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A pan-European Network for Marine Renewable Energy with a Focus on Wave Energy

WECANet COST Action CA17105
General Assembly 2019

GENERAL ASSEMBLY REPORT

Collected conclusions from the Working Groups workshops

Porto, Portugal | November 28-29, 2019

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EUROPEAN COOPERATION
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a pan-european network for marine renewable energy

Report of the General Assembly 2019 (Porto, Portugal) of the

WECANet COST Action CA17105:

A pan-European Network for Marine Renewable Energy with a Focus on Wave Energy

Edited by

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Contents

Chapter 1

Introduction

1.1 About the WECANet European COST Action CA17105

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 (WEC) 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, lawyers, regulators and policy experts. 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 is contributing to large-scale WEC array deployment by dealing with the current bottlenecks. The WECANet (Wave Energy Converter Array Network) European COST Action, introduced in September 2018, 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. An important characteristic of the WECANet Action is that participation is open to all parties active in the development of wave energy. Previous activities organised by WECANet core group members have resulted in a number of joint European projects and scientific publications. WECANet's main target is the equal research, training, networking, collaboration and funding opportunities for all researchers and professionals, regardless of age, gender and country in order to obtain understanding of the main challenges governing the development of the wave energy sector. Currently, 31 partner countries are active in WECANet.

1.2 Outline

A key activity within the WECANet COST Action CA17105 is the General Assembly, whereof the most recent one at the time of writing was held in Porto, Portugal on 28-29 November 2019. Within this assembly workshops for each of the working groups (WGs) were arranged. At these workshops key topics considered the most relevant by the WG leaders and the participants, were discussed. These discussions serve also the purpose to guide the further development within each of WGs, and further action points are put forward.

These, as well as the key discussion points, are summarized in the following Chapters, for each of the WGs individually.

Chapter 2

Working Group 1: Numerical hydrodynamic modelling for WECs, WEC arrays/farms and wave energy resources

Leader: Prof. Moncho Gómez-Gesteira, University of Vigo, Spain
Vice leader: Prof. Aleksander Grm, University of Ljubljana, Slovenia

2.1 Description

Numerical modeling of WECs has reached the desired level of maturity in the last decade. A wide variety of models are currently available, ranging from the simplest ones that can to simulate wave propagation and far-field effects to the more complex models that can deal with the actual interaction between the waves and the devices. The latter can even simulate the mooring system and the presence of articulated parts connected by hinges, springs, pulleys, etc; being mandatory their use to simulate properly the behavior of the PTO. These models, which are based on a good understanding of the governing physics, can now help to optimize the design phase of WECs and to analyze their survivability, covering different time and space scales.

In addition, coupling techniques have gained popularity in recent years as a useful way to take advantage of the main strengths of each particular model and deal with the multiscale nature of the problems. Based on the fact that the efficiency of state-of-the-art models remains low, even with the notable increase in computational power achieved, coupling is especially appropriate when it comes to integrated problems that cover both far-field and near-field effects.

However, the multiscale nature of the problems, the lack of reliable and repeatable experiments to calibrate the models and the existence of communication gaps between modelers and experimentalists make the simulation of WECs an arduous task. Additional research should be conducted to develop a structural modelling based on benchmarking, in order to determine which model is best suited to each specific problem and build unified platforms for coupling between models (especially open-source models).

2.2 SWOT analysis conducted at the WECANet General Assembly in Thessaloniki, Greece on 11-12 February 2019

At the General Assembly in Porto, the SWOT analysis prepared during the first General Assembly held in Thesaloniki was presented to the attendees, as well as a brief description of the main research foci, also calculated from the attendees who filled out the form during the first assembly (59 people).

- Wave Structure Interaction (WSI): 35 people (59%)
- Mooring: 21 people (36%)
- Power take-off (PTO): 23 people (39%)
- Materials: 7 (12%)
- Near-field: 36 (61%)
- Far-field: 29 (49%)

2.3 Discussion at the WECANet General Assembly in Porto, Portugal on 28-29 November 2019

According to the content of the accepted abstracts for WG1 of the WECANet General Assembly in Porto, the group was split into 4 subgroups working together in a plenary session on:

1. Resource (8 abstracts)
2. Potential Models (7 abstracts)
3. CFDs (6 abstracts)
4. Multi-Physics/Coupling (8 abstracts)

One minute was devoted to the presentation of each abstract. A specific need to collaborate with WG2 was identified. Benchmarking and validation were discussed between both groups. Actually, a common plenary session of 20 minutes was organized at the end of the WG1 and WG2 sessions to discuss about benchmarking and validation. People from both WGs were invited to this join the discussion. Part of the initiatives considered during the General Assembly in Porto were reinforced during the meeting of the WG1 held in Ourense (Spain) on January 22, 2020. The overall output of both events is summarized in Section 2.4.

2.4 Defined workpackages

2.4.1 Coupling between BEM and CFD codes

- Estimating the intervals of different numerical models validity for the operational WECs regimes: Debate was about to compare numerical results with known data and to estimate interval of confidence (correctness of numerical model) for different numerical approaches. A nice name was coined; NM mirror (Numerical Model mirror of Realistic model).
- Create a scheme and device properties for the validity tests: If a detailed validity test should be outperformed, it is needed to set the benchmark cases that can be reproduced by numerical and experimental groups.
- Outperform tests for long wave, short wave, mild amplitude and big amplitude waves for few different WECs: This is related to the previous item, already suggesting possible test that can be used as benchmark cases.

2.4.2 Collaboration with WG2

- Joined (WG1+WG2) numerical experiments to define a precise test that will be done in real experiments and numerical experiments. The aim is to define WECs type, geometry/size, type of mooring system, type of PTO, ... that will incorporate all the WECs complexity but to be still simple that the accurate measurements can be performed in tanks (numerical and ocean). This is related to the items in Subsection 2.4.1.

- Select the laboratories and equipment for defined tests (agreed benchmark cases). The issue of model scaling for different benchmark cases: doing different WEC types in different labs or doing same WEC type of different dimensions in different labs (the effect of scaling). Probably, in the beginning, it is convenient to agree on three WEC types that will be tested in different labs, but models should be of a different scale to identify also the effect of scaling (model WEC →real WEC).

- Corrado Altomare accepted to be the interface between WG1 and WG2 in the design of experiments to be used by modellers.

2.4.3 Identification of potential developers for Hydrodynamic numerical modelling

- Who develops new numerical models for WECs: Identify the labs/centres which are involved in the development of new numerical methods instead of only using it.

- Improvements in current BEM codes and potentially create an initiative for new BEM higher-order model project to compute near field effects. Proposals of new ways to improve the validity intervals of existing BEM models and possibly to move forward with the initiative of new open-source BEM library for the specific usage for offshore structures (designed in the fashion to enable the ground for natural integration of coupling methods).

2.4.4 Publishing

- Preparation of review article on a discussion of state-of-the-art in numerical modelling of WEC and WECs array. Possibly four-five different labs/centres would provide their experience with special numerical model BEM, FVM, SPH, coupled systems (Far-field + Near-field (BEM, CFD), CFD + moorings, CFD + multibody, CFD + moorings + multibody) using different numerical models. Each lab/centre should focus on the specific numerical model, present the approach, limits of model validity, issues with modelling out of validity intervals and future development directions to overcome the encountered problems.

- Preparation of Special issue for the problems related to the energy resources for wave energy. Now research in analysing the wave energy resources is widespread. This issue would help to bring all of them in a single place. Collected results of research published in a special issue, would be a basis for the next step, that is to identify conventional approaches for the specific geographic area and WEC type. Three people have been identified to lead this Special Issue, namely L. Rusu (Romania), M. Bernardino (Portugal) and M. de Castro (Spain).

2.5 Identification of Action Book WG1 chapter headers

Furthermore, headings for the WG1 chapter in the WECANet Action Book were identified. Based on the issues identified the following topics are proposed:

1. Resource modelling

2. Device modelling using Potential Models

3. Device modelling using Computational Fluid Dynamics
4. Device modelling using Multi-Physics/Coupling

Chapter 3

Working Group 2: Experimental hydrodynamic modelling and testing of WECs, WEC arrays/farms, PTO systems, and field data

Leader: Dr. Francesco Ferri, Aalborg University, Denmark
Vice leader: Prof. Lorenzo Cappietti, University of Florence, Italy

3.1 Description

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.

3.2 Discussion at the WECANet General Assembly in Porto, Portugal on 28-29 November 2019

At this assembly, focus was on the following 3 topics aiming at supporting some of the different WG tasks and deliverables:

1. Facilities and Databases
2. Wave-WEC interactions
3. Round Robin Testing Program

Discussions, following presentation of the accepted abstracts supporting these topics (16 in total), of each of the 3 topics are summarized in Section 3.3.

3.3 Defined workpackages

3.3.1 Facilities and Databases

Some partners of the WECANet community manage facilities, at their own institutions, where installations are present for laboratory-scale WEC models or field prototype experimental testing. Some of them agreed the idea of offering two/three weeks of use of their installations in support of WECANet aims, see Section 3.3.3 on "Round Robin Testing Program". It is highlighted that, since there are no specific funds, the use of installations will be free-of-charge for WECANet and at the minimum/affordable level, as judged by the infrastructure manager.

Capabilities of facilities and testing procedures were discussed and the following points are highlighted. The experiments should be deeply described in a design report shared among the WECANet community before starting the experiments. The experimental activity should be deeply and clearly described in a post-access report in order to be fully understandable in view of replication of the experiments in different facilities or in view of the use of experimental measurements in the framework of the numerical modelling. Pictures and videos of the experiments are necessary; the numerical experts should take also part in the laboratory activities; the experimental measurements and videos should be stored in a database that should be properly designed (worth to mention the need to store large videos and pictures) and it should be accessible 24h from remote. Therefore, a clear data management plan will be defined prior to testing and followed accordingely.

Moreover, the following topics are surfaced during the discussion. In general, there is a clear need of facilities where hybrid wave-wind devices can be tested. Moreover, there is a clear need of large facilities where WEC arrays can be tested. Before conducting experiments, the effectiveness of active and/or passive wave reflection absorptions, or other lab methodologies, should be clarified in terms of percent of reduction of lab-effect that can plague the target phenomenon under study.

Protocols for WEC model testing have to be reviewed and a WECANet report could be very beneficial for the WECANet community. The meeting attendees have suggested to review the following examples:

1. ITTC Quality System Manual, Recommended Procedures and Guidelines, GuidelineWave Energy Converter Model Test Experiments: https://www.ittc.info/media/8125/75-02-07-037.pdf
2. MaRINET2 Research Reports: http://www.marinet2.eu/archive-reports-2/research-reports/
3. Test recommendations and gap analysis report, MaRINET2 Deliverable 2.1: https://www.researchgate.net/publication/325781217_Test_recommendations_and _gap_analysis_report_MaRINET2_Deliverable_21
4. IEC TS 62600-103:2018 Marine energy - Wave, tidal and other water current converters - Part 103: Guidelines for the early stage development of wave energy converters - Best practices and recommended procedures for the testing of pre-prototype devices: https://webstore.iec.ch/publication/32966

A review of existing knowledge in database structures particularly suited for lab-scale models' experiments is going at the LABIMA partner within the STSM of Dr. Dogan Kisacik. The meeting attendees have suggested to review the HYDRALAB example.

3.3.2 Wave-WEC interactions

The discussion focusses on the need of performing accurate laboratory-scale model tests specifically designed for the numerical models benchmarking. Instead of assessing the effectiveness of a specific WEC technology, the lab experiments should be devoted to the modelling of those specific wave-WEC phenomenon that are most challenging to be numerically simulated. Such laboratory process modelling will feed a database for the numerical model benchmarking thus offering a wider support to the WECAnet community instead of developing a specific WEC technology in the interest of just one or few parties. So, the following wave-WEC phenomena that are very difficult to be modelled numerically are highlighted:

1. External forces that alter the WEC response to the wave action (e.g. arising from control strategies of the WEC or PTO)
2. Extreme wave loads-WEC interaction, survivability tests
3. Hydrodynamic of two-phase system (e.g. water and air)
4. Moorings

It is desirable that some of these phenomena will the subject of the Round-Robin testing program, discussed in Section 3.3.3.

3.3.3 Round Robin Testing Program

The objective of this Round-Robin program is to assess quality of experimental measurements conducted in a laboratory-scale WEC model by means of the repetition of tests on the same model but carried out in different infrastructures. Moreover, the tests will be devoted to collect good quality measurements for numerical model benchmarking. Finally, the measurements will be stored in a data-base accessible to the whole community. The following aspects are highlighted:

1. The participation of the whole WECANet community (WG1 and WG2 at least) should be promoted starting from the phase of experiments design.
2. The experiments should allow to conduct redundant measurements to quantify accuracies and errors (multiple measurements in the same installations and same measurements in different installations,...).
3. Conduct specific tests for characterizing the model responses (e.g. free decay tests) and the features related components (e.g. centre of masses, inertia, stiffness,...).
4. Controlling the systematic errors (e.g. due to the wave-reflections that characterize a specific installation).
5. Define a protocol to be used in the different installations.

The execution of the same test program in different laboratories, where the same device is tested according to the same experimental procedure, seems the most viable methodology for assessing the goodness of the laboratory measurements in view of their use in the numerical models benchmarking.

Need of the building of a lab-scale model to be tested in the different WECANet installations (check the OES task 10 model). In absence of specific funds, the LABIMA-UNIFI partner is available for financing the building of the laboratory-scale model and the needed related sensors to be embodied into the model. Considering the aim of introducing an external force that alter the WEC interaction with waves, the most economical and feasible WEC seems to the an OWC equipped with a remotely controllable valve for real time changing the air pressure drop that mimic the presence of a turbine and thus altering, in real time, the model response to the wave actions.

The proposal for enlarging the aim of this Experimental Round-Robin Program also to a Numerical Round-Robin program emerged and was discussed.

Need for a WG2 and WG1 joined committee for the development of the Experimental and Numerical Round-Robin Testing Program taking into consideration, among other:

1. Finalizing the specific WEC model to be built by means of coordinating the inputs of all WECANet members.
2. Writing of the testing program design report (timing to be agreed by email iterations whit WG2 and WG1 meeting attendees).
3. Planning and coordinating the execution of experimental and numerical tests in a mid-term perspective (timing to be agreed by email iterations whit WG2 and WG1 meeting attenders) under a voluntary base, within the WECANet network.
4. Setting the database structure for data storage and letting it fully open for wide-scale adoption as standard benchmark database which is currently hard to access freely.
5. The outputs of this activity may also provide recommendations for further coordination of laboratories practices and procedures.

So far, partners from University of Florence (IT), University of Porto (PT) and Aalborg University (DK) agreed to the plan of offering one/two weeks of use of their installations in support of the LABIMA's proposal for a "Round-Robin" testing program under the WECANet Network. Involvement of further partners is encouraged.

3.4 Identification of Action Book WG2 chapter headers

Furthermore, headings for the WG2 chapter in the WECANet potential book were identified. Based on the issues identified the following topics are proposed:

1. Experimental modelling of WEC: review of existing protocols and guidelines
2. Database of experimental measurements for benchmarking numerical modelling of WEC: a review of available examples
3. Round-Robin tests of spherical point absorber WEC
4. Round-Robin tests of OWC WEC

Chapter 4

Working Group 3: Technology of WECs and WEC arrays

Leader: Dr. Irina Temiz, Uppsala University, Sweden
Vice leader: Dr. Constantine Michailides, Cyprus University of Technology, Cyprus

4.1 Description

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: WEC survivability addressing structural loads, mooring and extreme loading of individual WECs and fully-integrated systems; WEC design optimization by developing common protocols, standards and guidelines of best practices for WECs and WEC arrays; electrical aspects such as control, grid integration, transmission to shore with a focus on stability of electricity production; installation, operation, cabling, WEC interconnections and maintenance of WEC arrays; and feasibility for co-location of wave and wind farms. WG3 aims at a better understanding of the techno-economic aspects of wave energy, which is a key objective of WECANet.

4.2 Discussion at the WECANet General Assembly in Porto, Portugal on 28-29 November 2019

At this assembly, discussions focused on "Survivability-Optimization of WECs and WEC arrays". The round-table discussion identified challenges for both optimization and survivability that are important to be examined, summarized in Section 4.3.1. Based on the challenges actions were defined, summarized in Section 4.3.2. Potential content of the review study for optimization and survivability was defined, summarized in Section 4.3.3.

4.3 Defined workpackages

4.3.1 Challenges for optimization and survivability

1. Shape optimization of WECs addressing hydrodynamic loads and interaction effects.

2. Configuration/layout optimization of different bodies in an array.

3. Control of WECs should be included when optimization is made.

4. Optimal configuration/layout is sensitive to the applied control scheme (depending to the WEC type - e.g. flaps are not sensitive while heaving type WECs are; a better study is required here from the very beginning).
5. Selection of relevant optimization criteria that are formulating the objective function is required but LCOE is critical to be included in criteria or in the objective function (the best is a combination of reduction of LCOE and increase of survivability).
6. Electrical grid aspects should be accounted for optimization calculations.
7. Interaction of WECs with vertical walls and breakwaters should be accounted for specific types of WECs.
8. Tools that exist for multi-level optimization as well as for optimization problems.
9. Inclusion of standardization in optimization.
10. Inclusion of different site effects in optimization.
11. Optimization of air turbine design for OWC (by rotating the air turbine based on measurements of wave frequency and wave characteristics).
12. Survivability in extreme conditions should be investigated for all types of WECs.
13. The ratio of extreme loads to operational loads is a good indicator for the survivability of a WEC and should be kept as minimum as possible (maybe optimization can be made for this objective function separately - e.g. for a monopile this ratio is 50 times).
14. Survivability related regulations.
15. What is survivability and what is included in this term.
16. What is the meaning of survival modes and if exist any good practice for establishing survival modes.
17. Effect of control scheme of WECs in survivability issues.

4.3.2 Planned actions for optimization and survivability

1. Preparation of an initial review study with regard to the identified challenges.
2. Identification of specific topics included in the review study which will be studied in more detail.
3. Identification of specific topics included in the review study for comparative studies.

4.3.3 Potential content of the review study for optimization and survivability

Optimization:

1. Theory, definitions and basics behind optimization problems (single and multi -objective as well as multi-level optimization problems).
2. Numerical methods for solving optimization problems.
3. Available tools for solving optimization problems.
4. Optimization methods and tools used for the optimum design of one WEC device.
5. Optimization methods and tools used for the optimum design of WECs array (including WEC layout optimization).

6. Objective functions used so far for WEC related optimization problems (both for one WEC and also for WECs in array).
7. Optimization of components of WECs (e.g. air turbine of OWC, shape of hull of a WEC).
8. Control issues and optimization methods.
9. LCOE of WECs and optimization.
10. Hierarchical methodologies to account for multi-parameter optimization problems (in general but also if are used for WECs).
11. Integrated optimization approaches of WECs including WEC array deployment information, physical modelling data and field observations.
12. Experimental campaigns (physical model testing) focusing to optimization of WECs.

Survivability:

1. Methods and tools for the assessment of the survivability of WECs and WEC components due to cyclic loading.
2. Methods and tools for the assessment of the survivability of WECs and WEC components due to extreme loading conditions.
3. Suggested existing survival modes of WECs (of different types) and WEC arrays.
4. Existing design guidelines related with survivability of WECs.
5. Experimental campaigns related with survivability of WECs.
6. Control and survivability of WECs.
7. Good practices for eliminating survivability related problems.

4.4 Identification of Action Book WG3 chapter headers

Furthermore, headings for the WG3 chapter in the WECANet potential book were identified. Based on the issues identified the following topics are proposed:

1. Review of key topics regarding optimization of WECs and WEC arrays
2. Review of key topics regarding survivability of WECs and WEC arrays

Chapter 5

Working Group 4: Impacts and economics of wave energy and how they affect decision- and policy-making

Leader: Dr. George Lavidas, Delft University of Technology, Netherlands
Vice leader: Prof. Milen Baltov, Burgas Free University, Bulgaria

5.1 Description

The activities of WECANet aim to reduce decision uncertainties for wave energy investments and contribute in enhancing investor's confidence by dealing with: identification of resource, deployment; environmental aspects that affect WECs farms; regulatory frameworks, and examine the social acceptance of WEC farms. Furthermore, WG4 aims to identify the markets that WECs can be competitively incorporated and have rapid deployment rates, reduce the uncertainties Levelized Cost of Electricity (LCoE), Capital and Operational Expenditures (CApEX-OpEX) across different WECs, and assess the Life Cycle Analysis (LCA) as a useful metric to help in device convergence. WG4 aims to develop evaluation of tools which target key decision-investment barriers; creation of industry guidelines to be used for project development; supply chains; bottlenecks; incorporating the feedback on the needs of industry; public acceptance; socio-economic; environmental impacts (e.g. on marine ecosystems, fisheries); multi-parameter problems and optimisation techniques.

As a result, the introduction of systematic approaches shall improve investor confidence; going beyond the scope on technological barriers and incorporating non-technological assessments, the way in which non-technological barriers affect the development of the wave energy sector. WG4 aims at a better understanding of the nontechnological aspects affecting the sector, which is a key objective of WECANet.

5.2 Discussion at the WECANet General Assembly in Porto, Portugal on 28-29 November 2019

At the assembly the main themes, with 2 subtopics each, where presented. Open discussions through the workshop entailed a merger of the subtopics in theme "Identification of limiting parameters", see Section 5.3.1. Section 5.3.2 defines the two subtopics of the theme "Reducing uncertainties and costs". As a summary of the Assembly, remaining subgroups have shown increased interest to develop collaborative work and have already started with proposed actions, including database construction, and research case study publications. Indicatively, some of the collaborative topics that are being developed are summarized in Section 5.3.3.

5.3 Defined workpackages

5.3.1 Identification of limiting parameters

Subgroup 1: Identification of resource, environmental and legal frameworks that support and/or hinder wave energy in MS and the EU. Investigate the awareness and acceptance of WECs at various levels, stakeholder, local communities, identify perception barriers.

5.3.2 Reducing uncertainties and costs

Subgroup 2: Identification of innovation and financing potential, Life Cycle Analysis (LCA), to devise a helpful metric for WECs convergence.

Subgroup 3: Explore market potential of wave energy in current (and future) mix of renewables, suggesting niche markets/applications where WECs can contribute. Uncertainties-influence of resource and device(s) in the economic feasibility.

5.3.3 Identified collaborative topics

1. Raul Cascajo, George Lavidas, Nikolaos S. Thomaidis, Decarbonisation and optimisation of the energy mix in the Port of the Valencia.
2. Loukogeorgaki Eva, George Lavidas, Nikolaos S. Thomaidis, Feasibility of energy independent islands with offshore wind and marine energies at the Aegean Sea.
3. Sara Ramos, Hugo Diaz, George Lavidas, Carlos Guedes Soares, A multi criterion decision making GIS method for marine renewables.
4. Stansby Peter, George Lavidas, Optimisation and Applicability of M4 converter with co-located wind farms at Dogger Bank.

5.4 Identification of Action Book WG4 chapter headers

Furthermore, headings for the WG4 chapter in the WECANet potential book were identified. Based on the issues identified the following topics are proposed:

1. Identifying regions suitable for wave energy
2. Environmental and Life Cycle Analysis on wave energy converters
3. Market viability and schemes development for wave energy converters
4. Innovation financing potential, focusing stakeholder awareness for wave energy incorporation

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