Aegean Offshore Wind Desalination

EcoWindwater

1 Contents

1.1 Introduction

A detailed Implementation Plan was not a requirement for the B projects, however one is presented on section 8 herein.

In addition to the main text of this report a more thorough 70-page document discussing all of the sections in more detail has been produced. This is included as an Appendix to this report.

1.1.1 Combination type

Combines: Floating wind and desalination technology

Space share type: Multi-use platform (MUP)

1.1.2 Company description

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

1.1.3 Combination project description

1.1.3.1 Current status

The technology current status is at TRL 6. EWW has been operating over 10 years at 1:8 scale in an offshore environment and delivered desalinated water to the grid via a pipe at 70 m3/day maximum capacity. The corresponding Technology Performance Level (TPL) is considered to be at TPL7+ and the Investment Readiness Level (IRL) positioning is at IRL 4+.

1.1.3.2 Strategic Roadmap to commercialisation

The commercial development plan for the technology has three key stages. The first stage is a 800 kW demonstration platform, deployed a few km offshore in island of Santorini, Greece. The next stage will see the construction of a 2 MW Pilot (2nd generation MUP). At commercial level it is anticipated the optimization of the full scale 2MW Pilot will result in the 3rd generation full scale 2MW MUP.

1.2 Technical Brief with Planned Phases of Development

1.1.1 Overview

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

1.1.3.1 EU proposed pilot: TRL7, TPL9, IRL5+

- *Aim: Deliver a Pilot MUP unit as an intermediary scale up to full commercial*
- *Comprises 1 MUP*
    - *Wind: one 0.8MW wind turbine*
    - *Desalination: one unit with 1344 m3/d potable water capacity*
- *Footprint combined approx. 250 m X 250 m*
- *Located: 2Km off the coast of Santorini, Cyclades Greece*
- *Water depth: 60m- 100m*
- *Fabricated at:*
    - *Wind turbine: assembled at Eleusis Port*
    - *Desalination: c assembled at Eleusis Port; electrical control units fabricated locally*
    - *platform: fabricated at Eleusis Port*
- *Brought to location by: towing vessel*
- *Installed using: towing non-specialist vessel; Cable laying vessel; shore station built; connection to local grid*
- *Cable to shore or power source: Desalination powered by wind turbine. Electricity exported to grid via 11KV, 1MW cable capacity*
- *Moorings: standard anchor and chain mooring system (e.g. Stevshark Mk5).*
- *O/M and access: Access is by work boats; access to platform; towed to Santorini port for major service.*

- *Target deployment in: 2022*

1.1.3.2 Commercial TRL8/9

- *Aim: Deliver a 2MW MUP unit as an intermediary scale as well as full scale version for commercial. Initially deployed at the same consented site for the Pilot for cost reduction savings with the option to relocate. 20 years' operational lifetime*
- *Comprises 1 MUP*
  - *Wind: one 2MW wind turbine*
  - *Desalination: one unit with 3360 m3/d potable water capacity*
- *Footprint combined approx. 250 m X 250 m*
- *Located: 2Km off the coast of Santorini, Cyclades Greece*
- *Water depth: 60m- 100m*
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  - *platform: fabricated at Eleusis Port*
- *Brought to location by: towing vessel*
- *Installed using: towing non-specialist vessel; Cable laying vessel; shore station built; connection to local grid*
- *Cable to shore or power source: Desalination powered by wind turbine. Electricity exported to grid via 33KV/2MW (cable capacity can increase to accommodate multiple MUPs)*
- *Moorings: standard anchor and chain mooring system (e.g. Stevshark Mk5).*
- *O/M and access: Access is by work boats; access to platform; towed to Santorini port for major service.*
- *Target deployment in: 2024*

1.1.3.3 Other technical project details

- Past experience in deploying and operating a 1:8 scale (capacity of 30 kW) MUP will be beneficial. This was installed in the Aegean Sea, on Iraklia island (Small Cyclades, Greece) where was tested successfully under real sea conditions for 49 months, with wind speeds up to 120 Km/hour.
- It is intended to streamline the consenting and licensing process by nominating the same site (i.e. Santorini Island) for all three projects (TRL7 to 9) in order to accelerate the route to commercialization. Future market deployment sites considered around Greek island complexes including: Cyclades (Mykonos-Dilos, Naxos, Syros, Tinos), Dodecanese (Rhodes and Kos) and North Aegean (Limnos, Lesbos, Chios and Samos).
- EWW will have established academic and industry collaborations which provide access to expertise in desalination, energy, renewable sources, engineering and design.
- The commercial deployment of 2MW MUP desalination-wind device will allow the export of two products tailored around specific client needs under different configurations including:

- Configuration A: Grid connected (water) continuous water production during high tourism season -i.e. summer months with the wind turbine covering the power needs.
- Configuration B: Grid connected (electrical) continuous electricity production during low tourism season -i.e. winter months covering the electricity needs of the same population centres.
- Configuration C: Grid connected (water, electrical) simultaneous water production and electricity export –i.e. allowing to export excess power to the grid which can be used during low wind periods to avoid downtime in water production
- Configuration D: Off-grid continuous water and/or electricity production –i.e. using water transport barge/vessel located further offshore or an offshore platform –e.g. oil & gas, offshore aquaculture etc.
- Configuration E: Micro-grid continuous water and/or electricity production in a fixed location supplying the needs of a primary island with electrical and/or water grid connection and serving other islands' needs off-grid i.e. supplying water using water transport barge/vessel

1.1.2 Advantage of combination

1.1.3.1 General for both sectors

- 100% renewable sources with low carbon footprint including low overall environmental impact due to MUP design
- Cost reduction by integration of offshore activities
- As technology is not geographically/morphologically site-specific can be moored at various locations avoiding conflicts with other sectors (such as fishing, aquaculture, tourism, leisure (marinas) and port/shipping).
- Dynamic configurations maximizing water and/or electricity production meeting seasonal needs
- Fabricated and assembled in its upright position at shipyard and towed to offshore location reducing costs

1.1.3.2 Desalination

- Lower costs than land-based conventional desalination
- Chemical-free renewable powered desalination system compliant with EU directives
- Site selection process on case-by-case basis working closely with local stakeholders for an optimum use of the sea space.

1.1.3.3 Wind

- Energy used at source, therefore low losses.
- Guaranteed customer for electricity purchase

1.3 Business section

1.1.1 Competition

Competitor	Key Differentiators	Competitive Threat Rating (1-5)*
Power Public Corporation of Greece	Non grid-connected islands operate diesel generators and energy price depends on oil price and exchange rates (USD:EUR) hence not stable electricity pricing. Diesel generated power must also supply required energy for land based desalination plants. EWW avoids the above by supplying energy locally but also storing energy in form of water which is more profitable at low tariffs and during water demand periods (even more during tourism seasons). In near future the energy demand will be increased (e.g. electric cars) hence EWW will be best positioned to respond to this demand.	**4**
Land-based desalination	Operational cost estimated in excess of 2.3EUR/m3 excluding profit margin. These companies are subsidised by government (i.e. free electricity) and this is under EU pressure to change in the near future. When support tariffs are removed, the cost of water to the consumer will increase to over 4EUR/m3 (current pricing in Canaria). EWW offering is very competitive selling at 2EUR/m3 including profit margin.	**4**
Water transportation	Cost to Greek Government ranging from 5-15 EUR/m3. EWW will displace these type of companies capturing their entire market share	**1**
Renewable energy (offshore/onshore)	Able to compete with offshore wind on equal terms and tariffs. Onshore wind is challenged by local opposition due to potential displacement of tourism in islands. EWW is flexible to move further offshore or at less vis site, i.e. better acceptance. Also EWW does not need local infrastructure (roads, cranes etc) to be installed, also avoiding land based costs (cost of land, building regulations etc). EWW has the option to operate off-grid if needed to supply niece market (e.g. hotel complex, aquaculture farm, floating marine etc).	**3**

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

1.1.2 Business Model

EcoWindWater plans a two staged commercial business model in their home market of Greece. In the short term utilising a PPP model to overcome the water and fuel subsidy of Greek islands.

- For the first market (GREECE)
  - ➢ Short term (5-10 years) [i.e. currently subsidies are in place and Greek Islands local authorities <u>do not have to buy</u> their own water and/or electricity]
    - Public Private Partnership -PPP model
    - Special Purpose Corporation (SPC) with Greek government OR local authorities (e.g. municipalities, social cooperative) via possible tender for infrastructure projects
    - Develop the technology to 3rd generation
    - Maintain and operate the devices for a period of 3-5 years at specific locations
  - ➢ Long term (>10 years) [i.e. expect subsidies have been removed and Greek Islands local authorities <u>must buy</u> their own water and/or electricity]
    - Lease/hire purchase model possibly combine it with financial investor model
    - Consider continuation of PPP to run alongside (if needed, for instance to help very remote small islands with low economic activity and still depend on water supply/subsidies by Greek government)
    - Devices are leased to island local authorities, municipal water companies, national electricity company, grid owner for a period of 10-20 years in exchange for regular payments
    - Devices are leased to private sector large hotel complex and other tourism business developers
    - Operate a service contract as a separate product to provide O&M (but customer has full responsibility/choice to outsource maintenance O&M)
- For the the second market (Europe)
  - ➢ Manufacturing and selling the units to 3rd parties. Keep part of the ownership (if requested by the clients) and be responsible for the maintenance of the systems.
  - ➢ Long term. Depending on the number of units in a region, consider establishing a local company with local firms to undertake the maintenance
- For the the third market GLOBAL (e.g. Caribbean)
  - ➢ Manufacturing and selling the units to 3rd parties. But also..
  - ➢ Establishing a Joint Venture with Local firm(s) and participate in it with a limited percentage.
    - EWW wants to sell the units to this company
    - Joint Venture company responsible for O&M (in the region) and for finding new customers
    - Establishes PPP or Mixed or even Lease and Hire Purchase model with local customers

1. Customer Segments

- Potential customers for water include
  - Greek government, island local authorities, municipal water companies, grid owner
  - Private sector tourism business developers, 3rd party operators
- Potential customers for electricity include
  - the Power Public Corporation of Greece (in future private utilities)
  - Hellenic Transmission System Operator
  - the Greek government, island local authorities

2. Value Proposition

- Efficient technology
  - Dynamic configurations maximizing water and/or electricity production
  - Sophisticated management system for dynamic configuration maximise water desalination and electricity production.
  - Efficient load matching to wind resource.
- Easy grid connection.
- Advantages of Floating Design
  - Stability in pitch while allowing the floater to slide vertically
  - Flexibility of location
  - Full Assembly at a Coastal Facility
- Reduced environmental impact
  - Reduced overall environmental impact due to MUP design
  - Reduce risk hazards associated with navigation and aviation
  - Chemical-free desalination system compliant with EU directives
- Consent and licensing – reduced time delays due to mooring licensing.
- Cross-sectoral Opportunities
  - Ability to engage with other blue economy/blue growth sectors
  - Cost reduction through integration of offshore activities.

3. Channels

- Sales and marketing: EcoWindWater will be selling directly to the end buyer
- marketing communications targeted at the final customer
- focus on the 'green' credentials of the project: renewables, chemical free
- potential for creation of jobs, and the accelerating necessity for renewable energy as part of tackling climate change.
- Physical distribution: The fully assembled device can be towed to the chosen offshore site
- eliminate lengthy and expensive offshore operations during installation

4. Customer Relationships

- A close partnership with customers will enhance relationships and give Ecowindwater a competitive advantage over competitors if these relationships are maintained.

▪ use of conventional towboat eliminating the need for specialist vessels ▪ A close partnership with customers will enhance relationships and give EcoWindWater a competitive advantage over competitors if relationships are maintained.	
5. Revenue Streams ▪ The main revenue stream will be the sale of clean drinking water to customers. ▪ Operate a service contract as a separate product to provide O&M. ▪ Surplus electricity can be exported to the grid. ▪ Sale of licences to businesses that can then manufacture and operate devices. ▪ Manufacturing and selling the units to 3rd parties. ▪ Establishing a Joint Venture with Local firm(s) and participate with a limited percentage.	**6. Key Resources** ▪ Both technologies are well proven and prototypes have operated without issue for extensive periods in identical conditions. ▪ Specialised expertise and local knowledge. ▪ Intellectual Property (IP) and protection of patents
7. Key Activities ▪ R&D ▪ Customer development, marketing and selling the units to 3rd parties ▪ Managing manufacturing process (co-ordinating contractors) ▪ Operate a service contract to provide O&M ▪ Establishing Joint Venture/PPP with Local firm(s) globally, leasing management ▪ IP management	**8. Key Partners** ▪ customers, suppliers and contractors ➢ Greek government including Ministry for Development Competitiveness and Shipping, Ministry of Infrastructure Transport and Networks, island local authorities, municipal water companies, grid owner ➢ Wind turbine (Siemens), desalination and automation suppliers (Technava S.A., Reflection LTD, Algosystems S.A), Electrical system and Interconnection (Algosystems S.A), Floating platform (Lamda Shipyards, Hellenic Register of Shipping, Koumanis & Co), Power cables (Meinhart Kabel, ABB), towing vessels (Spanopoulos Group). ▪ venture capital and private equity firms ▪ 3rd party operators including joint venture companies ▪ research and academic partners such as University of the Aegean, National Technical University of Athens, MARIBE consortium partners
9. Cost Structure ▪ Technology combination savings ▪ R&D costs to scaling up from 30kW => 800kW => 2MW ▪ Fabrication of devices ▪ Consenting, certification and approval ▪ Deployment, operations & maintenance, insurance ▪ Overheads, new IP generation and IP management	

1.4 Management Section

1.1.1 Existing management team and company organisational structure

Founded in 2007 in Greece, EcoWindWater is a Greek registered SME, which specializes in ecological seawater desalination.

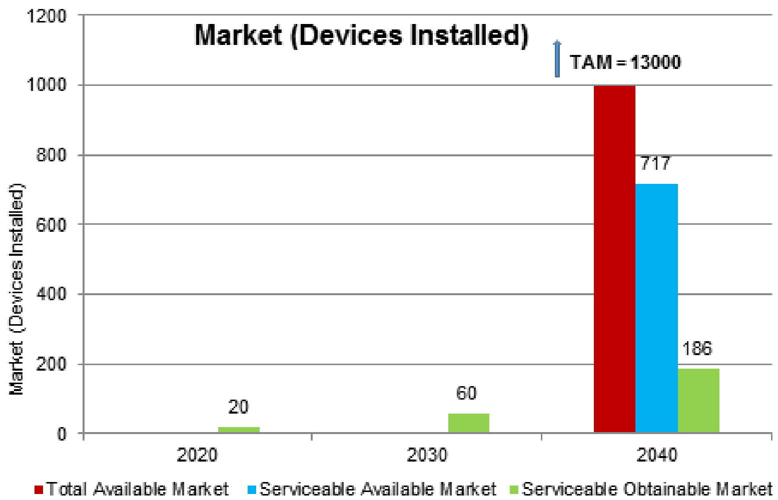
The company has three directors (Nikitakos Nikitas; Lilas Theodoros and Vatistas Athanasios), who are responsible for the management of the company, as well as for the decision-making, such as procurement critical items, choice of subcontractors, etc. Also, due to EcoWindWater is a small enterprise employs few staff mainly at assistant positions on short contract basis and has a close working relationship with external partners, such as universities, enterprises, renewable energy organizations, ministries, classification societies etc.

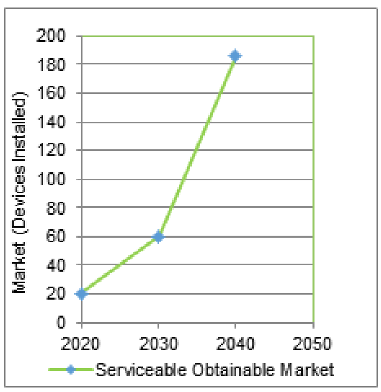
For this combination, it is anticipated that the management team contains all the requisite skills and expertise necessary in order to accomplish the project goals under the business model of "Technology provider" and outsourcing to external service providers.

1.5 Market Section: Market Share from 2020 until 2040

1.1.1 Market Analysis

Three markets have been identified – the domestic Greek market, local European market and the global market. It is estimated that 186 2MW desalination units would be required to cover total demand in the Aegean Islands in Greece. There is a market for over 14,000 devices in the EU and over 1.34 million in the rest of the world.





1.1.2 List of investors and sources of funding

1.1.3.1 Investors and funding to date

- Total EUR 3.47m (Public: 2.02m, Private: 1.45m)
- 30kW pilot:
  - Design, delivery and operation
  - Site and resource studies, weather data collection
  - Socioeconomic studies assessing the needs of Greek islands
  - Total Cost: €2,872,312 (EU grant 60.63%, Private 39.37%)
- Operational optimization of 30kW Pilot
  - Improvements on working prototype
  - In situ installation
  - Company start-up
  - IP protection, patent fees
  - Dissemination of technology (conferences, peer reviewed publications, undergraduate courses ..)
  - Total Cost: €600,000 (EU grant 50%)
- In-kind contributions
  - directors time
  - PhD/Master thesis at University of Aegean and National Technical University of Athens
  - Participation in other projects (e.g. MET3)

1.1.3.2 Grants funds required and potential sources

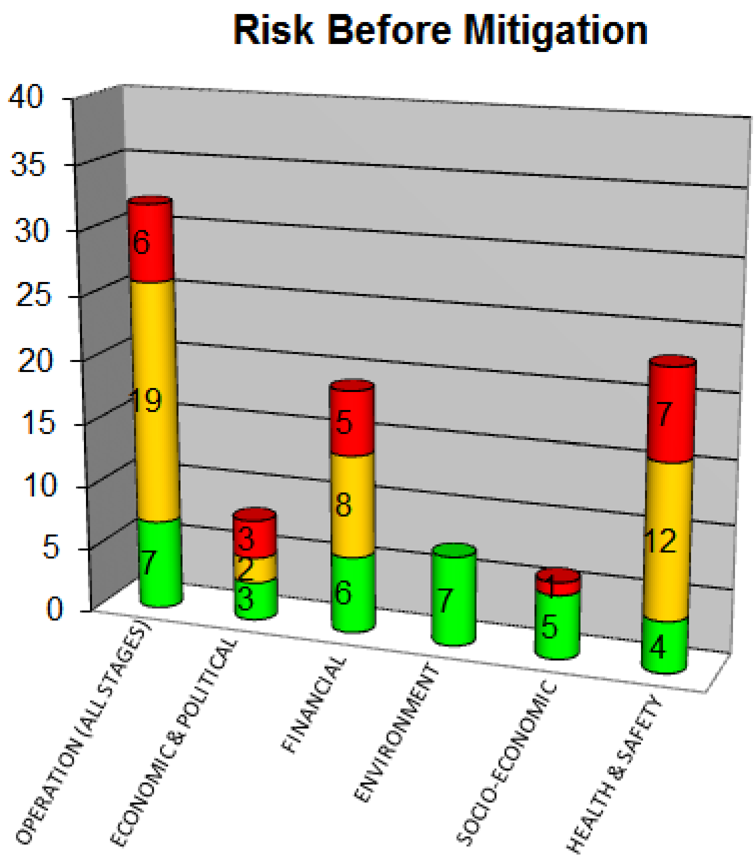
- List of potential investors and sources of funding
  - Short term: develop the technology to 3rd generation
    - Greek Government tender for infrastructure projects
    - EU funding (H2020, SME Instrument, INTERREG South East Europe: Adriatic Ionian Programme 2014-2020, INTERREG: MED Programme ...)
- Longer term: capture market share
  - Debt/equity finance
  - Revenue from leasing to private (tourism business developers e.g. large hotel complex) and public (local authorities, utilities, grid operators) sectors

1.6 Risk section

1.1.1 Commercial Risk Analysis

1.1.3.1 Hazards description

- 95 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 **22 High (red)**, **41 Medium (orange)** and **32 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.



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

Hazard Category		Issue	Sum
1. Operation (all stages)	Pre-construction	Site problems and licensing	2
		Insurance issues	1
	Construction		0
	Operational	Maintenance and logistics issues	1
		Health and Safety/access to emergency response	2
	Decommissioning		0
2. Economic and Political	Public Sector Support	Grants and subsidies (Feed-in-Tariff, Renewable Obligations and Tax credits)	2
		Applied price forecast	1
3. Financial	Financial support	Lack of investment	5
4. Environment	Ecology, physical environment		0
5. Socio-economics	Displacement	dependency of other sectors to a company of a sector at early lifecycle stage; knock on effect of company failure to dependencies	1
6. Health and Safety	Personal Injury	Aviation	1
	Personal Injury	Confined Spaces	1
	Personal Injury	Electrical Safety	1
	Personal Injury	Lifting	1
	Personal Injury	Marine Coordination	1

	Personal Injury	Remote Working	1
	Personal Injury	Working at Height	1
		Total	**22**

1.1.3.3 Commercial High Risk Response

Operation (all stages)

Description: The Operational risks account for over 60% of all red-category risks identified. At pre-construction phase "Site problems and licensing" issues relate to i) site compliance from environmental perspective ii) delays in the licensing due to the sector's infancy, and iii) insurance issues (high cost, complexity from combined activities and lack of class approval, conflict with other sectors -tourism, fishing) were identified as the main causes for potential delays and increased costs.

Risk response: Pre-planning as early as possible for a thorough EIA study can help avoid such issues. Employing an experienced Environmental Manager and collection of high quality environmental data will avoid elevation of these risks. The design of the floating desalination plant offers flexibility to operate a few Km offshore to speed up consenting process and connect to grid at a later time. The company EWW is already experienced in the consenting process from their TRL6 deployment. Knowledge from maritime/shipping sector negates the risk associated with the novelty. The company will be looking to keep staff costs/numbers low to be able to wait long periods before approval granted. Insurance issues could be overcome from EWW's careful planning on developing the project in a stepwise scale-up approach: 30KW => 800KW => 2MW. Gathering operational experience and completing thousands of operation-hours will help qualify devices beyond prototypical stage and inspire confidence to the insurance industry.

Description: Operational risks due to i) Maintenance and logistics Issues ii) Health & Safety and emergency response could result in higher costs, delays and injured staff if not addressed appropriately. Examples from possible causes are listed below:

- Bad weather may increase downtime and shorten maintenance time windows
- Low skilled workforce, inexperienced workforce, failing to comply with H&S regulations/guidelines
- 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
- Distance of site from emergency response

Risk response: Will ensure provision of maintenance by qualified and offshore-experienced contractors. Due to location in Aegean islands there is established network of emergency response from local coast guard and army. Employing experienced environmental/H&S managers and the close proximity from the shore with nearby port facilities (as it is the case for all islands at the Aegean) will negate many of the aforementioned risks.

Economic and Political

Description: Public sector support and the lack of market due to the existing subsidy regime (both water and electricity) in the Greek islands are issues that can result in delays or compromise the success of the proposed business offering. The causes are summarised below:

- Energy/water national policy changes, change of terms for receiving grants and subsidies (inc. conditions for being eligible), the size of the subsidy and the period in which a project is eligible for subsidies, removal or phase-out of subsidies, delays in release by government
- At present government subsidises water and electricity to the islands hence unable to compete directly in many cases (e.g. allowance for free land use to competitor for setting up land desalination; government subsidising water supply to islands under water draught hence they don't need to buy the water from a supplier at present)
- sensitivity analysis; exposure to market risk; long-term price forecast and divergence in the expectations for power prices

Risk response: In the short term (i.e. for next 5yrs) offshore wind will be subsidised to support growth in sector; also infrastructure projects fall under a similar support mechanism accessible to desalination plants. Ecowindwater is considering these options while also considering competing to secure procurement contracts with the Greek government to supply cheaper drinking water than current competition (in some cases water by transportation - EURmillions/y). This will position the company to be able to sell directly to customer when subsidies are phased out and or/removed. A Public Private Partnership (PPP) formation would be a favoured option in the short term and until subsidies are phased out and or/removed. Detailed techno economic studies have been carried out in the past and confirmed with MARIBE project adding confidence to the financial modelling results and projections of costs and revenue streams.

Financial

Description: Financial support was identified as the category where all red financial hazards are found. Potential issues identified around lack of (or removal of) investment which could be triggered due to a number of possible causes:

- investors who do not invest due to risk of losing development costs and due to little benchmark data
- lack of experience and knowledge (i.e. Life cycle stage S0) may discourage investors to assume unknown risks
- First mover means that there is no established market and investors will need to create a market for the product (e.g. strike price negotiation for Swansea Lagoon)
- Wrong sensitivity analyses and price forecast; Bridge financing problems arise (e.g. from exposure to market changes); change of business climate; Applied price forecast;
- public sector support: unexpected phase-out or change of policy/terms/rules, delays in payment;

- finance instruments related problems (e.g. Risk Capital, Mezzanine/Corporate/Project/ Participation/Consumer/3rd Party – Finance); 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 TRL stages transition. Moreover, benchmark data will be collected from the 2 planned pilot deployments (0.8 and 2 MW) to help in classifying the MUPs as post prototypical. Detailed risk assessment studies during the multiple stages with incorporating lessons learned will help overcome first mover risks due to the infancy of the sector. Lobbying and seeking to for PPP partnership with national and local governments can help reduce cost associated with cost of capital (WACC) and facilitate the market entry for EWW. The inevitable phase out of the existing subsidy regime coupled with the driving force of national agreements to reduce carbon and mitigate climate change committed to supply energy from ocean will help EWW to keep risks of financial support at a low magnitude.

Health and Safety

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

- Aviation (radar interference: low-flying military aircraft; civilian takeoff/landing approach; search and rescue aircraft)
- Confined Spaces (injury/loss of consciousness/asphyxiation from temp. increase, release of dangerous chemicals, oxygen displacement, drowning due to ingress of water, fire or explosion)
- 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 wave devices)
- Lifting (during construction and assembly, lifting of major components offshore, failure of lifting equipment, lifting tools and minor components from access vessel)
- Marine Coordination (conflicting offshore operations e.g. vessel collision)
- Remote Working (Injury unnoticed, Lack of management supervision, Transit time to obtain treatment of injury)
- Working at Height (falls, dropped objects)

Risk response:

- Aviation
    - fitted with aviation obstruction warning lights in accordance with international law/regualtions (Air Navigation Order 2009/CAP 393)
    - positions and heights of obstructions should be notified to the national military and civilian geographic/hydrographic offices as required
    - initial notification as an outcome of the planning process with accurate and timely notification of the actual date on which a structure will be erected
- Confined Spaces

    - Reduce the number of confined space in design phase and apply strict ventilation conditions whilst working in confined space
    - Conduct a thorough risk assessment for confined space entry including identification of measures that avoid the need to work in the confined space and elimination of sources of danger to people who will enter the space
    - Permanent measures in place to restrict entry and when these spaces are used for certain operations to be carried out under well-defined procedures (including, training supervision, Communication systems, test and monitor the atmosphere, purging hazardous gases or vapours from the space, fire prevention etc.) in accordance with national and international regulatory and policy making bodies
    - Unless or until a confined space has access procedures defined for safe use it will be treated as a potentially hazardous confined space.
- 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 renewable device energy generators.
- Lifting
    - Ensuring that all cranes are designed and certified for offshore use. Ensure compliance to regulatory requirements using lifting equipment suitable for the purpose of the intended use, in terms of properties such as materials of construction, accessibility, protection of personnel, and withstanding the effects of high wind.
    - Giving thorough consideration to lifting requirements at floating terminal early design phase including equipment that matches the capabilities of foreseeable vessels. Adopt best practices in the lifting operation
    - Carrying out thorough early planning of lifting operations, so that firm vessel requirements can be established;
    - Selecting the most appropriate cranes for the tasks of routine/non-routine, heavy/light, restricted/unrestricted (by weather) operations. Adopt standards set by IMCA, DNV, Noble Denton
    - Ensuring that the suspended load will not pass over locations where people will be present during the lifting operation
    - Advance contingency planning in place to cope in case of problems such as interruptions in power and communications systems, failures of load-bearing components, and unexpected problems with the parts to be assembled

- Marine Co-ordination
    - establishing an effective Marine Co-ordination function, with sufficient numbers of competent people, and suitable supporting systems in place (communication hardware, software systems to assist planning and monitoring) to manage the workload in each phase of the project lifecycle
    - Provision of information and warnings to project vessels and other sea users
    - Continuous co-ordination and monitoring of all marine activities, including movements of non-project vessels in the vicinity
    - Continuous control of access, and tracking of personnel and vessels
    - Emergency co-ordination, including liaison with emergency services as required
    - Carrying out site inductions for offshore work
    - Ongoing liaison with other sea users
- Remote Working
    - The effects of remoteness will be considered when planning work such as lifting (LOLER), work in confined spaces, the use of hazardous substances, and work at height.
    - Thorough planning, to ensure that the necessary resources are in place to support the RW tasks, and foreseeable incidents that may occur
    - All necessary work, equipment, consumables, and means of waste disposal are provided, with appropriate spares as necessary.
    - Competence and equipment to manage foreseeable situations will be in place up to the point where additional help will be available
    - Effective communication with all personnel working in diverse areas of the floating terminal.
    - Location of all personnel and vessels known/recorded at all times: personnel tracking systems including procedures that require manual reporting over radio, RFID (Radio Frequency Identification) contactless swipe cards, and GPS systems.
    - Each offshore work party under suitable fitness (i.e. no underlying health conditions) and competent with skills such as first aid and rescue, to ensure self-sufficiency and preservation of life in the event of an accident, until further support is in attendance.
    - Suitable supervision and audit arrangements in place (i.e. ensure safe working practices)
- Working at Height
    - During detailed design of the floating terminal structures and equipment assess whether foreseeable tasks can be carried out without the need to work at height;
    - Where an unavoidable need to work at height is identified, the design will ensure that the risks are minimised such as adoption of measures (e.g. fall-arrest systems, fixed fall-arrest systems on ladders, anchor points for use with equipment for work positioning) to reduce the risk of serious injury

- Follow standard guidance to assess the risks of work at height, and, so far as is reasonably practicable, take steps to avoid those risks, according to a clear hierarchy:
    - Avoid work at height
    - Where work at height cannot be avoided, use work equipment or other methods to prevent falls from occurring
    - Where the risk of falls cannot be eliminated, take suitable measures to minimise the distance and consequences of a fall

1.1.2 Pilot Risk Analysis

1.1.3.1 Pilot High Risk Response

Operation (all stages)

Description: Operational risks due to i) technical issues including component failure ii) Maintenance and logistics Issues iii) Health & Safety and emergency response and iv) pollution. Should these risks materialise, they would result in potential delays, increased costs and redesign if not addressed appropriately. Examples from possible causes are listed below:

- Mooring failure due to extreme weather conditions
- Incompatibility of win and desalination on the same platform
- Pollution from leaked chemicals (i.e. wind turbine) that could destroy local fish stock or at lesser amounts could enter food chain via contaminated fish populations, with also potential knock on effect to other sectors such as tourism and leisure (liable losses)
- Bad weather may increase downtime and shorten maintenance time windows
- Low skilled workforce, inexperienced workforce, failing to comply with H&S regulations/guidelines
- 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
- Distance of site from emergency response

Risk response: The use of standard technology where possible including mooring coupled to the benaine local sea conditions at the Aegean (also nearshore deployment) will help reduce the risk associated with component failure. Combination of technologies has already been demonstrated at TRL4/5/6 successfully. Company, has already completed simulation modeling in order to fully understand technology at an early stage. The results simulations, that were carried out at these technology development levels, verified that the pilot works as expected on simulations and validated the technology of total system and subsystems. Extensive real sea testing has already ensured the compatibility of the platform for both the wind and desalination technologies. A careful approach in scaling up to 2MW has already been adopted: Pilot stage 1: 30 to 800KW; Pilot stage 2: 800KW to 2MW.

Monitor general activity in surrounding waters from other sectors (e.g. tourism, fishing) and direct communication with their stakeholders will ensure enough reaction time is available to industries to respond in case of unforeseen pollution incidents. Due to the floating design it is possible to choose deployment location that is not visible from highly touristic hotspots and ensure any noise propagation does not affect residential areas. Due to location in Aegean islands there is established network of emergency response from local coast guard and army. Employing experienced environmental/H&S managers and the close proximity from the shore with nearby port facilities (as it is the case for all islands at the Aegean) will negate many of the aforementioned risks.

Economic and Political

Description: The same economic and political risks have been identified for the pilot, but to a lesser extent.

Risk response: Mitigation measures remain as they are.

Financial

Description: The same financial risks have been identified for the pilot, but to a lesser extent.

Risk response: Mitigation measures remain as they are. Especially for the pilot, due to lack of benchmark data, company intends to present results, which will be communicated across from studies undertaken during TRL stages transition. Moreover, for the pilot phase, baseline data is already available from the pilot project of 30 kW, which will be used in order to inspire investor confidence and increase the reliability of the project.

Socio-economics

Description: Socio-economic risks are associated with i) Introduction of a new servicing industry ii) dependency of other sectors and iii) knock of effects following possible future collapse. These risks were identified as the main causes for negative publicity.

Risk response: Technology has been tested extensively during TRL4/5/6 pilot stage for feasibility and will be tested further during scale-up stages 0.8 MW and 2MW. The direct dependency of other sectors (e.g. for jobs) is unlikely as no frequent service is required and this can be carried out on the platform (hence no need to use a port or ship repair yard on a frequent basis). Also, business model of leasing technology to end-user local authorities will minimize the risk as the technology does not require highly skilled expertise to maintain and O&M can be operated by 3rd party.

Many islands have established sectors which are expected to become dependent of clean water and/or electricity from the proposed operations. Also, existing supply chains for water/electricity exist (e.g. supply of water by transportation, onshore desalination, diesel power-stations) and will not become obsolete as a result of Ecowindwater market entry.

Health and safety

The same Health and Safety risks have been identified for the third commercial. These risks are somewhat lessened as the project is at a smaller scale, but exist nonetheless.

1.7 Implementation Section

Work package number	1	Timeline (months):	T0-18
Work package title	Investment feasibility studies		

Objectives

- strategic evaluation and assessment of opportunities
- analysis of feasibility
    - Including financial risk assessment

Milestones

- Milestone 1.1: conclusion, recommendations and action plan
- Milestone 1.2: Finance secured for Pilot Phase I 800kW MUP: site investigations, design, fabrication, installation, license applications

Work package number	2	Timeline (months):	T0-18
Work package title	Construction site survey for Pilot Phase I: 800kW 1st Gen MUP		

Objectives

- Baseline environmental surveys to inform consenting and licensing process
- Establish baseline conditions on selected site location and vicinity
    - Wind Speed (average wind speed; annual wind speed distribution; extreme wind speed)
    - Water Depth (average water depth)
    - Wave Height and Period (average wave height, annual wave height distribution, peak period for annual waves, extreme wave height, peak period for extreme waves
    - Water Level (average tidal range, extreme low water level, extreme high water level including storm surge)
    - Current (average current speed, extreme current speed)
    - Distance to port
    - Seabed
- Geophysical survey
    - Seabed topography (swath bathymetry, preferably multibeam)
    - Seabed features (Sidescan sonar, using best practice survey layout)
    - Subsurface information shallow geology and fault offset analysis (high/ultra-high resolution seismic survey)

- Geotechnical survey
    - Soil investigation for anchored structures (as required due to cost implications)
- Shoreline survey
    - Identification of planning requirements and consents for cable and water pipe routes onto shore
    - Scope of planning application for onshore equipment and buildings and land based connection into water/electricity grid.

Milestones

- Milestone 2.1: engaged with local authorities and licensing/permit bodies
- Milestone 2.2: site survey completed

Work package number	**3**	**Timeline (months):**	**T0-18**
Work package title	**Conceptual, Basic Design & Approval In Principle**		

Objectives

- 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)
    - Establish design requirements of floating platform due to presence of wind turbine
    - Seabed characteristics
    - Intensity level of consequences of failure
    - Proposed design, installation, and operation approval by the client/partners/stakeholders
    - Functional design specification or Product design specification, as appropriate and utilising best practice and/or systems engineering procedures
- Basic design
    - In-place analysis including extreme events
    - Earthquake analysis
    - Fatigue analysis
    - Impact analysis
    - Temporary analysis
    - Loadout analysis
    - Transportation analysis

- Appurtenances analysis
- Lift/Launch analysis
- Upending analysis
- Uprighting analysis
- Cathodic protection analysis
- Installation analysis

Milestones

- Milestone 3.1: Site Approval Road Map defined with local authorities and licensing/permit bodies
- Milestone 3.2: Design Approval Road Map defined with regulating authorities
- Milestone 3.3: Conceptual Basic Design complete
- Milestone 3.4: Approval in principle granted by site-permit authorities
- Milestone 3.5: Approval in principle granted by design-regulating authorities

Work package number	**4**	**Timeline (months):**	**T0-18**
Work package title	**Design verification by the regulating authorities**		

Objectives

- Determine approval route (CONCEPT DEVELOPMENT PHASE)
  - authorities lay out the 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.
- Final Class (Type) Approval (DETAILED 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 4.1: Design requirements completed
- ➢ Milestone 4.2: Class requirement completed
- ➢ Milestone 4.3: Class approval completed

Work package number	**5**	**Timeline (months):**	**T0-18**
Work package title	**Environmental Consent and Operational Permits**		

Objectives

- ➢ Informal consultation
    - Identify which items of legislation apply
- ➢ Environmental scope (formal)
    - Confirm which baseline studies are required and scope of work
    - Preliminary consultation with stakeholders
- ➢ Environmental statement (formal)
    - 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
    - Terrestrial ecology
    - Seascape, landscape and visual assessment
    - Navigation and marine transport assessment
    - Onshore transport assessment
    - Air quality
    - Hydrology and flood risk
    - Land quality and hydrogeology
    - Noise and vibration
    - Marine archaeology
    - Terrestrial archaeology and historic landscape
    - Economy, tourism and recreation
    - Mitigation and monitoring
- Other permits as required
    - Grid connection
    - Electricity export
    - Onshore planning
    - Offshore planning
    - Seabed lease
    - Coastguard/port approval

Milestones

- Milestone 5.1: Environmental Consent and site Operational Permits granted
- Milestone 5.2: Other permits granted as required: Grid connection, Electricity export, Onshore planning

Work package number	**6**	**Timeline (months):**	**T0-18**
Work package title	**Detailed Design and Strength Calculations and Detailed Design Approval**		

Objectives

- Final Class Approval process (detailed design/construction/commissioning phase)
    - Hazard and operability study (HAZOP)
    - Failure mode and effects analysis (FMEA)
    - Fault Tree And Event Tree Risk Analysis
    - Reliability Analysis
- Detailed design for manufacture

- Published international and national standards to be applied if project is within scope of the standard, in particular the IEC61400 series (wind turbines) and ISO19900 series (offshore structures)
- STRUCTURAL DESIGN
  - Loads: Permanent (dead) loads; Operating (live) loads; Environmental loads; Wind load; Wave load; Current load; Earthquake load; ice and snow loads; Construction, transportation, installation loads; Launching and Upending Forces; Accidental loads
  - Load Combinations
- STRUCTURAL (RESPONSE) 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
- LOCAL STRESS ANALYSIS
  - Calculations and checks the stress concentration around openings in the structural members.

➢ DETAILED DESIGN for costings

Milestones

➢ Milestone 6.1: Detailed Design and Strength Calculations completed
➢ Milestone 6.2: Final Class Approval process completed for detailed design phase
➢ Milestone 6.3: Detailed Design for costings completed

Work package number	**7**	**Timeline (months):**	**T0-18**
Work package title	**Cost plans for construction**		

Objectives

➢ Initial cost appraisals (studies of options prepared during the feasibility study stage).
➢ Elemental cost plan (prepared during concept/basic project design stage and carried through to detailed design)
➢ Approximate quantities cost plan (from the end of detailed design through to tender).
➢ Pre-tender estimate (prepared alongside tender documentation).
➢ Tender pricing document (part of the tender documentation issued to the contractor for pricing).
➢ Contract sum (agreed with the contractor during the tender period and adjusted during the construction period).
➢ Contract sum analysis (breakdown of the contract sum prepared by the contractor on design and build projects).

- ➢ Final account (agreed during the defects liability period).

Milestones

- ➢ Milestone 7.1: Construction cost plan completed

Work package number	**8**	**Timeline (months):**	**T0-18**
Work package title	**Procurement**		

Objectives

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

Milestones

- ➢ Milestone 8.1: Procurement for critical and non-critical items completed
- ➢ Milestone 8.2: Manufacturing drawings & bill of material completed
- ➢ Milestone 8.3: Obtain construction insurance

Work package number	**9**	**Timeline (months):**	**T18-30**
Work package title	**Construction and 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 9.1: Fabrication completed
➢ Milestone 9.2: Fitting and connection of components and systems completed
➢ Milestone 9.3: Pre-Commissioning activities completed
➢ Milestone 9.4: Final Class Approval process completed for construction phase

Work package number	**10**	**Timeline (months):**	**T18-30**
Work package title	**Preparation of transportation and offshore installation 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, seafastenings, rigging, slings, shackles and installation aids, etc.

Milestones

➢ Milestone 10.1: Installation Planning completed
➢ Milestone 10.2: Obtain operating insurance

Work package number	11	Timeline (months):	T30-32
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 11.1: Installation completed

Work package number	12	Timeline (months):	T30-32
Work package title	**Commissioning and Testing**		

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
- Testing: establish performance over a 6 month period

Milestones

- Milestone 12.2: Commissioning completed
- Milestone 12.2: Final Class Approval process completed for commissioning phase
- Milestone 12.3: Final Class Approval granted
- Milestone 12.4: In-service monitoring schedule issued and Maintenance of Class process initiated

Work package number	**13**	**Timeline (months):**	**T30-32**
Work package title	**Secure finance for Pilot Phase II 2MW MUP**		

Work package number	**14**	**Timeline (months):**	**T30-56**
Work package title	**Repeat of the steps 2-12 above for Pilot Phase II 2MW 2nd Gen MUP**		

Work package number	**15**	**Timeline (months):**	**T44-46**
Work package title	**Secure finance for Commercial 2MW MUP**		

Work package number	**16**	**Timeline (months):**	**T44-60**
Work package title	**Repeat of the steps 2-12 above for Commercial 2MW 3rd Gen MUP**		

Work package number	**17**	**Timeline (months):**	**T44-60**
Work package title	**Decommissioning**		

Objectives

- ➢ Outsourcing of dismantling components/structures and scrapping metal structures
- ➢ Removal of moorings and transportation to dismantling site (fabrication yard at coastal location)
- ➢ Dismantling of turbine, rotor blades tower house and other components including desalination modules and metal structures
- ➢ Arrangements for selling of metal components for scrap and disposal of remaining components

Milestones

- ➢ Milestone 17.1: Contractor agreement to undertake removal of structure, dismantling and selling off metal for scrap
- ➢ Milestone 17.2: MUP structure removed and transported to dismantling location
- ➢ Milestone 17.3: MUP structure dismantled and components disposed or recycled (scrap metal)
- ➢ Milestone 17.3: Recovery of decommissioning costs from metal scrappage

Note:

- In steps 14 and 15 above some of the corresponding tasks are expected to be less intensive and less time consuming. For instance Basic and Detailed Design will involve optimisation studies which will require less intensive effort and time. Similarly the site studies and licensing process will be streamlined as the same site is intended for the deployment for the Phase I and Phase II Pilot (800kW, 2MW).
- Step 17 'Decommissioning has been considered during risk assessment and costing but not included in timeline.

The following GANTT chart summarises the steps described above.

Construction Timetable: Floating Wind and Desalination Multi-Use Platform							
	Nov. 2018-Jun.2021			***Jul.2021-Oct.2023***			
Months	*T0-18*	*T18-30*	*T30-32*	*T32-44*	*T44-56*	*T56-58*	*T58-60*
***1. Investment feasibility studies* (MARIBE)**	■						
2. Securing finance for design, fabrication, installation, site investigations, approval and license granting for Pilot Phase I 800kW MUP	■						
3. FEED: Construction site survey for 800kW 1st Gen MUP	■						
4. Geophysical and geotechnical survey	■						
5. Conceptual, basic design	■						
6. Design approval with the regulating authorities	■						
7. MUP strength calculations and detailed design	■						
8. Cost plans for construction	■						
9. Procurement		■					

10. Fabrication of 1st Gen 800kW MUP device							
11. Installation & Performance Verification							
12. Commissioning and Testing							
13. Securing finance for design, fabrication, installation, site investigations, approval and license granting for Pilot Phase II 2MW (2nd Gen) MUP							
14a. Repeat of the steps 3-8 above							
14b. Repeat of the steps 9-10 above							
14c. Repeat of the steps 11-12							
15. Securing finance for design, fabrication, installation, site investigations, approval and license granting for Commercial 2MW (3rd Gen) MUP							
16a. Repeat of the steps 3-8 above							
16b. Repeat of the steps 9-10 above							
16c. Repeat of the steps 11-12							

1.8 APPENDIX: Extended B8 project report discussing all of the above sections in more detail

WP 10 Individual Reports Template

This document consists of a number of smaller documents that can be used as standalone to help with discussions around a specific topic (e.g. risk assessment). Collectively they deliver a complete BUSINESS CASE for each Maribe project.

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