PART IV

Combining Uses

14

Multi Use Platforms (MUPs) and Multi Use of Space (MUS)

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14.1 Introduction

Our oceans are important drivers of economic growth. They provide natural resources, access to trade and transport and opportunities for leisure activities. 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’ (BG5 2014). 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 project “Marine investment in the blue economy” (or Maribe www.maribe.eu) was initiated with the aim of promoting growth and jobs within the blue economy. The Maribe project started in March 2015, with a duration of 18 months and a total budget of 2 million euros under the European Commission’s Horizon 2020 programme, it was led by the MaREI Centre in University College Cork (www.marei.ie). A total of 11 partners contributed to the project from Ireland, United Kingdom, Belgium, Spain, Italy, Malta and the Netherlands, including FAO, who add an international extra-EU dimension to the consortium.

The primary objective of Maribe was to promote smarter and more sustainable use of the sea through the sharing of space. It investigated the potential of combining maritime sectors in the same place (Multiple-Use-of-Space (MUS)) or on a specifically built platform (Multi Use Platform (MUP)) in order to make more efficient use of space and resources. It paid particular attention to new and emerging industries featured in the other chapters of this book that could benefit greatly from the synergies created, increasing their chances of survival and enabling future growth. In order to achieve its aim, Maribe conducted:

- A study on "*socio-economic trends and EU policy in the offshore economy*", to review each sector from a business lifecycle and socio-economic perspective. A review of the policy and planning frameworks that applied to the sectors was conducted for each of the sea basins under study: Baltic basin, Atlantic basin, Mediterranean and Black sea Basin, and the Caribbean Basin.
  WP4 (http://maribe.eu/blue-growth-deliverables/blue-growth-work-packages/) The results of this work package formed the basis for this book.
- A study on "*Technical and non-technical barriers facing Blue Growth sectors*", to look at barriers by sector and also by combination and to identify the barriers that existed when two sectors shared marine space or multi-use platforms; WP5 (http://maribe.eu/download/2581/).
- An "*investment community consultation*" to assess the current investment environment, as well as best practices and key barriers for investment; WP6 (http://maribe.eu/download/2575/).
- A "*business model mapping and assessment*" to analyze and map the business models that lie behind Blue Growth/Economy industries. WP7 (http://maribe.eu/download/2569/).

Building on the above studies, Maribe then assessed the potential for each of the sectors falling within its scope to combine their activities with those of other Blue Growth or Blue Economy sectors.

14.2 A Methodology for the Selection of a Promising Combination of Blue Growth Sectors

The 4 Maribe sea basins were reviewed using an Excel based spread sheet for each basin:

1. Atlantic and North Sea
2. Baltic

Table 14.1 Maribe Blue Growth Matrix selection template showing the Atlantic basin and average of all marks for the 5 headings listed below[1]

Atlantic Basin - Final Score													
	Wave	Tidal	Tidal Lagoon	Desalination	Offshore W	Offshore Wind	Aquaculture	Biotechnology	Seabed Mining	Offshore fixed ter	Toursim	Oil & Gas	Fisheries
Wave													
Tidal													
Tidal Lagoon													
Desalination													
Offshore Wind fixed													
Offshore Wind floating													
Aquaculture													
Biotechnology													
Seabed Mining Offshore													
Offshore fixed terminal													
Tourism													
Oil & Gas													
Fisheries													

3. Mediterranean
4. Caribbean

A two dimensional matrix was created with the 13 Blue Growth and Blue Economy sectors on both x and y axis, and is visual presented in Table 14.1

For each basin, the potential for combination of Blue Growth sectors was rated from 1–5 (5 was maximum rating = best) under the headings of:

- technical,
- environmental,
- socio-economic,
- financial and
- commercial perspective.

The top 24 potential Blue growth combinations were initially selected. Blue Growth Companies were then matched to the chosen Blue Growth combinations and shortlisted in liaison with the European Commission.

It was a difficult task to find existing Blue Growth companies to match the top ranked Blue growth combinations arising from Table 14.1. It was even more challenging to gain cooperation form these companies to participate in the Maribe case studies. Finally, Maribe succeeded in securing 9 companies related to the top ranking blue growth combinations in Table 14.1. Table 14.2 lists the 9 case studies, the companies that participated and their relevant Blue growth sectors.

This chapter will present three representative case studies and will conclude with an overall evaluation of the viability of Blue Growth combinations.

[1]The marks ratings are not disclosed here, but are available from the Maribe website.

Table 14.2 Case studies of Blue Growth combinations

Case Study[2] and Maribe report link	Company 1	Technology 1	Company 2	Technology 2
A1	Floating Power Plant, Denmark	Floating wind		Wave Energy
A2	ASC, Spain	Floating Wind	Cobra/Besmar, Canaries	Aquaculture
A3[3]	Grant Port Guyane	Floating shipping Terminal		Aquaculture
B1	Float Inc, USA	Floating shipping terminal		Wave Energy
B2	Wave Dragon, Denmark	Wave Energy	Seaweed Energy Solutions	Seaweed macro Algae
B4	Albatern, Scotland	Wave Energy	Aquabiotech	Aquaculture Finfish
B5[3]	JJ Cambells, Ireland	Wave Energy		Floating wind
B6[4]		Fixed Wind		Mussel farm
B8	EcoWindWater, Greece	Desalination		Floating wind

14.3 Case Study Description Methodology

Each Maribe case study was assessed under 4 sub-sections:

1. Technical brief
2. Financials
3. Business plan
4. Risk Assessment

Extensive efforts were made during the project to protect the value proposition of the companies that contributed to the case studies. There were extensive discussions around non-disclosure agreements and protection of IP. Therefore, the sections on the financial details of the proposition and the risk identified will not be discussed here. However, the technical brief and business plan of the three case studies below provides very interesting reading and shows how blue growth combinations can become viable companies.

[2]Maribe numbering: Project B3 and B7 were dropped from the case studies, due to lack of sufficient data. Partners in A3 and B5 declined permission to make their reports publically available.

[3]Companies did not provide permission for their reports to be made publically available on Maribe website.

[4]No companies were found to provide data for project. Maribe had enough expertise to complete the case study.

The reader should also note that dynamic start up companies such as those featured here can change significantly in a short space of time. The case studies here reflect the status of the company during the course of Maribe in approximately 2016. Each of the case studies was subject to extensive investigation by the consortium and by a panel of experts, the three projects chosen here were among those that received positive feedback and ratings from this assessment.

14.3.1 Technical Brief Methodology

The technical brief of each case study contains the following information:

- Size and scale: *Number of units, rating of each unit, for instance: wind: one unit rated at 5 MW; wave: four units rated at 2MW total wave power take-off.*
- Footprint incl. boundary: *Information on the site the deployed asset is expected to occupy. For instance: "approx. 0,25 km^2".*
- Located: *Information on the proposed or intended location for the proposed project. For instance: "24 km (15 miles) off the coast of Wales".*
- Water depth: *Range or maximum water depth at the specific location based on readily available information in the literature of company's survey. For instance: "60 m".*
- Cable to shore or power source (if applicable): *For electricity exporting projects only. Informing if grid connection is available near the project deployment site, size of cables to be used and any other relevant information. Even at pilot stage some project developers are looking to demonstrate electricity exported to the grid as this often presents as a milestone in the development stages. For instance: "Grid connection available at Galway Bay test site".*
- Moorings: *Information on what mooring technology will be used to secure the assets to the seabed if a structure is floating, as this could present a major risk if not addressed appropriately.*

14.3.2 Business Plan Using Business Model Canvas

The Business Model Canvas tool is a method that is used by companies to describe their business models using nine building blocks. It was developed by Alexander Osterwalder based on his earlier Business Model Ontology[5,6].

[5]Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers.* John Wiley & Sons.

[6]Osterwalder, A. (2004) *The Business Model Ontology – A Proposition in a Design Science Approach* PhD Thesis, University of Lausanne.

Each of these building blocks represents a key organisational structure that is required to have a functioning business. It has been utilised by companies and organisations such as NASA, Intel, Microsoft, PWC, and Ernst & Young.[7]

A business model canvas has 9 building blocks. Maribe added four extra blocks (to total 13): competition, market, management and Financing/ investment. Due to space limitations, this chapter will only present the four of the most relevant building blocks. The following presents their description:

1. Competition

The competition section for each combination was drawn up to include a cross-section of direct and indirect competitors based on the companies' information and publicly-available information regarding projects with similar characteristics. Indirect competitors were included, for example conventional carbon and nuclear energy generation for wave and offshore wind energy, to reflect the reality that in order for the businesses to reach commercial viability, they must compete on price with conventional established industries. These competitors were listed, together with 'Key Differentiators' and a competitive threat rating. The competitive threat rating was based on the companies' rating of the perceived threat from their perspective.

2. Business model

Bringing together different types of business into a single location is, by definition, a new way of working that normally involves more than one company. This building block contains a description of how the company or companies will work together to create the value proposition, and get it to market. This may include business models such as special purpose vehicle, partnerships, mergers etc.

3. Value proposition

Value proposition provides a unique combination of products and services which provide value to the customer by resulting in the solution of a problem the customer is facing or providing value to the customer.

4. Market analysis

Market analysis of the sectors involved in each combination was compiled from a combination of desk studies of existing market research and reports, together with information provided by the companies involved. This was then used to calculate:

[7] http://www.businessmodelgeneration.com/canvas/bmc

- Total Available Market (TAM),
- Serviceable Available Market (SAM) and
- Serviceable Obtainable Market (SOM).

14.4 Case Study 1 – Floating Wind and Wave – Floating Power Plant

14.4.1 How Floating Power Plant Was Selected by Maribe

The Maribe ranking of BG combinations exercise determined that floating offshore wind with wave energy would be both technical, and economically viable, whilst also having large socio-economic and environmental benefits. The combination of the two sectors could either be sharing one space (MUS), or in a MUP. The following are the Maribe findings for both MUS and MUP possibilities:

- Technically:
  - MUS: there are no technical barriers faced by mixing wave energy with floating offshore wind parks.
  - MUP: One company has championed this technology and is at TRL8. Although technical challenges still exist, the commination looks technically favourable.
- Economic: Both sectors are economically viable by themselves providing they receive appropriate Feed in Tariffs. Higher tariffs for wave energy may prove beneficial for the floating wind part of the project. Cost savings should accrue in shared costs, and reduced materials, both in MUS and MUP.
- Environmentally: The environmental impact of these two sectors in MUS or MUP would not increase, than if they were deployed completely separately.
- Socio-economically: it was determined that public acceptance would be high, and assist in green renewable energy, increasing job prospects.
- Commercial development: floating wind is at TRL 7 of higher. Wave energy is still at TRL5.

The Atlantic was deemed the best basin, due to extremely good resources of both wave and wind.

The MUS option theoretically had the most possibilities. There are already a number of pilot prototype floating offshore wind farms in development: e.g. Hywind Park off Scotland, Windfloat project off the Mediterranean cost of France, and ASC NER 300 FLOCANS 5 project in Canaries. There would also be a number of wave energy candidate technologies that could be deploy in the midst of the floating wind farms. However, to date, there are no current projects exploring this combination. This is probably because floating offshore wind is currently emerging from the high risk prototype stage. Therefore, combining another technology with floating wind may be seen to increase the risk above investor tolerance or interest.

Fixed offshore wind, which is now considered in the mature commercial phase, is also hesitant about combining other technology types within its wind farm. Significant progress was made in 2016, when Wavestar was awarded €28M H2020 award to test pilot deployment of one of its devices within a Belgian wind farm. Unfortunately, a combination of key investor withdrawal, and difficulties in finalising a deployment location suitable for Wavestar ended in termination of the project.

The other combined option discussed earlier, is the MUP option. Currently the only technology that is successfully exploring this option is Floating Power Plant. The Business plan fitted perfectly within the Maribe ranking criteria, of an Atlantic deployment and TRL 5 or higher having been already achieved.

14.4.2 Company Description

Floating Power Plant A/S[8] 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. 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. 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 one is a unique FPP solution[9]:

1. A semi-submersible floating platform
2. An offshore wind turbine (5–8 MW)

[8] http://www.floatingpowerplant.com/

[9] All patents and IPR are placed with the company.

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).

The design combination of a highly efficient wave energy device on a stable structure connected to a disconnectable turret ensures that the platform passively vanes to face the primary wave direction. The disconnectable turret mooring allows the device to be completed constructed and commissioned in harbour and returned to harbour for major maintenance activities, eliminating the extra risk of performing these offshore and avoiding the use of costly specialist vessels. The platform orientation into the primary wave directly combined with the high wave absorption (50–70% of the wave energy is absorbed) results in an artificial offshore harbour effect at the aft end of the system, enabling significantly increased accessibility for routine maintenance and repairs.

14.4.3 Technical Specification of Technology

14.4.3.1 Current status

The technology is at TRL 6. FPP is the only wind/wave hybrid technology in the world that has been proven in the offshore environment. P37, the half-scale grid connected prototype, has operated for 4 offshore tests periods constituting more than 2 years of data. The commercial development plan for the technology has three key stages and is performed with an Irish end customer (project developer). The first stage is a full scale pilot demonstration platform, deployed at a Welsh or Scottish offshore site (Welsh project presented here and shown in Figure 14.1).

- Located: 24 km (15 miles) off the coast of Wales
- Water depth: 60 m

Pilot Demonstration project has a 7MW total capacity with 3 years' operational lifetime (assets to be transferred to early commercial follow up project). The pilot comprises of a single P80 first generation MUP hosting:

- Wind: one unit rated at 5 MW
- WECs: four units rated at 2MW total wave power take-off

Other details

- 77 GWh delivered to the grid (over 3 years) from a single MUP during the demonstration project

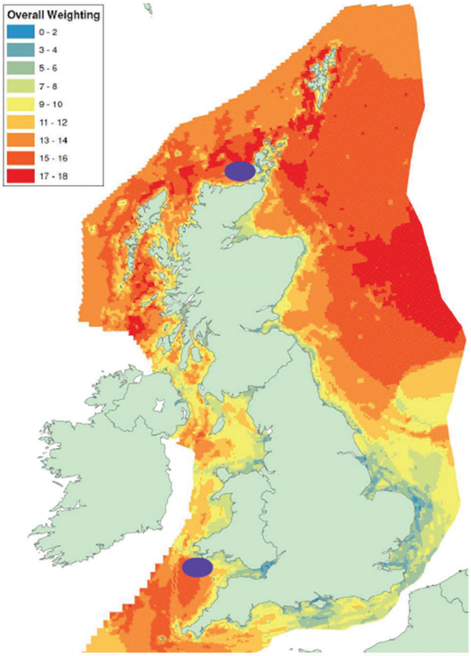

Figure 14.1 UK map, showing hotspots of combined wave and wind resource. Circles show FPP proposed deployment sites in Scotland and Wales.

   - Total capex incl. grid capacity for the worlds full scale hybrid 7 MW: €64.1 million

- After 3 years operation, the next stage will see the addition of 27 P80 platforms to the same site, totalling 28 platforms.
   - *Power generated: 13600 GWh*
   - *Total capex: €889 million*

The combined array project will be commercial and will make a profit over the indented 20 year design life at the current feed-in-tariff with a CfD contract mechanism (agreed "strike" price set with the UK Government).

1. The third stage is a commercial outlook case, deploying 2nd and 3rd generation P80 platforms at high energy sites, where each generation represents a significant step up in technology improvement.

   P80 3rd Gen specs:

      - *Wind: 8 MW wind turbines*
      - *WECs: 3, 2 MW wave power take-offs*

The 3rd generation P80 commercial array will have a total power capacity of 464 MW and 20 years' operational lifetime.

Other details:

- *Footprint approx. 72km^2*
- *Located 100 km of the west Scottish coast*
- *Water depth: 75 m*
- *Power generated: 31746 GWh*
- *Total capex: €1383 mill*

14.4.3.2 Advantages of floating power plant combination

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

14.4.4 Business Section

14.4.4.1 Competition

Wave device developers are not considered direct competition due to their high projected LCOE and the small number of other hybrid devices under

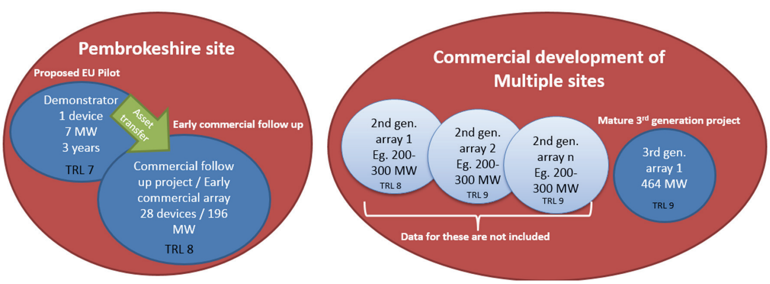

Figure 14.2 Diagram showing the project stages in FPP commercialisation process. The Pembrokeshire site contains the first two project stages and the commercial development of multiple sites is the 3rd stage. Projects in dark blue are described and costed in this document reflecting the 1st and 3rd technology generation.

development, are significantly less mature than FPP, who are the only developer to have undergone grid connected offshore testing. The direct competitors can be divided into separate sub groups as represented in Figure 14.3.

1. Windfloat project – a single demonstrator with a small array planned
2. Hywind Demo – A single turbine deployed on a spar buoy
3. Hywind Pilot – An array of 5 Hywind turbines, fully consented and under construction
4. Kincardine – An array of up to 8 floating turbines, consent application submitted

No project or technology is currently targeting the green area of the map due to the operational challenges of the high wave resource (Figure 14.3). FPP provides a unique option to exploit this vast area of resource.

14.4.4.2 Value proposition

FPP presents a simple 3 pronged value proposition in Figure 14.4, based on a versatile product which is both profitable and low cost of energy. The value proposition is sensibly linked to technology offering and technology risk mitigation plans.

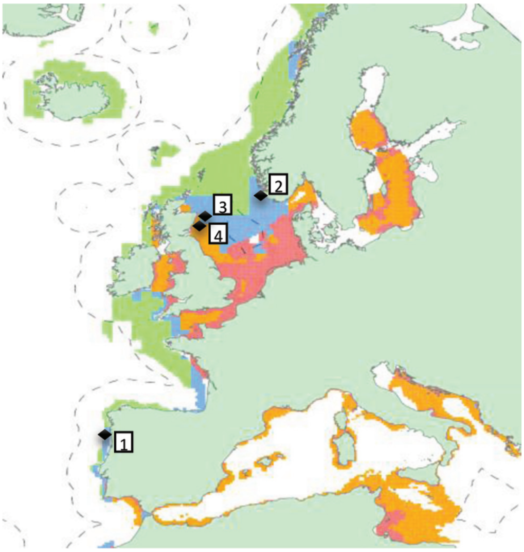

Figure 14.3 Combined Wind and wave resource map (green indicating highest combined potential where Floating Power Plant will be deploying).

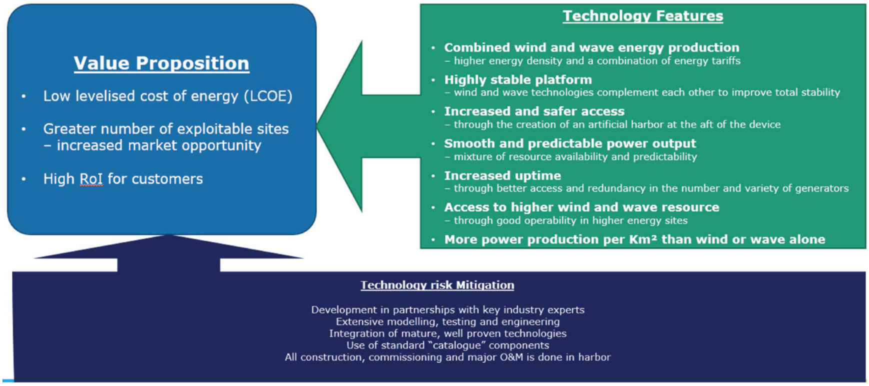

Figure 14.4 Floating Power Plant value proposition.

14.4.4.3 Business model

One key difference is that the goal of FPP is not to be producer of the technology, but the designer and manager thereof. The production and assembly will be handled by preferred partners and in some cases sub contracts. This is also the reason for FPP's partnering model, the value chain is built up alongside the technology development. This strategy reduces the capital burden and increase global flexibility. As the company develops, a strategic partner/value chain investor will be taken in to the required balance sheet to provide cheaper finance and trustworthy warranties/guaranties.

14.4.4.4 Market capture

Figure 14.5 presents FFP TAM, SAM and SOM: predicting a SOM (Serviceable Obtainable Market) of 20GW of installed product by 2050, 10% of the SAM (Serviceable Available Market).

Figure 14.5 Floating Power Plant market capture.

14.5 Case Study 2 – Floating Wind and Aquaculture – Besmar and Cobra/ACS

14.5.1 How Besmar Cobra/ACS Was Selected by Maribe

The Maribe ranking of BG combinations exercise determined that floating offshore wind with aquaculture would be both technically and economically viable, whilst also having large socio-economic and environmental benefits.

There are no MUP floating offshore wind and aquaculture enterprises. Therefore, Maribe explored whether floating offshore wind parks could host aquaculture farm in its midst. The following were its findings:

- Technically: there are no technical barriers faced by mixing aquaculture with floating offshore wind parks.
- Economic: Both sectors are economically viable by themselves, and together might prove to have increased economic viability.
- Environmentally: The environmental impact of these two sectors in MUS would not increase, than if they were separate.
- Socio-economically: it was determined that public acceptance would be high, and assist in moving aquaculture offshore, increasing job prospects.
- Commercial development: both are at TRL 6 of higher.

The Atlantic was deemed the best basin, due to extremely good resources of both wind and aquaculture production.

There are only a few floating offshore wind parks currently in deployment: e.g. Hywind Park off Scotland, Windfloat project off the Mediterranean cost of France, and ASC NER 300 FLOCANS 5 project in Canaries. Hywind will be exploring combining offshore aquaculture with their wind farm in the future once the Scottish pilot has passed a certain stage of testing. Thus they were not willing to cooperate with Maribe at this stage. WindFloat are in a similar phase. Fortunately ACS were in a position to consider combining with an aquaculture partner, which was Cobra Besmar.

14.5.2 Company Description

Grupo **COBRA**[10] is a subsidiary of ACS, a Spanish multinational company with long experience in the construction and operation of fixed wind farms. **BESMAR**[11] Aquaculture Company was established in 2004 as a specialist

[10]http://www.grupocobra.com/content/page/group-companies/

[11]http://www.besmaraquaculture.com/

offshore aquaculture company to consult and develop commercial projects that are unique and front runners at both the commercial and technical level.

14.5.3 Technical Specification of Technology

COBRA/ACS floating wind technology is at TRL5/6 and has successfully completed the testing of their floating wind turbine at 1:40 scale, 78 Kg in weight in 2014 in a laboratory test channel in the Canaries (more information at http://www.cehipar.es/). COBRA has been awarded €34 million (FLOCAN 5) from the €1 bn NER 300 Program in 2014 to deliver the FLOCAN 5 project (i.e. Pilot TRL 8 pre-commercial farm Gran Canaria) which is expected to be operational in 2017–18.

BESMAR aquaculture technology is at TRL9 with a 1^{st} commercial aquaculture farm deployed in Gran Canaria. The BESMAR organic aquaculture plant has been operating since 2012 and has the latest technology cages constructed from heavy duty Polyethylene (PE). Measuring 25m diameter and 5000 m^3 volume the main frame of the cage is composed of three 400 mm diameter rings with heavy walled pipe to resist impact and kinking, it also has a 5 tonnes weight "froya ring" to tension the net pen.

The Cobra Besmar project is planning 2 phases of development:

1. Phase 1: TRL 7/8 per-commercial pilot
2. Phase 2: TRL9 Commercial project

14.5.3.1 Phase 1: TRL 7/8 pre-commercial pilot

The pilot project will consist of:

- COBRA: 5 floating wind turbines rated at 5 MW each total capacity, total 25 MW
- BESMAR: 6 fusion type offshore aquaculture cages with 40 tons capacity (organic sea bass production)

The location for the pilot project will be South-East coast of Gran Canaria 5.2 Km from shore, at water depth range 40 to 200 m for wind turbines, and 40m for aquaculture (Figure 14.6).

Other relevant technical details:

- Cable to shore or power source: submarine cable 2×(5MW/13.2kV) linking the wind farm to an offshore floating substation
- Array connection or autonomous power: 33 kV

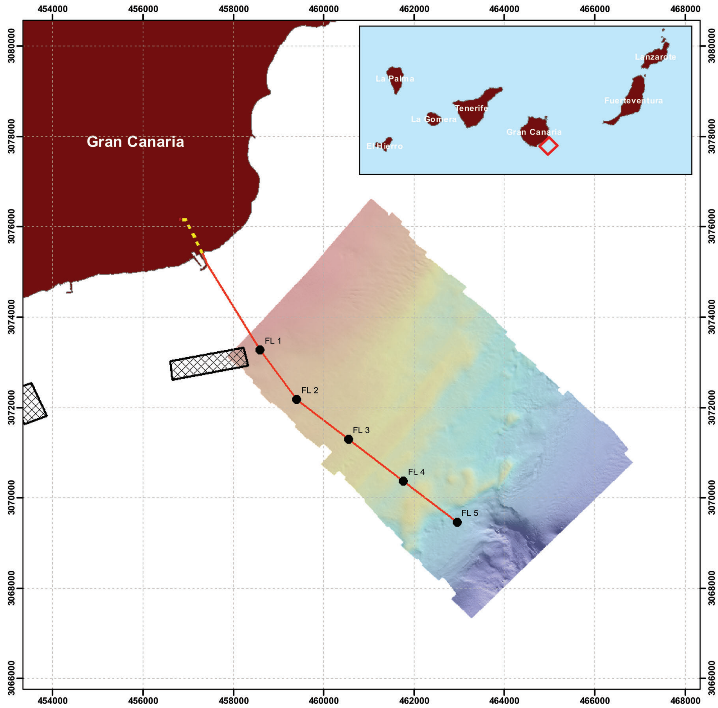

Figure 14.6 Potential location for Cobra/Besmar pilot project off the SE coast of Gran Canaria.

- Moorings:
    - COBRA: Tensioned mooring lines anchored to seabed
    - BESMAR: Tensioned mooring lines anchored to seabed
- Operations and Maintenance: COBRA: Wind turbines O&M will be supported by the port and shipyard of “Puerto Las Palmas”. BESMAR: supported by port “Puerto de Taliarte”

This pilot project has secured part of the funding required from NER 300 (project FLOCAN).

14.5.3.2 Phase 2: TRL 9 commercial

Expansion to a full commercial farm will be the next phase with additional wind units and aquaculture cages installed at the same site. Market entry will be completed with a 2nd commercial farm, followed by a 3rd commercial project. The commercial projects will deployed in a new site at PLOCAN testing site in South-East coast of Gran Canaria, Plataforma Oceanográfica de Canarias (PLOCAN) a Research Institute co-funded by the Economy and Competitiveness Ministry of the Spanish government and the Canary Islands government.

The commercial project will consist of a total of 125 MW and 1300 tons/year organic sea bass

- *COBRA: 25 floating wind turbines rated 5MW each*
- *BESMAR: 24 fusion type offshore aquaculture cages with 40 tons sea bass production capacity each*

Other relevant technical details:

- *Footprint combined approx. 23 Km^2*
- *Water depth: 600m*

14.5.3.3 Advantage of floating wind and aquaculture combination

14.5.3.3.1 *General for both sectors*

- Cost savings on O&M due to shared vessels, using multi-purposes vessel should have all the equipment and facilities to operate for both activities.

14.5.3.3.2 *Aquaculture farm*

- Cost savings on energy due to energy supplied by wind farm.
- Wind farm provides protected calmer waters for aquaculture cages, increasing cage longevity and also increasing performance at earlier stages by reducing fish losses due to broken nets.
- Healthier product, the fish will have less stress and clean water, increasing animal welfare and the final quality of the product.
- Less environmental pollution due to better dispersion by currents due to distance from coast.
- Security camera and radar systems can be installed at the turbine to protect finfish farm from robbery.
- Automatic feeding systems could be installed (not included in this project).

14.5.3.3.3 *Offshore platform wind farm*

- Good public perception, allowing the companies to advertise their products as environmentally friendly produced.
- Tax exemption: is considered in the Spanish law for those companies providing renewable energy.

14.5.4 Business Section

14.5.4.1 Competition

Key Competitors

Table 14.3 presents the 3 main competitors to the Cobra Besmar cooperative venture. Competition from thermo-electric electricity company is perceived to be the main threat, mainly due to the the fact that thermo-electric power will be cheaper than the offshore offering, at least initially, and enjoys a monopoly on the island at present.

There will be competition from other aquaculture producers, but only one so far is targeting organic produce; Kefalonia.

14.5.4.2 Value proposition

A floating platform enables the device to generate electricity in areas that typically have more powerful wind resources. The floating wind platform can also partially protect juvenile fish cages and security systems for the fish farm. The power generated can also aid installation of other equipment such as automatic fish feeder, underwater CCTV, etc.

"Green energy" integration with ecological fish production, maximizes the use of the space, and increase consumer perception of ecological fish production.

Table 14.3 Key competitors

Competitor	Key Differentiators	Competitive Threat Rating (1–5)*
Unelco-Endesa	The main Spanish electrical producer company. Electricity produced by ENDESA is mainly generated by thermo-electrical power plant in the Canary Islands. http://www.endesa.com/es/home	5
Kefalonia	Greek Sea bass and Sea bream producers. Their production is focusing on organic fish production. http://kefish.gr/mobile/organic/en_organic.html	3
Nireus	One of the biggest aquaculture companies in Greece. Their produce standard Seabass and Seabream. No reference on organic production of these fish. http://www.nireus.com/1_2/Home	1

*Competitive threat based on companies' appraisal of perceived threat with 5 being severe competitive threat.

14.5.4.3 Business model

The long term business model proposed is that COBRA & BESMAR cooperate through an SPV or similar to sell combined wind and aquaculture installations. BESMAR will subsequently operate the aquaculture elements.

14.5.4.4 Market capture

The target in the Canary Islands is to have at least 60% of the total electricity produced coming from renewable energy by 2020 through the PECAN (Canary strategic energy plan). The 25 MW produced in the pre-commercial farm will increase the renewable electricity generation up to 17% for Gran Canaria Island. Thus the offshore wind platform electricity generated by COBRA will have a secure market in Gran Canaria for the 25 MW produced. Long term the model is based on selling installations in Europe, North and South America and Japan, and plans to capture 10% of the Serviceable Available Market (SAM) (Figure 14.7). Currently BESMAR produce 240

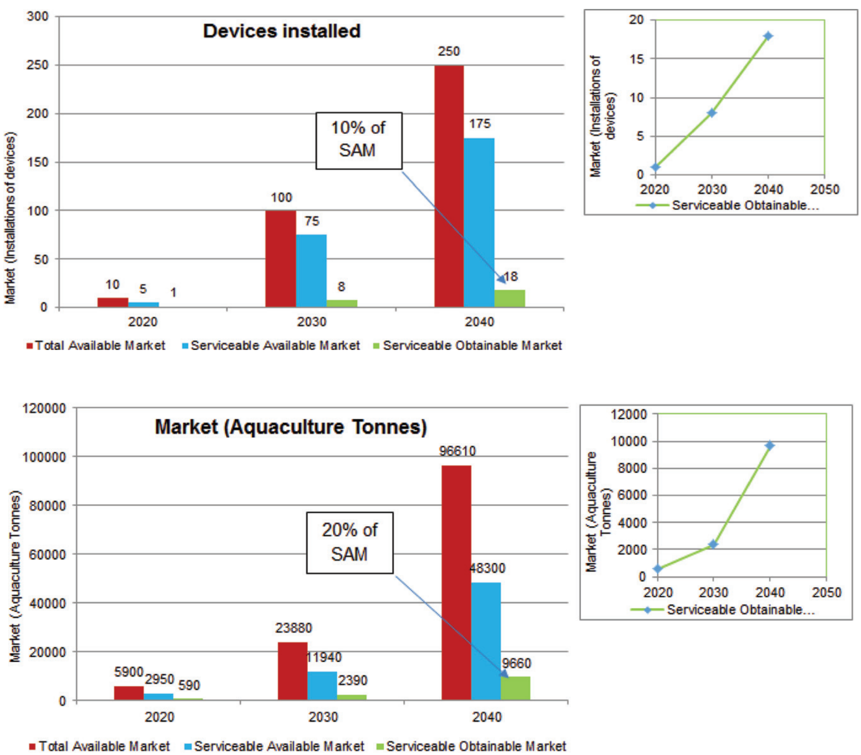

Figure 14.7 Market analysis: Floating wind devices and aquaculture production.

tons of organic Sea bass annually, and through their commercial branch, Naturally Atlántico, sell their products in Canada, US, France and Spain. Only 5% of sales are in the Canary Islands, therefore the focus of increased production will be on exports. The company plan to expand to capture 20% of SAM by 2050 (Figure 14.7).

14.6 Case Study 3 – Mussel Aquaculture in Borssele Offshore Wind Parks

14.6.1 How Mussel and Offshore Wind Farm Case Study Was Selected by Maribe

The Maribe ranking of BG combinations exercise determined that fixed offshore wind with an aquaculture farm would be both technical, and economically viable, whilst also having large socio-economic and environmental benefits. MUS option was the only combination considered.

The following are the Maribe findings for the MUS:

- Technically: there are no technical barriers faced by mixing aquaculture with fixed offshore wind parks.
- Economic: Both sectors are economically viable by themselves, and together might prove to have increased economic viability.
- Environmentally: The environmental impact of these two sectors in MUS would not increase, compared to the situation where they are separate. In some cases, such as seaweed, the environmental impact would improve.
- Socio-economically: it was determined that public acceptance would be high, and assist in moving aquaculture offshore, increasing job prospects.
- Commercial development: both are at TRL 8 of higher.

The Atlantic was deemed the best basin, due to extremely good resources of wind, as well as the best basin for most types of aquaculture.

The 3 types of aquaculture were considered for the case study:

- Finfish: The Mermaid project explored this combination. Unfortunately, Maribe were unable to secure the cooperation of the project as a case study in Maribe.
- Seaweed: Seaweed production is mostly in the North Sea and Baltic, and near shore. There were no fixed offshore wind farms currently exploring this combination.

- Mussels: There are a number of wind farms currently being constructed in Belgium and Netherlands. The waters of these coast are perfect for mussel production. Maribe selected this final combination as the basis for its case study, due to expertise within the consortium.

14.6.2 Project Background and Description

Maribe project did not succeed in obtaining candidate companies in fixed wind and mussel farms to cooperate in the case study. Never the less, Maribe consortium decided to undertake the study as there was sufficient expertise within the consortium to complete the relevant sections, and commercial interest in the case study is increasing. Since the Maribe project completion, an actual project has commenced in Belgium, and described in the following link: https://www.offshorewind.biz/2017/06/02/belgians-start-growing-mussels-on-offshore-wind-farms/. Further development of offshore wind in the North Sea is expected and now that Belgian and Dutch governments have established support schemes, various new wind parks are being proposed off the coast of Belgium and the Netherlands.

The project case study presented is based on a previous FP7 research project, MERMAID, which explored multiple use concepts for four European basins, either multiple use of space or multiple-use platforms. One of the most promising designs emerging from the project was wind farms with bottom-fixed offshore wind turbines and mussel aquaculture for the North Sea area. The case study uses the planned phased development of the Borssele windpark (Figure 14.8). This wind park consists of 4 plots. The total site area equals 344 km^2. Due to existing pipelines and cables that cross the site, the plot has been subdivided into 4 parcels (25.2 km^2, 17.8 km^2, 2.1 km^2, and 4.1 km^2). Plot II does not have cables or pipelines crossing this site; it consists of one parcel with an effective area of 63.5 km^2. It is located 12 nautical miles (22–39 km) offshore. Grid connection is scheduled to be ready 31 August 2019. The tender document provides detailed information on routing of the underwater cables and land connection. Delivering this is the responsibility of the Dutch offshore grid operator, Tennet, and not part of the tender. 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, the wind park includes space for the production of mussels. The relevant system in this case study has a culture grown on simple structures such as ropes and frames on subsea lines as shown schematically in Figure 14.9. These lines are connected to the sea bottom through a mooring

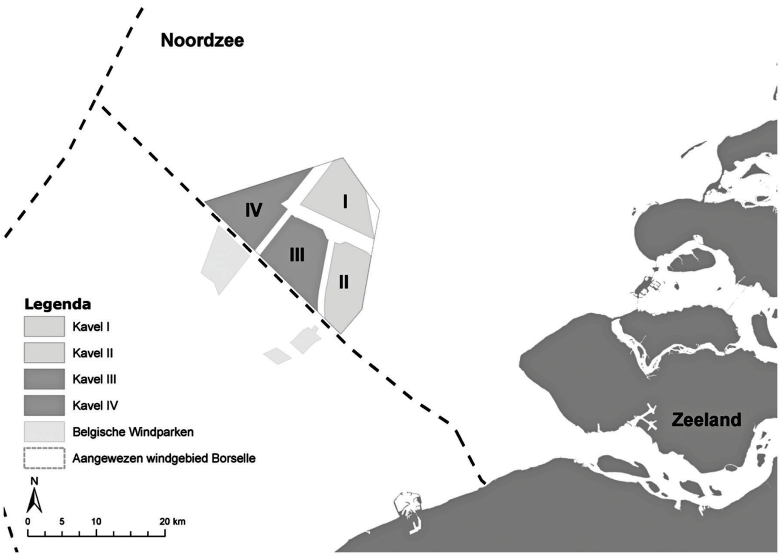

Figure 14.8 Potential location of Maribe case study project for mussel farm in fixed wind farm.

system. Installation time for this option is less than a week. The Dutch Mussel industry and NGO's have agreed that best practice for the collection of mussels will be the use of long-lines. These long lines are mainly used in the Wadden Sea. It is assumed that the mussels are not restocked during growth (i.e. taken of the longline and put back with greater distance between them). Instead, the system is thinned out. The resultant mussel spat and half-growns are transported to the Eastern Scheldt to grow further.

14.6.3 Technical Specification of Technology

14.6.3.1 Phase 1: TRL 7/8 per-commercial pilot

The pilot project will be located in Wind park Amalia using 60 Vestas V80, 2 MW turbines.

The footprint of the wind park 49.5 km^2, located: 23 km off the coast of Netherlands, water depth: 19–24 m.

Aquaculture will have a target output of 0.5 million kg mussel seed in 21.4 hectares. The aquaculture long line system will be fabricated at Machinefabriek Bakker or comparable.

CAPEX is likely to be in the order of €12 million so grant funding required in the order of €5 million (No detailed estimates were carried out for this project case study).

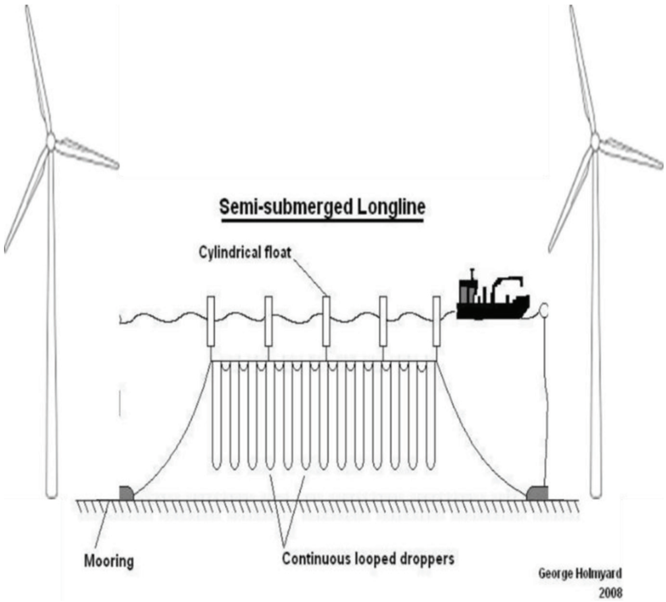

Figure 14.9 Artist impression of mussel string in between wind turbines.

14.6.3.2 Phase 2: TRL 9 commercial

The next phase plans to be situated in a larger Wind park: 380 MW installed capacity using 4 to 10 MW turbines, with a footprint of 49.5 km^2, located 22–38 km off the coast of Netherlands and Belgium, in 15 to 35 m of water.

The aquaculture target output is planned to be 5.5 million kg of mussel seed over the project period, covering 235 ha.

Based on the literature, the estimated annual production per unit is as follows, in two years:

- 14,064 kg of mussel seed, harvested in autumn
- 14,064 kg of half-growns, harvested in early spring
- 9,376 kg of consumption size mussels, harvested in autumn

14.6.3.3 Advantage of floating wind and aquaculture combination

14.6.3.3.1 *Aquaculture farm*

- 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.

14.6.3.3.2 *Offshore platform wind farm*

- Mussel aquaculture makes areas less accessible for other vessels, reducing risk of collisions with unfamiliar vessels. 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.

14.6.4 Business Section

14.6.4.1 Competition

Competitor	Key Differentiators	Competitive Threat Rating (1–5)*
Conventional Mussel Farming	One of the advantages of this combination is the multiple use of space. This gives the combination an advantage over conventional mussel farming, especially in countries which have increasing demands on limited space.	4
Floating offshore wind	Fixed offshore wind is the most cost-effective technology given the low water depths in this area. Other foundations are not eligible under the prevailing subsidy scheme.	1
Wave and/or tidal energy	Both wave and tidal energy are not cost-competitive as they are much more expensive the fixed offshore wind. They are also not eligible under the prevailing subsidy scheme.	1
Wave energy/aquaculture concept (e.g. Albatern WaveNET)	The Albatern WaveNET devices may not be suitable for the conditions found at the mussel farms. It would also take up space that could be more suitable for fixed offshore wind. Wave energy is not eligible under the prevailing subsidy scheme.	1

14.6.4.2 Value proposition

- Company A – reliable, less expensive renewable electricity due to combination, more sustainable image, possibility of easier consenting if government policy advocated more efficient use of space. Concept is easily transferrable to other sites once concept is proven.
- Company B – cheaper mussels due to combination, more sustainable image, mussels with less toxins, increase in the areas available to the industry to utilise.

14.6.4.3 Business model

Two independent companies will operate each sector (fixed offshore wind and aquaculture) separately. The offshore wind energy company (Company A) will be an offshore wind project developer who source, install and operate offshore wind farms. Examples of such companies include DONG Energy, Vattenfall, etc. The aquaculture company (Company B) will be a company who has experience in operating aquaculture farms. Examples of such a company include Prins & Dingemans, Delta Mosselen, Roem van Yerseke, etc. While both companies will remain separate and not form a joint venture or special purpose vehicle (SPV), both companies will have a legal agreement to install and operate wind farms with integrated aquaculture installations (most likely mussel farms in this case). Company A will sell electricity with revenue from CFD supplied by government for 15 years, and Company B will sell mussels with revenue from mussel markets.

14.6.4.4 Market capture

The market for this combination is twofold: Electricity wholesale market and mussel wholesale market. In the Netherlands, electricity production capacity equals 31.5 GW, out of which 20.1 GW consists of centralised production (i.e. powerplants) and 11.4 GW is decentralised production. In 2014, total installed wind capacity in the Netherlands equalled 2.7 GW. This capacity was used to produce 5.627 million kWh of electricity from wind, making it the second-largest source of renewable electricity.

The aquaculture sector of the Netherlands can be divided into two different sectors, namely shellfish and finfish. The shellfish sector is an older and more established sector, and consists of 50 companies growing blue mussels which result in between 50,000 to 60,000 tonnes of mussels per year. Shellfish culture takes place in the estuarine waters in the southwest Netherlands and in the shallow Wadden Sea in the North of the country. The mussel wholesale market is based in Yerseke where mussels are auctioned. By 2020, the case study analysis estimates that the project will attain 20% of SAM (Figure 14.10).

14.7 Conclusion

There has been much scepticism of the value of combining Blue Growth sectors together, or Blue Growth with mature Blue Economy sectors. Market forces today has favoured the more established single technology BG sectors and enterprises (e.g. fixed offshore wind) which are continuing to thrive

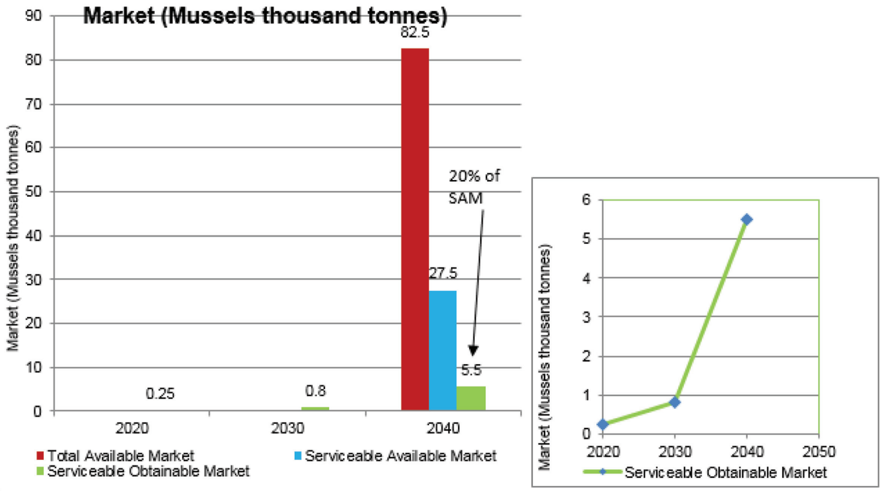

Figure 14.10 Market assessment for mussel production.

having proven they can achieve EC and member state targets for lowering the cost of energy. The EC have tried to stimulate Blue Growth, by funding a number of projects exploring multi-use of space and multi-purpose platforms. The most notable funded activities were the four Oceans of Tomorrow projects (OoT): Tropos, Mermaid, H2Ocean, Marina. The projects were not successful in developing strong IP from the projects that was able to progress to commercialisation. One observation of the results developed from these projects was that the focus was on the technology, creating a situation of "technology push" rather than "market pull". To put this another way, there may have been great technology developments but did not find a market willing to purchase these products. Unfortunately, these unsuccessful OoT projects have reduced EC confidence in MUS/MUP.

The Maribe case studies demonstrated that combining Blue Growth sectors with more established or mature Blue Economy sectors can make their overall value proposition more attractive. The advantages of combining are substantial, benefiting the newer technology tremendously, reducing the risk for the newer technology, and enabling learning. More importantly, MUS/MUP combinations conforms to EU Maritime Spatial Planning directive, thus should attract continued EC funding.

Case study of projects combining aquaculture with fixed or floating wind energy presented attractive business cases, and projects were highly rated by independent experts organised by Maribe. The mature sector of each project assisted in de-risking the less mature sector by ensuring good financial returns for the combined projects. Aquaculture benefited from using green powered electricity thereby increasing its public image. Incorporating wind energy is also relatively easy for aquaculture, and increases its position within the MSP directives, leasing/licencing etc.

Combining floating wind and wave also received very high independent review scores in Maribe assessment. The business case presented was very thorough and well researched. It highlighted the importance of a holistic approach, project consortiums that start off with well-developed business plans have a great chance of success, in comparison to those that rely for success solely on their technology.

Maribe cautioned that combining a new technology sector with a more mature technology (either MUP or MUS) will never fully compare financially with the mature sector operating by itself. For example, offshore wind parks operated by itself will always be a large competitor to MUS/MUP combination projects. Thus, MUS/MUP combination projects will consistently require EC support in the medium term.

In summary, the Maribe cases studies identified a range of MUS and MUP combinations that have the potential to become attractive business cases by their third phase of commercial deployment. The results should give confidence to the EC to pursue policy to promote appropriate MUS and MUP combinations both in the Strategic Energy Technology Plan (SET-Plan) and continued funding for MUS and MUP in H2020. The Commission's drive to promote multiple-use of space (MUS) (an important part of the Marine Spatial Planning directive) and multi-use platforms (MUP) has been justified by the positive outcomes from the Maribe evaluation.