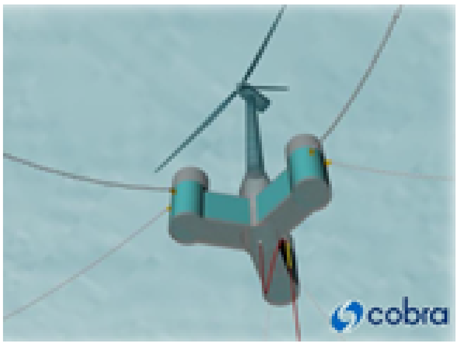
Project A2: COBRA-BESMAR Gran Canaria Offshore Wind Platform and Aquaculture



Contents

1.1 Introduction

1.1.1 Combination type

Combines: Offshore wind platform and Aquaculture

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

1.1.2 Company description

Grupo **COBRA** is a subsidiary of ACS, a Spanish multinational company with long experience in the construction and operation of fixed wind farms.

BESMAR Aquaculture Company established in 2004. It´s offshore aquaculture specialist, consult and develop commercial projects that are unique and front runners at both the commercially and technically level.

1.2 Combination project description

1.2.1 Current status

COBRA floating wind technology is at TRL5/6 with a small scale prototype already deployed and tested at a testing channel. **BESMAR** aquaculture technology is at TRL9 with a 1st commercial aquaculture farm deployed in Gran Canaria.

1.2.2 Strategic Roadmap to commercialisation

The commercial development will begin with 5 offshore wind turbines mounted on floating platforms, sharing the same offshore space with an operational finfish type aquaculture installation. This pre-commercial first stage is underway having secured part of the funding required from NER 300 (project FLOCAN). 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 at a new site at Gran Canaria followed by a 3rd commercial project including 25 offshore wind turbines and 24 cages for Seabass production to be deployed at PLOCAN testing site in South-East coast of Gran Canaria (Figure 1).

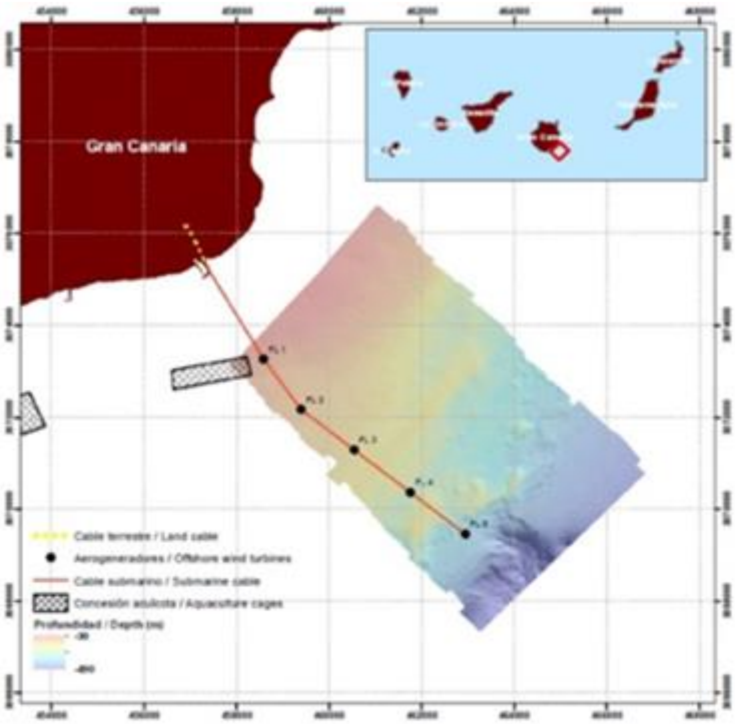


Figure 1. Potential location for A2 project.

1.3 Technical Brief with Planned Phases of Development

1.3.1 Overview

1.3.1.1 EU proposed pilot phase 1: TRL7, TPL9, IRL5+

- *Aim: deliver an MUS pre-commercial floating wind farm at a commercial offshore aquaculture operating site*

- *Comprises of*
  - *COBRA: 5 floating wind turbines rated at 5 MW each total capacity 25 MW*

- *BESMAR: 6 fusion type offshore aquaculture cages with 40 tons production capacity each; total capacity 240 tons/year Organic Sea bass*
- *Footprint combined approx. 5 Km²*
- *Located: South-East coast of Gran Canaria 5.2 Km from shore*
- *Water depth: range 40 to 200 m for wind and 40m for aquaculture*
- *Fabricated at*
    - *COBRA: shipyard of Puerto Las Palmas, Gran Canaria*
    - *BESMAR: N/A (existing)*
- *Brought to location by:*
    - *COBRA: towing vessel*
    - *BESMAR: N/A (existing)*
- *Installed using*
    - *COBRA: wind turbines will be connected to an offshore floating substation and installed with use of a specialist vessel.*
    - *BESMAR: N/A (existing)*
- *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*
- *Moorings:*
    - *COBRA: Tensioned mooring lines anchored to seabed*
    - *BESMAR: Tensioned mooring lines anchored to seabed*
- *O/M and access:*
    - *COBRA: Wind turbines O&M will be supported by the port and shipyard of "Puerto Las Palmas"*
    - *BESMAR: supported by port "Puerto de Taliarte"*
- *Target deployment in:*
    - *COBRA: 2018*
    - *BESMAR: currently in operation at this location*

1.3.1.2 Commercial TRL9: 3rd commercial scale- Location Gran Canaria

- *Aim: deliver an MUS commercial floating wind and aquaculture farm at PLOCAN testing site (Gran Canaria) allowing for a larger project*

- *Comprises 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*
- *Footprint combined approx. 23 Km²*
- *Located: North-East coast of Gran Canaria from shore (PLOCAN testing site)*
- *Water depth: 0-600*
- *Fabricated at:*
    - *COBRA: shipyard of Puerto Las Palmas*
    - *BESMAR: Puerto las Palmas (Gran Canaria)*
- *Brought to location by:*
    - *COBRA: towing vessel*

- *BESMAR: towing vessel*
- *Installed using:*
    - *COBRA: a specialist vessel*
    - *BESMAR: N/A (existing)*
- *Cable to shore or power source: submarine cable 10*(5MW/13.2kV) linking the wind farm to an offshore floating substation*
- *Array connection or autonomous power: MW, kV*
- *Moorings:*
    - *COBRA: Tensioned mooring lines anchored to seabed*
    - *BESMAR: Tensioned mooring lines anchored to seabed*
- *O/M and access:*
    - *COBRA: Wind turbines O&M will be supported by the port and shipyard of Puerto Las Palmas.*
    - *BESMAR: supported by port and shipyard of Puerto Las Palmas.*
- *Target deployment in:*
    - *COBRA: 2021*
    - *BESMAR: 2026*

Gantt

		2018	2020	2022	2024	2026	2028	2030	2032	2034	2036	2038	2040
TRL 5	Offshore wind platform												
TRL 6	Offshore wind platform												
TRL 7	Offshore wind platform												
TRL 8	Offshore wind platform												
TRL 9	Aquaculture												
TRL 9 2040	Offshore wind platform & Aquaculture												

Table 1: Roadmap to commercialisation.

1.3.1.3 Other technical project details

- COBRA has successfully completed the testing of their floating wind turbine at 1:40 scale, 78 Kg in weight in a test site at http://www.cehipar.es/. Test completed in 2014
- COBRA has been awarded €34 million (FLOCAN 5) from the €1 bn NER 300 Program in 2014 to deliver the FLOCAN5 project (i.e. Pilot TRL 8 pre-commercial farm Gran Canaria) which is expected to be operational in 2017-18
- The BESMAR organic aquaculture plant has been operating since 2012 has latest technology cages constructed from heavy duty Polyethylene (PE). Measuring 25m diameter and 5000 m3 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 5 tonnes heavy "froya ring" to tension net pen.
- 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. PLOCAN will offer the testing site, facilities and services to the MUS development
- The Puerto Las Palmas harbour is the nearest port available with adequate facilities to support construction and O&M. It is expected a small number of skilled jobs will be created or secured in the local area as a result of the proposed MUS farm

deployment. Provision of space for servicing and accommodating vessels for towing the platform in case of major repairs available if required.

1.4 Advantage of combination

1.4.1 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.

1.4.2 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.
- Wider stock and healthier product, fishes will have less stress, clean water, increasing animal welfare and the final quality of the product.
- Less environmental pollution due to distance from coast and better dispersion.
- 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).

1.4.3 Offshore platform wind farm

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

1.5 Business section

1.5.1 Competition

Table 2. 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**

KEFALONIAN	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 fishes. http://www.nireus.com/1_2/Home	**1**

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

1.5.2 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. The following business model canvas is based on this.

Table 3. Business Model Canvas Building Blocks.

<table>
<tr><td colspan="2">1. Customer Segments
The Canary Island government will be the customer for the pre-commercial stage. Thereafter, utility–scale developers.
BESMAR sell their products through retailers such as El Corte Inglés, Makro and other Spanish supermarkets, and to wholesalers in Canada, US and France through Naturally Atlántico.</td></tr>
<tr><td colspan="2">2. Value Proposition
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, maximize the use of the space, and increase a perception of ecological fish production.</td></tr>
<tr><td>3. Channels
The main sales channel is through direct contact with potential clients. Through senior management and dedicated account managers, with wider awareness being raised through exhibitions, conference presentations, journal articles, digital media etc.</td><td>4. Customer Relationships
COBRA have existing relationships with numerous utility scale developers worldwide.
Similarly BESMAR have established relationships with supermarkets in Spain, and through wholesalers worldwide.</td></tr>
</table>

● The floating platform allows a variety of distribution and installation methods. The exact method will be determined by project economics and contract structure	
5. Revenue Streams ● Revenue will be generated from the sale of installations. ● Revenue will also be generated for BESMAR from the sale of organic fish.	**6. Key Resources (at commercial stage)** ● Intellectual property – the design of the floating wind platform and the configuration of the fish cages. ● Developed value chain of preferred partners. ● Access to construction finance. ● Established brand reputation for both companies. ● Key expertise and specialist personnel.
7. Cost Structure ● Labour & Overheads ● IP ● Financing, guarantees and warranties ● PR, marketing and sales ● Purchase of fish stock & feed (BESMAR)	
8. Key Activities (at commercial stage) ● Business development ● R&D and IP development ● Project engineering ● Project management ● Construction financing ● Operation and maintenance	**9. Key Partners (speculative)** ● Suppliers: Fusion Marine Ltd. (Cages), Boris Net Ltd. (Nets), Thyson Ltd. (Anchoring), Elimat S.L. (buoys) ● Environmental: ECO Canarias S.L. ● Investors: SEPIDES & Caixa Capital Risk. ● Associations: APROMAR

1.6 Management Section

2.6.1 Existing management team and company organisational structure

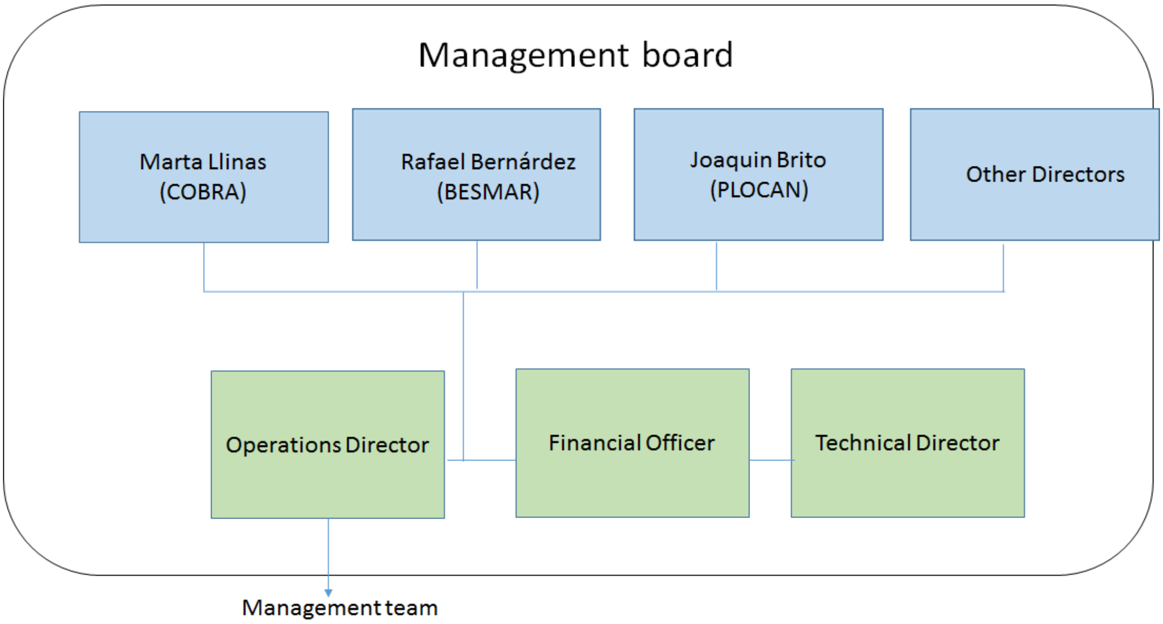


Figure 2. Management structure.

COBRA is part of the multinational holding ACS, as a holding they have different companies in different energetic and construction sectors. COBRA is the company that develop the wind projects for the ACS holding. Also the COBRA group have several business group member's focus on different activities. Is highly likely that the new offshore platform wind business based in Gran Canaria will have their own management structure and perhaps they can share some management with BESMAR aquaculture.

BESMAR aquaculture is a company focused on aquaculture organic production, service and consultancy. This SME company have a management board mainly composed for experienced professional in the aquaculture business.

For this combination, it is anticipated that the management team contains all the requisite skills and expertise necessary in order to accomplish the project goals.

1.7 Market Section: Market Share from 2020 until 2040

1.7.1 Market Analysis

The offshore wind platform electricity generated by COBRA have a secure market for the 25MW produced. 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 25MW produced in the pre-commercial farm will increase the renewable electricity generation up to 17% for Gran Canaria Island. Long term the model is based on selling installations in Europe, North and South America and Japan. Currently BESMAR produce 240 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.

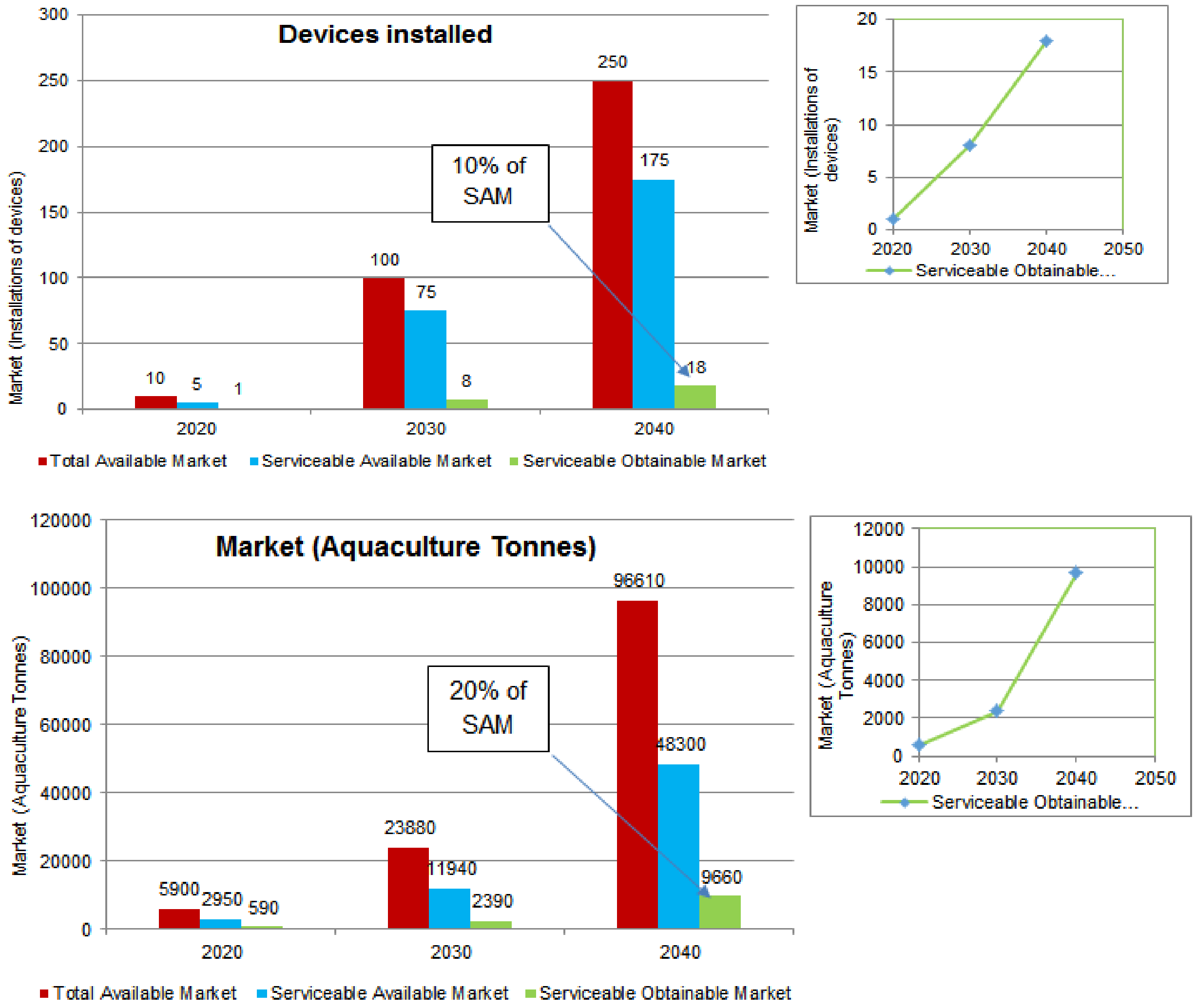


Figure 3. Market Analysis: Devices.

1.7.2 List of investors and sources of funding

1.7.2.1 Investors and funding to date

The technology concept developed by COBRA has been awarded with the following grants:

- ❖ EEA Grants funding in order to support the engineering development of the wind offshore platform COBRA technology. 15 months. Budget: € 1,286,286 (Fund by CDTI)
- ❖ CIEN project to support the engineering development of the wind offshore platform COBRA technology. Budget: € 8,000,000 (Fund by MINETUR, Spanish Government)
- ❖ FLOCAN5 project was awarded NER300 € 34,000,000 Project developer ACS-COBRA and Canary government. More information available: http://www.4coffshore.com/windfarms/flocan5-spain-es55.html

1.7.2.2 Time frame for grants

- EEA grant, CIEN project and FLOCAN5 grant are already secured to fund the offshore platform wind technology project developed by ACS-COBRA. It is expected to start with the TRL6 project during 2016.
- There is private interest to fund this project, but, for confidentially reasons the amount cannot be revealed, likewise for origin and schedule to spend the private money in this project.

1.8 Assumptions

Costs are based on the following assumptions.

1.8.1 Global assumptions

Real (end-2014) electrical prices for Spain ca. 0.1€ to 0.15€ per kW.
Real (end-2014) prices for Sea bass ca. 4€ to 6€ per Kg.
Commodity prices fixed at the average for 2015
Exchange rates fixed at the average for 2016 (that is, for example, £1 = €1.26)
Electrical prices fixed at the current rate

1.8.2 Wind Offshore Platform assumptions (PLOCAN testing site)

General

The general assumptions are:

- The 25MW wind offshore platform farm consists of 5 units and is not part of a larger multi-gigawatt zone
- Turbines are spaced at nine rotor diameters (downwind) and six rotor diameters (across-wind) in a rectangle
- A wind farm design is used that is certificated for an operational life of 20 years
- The lowest point of the rotor sweep is at least 22 meters above MHWS
- The development and construction costs are funded entirely by the project developer, and
- A multi-contract approach is used to contracting for construction.

Meteorological regime

The meteorological regime recorded data (AEMET meteorological station) are:

- Annual average wind speed 23.3-25.3 km/h (6.5-7.0 m/s)
- NNE (45% of the year) and N (40% of the year) is the main wind direction
- Annual wind power density between 300-450 W/m^2
- No tidal range is considered

- *Geological, Biodiversity and Hydrodynamics information*
- More than 60% of the area have sediment formed by medium-coarse sand
- 13 Taxonomical benthic groups identified in the area
- The main taxonomic groups are Polychaeta (65.8%) followed by Amphipoda (21.6%)
- An average wave period of Tm: 5.21 s, and an average wave height Hs: 1.05 (m)
- The main wave direction is NNE
- The main marine current direction is NNW-SSE

Turbine

- The turbine is certified to Class IA to international offshore wind turbine design standard IEC 61400-3

- The baseline turbines have a three-bladed upwind, a gearbox (two planetary stages type with a ratio of 1:41.405).
- The rotor have a diameter of 128 m, with a swept area of 12.868 m^2
- The blades are made by an organic matrix composite reinforced with fiberglass or carbon fiber, and a length of 62.5 m each blade.
- The tower will be a conical barrel tube, made by structural carbon steel and 80 to 94 m in height
- The generator will be 5.0 MW nominal power type, with synchronous with permanent magnets, having six independent modules in parallel. Will have a rotation speed of 490 rpm, a frequency 50-60 Hz and a power factor of 0.9 CAP – 0.9 IND

Array Cables

- The 5 wind turbines of the offshore platform will be connected to the substation through a submarine cable: 2*(5MW/13.2kV)

Installation

- Installation is carried out sequentially by towing the pre-assembled components (Offshore platform, tower and turbine together) to the site location and securing each one by mooring to the marine bottom floor.
- Each complete pre-assembled unit is transferred to the port of Puerto Las Palmas by haulage and put into the sea water by crane.
- A towing vessel collects each complete pre-assembled unit from the deployment port (Puerto Las Palmas) to the defined area.
- The 5 wind turbines will be connected to the substation through a submarine cable: 2*(5MW/13.2kV)
- BESMAR aquaculture cages will be installed behind the nearest shore turbine
- Decommissioning reverses the assembly process to result in installation taking 6 months. Environmental monitoring is conducted at the end. The residual value and cost of scrapping is ignored.

Operation, Maintenance and Service

- Transmission charges for use of system are incurred as OPEX (the build is incurred as CAPEX), and
- Access is by work boats, no staff accommodation on board. No specialist vessels are used for major component replacement.

1.9 3rd commercial project improvement on pilot project

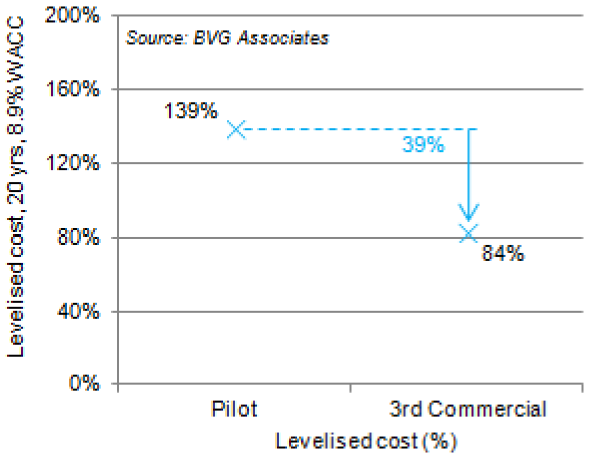


Figure 7: 3rd commercial improvement on pilot

1.10 Risk section

1.10.1 Commercial Risk Analysis

1.10.1.1 Hazards description

- 100 Hazards identified under six categories: 1. Operation - all stages, 2. Economic and Political, 3. Financial, 4. Environment, 5. Socio-economic, 6. Health and Safety.
- Hazards were colour coded (risk matrix 1-25) depending on risk magnitude revealing
  - **25 High (red)**,
  - **58 Medium (orange)** and
  - **17 Low (green)**.
- Issues and causes described for each hazard, including the effect (-/+) of multiple industry and technology co-location.
- A ranking (1-5) used to quantify Consequence and Likelihood with resultant risk magnitude for each hazard.
- Risk response strategy proposed and residual risk magnitude quantified for each hazard.

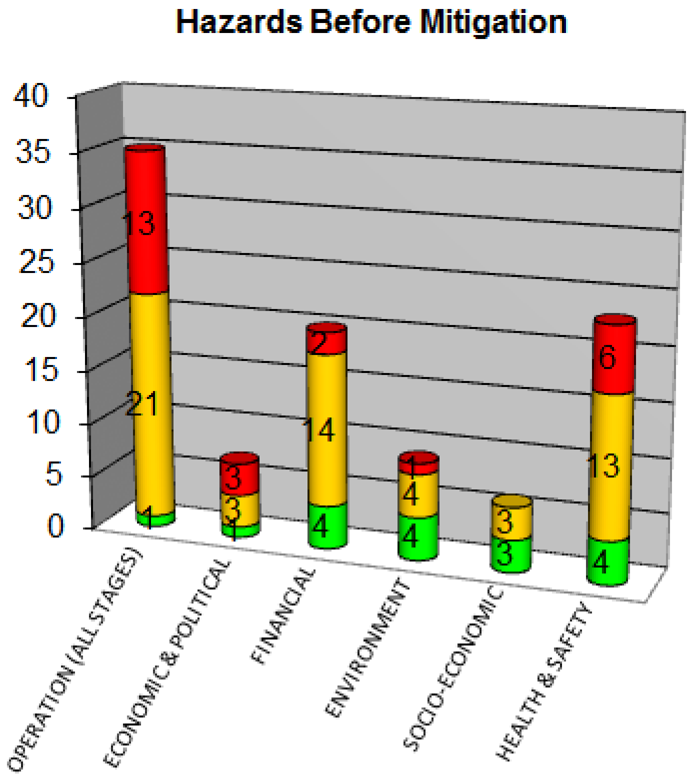


Figure 9: Hazards before mitigation

2.13.1.2 High risk (red) hazards identified pre/post mitigation

Table 11: Identified Hazards

Hazard Category		Issue	Sum
1. Operation (all stages)	**Pre-construction**	Site problems and licensing	2
		Insurance	3
	Construction	Weather conditions	1
	Operational	Less yield; component or system failure	1
		Component/System Accidental Damage	1
		Pollution	1
		Maintenance and logistics issues	1

		Emergency response	1
	Decommissioning	Device removal	1
		Environmental impacts	1
2. Economic and Political	**Public sector support**	Grant and subsidies	1
		Applied price forecast	1
	Competition	Issues entering energy market/ Organic activity terminated	1
3. Financial	**Financial support**	Lack of investment	2
4. Environment	**Physical environment**	cumulative and in-combination adverse impacts	1
5. Socio-economics			0
6. Health & Safety	**Personal Injury**	Electrial Safety	1
	Personal Injury	Ergonomics	1
	Personal Injury	Fire	1
	Personal Injury	Ports and Mobilisation	1
	Personal Injury	Subsea Operations	1
	Personal Injury	Electrical Safety	1
		Total	**25**

1.10.1.3 Commercial High Risk Response

Operation (all stages)

Description: The Operational risks account for over 75% of all red-category risks identified.

“Site problems and licensing” issues relate to site compliance from environmental perspective, and granting of licence process as regulation and legislation may prove more complex than expected coupled to a prolonged process. Currently intensive aquaculture for shellfish has a long licensing process (circa 1 year) with numerous environmental and biological studies needed to validate the site suitability. In addition granted license duration may be too short to guarantee safe return on investment and discourage investors. These risks can result in higher costs and delays.

Insurance issues may be encountered due to the perceived increased complexity and unproven nature of technology combination resulting in over-cautious approach which could severely limit the scale of the aquaculture deployment. In addition, over-cautiousness on the potential impact from each industry to the other may result in prohibitively high insurance quotation. These risks can result in higher costs, delays and even project failure.

Risk response: Wind farm licensing requires having adaptive management procedures in place to avoid conflict with existing aquaculture plant (additional temporary licensing during construction). The selected PLOCAN site have already all the licence and permits to operate offshore platform wind and aquaculture activities with aquaculture plant currently deployed. Additional environmental and biological data from monitoring studies will be collected by both industries due to the colocation. Employing an experienced Environmental Manager and working with marine environmental specialist contractors that have extensive local knowledge of the site will ensure a continuous monitoring of the environmental issues. The distance of the offshore platform wind from the shore and a carefully planned sequential 2-phase deployment will avoid conflicts with other near-shore activities including risks to the coastal environment.

Existing experience on insurance does not cover the combination (i.e. unique). Insurance risks will be tackled by liaising closely with the insurance industry from the Pilot and early commercial deployments. This will ensure that both sectors’ requirements are fully understood and appropriately addressed.

Description:

During construction phase adverse weather conditions may prevent access during allocated construction/installation shortening time window and increase downtime. If deployment of wind farm is undertaken at the same time as aquaculture by sharing resources to keep costs down, adverse weather may result in unexpected construction issues affecting wind farm construction. These issues could result in delays and higher costs.

Risk response: The offshore wind platform construction and aquaculture cages will be carried out in sheltered waters in the near port of Puerto Las Palmas and subsequently towed to deployment location using experienced contractors with specialist vessels capable to operate on offshore environment will extend installation time windows. The majority of the installation is quayside with offshore operations limited to anchor installation and hooking up platform with turbine already installed and part commissioned. The sheltered assembly together with the close proximity to deployment site reduce the risk of running into bad weather, In addition the Canary Islands have a large enough construction time window (4 months).

The commercial deployment site has existing connections to specialised vessel due to existing aquaculture presence (early commercial scale activities) capable working on offshore harsh environment. Indeed, deployment of the aquaculture early commercial plant was carried out without delay or disruption of supply or installation. Knowledge will be transferred across to Wind.

For the full commercial, the use of experienced aquaculture contractors to deploy the mooring, anchoring and cage system will allow a rapid fish farm deployment. Also working closely with the wind farm installation contractors will enable coordination of activities to avoid conflict and reduce costs where applicable.

Description: At operational stage the biggest risks are associated with failure at component or system level due to reliability (e.g. mooring due to extreme weather) or accidental causes (e.g. vessel collision). Environmental impacts due to physical (e.g. Fishing boats), chemical (e.g. accidental spills) or biological (pathogen transfer to aquaculture stock) causes could result in higher costs, fines and delays.

Component failures may present themselves during extreme weather conditions (e.g. mooring failure on aquaculture farm). This could be significant risk to the nearby wind farm from collision of aquaculture farm drifting components with wind farm fixed structures.

Bad weather may also increase downtime and shorten maintenance time windows. The consequence of the above risks is less revenue generated, redesign efforts, higher costs and project failure if not addressed appropriately.

Risk response: While the distance of operations from shore will mitigate against some of the issues identified it is also important to establish safe working distance between the combined sectors, is highly advisable to modelling the combination (offshore platform wind shadow and aquaculture cages position) prior to the installation of the structures. Rigorous monitoring of quality and stock integrity for aquaculture will be enabled by the logistical support sharing costs with offshore wind.

Complete Failure Mode and Effect Analysis of all components will be undertaken so that all failures will be properly understood. Extensive testing will be undertaken at component and system level considering presence of aquaculture type activities and possible adverse effects (e.g. accelerated corrosion), determining safe distance between the two operations. Knowledge from the fixed offshore wind sector will be incorporated as many such commercial developments exist, but not in combination.

Moorings extensive testing and fail-safe solutions by the aquaculture farm will reduce the risks associated with this particular issue which could pose a collision risk to the wind farm. The aquaculture shellfish production involves ropes rather than solid cages which from a hydrodynamic perspective is expected to incur less stress by waves and currents and less likely for moorings to fail. In addition the flexibility in structure would be less likely to cause an impact during a possible collision with a solid wind turbine structure.

<u>Description:</u> At operational stage pollution and emergency response issues that may result in ceasing power production, higher costs and delays and implications to potential injured personnel/subcontractors:

- At extreme circumstances pollution (e.g. from leaked chemicals) from wind turbine components could destroy or contaminate fish populations affecting nearby aquaculture or even fisheries industries resulting in liable losses.
- Distance of site from emergency response and increased offshore activity will increase (risk for) incidents and therefore increased need for extra capacity (i.e. more pressure) on emergency response services at national level.

<u>Risk response:</u> Insurance cover will transfer the aforementioned risks while the insurance sector involvement will ensure that the risk response measures are adequate for the scale of the intended operation.

The aquaculture and wind farm will be located relative in a secure distance one to another to minimise any harm to each other. This distance will be agreed by mutual consent to ensure that cost reduction benefits can also be realised. Employing an experienced environmental manager and team and monitoring of wild population with already established water monitoring techniques/regimes (adaptive monitoring programme) will ensure enough reaction time is available to all industries.

Regarding issues of accelerated corrosion as a result of exposure to aquaculture activities standard protection techniques are already in use in the offshore wind sector with sacrificial anode blocks or impressed current cathodic protection becoming standard practice. Maintenance and inspection regimes will be revisited to ensure that any adverse effects will be captured early and acted upon (e.g. can increase distance between the deployments with aquaculture farm location change).

Navigation is highly regulated by the Spanish government, limiting congestion. It prevents any operation in adverse weather conditions. In addition, the site selected on average has mild sea state. Issues in relation to emergency response will be adequately addressed before starting the construction phase because the legislation requires this as part of consent process. The proximity of the deployment site from emergency response station at shore will help mitigate the relevant risk identified.

Implementation of strict emergency response plans, employing experienced staff in key positions (i.e. H&S/Environmental Managers/teams) and ensuring high awareness regarding offshore H&S issues at all personnel levels will keep the identified risks at reduced frequency levels. Development and implementation of in-house emergency response and cooperation plan will define the response of all parties involved in foreseeable emergencies. This will be carried out in cooperation with the authority responsible for the provision of response procedures designed to deal with any emergency at sea.

Description: During decommissioning risks associated with the lack of experience with the process due to novelty around combination of these sectors, coupled to potential changes in the decommissioning responsibility/process (politically driven) could result in higher costs or fines. Removal of marine structures may result in pollution and disturbance of established habitats on the structures. The consequences above can be amplified further due to factors such as distance from emergency response, inexperienced/low skilled workforce.

Risk response: Adequate decommissioning and contingency funds have been costed to be allocated. Standard decommissioning measures for the removal of offshore marine structures will be followed based on best practices (environmental, navigation, displacement, H&S).

Mooring is not expected to present any risks during decommissioning as standard sea anchoring systems will be used for the floating wind/aquaculture platforms and cages, which will be towed away for dismantling at a shore location.

Regarding decommissioning of turbine components, any hazardous or potentially polluting fluids or materials are removed from the nacelle if they are considered to be posing a potential hazard to the environment during turbine dismantling.

Economic and Political

Description: Potential issues identified under “public sector support” and “competition” subcategories. Grants and subsidies issues could arise from change in policy direction and appetite for renewables, conditions of Feed-in-Tariff eligibility criteria (inc. value and period) could affect the financial projections for the wind farm. The financial modelling results could also be affected from other factors including sensitivity analysis, exposure to market risk, long-term price forecast and divergence in the expectations for power prices. For aquaculture, variations in consumer preferences, potential major shellfish disease outbreak, improvement of capture fisheries productivity and effect of climate change could affect product demand and pricing. This could result in less revenue generated affecting rates of return on capital investment.

Other factors in relation to issues around market entry due to intense competition including against established sectors such as fossil fuels and nuclear vs offshore wind and fisheries vs aquaculture shellfish. Competition against other renewables or organic farming would add magnitude to the risk. The "organic farming" brand name could be compromised due to combination of aquaculture-shellfish with a wind park on "industrial" production setting. The above risks could ultimately result in higher costs and/or lower revenue generated.

Risk response: Accepting the above risks will include careful monitoring for possible escalations. The current trend dictates that the renewable energy sectors (including ocean energy) need to grow if national governments are to meet obligations around emissions (mitigate climate change), security of energy supply and energy cost reduction. Therefore, it is expected that the need for growth will negate the risk of removal or phase-out of subsidies. The Paris Climate Agreement has targets to combat climate change by carbon reduction which can only be met by reducing fossil fuels and increasing renewables and nuclear.

The aquaculture sector including offshore aquaculture is expected to grow significantly in order to meet the global demand for protein source to satisfy fast growing global population. I is projected that by 2030 aquaculture will overtake fisheries and cover over 60% of global total fish demand as projected by FAO.

It is important to ensure that residual risks from individual sectors are not transferable to others in the MUS combination. Individual companies involved will be carrying out extensive due diligence/audits on each other's' business plans and financials and these results can be incorporated to adjust own projections. Offshore platform wind and aquaculture are competitive industries that require robust logistic and administrative support that can be outsourced to experienced contractor firms who can offer a fall back-up to the issues mentioned above.

Financial

Description: "Financial support" related potential issues were identified that could develop due to lack of (or removal of) investment which could be triggered due to a number of possible causes:

- many wait-and-see investors who do not invest due to risk of losing development costs and due to little benchmark data
- finance instruments related problems

- poor lending appetite from banks due to low economic climate
- lender fail to comply with financial legislation/regulation (Basel III, Solvency II)

Risk response: In order to inspire investor confidence in the absence of benchmark data, clearly demonstrable results will be communicated across from studies undertaken during pre-commercial TRL stages validated during early pilots and commercial deployments. Flexibility to form Special Purpose Vehicle with partner/investor organisations will reduce financial risk exposure.

Moreover working with highly reputable contractors and project developers experienced in delivering offshore platform wind major projects and extensive due diligence working with investors will help avoid some of the risk hazards. Also the need for growth in associated industries such as aquaculture (need to increase production at global scale to meet future demand) will be another driving force. Finally working with expert contractors and advisors tasked with detailed assessment and offsetting of financial risks will be important for such a large project.

Environment

Description: Risks to the physical environment have been identified due to potential destruction to the local environment. Issues around introduction of noise during pile driving operations would affect marine mammals, herring and other species.

Risk response: Comply with relevant directives such as MSFD (GES -Good Environmental Status) which are being implemented in all EU member countries particularly sections referring to energy introduction (i.e. noise production limits) to the sea environment. Good practices for noise mitigation can be adopted from existing offshore wind deployed farms, for instance pile driving for fixed foundations to be carried out outside breeding season to reduce the impact on marine species.

Health and Safety

Description: Red risk identified under several subcategories which could lead to personal injury including:

- Electrical Safety (electrical shock, heat build-up/burns, fire and/or smoke, arc flash eye damage/burns, explosion from rupture of components, electrocution from HV switchgear related to wind turbine devices)

- Ergonomics (difficult to construct design; moving around system: slips, trips and falls; restricted movement: lack of space to access components; lifting: hoisting parts and tools into position)
- Fire (Direct -burns, smoke inhalation, Indirect –fall/sea entry during escape, falling objects, on board access vessels causing incapacitated or abandoned vessel at sea)
- Ports and Mobilisation (vessel movements: collision; port operations: material handling, refuelling, waste disposal; unsuitable facilities: quayside loading limits)
- Subsea Operations (entrapment, falling objects, decompression sickness, use of tools underwater
- Working at Height (falls, dropped objects)

<u>Risk response:</u>

- Electrical Safety
    - Ensure that the design enables safe commissioning, operation and maintenance. Ensure having competent people involved at each stage of the design process
    - Residual risks are identified, communicated and mitigated through safe systems of work
    - Tasks carried out in accordance with national and international regulations with adequate provision on infrastructure and procedures in place, including installing electrical equipment in secure space, provide safety equipment for staff working with or in proximity to electrical equipment and apply strict safety procedures when working with or in proximity to electrical equipment
    - Application of IMO and SOLAS requirements. Best Practice for HV working for maintenance of wind turbine generators.
- Ergonomics
    - Rigorous safety plan for fabrication and construction which must be adhered to including preliminary safety plan including risk analysis from all designers.
    - Fully resourced, site specific construction safety plan including programme for the works
    - Independent onsite safety team with marine safety experience
    - Regular independent equipment inspections
- Fire
    - Fire prevention and protection systems (e.g. high temperature alarms) from early design stages to reduce potential future risk exposure. Maintenance requirements of the fire protection system also considered including condition monitoring and scheduled inspections for early warning of equipment deterioration.
    - Emergency fire response procedures will be in place.

    - Safe systems of work in accordance with national and international regulations (e.g. Health and Safety at Work, Personal Protective Equipment, Work Equipment Regulations etc.). Ensure control of hot work that can introduce a source of ignition, such as welding or grinding.
    - High standards of housekeeping and maintenance avoid the build-up of combustible materials, and ensure that any leaks are repaired in a timely manner. Hidden locations, such as the inside of ventilation ducting, should also be considered, in order to ensure that these do not accumulate combustible dusts.
- Ports and Mobilisation
    - Port traffic management plan enforced by harbour master.
    - Adequate site safety plan
    - In-port medical facility including medical helicopter for emergency evacuation
    - Warning notices re loading limits clearly visible and communicated
- Subsea Operations
    - Minor requirement for divers to be met using fully certified, reputable dive company with accident free track record are used.
    - Ensure this company produces and complies with high level safety plan for the work being undertaken
- Working at Height
    - All work to take account of the principles of prevention in relation to working at height. Risks to be taken account of and mitigated against in safety plan for the project.
    - All workers to undergo certified working at height training.
    - Safety cages to be installed around all ladders
    - Fall arrest systems (harness etc.) to be employed in all risk areas.

1.10.2 Pilot Risk Analysis

1.10.2.1 Pilot High Risk Response

The principal red hazard risks identified are mainly in the operational section and the health and safety section. Due to the size of the project during the pilot phase, the number of offshore platform wind (5) and the total number of the aquaculture cages (6), the total red risk identified can be controlled and diminish the degree of risk using pre-planned control measurement during the operational time of the project. During the pilot phase those risks identified as a high risk must be evaluated in order to establish proper control mitigation measures that can be applied for the commercial phase.

Health and Safety

The same Health and Safety risks have been identified for the third commercial as for the pilot phase. These risks are somewhat lessened as the project is at a smaller scale, but exist nonetheless. Once the health & safety protocol is deployed during the pilot phase, same approach must be done for the commercial phase

1.11 Implementation Section

Work package number	**1**	**Timeline (months): M0-M12**	**TBD**
Work package title	**Offshore & Aquaculture Investment feasibility studies**		

Objectives ➢ Strategic Evaluation and Assessment of Opportunities ➢ Analysis of Feasibility including financial risk assessment ○ Initial cost appraisals (studies of options). ○ Elemental cost plan ➢ Conclusion, Recommendations and Action Plan **Milestones** ➢ Milestone 1.1: conclusion, recommendations and action plan ➢ Milestone 1.2: Finance defined, identified and sequentially secured for Phase I: site investigations, design, inter-modules connection development, fabrication, installation, license application

Work package number	**2**	**Timeline (months): M0-M18**	**TBD**
Work package title	**Offshore & Aquaculture Conceptual Design & Approval In Principle**		

Objectives

This Work Package focuses on the design considerations of the offshore system. The objectives include:

- Approval in principle (AIP) with Approval Road Map
  - lay out the plan with external permit authorities for achieving Approval in Principle
  - WHAT-IF method for risk Identification: Capturing deviation from the normal
  - HAZID method for analysing hazards: identify hazards, their potential consequences, and requirements for risk reduction
  - Change impact analysis: identifying the potential consequences of a change, or estimating what needs to be modified to accomplish a change
- Development of design specification
  - Environmental (initial transportation, and in-place 100-year storm conditions)
  - Seabed characteristics
  - Intensity level of consequences of failure
  - Proposed design, installation, and operation approval by the partners / stakeholders
  - Functional design specification
- Concept design
  - Load out analysis
  - Fatigue analysis
  - Impact analysis
  - Building analysis
  - Functional and physical integration analysis
  - Launch analysis
  - Transportation analysis
  - Installation analysis including inter-modules connections and anchorages
- Eco Design
  - LIFE CYCLE COST
  - ACCOMMODATION AND EVACUATION
  - DISMANTLING

Milestones:

- Milestone 2.1: Site Approval Road Map defined with local authorities and licensing/permit bodies
- Milestone 2.2 Eco-conception implementation plan
- Milestone 2.3: Design Approval Road Map defined with regulating authorities
- Milestone 2.4: Conceptual Basic Design complete, including:
  - Fabrication plan
  - Launch plan
  - Pre-installation plan
  - Transportation plan
  - Installation plan
  - Commissioning plan

- Decommissioning plan
- Dismantling plan

➢ Milestone 2.5: Accommodation plan and Evacuation plan complete
➢ Milestone 2.6: Life cycle cost analysis complete
➢ Milestone 2.7: Dismantling operation plan complete
➢ Milestone 2.8: Approval in principle granted by site-permit authorities
  ➢ Milestone 2.9: Approval in principle granted by design-regulating authorities

Work package number	**3**	**Timeline (months): M18-M24**	**TBD**
Work package title	**Offshore & Aquaculture design verification by regulating authorities**		

Objectives

This Work Package focuses on the offshore system design approval by the regulating authorities:

➢ Determine approval route (CONCEPT DEVELOPMENT PHASE)
  - Plan for achieving approval in principle
  - Outline of necessary engineering and risk assessments to be conducted appropriate to the level of design evolution expected in the conceptual design stage
    - Risk Assessment Plan from concept through detailed design
    - Design Review Assessment plan

➢ Approval in principle with Approval Road Map (CONCEPT DEVELOPMENT PHASE)
  - identification of hazards and failure modes applicable to the concept
  - suitable support information demonstrating control of hazards and failure modes is proved to be feasible
  - determine list of information to be collected and the refined analyses to be performed in the Detailed Design phase in order to prove the viability of the design (i.e. use of preliminary material properties, dimensional variations, operating loads, assumed probability distributions etc.)
  - condition for issuance adhering to an "Approval Road Map" outlining the necessary conditions that must be met to achieve full class approval of the design covering all engineering analyses, drawings and specifications, testing and test reports and risk assessments.

➢ Class Approval (DESIGN/CONSTRUCTION/COMMISSIONING PHASE)
  - typical drawings, specifications, calculation packages and support documentation, along with submission of those items outlined in the Approval Road Map
  - surveyor attendance at model or proof testing, if required

- agree-upon acceptance criteria to a level of confidence necessary to grant full class approval of the concept (i.e. assessment of potential hazards and failure modes)
- demonstrate sound basis for class approval: conduct engineering and risk assessments related to the novel features

➢ Maintenance of Class (IMPLEMENTATION/OPERATIONAL PHASE)
- identification of the necessary elements of in-service survey, inspection, monitoring and testing requirements
- Identification of need for special in-service requirements dependant on any maintenance schedules, inspection scope/frequency, conditional failure probabilities, etc. assumed in the risk and design assessments for the novel aspects.
- Annual Special Surveys (if necessary) as a condition of Class. As experience accumulates and confidence in the design is gained, these Annual Special Survey requirements may be relaxed.

Milestones:

➢ Milestone 3.1: Class requirement completed

➢ Milestone 3.2: Class approval completed

Work package number	**4**	**Timeline (months): M18-M24**	**TBD**
Work package title	**Offshore & Aquaculture Environmental Consent and Operational Permits**		

Objectives

This Work Package focuses on the environmental consent and operational permits by the regulating authorities. The approval milestones are achieved at different stages of the process from Concept design to Installation, using industry standard verification procedures:

➢ Informal consultation
- Identify which items of legislation apply

➢ Environmental scope (formal)
- Confirm which baseline studies are required and scope of work

➢ Environmental statement (Requirement definition and submission process)
- Formal application for permits under the following example headings
  - Coastal processes, sediment transport and contamination
  - Marine water quality
  - Intertidal and sub-tidal benthic ecology
  - Fish, including recreational and commercial fisheries
  - Marine mammals
  - Coastal birds

- Seascape, landscape and visual assessment
    - Navigation and marine transport assessment
    - Onshore transport assessment
    - Air quality
    - Hydrology and flood risk
    - Noise and vibration
    - Economy, tourism and recreation
    - Mitigation and monitoring
- Other permits as required
  - Telecommunications frequencies
  - Onshore planning
  - Offshore planning
  - Marine Renewable Energy /OTEC permit
  - Seabed lease
  - Coastguard/port approval

Milestones

- Milestone 4.1: Environmental Consent and site Operational Requirements defined
- Milestone 4.2: Environmental Consent and site Operational Permits granted

Work package number	**5**	**Timeline (months): M12-M24**	**TBD**
Work package title	**Offshore & Aquaculture Structural analysis and Fluid Structure interaction analysis**		

Objectives

- Class Approval process (design/construction/commissioning phase)
  - hazard and operability study (HAZOP)
  - Failure mode and effects analysis (FMEA)
  - Fault Tree And Event Tree Risk Analysis
  - Reliability Analysis
- Design for manufacture
  - Structural Design
    - Loads: Permanent (dead) loads; Operating (live) loads; Environmental loads; Wind load; Wave load; Current load; Construction, transportation, installation loads; Launching and Upending Forces; Accidental loads
    - Load Combinations
    - Modules assembly
  - Industrial operation integration
    - Logistic flow
    - Vessel operation for both activities

- Fresh Water production, storage and delivery
- Aquaculture tank

- Structural Analysis
  - Code requirements (e.g. American Institute of Steel Construction “AISC” codes)
  - Analysis model generation (computational modelling)
  - Analysis of the structure above the seabed combined with analysis of the soil with the mooring/anchor system
  - Analysis of the Modules connexions system.
- Fluids structure and offshore platform structure interactions analysis
  - Hydrostatic analysis
  - Hydrodynamic analysis
  - Aerodynamic analysis
  - Ship alongside platform quay hydrodynamic analysis

Milestones

➢ Milestone 5.1: Structure & Strength Calculations completed

➢ Milestone 5.2: Fluid & Ship Structure interaction analysis completed

Work package number	**6**	**Timeline (months): M12-M24**	**TBD**
Work package title	**Costing**		

Objectives

This Work Package focuses on the costing considerations. The objectives include:

➢ Studies cost plan, including procurement plan
➢ Modules and connectors construction cost plan (prepared during concept/basic project design stage and carried through to detailed design)
➢ Launch and pre-installation cost plan
➢ Transportation cost plan
➢ Installation cost plan
➢ Commissioning cost plan

Milestone

➢ Milestone 7.1: Costing plan completed

Work package number	**7**	**Timeline (months):M12-M24**	**TBD**

Work package title	**Procurement**

Objectives

- Procure critical long lead items
- Produce manufacturing drawings & BOM
    - Conduct procurement of non-critical items

Work package number	**8**	**Timeline (months): M24-M36**	**TBD**
Work package title	**Construction & Final Class Approval: Fabrication of steel structures**		

Objectives

- Survey during Construction
    - Prototype Test Plan addressing materials, fabrication and testing
    - Operational Test addressing process simulations and sea trials to verify that the floating structure (e.g. vessel) and components meet specified performance requirements
- Final Class Approval process (detailed design/construction/commissioning phase)
- Fabrication
    - Structural (i.e. steel structures)
    - Mechanical
    - Electrical
    - Instrumentation and controls
- Fitting and connection of components and systems
- Conduct dry testing
- Pre-Commissioning activities
    - Address potential flaws of construction, uncompleted tasks and system inadequacies

Milestones

- Milestone 8.1: Fabrication completed
- Milestone 8.2: Fitting and connection of components and systems completed
- Milestone 8.3: Pre-Commissioning activities completed
- Milestone 8.4: Final Class Approval process completed for construction phase

Work package number	**9**	**Timeline (months): M36-M48**	**TBD**

Work package title	**Preparation of transportation and offshore installation procedures**

Note that for offshore renewable energy installations, installation is a significant proportion of cost and good installation design at an early stage will reduce cost, time and risk to life. Many high energy sites are outside the safe operational envelope of some vessels, ROVs and diving procedures.

Objectives

- Installation Planning for avoidance of unacceptable risk during offshore activities: loadout, seafastening, transportation and installation
  - Detailed procedures and instructions for any special items (grouting, diving, welding inspections, etc.)
  - Limitations defined on the various operations due to factors such as environmental conditions, barge stability, lifting capacity, etc.
  - Installation drawings, specifications and procedures with all pertinent information necessary for installation/construction of the total facility on location at sea
  - Details of all inspection aids such as lifting eyes, launch runners or trusses, jacking brackets, stabbing points, etc.
- Engineering input into offshore installation
  - design of all temporary bracing, sea fastenings, rigging, slings, shackles and installation aids, etc.

Milestones

- Milestone 9.1: Installation Planning completed
- Milestone 9.2: Obtain operating insurance

Work package number	**10**	**Timeline (months): M48-M60**	**TBD**
Work package title	**Loadout, transportation and installation operations**		

Objectives

- Mobilisation of the completed structure and transportation to offshore installation location
  - Loadout
  - Seafastening
  - Offshore Transportation
  - Installation

Milestones

- Milestone 10.1: Installation completed

Work package number	**11**	**Timeline (months): M48-M60**	**TBD**

Work package title	Commissioning

Functional commissioning is expected to be complex and will require planning. In addition, the following are required to maintain a safe structure:

Objectives

- Maintenance of Class
    - in-service monitoring
    - key critical structural areas will be strain-gauged
- Final Class Approval process (detailed design/construction/commissioning phase)
- Commissioning
    - System Commissioning
    - Integration Testing