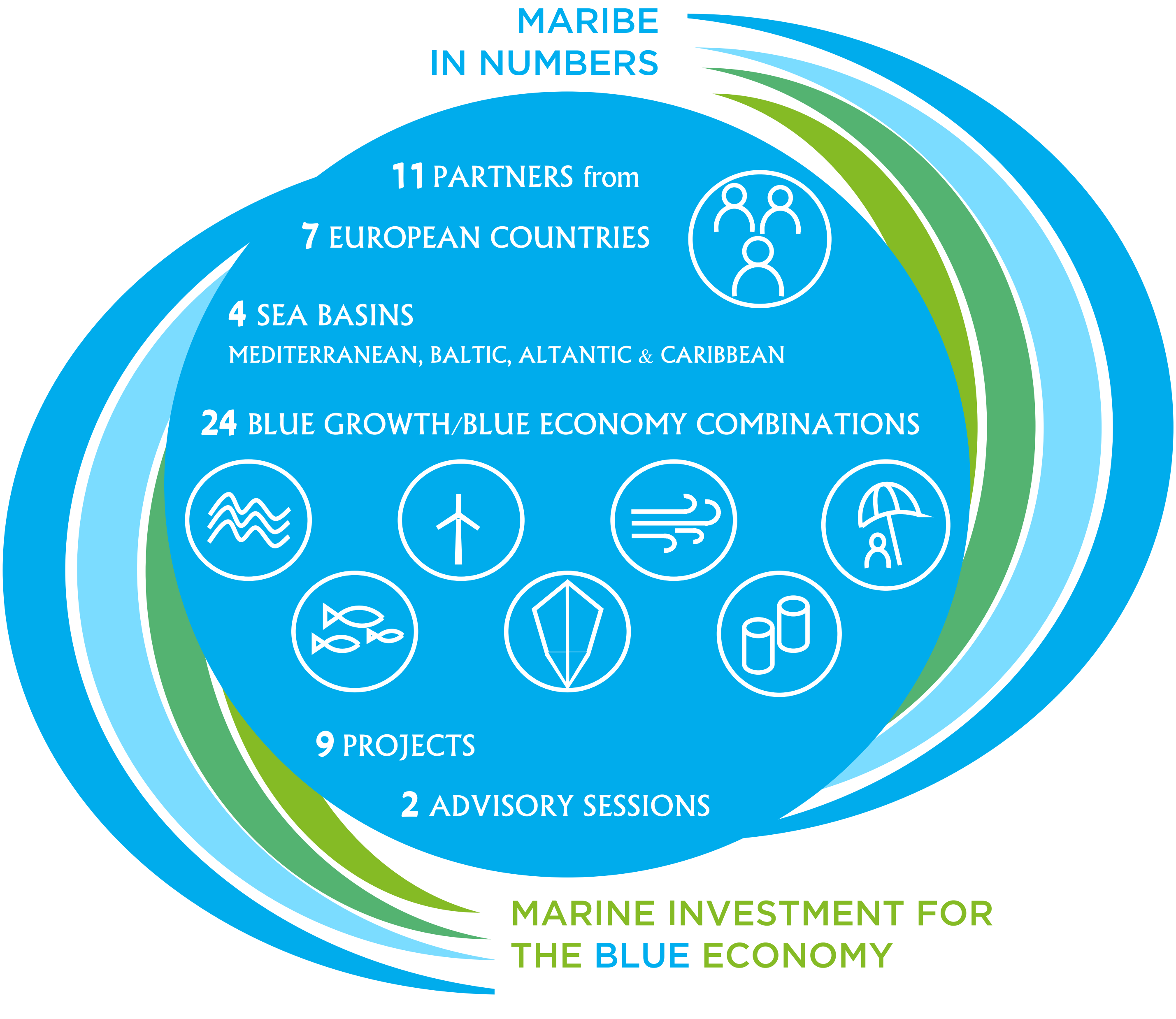
UNLOCKING THE POTENTIAL OF MULTI-USE OF SPACE AND MULTI-USE PLATFORMS



MARIBE PROJECT BOOKLET: WORKPACKAGES, CASE STUDIES AND RESULTS

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MaREI

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MARIBE project partners :

List of Abbreviations

ABT	AquaBioTech Group
BE	Blue Economy
BG	Blue Growth
BMI	Business Models Inc.
BVG	BVG Associates
DLO	Dienst Landbouwkundig Onderzoek, Wageningen University
EC	European Commission
EU	European Union
FAO	Food & Agriculture Organisation of the United Nations
FPP	Floating Power Plant
GPMG	Grand Port Maritime de Guyane
HWU	Heriot-Watt University
MaREI	Centre for Marine and Renewable Energy Ireland
MARIBE	Marine Investment for the Blue Economy
MSP	Marine Spatial Planning
MUS	Multi-use of space
MUP	Multi-use platform
O&M	Operation & maintenance
UC	Universidad de Cantabria
UCC	University College Cork
UCCAL	UCC Academy Ltd
WP	Work package

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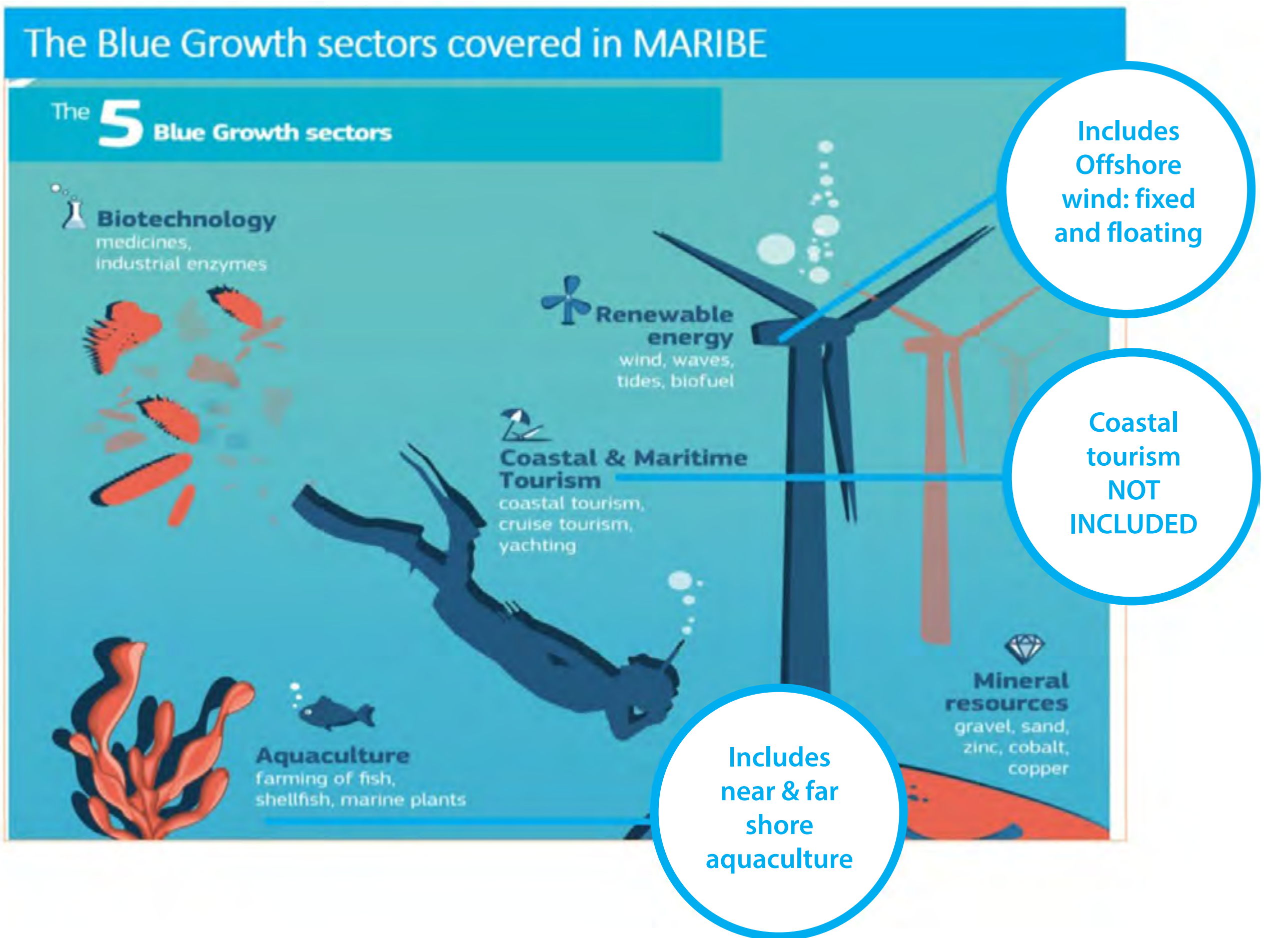
Introduction

Our oceans are important drivers of economic growth. They provide natural resources, access to trade and transport and opportunities for leisure activities. According to the European Commission, the 'blue' economy represents roughly 5.4 million jobs and generates a gross added value of almost €500 billion a year. They also state that there is potential for further growth; something which has been demonstrated by the recent announcement by the Port of Cork that their profits for 2015 have increased by 79%.

As maritime activity increases, however, so does the competition for space as coastal areas become overcrowded. This led the European Commission to publish a call in 2014 asking researchers to prepare for the 'future innovative offshore economy'. Expecting economic activities to move further offshore as competition for space increased, this call was designed to promote smarter and more sustainable use of our seas.

It was in response to this call that **the MARIBE project was initiated with the aim of promoting growth and jobs within the Blue Economy**. An 18-month project funded under the European Commission's Horizon 2020 programme, MARIBE is led by the MaREI Centre in University College Cork. A total of 11 partners from Ireland, United Kingdom, Belgium, Spain, Italy, Malta and the Netherlands contribute to the project.



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MARIBE is particularly interested in promoting smarter and more sustainable use of the sea through the sharing of space. It has investigated the potential of combining the activities of different maritime sectors in the same place or on a specifically built platform in order to make more efficient use of space and resources. It pays particular attention to new and emerging industries that can benefit greatly from the synergies created, increasing their chances of survival and enabling future growth. These sectors are often referred to as Blue Growth industries; Marine Renewable Energy, Aquaculture, Marine Biotechnology and Seabed Mining. **By developing Blue Growth industries and encouraging smarter use of our seas, MARIBE hopes to fulfil its aim of promoting jobs and growths.**

In order to achieve its aim, MARIBE began by undertaking a contextual study of Blue Growth sectors. Each sector was reviewed from a business lifecycle and socio-economic perspective. A review of the policy and planning frameworks that applied to the sectors was conducted. The current investment environment in Blue Growth was assessed and best practices as well as key barriers to investment were identified. In parallel, the business models that lie behind Blue Growth industries were analysed and mapped. Finally, a study of the technical and non-technical barriers facing Blue Growth sectors was also conducted. This last study looked at barriers by sector but also by combination, identifying the barriers that existed when two sectors shared marine space or multi-use platforms. This study was fed in part by an examination of key FP 7 projects that focused on multi-use of space or multi-use platforms.

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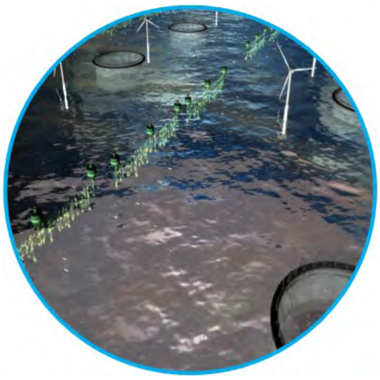

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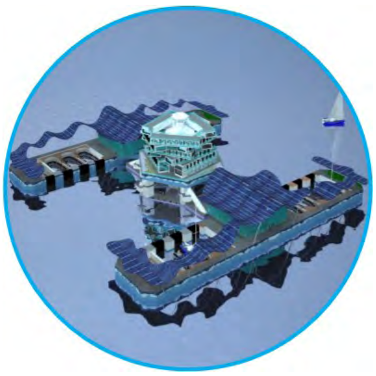

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'Images are from two of the FP7 projects examined, the MERMAID and TROPOS projects.'

Building on this contextual study, MARIBE then assessed the potential for each of the Blue Growth sectors falling within its scope to combine their activities with those of other Blue Growth or Blue Economy sectors. The potential for combination was rated from a technical, environmental, socio-economic, financial and commercial perspective. This resulted in the identification of a list of high-potential combinations which were then shortlisted in liaison with the European Commission. This short list formed the basis for the selection of 9 case studies of combination concepts that were undertaken in WP 9 & 10. MARIBE engaged with industry partners to conduct these case studies. In cooperation with the selected companies, 9 multi-use of space or multi-purpose projects have been advanced. The consortium has used its diverse expertise to assist the stakeholders involved in preparing for the next phase of the project's development. This included developing a feasible business plan and financial projections for the project.

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To maximise the opportunity for each project to develop a robust business case, projects were pitched to an independent panel of experts. Echoing a Dragon's Den style pitch, the companies involved presented their business case to the panel which included representatives from Ernst & Young, Black &Veatch, DNB Norway, Scottish Investment Bank, ORE Catapult, International Energy Agency as well as relevant trade associations including the European Aquaculture Society, Federation of European Aquaculture Producers and the World Ocean Council. The event, which was held in Brussels on the 15-16 of June 2016, gave the companies an opportunity to communicate their projects to industry experts and receive impartial advice. Their feedback was recorded and incorporated when revising the final reports of each project. The following booklet describes the MARIBE project in more detail offering an overview of the core work packages as well as descriptions of all of the case studies that were undertaken.

In a report delivered directly to the European Commission, MARIBE has recommended that further funding should be given to the MUS/MUP sector. Following our review of the funds invested to date by the commission and the MARIBE case study projects investigated, and through detailed business planning of the next stages in development, we recommend that a series of calls for proposals are funded with a budget of the order of €120 million in the next round of Horizon 2020 funding calls to promote Multi-use of space projects. This would successfully move MUS and MUP projects through the so-called valley of death and would develop projects that use our seas in a smarter and more sustainable way. Therefore, we will collectively ensure Blue Growth jobs and growth in a timely manner.

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Work Package Summaries

Work Package 4 - Socio-Economic Trends and EU Policy in the Offshore Economy

Leader - Heriot-Watt University (HWU); Kate Johnson

Contributing Partners - ABT; BVG; DLO; ECoast; FAO; HWU; SU; UCC, UC, BMI, UCCAL

WP4 Objectives: The aim of WP4 was to set the context for business plans in the maritime economy to be developed in subsequent work packages. The objectives were initially threefold.

- First, to research and identify the workings of significant maritime business sectors and their respective positions in the business lifecycle from inception to maturity and closure.
- Second, to undertake a socio-economic review of the existing and anticipated business sectors under study with a focus on employment.
- Third, to determine the policy and planning frameworks which might apply to 'Blue Growth', or be developed, in the four sea basins of interest (Atlantic; Baltic/North Sea; Mediterranean; and Caribbean).

As the MARIBE project developed an additional, fourth, WP4 objective was introduced to make a socio-economic analysis of proposed combinations of maritime businesses to be taken forward to development in WPs 8, 9 and 10.

WP4 Methodology: The first task in the WP4 process was to identify the maritime business sectors to be included in the study and their classification. Five industries identified at early stages in their lifecycles were classified as **'Blue Growth'** sectors:

1) Aquaculture
2) Energy (wave and tide)
3) Energy (offshore wind)
4) Biotechnology
5) Seabed Mining.

Another four industries identified at mature stages of their lifecycles were classified as **'Blue Economy'** sectors:

1) Fisheries
2) Offshore Hydrocarbons
3) Shipping
4) Tourism.

Suitably qualified 'Sector Leaders' were appointed from among the contributing partners. The leaders were responsible for reporting on their allocated business sector working to a standard template prepared by the WP4 leader and agreed by them. A paper on business lifecycles was researched, written and distributed to contributors by the WP4 leader.

At the same time work started on the policy and planning review with the appointment of 'Basin Leaders' for each of the four European sea basins under study - 1) Atlantic; 2) North/Baltic Seas; 3) Mediterranean and 4) Caribbean. Each leader was responsible for reporting on their allocated basin working to a standard template prepared by the WP4 leader and agreed by them. Common lessons by sector and by basin were regularly reviewed in the process and at the end. The WP4 sector and basin reports were subsequently used in the process to select and analyse the combinations in WPs 8, 9 and 10.

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WP4 Deliverables: The Deliverables required of WP4 were initially fivefold. Three deliverables were listed as resulting from the sector socio-economic reviews describing first the baseline and context by sector (D4.1); second, the market context by sector (D4.2); and third, the social and employment aspects of each sector (D4.3). With the agreement of the Project Officer these three deliverables were combined into a single document which became known as the WP4 Sector Report (D4.1-3). This report, delivered in November 2015, provided comprehensive information by individual sector and in combination. The fourth deliverable concerned the policy and planning frameworks by sea basin (D4.4) and was also delivered in November 2015. The 'Tools and Guidelines' (D4.5) deliverable describes use of the outputs from WP4 and was extended to develop standards and templates for the analysis of the combinations of activities chosen for development under WPS 8, 9 and 10.

WP4 Key Findings, Lessons Learned and Recommendations:

- Each SECTOR report under WP4 identified the respective market, structure, lifecycle, working environment, employment, innovation and investment conditions for each industry or prospective industry. Activity was also noted by EU Sea BASIN. Direct comparisons are difficult in such a diverse range of activities at widely divergent stages of development. However, each report stands on its own as a guide to the state and prospects of each industry and guided subsequent work on potential multi-use platforms. It can be seen that marine energy and aquaculture predominate in the suggested combinations with desalination and shipping terminals as less frequent but significant possibilities. There is an important distinction to recognise between activities which will take place within the EU sea basins creating direct employment and those which benefit from European expertise and investment but actually taking place elsewhere. Seabed mining, for example, will take place almost entirely outside Europe but is a good innovation and business opportunity for European companies and interests. All the sectors have strong export potential.

- Each BASIN report under WP4 identified the respective basin details by geography, activities and features before going on to look at environmental policy, regulatory requirements, planning policy and progress and support schemes to prospective industries. Regulation and planning are most developed in the Atlantic and North Sea/Baltic basins making them a more certain environment for prospective industries. The Mediterranean is less prepared and the Caribbean least prepared. Marine spatial planning is in its infancy everywhere with few complete examples. In the face of uncertainty about the detail of Blue Growth industries many authorities look to keep options open. They wish to avoid closing areas to potentially valuable development in the future.

- Internally to the MARIBE Project WP4 provided a significant part of the foundation for the work on WPs 8, 9, and 10 which developed combination proposals and developed business plans with industry. WP4 developed in close liaison with WPs 5, 6 and 7 to build the baseline data, such as socio-economic and financial review, for the combinations proposals and analysis. The WP4 Sector Leaders and Basin Leaders went on to take the roles of Sector Experts and Basin Experts in specific combinations of activities carried through to the Brussels workshops in June 2016.

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- A summary of Blue Growth and Blue Economy potential by industry and basin is detailed in Fig. 1 below.

Fig 1. INDUSTRY BY BASIN - Now and Future Potential (by relative employment)

Dark blue	= HIGH
Light blue	= MEDIUM
Green	= LOW
Grey	= ABSENT

BASIN >	Atlantic		North/Baltic		Mediterranean		Caribbean		Global	
Blue Growth v	Now	**Future**	Now	**Future**	Now	**Future**	Now	**Future**	Now	**Future**
Aquaculture	MEDIUM	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	HIGH
Biotechnology	ABSENT	MEDIUM	ABSENT	MEDIUM	ABSENT	MEDIUM	ABSENT	MEDIUM	LOW	MEDIUM
Seabed Mining	ABSENT	LOW	ABSENT	LOW	ABSENT	LOW	ABSENT	LOW	LOW	HIGH
Wave / Tidal	ABSENT	HIGH	ABSENT	MEDIUM	ABSENT	LOW	ABSENT	LOW	ABSENT	MEDIUM
Offshore Wind	LOW	HIGH	MEDIUM	HIGH	LOW	MEDIUM	ABSENT	LOW	LOW	HIGH
Blue Economy v										
Fisheries	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
Oil and Gas	LOW	LOW	HIGH	LOW	MEDIUM	LOW	LOW	LOW	MEDIUM	LOW
Shipping	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
Tourism	MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH

NOTES

Industries by BASIN denote activities within each basin generating direct employment and industry support. Direct employment means trades and labour sourced within Europe and the local area. Industry support means research, design, management, finance and high level technical jobs.

Industries by GLOBAL denotes activities outside each basin but supported by skills and capital from within Europe

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WP 5 - Technical and Non-technical Challenges, Regional and Sectoral

Leader - Universidad de Cantabria; Pedro Díaz-Simal

Contributing Partners - ABT; BVG; DLO; ECoast; FAO; HWU; SU; UCC

WP 5 Objectives

- Assess & review four key FP 7 projects related to multi-use of space or multi-use platforms: MARINA Platform, H2OCEAN, TROPOS and MERMAID.
- Produce a comprehensive report that outlines each project, its structure, partners involved, main objectives, deliverables summary and provides a description of the concepts developed.
- Identify the technical and non-technical barriers relevant to the combination projects being developed in WP 9 & 10, analysing and reporting the limitations by basin, sector and combination.

WP 5 Methodology

Two main tasks were completed in this WP. First, a descriptive review of four key FP 7 projects was undertaken, listing main facts and data, partners, working structure and main deliverables. For each reviewed project, proposed multi-use platform concepts were identified and their descriptions were presented in different headlines. For each project, all available public information was analysed and the main technical, environmental, socio-economical and financial aspects were identified.

Second, an Excel database was created to identify all possible barriers that could affect the development of BG sectors, separating them into two main categories: technical and non-technical. The barriers were classified according both to the basin in which they appear and the combination of sectors selected in WP 9 & 10. The barriers associated with each individual sector were then analysed and a number of possible proposals were proposed.

WP 5 Deliverables

- D5.1: REVIEW OF MULTI-USE OF SPACE AND MULTI-USE PLATFORM PROJECTS. The aim of this deliverable is to assess key projects that focus on multi-use of space and multi-purpose platforms to ensure maximum use of their outputs, contacts, excellence, recommendations and information. The four projects selected for this analysis were MARINA Platform, H2OCEAN, TROPOS and MERMAID.
- D5.2-D5.3: DATABASE ON CURRENT AND EXPECTED TECHNICAL AND NON-TECHNICAL CHALLENGES. These two deliverables focus on the identification of the past, present and expected technical and non-technical challenges facing multi-use of space and multi-purpose platforms projects and technologies.
- D5.4: COMPARATIVE REVIEW OF THE SITUATION IN THE 4 BASINS. This deliverable aims to respond the MARIBE objective: identify utilised and proposed solutions to the barriers identified and recommend research and technical agendas where either no solutions exist, are proposed or where solutions are inadequate.
- D5.5: TOOLKITS AND GUIDELINES. This document offers a brief summary of all the concepts and information that can be found in the different WP 5 deliverables.

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WP 5 Key Findings, Lessons Learned and Recommendations:

The review of the four Ocean of Tomorrow projects presents a summary of the different multi-use concepts designed and allowed for identification of the differences and overlaps between the FP7 projects. Main characteristics (budget, objectives, structure) of the projects were described and the main findings and outputs were summarised.

The study of technical and non-technical barriers produced the findings included in D5.4. Among the main findings, some can be highlighted:

- Technical barriers, related to mooring systems (mainly in the Atlantic basin), weather and sea conditions (which appear in the Atlantic, Baltic and North Sea basins), or grid connection (related to energy sectors) are likely to appear. But technical solutions can be developed with investment and research funding.
- Problems arise in all basins due to the lack of a clear definition of administrative and legal proceedings related to the implementation of offshore projects. A common regulatory framework would greatly facilitate the growth of blue sectors.
- Problems related to financing may occur, due to the uncertainty that some sectors have with respect to their economic viability. Combining activity with weak sectors can jeopardize stronger sectors.

WP 6 - Investment community consultation and commitment

Leader – Dienst Landbouwkundig Onderzoek, Wageningen University: Dr Ir Sander van den Burg

Contributing Partners - ABT; BVG; BMI; ECoast; FAO; HWU; UCC; UC

WP 6 Objectives

The following objectives were formulated for this WP:
1. To build relations and establish a forum for on going communication between the MARIBE project and the investment community.
2. To map the relevant investment community for the selected maritime basins and the sectors relevant for future BG (offshore energy, aquaculture, blue biotech, deep sea mining) and comprehensively record the past, planned and expected investments in these sectors.
3. To identify best practices and barriers to investment in BG.
4. To secure involvement of investors in the MARIBE project.

WP 6 Methodology

Four different methods were used: (1) literature review, (2) compilation of a database of investors, (3) survey and (4) in-depth interviews. This cascade of methods was selected to – respectively – get acquainted with the discussion of investment in Blue Growth, identify investors, collect limited information from a larger group of respondents and engage with selected investors. The survey was sent out to the investor community, resulting in a response rate of app. 9% (20 out of 227). The response rate of the interviews was 0.05% (6 out of 120).

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WP 6 Deliverables

Deliverable 6.1: This deliverable aimed to analyse how to involve investors in the MARIBE project, based on literature review. The main conclusion was that investors are reluctant to participate in the project, despite significant efforts by the researchers.

Deliverable 6.4 synthesizes the results collected in WP6. It is based on (1) analysis the database of investors and (2) deliverable 6.1, (3) a survey set out among identified investors and (4) in-depth interviews with a selected number of stakeholders. Among the main conclusions are

- Investors prefer to stay anonymous towards the public as they want to prevent being approached by others all the time
- The issue of Blue Growth and more specifically multi-use platforms is an unclear concept for them. Investing in complex projects off-shore is not in their priority list. Investing offshore is already a risk for them when it is single use only. Investing in complex projects is not relevant to them in terms of return on investment
- Many investors do not see the need to have connections with scientists, as they have their own experts who investigate interesting options. Furthermore, there is a language barrier between scientists and the investment community

Deliverable 6.5 is an excel file with 247 investors and their contact details. The excel sheet also contains definitions that are needed to understand the different types of investor categories. It also contains guidance on how to classify the investor in terms of: Name of organisation; Country HQ; Basins active; Active in Aquaculture; Active in Sea bed mining; Active in Ocean Energy; Active in Marine Biotechnology; Multi Use Platforms; Oil and Gas Shipping; Fisheries; Shipbuilding & Repair; Tourism

Deliverable 6.6 is a background document to the other deliverables in which the definitions used are provided. Also, this document explains how the deliverables relate to each other and can be accessed, and provides guidelines for use of the database.

WP 6 Key Findings, Lessons Learned and Recommendations:

The objective of this WP was to discuss the current state of affairs regarding investment in Blue Growth and identify the conditions and criteria relevant for investors in Blue Growth. It must be concluded that there is not one type of "Blue Growth investor". There is a large variation in investors; large and small, private or public, low- or high-risk taking, ideological or conservative. Also hybrids between types of investors were encountered.

Investments in Blue Growth do take place but there is no vibrant investment scene – *à la* Silicon Valley - where entrepreneurs have easy access to investors to discuss availability of capital required for commercial expansion.

Figure A below illustrates why a certain sector can be of interest to an investor. Among the highest ranking 'reasons' are a) innovative character of a sector and b) expected attractive return on investment. Clearly less important is a contribution to the diversification of investment portfolio; this is not a reason to invest in new sectors. The most important barriers to investment – according to the respondents – are the lack of confidence in technology and difficulties in access to finance (Figure B). It is noteworthy that the least important barriers are a lack of demand for the products and high negative environmental impact.

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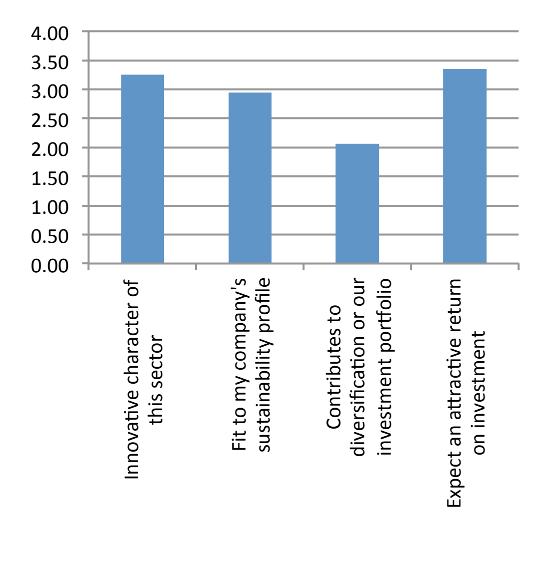

Figure A: reasons to invest

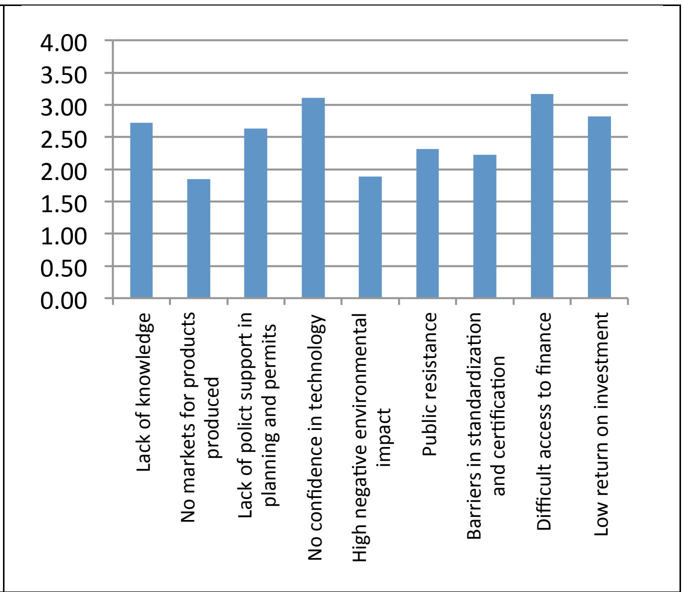

Figure B: importance of various barriers to invest

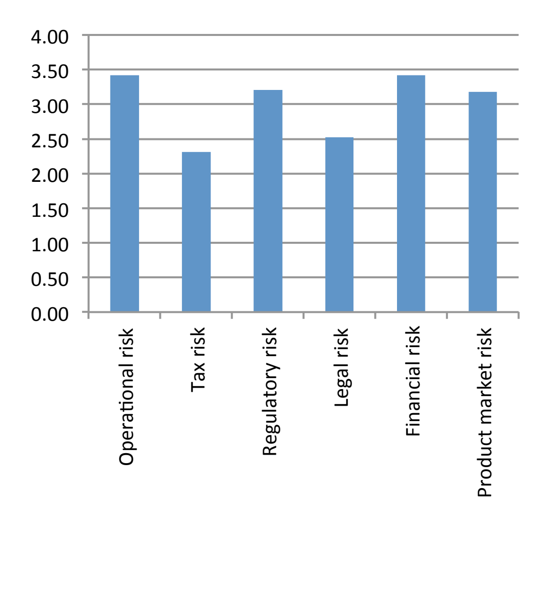

Figure C: risks

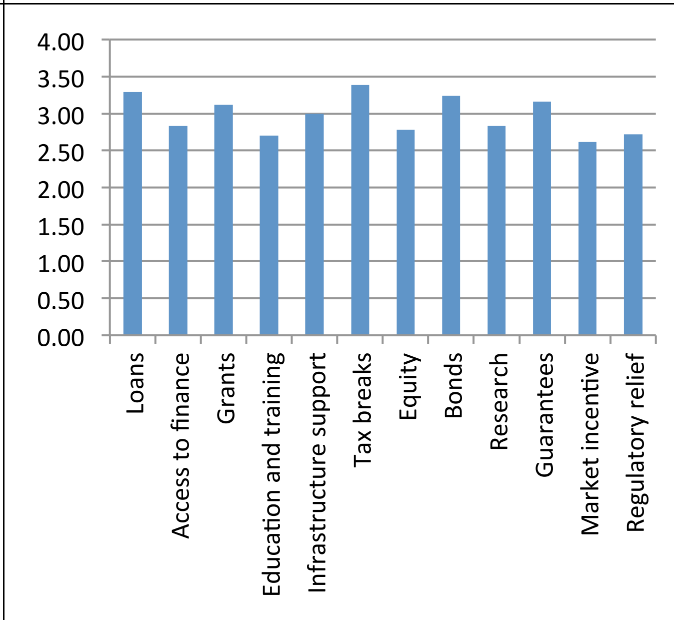

Figure D: preferred government support schemes

A number of risks are identified that can hamper investment in the Blue Growth sectors. The most important risks according to the investors consulted are financial and operational risks. The risks considered least important are tax and legal risks (Figure C). Among the respondents, the most preferred governmental support schemes are tax breaks, loans and guarantees (Figure D). All three relate to financial aspects and these kind of government supports can help to increase "access to finance", removing this barrier. Government support for research, education receive lower scores.

The consulted Blue Growth investors find it important to depart from a vision and strategy, rather than respond *ad-hoc* to new developments of investment opportunities. They have a long-term view, based on a combination of idealism and realism. Their investment vision does not bet on company or technology. Instead, they prefer to invest smaller amounts in a broader portfolio of companies, recognizing that SMEs seem to be most innovative and flexible in the begin stage of new concepts.

The relationship between investors and government regulation is ambivalent. On the one hand, investors do not like additional complexity from the regulatory or planning side. On the other hand, they are not going to invest in markets where regulation is yet to be developed or lagging behind. It is relevant to smoothen the regulatory framework and permitting procedures.

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A key insight from the interviews is that investment in Blue Growth are seldom the outcome of one-on-one contact by a company and an investor. It is necessary to bring together different investors – either public and/or private investors – to bring together the millions required for early investments. A shared investment is a way to spread risks and allows investors to invest in multiple companies. Public investors – whether that is the European Investment Bank, a nation-state or provinces – play a key role in funding of many Blue Growth investments.

Given the diversity of investors, it is no surprise that the current status quo and barriers can only be described on a general level. For some investors, the return on investment is the most important criteria, for others risks are more important. In short, it is not all about the money. Concerns of investors have been identified at an abstract level, two issues arise: (1) concern about maturity of the technology and (2) concerns about the market risk, i.e. risk about commercial attractiveness of the sector.

WP 7 - Business Model Mapping and Assessment

Leader – Business Models Inc.: Roland Wijnen

Contributing Partners - UCC, DLO, ECoast, HWU, UC, ABT, FAO, BVGA

WP 7 Objectives

The overall objective of this work package was to build a broad and deep understanding of how value is created, delivered, and captured in the Blue Economy in general and the Blue Growth sectors specifically. The six specific objectives were: (1) Show how value is created, delivered and captured by visualizing a number (i.e. 20-30) of specific business models from established companies and early-stage companies using the Business Model Canvas; (2) make explicit how each of the business models is connected to important socio-economic trends (WP4), with a focus on how these business models are leveraging technologies; (3) assess the business model mechanics, the strengths and weaknesses, and social and environmental costs and benefits of each of the business models; (4) synthesize differences and similarities between each of the business models; (5) identify ways for innovating the examined business models as well as identify opportunities for entirely new business models; (6) life cycle learning from mature business models.

WP 7 Methodology

The first step was to select 30 companies whose business models were to be studied. A case study approach was used to capture understanding of the vision, context, and business models of each of the 30 companies. A template format was used for each of the case studies. The studies included an assessment of the business models, looking into the business model mechanics, Investor Readiness Level, and socio-economic impact. In addition, detailed analysis reports were produced. Next, similarities and differences between business models from a single sector and across sectors were identified. From this, three generic business models were identified for each sector, to be used as a fire-starter for business model innovation and/or partnership design in WP9/10.

WP 7 Deliverables

- D7.1 Innovation of a common language
- D7.2 Case studies for specific business models
- D7.3 Mapping of all business models
- D7.4 Innovation of existing business models
- D7.5 Life cycle learning from mature business models
- D7.6 Tools and guidelines for evaluation and innovating business models.

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WP 7 Key Findings, Lessons Learned and Recommendations:

To unlock the Blue Growth (BG) potential it is crucial to understand how value is created, delivered, and captured today, and what the growth potential could be. Within the MARIBE project, 29 companies (21 companies from 4 BG sectors and 8 companies from 4 BE sectors) and their business models were mapped and assessed in order to create this understanding. Beyond understanding individual business models, similarities and differences between business models have been synthesised. This led to the identification of generic business models, which can be used for business model innovation.

The case studies created insights into each of the companies' ambition, context, and business model as well as insights into the partnerships a specific company has with other companies. We used those insights to visualise value creation as shown in the MARIBE Sea Chart (figure 1). For each company its key partners are visualized in the blue bubbles, with an indication of the type of partnership. Seven different partnerships are identified.

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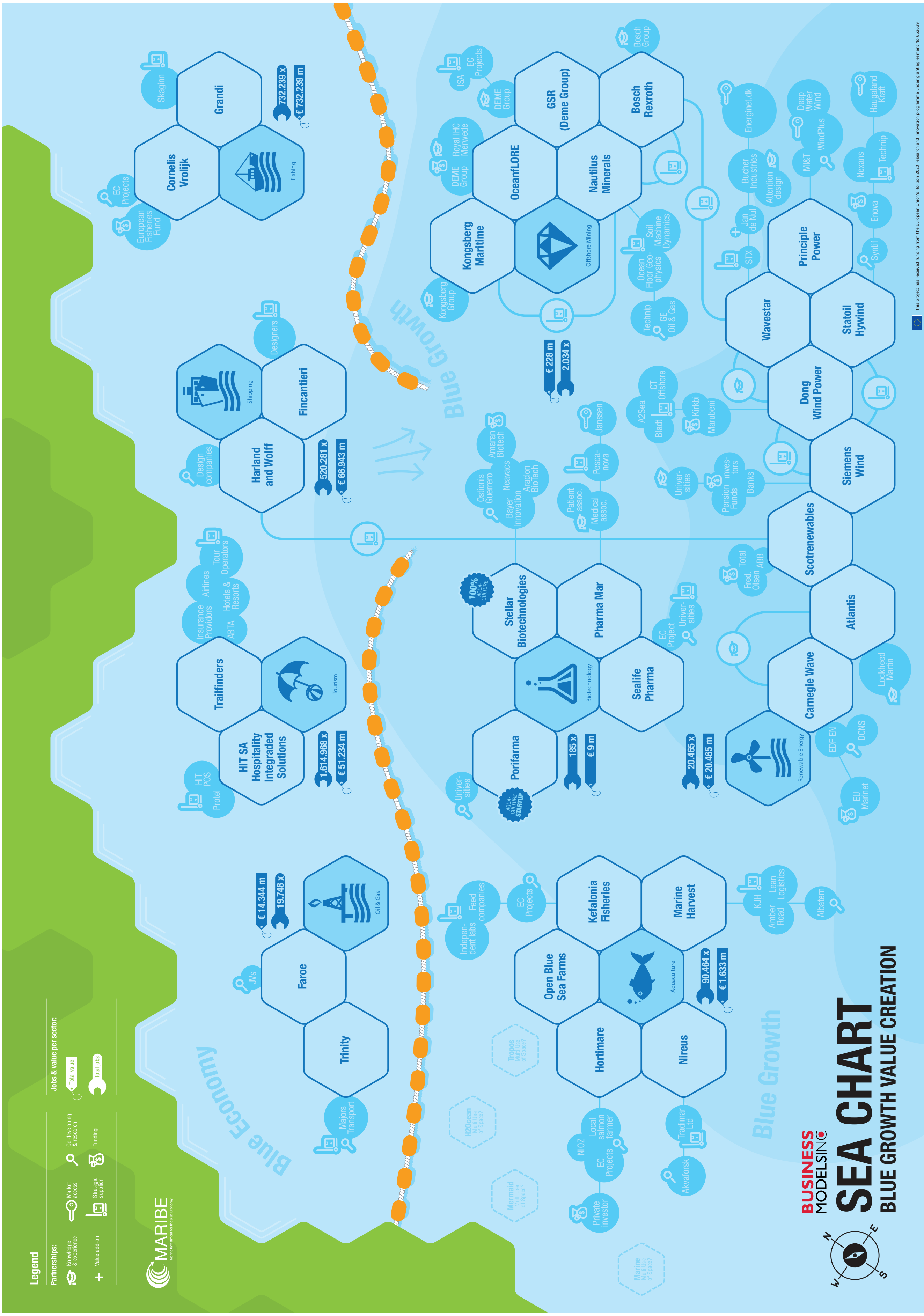

Figure 1: Sea Chart: Blue Growth Value Creation

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The following is observed from looking at the Sea Chart:

Value networks are being reconfigured Blue Growth companies are connected to companies from Blue Economy sectors mostly through a strategic supplier (Partnership Type 2), funding (Partnership Type 4), or knowledge and experience (Partnership Type 6) partnership. The early stage companies from the emerging BG sectors focus on delivering their promise and tap into existing value chains within the Blue Economy wherever possible. Existing knowledge and experience is leveraged through people and partners with extensive maritime knowledge and experience. The map also shows that the BG sectors seem to begin pulling value away from the BE sectors. Value networks are slowly being reconfigured. For example: Harland & Wolff (BE Shipping) is divesting in shipbuilding and offering more and more services to the renewable energy sector.

Renewable energy leads the way The highest number of partnerships are seen in the Ocean Renewable Energy sector. These BG companies have many partnerships with BE companies from the Oil & Gas sector. There is one oil & gas company that is active in both the Blue Economy and a Blue Growth sector (Renewable Energy). This company is Statoil, which is doing adjacent innovation (offshore wind) as well as disruptive innovation (floating wind) with their Hywind floating wind turbine (together with Siemens).

Combined use of space is still a floating idea So far, there are no identified partnerships of the type *Combined use of space/resource* (Partnership Type Nr. 7) for these 29 companies. The concepts and ideas are considered by some of the companies, such as Hortimare and Kefalonia, who were both involved in the MERMAID project. However, none of the proposed applications (e.g. a Multi-Use Platform (MUP)) has been turned into partnerships that create shared value. For that reason the conceptual designs for enabling multi-use of space, like MERMAID, H2OCEAN, TROPOS, and MARINA are still not realised. The only existing example where two sectors are combined is Stellar Biotechnologies, which has fully embraced Aquaculture. Stellar Biotechnologies is simultaneously a biotechnology and a cutting-edge aquaculture company.

Lessons Learnt

<u>Winning Ambition.</u> All BG companies have winning ambitions, focus, and are committed to change and/or disrupt markets. The companies from the renewable energy, marine biotechnology, and aquaculture sectors address big societal problems in entirely new ways. There are companies with business models that will enable entire new fields of value creation, such Stellar Biotechnologies (immunotherapy) and Hortimare (seaweed farming for a wide range of applications). The offshore mining sector is an exception; fulfilling a current need (supply of metals) in just another way.

<u>It is about the long-term.</u> Companies and investors are in it for the long-term. Almost all companies rely to some degree on public to overcome the riskiest part of the technology development process. Most BG companies are still searching for a repeatable, profitable, and scalable business model. Several companies have to find an early adopter and/or prove commercial application of their idea or technology (e.g. Wavestar, Scotrenewables). Some have found their market and are already providing value to customers (e.g. Carnegie Wave, Atlantis, Hortimare), while others achieved product-market fit and are ready to scale (e.g. Stellar, Open Blue, Pharmamar).

<u>Grow slowly through scaled prototyping.</u> All companies are growing slowly through some form of scaled prototyping. Technology and customer value is developed first at small scale and proven before moving to the next level.

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Recommendations

Multi-use of space. None of the 29 companies adopts Multiple Use of Space (MUS) or Multi Use Platforms (MUP) in their business model. Companies and entrepreneurs understand the basic idea and concept, but they do not see how this is of practical value to them. Many of the MUS/MUP concepts are at the design stage on paper and have yet to be realised in one form or another. It is difficult for companies to assess how and if the concepts could support them to grow their business.

Current Partnerships. The BG companies are focused on getting their own business (model) off the ground and growing/scaling their business. Companies have partnerships that create value for both businesses involved. Companies invest time and money in partnerships or activities that grow their business. Investors require companies to focus on getting traction and not work on side-projects that don't grow the value of the company in one way or another.

Facilitating new partnerships. Companies and investors these days have access to much better methods and approaches to develop their business, such as Customer Development, Business Modelling, and Lean Start-up. A number of the investigated companies are working in similar ways, e.g. the scaled prototyping approach in the Renewable Energy sector. By taking small, iterative steps these companies learn what creates value and what doesn't.

These new approaches are also perfectly suited for exploring and designing new partnerships. These approaches enforce the articulation of a shared vision on the market, a deep understanding of each other's business models, and exploring synergies between the partner companies from a market and customer point of view. These approaches force two or more companies that want to work together to consider the riskiest part of their partnership first, i.e. the market opportunity, the customer or societal problem to be solved, and the customer willingness to pay for potential solutions.

WP 8 - Assessment of the potential of combinations of maritime activities

Leader – University College Cork – Gordon Dalton

Contributing Partners - ABT; BVG; DLO; ECoast; FAO; HWU; SU; UCC, UCCAL

WP 8 Objectives: The aim of WP8 was to assess all the possible sectoral combinations that fell under the project's scope (as set out in WP 4) and to identify 24 high-potential combinations.

1. Rate BG or BG and BE combinations and identify the 24 combinations with the highest potential.
2. In conjunction with the European Commission, identify 12 high priority combinations from the above list that require detailed examination. These are to be studied in WP 9 & 10.
3. Create strategic plans for 12 combinations that were not judged as being of high priority at this point.

WP 8 Methodology: 1. The sector leaders identified in WP 4 first created reports termed 'Technology Opportunity Reports' (TORs) for their sector. The aim was to outline the opportunities that existed for that sector to combine its activities with those of other BG and BE sectors. These were circulated to all sector leaders to provide context outside of their own sector. Each sector leader then proceeded to rate the potential for their own sector to combine with each of the other BG and BE sectors. They were rated under the following headings:

a. Technical
b. Socio-economic
c. Environmental
d. Financial
e. Commercialit

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2. A list of the top ranking combinations was created and this was discussed with the EC to identify a list of priority combinations to be studied in more detail in WP 9 & 10.

3. For the combinations that were not top ranking, a strategic road map was created for their future development. Twelve 4-page reports were created under the umbrella of WP8, that discuss a concept for combining two or more sectors under the following headings:

a. market analysis
b. products
c. customer
d. competition
e. revenue

These reports were created by the sector leaders for each of the sectors included in the combination.

4. For the combinations being studied in WP 9 & 10, companies were engaged to conduct 9 'real-life' case studies of how the combination would work.

WP 8 Deliverables

WP 8 Key Findings, Lessons Learned and Recommendations:

WP8 Deliverables:

1. Ranking of all combinations in BG and BE: 9 top ranking sectoral combinations that were identified as having a high potential for success and deemed as requiring detailed examination by the European Commission. These combinations were the basis of the 9 case study projects carried out in WP9&10.
2. 12 combination Strategic Roadmaps: 12 of the lesser ranked combinations deemed to have potential and a strategic roadmap for future development had 4 page strategic roadmaps created, and these reports were finalised under WP8.

WP8 Key Findings, Lessons Learned and Recommendations:

Nine combinations were deemed to have great potential and were put forward for further study via case study project analysis in WP9&10. These projects are discussed in WP9&10 sections.

The following 12 combinations were also identified as having potential and strategic road maps were created for them. These roadmaps were delivered in WP8.

Basin	Sector 1	Sector 2
Caribbean	Aquaculture	Tourism
Caribbean	Wave	Desalination & Tourism
Atlantic	Tidal Lagoon	Tourism & Aquaculture
Atlantic	Offshore Wind + Desalination	Oil & Gas
Baltic / North Sea	Aquaculture	Wave
Baltic / North Sea	Aquaculture	Oil & Gas
Caribbean	Aquaculture	Wave
Mediterranean and Black sea	Aquaculture	Tourism
Baltic / North Sea	Aquaculture	Tourism
Baltic / North Sea	Seabed Mining	Fisheries
Atlantic	Aquaculture	Biotechnology/Blue Life Sciences
Mediterranean and Black sea	Offshore Wind fixed	Fisheries
North Sea	Oil & Gas	Floating Offshore Wind

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A summary of a selection of promising combination reports is available below and all reports are available on the MARIBE website (www.maribe.eu).

Tourism and Aquaculture

This combination was ranked favourably in all basins, thus demonstrating its wide ranging potential.
Funding requirements would be low to trigger the industry. The EC has invested in the development of aquaculture products and production and the promotion of awareness to increase consumer acceptance and grow demand of the products and the sector. By widening the offer of tourist attractions and production of fish, it provides a good opportunity for employment and income generation, as well as reducing the pressure on fish stocks and the wider marine ecosystem.
Both are very strong individual sectors. The targeted consumer/tourist would most likely be an educated population with a relatively high purchasing power and conscious of environmental preservation issues.

Seabed Mining and Fisheries

Funding for this combination would trigger the highly innovative seabed mining sector and the struggling fishing sector which is being displaced by aquaculture. The products of both sectors (ores and fish) can readily be distributed potentially resulting in large revenues if the concept is as successful as expected.
The upwelling concept aims to release controlled nutrients from discharged waters of mining for enhancement of primary production to feed fish populations and create a confined fish farm area. (note: ecological aspects need to be studied, especially when thinking of active stock enhancement).
Opportunities for mining (SMS deposits and potentially commercially exploitable crust) exist in areas where fisheries are present including near the Canary and Azores (Atlantic ridge), and western Mediterranean Sea.

Tidal Lagoon Tourism/Leisure and Aquaculture

Low cost investment required to start pilot. The revenue generated from the electricity export is the main driver for the concept, as it is estimated that the capacity of the international tidal lagoon sites with the potential for commercial development amounts to 80 GW estimated to be worth as much as £383 billion.
The concept of a tidal lagoon offers economic opportunities for other business sectors, in particular for tourism and aquaculture using the MUS concept.
Investment in and operation of a total of six tidal lagoons in UK, France and Wales is expected to deliver a range of benefits to the UK economy as well as to the environment. An accumulated contribution of £27 billion (€35 billion) to UK GDP over the period 2015-2027 sustaining an annual average 36,000 jobs throughout the UK. At its peak in 2021, the programme is expected to sustain up to 71,000 jobs. The spatial segregation of the different activities permits the combination of the three sectors: energy production, aquaculture and tourism in a MUS concept.

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Biotechnology and Aquaculture

This combination can increase Europe's local food security (reducing the dependability for marine proteins from Asia, cheaper production), enable a higher food security for the customers (track and trace, from feed to food) and mitigate the negative output from marine aquaculture. Two very highly synergistic technical industry sectors combining blue life sciences (i.e. biotechnology application in the marine environment) with aquaculture to increase production, environmental sustainability or bioremediation of aquaculture, or reduce the risk of unpredictable loss of production (incl. vaccination methods, protein-carbohydrate feed complexes, modified ingredients, modified probiotics, cage coating, etc.). Biotechnology tools can also be used for food safety and tracing through genomics and satisfy the Western-European need for food-safety (food-tracking). The technical and practical advantages of this combination mostly benefit aquaculture, although biotech companies will increase revenue and may benefit from the production of resources in aquaculture.

Project Descriptions (WP 9 & 10)

Leader – University College Cork – Gordon Dalton (WP 9); Swansea University – Ian Masters (WP 10)

Contributing Partners – UC, ABT; BVG; DLO; ECoast; FAO; HWU; SU; UCC, UCCAL

Nine combinations were selected for further study in WP 9 & 10. Those combinations are as follows:

Case study	Basin	Sector 1	Sector 2
1	Atlantic	Floating Offshore Wind	Wave
2	Canaries - Atlantic	Aquaculture	Floating Offshore Wind
3	Caribbean - French Guiana	Floating terminal/Shipping	Aquaculture
4	Atlantic	Floating terminal/Shipping	Wave
5	Atlantic	Wave	Aquaculture
6	Mediterranean	Wave	Aquaculture
7	Atlantic	Wave	Floating Offshore Wind
8	North Sea	Aquaculture	Fixed Offshore Wind
9	Mediterranean	Floating Offshore Wind	Desalination

These combinations were studied using a case study approach. Below is a description of the 9 case studies, each of which focuses on a multi-use of space or multi-purpose platform project.

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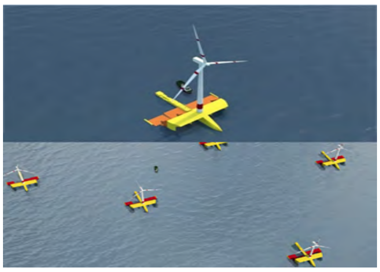
Case Study 1: Floating Wind & Wave Technology

FLOATING POWER PLANT

Company involved: **Floating Power Plant (FPP)** is a Danish clean-tech company that develops, designs and provides a unique patented technology integrating wave energy convertors into a floating offshore wind device. The company is entering the commercialization stage, based on over 8 years of R&D, testing and business development. The company is backed by 156 private shareholders and leading industrial development partners having raised more than 15m€ to date.

Combines: Floating wind and wave technology   Space share type: Multi-use platform (MUP)

Project/technology description: The hybrid device/technology has been developed over the last eight years, from concept to four offshore grid connected test phases totalling two years of operation with a scaled prototype. This makes FPP is the only company in the world that has supplied power to the grid from a combined floating wind and wave device. The FPP hybrid technology consists of five key technology elements, four of which are existing solutions from the oil and gas and offshore wind industries and 1 is a unique FPP solution:

1. a semi-submersible floating platform
2. An offshore wind turbine (5-8 MW)
3. A disconnectable and vaning turret mooring system allowing 360-degree rotation
4. Flexible subsea cables and power export system
5. A unique wave energy and PTO systems placed on a known stable structure (2-3,6 MW in total).

All patents and IPR are placed with the company.

Advantages of combination include (but are not limited to):

1. Increased uptime through greater access for O&M, due to the harbour effect
2. Greater addressable market (exploitable sites) through improved operability
3. Greater energy density (MW/km^2) with a smoother, more predictable power output
4. Cost savings in construction, installation and operation
5. Conforms to EU directives multi-use of space and MSP directives
6. Low LCOE relative to competitors, declining further with maturation

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Case Study 2: Aquaculture & Floating Offshore Wind

Companies involved: **Grupo Cobra** is a subsidiary of ACS, a Spanish multinational company with long experience in the construction and operation of fixed wind farms. **Besmar** is an offshore Aquaculture Consulting Company which was established in 2004. It´s an offshore aquaculture specialist that consults and develops commercial projects that are unique and front runners at both the commercial and technical level.

Combines: Aquaculture and Floating Offshore Wind

Space share type: Multi-use of space (MUS)

Project/technology description: This combination involves offshore wind turbines mounted on floating platforms, sharing the same space as an aquaculture installation. The two companies involved have a high level of experience in their respective sectors. Cobra's floating wind platform concept has already undergone early testing and is well positioned to be developed further as part of this combination, through the NER 300 program supported FLOCAN project. The deployment location planned is the South-East coast of Gran Canaria. The concept was identified and examined previously in the EU TROPOS project. The TROPOS Project aimed at developing a floating modular multi-use platform system for use in deep waters, with an initial geographic focus on the Mediterranean, Tropical and Sub-Tropical regions, but designed to be flexible enough so as to not be limited in geographic scope. TROPOS gathers 20 partners from 9 countries (Spain, the United Kingdom, Germany, Portugal, France, Norway, Denmark, Greece and Taiwan), under the coordination of PLOCAN (Spain - http://www.plocan.eu/es/).

Advantages of combination include (but are not limited to):

The advantages of this multiple use of space (MUS) include more efficient use of scarce licenced space and possible complementarities, including, among others, using the floating structures to protect part of the "cages" from the damage of strong currents and shared security and monitoring systems

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652629

Case Study 3: Floating Shipping Terminal & Aquaculture

Company involved: The **Grand Port Maritime de Guyane** (GPMG) is one of the 11 large sea ports operated by the French State, handling more than 95% of the goods traffic of French Guiana, with a flow of 55000 TEU in 2015.

Combines: Floating platform, shipping terminal, aquaculture, oil & gas services, OTEC (energy solution for platform)
Space share type: multiple use of space + multi-use platform

Project/Technology description: **Grand Port Maritime de Guyane** is developing a floating multi-use terminal. The platform will serve three main sectors – shipping (container transfer hub), oil & gas logistics hub, and aquaculture support.

This facility will be located on the maritime cross route between from East to West, Central America and Western Africa, and from South to North, Brazil and Caribbean Islands. The current ports on the coast of Guyana Shelf are all river ports and require regular, expensive dredging in order to accommodate modern container vessels. It will not be possible to extend this dredging programme to an extent that the new generation of Panamax container vessels can be hosted– thus the main driver behind the concept. The location also has the added advantage of potentially serving most of the Guyana Shelf Oil & Gas production platforms and enabling offshore aquaculture in one of the most propitious area in the world. The multi-use offshore platform architecture will be scalable and its structure will be constructed using multiple floating concrete modules.

Advantages of combination include (but are not limited to):

- Proximity to floating platform good environmental conditions for aquaculture.
- Favourable maritime support provided by the multi-use offshore platform, for instance logistical support, grow out tanks for juveniles, algae processing plant, quay for fresh water and ice production.
- No conflict of use with other marine activities.
- High level support to R&D offshore activities.
- A better contribution to international mutual efficiency for Guyana Shelf Countries, facing the lack of deep water facilities.
- The possibility to host other activities by providing basic logistical means.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652629

Case Study 4: Floating Shipping Terminal & Wave

Company involved: Float Inc. provides services that include research, design and development of marine oriented products and specializes in very large floating platforms. It is a marine technology company with proprietary and patented marine technologies that are capable of changing the way mankind uses the almost three quarters of the earth's surface that is covered by water, including how and where the world generates its electrical energy; moves its waterborne cargos; protects its ports and port cities from erosion; provides urban coastal expansion possibilities; and ways it can cleanly farm its oceans.

Combines: Floating shipping terminal and wave technology
Space share type: Multi-use platform (MUP)

Project/Technology description: **Float Inc.** is working with MARIBE to develop their Float Inc. Security Port, composed of the **Pneumatically Stabilized Platform** (modular, monolithic platform; stable; variable deck load capabilities; mobile, and extensible) which is constructed of pre-stressed reinforced concrete, and incorporates the **Rho-Cee Wave Energy Converter** as well as an **LNG terminal** for a baseload power source. Additionally, the Pneumatically Stabilized Platform forms a **Potential Energy Storage** system and power provider in support of the Rho-Cee Wave Energy Converters, offshore wind turbines and ocean current turbines as an inherent part of the Pneumatically Stabilized Platform. The synergetic combination of two or more of these or other applications on one MUP results in superior economic investment and cost savings. This Float Inc. multi-use platform is designed to serve as a central hub shipping and container terminal and using Rho-Cee Wave Energy Converter as a complementary renewable energy source for powering the platform and/or potentially export to the grid. The primary business model element is the hub shipping and container terminal supplying a centralized hub for in/outbound container service for Ultra Large Container Ships (ULCS) currently under development. The anticipated location is off the south coast of Ireland, an ideal location for a central hub shipping and container terminal providing Short Sea Shipping re-distribution of in/outbound container traffic entering European waters.

Advantages of combination for Wave energy:

- Reduced cost of installation due to combined construction.
- Reduced O&M due to ease of access.
- Wave energy for standalone power generation resulting in reduced operating costs.

Advantages for platform:

- Monolithic platform – modular construction and assembly. This is extensible, stable with variable deck loads capabilities.
- Wave attenuation - Autonomous supply of clean renewable energy, balanced by compressed air storage and LNG terminal production of baseload electricity, potable water, and regasification facilities.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 652629

Case Study 5: Wave & Offshore Aquaculture

Companies involved: The consortium will be composed of two companies, Wave Dragon and Seaweed Energy Solutions (SES), and the independent organisation Bellona Foundation. Wave Dragon is a private Danish/UK based company working towards the commercialisation of wave energy converter (WEC) technology to extract electricity directly from ocean waves. Seaweed Energy Solutions (SES) is a Norway-based seaweed innovation and business development company. Bellona Foundation is an independent environmental NGO that aims to meet and mitigate challenges of climate change through identifying and implementing sustainable environmental solutions.

Combines: Wave Energy and Offshore Aquaculture
Space share type: Multi-use of space (MUS)

Project/Technology description: This concept envisages an array of wave energy converters (WEC) of a design created by the Wave Dragon, combined with a seaweed farm. Wave Dragon has deployed a grid connected 237 tonnes pilot WEC plant in Nissum Bredning, Denmark. The technology is a floating, slack-moored energy converter of the overtopping type. SES has proven capacity to cultivate brown seaweed (*Saccharina latissima* and other kelp genus) on a large scale (long-lines). It provides a platform for the further development of cultivation technology. An industrial scale hatchery was built, and it successfully supplied seeds for 100-150 tonnes wet weight biomass. A pilot farm in Frøya is one of the largest seaweed cultivation farms to date in Europe. The current products are distributed to a niche food industry market.

Wave Dragon is looking to develop its technology further at commercial farm scale. SES is looking to further improve its harvesting technologies, including mechanisation, and to help increase harvest volumes. Location of farms in Welsh offshore waters, calmed and occasionally being submerged by a wave machine, will increase the operational days and thus make kelp production feasible in exposed waters. The processed seaweed can be sold as a high value material for food and health products (nutraceuticals), cosmetics, animal feed markets, among others.

Advantages of combination include (but are not limited to): The seaweed farm will benefit from calmer water behind the devices, enabling them to be located in areas which would not normally be viable. During periods of rough seas, electricity from the WECs can be used to winch the seaweed farms lower into the water, protecting them from any ill-effects. Electricity from the WECs will be exported to the grid. The combination will benefit from an easier licensing process due to the multiple use of space, and there are also significant synergies for installation, inspection and maintenance operations. The expected location of the pilot deployment is off the Welsh coast.

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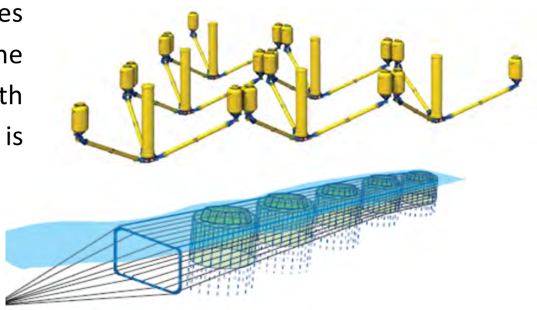
Case Study 6: Offshore Aquaculture & Wave

Companies involved: **AquaBioTech Group** is an international research and development, engineering and consulting company operating globally in over fifty-five countries. The vast majority of the company's work is related to the marine or aquatic environment, encompassing aquaculture developments, market research / intelligence, through to project feasibility assessments, finance acquisition, project management, technology sourcing and technical support and training. **Albatern's WaveNET** is a radical new wave energy device that captures energy from ocean waves and converts it into sustainable low-carbon electricity, providing improvements in operational efficiency at lower cost.

Combines: Offshore FinFish Culture and Wave Energy Generation

Space share type: Multi-use of Space

Project/Technology description: These two companies have come together to form a Special Purpose Vehicle (SPV) to provide a one-stop-shop for wave energy enabled aquaculture solutions utilising the synergies in sea-space equipment usage to provide electricity for energy intensive aquaculture installations, facilitating amongst others the movement of commercial cage farming further offshore. Utilising the combination, fish can be produced with a vastly reduced environmental impact by utilising the renewable electricity provided by the WaveNet devices to service specifically the energy requirements of the farming operations. The SPV's target market focuses on both existing and new cage farming operations, however it is envisaged that the WaveNet will also be utilised extensively to provide power (and potentially potable water) to shore based marine aquaculture facilities in areas where wave energy is suitably abundant and supply of grid-based electricity is expensive or unavailable.



Advantages of combination include (but are not limited to):

- Cost savings on Delivery, Storage, Installation and Commissioning, O/M due to shared vessels, technical Support Team and Overhead.
- Cost savings on energy for aquaculture due to energy supplied by sustainable power from on-site wave resource.
- Increases sustainability of operations and reduces additional logistics costs and challenges of transporting and handling diesel fuel in rougher waters offshore.,
- Wave farm to provide protection from rough seas - calmer waters for aquaculture farm,
- Enables aquaculture farm to be further offshore where clean nutrient rich water exists, higher stocking densities due to the depth and limited environmental impact.
- Guaranteed sale of electricity to aquaculture customer.
- Low electrical losses and cabling costs due to proximity of customer.

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Case Study 7: Offshore Floating Wind & Wave

Company involved: J.J. Campbell & Associates is a structural and civil engineering company with a variety of design projects including multi storey buildings, shopping centres, industrial and residential projects with public and private sector clients established in 1996 and having a reputation for delivering design and detail within budget and on time.

Combines: Floating wind and wave technology
Space share type: Multi-use platform (MUP)

Project/Technology description: This combination is a mixed use platform (MUP) designed by **J.J. Campbell & Associates**, consisting of a large V-shaped concrete structure incorporating Oscillating Water Column (OWC) wave energy converters, with a wind turbine mounted on the platform via a steel superstructure.

The concrete construction is modular allowing easier fabrication and assembly. Other advantages of the concrete construction include the cost-effectiveness of concrete as opposed to an entirely steel construction, ease of maintenance and the proven technique of slip-form concrete construction.

By combining wave and wind technology in the same platform, the economic viability of the technology will be increased. The aggregation of wind and wave energy converting technologies reduces the variability of the power generated by the platform as a whole with respect to time. It will also be able to make maximum use of the resources available at any particular location, and due to the floating aspect, will be deployable in water depths previously beyond the limits of current fixed offshore wind technology. Planned deployment location for the pilot is off the west coast of Ireland.

Figure 1.1: Location of pilot location (AMETS) and fabrication site (Foynes)

Advantages of combination include (but are not limited to):

1. Two non-correlated out-of-phase power sources on one platform resulting in smoother power delivery and obviating the need for storage
2. Cost savings on materials by combining on one floating platform
3. Cost savings on O & M due to 'harbour' effect
4. Cost savings arising from shared wind & wave electrical infrastructure
5. Conforms to EU directives on multi-use of space and MSP directives
6. High local content for deployment areas on the periphery of Europe

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Case Study 8: Offshore Fixed Wind & Aquaculture

Company involved: This project draws on the results of the MERMAID consortium. The FP7 research project MERMAID designed multiple use concepts for four European basins, either multi-use of space or multi-use platforms. This was done through a participatory design process, involving companies, authorities and civil society. The designs were evaluated, among others through societal cost-benefit analysis. One of the most promising designs for the North Sea included wind farms with bottom-fixed offshore wind turbines and mussel aquaculture.

Combines: Fixed wind and mussel aquaculture

Space share type: Multi-use of space. The envisaged system is a multi-use of space (MUS) only. The turbine foundations are not used to attach the mussel aquaculture systems.

Project/Technology description: This technical brief focuses on the wind park Borssele (see Figure). This wind park consists of 4 plots. The total site area equals 344 km². The development builds upon experience with existing wind parks, and technologies for offshore wind are available and tested. The permitted foundations are monopile, tripod, jacket, gravity based and suction bucket for turbines in the range of 4 to 10 MW. The government support scheme is a contract-for-difference (CFD).

In this combination, multi-use of the wind parks includes the production of mussels. Due to the growing pattern of mussel aquaculture mussel seed, half-grown and full-size consumption mussels are produced. The Dutch Mussel industry and NGO's have agreed collect mussel using long-lines. Although these devices are mainly used in the Wadden Sea, it is expected that by 2020, 5.5 million kg of mussel seed is to be collected annually in the North Sea. In the commercialisation phase of the project the installation of 98 ha of mussel aquaculture units is proposed. This equates to 98 ha of support lines. The wind park development is guaranteed.

Advantages of combination include (but are not limited to):

- General socio-economic societal benefit, as 100% renewable sources with low carbon footprint including low overall environmental impact due to MUP design.
- Cost reduction by integration of offshore activities and O&M costs due to shared facilities.
- The wind park provides the mussel companies with an area not accessible for large other vessels, reducing risk that the mussel facilities are negatively affected by these vessels.
- Mussel aquaculture makes area less accessible for other vessels, reducing risk of collisions with unfamiliar vessels (for wind farm).
- Mussel aquaculture can have a wave dampening effect, reducing fatigue and resultant O&M for wind farm structures. Dampened seas will also enable access for O&M for longer periods increasing wind farm availability.

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Case Study 9: Offshore Floating Wind & Desalination

Company involved: EcoWindWater (EWW) is a clean-tech company that addresses the scarcity of freshwater and energy commodities in identified domestic and global markets. The combined technologies can deliver both fresh water and electricity in a dynamic configuration meeting customer needs including catering for seasonal fluctuations. EWW's domestic market focuses around several Greek islands especially in the Cyclades complex that experience water stress during high tourism season and having to import fresh water to meet their needs. The global market stretches to other island locations in the Caribbean and Canaries but also to countries of the Middle East such as Yemen that face extremely high levels of water stress as underground aquifers are depleted and where water management is becoming increasingly costly.

Combines: Floating wind and desalination technology
Space share type: Multi-use platform (MUP)

Project/Technology description: The floating platforms located within a few kilometres distance from the shore are independent of water depth which allows extra flexibility to avoid conflicts with other active sectors such as tourism. The combination of technologies is based on a semi-submersible steel platform, accommodating an offshore wind turbine (2 MW) and a desalination plant using Reverse Osmosis (RO) desalination with a maximum output of 3360 m3 per day. They can desalinate seawater at times of high wind resource which is transferred via water pipes to the islands and stored in existing drinking water storage tanks. The intended deployment location Cyclades island complex in the Aegean Sea, Greece within few km from the shore at water depth exceeding 40 meters. The area has good wind resource with average wind speed measured offshore to Santorini island at 8.6 m/s at 100m high. During installation the MUP will be towed to location avoiding the use of costly specialist vessels which also enables the unit to be towed to the nearest harbour easily for major maintenance. While initially the MUP turbines will focus simply to power the desalination process they can also export surplus electricity to the island grid via cable.

Advantages of combination include (but are not limited to):

- 100% renewable sources with low carbon footprint including low overall environmental impact due to MUP design.
- Cost reduction by integration of offshore activities.
- Lower costs than land-based conventional desalination.
- Chemical-free renewable powered desalination system compliant with EU directives.
- Site selection process on case-by-case basis working closely with local stakeholders for an optimum use of the sea space.
- Wind generated energy used at source, therefore low losses.
- Guaranteed customer for electricity purchase

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