultimately, a configuration such as this sets the trajectory for the continuation of an interdisciplinary dialogue and a common research agenda among all the involved participants, through the mapping of synergetic topic areas and foci that **only a network of this scale can establish**.

1.4.2. IN RELATION TO EXISTING EFFORTS AT EUROPEAN AND/OR INTERNATIONAL LEVEL

This is the first **COST Action on Marine Renewable Energy with a focus on wave energy**. Projects on wave energy which have been completed include WAVEPLAM, with the main objective of introducing wave energy sources into the European renewable energy market, from a marketing point of view, and SOWFIA, which collected data on environmental, social, and economic impact assessments.

On the other hand, regarding **“ocean renewable energy”**, there are already **several projects or networks**, however all of them are **missing** the techno-economic and research focus, as well as the **interdisciplinary and multi-layer approach, which are the pillars of this COST Action**. Ocean Energy Europe and Forum (OEE) is an association of professionals from the entire ocean energy sector, which focuses on ocean energy policy and the industry. OEE deals with five different renewable energy technologies and coordinates the SI Ocean project (completed) as well as TP Ocean, which is an advisory body to the Commission and defines technology priorities for research programmes such as Horizon2020. The European Energy Research Alliance (EERA) includes public research centres and universities. It has a very wide scope as it deals with all energy-related research topics (not only marine renewables). The OES is an intergovernmental collaboration programme between countries, which operates under framework established by the International Energy Agency in Paris, and deals with ocean energy technologies. INORE is a network of postgraduate researchers working with issues related to offshore renewable energy. DTOcean, an FP7 European collaborative project, aimed at the industrial development of ocean energy power generation, and provided design tools for deploying the first generation of wave and tidal arrays. FORESEA, MaRINET2 and HYDRALAB+ aim at supporting the development of marine energy technologies and coastal structures by providing access to test facilities and sites through programmes of competitive calls. OCEANERA-NET launches transnational competitive joint calls for funding collaborative R&D in ocean energy. EquiMar (completed in 2011) allowed testing of ocean energy technologies in terms of performance, cost and environmental impact. The FP6 CA-OE project (completed in 2007) aimed at developing a common knowledge base necessary for coherent development of policies in European, dissemination of this knowledge base and promotion of ocean energy technologies. The MERMAID project took into account socio-economic and environmental pressures on the oceans and marine ecosystems, however it focused on offshore platforms.

This **WECANet** COST Action addresses the wave energy sector with a strong emphasis on multidisciplinary approaches. It gathers together perspectives from the fields of engineering, socio-economics, law, environmental sciences, that have not extensively been included in the previously mentioned projects. Furthermore, it focusses on the active role of stakeholders in all planned activities.

2. IMPACT

2.1. EXPECTED IMPACT

2.1.1. SHORT-TERM AND LONG-TERM SCIENTIFIC, TECHNOLOGICAL, AND/OR SOCIOECONOMIC IMPACTS

Section 1.2 provides information on impacts of this Action through achieving its objectives. In the present section the impacts are extended to:

SHORT-TERM IMPACT

a. Science and Technology:

- Place attention on the urgent needs of the wave energy sector and contribute in its progress;
- Advancement of multi-layer scientific approaches to wave energy sector with regard to technological, environmental, socio-economic etc. viability;
- Deriving integrative concepts and tools for wave energy applications to increase investors' confidence;
- Common research agenda: The synergies between disciplines leads to more effective and efficient research and finally better practical implementation of its results. A first step towards such a common research agenda are guidelines to be prepared for modelling and designing WEC arrays, as well as collaboration within projects and national and European funding applications;
- Interdisciplinary knowledge production: by bringing together stakeholders and practitioners, the COST Action contributes towards the co-creation of scientific and practical knowledge, which may be immediately relevant for developing novel approaches;
- The creation of inter- and multidisciplinary research clusters to nurture local and regional research.

b. Socio-economic impact:

- Focus on wave energy and on niche European markets from a techno-economic perspective;
- Provide access of ECIs and other researchers to state-of-the-art European infrastructure;
- Provide equal research, collaboration, -finaland funding, professional opportunities for all researchers regardless of age, gender and location;
- Advancement of an inter- and multidisciplinary knowledge-based and evidence-led approaches to the implementation of wave energy projects;
- Developing capacities on inclusive multidisciplinary practices for ECIs and mechanisms to involve ITCs, countries non-leader in wave energy, as well as countries affected by the economic crisis;
- Strengthening cross-sectoral cooperation between state and non-state actors with regard to strategies supporting Blue Growth and Blue Energy.

LONG-TERM IMPACT

c. Science and Technology:

- Establishing an internationally recognised network for research, publishing, advice and guidelines;
- Sustaining a generation of Early Career Investigators and young professionals familiar with approaches to integrated and multi-disciplinary practices for wave energy;
- Increase of successful wave energy projects: the WECANet focuses on the current challenges and bottlenecks of the wave energy sector and makes an important contribution to solving main problems.

d. Socio-economic impact:

- Strengthening pathways that promote cross border and multi-disciplinary cooperation on marine renewable energy themes;
- Developing mechanisms to sustain inclusive multidisciplinary practices for ECIs, ITCs, etc.;
- Awareness raising: wave energy developers, industry, governments, NGOs and engineers will be made aware of the WECANet results, which is vital for the efficient development of the sector.

2.2. MEASURES TO MAXIMISE IMPACT

2.2.1. PLAN FOR INVOLVING THE MOST RELEVANT STAKEHOLDERS

In order to realize the long- and short-term impact, WECANet has developed a **Stakeholder Outreach and Engagement Strategy**. Interested stakeholders will be regularly updated through its quarterly digital newsletter and website. Stakeholders may also choose to attend the two international Action Conferences, working-level Interdisciplinary Workshops etc. Four target groups of stakeholders are identified: **1)** Wave energy developers and supply chain; **2)** End-users (investors, insurance companies, utilities, energy companies, offshore industries and service providers); **3)** Policy makers and NGOs (on the national and international level); **4)** Scientific community, educational institutes and engineers.

The WECANet kick-off meeting maps a broad range of relevant institutional stakeholders in ways that crosscut the thematic areas of all 4 WGs. The local, national, regional and international landscape of governmental and non-governmental stakeholders will be charted in an inventory made available to the COST Action participants.

2.2.2. DISSEMINATION AND/OR EXPLOITATION PLAN

The dissemination and uptake of research findings and other deliverables/outcomes from the networking initiatives are integral to the success of this COST Action. Key research and industry-oriented outputs are communicated directly to relevant stakeholders and will be made available on the WECANet website. To ensure this, a collaboratively appointed **Stakeholder Relations Coordinator**, based on the input of the Working Groups, will develop and oversee implementation of a **Common Outreach and Dissemination Plan**. Moreover, many WECANet participants have access to and organise several working platforms which offer expertise to supply support to scientific, demonstrative and educational projects; to interlink the business and research communities; to support fundamental and applied research in wave energy and to stimulate the innovation and implementation of wave energy technologies. These platforms enjoy governmental and European support. Moreover, the WECANet public **Stakeholder Outreach and Engagement Strategy** goes beyond this COST Action’s immediate scientific and networking activities and core deliverables. These include:

a. Cross-sector and multi-stakeholder dialogue through interdisciplinary **workshops**;
b. Quarterly WECANet Newsletters (in digital format) that are specifically targeted at identified clusters both regionally as well as internationally;
c. The WECANet Website that acts as the main public relations organ (integrating google & google scholar friendly programming) for all WECANet events, outreach activities, publications;
d. Public Representation made by Action participants within broader conferences and policy fora (OEE, EWTEC, ICOE, Renewable UK, THETIS MRE, OMAE, ISOPE, etc.).
e. Regarding the dissemination of findings within the scientific community the Action plans two special issues in peer-reviewed research journals, such as Renewable Energy, Ocean Engineering, Science of The Total Environment, Environmental Science & Policy etc.
f. An **Action book** will document and reflect on the most important findings, guidelines, practices, etc. The book will target a wide audience with an interest in marine renewable (wave) energy.

2.3. POTENTIAL FOR INNOVATION VERSUS RISK LEVEL

2.3.1. POTENTIAL FOR SCIENTIFIC, TECHNOLOGICAL AND/OR SOCIOECONOMIC INNOVATION BREAKTHROUGHS

WECANet has a high potential for socio-economic and technological breakthroughs with a minimal level of risk. The main breakthrough accomplished by the action will be an increased awareness of the potential to efficiently exploit wave energy through advanced approaches. The WECANet’s innovation outcomes primarily comprise scientific findings and technology insights, being in line with current state-of-the-art research. The risks however, that are associated with network innovation, largely comprise relational aspects between the Action participants. The countervailing measures built into the network structure are two-fold. First, the COST Action is guided by clear coordinated leaders through the Management Committee (MC), the Action Chair and Vice Chair. Second, the WECANet initiative itself is a grown network and its interaction and output derives from participants bringing their own knowledge into the Action. Given the decentralised and inclusive mode of production within and between WGs, the network strives to reduce two organisational risks: hierarchies on the one hand, leading to shortcomings such as participant disengagement, and the lack of groundedness and diffuse responsibility on the other.

3. IMPLEMENTATION

3.1. DESCRIPTION OF THE WORK PLAN

3.1.1. DESCRIPTION OF WORKING GROUPS

This Action consists of Working Groups (**WGs**), whose interaction will be regulated by the Management Committee (**MC**) through the **COD** (COST Action Coordination and Dissemination) activities. Each WG and the COD will have a specific function and focus as described in the following:

COD – COST Action COordination and Dissemination: Coordination activities are undertaken by the Steering Committee (**SC**) of this Action throughout its entire duration, e.g. web-site development, Training Schools, STSMs, newsletter production, annual report development, MC meetings organization and the organization of the Final Conference. Also, the final report for stakeholders and policy-makers will be coordinated by the SC. Other important tasks of COD are to ensure an easy flow of information between the different WGs, and to identify and discuss funding and collaboration opportunities on wave energy projects. Dissemination of information and knowledge gathered during the Action will be addressed to wave energy communities, public authorities, developers and industry, covering a large part of the WECANet metrics (Key Performance Indicators) e.g. in terms of publications, education activities etc. The dissemination tasks within WECANet are presented in detail in Sections 2.2.1 & 2.2.2. The COD will ensure coordination, management and communication (internal and external communication of WECANet). Communication and interaction between the WGs will ensure the targeted integrated techno-economical approach of wave energy in Europe (interaction between hydrodynamics, array optimization, concept and PTO optimization, economics, policy, legislation, etc.).

WGs 1-4: Common secondary objectives and sub-Tasks to support achievement of the specific Tasks in each WG:

a. Discuss current research topics/questions/issues
b. Map wave energy related research activities and projects of participants across Europe
c. Discuss publications (published or in-preparation) and technical reports
d. Establish a wave energy research literature database
e. Review techniques, methodologies and approaches employed for wave energy research
f. Share expertise in techniques, methodologies and approaches employed for wave energy
g. Identify current needs in the wave energy field and plan future activities and actions
h. Distribute updates from members on relevant R&D progress
i. Identify and discuss funding and collaboration opportunities on wave energy projects and on the specific WG topics

WG1 – Numerical hydrodynamic modelling for WECs, WEC arrays/farms and wave energy resources (accuracy, uncertainty, coupling, applicability, usability): For evaluation of wave energy resources and site characterization, and for studying far-field effects of WEC arrays/farms, typically wave propagation models are employed, while for studying WECs and their near-field effects, wave-WEC interaction solvers are used (e.g. based on Boundary Element Methods (BEM), Computational Fluid Dynamics (CFD) etc.). Nowadays, coupling techniques are also used between wave propagation models and wave-WEC interaction solvers. During the past 5 years the sector has witnessed the rapid development of numerical tools which can model multi-body interactions to the second order or higher accuracy, such as non-linear BEM, CFD and particle-following (Lagrangian) models. Within WECANet, a large number of researchers use such models, and thus WG1 aims to increase the understanding of the pros and cons of each method and their ranges of applicability.

Tasks of WG1:

T1.1 Classification and review of available numerical models for single WECs, WEC arrays, WEC farms, multi-body WECs and site characterization (floating body behaviour, wave impact simulation, wave propagation through arrays, wave-structure interaction etc.)
T1.2 Set up a hierarchical methodology to account for available wave energy resources, WEC-WEC interaction effects, array interaction, and farm impact on the environment, the coast and other sea users.
T1.3 Organise STSMs, Training Schools and workshops to educate researchers, ECIs **(link to all WGs)**.
T1.4 Provide expertise: i) Benchmark cases (numerical); ii) Literature assessment; iii) Guidelines for the design of wave energy projects and for model use; iv) Development of WEC (array) modelling protocols.

T1.5 Establish an integrated modelling approach of WECs and WEC arrays/farms, based on numerical and physical modelling techniques, as well as sea test site data **(link to WG2, T2.6)**.
T1.6 Integrated optimization approach of WECs, WEC array deployment, based on numerical and physical modelling, field observations, and non-technological constraints **(link to WG2, WG3 and WG4)**

Deliverables of WG1:
D1.1: Workshop on numerical modelling advancements + Workshop report (M24)
D1.2: Special issues published in peer reviewed journals (M9); (M36) **(link to all other WGs)**
D1.3: Guidelines reports for model use (M39)

<u>WG2</u> – Experimental hydrodynamic modelling and testing of WECs, WEC arrays/farms, PTO systems, and field data (accuracy, uncertainty, testing facility suitability, measurement techniques): During the past 5 years the sector has witnessed the rapid development of numerical tools used for wave energy projects, however there is at present an acute need for data that can be used for their validation and thus for the assessment of the related uncertainties. The experimental facilities typically employed to model WECs, WEC arrays or WEC components are wave basins/flumes and towing tanks for hydrodynamic testing, wave emulators to perform dry tests for PTO systems, and sea test sites. WG2 aims at a better understanding of physical modelling aspects: scale, laboratory effects etc.

Tasks of WG2:
T2.1 Classification and review of facilities employed for WEC testing (floating body behaviour, wave impact simulation, wave propagation through arrays, wave-structure interaction, PTO systems etc.)
T2.2 Classification and review of available experimental databases for single WECs, WEC arrays, WEC farms and multi-body WECs.
T2.3 Organise STSMs, Training Schools and workshops which will bring PhD researchers and ECIs whose institutions lack research facilities in contact with infrastructures owned by participants of this Action, and even provide access to these facilities in case of collaboration **(link to all WGs)**.
T2.4 Set-up a methodology to account for the best practices for WEC testing and field measurements.
T2.5 Provide expertise through: i) Benchmark cases (experimental treatment); ii) Literature assessment; iii) Guidelines for the design of wave energy projects and use of data; iv) Development of WEC (array) experimental modelling and testing, and data recording protocols.
T2.6 Establish an integrated modelling approach of WECs and arrays **(link to WG1, T1.5)**.
T2.7 Integrated optimization approach of WECs, WEC array deployment, based on numerical and physical modelling, field observations, and non-technological constraints **(link to WG1, WG3 and WG4)**

Deliverables of WG2:
D2.1: Workshop on experimental modelling and sea site field measurements advancements + Workshop report (M24)
D2.2: Special issues published in peer reviewed journals (M9); (M36) **(link to all other WGs)**
D2.3: Guidelines reports for experimental model set-up and field device instrumentation (M39)
D2.4 Create an inventory of unique databases for validation of models used by researchers worldwide

<u>WG3</u> – Technology of WECs and WEC arrays: The activities of WECANet aim to reduce costs and risks of wave energy technologies, and to contribute to the advancement of the sector by dealing with: improvement of the performance of WECs (optimal design, control & electrical aspects); WEC survivability, structural loads, loading and moorings of WEC arrays; deployment, installation, operation, cabling, WEC interconnections and connection to the grid, maintenance; feasibility for co-located wind and wave farms; WEC system design and sub-system integration; tools addressing industry-wide questions, multi-parameter problems and efficient optimisation techniques. WG3 aims at a better understanding of the techno-economic aspects of wave energy, which is a key objective of WECANet.

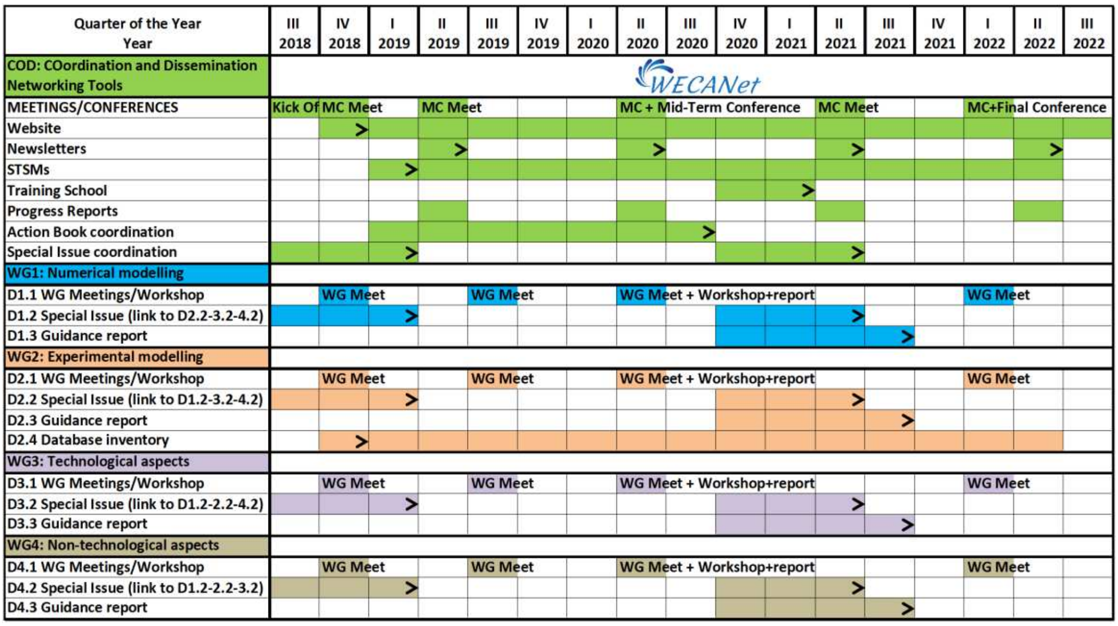
Tasks of WG3:
T3.1 Classification and review of available tools and approaches dealing with the technological aspects
T3.2 Set up a hierarchical methodology to account for multi-parameter problems.
T3.3 Organise STSMs, Training Schools and workshops to educate researchers, ECIs **(link to all WGs)**.
T3.4 Provide expertise through: i) Literature assessment; ii) available tools; iii) Design guidelines;
T3.5 Integrated optimization approach of WECs, WEC array deployment, based on numerical and physical modelling, field observations, and non-technological constraints **(link to WG1, WG2 and WG4)**

Deliverables of WG2:
D3.1: Workshop on technology advancements + Workshop report (M24)
D3.2: Special issues published in peer reviewed journals (M9); (M36) **(link to all other WGs)**
D3.3: Guidelines reports for the use of existing tools and techniques (M39)

<u>WG4</u> – Impacts and economics of wave energy and how they affect decision- and policy-making: The activities of WECANet aim to reduce uncertainties when deciding on wave energy investments, and to contribute to increasing confidence of potential investors by dealing with: probabilistic lifetime design and O&M strategies; evaluation of tools which target key decision-investment barriers; the creation of a set of industry guidelines to be used for project development; incorporating the feedback on the needs of industry; multi-parameter problems and optimisation techniques; life-cycle assessment, technology economics, legislation, policy, risk management; the introduction of systematic approaches to improve investor confidence; the way in which non-technological barriers such as regulatory frameworks, public acceptance and socio-economic and environmental impacts (e.g. on marine ecosystems, fisheries) affect the development of the wave energy sector. WG4 aims at a better understanding of the non-technological aspects affecting the sector, which is a key objective of WECANet.

Tasks of WG4:
T4.1 Classification & review of available approaches dealing with the above (non-technological) aspects
T4.2 Set up a hierarchical methodology to account for multi-parameter problems.
T4.3 Organise STSMs, Training Schools and workshops to educate researchers, ECIs **(link to all WGs)**.
T4.4 Provide expertise through: i) Literature assessment; ii) available tools; iii) Design guidelines;
T4.5 Integrated optimization approach of WECs, WEC array deployment, based on numerical and physical modelling, field observations, and non-technological constraints (**link to WG1, WG2 and WG3**)
T4.6 Bring together researchers and find a strategy to translate the results into decision and policy support tools essential for wave energy applications **(link to all other WGs)**
Deliverables of WG2:
D4.1: Workshop on non-technological aspects + Workshop report (M24)
D4.2: Special issues published in peer reviewed journals (M9); (M36) **(link to all other WGs)**
D4.3: Guidelines reports for the use of existing tools and approaches (M39)

3.1.2. GANTT DIAGRAM – IMPORTANT **MILESTONES** FOR PARTICULAR DELIVERABLES



3.1.4. RISK AND CONTINGENCY PLANS

<u>Risk No. 1:</u> Delays in the development of special issues (due to standardized journal procedures). To avoid this risk, timely communication with the journal editors will be pursued, by respecting the good practice of a two-round approval, reviewing, etc. <u>Risk No. 2:</u> Low number of stakeholder participants for

the workshops and conferences. This risk is addressed by the large size of WECANet, with more than 100 participants from NGOs, SMEs, research centres and universities, which will also ensure the WECANet flow of activities in case of unforeseen changes in WG leadership. Moreover, WECANet builds upon the existing large network as a basis for attracting new participants. Risk No. 3: Low number of ECIs/students interested in the Training Schools, workshops etc. To avoid this risk, a good dissemination among potential candidates is necessary which is ensured by the structure of the consortium (mostly researchers teaching at universities). Also, more than 50% of the total number of the WECANet participants are ECIs. In order to avoid all risks, the COST Action activities will be carefully monitored against planned objectives, deliverables and milestones. Internal evaluation processes will be established and the Management Committee and the COD will control the progress.

3.2. MANAGEMENT STRUCTURES AND PROCEDURES

Management structures and procedures of the WECANet are organized through the activity of the Management Committee - MC, the COD and four WGs. The MC is responsible for the development of the COST Action structures and strategies. –The composition of Core Group (CG) will be discussed at the first MC Meeting such as the Action Chair, Vice Chair and the Grant Holder of the Action, WG Leaders and other horizontal roles. The MC is collectively responsible for the successful fulfilment of the Action tasks and supervises the use of funds. The Grant Holder is responsible for administrating the budget with respect to activities and deliverables and reports to the MC. WG Leaders: **a)** organize the progress within WGs based on the approved Work and Bugdet Plan, **b)** develop annual WG activity reports, **c)** collaborate with other WG Leaders, d) propose ad hoc participants, **e)** provide material for the WECANet website and undertake other dissemination activities.

3.3. NETWORK AS A WHOLE

The **WECANet consortium** is an initiative by participants from number of COST Countries and 1 IPC Country focussing on their direct interest in, and benefits from, this COST Action. A large number of the participants are experienced in the HORIZON2020, Hydralab+, MaRINET2 Programmes. Women represent almost 1/3 of the participants and 50% of the network participants are Early Career Investigators. The Inclusiveness Target Countries (ITCs) have very strong participation in WECANet (51%) which demonstrates the determination of this COST Action to support the development of research and coordination capacities in ITCs. The participants represent the critical mass needed to address cross-border challenges of marine and specifically wave energy in Europe, as well as neighbouring countries which have an interest in European seas. The intention is to set up a plan to actively involve representatives from Near Neighbouring Countries. The WECANet participants cover the wide range of scientific and professional backgrounds, necessary for the integrated approach of this COST Action, such as: **(a)** Industrial partners and experts on technology commercialization within the Marine Renewable Energy sector; **(b)** Partners from the 'Engineering world': Coastal and Ocean Engineering, Civil and Mechanical Engineering, Environmental Engineering, Electrical and Electronic Engineering, Naval Architecture Engineering, Ship Hydrodynamics, Maritime Technology, Computational and Chemical Engineering; **(c)** Partners from the sciences of Applied Mathematics, Physics and Biology; **(d)** Partners from the sciences of Economics and Business administration, Law, Policy and Environmental Assessment, Social and Gender sciences; **(e)** Stakeholders: wave developers and supply chain, output end-users, utilities, energy companies, financing authorities, offshore industries and service providers, policy makers, other sea users, general public communication specialists and local communities, researchers and industry.

Moreover, the consortium includes not only universities and research organizations but also involves NGOs, SMEs, large companies, and local governmental organizations. Therefore, the network is **fully capable** of undertaking this transdisciplinary COST Action and integrating different types of knowledge. In the future, the goal is to further enlarge the number of non-university participants in the network. Participants from 3 large research organizations from the USA are involved. The benefit for the European research community is access to the IPCs' expertise in marine wave renewable energy, while IPC partners appreciate learning about the European approach to wave energy issues, and especially the differences related to geographical distribution of wave energy resources. The academic exchange of cross-continental perspectives is mutually beneficial.