HWEA
Hellenic Wind Energy Association

Norwegian Offshore Wind

Status & Challenges for the supply chain for Offshore Wind in Greece

June 2024

Funded by: Iceland Liechtenstein Norway grants

Innovation Norway

Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Grants 2014-2021, in the frame of the Programme "Business Innovation Greece", within the projects GR-INNO-SGS2 Soft Measures and GR-INNO-Restricted Call- HWEA/ELETAEN.

INTRODUCTORY NOTE

The offshore wind energy industry in Europe has been gaining momentum for several years as the project pipeline has expanded, EU countries have established procurement targets, and investments have been made in ports and manufacturing facilities. In Greece there are no operational offshore wind projects, but the Greek Government has set a target of approximately 2GW for 2030. The recently published National OWF Development Program (NDP-OWF) sets the potential OWF Organized Development Areas (OWFODA), which are areas that could potentially accommodate OWF projects in Greece for development in the medium and long-term future. This means that the Greek offshore wind market is starting to take off.

The sustainable development of the Greek offshore wind sector requires the development of a domestic offshore wind energy supply chain. The latter requires significant development of manufacturing facilities, ports, vessels and a trained workforce to produce, transport and install the major components required for an offshore wind energy project.

Projects “GR-INNO – SGS2 Soft Measures – HWEA/ELETAEN” and “GR-INNO-Restricted Call - HWEA/ELETAEN” aim to identify the missing parts of the OWF supply chain and what is necessary to be done in order to establish this supply chain effectively, promoting the cooperation between Greek businesses and Norwegian ones. The Projects are supported by a grant through the EEA Grants 2014-2021, in the frame of the Programme "Business Innovation Greece".

Preliminary analysis shows that the Greek and Norwegian supply chains have different strengths and capabilities. Thus, the Project’s approach promotes the creation of strong synergies and commercial opportunities. For this purpose, Hellenic Wind Energy Association HWEA ELETAEN has been partnered with Marin Energi Testsenter AS - Norwegian Offshore Wind – which is the largest offshore wind body in Norway with the overall mission to develop world leading supply chains within floating wind.

Among others, three reports have been executed within the Projects.

Two of them have been prepared by **Samaras & Associates**. The first one includes a market survey and an analysis of the supply chain for offshore wind in Greece, based on the finding of a report prepared by Wind Renewables. In the frame of this study, a market research was carried out with interviews to identify the possible "links" of the supply chain, i.e. the Greek companies that could be part of the supply chain. After this report, a second one followed assessing the impact of the announcement for the possible acceleration of the development of the first floating offshore wind farms.

The third report has been prepared by **iWind Renewables** and defines a set of the technical specifications for the sites for the construction of a typical Greek offshore wind farm with a reference wind turbine.

The outcomes of these studies were presented at the Conference for the Offshore Wind Supply Chain in Greece which was organized by the Hellenic Wind Energy Association ELETAEN in collaboration with the Norwegian Offshore Wind NOW, on November 23, 2023 as well as in HWEA's General Assembly which was held on March 5, 2024. Over 65 companies from Greece, Norway and other countries participated in this event. It was the first time that companies from the entire supply chain for OW came together in the same venue to meet each other, exchange experiences and know-how and consider how they can plan the next steps. A key conclusion was that there are many challenges for the development of the domestic supply chain for OW, but at the same time there is significant potential and opportunities. Greece has already developed, at a sufficient or significant extent, critical links of this chain such as the cable, cement and metal industries. It has also a tradition in other important sectors such as shipyards, ports and shipping and significant research experience through academia and Universities.

The present volume includes all the above reports.

CONTENTS

Status and Challenges for the supply chain for Offshore Wind in Greece

November 2023

SAMARAS & ASSOCIATES S.A.
CONSULTING ENGINEERS

HWEA
Hellenic Wind Energy Association

Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Grants 2014-2021, in the frame of the Programme "Business Innovation Greece", within the project GR-INNO-SGS2 Soft Measures - HWEA/ELETAEN.

Table of Contents

INTRODUCTION

Background

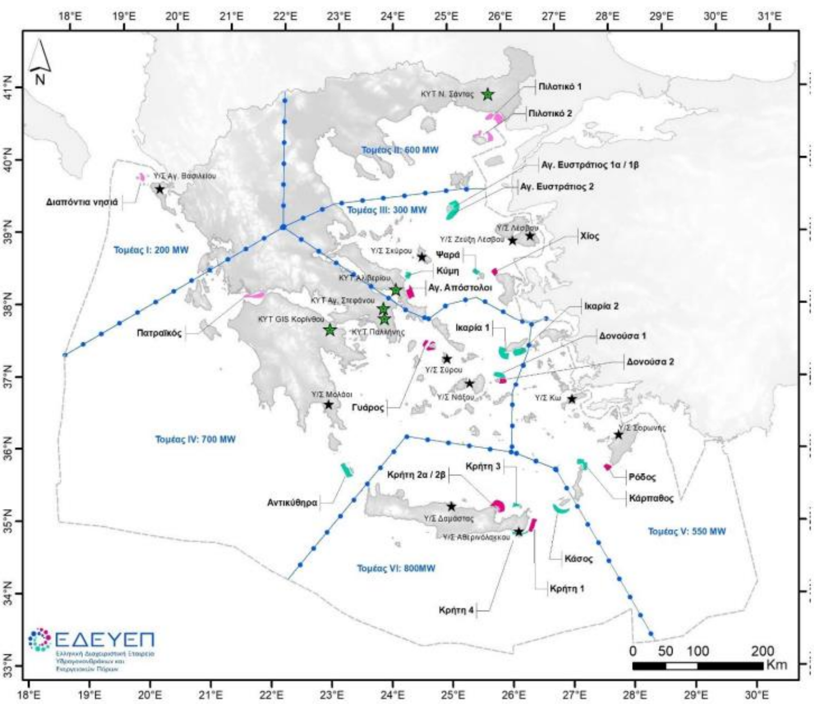
According to the country's preliminary energy planning, the target for the development of Offshore Wind Farms (OWF) in Greece is 1,900 MW for 2030, 6,200 MW for 2035 and 17,300 MW for 2050. [1]

The development of offshore wind farms, according to the IOBE study, can boost domestic GDP by up to €1.9 billion per year on average over the period 2024-2050. Over the same period, it can make a significant contribution to employment, supporting up to 44,400 jobs per year. [2]

Achieving these goals requires significant investment: Over 6 billion by 2030 and over 28 billion by 2050. These investments could have a high added value, up to 67%.

Therefore, the immediate and effective implementation of the goals that have been announced for the national program for the development of offshore wind farms is an important opportunity for both the state and society.

Figure 1: Possible Areas of Development of Offshore Wind Farms [3]



[1] https://eletaen.gr/en/press-release-for-offshore-wind-parks-in-greece/
[2] https://herema.gr/the-draft-national-programme-for-offshore-wind-energy-unlocking-a-natural-wealth-for-clean-energy-and-billions-of-euros-investments/
[3] https://herema.gr/announcement-seia-ndp-owf/

Importance of Supply Chain Development in Greece

Today projects that sum up to hundreds of Gigawatts have been announced and planned internationally, with each one of these projects requiring the construction of dozens of Wind Turbine Generators, Towers and Floaters. This has led to the speculation that the emerging supply chain today is unable to support even a fraction of the capacity of the wind farms planned and announced worldwide, according to market factors.

The development of the Greek offshore wind sector requires the development of a domestic offshore wind energy supply chain. It is considered that the only way to ensure the achievement of national targets is to achieve high levels of domestic production development. This way one could argue that domestic OWF supply chain could provide a higher priority in delivering the necessary components to local projects over foreign ones.

Otherwise, the development of the OWF sector in Greece will depend on the production capacity which may be created in other countries of the region, which in turn could provide higher priority to their domestic projects and the needs of the Greek OWF projects will inevitably take second place.

The development of the Greek OWF supply chain will however require significant development of the local manufacturing facilities, the ports infrastructure, the lease or acquisition of specialized vessels and a skilled and trained workforce so that it will be able to carry out the task of production, transportation, installation, and maintenance of the major components required for an offshore wind energy project.

Comparative advantages of Greece

With offshore wind resources in Greece considered among the most attractive for energy production in Europe the potential of the sector cannot be overemphasized. Although onshore wind continues to dominate global wind energy production, the saturation of exploitable sites, a lower comparative energy capacity, and visual and noise disturbances are just a few of reasons behind the current international surge in offshore wind farm (OWF) development.

Greece has several comparative advantages for the development of the OWF sector:

- **Strategic location**

The country is located in the Southwestern edge of Europe, and is neighboring the Middle East, Eastern Mediterranean and Northern Africa, close to the Suez Canal logistics corridor, and can be risen to be a significant energy hub for the region, by transmitting green electricity produced in Egypt and Israel (or even Saudi Arabia), green Hydrogen produced in the countries of the Persian Gulf, Natural Gas drilled from the Seabed of East Mediterranean, etc.

- **Ideal climatic characteristics**

With offshore wind resources in Greece considered among the most attractive for energy production in Europe the potential of the sector cannot be overemphasized. Although onshore wind continues to dominate global wind energy production, the saturation of exploitable sites, a lower comparative energy capacity, and visual and noise disturbances are just a few of reasons behind the current international surge in offshore wind farm (OWF) development.

- **Infrastructure with sea access**

Greece is a maritime country, with more than 2.000 islands, more than 200 inhabited islands and more than 70% of its mainland population living seaside. Therefore, there is a large number of existing sea infrastructure, such as dozens of commercial ports, shipyards, etc.

- **Marine and shipbuilding industry with extensive experience**

Greece is a maritime nation by tradition, as shipping is arguably the oldest form of occupation of the Greeks and has been a key element of Greek economic activity since ancient times. Today, shipping is the country's most important industry worth $21.9 billion in 2018. If related businesses are added, the figure jumps to $23.7 billion, employs about 392,000 people (14% of the workforce), and shipping receipts are about 1/3 of the nation's trade deficit. In 2018, the Greek Merchant Navy controlled the world's largest merchant fleet, in terms of tonnage, with a total DWT of 834,649,089 tons and a fleet of 5,626 Greek-owned vessels, according to Lloyd's List. Greece is also ranked in the top for all kinds of ships, including first for tankers and bulk carriers.

- **Strong domestic steel, cable, and cement industries**

Greek companies that are involved in the steel, cable and cement business are export oriented, internationally competitive, among the biggest companies in the country with a significant contribution in the local GDP.

PROJECT DESCRIPTION

Scope of the Project

The scope of this project is the analysis of the supply chain of offshore wind development in Greece. More specifically the goal is to identify the possible parts of the domestic OW supply chain and highlight what is necessary to be done to establish this supply chain effectively, promoting the cooperation between Greek businesses and foreign ones.

In order to preform the analysis of the supply chain for the development of offshore wind in Greece the following steps were followed:

1. The possible "links" of the supply chain were identified, i.e. the Greek companies that could be part of the supply chain.
2. A questionnaire was drawn up to be completed by the companies.
3. Interviews were conducted with the companies based on the issues raised in the questionnaire.
4. The outcome of these interviews is presented, trying to answer the following questions:
   a) Who are the companies?
   b) Are they looking to get involved in the offshore wind industry?
   c) Are they ready to get involved in the offshore wind industry?

In the following sections the answers to these three questions will be presented, based upon the answers provided by the companies themselves.

Key Players - Survey participants

To our knowledge this was the first attempt to capture the entire offshore wind supply chain industry in the country.

In order to point out the companies that could be part of the OWF supply chain in Greece, we started by examining similar supply chains in other countries, which industry sectors participate in the construction of the components of which an OWF consists, and examined if there are companies with similar activities in Greece.

Therefore, we targeted the country's main ports, shipyards and steel, cable and cement industries as the main parts of the supply chain.

Ports

The Greek port system consists of approximately 900 ports of different size, administrative organization, uses, and different importance for the national and local society and economy.

The classification of seaports, which is valid today, was published with Joint Ministerial Decision. During the ranking, the following were considered:

- The peculiarities of the Greek geographical area (division into numerous islands, existence of ferries, intra-island, and interregional connections).
- The statistics of the total annual traffic volume of goods (in tons) and passengers of the ports that meet the features A and B of EC decision No. 1346/2001/22.5.2001 of the European Parliament and the Council of the European Union (DDR), combined with the criteria of native geographical the advantages and their effect on the international network and of the country's national transport, as well as the looming perspectives development they show.

This decision groups the Greek ports in four main groups, as following:

- Ports of International Interest – Group K1 which consists of 16 ports.
- Ports of National Interest – Group K2, which consists of 16 ports.
- Ports of Lesser Interest – Group K3, which consists of 25 ports.
- Ports of Local Interest – Group K4, which consists of all the rest of the ports.

For the purpose of this survey, we focused on ports that belong in the Group K1, which are the main Greek ports. From those 16 ports we excluded ports that are in sites where no OWF are scheduled to be installed, at least in the first phases of the National OWF program. That left us with the ports of Piraeus, Thessaloniki, Alexandroupolis, Volos, Elefsina, Heraklion, Kavala and Lavrion. Furthermore, due to its location we also examined the port of Kymi in the island of Evia.

The ports we examined, along with their websites are listed below in Table 1.

Table 1: Main Greek Ports examined in the survey.

Port Name	website
PIRAEUS	www.olp.gr
THESSALONIKI	www.thpa.gr
VOLOS	www.port-volos.gr
ALEXANDROUPOLIS	www.ola-sa.gr
ELEFSINA	www.elefsisport.gr
HERAKLEION	www.portheraklion.gr
KAVALA (FILIPPOS B')	www.portkavala.gr
LAVRION	www.oll.gr
EVIA (KYMI)	www.olne.gr

Shipyards

The Greek shipyard industry is only recently coming out of a decades long decline. Previously state-owned shipyards were heavily in debt and the previous privatization efforts failed. Luckily this situation has recently changed. Firstly, the Syros Shipyards were acquired by ONEX Shipyards in 2017 and saw a drastic increase in turnover. Later, in 2021 ONEX Shipyards also took over the Elefsis Shipyards, while the "Milina Enterprises Company Limited" owned by shipping magnate George Prokopiou has been in discussions with the Greek Government to buy the Hellenic Shipyards S.A. in Skaramangas. Apart from these three larger Greek Shipyards, there are also smaller shipyards in Chalkis, Perama and Salamina. It is a fortunate circumstance that the Greek shipyard industry appears to be growing again just as the OWF sector calls for a significant demand for floaters and offshore construction.

The shipyards we addressed are presented in Table 2:

Table 2: Main Greek Shipyards examined in the survey.

Corporate Name	website
Hellenic Shipyards S.A. (Skaramangas Shipyards) ** Under special administration: transfer of Skaramangas Shipyards to «MILINA ENTERPRISES COMPANY LIMITED» owned by George Prokopiou.*	https://hsy-under-special-administration.gr
Elefsis Shipyards ** Resolution agreement with ONEX Elefsis Shipyards Industries SA*	www.elefsis-shipyards.gr
ONEX Syros Shipyards S.A.	www.onexsyrosshipyards.com
Chalkis Shipyards S.A.	www.chalkis-shipyards.gr
Salamina - New Hellenic Shipyards S.A.	www.spanopoulos-group.com

Steel & Cables Industry

Metals manufacturing is by far the biggest heavy manufacturing segment in Greece, with more than 4 billion sales in 2019. The basic metals industry is on the rise, due to increased exports and significant infrastructure projects, while basic metals production comprised 8,4% of total Greek exports, the second largest export category. Large players in this industry are focused on Aluminum, iron, steel, and copper. All key players in this industry produce one type of metal, apart from Viohalco group which produced 3 metals and dominates the copper market.

Hellenic Cables S.A., which is a company of Viohalco Group has extended expertise in the construction of underwater cables and has already built such cables for OWF in projects abroad.

Lykomitros Steel S.A. is already active in construction of steel structures for bottom fixed OWF such as monopiles and jackets, while EMEK S.A. has been building towers for onshore wind farms for years.

The Steel and Cable companies we examined, along with their websites are listed in Table 3:

Table 3: Main Greek Steel & Cables Industries we examined in the survey.

	Corporate Name	Segment	website
Viohalco Group	Cenergy Holdings S.A.		https://cenergyholdings.com
	Hellenic Cables S.A.	Cables	www.hellenic-cables.com
	Corinth Pipeworks (CPW)	Steel pipes	www.cpw.gr
	Sidenor S.A.	Steel	https://sidenor.gr
	Sovel S.A.	Steel	https://sidenor.gr
Hellenic Halyvourgia S.A.		Steel	www.hlv.gr
SIDMA STEEL S.A.		Steel	https://sidma.gr
ELASTRON S.A.		Steel	www.elastron.gr
LYKOMITROS STEEL S.A.		Steel	www.lykomitros-steel.gr
EMEK S.A.		Towers	www.emek.gr

Cement Industry

Cement production is one of the most important industrial activities in Greece, offering great export opportunities and contributing significantly to the national economy.

Limestone, the main raw material for the production of cement and aggregates, is abundant in Greece, which is a strong advantage for the development of the domestic cement industry. At the same time, the intense seismic activity in the country and the requirement for durable construction of private and public projects, result in an increased demand for concrete, as a building material, due to its great durability and strength.

Today, the cement industry in Greece has an annual production capacity of approximately 15 million tons and consists of 3 companies, which are listed in Table 4:

Table 4: Main Greek Cement Industries we examined in the survey.

Corporate Name	website
Heracles General Cement Company S.A., a member of the Holcim Group	www.lafarge.gr
TITAN Cement Company S.A.	www.titan.gr
HALYPS Building Materials S.A., a member of the Heidelberg Group	www.halyps.gr

Survey Focus

A. Outlook on the Offshore Wind Farm Sector

- ✓ Awareness of the sector
- ✓ Opinion of the company's management on the offshore wind farm sector
- ✓ Views on public policies
- ✓ Willingness to involve
- ✓ Key factors for involvement
- ✓ Readiness of the company
- ✓ Strengths & Weaknesses

B. Technical information

- ✓ Identify current situation
- ✓ Report existing infrastructure
- ✓ Examine compliance with "Typical Greek Offshore Wind Farm" and "Reference Turbine"
- ✓ Report any relative experience in similar projects
- ✓ Point out possible obstacles

A. Outlook on the Offshore Wind Farm Sector

The survey focused mainly on the companies' perspective on the industry. The information we wanted to acquire was:

- ❖ What the Outlook of the Offshore Wind Farm Sector in Greece in their opinion was and which they believed were the prospects of the Sector.
- ❖ Their views on current public policies for the development of the offshore wind farm sector and which were their expectations on state incentives by the Government for the development of the offshore wind farm sector.
- ❖ Which they identified as the business opportunities and threats of the Offshore Wind Farm sector.
- ❖ A comment on the willingness of the management to involve with the offshore wind farm sector.
- ❖ Which were the Key factors for involvement with the offshore wind farm sector.
- ❖ Which they identified as Strengths Weaknesses for involvement with the offshore wind farm sector.

B. Technical information

Simultaneously an attempt was made to collect technical information, mainly about the ports and shipyards, in order to:

- evaluate the current situation,
- record the existing infrastructures,
- examine their possible compatibility with the "typical Greek wind farm" and the "reference wind turbine" as suggested by the Report prepared by iWind Renewables on behalf of ELETAEN NPO[4],
- take into account any experience of the companies in respective projects and
- demonstrate possible obstacles.

[4] Project: "GR-INNO – SGS2 Soft Measures HWEA/ELETAEN'', Deliverable of Task 1.1, "Definition of a typical Greek offshore wind farm and a reference turbine "Definition of a set of technical specifications", prepared by iWind Renewables.

OUTCOMES

Outlook on the Offshore Wind Farm Sector

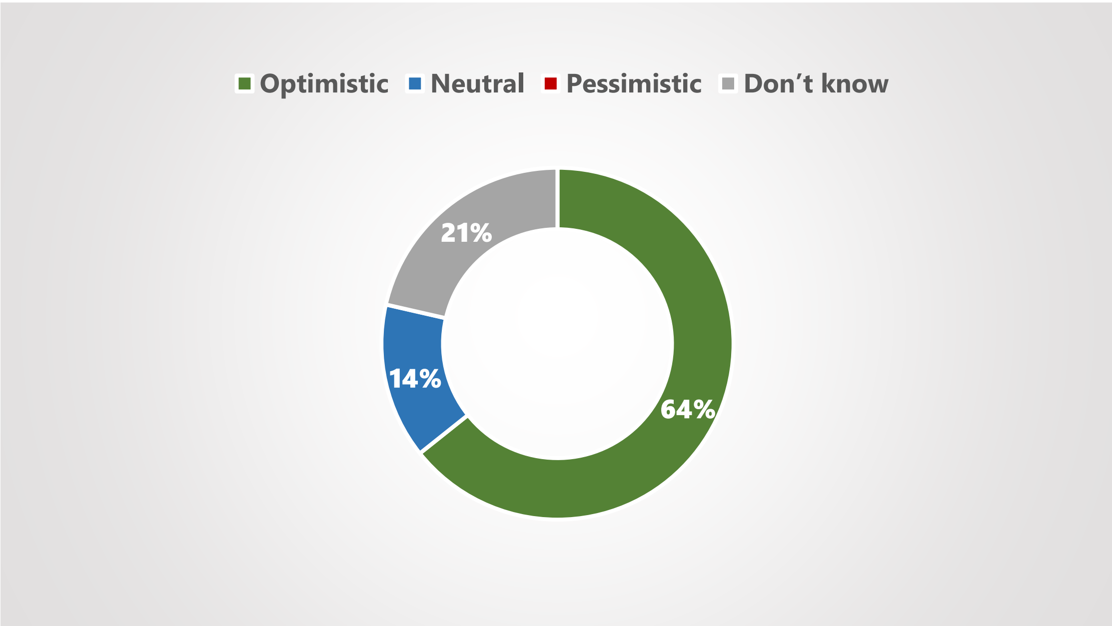
Positive Attitude for the Outlook of Offshore Wind Development in Greece

We asked the companies' management for their outlook on the Offshore Wind Farm Sector, and requested them to declare themselves as Optimistic, Neutral, Pessimistic, or that they do not know.

We recorded positive attitudes, but also relatively low awareness of the outlook for the offshore wind industry.

6 out of 10 are positive about the industry's prospects while 2 out of 10 are unaware. It should be pointed out that no one was pessimistic on the Outlook of the Development of the Offshore Wind Sector in Greece.

Figure 2: Outlook of the offshore wind farm sector

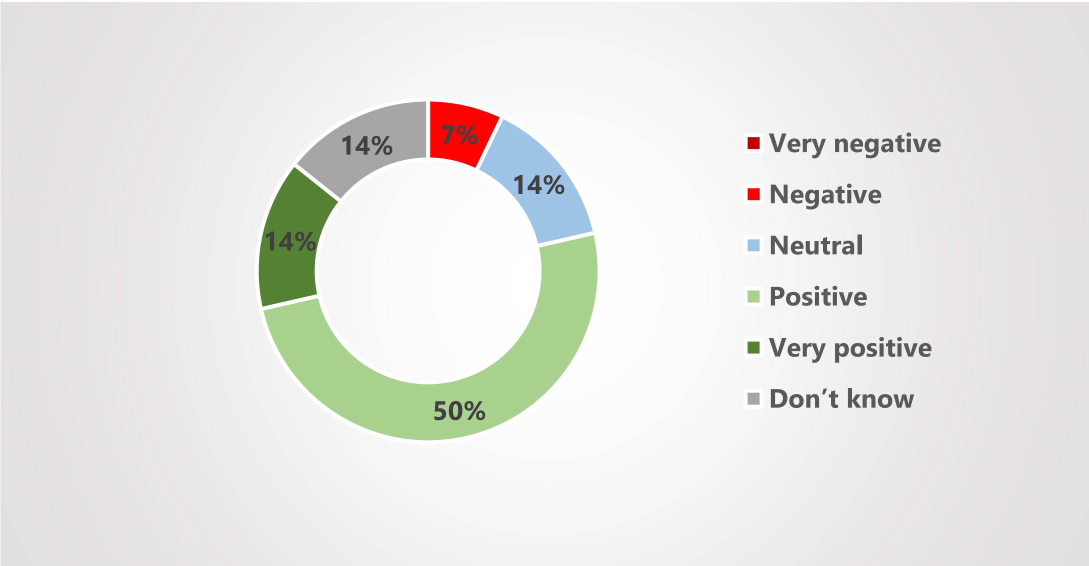


Views on current public policies

Positive Opinions on Government Policies

We received positive views on government policy regarding the development of the offshore wind industry, with half expressing positive views, and a total of 2/3 expressing positive or very positive views.

Figure 3: Views on current public policies for the development of the offshore wind farm sector



As the main positive points, we noted the strong commitment of the state to the energy transition, the orientation of the government to attract investments in energy projects and the announcements of the national program for offshore wind farms.

On the other hand, concerns were expressed about the risks of delays in the implementation of the program, since if the objectives of the program are not met, there is a risk of losing the opportunity that opens for the country.

Concerns were also expressed about the progress of the permitting process and ensuring that projects do not face bureaucratic hurdles and delays.

Finally, there is uncertainty about the state's consistency in meeting the schedules.

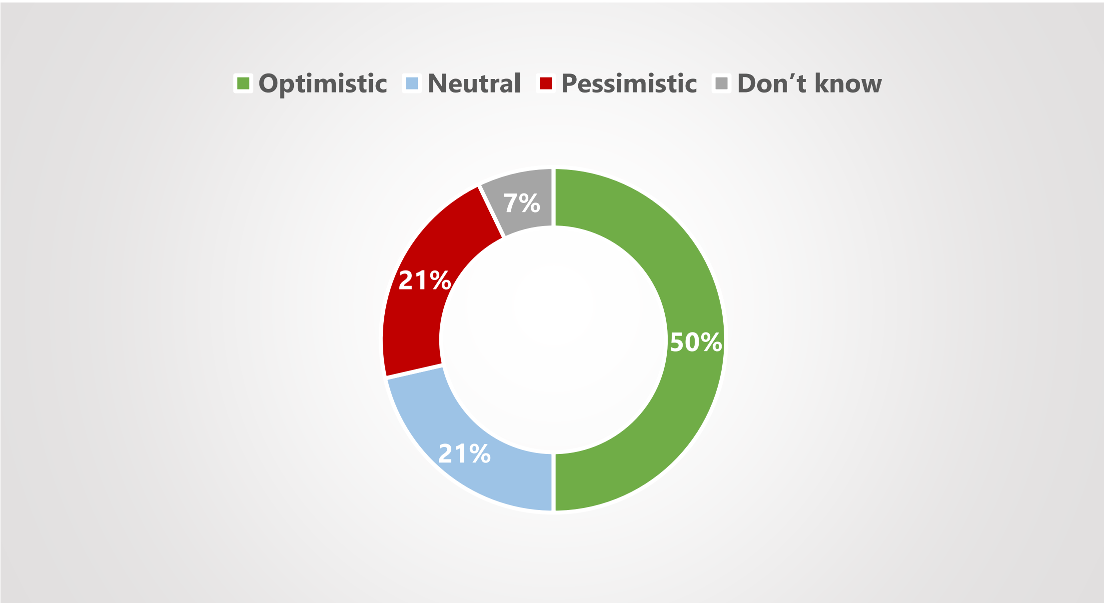
Balanced Expectations on Government Incentives

There are balanced expectations on government incentives, with half of survey respondents optimistic about government incentives.

The main highlights that emerged are that:

- *It is taken for granted that the required investment in ports will require some form of government funding.*
- *European funding opportunities must be exploited.*
- *To ensure a high percentage of domestic added value*
- *While the possibility of providing compensation to local communities should also be considered in order to reduce any local reactions.*

Figure 4: Expectations on state incentives by the Government for the development of the offshore wind farm sector

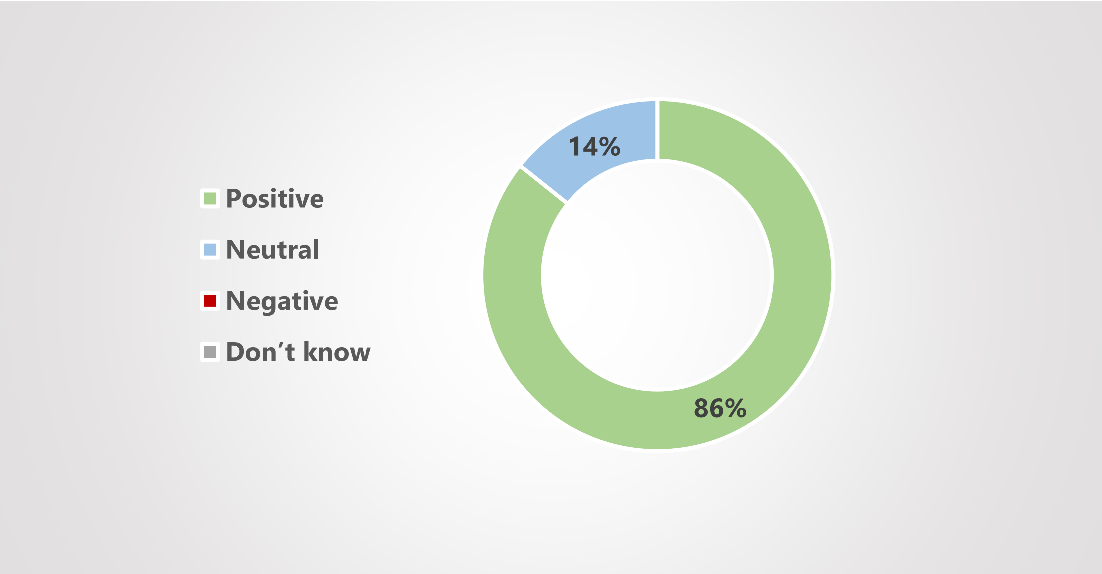


Involvement intentions

Absolutely positive attitude about involvement with the offshore wind farm sector

We found a completely positive attitude regarding the intention of company managements to get involved in the offshore wind industry, with 86% of respondents responding positively, and no one responding negatively.

Figure 5: Willingness of the management to involve with the offshore wind farm sector.

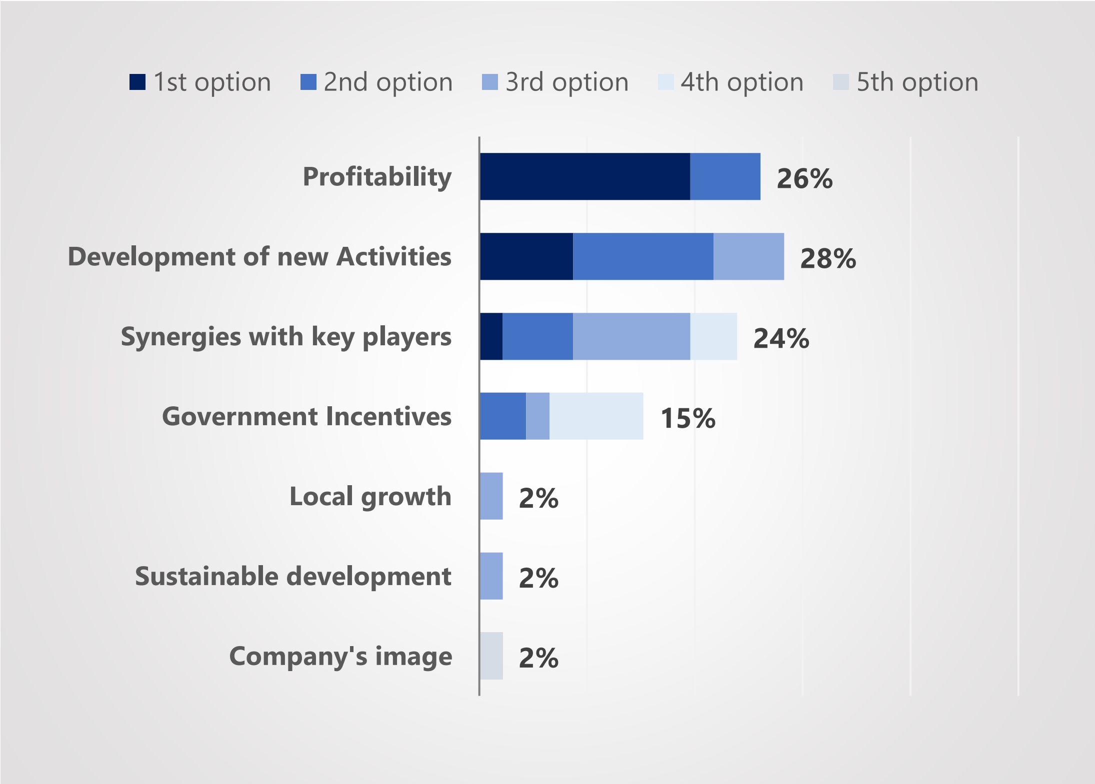


Key Factors for involvement

Development of new and innovative activities and profitability are the most important factors for involvement with the offshore wind farm sector. Main factors for involvement in the sector are the expected profitability and the prospect of developing new activities. Synergies with key players and possible Government Incentives are also mentioned as factors for involvement in the offshore wind farm sector.

Finally, some companies also pointed out that their contribution to local growth and sustainability, as well as their perceived improved company image due to involvement with the offshore wind farm sector as key factors.

Figure 6: Key factors for involvement with the offshore wind farm sector (rank by importance).



TECHNICAL SPECIFICATIONS OF PORTS AND SHIPYARDS

Ports are central to the development of offshore wind. They play a key role for the local supply chain, logistics and supporting infrastructure (e.g. storage of components). Ports are where operation and maintenance of offshore wind farms are run, where all offshore wind turbines and other equipment get transported, and where floating turbines are assembled[5].

In order to examine the needs regarding port and shipyard infrastructure, a study was carried out by **iWind Renewables** to determine a "typical offshore wind farm" and the "reference wind turbine", as well as their staging needs. This consisted the Deliverable of Task 1.1 of the project "**GR-INNO – SGS2 Soft Measures – HWEA/ELETAEN**" granted from the "**EEA Financial Mechanism 2014-2021, Business Development, Innovation and SMEs "Business Innovation Greece**" program, whose main points and conclusions will be mentioned below for the sake of completeness.

Reference Wind Farm

According to the report prepared by iWind Renewables on behalf of ELETAEN NPO, for both bottom-fix and floating reference wind farms the installed capacity is **300MW**, comprising **20X15MW** turbines of the "reference" type presented in the next chapter. The reference turbine is of IEC Class IB and has **240m** diameter and **150m** hub-height. The 20 turbines layout assumes 7DX5D distances between the turbines, 7D (1680m) in the prevailing wind direction and 5D (1200m) in the normal to the prevailing direction. A 5X4 turbines layout requires a deployment area of ~**25km^2**.

The mean sea depth for the bottom fixed turbines is **50m** with the offshore support structure being of the jacket type. The mean sea depth for the floating turbines is **200m** with the offshore support structure being of the semisubmersible type with a chain catenary mooring system.

The wind conditions assumed for the two reference wind farms at their hub-height are:

[5] https://windeurope.org/intelligence-platform/product/a-2030-vision-for-european-offshore-wind-ports-trends-and-opportunities/

For bottom-fixed turbines

- Mean annual wind speed (m/s) : 8.2
- Weibull shape factor k : 2.4
- Prevailing wind direction (o) : 340

For floating turbines

- Mean annual wind speed (m/s) : 9.6
- Weibull shape factor k : 2.0
- Prevailing wind direction (o) : 305

While the wave conditions for the two reference wind farms are:

For bottom-fixed turbines

- Mean significant wave height (m) : 0.8
- 50-years extreme SWH (m) : 4.6
- Spectral peak period (s) : 4.2
- Prevailing wave direction (o) : 8

For floating turbines

- Mean significant wave height (m) : 1.2
- 50-years extreme SWH (m) : 6.9
- Spectral peak period (s) : 5.0
- Prevailing wave direction (o) : 314

Reference Wind Turbine

In the deliverable prepared by iWind Renewables for ELETAEN NPO, the IEA 15MW Wind Turbine[6] has been selected as the reference turbine of the present assignment. This is an offshore turbine, originally supported by a monopile. A bottom-fixed version of the same turbine for deeper waters (~50m) supported by a jacket substructure has been obtained in the present context using the INNWIND.EU reference jacket upscaled to 15MW using the INNWIND.EU cost model[7]. A floating version of the IEA 15MW turbine for water depths ~200m has been also defined in[8].

Table 5 presents the key parameters of the 15MW Reference Wind Turbine. It has a 3-bladed, upwind, pitch variable rotor with a direct drive drivetrain. The Table shows under the column "IEA 15-MW Turbine" the values of the relevant parameters as provided in [5], while in column "Innwind.EU" the corresponding values have been obtained through the upscaling of the INNWIND.EU 10MW turbine using the upscaling and cost modelling tool of [6]. It is seen that the two parameters' sets are quite identical, strengthening thus the representativity of the 15MW design.

[6] Global Wind Atlas 3.0, a free, web-based application developed, owned, and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info "

[7] Deliverable 1.21 - INNWIND.EU Cost Model, http://www.innwind.eu/publications/deliverable-reports.

[8] Allen, Christopher, Anthony Viselli, Habib Dagher, Andrew Goupee, Evan Gaertner, Nikhar Abbas, Matthew Hall, and Garrett Barter. Definition of the UMaine VolturnUS-S Reference Platform Developed for the IEA Wind 15-Megawatt Offshore Reference Wind Turbine. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-76773. https://www.nrel.gov/docs/fy20osti/76773.pdf

Table 5: Key parameters for the 15MW Reference Wind Turbine

Key Parameters		IEA 15-MW Turbine	Innwind.EU
Parameter	**Units**	**Value**	**Value**
Power rating	MW	15	15
Turbine class	-	IEC Class 1B	IEC Class 1B
Specific rating	W/m2	332	.//.
Rotor orientation	-	Upwind	.//.
Number of blades	-	3	.//.
Control	-	Variable speed Collective pitch	.//.
Cut-in wind speed	m/s	3	.//.
Rated wind speed	m/s	10.59	.//.
Cut-out wind speed	m/s	25	.//.
Design tip-speed ratio	-	9 0	.//.
Minimum rotor speed	rpm	5	.//.
Maximum rotor speed	rpm	7.56	.//.
Maximum tip speed	m/s	95	.//.
Rotor diameter	m	240	.//.
Airfoil series	-	FFA-W3	.//.
Hub height	m	150	.//.
Hub diameter	m	7.94	
Hub overhang	m	11.35	
Rotor precone angle	deg	-4	
Blade prebend	m	4	
Blade mass	t	65	66.5
Drivetrain	-	Direct drive	Medium Speed
Shaft tilt angle	deg	6	
Rotor nacelle assembly mass	t	1,017	1,073

Offshore Support Structures

In the deliverable prepared by iWind Renewables for ELETAEN NPO, three alternative offshore support structures are considered for the 15MW reference wind turbine. For relatively low (~30m) water depths (w.d.) a monopile design is provided in [5]. For higher water depths (~50m) a jacket substructure can be obtained by upscaling the reference 10MW jacket of the INNWIND.EU project using[6]. In both the above bottom-fixed cases the same tower is used, starting at 15m a.s.l. and ensuring the hub-height of 150m a.s.l. The third alternative is a semisubmersible floating substructure for deeper waters (~200m) made from steel (see [7]). The floating substructure is accompanied by a new tower design too.

The key parameters of the three offshore support structures discussed above are given in Table 6.

Table 6: Key parameters for the Offshore Support Structures of the 15MW Reference Wind Turbine

Monopile Version (30m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**	**Value**	
Transition piece height	m	15	
Monopile length (from t.p. to seabed)	m	45	
Monopile embedment depth	m	45	
Monopile base diameter	m	10	
Tower mass	t	860	
Monopile mass	t	1,318	
Jacket Version (50m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**		**Value**
Transition piece height	m		15
Jachet length (from t.p. to seabed)	m		65
Piles embedment depth	m		
Jacket base diameter	m		
Tower mass	t		1,043
Jacket overall mass (incl. tp and piles)	t		2,700
Semisubmersible Floater (200m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**	**Value**	
Excursion1 (Length, Width, Height)	m	90.1, 102.1, 290.0	
Freeboard	m	15	
Draft	m	20	
Total System Mass (incl. ballast)	t	20,093	
Hull Steel Mass	t	3914	
Platform Mass (incl. ballast)	t	17,839	
Tower Mass	t	1,263	
RNA Mass	t	991	
Water Depth	m	200	
Mooring System	-	Three-line chain catenary	

For more details regarding the floating substructure, we quote below relevant expressions used by the reference[7] authors:

«This part is taken from the work performed by University of Maine (UMaine) VolturnUS-S on defining a reference floating wind turbine to support the International Energy Agency (IEA)-15-240-RWT 15-megawatt (MW) reference wind turbine. The reference floating offshore wind turbine comprises a floating semisubmersible platform, a chain catenary mooring system, a floating-specific tower, and a modified float-specific controller tuning. The semisubmersible is a generic steel version of the UMaine patented concrete floating foundation technology developed in collaboration with the U.S. Department of Energy. The reference platform is a four-column, steel semisubmersible. The arrangement of the hull comprises three 12.5-m-diameter buoyant columns radially spaced with centers that are 51.75 m from the tower's vertical axis. The platform-tower interface is atop a fourth buoyant column located at the center of the platform in the surge-sway plane. This central column is connected to the outer columns via three 12.5-m-wide-by-7.0-m-high rectangular bottom pontoons and three 0.9-m-diameter radial struts attached to the bottom and top of the buoyant columns, respectively. When on station, the total mass of the platform is 17,854 t, of

which 3,914 t is structural steel, 2,540 t is fixed iron-ore-concrete ballast, divided equally and placed at the base of the three radial columns, 11,300 t is a seawater ballast that floods the majority of the three submerged pontoons, and a 100-t tower interface connection detail. When installed, the platform has a draft of 20 m with a 15-m freeboard to the upper deck of the columns. The completely assembled unit displaces 20,206 cubic meters (m3) of seawater (with an assumed density of 1,025 kilograms per cubic meter [kg/m3]), which consists of a 1,263-t (metric tonne) tower, a 991-t RNA, and a 17,839-t ballasted platform with 6,065 kilonewtons (kN) of mooring vertical pretension. The system has an assumed deployment depth of 200 m and is held on to the station by a three-line chain catenary mooring system. The lines of the spread catenary system span radially to anchors located 837.60 m from the tower's centerline».

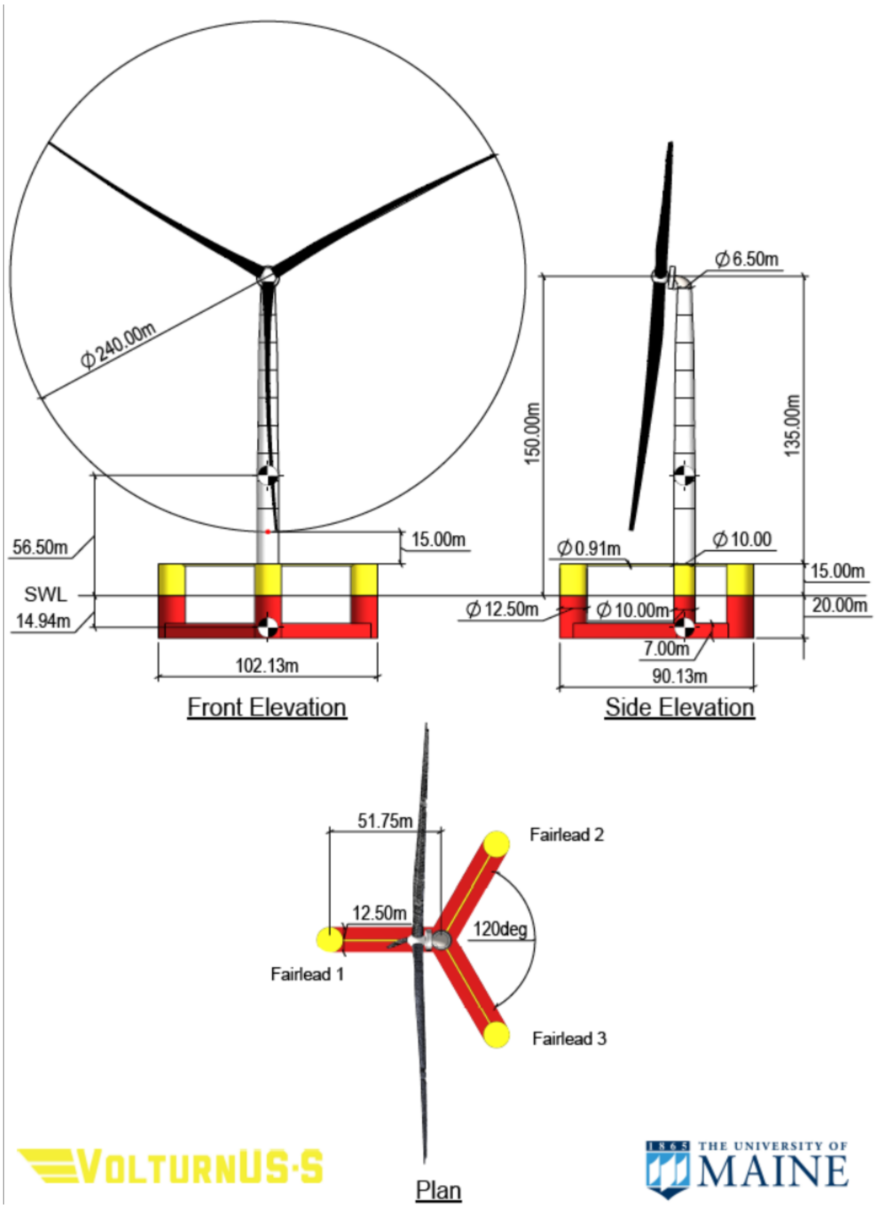
Part of the information provided above is summarized in Table 7.

Table 7: Key parameters for the Semisubmersible Platform and its Mooring system

Semisubmersible Platform Properties		
Parameter	**Units**	**Value**
Hull Displacement	m3	20206
Hull Steel Mass	t	3914
Tower Interface Mass	t	100
Ballast Mass (Fixed/Fluid)	t	2,540/11,300
Draft	m	20
Freeboard	m	15
Vertical Center of Gravity from SWL	m	-15
Vertical Center of Buoyancy from SWL	m	-14
Mooring System Properties		
Parameter	**Units**	**Value**
Mooring System Type	-	Chain Catenary
Line Type	-	R3 Studless Mooring Chain
Line Breaking Strength	kN	22,286
Number of Lines	-	3
Anchor Depth	m	200
Fairlead Depth	m	14
Anchor Radial Spacing	m	837.6
Fairlead Radial Spacing	m	58
Nominal Chain Diameter	mm	185
Dry Line Linear Density	kg/m	685
Extensional Stiffness	MN	3270
Line Unstretched Length	m	850
Fairlead Pretension	kN	2,437
Fairlead Angle from SWL	°	56.4

The floating platform design is illustrated in Figure 7.

Figure 7: The 15MW floating support structure designed by the University of Maine (Source [7])



According to this study it was estimated that the area required for the assembly of such a machine was estimated at 3.5 acres per machine, with the total required available area depending on the number of machines to be set up at the same time.

Reference turbine and wind farm staging needs

The staging needs for the dry parts of the reference turbine, as reported in the deliverable prepared by iWind Renewables for ELETAEN NPO, are summed up in Table 8. The net staging space needed per 15MW turbine when the individual subsystems are not piled-up is 3,570 m2. For 20 such turbines comprising the 300MW reference wind farm the net needed space is 71,408 m2. Assuming a 3.5 net to gross factor for the spacing needs, so that the individual pieces can be accessed and transported, the gross value of the staging space of the refence wind farm becomes 250,000 m^2, or 25 Ha.

It should be noted that it is not required to stage all 20 WTGs simultaneously, but one could stage as many WTGs as possible, based upon available space. However, this would, in turn, lead to challenges related with the logistics of the required components, added available space for storage of any components until they are needed for staging and of course transportation from storage to staging location.

Table 8: Staging needs for the reference wind turbine and wind farm

NET STAGING NEEDS	m2
Per 15MW Turbine	3,570
3 Blades	2,025
Nacelle-hub	245
Tower	1,300
300MW Wind Farm (20 WTG)	71,408
Net to gross factor	**3.5**
300MW Wind Farm GROSS	250,000

Soil bearing capacity

The highest value of surface pressure the deliverable prepared by iWind Renewables for ELETAEN NPO estimated for the dry components of the reference wind turbine is 3.35t/m^2 for the nacelle-hub assembly, weighting 821 t. This surface pressure derives if the total weight will uniformly transfer to the ground, which is not true given the geometrical particularity of the substructure. We anticipate that the weight load will be undertaken by the ¼ of the projected area, leading to a soil bearing capacity of 4*3.35 ~ 13.5 t/m^2. The soil bearing capacity of the areas where the blades and the tower substructures will be stored can be less.

Cranes will be needed for the assembly of the dry parts of the turbines. The heaviest single component to be lift-up is again the nacelle-hub assembly. It is anticipated that the soil bearing capacity un-der the crane-base area must be of the order of 35 t/m^2.

Draft

Assuming that the floater with will be transferred with tag boats having the turbine assembled on top and its fixed ballast in place, the total system mass will be 8,700 t (fixed ballast 2,540 t, hull steel mass 3,140 t, tower mass 1,263 t and RNA 991t). The draft of the fully assembled and moored turbine is 20m where the total system mass, including the water ballast is 20,000 t. It is reasonable to assume that (the less than half-weighted) system during its transfer will have a draft around 10m. Adding a 2m margin to that, we come to a minimum Harbor draft of 12m. Evidently, this minimum draft requirement refers to the considered floating platform. Different types of floating platforms may require higher or lower minimum draft values.

Technical Specifications of Ports and Shipyards in Greece

As part of the survey, we collected the technical characteristics of the ports and shipyards that participated in the survey, as answered by their administrations. Which are presented in Table 9.

We asked them to answer us regarding their main activities, the available free surfaces, the bearing capacity of the soil in them, the depth of the water in the dock, number of quays and docks, any equipment such as e.g. cranes, any future expansion plans as well as connectivity to the national road and rail network.

Table 9: Ports & Shipyards Technical Characteristics

General Info			Technical characteristics								
Port/ Shipyard	**Main activity**	**Employees**	**Surface available** sq.m.	**Soil bearing capacity.** tn/sq.m.	**Water depths** meters	**Piers**	**Wharves**	**Available equipment and machinery**	**Plans for possible expansions**	**Direct National Road Network Access**	**Rail Network Access**
Port 1	Container Terminal / Cruise / Coastal	962	Project specific	n/a	5-17	5	24	✓	✓	✓	✓
Port 2	Commercial	486	n/a	2-10	7-12,5	6	21	✓	✓	✓	✓
Port 3	Commercial	42	~ 60.000	25	9-11	4	11	✓	✓	✓	×
Port 4	Commercial	12	~ 400.000	n/a	10,5-12	4	8	By lease	✓	*Under construction	✓
Port 5	Commercial	36	~ 50.000	n/a	8-10	1	4	By lease	✓	✓	✓
Port 6	Coastal Shipping	34	~ 95.000	n/a	9-12	6	17	✓	✓	×	×
Port 7	Commercial	*	*	*	*	*	*	*	*	*	*
Port 8	Commercial / Cruise	16	~ 40.000	n/a	7,5-13	0	2	By lease	✓	✓	×
Port 9	Coastal Shipping	3	~ 14.000	n/a	6-9	2	3	By lease	×	×	×
Shipyard 1	Ship Repairs	~1.000	~ 64.000	10	9-12	1	3	✓	✓	✓	✓

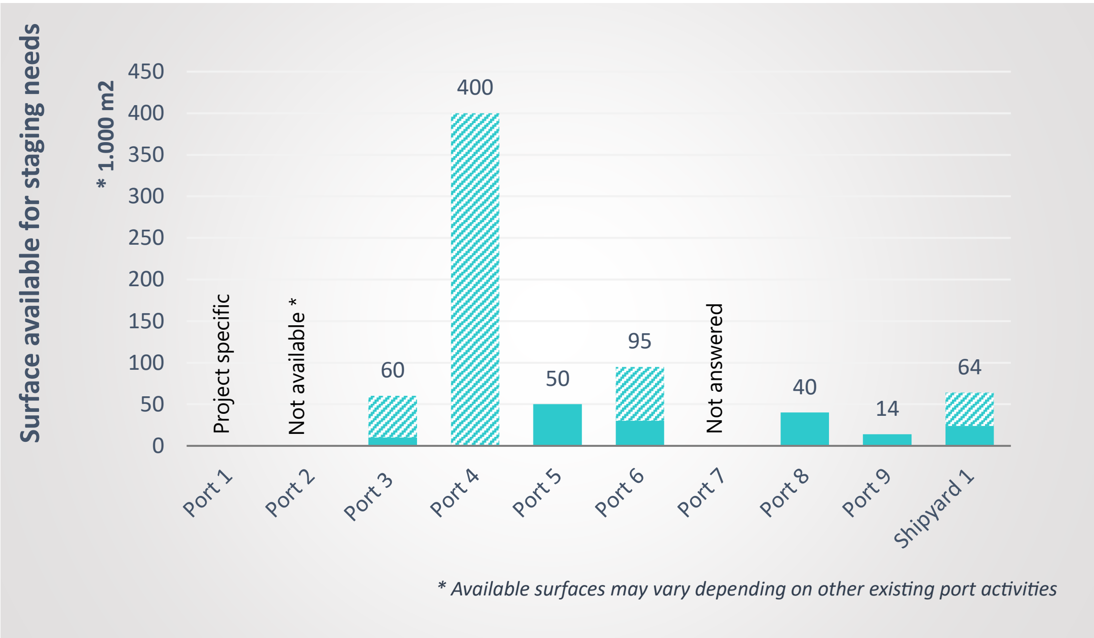
Conclusions: Insufficient port infrastructure

The responses revealed that in relation to the port infrastructure requirements as they arise from the typical offshore wind farm and the assembly needs of the standard floating wind turbine, there is insufficient port infrastructure, and we recognize this as the main challenge in supporting participation in the industry.

The main challenge for all the ports is that there are limited spaces available. This was a common answer, regardless of the size of the port or the possibility of future expansion. In some cases, there is a minor or major expansion in the ports' master plans, however the materialization of these expansions is often of uncertainty, either due to management uncertainty, or lack of funds. Several ports are scheduled to be privatized in the near or distant future, and the investment for the expansion will be performed by the new owners. Whereas port infrastructure projects are expensive projects and significant funds will be required for these expansion plans.

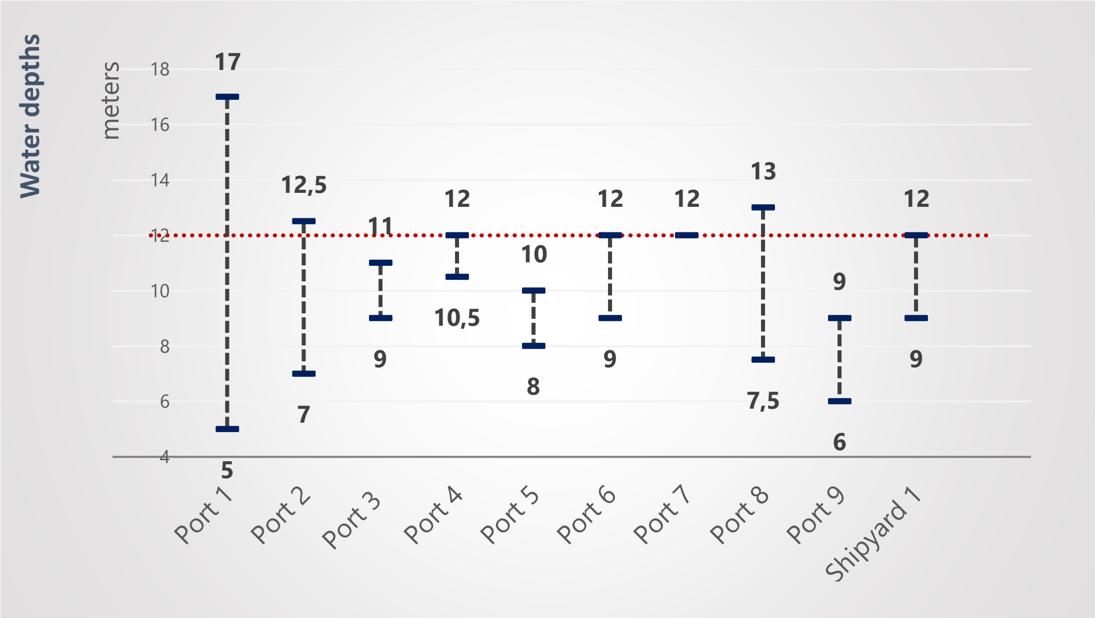
The availability of port space for staging needs, is portrayed in Figure 8:

Figure 8: Surface available for staging needs



Furthermore, regarding the draft, in several cases the water is not sufficiently deep (ports 3, 5, 9), while in other cases the available water depth is only deep enough in only part of the port, e.g. in one of multiple docks. The available water depth per port is depicted in Figure 9:

Figure 9: Available water depth



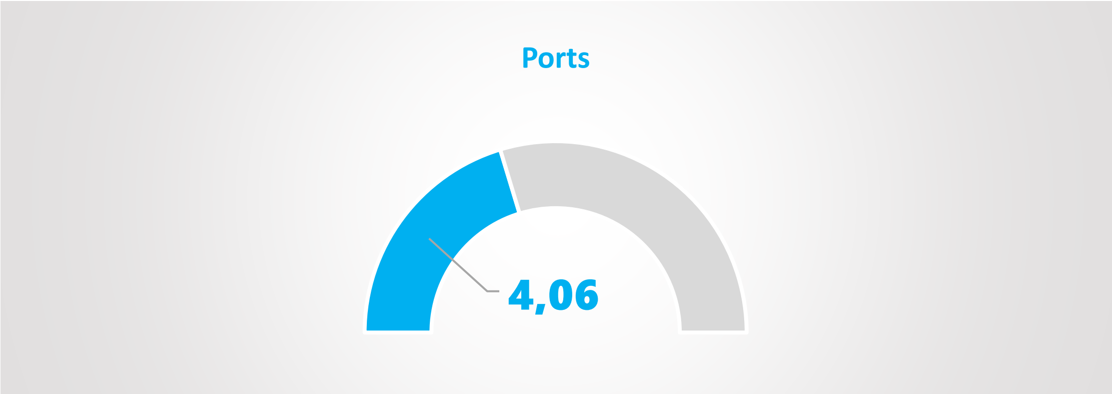
Finally, regarding the soil bearing capacity, most ports are not aware of it. This means that for the staging of the Offshore Wind Turbines to take place in the ports, geotechnical studies will have to be performed, before making any ground reinforcement works.

Readiness to participate

Participants were asked how they judged their readiness to participate in the industry.

Ports

Figure 10: Readiness of the company, in view of its commercial strategy, to involve with the offshore wind farm sector (score 1-10).



Ports assess that they are at a low level of preparedness, with the average response being 4/10, having several challenges to face. More specifically:

- Port authorities are currently focused on other, existing activities, which will compete with their involvement in the offshore wind industry, mainly due to limited space.
- In the ports that are under privatization there is uncertainty about the future, as the commercial strategy of the port will be determined by the private entity who will take over their operation.
- Another challenge is limited resources for infrastructure investment, especially since port infrastructure projects are expensive ones.
- Since the land uses within the port are determined by their master plan, these should be updated to foresee the use of available surfaces for the activity of assembling the floating wind turbines. It should be noted that by recent law all ports master plans issued after 2012 were considered invalid and new should be issued. To this end all ports either have already submitted their applications for the approval of new master plans or are in the process of drafting the new master plans.

- Finally, various licensing issues arise. For instance, construction within the ports is generally prohibited, as a measure of protection of shipyards. Hence licensing construction installations within the ports will be a challenge license wise. This will not affect the possibility of staging floating WTGs within the port area, but it would hinder possible plans for construction of floaters within the ports area.

Industry and Shipyards

In contrast to the low degree of readiness of ports, industry and shipyards report a higher degree of readiness, almost 8/10 – they feel ready to engage and expect domestic activity to begin.

Figure 11: Readiness of the company, in view of its commercial strategy, to involve with the offshore wind farm sector (score 1-10).

The challenges here are of different nature:

- A main challenge has been recognized to be the vast amount of available floaters designs, which hinders production schedule ability.
- Furthermore, the constant change and scaling of required sizes makes production planning impossible. It was pointed out that small changes to larger designs could affect the required investment in manufacturing infrastructure by tens of millions, while on the other hand investing for construction size smaller than the design that will eventually prevail would render the investment obsolete.
- The industrialization of the process is considered by many to be the main factor that will allow the reduction of production costs – which are currently considered excessive.

- Industries without direct access to the sea, recognize the lack of available space in ports as an obstacle to their production and expansion.
- Companies expect to make money be participating in this Sector. The uncertainty in the sector leads developers to be hesitant – therefore not making yet orders of components.
- Uncertainty prevails, due to the lack of confidence in the timely implementation of the tenders, due to the unknown compensation prices (based on which the investment interest and therefore their orders will move).
- Some of the Steel companies already produce similar or relative components: either for bottom fixed Offshore Wind Farms, such as monopiles and jackets, or towers for onshore Wind Farms. While the Cables company already produces underwater cable systems for worldwide projects.
- It should be noted that while the industry either declares themselves ready to participate, or already participates, they recognize that in order to participate in the floating Offshore Wind Farms, significant funds will be required for investments.
- Some participants have expressed concerns that key players in the industry, could plan to restrict availability of their products, by prioritizing delivery to international projects.

SUMMARY

A survey was conducted, to report on the status and challenges for the supply chain for Offshore Wind in Greece. Most key players of this supply chain were addressed, such as main ports, shipyards, as well as the steel, cement and cables industry.

In summary, the companies that can form the domestic supply chain assess that there are many strong points for the development of the sector in Greece, such as the strong wind potential, the strategic position of the country, its maritime heritage, the know-how of the industry, the shipyards, but also the ports regarding the management of wind farm components as cargo, the qualified workforce, and the political will to implement the projects.

They recognize the significant opportunities to be active in the sector, as it concerns an innovative technology that domestic industry can support, with prospects for activity in the next 30 years and the potential for strong locally added value. In addition, there is also the possibility of developing an industry in the maintenance of floating wind turbines.

They pointed out to us the weaknesses for engaging in the sector, which mainly concern the insufficient level of infrastructure in terms of equipment and available land in the ports, the lack of construction know-how in the ports, legal, institutional, and regulatory constraints as well as the uncertainty due to the impending privatization of the privatization of ports.

While they point out as threats the risk of delays in the implementation of the program, the bureaucracy and local reactions, the increase in the cost and size of the designs, the amount of required investments in infrastructure, and finally the limited capacity of construction throughout Europe.

These conclusions are thoroughly presented in a SWOT (Strengths – Weaknesses – Opportunities – Threats) type chart in Figure 12:

Figure 12: Conclusions of the Survey

Summary

STRENGTHS

- Significant wind potential.
- Strategic location.
- Maritime heritage.
- Industry and shipyards know-how.
- Skilled workforce.
- Experience by the management of onshore wind farms.
- Political will.

WEAKNESSES

- Insufficient infrastructure in port space and equipment.
- Lack of assembly know-how in ports.
- Regulatory constraints.
- Uncertainty due to port privatization plans.

OPPORTUNITIES

- A new innovative technology that may be developed in Greece.
- Novel industrial sector with prospects of at least 30 years of activity.
- Potential high local added value for Greece.
- Side – activities development: a new industry in offshore wind maintenance.

THREATS

- Risk of delays.
- Lack of a clear legal framework.
- Bureaucracy.
- Limited or lack of social acceptance.
- Increasing costs.
- Investments required in infrastructure
- Constant design upscaling.
- Limited capacity Europewide.

APPENDIX

Appendix A: Questionnaire for harbors and shipyards

Date: ____________

1. General Info / Γενικές πληροφορίες	
1.1. Name / Επωνυμία οργανισμού	
1.2. Location / Τοποθεσία	

1.3. Responsible person(s) / Υπεύθυνος (οι)

Communication data	Person #1	Person #2
Name:		
Surname:		
Office Phone:		
Mobile Phone:		
E-mail Address:		

1.4. Main Activities / Κύριες δραστηριότητες:

Harbors:	
Container Terminal / Σταθμός Εμπορευματοκιβωτίων	
Cruise / Κρουαζιέρα	
Coastal Shipping / Ακτοπλοΐα	
Ship repair zone / Ναυπηγοεπισκευαστική Ζώνη	
Logistics Center / Κέντρο εφοδιαστικής	
Real Estate / Αξιοποίηση χερσαίων χώρων	
Other (specify) / Άλλο (προσδιορίστε)	
Shipyards:	
Ship Repairs / Επισκευή πλοίων	
New building / Νέες κατασκευές	
Offshore experience / Πλατφόρμες γεώτρησης και εξόρυξης	
Other (specify) / Άλλο (προσδιορίστε)	

1.5. Other information / Άλλες πληροφορίες

1.5.1. Number of Employees / Αριθμός εργαζομένων	

1.5.2. Information about accessibility to/from the port/shipyard:

1.5.2.1. Direct National Road Network Access / Απευθείας πρόσβαση στο εθνικό οδικό δίκτυο	
1.5.2.2. Rail Network Access / Πρόσβαση στο σιδηροδρομικό δίκτυο	
1.5.2.3. Other accessibility constraints (specify) / Άλλα εμπόδια πρόσβασης (προσδιορίστε)	

2. Information for technical characteristics and capacity / Τεχνικά χαρακτηριστικά και δυνατότητες	
2.1. Surface available for staging needs (sq.m) / Διαθέσιμη επιφάνεια για τις ανάγκες συναρμολόγησης:	
2.2. Soil bearing capacity (t/sq.m) / Φέρουσα ικανότητα εδάφους (τ./τ.μ.):	
2.3. Water depths (m) / βάθη λιμένα (μ.):	

2.4. Plans for possible expansions / Σχέδια μελλοντικών επεκτάσεων

2.5. Available facilities / Διαθέσιμες εγκαταστάσεις

	Yes/No	Qty	Technical characteristics
2.5.1. Piers / Αποβάθρες			*(dimensions/ διαστάσεις)*
2.5.2. Wharves / Προκυμαίες			*(length/ μήκος)*
2.5.3. Wet Docks			*(dimensions/ διαστάσεις)*
2.5.4. Dry Docks			*(dimensions/ διαστάσεις)*
2.5.5. Slipways / Γλίστρα			*(length/ μήκος)*
2.5.6. Workshops / Εργαστήριο			*(Area/εμβαδόν)*
2.5.7. Other (specify) / Άλλο (προσδιορίστε)			

2.6. Available equipment and machinery / Διαθέσιμος εξοπλισμός και μηχανήματα

	Yes/No	Qty	Technical characteristics
2.6.1. specialized cranes / Ειδικοί γερανοί			*(load carrying capacity/μέγιστο βάρος φορτίου)*
2.6.2. reach stackers / φορτωτές			
2.6.3. heavy-duty forklifts / Ανυψωτικά βαρέως τύπου			
2.6.4. tractors / Ελκυστήρες			
2.6.5. tugboats / Ρυμουλκά			
2.6.6. special vessels / Ειδικά Σκάφη			
2.6.7. Other (specify) / Άλλο (Προσδιορίστε):			

2.7. Supporting material / Υποστηρικτικό υλικό

	Yes/No
2.7.1. Maps / Χάρτες	
2.7.2. Diagrams / Διαγράμματα	
2.7.3. Photos / Φωτογραφίες	
2.7.4. Other (specify) / Άλλο (Προσδιορίστε):	

2.8. Legislative & regulatory compliance status / Κατάσταση νομοθετικής & ρυθμιστικής συμμόρφωσης

	Yes/No	Number
2.8.1. Identification of the Land Boundaries of Port Area / Προσδιορισμός Χερσαίας Ζώνης Λιμένα		*(Government Gazette No / Αριθμός ΦΕΚ)*
2.8.2. Environmental Licensing / Περιβαλλοντική αδειοδότηση		*(Decision Number / Αριθμός Απόφασης)*
2.8.3. Master Plan		*(Government Gazette No / Αριθμός ΦΕΚ)*
2.8.4. Other (specify)		

3. Outlook of the offshore wind farm sector / Προοπτικές κλάδου των υπεράκτιων αιολικών πάρκων

3.1. Opinion on the prospects of the offshore wind farm sector / Ποια είναι η άποψή σας για τις προοπτικές του κλάδου των υπεράκτιων αιολικών πάρκων.

Optimistic / Αισιόδοξη	Neutral / Ουδέτερη	Pessimistic / Απαισιόδοξη	Don't know / Δεν γνωρίζω

Comments/Σχόλια:

3.2. Identify business opportunities & threats of the offshore wind farm sector (spontaneous reporting – up to 3 answers) / Προσδιορίστε ορισμένες επιχειρηματικές ευκαιρίες & απειλές από το περιβάλλον του κλάδου (αυθόρμητη αναφορά – έως 3 απαντήσεις)

Possible business opportunities / Πιθανές επιχειρηματικές ευκαιρίες	Possible Threats / Πιθανές απειλές

3.3. Comments on the willingness of the management to involve with the offshore wind farm sector / Πώς θα χαρακτηρίζατε τη διάθεση της διοίκησης ως προς την ενασχόληση με τον κλάδο.

Positive / Θετική	*Neutral / Ουδέτερη*	*Negative / Αρνητική*	*Don't know / Δεν γνωρίζω*

Comments/Σχόλια:

3.4. Comments on the readiness of the port – harbor, in view of its commercial strategy, to involve with the offshore wind farm sector / Πώς θα αξιολογούσατε την ετοιμότητα της επιχείρησης από άποψη εμπορικής στρατηγικής (βαθμολόγηση από το 1 έως το 10, όπου το 1 αντιστοιχεί στη χαμηλότερη και 10 στην υψηλότερη βαθμολογία)

1	2	3	4	5	6	7	8	9	10

Comments/Σχόλια:

3.5. Identify Strengths & Weaknesses for involvement with the offshore wind farm sector (spontaneous reporting – up to 3 answers) / Προσδιορίστε ορισμένα δυνατά σημεία & αδυναμίες της επιχείρησης αναφορικά με την ενασχόληση με τον κλάδο (αυθόρμητη αναφορά – έως 3 απαντήσεις)

Strengths / Δυνατά σημεία	Weaknesses / Αδυναμίες

3.6. Key factors for involvement with the offshore wind farm sector (please rank by importance) / Ποιοι είναι τα κυριότερα κριτήρια ενασχόλησης με τον κλάδο (εάν είναι περισσότερα από ένα, ιεραρχείστε με σειρά σημαντικότητας)

3.6.1.	Profitability / Αύξηση κερδοφορίας	
3.6.2.	Development of new Activities / Ανάπτυξη νέων δραστηριοτήτων	
3.6.3.	Synergies with key players / Ανάπτυξη συνεργιών	
3.6.4.	Government Incentives / Κυβερνητικά κίνητρα	
3.6.5.	Other (specify) / Άλλο (προσδιορίστε)	

3.7. Views on current public policies for the development of the offshore wind farm sector / Ποια είναι η άποψή σας για την κυβερνητική πολιτική σχετικά με την ανάπτυξη του κλάδου των υπεράκτιων αιολικών πάρκων

Very negative / Πολύ αρνητική	*Negative / Αρνητική*	*Neutral / Ουδέτερη*	*Positive / Θετική*	*Very positive / Πολύ θετική*	*Don't know / Δεν γνωρίζω*

Comments/Σχόλια:

3.8. Expectations on state incentives by the Government for the development of the offshore wind farm sector / Ποιες είναι οι προσδοκίες παροχής κινήτρων από την Κυβέρνηση για την ανάπτυξη του κλάδου των υπεράκτιων αιολικών πάρκων

Optimistic / Αισιόδοξη	Neutral / Ουδέτερη	Pessimistic / Απαισιόδοξη	Don't know / Δεν γνωρίζω

Comments/Σχόλια:

3.9. General assessment / Γενική Τοποθέτηση

Status and Challenges for the supply chain for Offshore Wind in Greece

Part II: Impact of the announcement of acceleration of the development of the first floating offshore wind farms.

April 2024

SAMARAS & ASSOCIATES S.A.
CONSULTING ENGINEERS

HWEA
Hellenic Wind Energy Association

Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Grants 2014-2021, in the frame of the Programme "Business Innovation Greece", within the project GR-INNO-Restricted Call - HWEA/ELETAEN..

Table of Contents

INTRODUCTION

Background

Following the announcement of a National Plan for the development of Offshore Wind Farms in Greece, which set a target for the development of 1,900 MW for 2030, 6,200 MW for 2035 and 17,300 MW for 2050 [1], and provided that this development, according to the IOBE study, can boost domestic GDP by up to €1.9 billion per year on average over the period 2024-2050 and supporting up to 44,400 jobs per year for the same time period[2], it was recognized that the Offshore Wind supply chain would play a crucial role for the materialization of the National Plan and the impact it would have in the Greek economy. Therefore, a survey was conducted, during the Autumn of 2023, and the results of this Survey were presented in a Workshop held by ELETAEN (HWAE) on November 23, 2023.

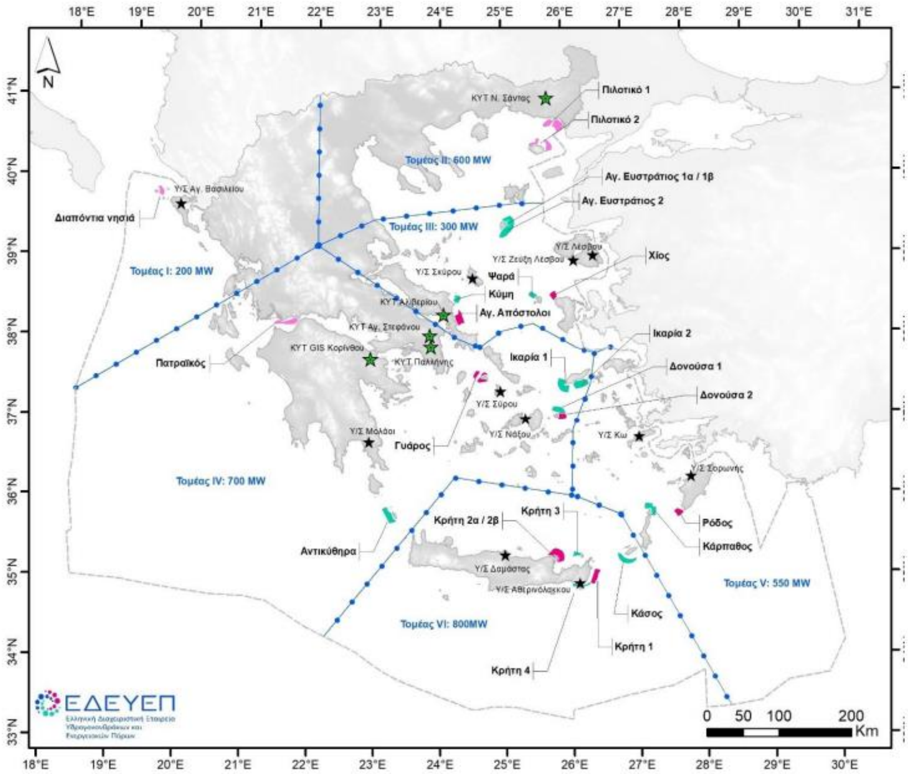
In the time following the presentation of the initial Survey at the Workshop held by ELETAEN (HWAE) and the discussion with its participants a series of further announcements by the government were made, that declared the acceleration of the development of the National OWF program[3]. More specifically it was announced that two floating offshore wind farms would be licensed and tendered by the end of 2025, in areas to be announced, so that they can be completed before 2030.

[1] https://eletaen.gr/en/press-release-for-offshore-wind-parks-in-greece/

[2] https://herema.gr/the-draft-national-programme-for-offshore-wind-energy-unlocking-a-natural-wealth-for-clean-energy-and-billions-of-euros-investments/

[3] https://ypen.gov.gr/th-skylakakis-i-ellada-borei-na-protagonistisei-pagkosmios-sti-viomichania-ton-yperaktion-aiolikon-parkon/

Figure 1: Possible Areas of Development of Offshore Wind Farms [4]



Scope of the Initial Survey

The scope of the Survey was the analysis of the supply chain of offshore wind development in Greece. More specifically the goal was to identify the possible parts of the domestic OW supply chain and highlight what is necessary to be done to establish this supply chain effectively, promoting the cooperation between Greek businesses and foreign ones.

In order to perform the analysis of the supply chain for the development of offshore wind in Greece the following steps were followed:

1. The possible "links" of the supply chain were identified, i.e. the Greek companies that could be part of the supply chain.
2. A questionnaire was drawn up to be completed by the companies.

[4] https://herema.gr/announcement-seia-ndp-owf/

3. Interviews were conducted with the companies based on the issues raised in the questionnaire.
4. The outcome of these interviews is presented, trying to answer the following questions:
   a) Who are the companies?
   b) Are they looking to get involved in the offshore wind industry?
   c) Are they ready to get involved in the offshore wind industry?

Scope of the Extension

Following the presentation of the initial Survey at the Workshop held by ELETAEN (HWAE) and the discussion with its participants, a few areas of a possible extension of the survey came to mind:

As is mentioned in the report of the initial survey, the survey focused on the main participants of the domestic supply chain: Ports, Shipyards, and the Steel and Cement industry. However, there are more sectors of the economy that are involved in offshore projects which did not participate in the initial survey, such as Offshore services provided by vessel owning and operating companies, Crane services, and cables. These sectors, while not in the foreground of the OWF sector development, are extremely crucial in the implementation of the OWF projects and should be included in the survey if the readiness of the Greek OWF supply chain is to be recognized and the possible issues highlighted.

Furthermore, after the completion of the initial survey, a series of further announcements by the government were made, that declared the acceleration of the development of the National OWF program. More specifically two floating offshore wind farms will be announced, licensed and tendered by the end of 2025, so that they can be completed before 2030, while the rest of the OWF of the first phase of the National Program are to be completed by 2032. This in turn is a step towards the reassurance of the political will of the government to forward the OWF sector, however new issues for the supply chain to address are to be examined, as moving the deployment of the first projects a couple of years forward challenges the readiness of the supply chain.

Key Players - Survey participants

In the following section, we point out the companies that could be part of the OWF supply chain in Greece. Both the ones participating in the initial survey, and the new companies that were approached during the extension.

Ports

The Greek port system consists of approximately 900 ports of different size, administrative organization, uses, and different importance for the national and local society and economy.

The classification of seaports, which is valid today, was published with Joint Ministerial Decision. During the ranking, the following were considered:

- The peculiarities of the Greek geographical area (division into numerous islands, existence of ferries, intra-island, and interregional connections).
- The statistics of the total annual traffic volume of goods (in tons) and passengers of the ports that meet the features A and B of EC decision No. 1346/2001/22.5.2001 of the European Parliament and the Council of the European Union (DDR), combined with the criteria of native geographical the advantages and their effect on the international network and of the country's national transport, as well as the looming perspectives development they show.

This decision groups the Greek ports in four main groups, as following:

- Ports of International Interest – Group K1 which consists of 16 ports.
- Ports of National Interest – Group K2, which consists of 16 ports.
- Ports of Lesser Interest – Group K3, which consists of 25 ports.
- Ports of Local Interest – Group K4, which consists of all the rest of the ports.

For the purpose of this survey, we focused on ports that belong in the Group K1, which are the main Greek ports. From those 16 ports we excluded ports that are in sites where no OWF are scheduled to be installed, at least in the first phases of the National OWF program. That left us with the ports of Piraeus, Thessaloniki, Alexandroupolis, Volos, Elefsina, Heraklion, Kavala and Lavrion. Furthermore, due to its location we also examined the port of Kymi in the island of Evia.

The ports we examined, along with their websites are listed below in Table 1.

Table 1: *Main Greek Ports examined in the survey.*

Port Name	website
PIRAEUS	www.olp.gr
THESSALONIKI	www.thpa.gr
VOLOS	www.port-volos.gr
ALEXANDROUPOLIS	www.ola-sa.gr
ELEFSINA	www.elefsisport.gr
HERAKLEION	www.portheraklion.gr
KAVALA (FILIPPOS B')	www.portkavala.gr
LAVRION	www.oll.gr
EVIA (KYMI)	www.olne.gr

Shipyards

The Greek shipyard industry is only recently coming out of a decades long decline. Previously state-owned shipyards were heavily in debt and the previous privatization efforts failed. Luckily this situation has recently changed. Firstly, the Syros Shipyards were acquired by ONEX Shipyards in 2017 and saw a drastic increase in turnover. Later, in 2021 ONEX Shipyards also took over the Elefsis Shipyards, while the "Milina Enterprises Company Limited" owned by shipping magnate George Prokopiou has been in discussions with the Greek Government to buy the Hellenic Shipyards S.A. in Skaramangas. Apart from these three larger Greek Shipyards, there are also smaller shipyards in Chalkis, Perama and Salamina. It is a fortunate circumstance that the Greek shipyard industry appears to be growing again just as the OWF sector calls for a significant demand for floaters and offshore construction.

The shipyards we addressed are presented in Table 2:

Table 2: *Main Greek Shipyards examined in the survey.*

Corporate Name	website
Hellenic Shipyards S.A. (Skaramangas Shipyards) ** Under special administration: transfer of Skaramangas Shipyards to «MILINA ENTERPRISES COMPANY LIMITED» owned by George Prokopiou.*	https://hsy-under-special-administration.gr
Elefsis Shipyards ** Resolution agreement with ONEX Elefsis Shipyards Industries SA*	www.elefsis-shipyards.gr
ONEX Syros Shipyards S.A.	www.onexsyrosshipyards.com
Chalkis Shipyards S.A.	www.chalkis-shipyards.gr
Salamina - New Hellenic Shipyards S.A.	www.spanopoulos-group.com

Steel & Cables Industry

Metals manufacturing is by far the biggest heavy manufacturing segment in Greece, with more than 4 billion sales in 2019. The basic metals industry is on the rise, due to increased exports and significant infrastructure projects, while basic metals production comprised 8,4% of total Greek exports, the second largest export category. Large players in this industry are focused on Aluminum, iron, steel, and copper. All key players in this industry produce one type of metal, apart from Viohalco group which produced 3 metals and dominates the copper market.

Hellenic Cables S.A., which is a company of Viohalco Group has extended expertise in the construction of underwater cables and has already built such cables for OWF in projects abroad.

Lykomitros Steel S.A. is already active in construction of steel structures for bottom fixed OWF such as monopiles and jackets, while EMEK S.A. has been building towers for onshore wind farms for years.

The Steel and Cable companies we examined, along with their websites are listed in Table 3:

Table 3: *Main Greek Steel & Cables Industries we examined in the survey.*

Corporate Name		Segment	website
Viohalco Group	Cenergy Holdings S.A.		https://cenergyholdings.com
	Hellenic Cables S.A.	Cables	www.hellenic-cables.com
	Corinth Pipeworks (CPW)	Steel pipes	www.cpw.gr
	Sidenor S.A.	Steel	https://sidenor.gr
	Sovel S.A.	Steel	https://sidenor.gr
Hellenic Halyvourgia S.A.		Steel	www.hlv.gr
SIDMA STEEL S.A.		Steel	https://sidma.gr
ELASTRON S.A.		Steel	www.elastron.gr
LYKOMITROS STEEL S.A.		Steel	www.lykomitros-steel.gr
EMEK S.A.		Towers	www.emek.gr

Cement Industry

Cement production is one of the most important industrial activities in Greece, offering great export opportunities and contributing significantly to the national economy.

Limestone, the main raw material for the production of cement and aggregates, is abundant in Greece, which is a strong advantage for the development of the domestic cement industry. At the same time, the intense seismic activity in the country and the requirement for durable construction of private and public projects, result in an increased demand for concrete, as a building material, due to its great durability and strength.

Today, the cement industry in Greece has an annual production capacity of approximately 15 million tons and consists of 3 companies, which are listed in Table 4:

Table 4: *Main Greek Cement Industries we examined in the survey.*

Corporate Name	website
Heracles General Cement Company S.A., a member of the Holcim Group	www.lafarge.gr
TITAN Cement Company S.A.	www.titan.gr
HALYPS Building Materials S.A., a member of the Heidelberg Group	www.halyps.gr

Secondary industries

It is needless to say that the supply chain for the development of the offshore wind farms does not end with ports and manufacturing. There are further industries that are involved in the development of such complex projects, which might be mentioned as secondary, but are as crucial for the development of the offshore wind farm sector, as ports and industries.

The vast dimensions of the floaters and pillars that support the wind turbines, as the wind turbines themselves require special handling when it comes to transporting and erecting them, as well as completing their assembly into an operating power generating machine. These services are carried out by specialized companies that have both the special craning equipment and the specialized stuff that operates them, but also carries out the assembly. Such companies exist in Greece, as Greece has seen an extensive installation of onshore wind farms, which are installed in mountainous terrain. Major Greek crane companies have extensive experience in lifting heavy and exceptional loads, as well as an extensive experience in lifting, transporting, installing and maintaining Wind Turbines for Onshore Wind Farms, which are usually installed in remote and challenging destinations.

Furthermore, as a floating offshore wind turbine, after shoreside assembly will have to be moved to the installation point and connected to the subsea electrical cable to transmit the generated power to the energy transmission system a series of offshore services should be provided: Tugging to the installation point, mounting the floaters to the seabed, and connecting the electrical subsea cable to the generator. Greece, as a marine country has several companies that own vessels and carry out specialized offshore maritime services.

The main companies that can provide secondary services which we examined, along with their websites are listed in Table 5:

Table 5: *List of main Greek companies that provide secondary services that we examined in the survey.*

Corporate Name	website
Anipsotiki S.A.,	www.anipsotiki.gr
Giannakos Group S.A.	www.rent-geranoi.gr
Ermis S.A.	www.hermesgroup.net
Nemeca Z	www.nemecaz.gr
MegaTugs	www.megatugs.com
Asso.subsea	www.assogroup.com

Survey Focus

it was decided that the new participants should fill in the initial questionnaire, that was sent to the supply chain during the initial survey. Furthermore, a new questionnaire would be drafted, that would examine the opinions of the supply chain regarding the acceleration of the development of the National OWF program. This questionnaire would be sent and filled in by all the members of the supply chain.

A. Outlook on the Offshore Wind Farm Sector

The initial survey focused mainly on the companies' perspective on the industry. The information we wanted to acquire was:

- What the Outlook of the Offshore Wind Farm Sector in Greece in their opinion was and which they believed were the prospects of the Sector.
- Their views on current public policies for the development of the offshore wind farm sector and which were their expectations on state incentives by the Government for the development of the offshore wind farm sector.
- Which they identified as the business opportunities and threats of the Offshore Wind Farm sector.
- A comment on the willingness of the management to involve with the offshore wind farm sector.
- Which were the Key factors for involvement with the offshore wind farm sector.
- Which they identified as Strengths Weaknesses for involvement with the offshore wind farm sector.

B. Outlook on the acceleration in the development of floating offshore wind farms

Simultaneously we wanted to examine the opinions of the supply chain in the announcement of the acceleration in the development of the floating offshore wind farms, by accelerating the development of the first two floating projects. More specifically we wanted to know:

- What was the participants' view on the acceleration?
- If they could identify positive and negative implications of the acceleration
- If the acceleration was affecting their business planning,
- Their readiness to immediately provide their services,
- How easy or difficult it would be to meet the needs of the first floating offshore wind farms,
- If they could identify any implications if the implementation of the first projects was actually delayed.

OUTCOMES

A. Outlook on the Offshore Wind Farm Sector

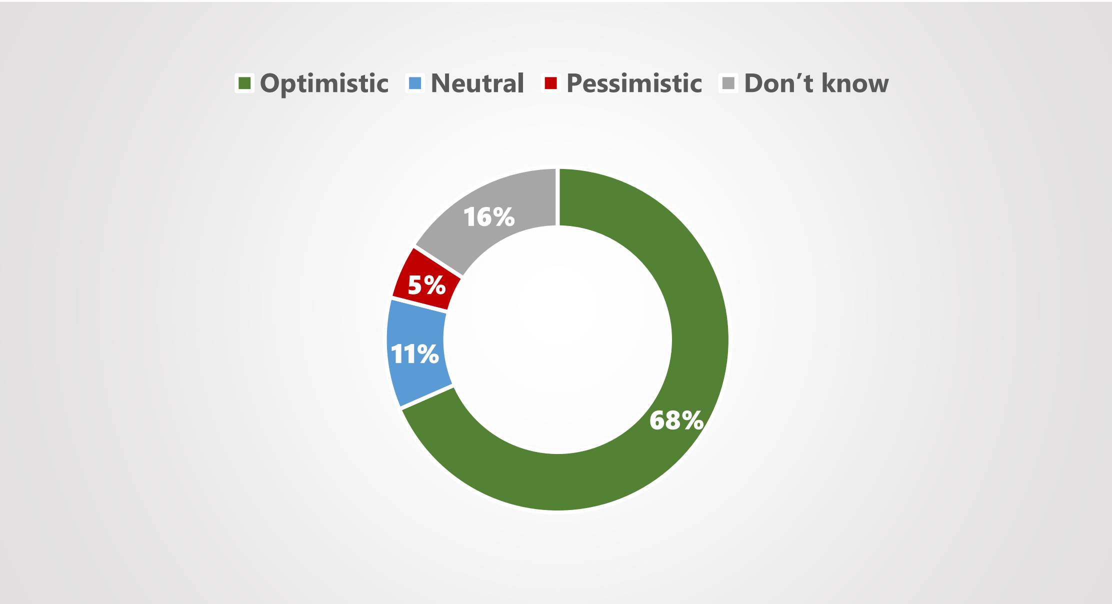
Positive Attitude for the Outlook of Offshore Wind Development in Greece

We asked the companies' management for their outlook on the Offshore Wind Farm Sector, and requested them to declare themselves as Optimistic, Neutral, Pessimistic, or that they do not know.

We recorded positive attitudes, but also relatively low awareness of the outlook for the offshore wind industry.

7 out of 10 are positive about the industry's prospects while less than 2 out of 10 are unaware. One participant was pessimistic on the Outlook of the Development of the Offshore Wind Sector in Greece, expressing their disbelief in the eventual materialization of the government announcements.

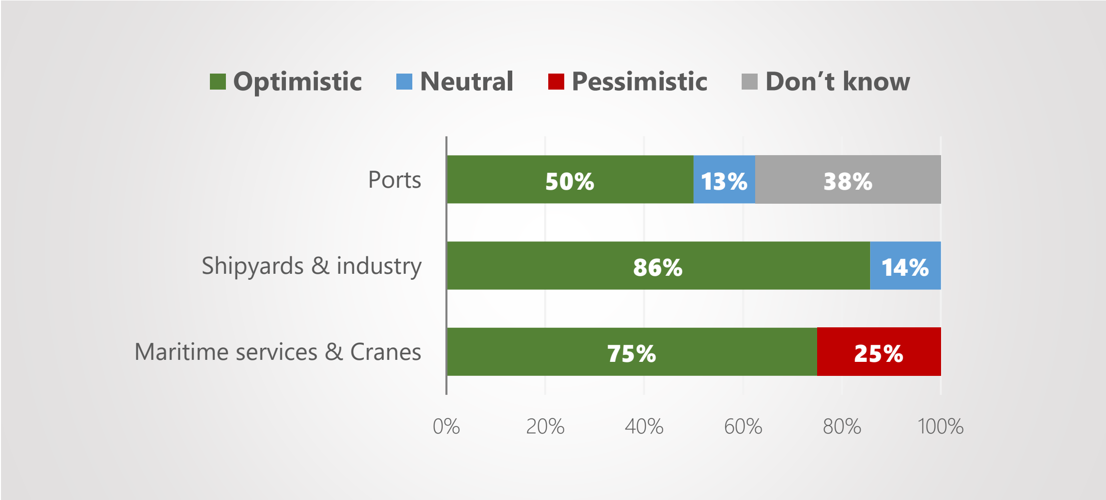
Figure 2: *Overall outlook of the offshore wind farm sector.*



The companies' outlook of the Offshore Wind Farms sector was also examined per industry. Half of the ports are optimistic on the prospects of the OFW sector and 4 out of 10 declare low knowledge on the sector. On the other hand, shipyards and industry are very optimistic, with 9 out of 10 being optimistic and 1 out of 10 being neutral.

Finally maritime 3 out of 4 services and crane companies are positive for the prospect of the sector, while 1 out of 4 are pessimistic.

Figure 3: Outlook of the offshore wind farm sector per industry.

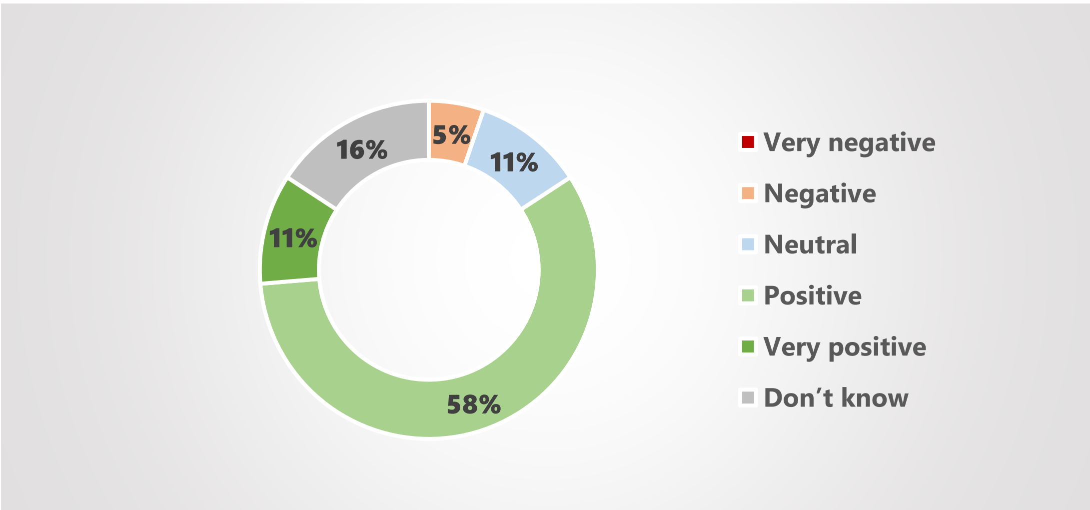


Views on current public policies

Positive Opinions on Government Policies

We received positive views on government policy regarding the development of the offshore wind industry, with more than half expressing positive views, and a total of 2/3 expressing positive or very positive views.

Figure 4: Overall views on current public policies for the development of the offshore wind farm sector.



As the main positive points, we noted the strong commitment of the state to the energy transition, the orientation of the government to attract investments in energy projects and the announcements of the national program for offshore wind farms.

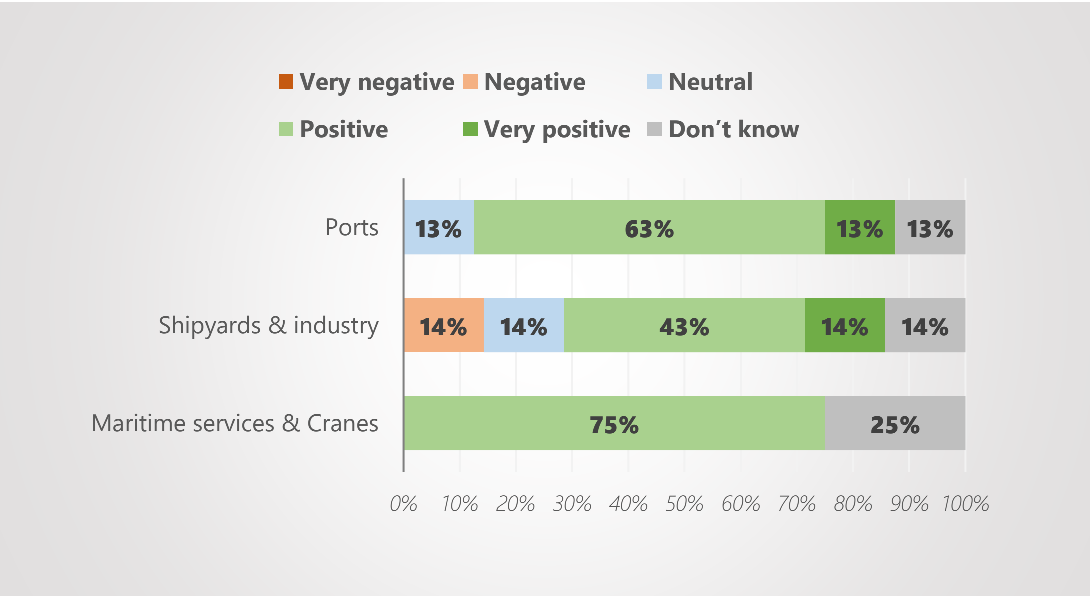
On the other hand, concerns were expressed about the risks of delays in the implementation of the program, since if the objectives of the program are not met, there is a risk of losing the opportunity that opens for the country.

Concerns were also expressed about the progress of the permitting process and it was pointed out that it should be ensured that projects will not face bureaucratic hurdles and delays.

Finally, there is uncertainty about the state's consistency in meeting the scheduled timetable.

When examining the opinions of the companies when grouped by industry, every industry is positive, with shipyards and industry being slightly more skeptical (14% negative and 57% positive or very positive).

Figure 5: *Views on current public policies for the development of the offshore wind farm sector per industry.*



Balanced Expectations on Government Incentives

There are balanced expectations on government incentives, with 4 out of 10 of survey respondents optimistic about government incentives.

The main highlights that emerged are that:

- It is taken for granted that the required investment in ports will require some form of government funding.
- European funding opportunities must be exploited.
- Further funding schemes such as the Greek Development Law or other forms of subsidies should be granted to aid the Supply Chain Companies in acquiring new infrastructure and equipment, as well as for training their personnel.
- The procedures of funding by the Greek Development Law should be accelerated.
- A high percentage of domestic added value should be ensured.
- The possibility of providing compensation to local communities should also be considered in order to reduce any local reactions.

Figure 6: *Overall expectations on state incentives by the Government for the development of the offshore wind farm sector.*

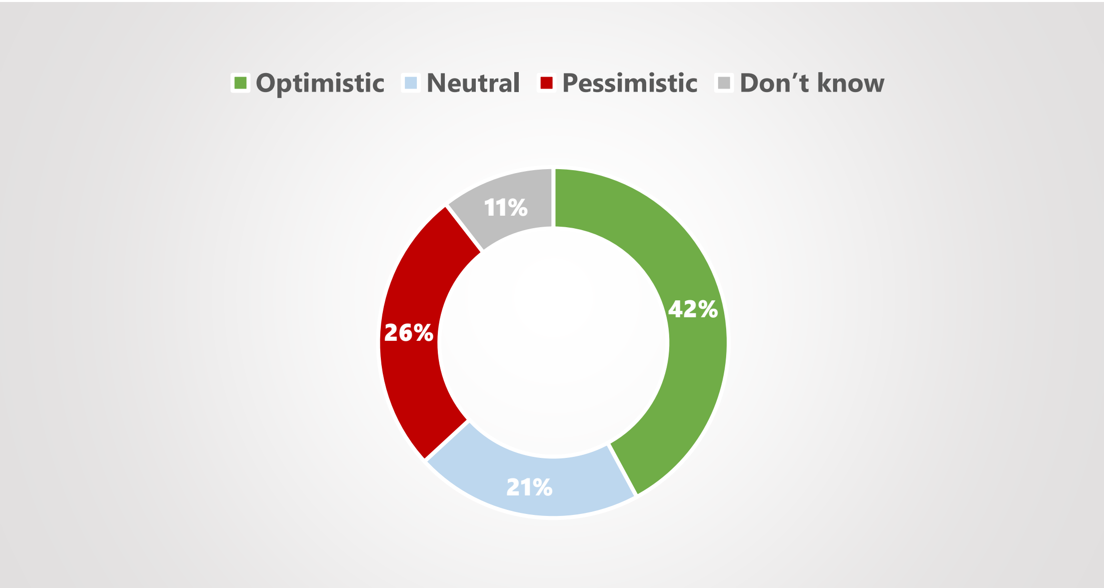
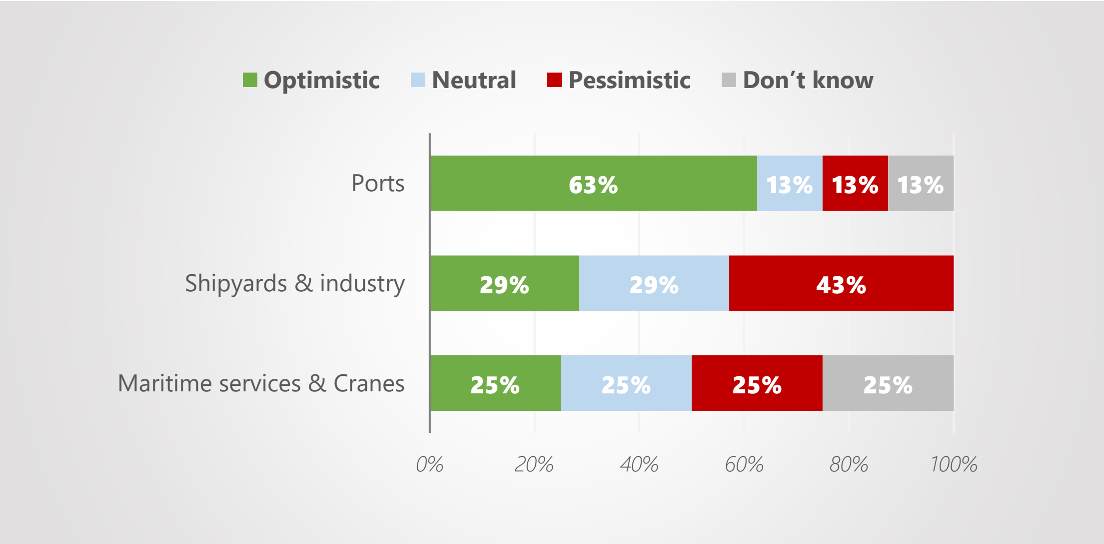


Figure 7: *Expectations on state incentives by the Government for the development of the offshore wind farm sector per industry.*



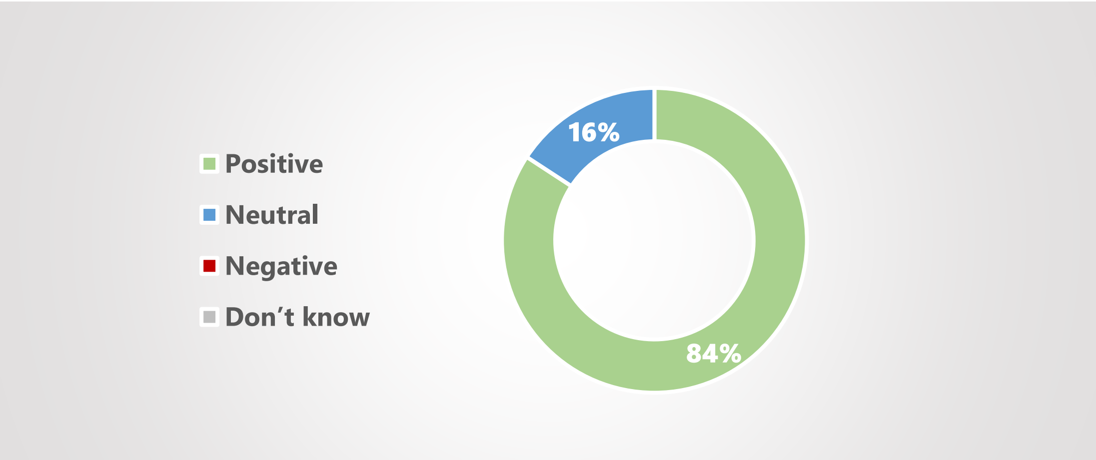
Shipyards and industry are mostly pessimistic on the expectations of government incentives, with 4 out 10 being pessimistic, 3 out of 10 optimistic and 3 out of 10 neutral. The expectations of Maritime Services and Cranes are balanced, while 6 out of 10 ports are optimistic. This could be explained by the greater necessity for public spending on port infrastructure, when compared to the industry or the services sector.

Involvement intentions

Absolutely positive attitude about involvement with the offshore wind farm sector

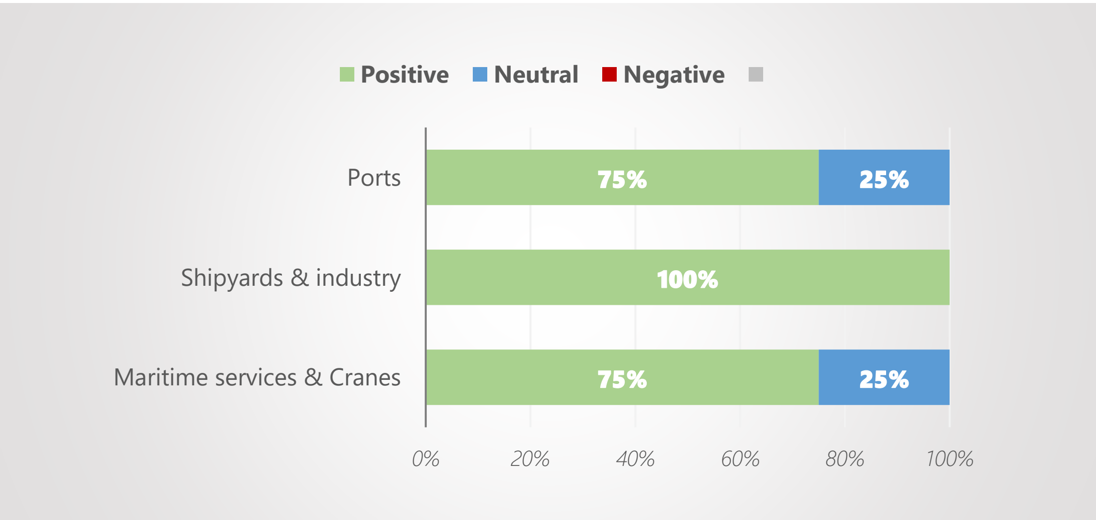
The attitude regarding the intention of company managements to get involved in the offshore wind industry is absolutely positive, with 84% of respondents responding positively, and no one responding negatively. The intention to involve highlights the sector's high potential prospects.

Figure 8: *Overall willingness of the management to involve with the offshore wind farm sector.*



Shipyards and industry are 100% positive on their involvement, while 3 out of 4 ports and maritime services and cranes companies are positive on their involvement, with the other 1 out of 4 being neutral.

Figure 9: *Willingness of the management to involve with the offshore wind farm sector per industry.*

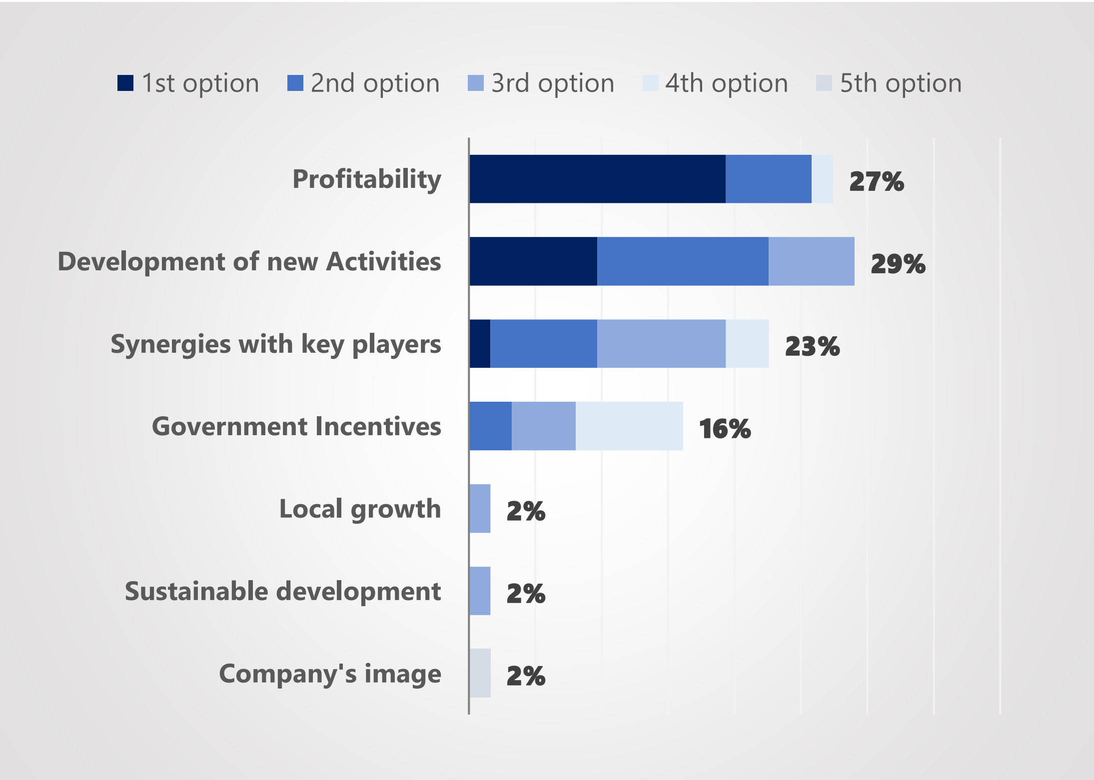


Key Factors for involvement

Development of new and innovative activities and profitability are the most important factors for involvement with the offshore wind farm sector. Main factors for involvement in the sector are the expected profitability and the prospect of developing new activities. Synergies with key players and possible Government Incentives are also mentioned as factors for involvement in the offshore wind farm sector.

Ports also pointed out that their contribution to local growth is a key factor, while shipyards and industry consider sustainability, as well as their perceived improved company image due to involvement with the offshore wind farm sector as key factors.

Figure 10: *Key factors for involvement with the offshore wind farm sector (rank by importance).*



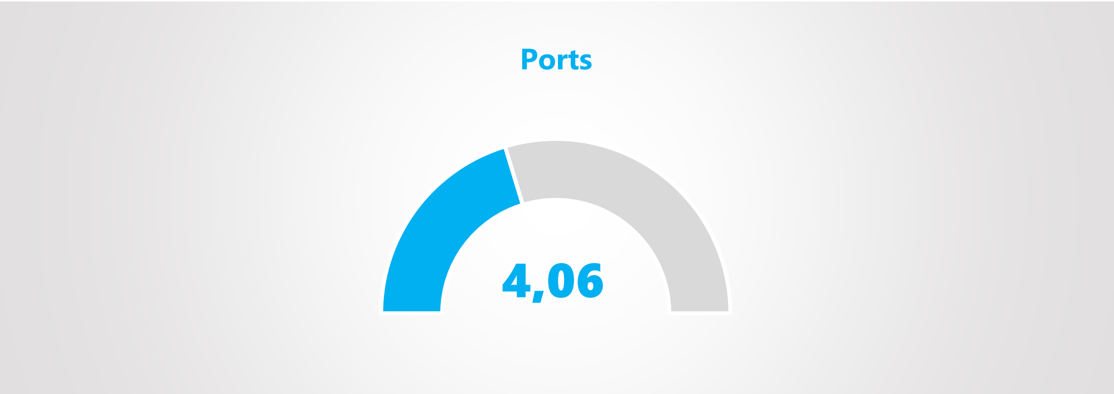
Readiness to participate

Participants were asked how they judged their readiness to participate in the industry.

Ports

Ports assess that they are at a low level of preparedness, with the average response being 4/10, having several challenges to face.

Figure 11: *Readiness of the company, in view of its commercial strategy, to involve with the offshore wind farm sector (score 1-10).*



More specifically:

- Port authorities are currently focused on other, existing activities, which will compete with their involvement in the offshore wind industry, mainly due to limited space.
- In the ports that are under privatization there is uncertainty about the future, as the commercial strategy of the port will be determined by the private entity who will take over their operation.
- Another challenge is limited resources for infrastructure investment, especially since port infrastructure projects are expensive ones.
- Since the land uses within the port are determined by their master plan, these should be updated to foresee the use of available surfaces for the activity of assembling the floating wind turbines. It should be noted that by recent law all ports master plans issued after 2012 were considered invalid and new should be issued. To this end all ports either have already submitted their applications for the approval of new master plans or are in the process of drafting the new master plans.

- Finally, various licensing issues arise. For instance, construction within the ports is generally prohibited, as a measure of protection of shipyards. Hence licensing construction installations within the ports will be a challenge license wise. This will not affect the possibility of staging floating WTGs within the port area, but it would hinder possible plans for construction of floaters within the ports area.

Industry and Shipyards

In contrast to the low degree of readiness of ports, industry and shipyards report a higher degree of readiness, 8/10 – they feel ready to engage and expect domestic activity to begin.

Figure 12: *Readiness of the company, in view of its commercial strategy, to involve with the offshore wind farm sector (score 1-10).*

The challenges here are of different nature:

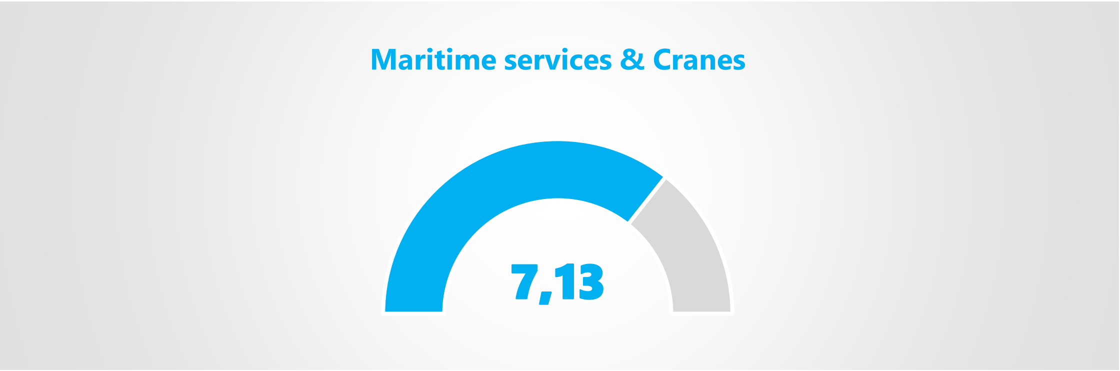
- A main challenge has been recognized to be the vast amount of available floaters designs, which hinders production schedule ability.
- Furthermore, the constant change and scaling of required sizes makes production planning impossible. It was pointed out that small changes to larger designs could affect the required investment in manufacturing infrastructure by tens of millions, while on the other hand investing for construction size smaller than the design that will eventually prevail would render the investment obsolete.
- The industrialization of the process is considered by many to be the main factor that will allow the reduction of production costs – which are currently considered excessive.

- Industries without direct access to the sea, recognize the lack of available space in ports as an obstacle to their production and expansion.
- Companies expect to make money be participating in this Sector. The uncertainty in the sector leads developers to be hesitant – therefore not making yet orders of components.
- Uncertainty prevails, due to the lack of confidence in the timely implementation of the tenders, due to the unknown compensation prices (based on which the investment interest and therefore their orders will move).
- Some of the Steel companies already produce similar or relative components: either for bottom fixed Offshore Wind Farms, such as monopiles and jackets, or towers for onshore Wind Farms. While the Cables company already produces underwater cable systems for worldwide projects.
- It should be noted that while the industry either declares themselves ready to participate, or already participates, they recognize that in order to participate in the floating Offshore Wind Farms, significant funds will be required for investments.
- Some participants have expressed concerns that key players in the industry, could plan to restrict availability of their products, by prioritizing delivery to international projects.

Maritime Offshore Services and Cranes

Similarly to industry and shipyards, the maritime services and crane companies also report a higher degree of readiness, 7/10. They too feel ready to be involved in the sector.

Figure 13: *Readiness of the company, in view of its commercial strategy, to involve with the offshore wind farm sector (score 1-10).*



Main challenges for this industry are:

- Crane companies have the knowledge and skilled personnel that are required to carry out such projects, due to their extended experience in onshore wind projects, however they recognize they might need new equipment, better suited to the specific and special needs of the offshore projects.
- Concern regarding the prospect of the projects' maturity have been expressed. This has mainly related to previous experience of delays of onshore wind projects due to licensing and bureaucracy.
- Finding new technical staff is considered a challenge, by both crane and offshore companies. Crane companies mentioned that they have hired people from abroad in the past, but the difficulty to find experienced and skilled technical personnel is still considered to be relatively high. Offshore companies also have faced challenges in finding staff, as they have recently experienced personnel fleeing to the Oil & Gas sector.
- It should be noted that while the industry either declares themselves ready to participate, or already participates, they recognize that in order to participate in the floating Offshore Wind Farms, significant funds will be required for investments.
- Offshore maritime services companies have had relative experience, either as parts of a group of foreign companies (with the experience in these relative projects mainly provided from sister companies abroad) or providing services to offshore wind projects abroad. These declare themselves definitely ready but will not necessarily be available for the Greek projects when these commence.

Opportunities, threats, strength, weaknesses of the Greek Offshore Wind Sector

The Participants were asked to identify business opportunities of the offshore wind farm sector. They assess that there are many strong points for the development of the sector in Greece, such as the strong wind potential, the strategic location of the country, its maritime heritage, the know-how of the industry and the shipyards the skilled workforce, and the political will to implement the projects. Furthermore, the ports have extended know-how regarding the management of wind farm components as cargo.

They recognize the significant opportunities to be active in the sector, as it concerns an innovative technology that domestic industry can support, with prospects for activity in the next 30 years and with potential for strong added value. In addition, there is also the possibility of developing a new industry in the maintenance of floating wind turbines.

They pointed out to us the weaknesses for engaging in the sector, which mainly concern the insufficient level of infrastructure in terms of equipment and available land in the ports, the lack of construction know-how in the ports, legal, institutional, and regulatory constraints as well as the uncertainty due to the impending privatization of the privatization of ports.

While they point out as threats the risk of delays in the implementation of the program, the bureaucracy and local reactions, the increase in the cost and size of the designs, the amount of required investments in infrastructure, and finally the limited capacity of construction throughout Europe.

The companies' answers regarding the business opportunities and threats of the offshore wind farm sector in Greece, as well as the strengths and weaknesses for involvement with the sector are presented in figure 14:

Figure 14: ***Business opportunities, threats, strengths, and weaknesses of the offshore wind farm sector in Greece***

STRENGTHS

- Significant wind potential.
- Strategic location.
- Maritime heritage.
- Industry and shipyards know-how.
- Skilled workforce.
- Experience by the management of onshore wind farms.
- Political will.

WEAKNESSES

- Insufficient infrastructure in port space and equipment.
- Lack of assembly know-how in ports.
- Regulatory constraints.
- Uncertainty due to port privatization plans.

OPPORTUNITIES

- A new innovative technology that may be developed in Greece.
- Novel industrial sector with prospects of at least 30 years of activity.
- Potential high local added value for Greece.
- Side – activities development: a new industry in offshore wind maintenance.

THREATS

- Risk of delays.
- Lack of a clear legal framework.
- Bureaucracy.
- Limited or lack of social acceptance.
- Increasing costs.
- Investments required in infrastructure.
- Constant design upscaling.
- Limited capacity Europewide.
- Staff shortage

B. Outlook on the acceleration in the development of floating offshore wind farms

Positive Opinions regarding the acceleration in the development of floating wind farms.

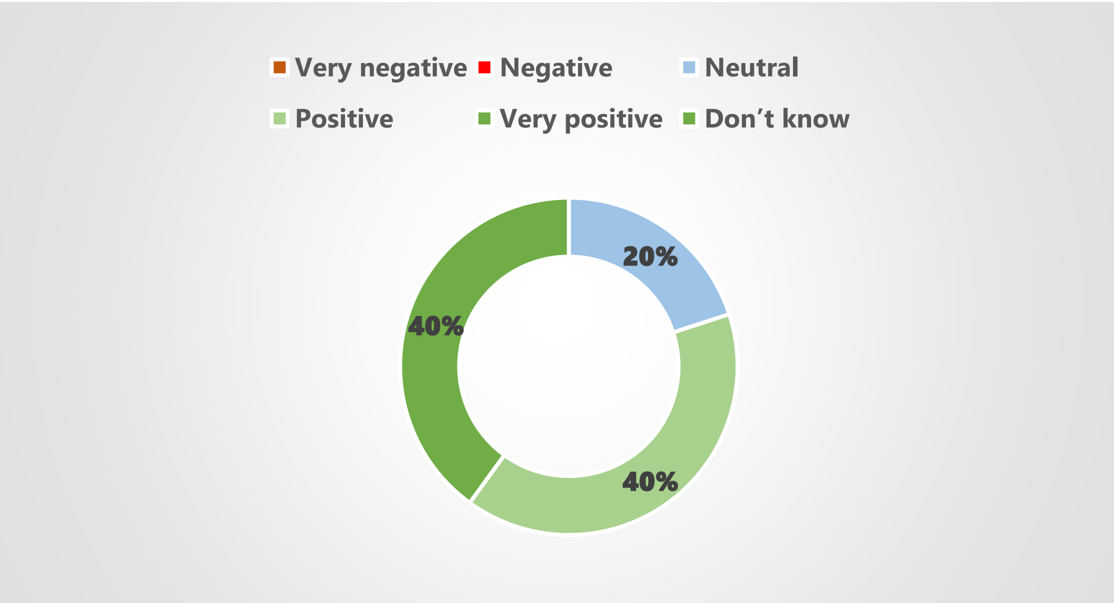
The companies were asked, what is their view on the intention to accelerate the development of floating offshore wind farms by tendering one or more projects to be commissioned earlier than the current National Offshore Wind Development Program's time horizon, and requested them to declare themselves as Very Positive, Positive, Neutral, Negative or Very Negative.

The participants replied with mostly positive opinions, as 8 out of 10 are positive or very positive about the acceleration of the program, while 2 out of 10 are neutrals.

It should be pointed out however that a minority of participants, despite being positive regarding the acceleration, expressed skepticism regarding the fact that pilot programs are not to be implemented. It was expressed that like in other countries, a few pilot projects, consisting of 2 or 3 floating wind turbines would make it easier for the supply chain to deal with any teething problems that may occur due to the technology, or the readiness of the ports, etc.

On the other hand, it was expressed from others that pilot projects are very expensive, and that the acceleration of the entire program, for the development of the floating offshore wind farms can solve the issues that may arise that we are not yet aware of.

Figure 15: *Overall opinions regarding the acceleration in the development of the floating offshore wind farms.*



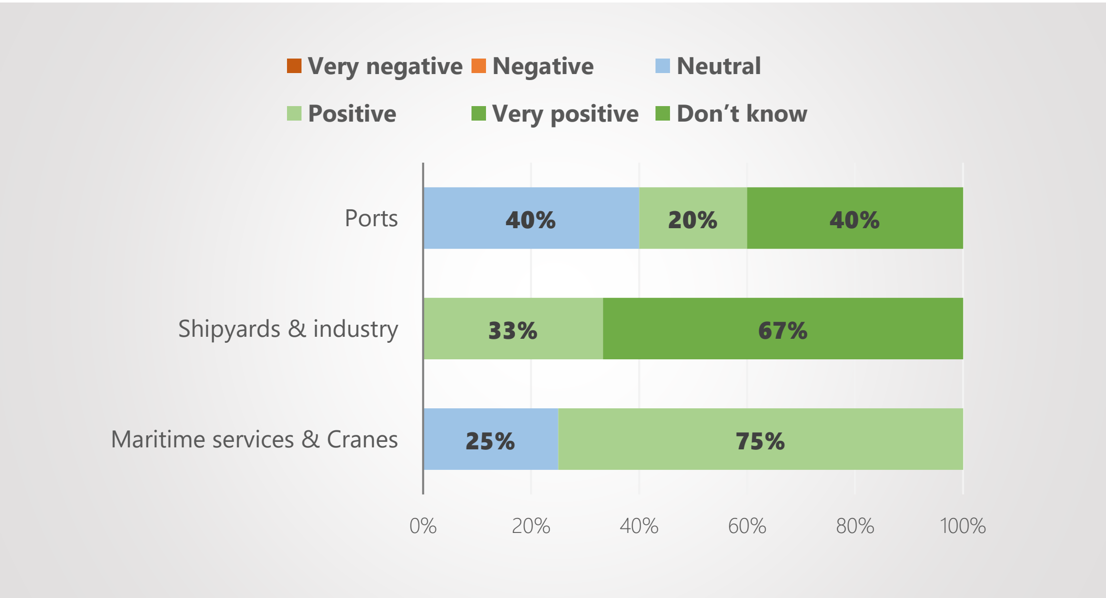
The companies' outlook of the acceleration of the floating offshore wind farm projects was also examined per industry.

Only 6 out of 10 of the ports are positive or very positive on the acceleration of the floating offshore wind projects and 4 out of 10 are neutral. We believe that this high percentage of neutrality correlates with the low level of awareness of the ports regarding the sector.

On the other hand, shipyards and industry all consider the acceleration to be positive, with a third being positive and two thirds very positive. We believe that this correlates with the high prospects for a new source of economic activity for shipyards and industry, and their high level of readiness; they consider that they are ready to reap the benefits of a new business opportunity that appears before them. The sooner, the better.

Maritime Services and Crane companies are also positive, with 3 out of 4 replying the deem the acceleration positive while 1 out of 4 have a neutral opinion.

Figure 16: *Overall opinions regarding the acceleration in the development of the floating offshore wind farms per industry.*



Pros and Cons of the Acceleration of the Development of the first floating offshore wind farms

We found mostly positive responses regarding the impact of the acceleration in the development of floating offshore wind farms.

Pros

The participants found that the acceleration of the development of the floating OWF projects will have mostly positive consequences as it would lead to faster growth of the industry, as a good business opportunity comes closer to fruition. They find that the fact that the State appears to commit to the OWF development is positive for the development of the sector and this increases the confidence of the supply chain and the developers to the materialization of the Greek OWF program.

Furthermore, it was pointed out that the acceleration of the program can be an opportunity to identify any procedural, legislative or supply chain issues, and help the market obtain know-how for future projects. And of course it would work as a competitiveness enhancement, as participants in the first Greek OWF projects, will be ahead of competing industries abroad that have yet not participated in any floating offshore wind projects.

Cons

On the other hand, the acceleration of the development of the first floating offshore wind projects reduces the available time for preparation. If the supply chain is not ready to involve, this could lead to unforeseen costs and greater involvement of foreign companies. Furthermore, the fear of possible shoddiness by the state due to the haste to accelerate the development of the floating offshore wind projects, could lead to investor discouragement.

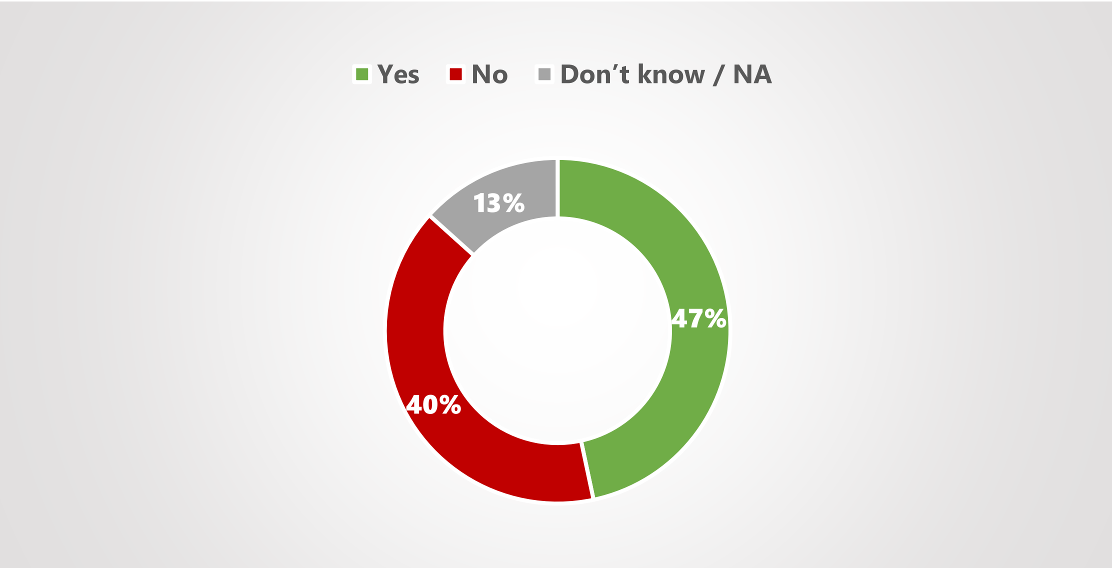
Impact of the Acceleration on the companies' business planning

Balanced Attitude regarding the impact of the potential acceleration of the development of floating offshore wind farms on the companies' business planning.

The participants were asked if the potential acceleration of the development of floating offshore wind farms is affecting their business planning.

Their responses revealed balanced attitude, as 5 out of 10 declared it did affect their business planning, while 4 out of 10 declared that it didn't and approximately 1 out of 10 replied that they didn't know.

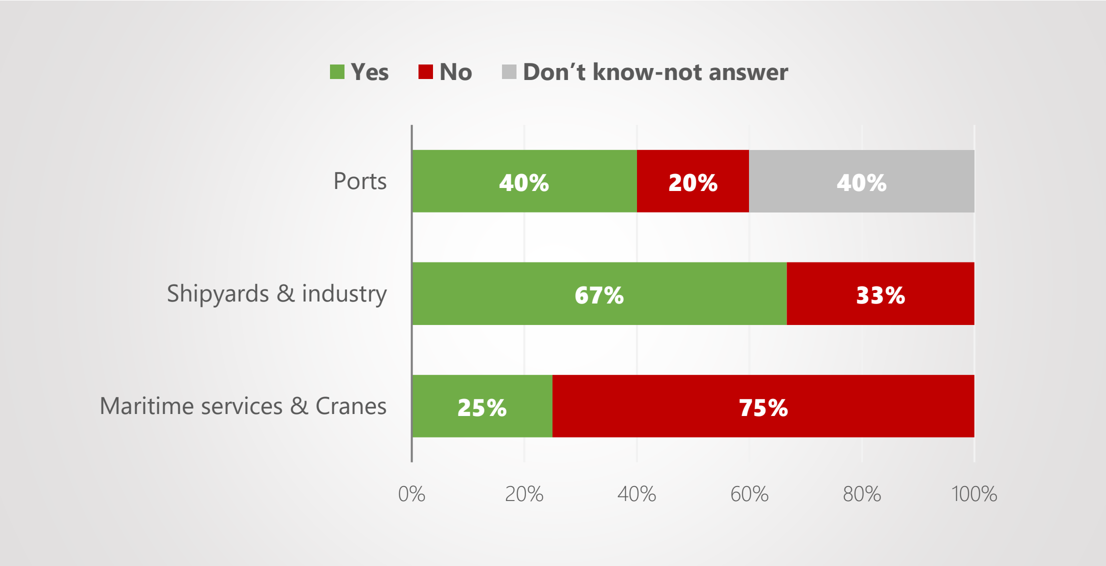
Figure 17: *Overall attitude on whether the acceleration of the development of the floating offshore wind farms affect the companies' business planning.*



We believe however that the companies' replies require further analysis. There has been a significant number of negative replies, coming from companies that stated that they are already active in the offshore wind farm sector, or are already ready to participate, therefore, they already have made their business plans regardless of the declared acceleration of the National OWF program, so the acceleration does not affect their decisions. These replies mostly come from companies in the industry and maritime and crane services sectors.

This is portrayed in the following chart, where the ports are balanced between being affected and unaware, while a third of shipyards and industry believe that their business planning will not be affected by the acceleration of the development of floating offshore wind farms. On the other hand, only a quarter of the maritime services and crane companies replied that their business planning will be affected by the acceleration of the development of floating offshore wind farms, while most of the rest replied either that they are already active in the sector, or relatively ready to participate, therefore the acceleration will not affect their planning.

***Figure 18:** Attitude on whether the acceleration of the development of the floating offshore wind farms affect the companies' business planning per industry.*



Readiness to offer work/services

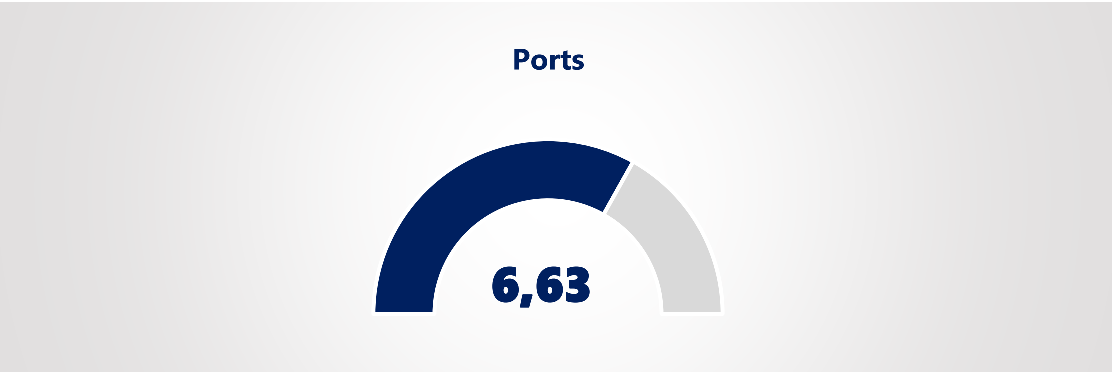
Medium to High Readiness for direct involvement in Offshore Wind Farm Projects

Participants were asked, if in theory, the tender for the first projects were completed today and the investor to undertake their construction was announced, how ready would they be to offer their work/services, in a scale from 1 to 10, with 1 being the least ready and 10 the readiest.

Ports

Ports assess that they are at a medium level of readiness, with the average response being 7/10.

Figure 19: *If, in theory, the tender for the first projects were completed today and the investor to undertake their construction was announced, how ready are you to offer your own work/services? (score 1-10).*



More specifically:

- It would mostly depend on the specific project requirements in land area, vessels, etc.
- It would also depend on port availability, taking into account existing customers, loads, etc.
- Added mechanical equipment would be needed, and the specific project requirements are necessary for scheduling how the required equipment would be acquired.
- The restrictions met in the initial survey are still valid. Many ports are under privatization, lack specialized equipment, have low land availability, low sea depths and have not performed any soil bearing studies. Furthermore, the participation of the ports in the OWF sector would require significant investments, which the ports

currently either cannot invest, or do not prioritize the OWF sector for allocation of any available funds.

- However, one can observe that the average response is significantly higher than the average response on the ports' readiness for participation in the OWF Sector in the initial survey, which was 4/10. We estimate that the ports' average response is now significantly higher because the ports now seem to face the Offshore Wind Farms activity as just another cargo related activity, without taking into account the possibility of participating in the manufacturing or staging procedure.

Shipyards / Industry

Shipyards and industry assess that they are at a high level of readiness, with the average response being 8,5/10.

Figure 20: *If, in theory, the tender for the first projects were completed today and the investor to undertake their construction was announced, how ready are you to offer your own work/services? (score 1-10).*

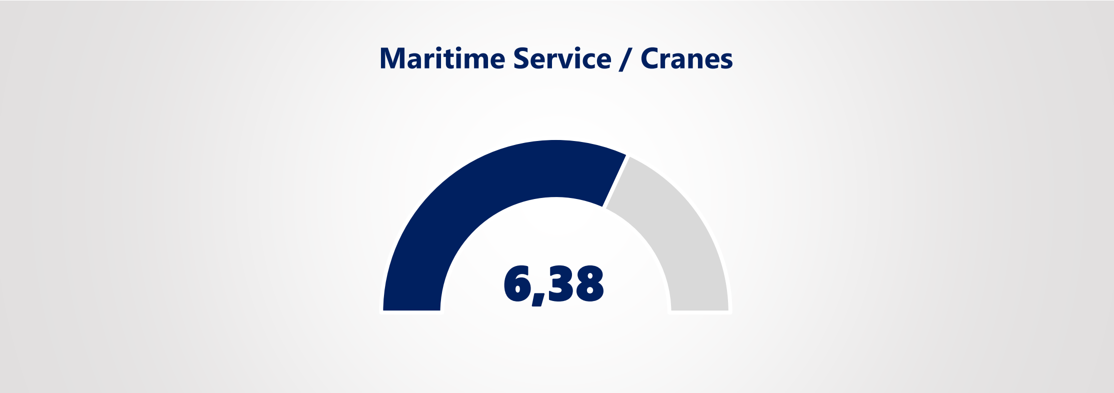
More specifically:

- Some of the companies have already produced parts for Offshore Wind Farms or are currently producing now. Others are in discussions with developers, or with other companies in Greece.
- Companies that provide raw materials (e.g. cement companies) say they already have the required capacity and know-how for the type and quantities that will be required.
- Those not already participating in the sector, declare that they have performed all the preliminary work and are expecting for the relative business decision to participate.

Maritime Service / Cranes

Maritime service and crane companies assess that they are at a medium level of readiness, with the average response being 6/10.

Figure 21: *If, in theory, the tender for the first projects were completed today and the investor to undertake their construction was announced, how ready are you to offer your own work/services? (score 1-10).*



More specifically:

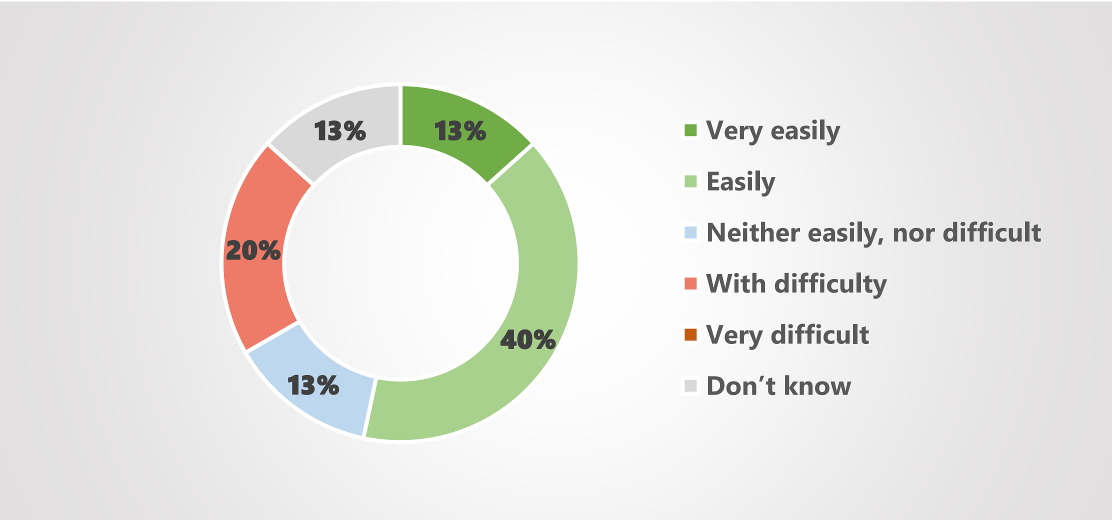
- Crane companies already have extensive experience from their participation in On Shore Wind farm projects.
- They regard that the specifications of the design used in OWF will have to be finalized, so that they can proceed to order the required equipment, which will take some time. This, in the theoretical scenario of an investor approaching them today for their services, makes them unable to offer services directly.
- Some offshore vessel companies also do not yet have the necessary equipment, but consider it is possible to obtain it if required.
- One maritime service company is already participating in Offshore Wind Farm projects in other countries and is already fully booked for the next years. So, they are absolutely ready, but would not be able to participate in projects starting now, since they lack the availability.

How easy is it to immediately meet the needs to build the first floating offshore wind farms.

Participants were asked how easy would it be to immediately meet the needs to build the first floating offshore wind farms and what would be the conditions?

We recorded balanced attitude, as 5 out of 10 stated that it would be easy or very easy to immediately meet the needs to build the first floating offshore wind farms. 2 out of 10 replied that it would be difficult, 1 out of 10 replied that it would not be easy, nor difficult, and 1 out of 10 that they do not yet know. It is also noteworthy, that no one replied that it would be very difficult.

Figure 22: *Overall attitude on how easy it would be to immediately meet the needs to build the first floating offshore wind farms.*

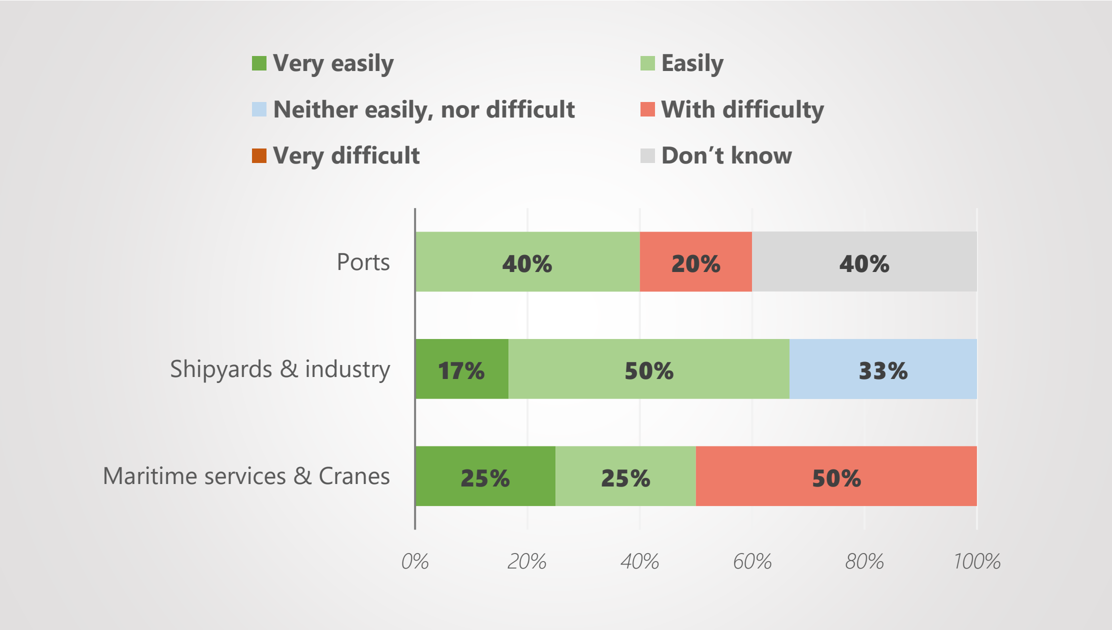


As in previous questions, it appears that the ports respond with lack of knowledge for the demands of the sector, and therefore their capability to respond immediately, while several ports reply that they would respond easily (4 out of 10) and a few (2 out of 10) reply that they would find it difficult to immediately meet the needs to build the first floating offshore wind farms.

Shipyards and industry find it easier to immediately meet the needs: 2 out of 3 find it easy, or very easy, and 1 out of 3 find it neither easy nor difficult.

Finally, Maritime Services and Cranes are balanced, as half reply that they would find it difficult to immediately meet the demand, while the other half would find it easy or very easy.

Figure 23: Attitude on how easy it would be to immediately meet the needs to build the first floating offshore wind farms per industry.



What are the Conditions?

It should be noted that the easiness to immediately meet the needs of building the first floating offshore wind farms come with the fulfillment of specific conditions. The main conditions that were pointed out by the participants were:

- Some sort of assurance for their long-term involvement in the floating offshore wind farm sector, so that their investment will be worth their while – they would not be involved for a single project, or for generally limited work.
- Design maturity so that exact specifications of the projects will have been defined, which is necessary for planning both the construction of the required infrastructure and the necessary equipment.
- State support for the local supply chain, so that they will not have to compete against unfair competition. An example that was pointed out had to do with the fact that the Greek steel industry cannot use cheap Chinese steel without paying antidumping fees, while this is not a restriction for competing Turkish steel companies, which manage to sell at a significantly lower price thanks to their not being subject to antidumping fees for cheap Chinese steel.

- Risk should be shared between the supply chain and the developers, as the projects in question cost hundreds of millions of euros, and they require significant investment on behalf of the supply chain.
- Furthermore, for companies that are already involved in the floating offshore wind farm sector, while they consider they are absolutely ready to meet the needs, an important condition would be that they will have spare availability and production capacity for the Greek projects, when the investors reach out.

What are the implications for the development of the sector and the supply chain, if the implementation of the OWF program is eventually delayed.

The participants reported mostly negative implications in the theoretical case that the implementation of the first floating offshore wind farms is eventually delayed.

Pros

A few positive outcomes would inevitably occur. The maturing of technologies could potentially reduce the cost. The supply chain would have more time to prepare. In the meanwhile, onshore wind farms could be further developed. In some cases where the immediate future is undefined, it could allow for the landscape to clarify. For instance, ports that are to be privatized still have the uncertainty regarding the plans of their new private management. This uncertainty could be clarified in a few years from now.

Cons

It should be mentioned though that the implications would mostly be negative. Developers would leave Greece for other markets, that will implement the original timetables without delays, and confidence in the country would be lost. The opportunity to develop know-how could also be lost, as the existing domestic supply chain of wind energy could be lost over time. Similarly, the opportunity for a new economic activity for the domestic supply chain will also have been lost, while the supply chain resources could be allocated to competing activities.

SUMMARY

Following the initial survey for the Supply Chain for Offshore Wind in Greece that was conducted in the Fall of 2023, an extension to it was conducted, to include more sectors and companies of the Supply Chain, as well as report on the impact government announcements for acceleration of the development of the first floating offshore wind farm projects had on the Greek supply chain.

The companies that participated in the first survey were again approached with a new questionnaire and interviews were performed, to identify their views on the announcement of the acceleration of the first floating projects.

Furthermore, new companies, involved in the Offshore Maritime Services Sector, and the Crane services sector in Greece, were approached, with both the new questionnaire, and a simplified version of the initial questionnaire. Interviews were performed with these companies as well.

The companies that form the domestic supply chain generally have faith in the prospects of this new sector and want to participate in it. They mostly find the announcement of the acceleration to be positive, as it establishes the commitment of the government to the offshore wind farm sector.

It should be noted that different industries have a different outlook on the OWF sector.

Ports still have the lowest knowledge on the sector requirements. They declare that they wish to be involved, however they do not seem to be interested in reserving their limited port space for many years, transform their facilities for that period and perform significant investments. All these are prerequisites for floaters to be put together and offshore wind turbines to be risen on the floaters in ports. Their view on their participation in the sector is to face the floating offshore wind farms equipment as plain cargo, which will be offloaded on the ports, stored for a few days, weeks, or even months on port facilities, and then taken away from the port, for the next cargo to take its place. Subsequently, the prospect of acceleration of the development of the sector does not change their planning, as they prefer to wait for technical specifications to be finalized, and see then, if their infrastructure and availability will allow them to participate.

On the other hand, shipyards and industries seem to have found more immediate prospects in the development of the OWF sector. In the few months since the initial survey, there has been remarkable activity, and discussions for cooperation between different companies, as well as with clients for OWFs abroad. While industrial companies not active in the OWF sector yet, declare themselves absolutely ready to participate. These companies, who are more informed, more prepared, or already active, also set more conditions for their involvement in Greek OWF projects. One main reason is that they identify that currently no industrialization of the production can easily take place. A second reason is that they might already see the challenges in practice.

It should also be noted that these companies that are already active in the OWF supply chain for projects that are developed abroad, are not likely to drop existing customers from these OWF projects, so that they can satisfy the demand that will arise from local projects. This means that the road map for the materialization of the first projects must take shape, and the developers must approach them so that they can put their orders, while there is still available capacity.

Finally, the new sectors that are approached in this extension of the Survey for the Supply Chain of the Offshore Wind Farms, maritime offshore service companies and crane companies, are either already active in the sector (in offshore projects developed in other countries), or are closely monitoring the developments in the sector, as they mostly find that it is fruitful for their involvement.

It should be noted that they recognize that they will need adjusting to the special requirements of these projects: crane companies are experienced in transporting, raising and putting together smaller scale wind turbines for onshore projects, they though believe that they can train and prepare for the larger scale and different conditions of offshore projects. They will also need to invest in new crane equipment, which in turn requires a significant time period of 18-24 months for delivery. They believe though that they can cooperate with foreign companies, to be ready sooner. Similarly, offshore vessel companies (e.g. tugboats) do not yet have the required equipment, however they believe that they can obtain the equipment.

Something that developers will have to keep in mind, is that there is cabotage law regarding offshore services in Greece: Vessels under the Greek flag must be employed for offshore services and only if such vessels are unavailable to provide the service can one employ vessels under different flag. This obviously works in the Greek maritime services companies benefit, and because of that they have added incentive to involve in the offshore wind farm sector.

The difficulty to find skilled personnel has been pointed out by several companies. Offshore companies have recently witnessed a tendency for staff fleeing to the Oil & Gas sector. Crane companies have faced difficulties in finding technical personnel in Greece, resulting in often having to find personnel from abroad. Even industrial companies mentioned to us that there is a significant difficulty in finding technical workers (such as welders) to employ.

Finally, the Supply Chain for the Offshore Wind Farm sector in Greece is content with the latest development in the sector, with the announcement of the national program, the announcement of the reservation of electrical space for the first phase of the program, and now the announcement of the acceleration of the development of the first floating offshore wind projects. However, they claim that the timeline and promises must be kept, otherwise the confidence in the country will be lost. And with it, the opportunity to develop a new industry in Greece, with locally produced knowledge and local added value will also have been lost.

APPENDIX

Appendix A: Questionnaire for Offshore Wind Farms

Part I

1. General Info / Γενικές πληροφορίες	
1.1. Name / Επωνυμία οργανισμού	
1.2. Location / Τοποθεσία	

1.3. Responsible person(s) / Υπεύθυνος (οι)

Communication data	Person #1	Person #2
Name:		
Surname:		
Office Phone:		
Mobile Phone:		
E-mail Address:		

1.1. Main Activities / Κύριες δραστηριότητες:

1.	
2.	
3.	
4.	
5.	
6.	

2. Outlook of the offshore wind farm sector / Προοπτικές κλάδου των υπεράκτιων αιολικών πάρκων

2.1. Opinion on the prospects of the offshore wind farm sector / Ποια είναι η άποψή σας για τις προοπτικές του κλάδου των υπεράκτιων αιολικών πάρκων.

Optimistic / Αισιόδοξη	Neutral / Ουδέτερη	Pessimistic / Απαισιόδοξη	Don't know / Δεν γνωρίζω

Comments/Σχόλια:

2.2. Identify business opportunities & threats of the offshore wind farm sector (spontaneous reporting – up to 3 answers) / Προσδιορίστε ορισμένες επιχειρηματικές ευκαιρίες & απειλές από το περιβάλλον του κλάδου (αυθόρμητη αναφορά – έως 3 απαντήσεις)

Possible business opportunities / Πιθανές επιχειρηματικές ευκαιρίες	Possible Threats / Πιθανές απειλές

2.3. Comments on the willingness of the management to involve with the offshore wind farm sector / Πώς θα χαρακτηρίζατε τη διάθεση της διοίκησης ως προς την ενασχόληση με τον κλάδο.

Positive / Θετική	*Neutral / Ουδέτερη*	*Negative / Αρνητική*	*Don't know / Δεν γνωρίζω*

Comments/Σχόλια:

2.4. Comments on the readiness of your organization, in view of its commercial strategy, to involve with the offshore wind farm sector / Πώς θα αξιολογούσατε την ετοιμότητα της επιχείρησης από άποψη εμπορικής στρατηγικής (βαθμολόγηση από το 1 έως το 10, όπου το 1 αντιστοιχεί στη χαμηλότερη και 10 στην υψηλότερη βαθμολογία)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments/Σχόλια:

2.5. Identify Strengths & Weaknesses for involvement with the offshore wind farm sector (spontaneous reporting – up to 3 answers) / Προσδιορίστε ορισμένα δυνατά σημεία & αδυναμίες της επιχείρησης αναφορικά με την ενασχόληση με τον κλάδο (αυθόρμητη αναφορά – έως 3 απαντήσεις)

Strengths / Δυνατά σημεία	Weaknesses / Αδυναμίες

2.6. Key factors for involvement with the offshore wind farm sector (please rank by importance) / Ποιοι είναι τα κυριότερα κριτήρια ενασχόλησης με τον κλάδο (εάν είναι περισσότερα από ένα, ιεραρχείστε με σειρά σημαντικότητας)

2.6.1.	Profitability / Αύξηση κερδοφορίας	
2.6.2.	Development of new Activities / Ανάπτυξη νέων δραστηριοτήτων	
2.6.3.	Synergies with key players / Ανάπτυξη συνεργιών	
2.6.4.	Government Incentives / Κυβερνητικά κίνητρα	
2.6.5.	Other (specify) / Άλλο (προσδιορίστε)	

2.7. Views on current public policies for the development of the offshore wind farm sector / Ποια είναι η άποψή σας για την κυβερνητική πολιτική σχετικά με την ανάπτυξη του κλάδου των υπεράκτιων αιολικών πάρκων

Very negative / Πολύ αρνητική	Negative / Αρνητική	Neutral / Ουδέτερη	Positive / Θετική	Very positive / Πολύ θετική	Don't know / Δεν γνωρίζω

Comments/Σχόλια:

2.8. Expectations on state incentives by the Government for the development of the offshore wind farm sector / Ποιες είναι οι προσδοκίες παροχής κινήτρων από την Κυβέρνηση για την ανάπτυξη του κλάδου των υπεράκτιων αιολικών πάρκων

Optimistic / Αισιόδοξη	Neutral / Ουδέτερη	Pessimistic / Απαισιόδοξη	Don't know / Δεν γνωρίζω

Comments/Σχόλια:

2.9. General assessment / Γενική Τοποθέτηση

Part II

General Info / Γενικές πληροφορίες	
Name / Επωνυμία οργανισμού	
Responsible person(s) / Υπεύθυνος (οι)	

3. Outlook of the acceleration in the development of floating offshore wind farms / Απόψεις σχετικά με την επίσπευση της ανάπτυξης των πλωτών θαλάσσιων αιολικών πάρκων.

3.1. ***From a business perspective, what is your view on the intention to accelerate the development of floating offshore wind farms by tendering one or more projects to be commissioned earlier than the current National Offshore Wind Development Programme's time horizon? / Πως αντιμετωπίζετε, από επιχειρηματική σκοπιά, την πρόθεση για επίσπευση της ανάπτυξης των πλωτών θαλάσσιων αιολικών πάρκων μέσω της δημοπράτησης ενός ή περισσοτέρων έργων που θα τεθούν σε λειτουργία νωρίτερα από τον χρονικό ορίζοντα που προβλέπει σήμερα το Εθνικό Πρόγραμμα Ανάπτυξης Υπεράκτιων Αιολικών Πάρκων.***

Very positive / Πολύ θετικά	*Positive / Θετικά*	*Neutral / Ουδέτερά*	*Negative / Αρνητικά*	*Very negative/ Πολύ αρνητικά*	*Don't know / Δεν γνωρίζω*

Comments/Σχόλια:

3.2. ***Could you identify some positives or negatives from the acceleration in the development of floating offshore wind farms (spontaneous reporting – up to 3 responses)? / Θα μπορούσατε να προσδιορίσετε ορισμένα θετικά ή αρνητικά σημεία από την επίσπευση της ανάπτυξης των πλωτών θαλάσσιων αιολικών πάρκων (αυθόρμητη αναφορά – έως 3 απαντήσεις);***

Pros	Cons

3.3. ***Is the potential acceleration of the development of floating offshore wind farms affecting your business planning? / Επηρεάζει τον επιχειρηματικό σχεδιασμό σας η ενδεχόμενη επίσπευση της ανάπτυξης των πλωτών θαλάσσιων αιολικών πάρκων;***

Yes / Ναι	*No / Όχι*	*Don't know-not answer / Δεν γνωρίζω-Δεν απαντώ*

Comments/Σχόλια:

3.4. ***If, in theory, the tender for the first projects were completed today and the investor to undertake their construction was announced, how ready are you to offer your own work/services? / Εάν θεωρητικά ολοκληρωνόταν σήμερα η δημοπράτηση των πρώτων έργων και ανακηρυσσόταν ο επενδυτής που θα τα αναλάμβανε, πόσο έτοιμοι είστε για να προσφέρετε τις δικές σας εργασίες/υπηρεσίες;***

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

Comments/Σχόλια:

3.5. ***How easy would it be to immediately meet the needs to build the first floating offshore wind farms? What would be the conditions? / Πόσο εύκολο θα ήταν να καλύψετε άμεσα τις ανάγκες για την κατασκευή των πρώτων πλωτών θαλάσσιων αιολικών πάρκων; Ποιες θα ήταν οι προϋποθέσεις;***

Very easily / Πολύ εύκολα	*Easily / Με ευκολία*	*Neither easily, nor difficult / Ούτε εύκολα ούτε δύσκολα*	*With difficulty / Με δυσκολία*	*Very difficult / Πολύ δύσκολα*	*Don't know / Δεν γνωρίζω*

Comments/Σχόλια:

3.6. ***If the implementation of the first floating offshore wind farms is eventually delayed, what do you think the implications would be? / Εάν τελικά καθυστερήσει η υλοποίηση των πρώτων πλωτών θαλάσσιων αιολικών πάρκων, ποιες θα ήταν κατά τη γνώμη σας οι επιπτώσεις;***

Pros	**Cons**

3.7. ***Comments or Suggestions on the acceleration of the National Offshore Wind development (spontaneous report – up to 3 responses). / Παρατηρήσεις ή Προτάσεις σχετικά με την επίσπευση του Εθνικού προγράμματος Υπεράκτιων Αιολικών (αυθόρμητη αναφορά – έως 3 απαντήσεις).***

Project: "GR-INNO – SGS2 Soft Measures HWEA/ELETAEN"

Deliverable of Task 1.1

Definition of a typical Greek offshore wind farm and a reference turbine

Definition of a set of technical specifications

Prepared by:

iWind Renewables

Supported by a grant from Iceland, Liechtenstein and Norway through the EEA Grants 2014-2021, in the frame of the Programme "Business Innovation Greece", within the project GR-INNO-SGS2 Soft Measures - HWEA/ELETAEN.

Table of Contents

Table of Tables

Table of Figures

Abbreviations

a.s.l.	Above Sea Level
IEC	International Electrotechnical Commission
LCoE	Levelized Cost of Electricity
RNA	Rotor-Nacelle Assembly
SWH	Significant Wave Height

1 EXECUTIVE SUMMARY

This is the Task 1.1 deliverable of the project "GR-INNO – SGS2 Soft Measures – HWEA/ELETAEN" granted from the "EEA Financial Mechanism 2014-2021, Business Development, Innovation and SMEs

"Business Innovation Greece" programme. The project promoter is HELLENIC WIND ENERGY ASSOCIATION ELETAEN NON-PROFIT ORGANISATION (ELETAEN NPO) collaborating with the project partner Marin Energi Testsenter As (NOW). The project will contribute to the following outcomes: i) Increased competitiveness of Greek enterprises within the focus area of Blue Growth and ii) Enhanced business collaboration between Greek entities and Beneficiary State entities.

Task 1 of the project aims in the analysis of the supply chain of offshore wind development in Greece. In that, subtask 1.1 defines a typical Greek offshore wind farm and a reference turbine, as well as a set of technical specifications (weights, staging area needed, minimum water depth, etc) needed for the rest of the project.

Two typical Greek offshore wind farms and a reference turbine are defined. The reference wind farms address medium (50m) and higher (200m) sea depths. The installed capacity is 300MW in both cases. The turbines offshore support structures are jackets in the first case and semisubmersible floaters with catenary mooring lines in the second. The metocean conditions assumed for the two cases are typical for Aegean Sea. The bottom-fixed site has a mean annual wind speed of 8.2m/s, significant wave height 0.8m and wave peak period 4.2s. The floating site is rougher, with mean annual wind speed of 9.6m/s, significant wave height of 1.2m and peak period 5.0s.

The IEA 15MW offshore wind turbine is selected as the reference turbine. It is a typical three-bladed upwind design, with variable speed and pitch control, having a rotor diameter of 240m and hub-height 150m.

Using the reference wind farm(s) and turbine characteristics one can obtain a set of prerequisites / technical specifications (weights, staging area, minimum water depth, etc) necessary for assessing the specific needs for harbours and the elements of the supply chain. It is seen, for instance, that the development of the 300MW reference wind farm an area of 25Ha is needed as a minimum for the staging of the "dry" wind turbines' components, the bearing capacity of the staging soil might need strengthening to host heavy equipment, while the exit from the harbour should support a minimum draft of 12m (it might be less for other floater designs and assembly practices).

2 INTRODUCTION

This is the Task 1.1 deliverable of the project "GR-INNO – SGS2 Soft Measures – HWEA/ELETAEN" granted from the "EEA Financial Mechanism 2014-2021, Business Development, Innovation and SMEs

"Business Innovation Greece" programme. The project promoter is HELLENIC WIND ENERGY ASSOCIATION ELETAEN NON-PROFIT ORGANISATION (ELETAEN NPO) collaborating with the project partner Marin Energi Testsenter As (NOW). The project will contribute to the following outcomes: i) Increased competitiveness of Greek enterprises within the focus area of Blue Growth and ii) Enhanced business collaboration between Greek entities and Beneficiary State entities.

Task 1 of the project aims in the analysis of the supply chain of offshore wind development in Greece. The starting subtask 1.1 defines a typical Greek offshore wind farm and a reference turbine, as well as a set of technical specifications (weights, staging area needed, minimum water depth, etc) needed for the rest of the project.

Chapter 3 of this report describes two reference wind farms (a bottom fixed and a floating) operating under typical Aegean Sea metocean conditions.

Chapter 4 of the report details the key parameters and technical characteristics of a generic 15MW wind turbine that will be used in the reference wind farms. Depending on the case, the reference turbine is supported by a jacket (bottom-fixed) or a semi-submersible floater (floating) anchored by catenary mooring lines.

Harbour needs for the staging, assembly and transportation of the "dry" components of the reference wind farm are discussed in Chapter 5.

3 REFERENCE WIND FARM

This chapter provides the key parameters of the reference wind farm(s) that will be used in the project. It addresses sizing of the wind farm (installed capacity, turbine type, number of turbines and a typical layout), water depth, as well as metocean conditions for wind and wave (currents are not considered). Two reference offshore wind farms are considered, one with bottom-fix and another with floating wind turbines. The metocean conditions used for the reference wind farms are typical for the Aegean Sea.

3.1 SIZING

For both bottom-fix and floating reference wind farms the installed capacity is **300MW,** comprising **20X15MW** turbines of the "reference" type presented in the next chapter. The reference turbine is of IEC Class IB and has **240m** diameter and **150m** hub-height. The 20 turbines layout assumes **7DX5D** distances between the turbines, 7D (1680m) in the prevailing wind direction and 5D (1200m) in the normal to the prevailing direction. A 5X4 turbines layout requires a deployment area of **~25km^2**.

The mean sea depth for the bottom fixed turbines is **50m** with the offshore support structure being of the jacket type. The mean sea depth for the floating turbines is **200m** with the offshore support structure being of the semisubmersible type with a chain catenary mooring system. Details of the offshore support structures are presented in the following chapters.

3.2 WIND CONDITIONS [1]

The wind conditions assumed for the two reference wind farms at their hub-height are:

For bottom-fixed turbines

- Mean annual wind speed (m/s) : 8.2
- Weibull shape factor k : 2.4
- Prevailing wind direction (°) : 340

For floating turbines

- Mean annual wind speed (m/s) : 9.6
- Weibull shape factor k : 2.0
- Prevailing wind direction (°) : 305

3.3 WAVE CONDITIONS [2]

For bottom-fixed turbines

- Mean significant wave height (m) : 0.8
- 50-years extreme SWH (m) : 4.6
- Spectral peak period (s) : 4.2
- Prevailing wave direction (°) : 8

For floating turbines

- Mean significant wave height (m) : 1.2
- 50-years extreme SWH (m) : 6.9
- Spectral peak period (s) : 5.0
- Prevailing wave direction (°) : 314

4 REFERENCE WIND TURBINE

The IEA 15MW Wind Turbine [1] has been selected as the reference turbine of the present assignment. This is an offshore turbine, originally supported by a monopile. A bottom-fixed version of the same turbine for deeper waters (~50m) supported by a jacket substructure has been obtained in the present context using the INNWIND.EU[1] reference jacket upscaled to 15MW using the INNWIND.EU cost model [4]. A floating version of the IEA 15MW turbine for water depths ~200m has been also defined in [5].

4.1 KEY PARAMETERS FOR THE 15MW REFERENCE WIND TURBINE

4.1.1 Rotor and RNA

Table 1 presents the key parameters of the 15MW Reference Wind Turbine. It has a 3-bladed, upwind, pitch variable rotor with a direct drive drivetrain. The Table shows under the column "IEA 15-MW Turbine" the values of the relevant parameters as provided in [1], while in column "Innwind.EU" the corresponding values have been obtained through the upscaling of the INNWIND.EU 10MW turbine using the upscaling and cost modelling tool of [4]. It is seen that the two parameters' sets are quite identical, strengthening thus the representativity of the 15MW design.

Table 1: Key parameters for the 15MW Reference Wind Turbine

Key Parameters		IEA 15-MW Turbine	Innwind.EU
Parameter	**Units**	**Value**	**Value**
Power rating	MW	15	15
Turbine class	-	IEC Class 1B	IEC Class 1B
Specific rating	W/m2	332	.//.
Rotor orientation	-	Upwind	.//.
Number of blades	-	3	.//.
Control	-	Variable speed Collective pitch	.//.
Cut-in wind speed	m/s	3	.//.
Rated wind speed	m/s	10.59	.//.
Cut-out wind speed	m/s	25	.//.
Design tip-speed ratio	-	9 0	.//.
Minimum rotor speed	rpm	5	.//.
Maximum rotor speed	rpm	7.56	.//.
Maximum tip speed	m/s	95	.//.
Rotor diameter	m	240	.//.
Airfoil series	-	FFA-W3	.//.
Hub height	m	150	.//.
Hub diameter	m	7.94	
Hub overhang	m	11.35	
Rotor precone angle	deg	-4	
Blade prebend	m	4	
Blade mass	t	65	66.5
Drivetrain	-	Direct drive	Medium Speed
Shaft tilt angle	deg	6	
Rotor nacelle assembly mass	t	1,017	1,073

For a more detailed description of the IEA design, we quote below relevant expressions used by the reference [1] authors:

[1] INNWIND.EU (http://www.innwind.eu/) was a European FP7 project. The overall objective of the INNWIND.EU project was the high-performance innovative design of a beyond-state-of-the-art 10-20MW offshore wind turbine and hardware demonstrators of some of the critical components.

«The blade design was driven by the selection of 240m as the rotor diameter and a maximum tip-speed of 95 meters per second (m/s). A fairly traditional structural configuration was selected, comprising of two main load-carrying, carbon-reinforced spars, connected by two shear webs, with reinforcement along the trailing and leading edge and foam fillers. »

« The 15-MW reference wind turbine uses a direct-drive layout with a permanent-magnet, synchronous, radial flux outer-rotor generator in a simple and compact nacelle layout. The assembly consists of a hub shaft supporting the turbine and generator rotors on two main bearings housed on a stationary turret that is cantilevered from the bedplate. The hub is a simple spherical shell, with cutouts for the blades and the flange. The main shaft has a hollow cylindrical cross section, with a constant wall thickness and a tilt angle of 6°. The main shaft, along with the rotor, is supported by two main bearings. Both these main bearings have rotating outer raceways and fixed inner raceways. The outer raceways and bearing housing are accommodated by a turret held by the bedplate. The entire weight of the turbine rotor, generator rotor, and hub loads are transmitted by the main shaft to the turret via the bearings. The bedplate is a hollow, elliptically curved, cantilever beam with circular cross sections. The yaw system bearings are double-row, angular, contact ball bearings. The generator construction features an external rotor radial flux topology machine with a surface-mounted permanent magnet. »

The drive train design is illustrated in Figure 1.

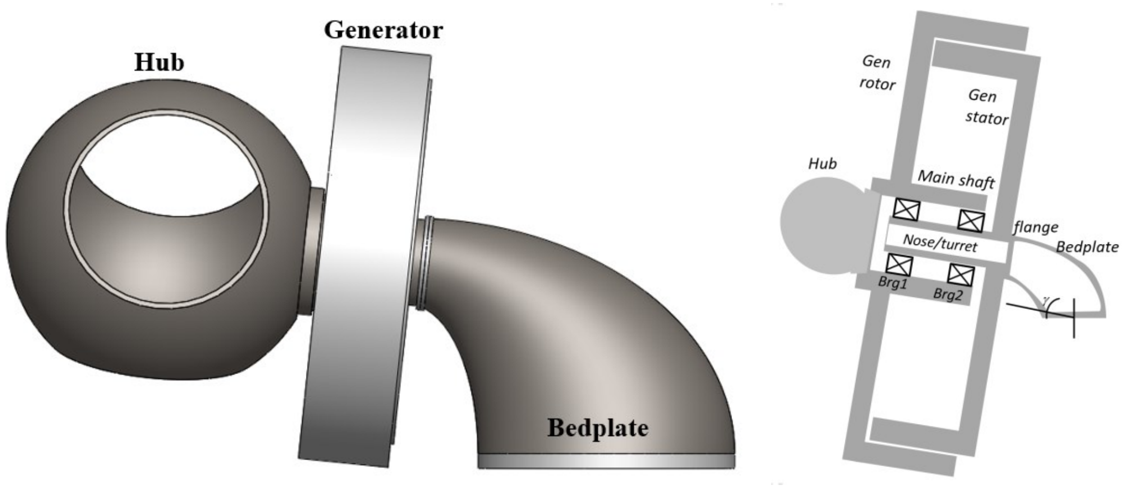


Figure 1: The hub-drivetrain arrangement of the IEA 15MW Wind Turbine (Source: [1])

4.1.2 Offshore Support Structures

Three alternative offshore support structures are considered for the 15MW reference wind turbine. For relatively low (~30m) water depths (w.d.) a monopile design is provided in [1]. For higher water depths (~50m) a jacket substructure can be obtained by upscaling the reference 10MW jacket of the INN-WIND.EU project using [4]. In both the above bottom-fixed cases the same tower is used, starting at 15m a.s.l. and ensuring the hub-height of 150m a.s.l. The third alternative is a semisubmersible floating substructure for deeper waters (~200m) made from steel (see [5]). The floating substructure is accompanied by a new tower design too.

The key parameters of the three offshore support structures discussed above are given in Table 2.

Table 2: Key parameters for the Offshore Support Structures of the 15MW Reference Wind Turbine

Monopile Version (30m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**	**Value**	
Transition piece height	m	15	
Monopile length (from t.p. to seabed)	m	45	
Monopile embedment depth	m	45	
Monopile base diameter	m	10	
Tower mass	t	860	
Monopile mass	t	1,318	
Jacket Version (50m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**		**Value**
Transition piece height	m		15
Jachet length (from t.p. to seabed)	m		65
Piles embedment depth	m		
Jacket base diameter	m		
Tower mass	t		1,043
Jacket overall mass (incl. tp and piles)	t		2,700
Semisubmersible Floater (200m w.d.)		**IEA 15-MW Turbine**	**Innwind.EU**
Parameter	**Units**	**Value**	
Excursion1 (Length, Width, Height)	m	90.1, 102.1, 290.0	
Freeboard	m	15	
Draft	m	20	
Total System Mass (incl. ballast)	t	20,093	
Hull Steel Mass	t	3914	
Platform Mass (incl. ballast)	t	17,839	
Tower Mass	t	1,263	
RNA Mass	t	991	
Water Depth	m	200	
Mooring System	-	Three-line chain catenary	

For more details regarding the floating substructure, we quote below relevant expressions used by the reference [5] authors:

« This part is taken from the work performed by University of Maine (UMaine) VolturnUS-S on defining a reference floating wind turbine to support the International Energy Agency (IEA)-15-240-RWT 15-megawatt (MW) reference wind turbine. The reference floating offshore wind turbine comprises a floating semisubmersible platform, a chain catenary mooring system, a floating-specific tower, and a modified float-specific controller tuning. The semisubmersible is a generic steel version of the UMaine patented concrete floating foundation technology developed in collaboration with the U.S. Department of Energy. The reference platform is a four-column, steel semisubmersible. The arrangement of the hull comprises three 12.5-m-diameter buoyant columns radially spaced with centers that are 51.75 m from the tower's vertical axis. The platform-tower interface is atop a fourth buoyant column located at the center of the platform in the surge-sway plane. This central column is connected to the outer columns via three 12.5-m-wide-by-7.0-m-high rectangular bottom pontoons and three 0.9-m-diameter radial struts attached to the bottom and top of the buoyant columns, respectively. When on station, the total mass of the platform is 17,854 t, of which 3,914 t is structural steel, 2,540 t is fixed iron-ore-concrete ballast, divided equally and placed at the base of the three radial columns, 11,300 t is a seawater ballast that floods the majority of the three submerged pontoons, and a 100-t tower interface connection detail. When installed, the platform has a draft of 20 m with a 15-m freeboard to the upper deck of the columns. The completely assembled unit displaces 20,206 cubic meters (m3) of seawater (with an assumed density of 1,025 kilograms per cubic meter [kg/m3]), which consists of a 1,263-t (metric tonne) tower, a 991-t RNA, and a 17,839-t ballasted platform with 6,065 kilonewtons (kN) of mooring vertical pretension. The system has an assumed deployment depth of 200 m and is held on to the station by a three-line chain catenary mooring system. The lines of the spread catenary system span radially to anchors located 837.60 m from the tower's centerline. »

Part of the information provided above is summarized in *Table 3*.

Table 3: Key parameters for the Semisubmersible Platform and its Mooring system

Semisubmersible Platform Properties		
Parameter	**Units**	**Value**
Hull Displacement	m3	20206
Hull Steel Mass	t	3914
Tower Interface Mass	t	100
Ballast Mass (Fixed/Fluid)	t	2,540/11,300
Draft	m	20
Freeboard	m	15
Vertical Center of Gravity from SWL	m	-15
Vertical Center of Buoyancy from SWL	m	-14
Mooring System Properties		
Parameter	**Units**	**Value**
Mooring System Type	-	Chain Catenary
Line Type	-	R3 Studless Mooring Chain
Line Breaking Strength	kN	22,286
Number of Lines	-	3
Anchor Depth	m	200
Fairlead Depth	m	14
Anchor Radial Spacing	m	837.6
Fairlead Radial Spacing	m	58
Nominal Chain Diameter	mm	185
Dry Line Linear Density	kg/m	685
Extensional Stiffness	MN	3270
Line Unstretched Length	m	850
Fairlead Pretension	kN	2,437
Fairlead Angle from SWL	°	56.4

The floating platform design is illustrated in Figure 2.

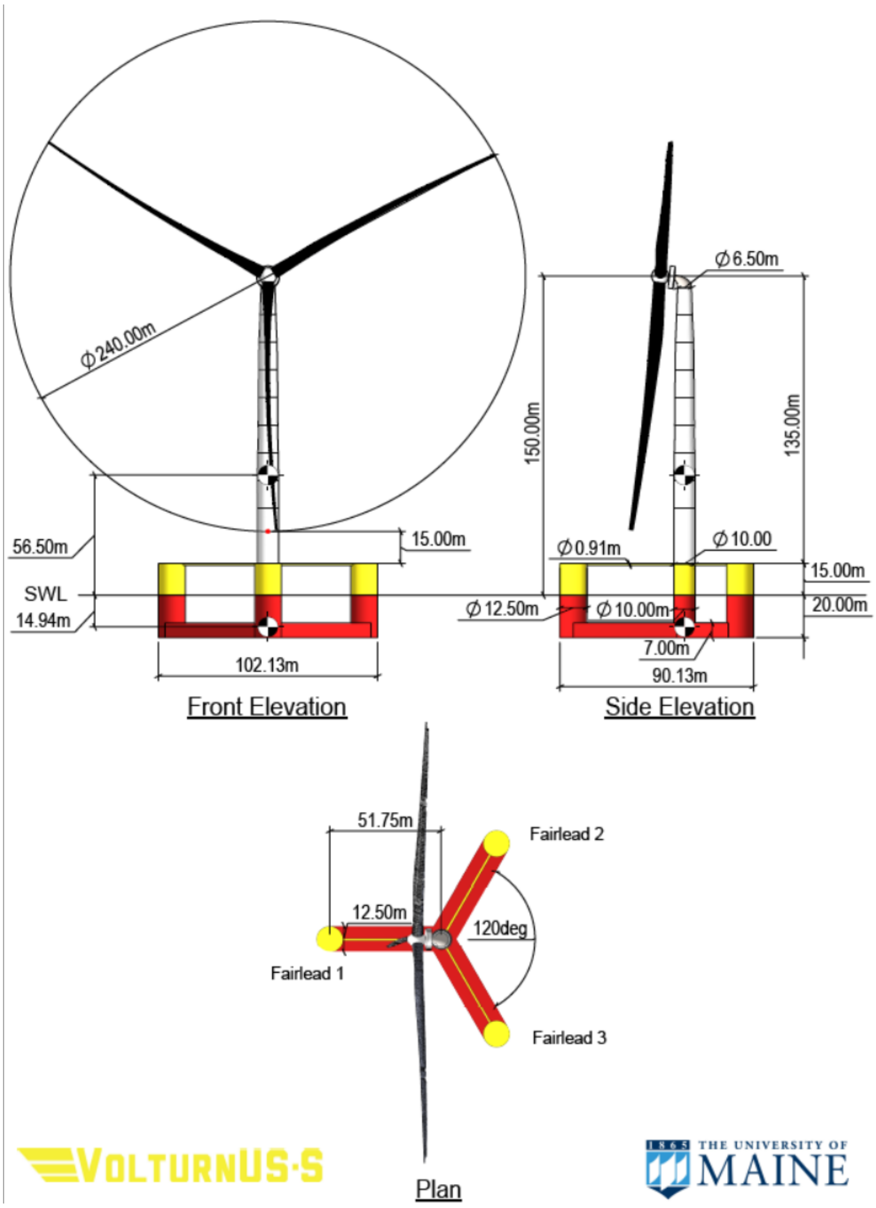


Figure 2: The 15MW floating support structure designed by the University of Maine (Source: [5])

4.2 SUBSYSTEMS' DETAILS AND STAGING NEEDS

In this chapter we provide further information at the subsystems level, addressing the 15MW reference wind turbine blades, drivetrain (and hub assembly) and tower (the floating tower in this case). For each subsystem we also evaluate its port staging needs in terms of its footprint (called "surface area") and its ground pressure. When the ground pressure is less than the affordable limit of the staging area, then the subsystems can be piled vertically to claim less space. This is, for instance, the blades case.

4.2.1 Blades

Important blade properties are listed in Table 4. The mass of 65.25t and the length 117m. The root diameter is 5.2m and the maximum chord 5.77m. The tip prebend is 4m. If the blade was to be stored in a box, the box dimensions would be the blade length, the maximum chord (as the width) and the root radius plus the tip prebend as the height. These dimensions are listed in Table 5. The footprint of the box (or surface area) is the product of its length and height. If the surface pressure of the box on the ground is assumed uniformly distributed, then its measure derives by dividing the blade weight by the surface area. The surface area and pressure are characteristic properties for the staging needs of the dry components of the reference wind turbine.

Table 4: Key parameters for the 15MW reference wind turbine blades

Blade Properties		
Parameter	**Units**	**Value**
Blade length	m	117
Root diameter	m	5.2
Root cylinder length	m	2.34
Max chord	m	5.77
Max chord spanwise position	m	27.2
Tip prebend	m	4
Precone	deg	4
Blade mass	t	65.25
Blade center of mass	m	26.8
Operational		
Design tip-speed ratio	-	9
First flapwise natural frequency	Hz	0.555
First edgewise natural frequency	Hz	0.642
Design CP	-	0.489
Design CT	-	0.799

Table 5: Staging needs for the 15MW reference wind turbine blades

Blade box dimensions & Weight		
Length	m	117
Width	m	6
Height	m	7
Weight	t	65.25
Surface Area	m2	675
Surface pressure	t/m2	0.10

4.2.2 Drivetrain and Hub

Similar considerations to those presented above for the blades apply for the drivetrain and the hub. Table 6 and Table 7 list the relevant values. Table 6 shows lamped masses for the nacelle assembly as provided in [1] and calculated using [4]. It is seen that the nacelle and hub masses estimated with two different approaches are quite close.

Table 6: Key parameters for the 15MW reference wind turbine drivetrain and hub

Lumped Masses for the Nacelle Assembly		**IEA 15-MW Turbine**	**Innwind.EU**
Name	**Units**	**Mass**	**Mass**
Yaw system	t	100	
Turret nose	>>	11	
Inner generator stator	>>	227	
Outer generator rotor	>>	145	
Shaft	>>	16	
Hub	>>	190	194
Bedplate	>>	70	58
Flanges and misc. equipment	>>	54	
Bearings	>>	8	
Nacelle total	>>	**821**	**869**
Nacelle total minus hub	>>	**631**	**675**
Main Shaft Dimensions and Bearings			
Description	**Units**	**Value**	
Shaft tilt angle	deg	6	
Length of main shaft	m	2.2	
Outer radius of the main shaft	m	3	
Inner radius of the main shaft	m	2.8	
Location of generator stator from bedplate flange	m	0.25	
Turret center of mass	m	1.2	
Distance of downwind bearing from bedplate flange	m	0.9	
Turret length	m	2.2	
Outer radius of the turret	m	2.2	
Inner radius of the turret	m	2	
Tapered double outer ring (TDO) mass	kg	2230	
Spherical roller bearing (SRB) mass	kg	5664	
Bedplate Properties			
Description	**Units**	**Value**	
Tower-top (bedplate base diameter)	m	6.5	
Bedplate wall thickness	mm	50	
Bedplate length w/o turret	m	8.3	
Bedplate mass	t	70.3	
Bedplate length with turret	m	10.5	
Bedplate width	m	6.5	
bedplate height	m	6.0	
Directdrive Generator Properties			
Description	**Units**	**Value**	
Air-gap radius	m	5.1	
Core length	m	2.2	
Generator mass	t	372	
Generator Diameter	m	13	
Generator height	m	4	
Hub Properties			
Diameter	m	7.94	

Table 7: Staging needs for the 15MW reference wind turbine drivetrain and hub

Nacelle-hub Assembly Dimensions & Weight		
Length	m	19
Width	m	13
Height	m	13
Weight	t	821
Surface Area	m2	245
Surface pressure	t/m2	3.35

4.2.3 Floating Tower

A similar analysis is performed for the floating tower and the outcome is shown in Table 8 and Table 9. The overall tower height is 129.5m comprising 10 parts of 13m each (except for the tower top part which is slightly shorter). Each part is flanged at its top and bottom area to be assembled with its neighbours. The top part supports the yaw ring and the bedplate above it. The mean weight of each of the 10 tower parts is 126.3t.

Table 8: Key parameters for the 15MW reference wind turbine floating tower

Floating Tower Properties		
Parameter	**Units**	**Value**
Mass	t	1,263
Length	m	129.5
Base Outer Diameter	m	10
Top Outer Diameter	m	6.5
Base thickness	mm	83.0
Top thickness	mm	21.2
No of substructures (flange to flange)	-	10
Length of sunstructures	m	13
1st Fore-Aft Bending Mode	Hz	0.496
1st Side-Side Bending Mode	Hz	0.483

Table 9: Staging needs for the 15MW reference wind turbine floating tower

Tower box dimensions & Weight		
No of sub-elements per tower	-	10
Length	m	13
Width	m	10
Height	m	10
Weight (mean value)	t	126.3
Surface Area	m2	130
Surface pressure	t/m2	0.97

5 HARBOUR NEEDS

5.1 REFERENCE TURBINE AND WIND FARM STAGING NEEDS

The staging needs for the dry parts of the reference turbine are summed up in Table 10. The net staging space needed per 15MW turbine when the individual subsystems are not piled-up is 3,570 m2. For 20 such turbines comprising the 300MW reference wind farm the net needed space is 71,408 m2. Assuming a 3.5 net to gross factor for the spacing needs, so that the individual pieces can be accessed and transported, the gross value of the staging space of the refence wind farm becomes 250,000 m2, or 25 Ha.

Table 10: Staging needs for the reference wind turbine and wind farm

NET STAGING NEEDS	m2
Per 15MW Turbine	3,570
3 Blades	2,025
Nacelle-hub	245
Tower	1,300
300MW Wind Farm (20 WTG)	71,408
Net to gross factor	**3.5**
300MW Wind Farm GROSS	250,000

5.2 SOIL BEARING CAPACITY

The highest value of surface pressure we have estimated for the dry components of the reference wind turbine is 3.35t/m2 for the nacelle-hub assembly, weighting 821 t. This surface pressure derives if the total weight will uniformly transfer to the ground, which is not true given the geometrical particularity of the substructure. We anticipate that the weight load will be undertaken by the ¼ of the projected area, leading to a soil bearing capacity of 4*3.35 ~ 13.5 t/m2. The soil bearing capacity of the areas where the blades and the tower substructures will be stored can be less.

Cranes will be needed for the assembly of the dry parts of the turbines. The heaviest single component to be lift-up is again the nacelle-hub assembly. It is anticipated that the soil bearing capacity under the crane-base area must be of the order of 35 t/m2.

5.3 DRAFT

Assuming that the floater with will be transferred with tag boats having the turbine assembled on top and its fixed ballast in place, the total system mass will be 8,700 t (fixed ballast 2,540 t, hull steel mass 3,140 t, tower mass 1,263 t and RNA 991t). The draft of the fully assembled and moored turbine is 20m where the total system mass, including the water ballast is 20,000 t. It is reasonable to assume that (the less than half-weighted) system during its transfer will have a draft around 10m. Adding a 2m margin to that, we come to a minimum harbour draft of 12m. Evidently, this minimum draft requirement refers to the considered floating platform. Different types of floating platforms may require higher or lower minimum draft values.

6 CONCLUSIONS

This report defines two typical Greek offshore wind farms and a reference turbine. The reference wind farms address medium (50m) and higher (200m) sea depths. The installed capacity is 300MW in both cases. The turbines offshore support structures are jackets in the first case and semisubmersible floaters with catenary mooring lines in the second. The metocean conditions assumed for the two cases are typical for Aegean Sea. The bottom-fixed site has a mean annual wind speed of 8.2m/s, significant wave height 0.8m and wave peak period 4.2s. The floating site is rougher, with mean annual wind speed of 9.6m/s, significant wave height of 1.2m and peak period 5.0s.

The IEA 15MW offshore wind turbine is selected as the reference turbine. It is a typical three-bladed upwind design, with variable speed and pitch control, having a rotor diameter of 240m and hub-height 150m.

Using the reference wind farm(s) and turbine characteristics one can obtain a set of prerequisites / technical specifications (weights, staging area, minimum water depth, etc) necessary for assessing the specific needs for harbours and the elements of the supply chain. It is seen, for instance, that the development of the 300MW reference wind farm an area of 25Ha is needed as a minimum for the staging of the dry wind turbines' components, the bearing capacity of the staging soil might need strengthening to host heavy equipment, while the exit from the harbour should support a minimum draft of 12m (it might be less for other floater designs and assembly practices).

References

1. Global Wind Atlas 3.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU). The Global Wind Atlas 3.0 is released in partnership with the World Bank Group, utilizing data provided by Vortex, using funding provided by the Energy Sector Management Assistance Program (ESMAP). For additional information: https://globalwindatlas.info"

2. Soukissian, T., Hatzinaki, M., Korres, G., Papadopoulos, A., Kallos, G., Anadranistakis, E., 2007: Wind and Wave Atlas of the Hellenic Seas, Hellenic Centre for Marine Research Publ., 300 pp.

3. Gaertner, Evan, Jennifer Rinker, Latha Sethuraman, Frederik Zahle, Benjamin Anderson, Garrett Barter, Nikhar Abbas, Fanzhong Meng, Pietro Bortolotti, Witold Skrzypinski,,George Scott, Roland Feil, Henrik Bredmose, Katherine Dykes, Matt Shields, Christopher Allen, and Anthony Viselli. 2020. Definition of the IEA 15-Megawatt Offshore Reference Wind. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-75698. https://www.nrel.gov/docs/fy20osti/75698.pdf.

4. Deliverable 1.21 - INNWIND.EU Cost Model, http://www.innwind.eu/publications/deliverable-reports.

5. Allen, Christopher, Anthony Viselli, Habib Dagher, Andrew Goupee, Evan Gaertner, Nikhar Abbas, Matthew Hall, and Garrett Barter. Definition of the UMaine VolturnUS-S Reference Platform Developed for the IEA Wind 15-Megawatt Offshore Reference Wind Turbine. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-76773. https://www.nrel.gov/docs/fy20osti/76773.pdf.