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

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INTRODUCTION

Background

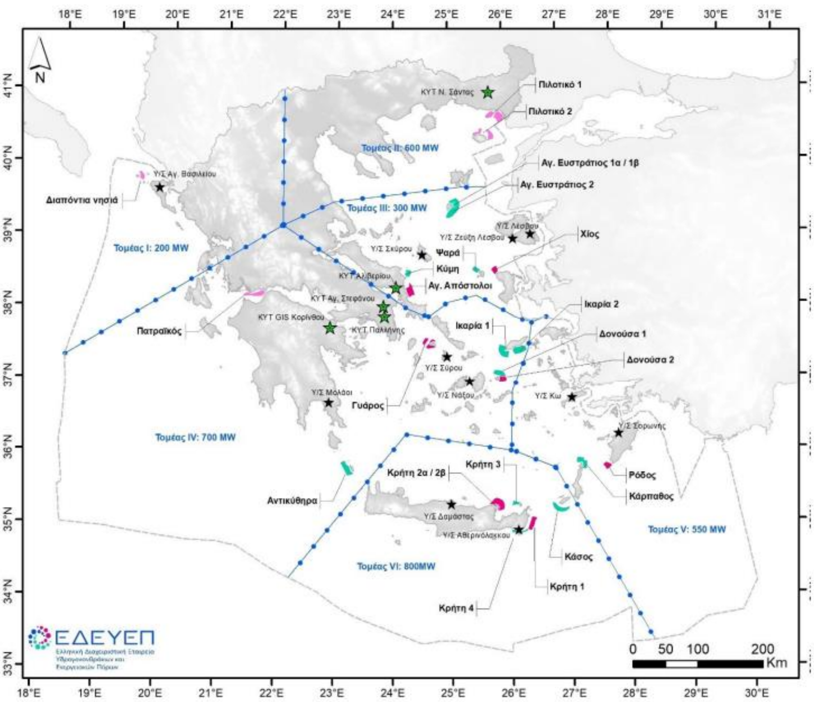
According to the country's preliminary energy planning, the target for the development of Offshore Wind Farms (OWF) in Greece is 1,900 MW for 2030, 6,200 MW for 2035 and 17,300 MW for 2050. [1]

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

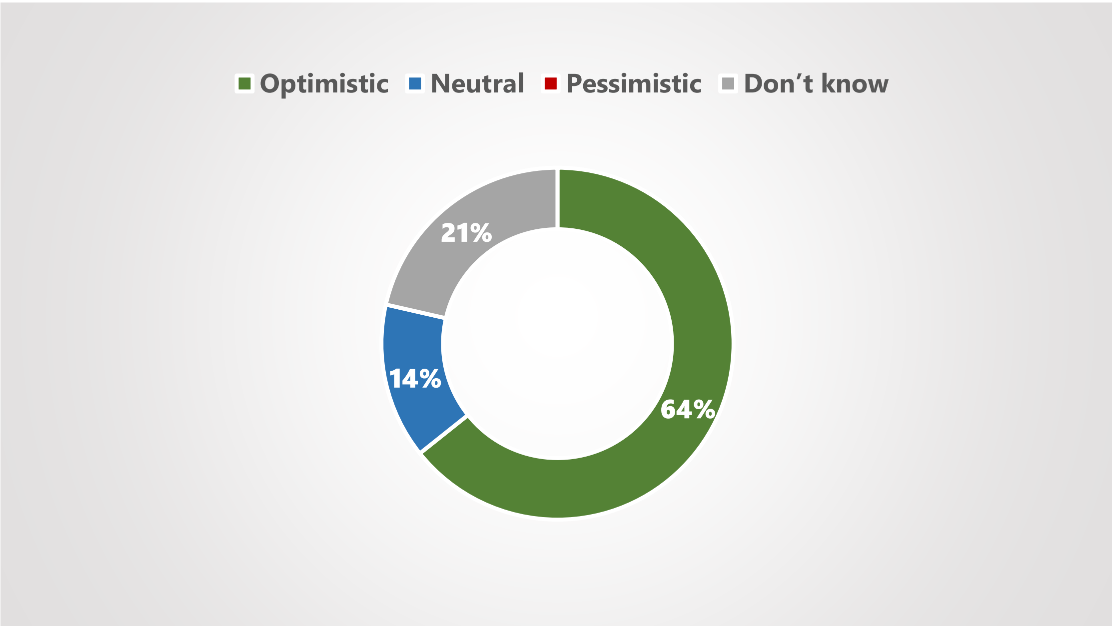
Positive Attitude for the Outlook of Offshore Wind Development in Greece

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

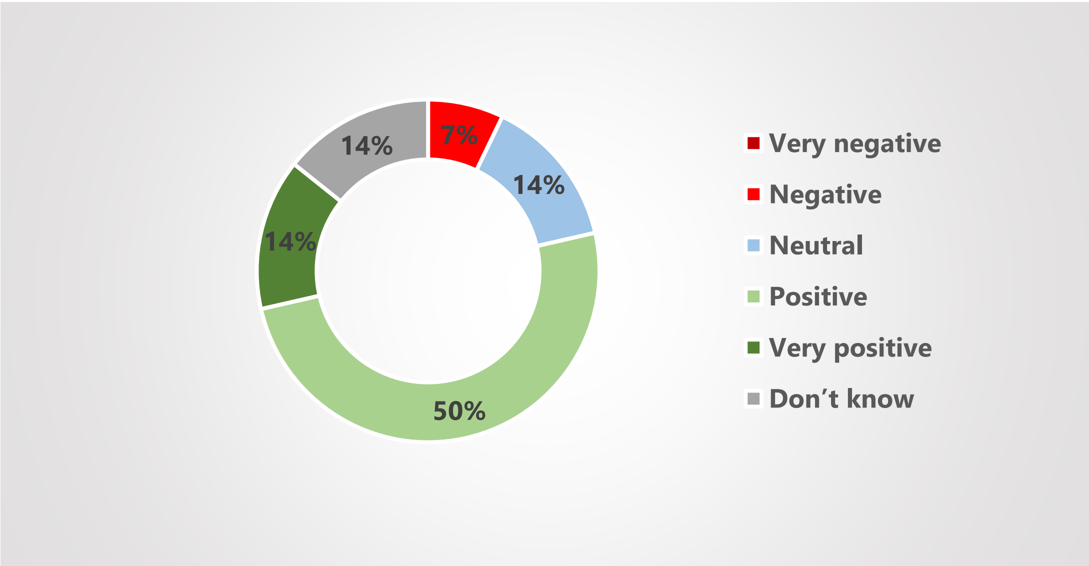


Views on current public policies

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.

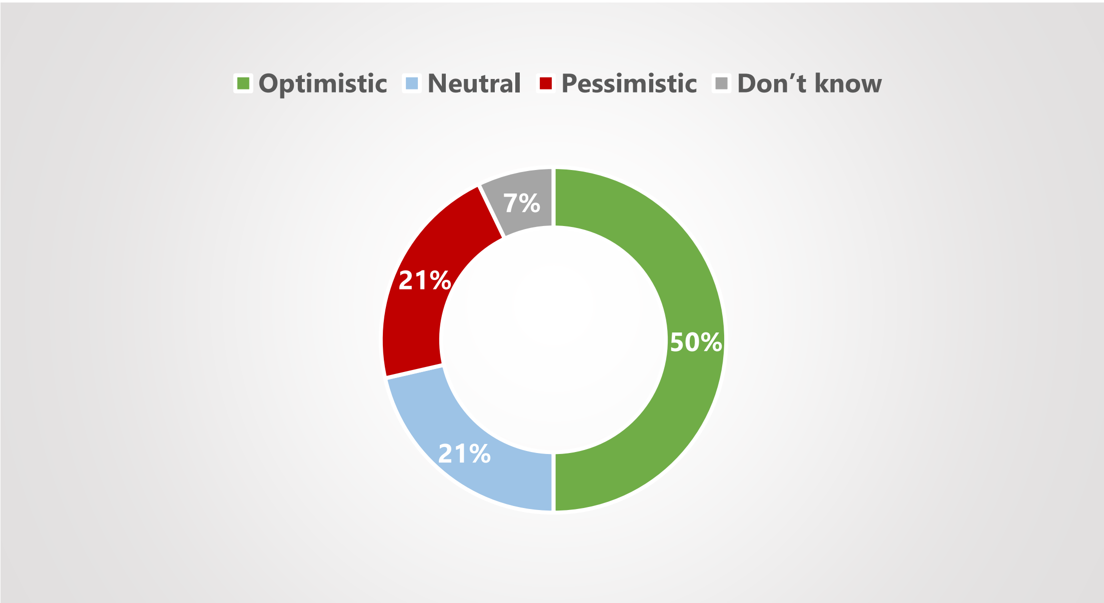
Balanced Expectations on Government Incentives

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

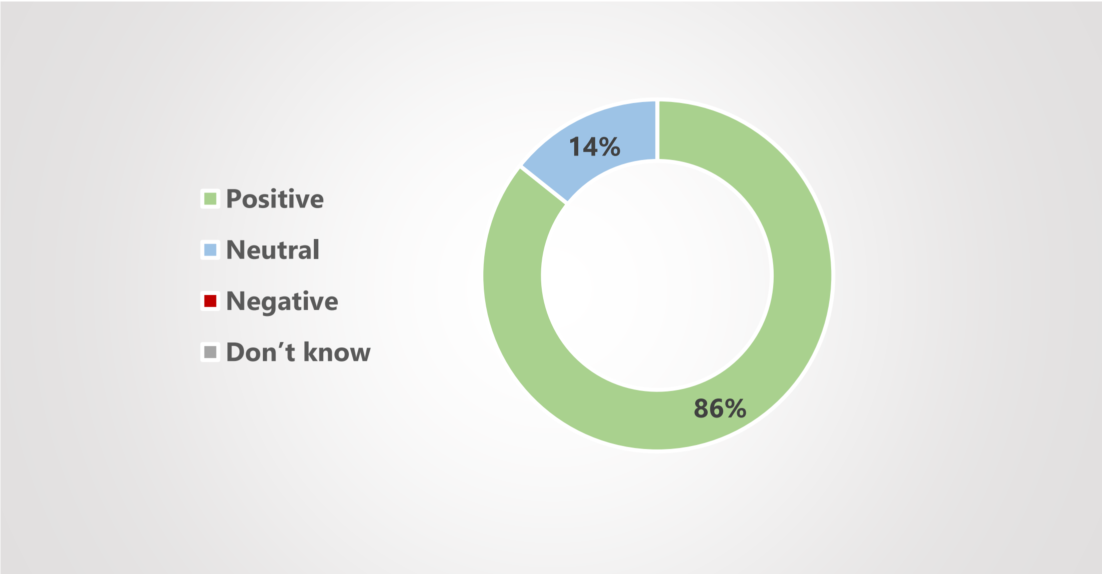


Involvement intentions

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.

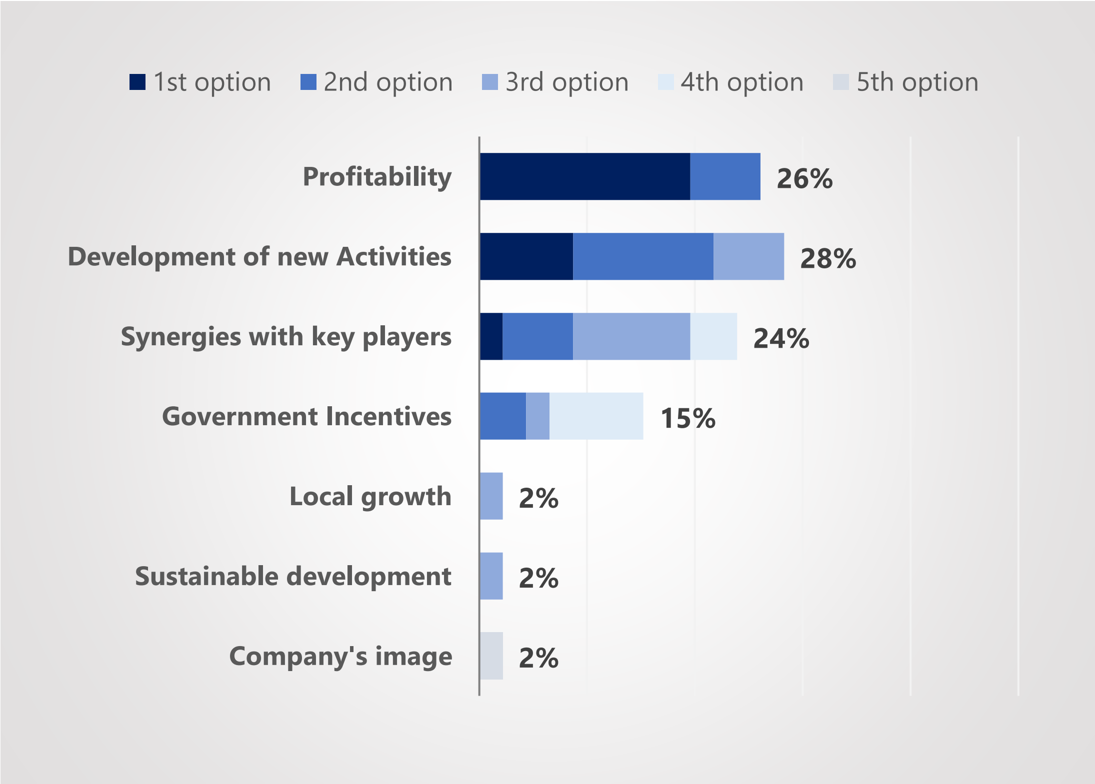


Key Factors for involvement

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 ~**25km²**.

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.

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[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».

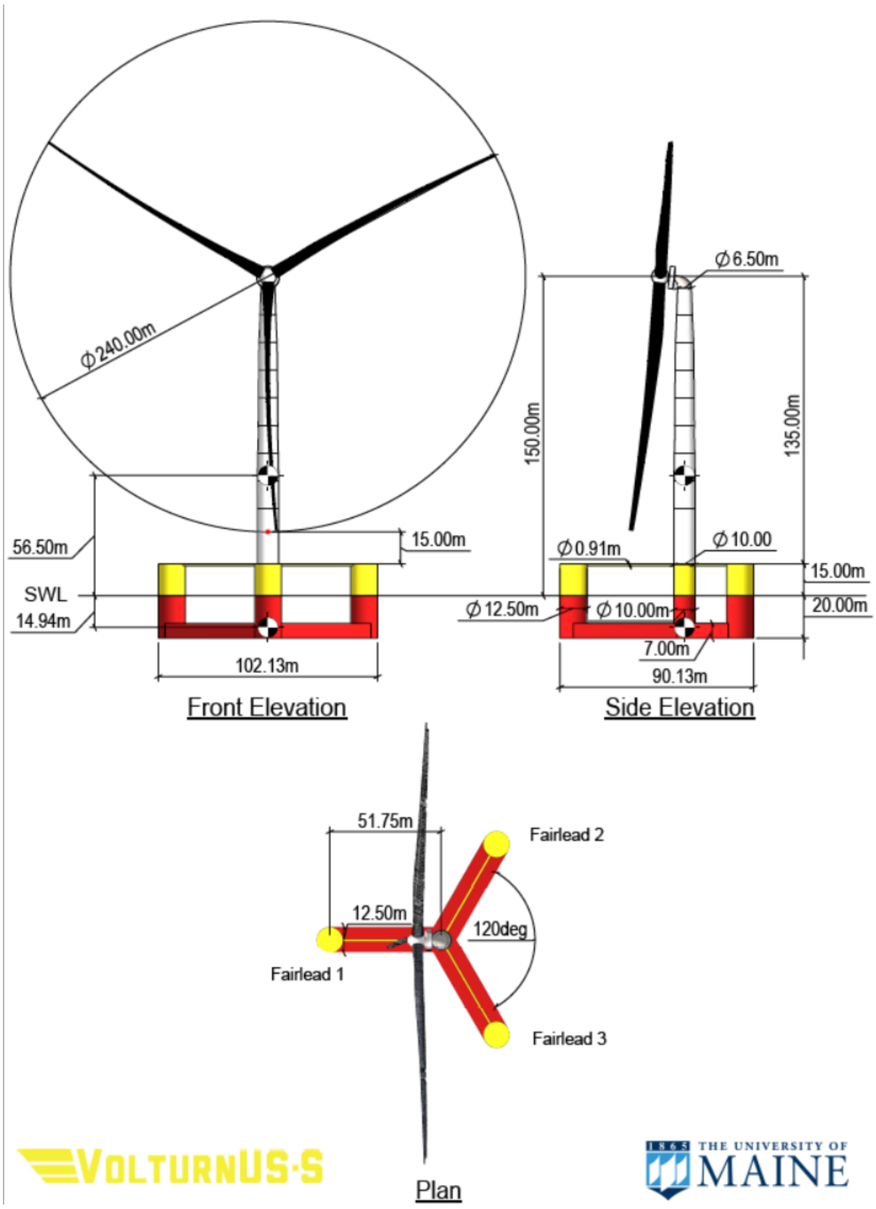
Part of the information provided above is summarized in Table 7.

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	✓	✓	✓	✓

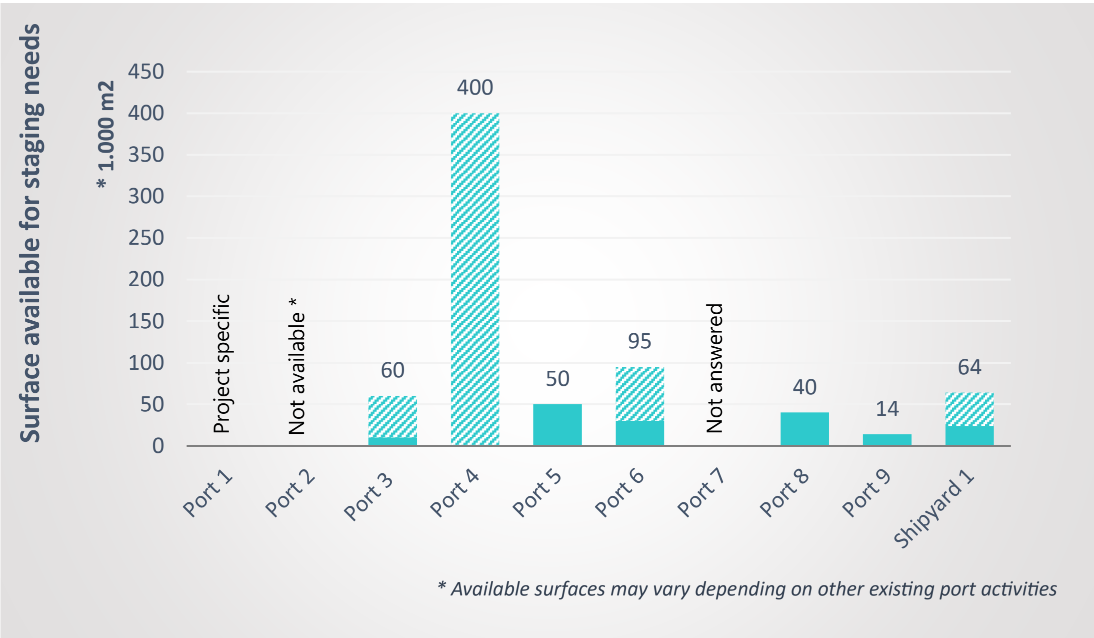
Conclusions: Insufficient port infrastructure

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.

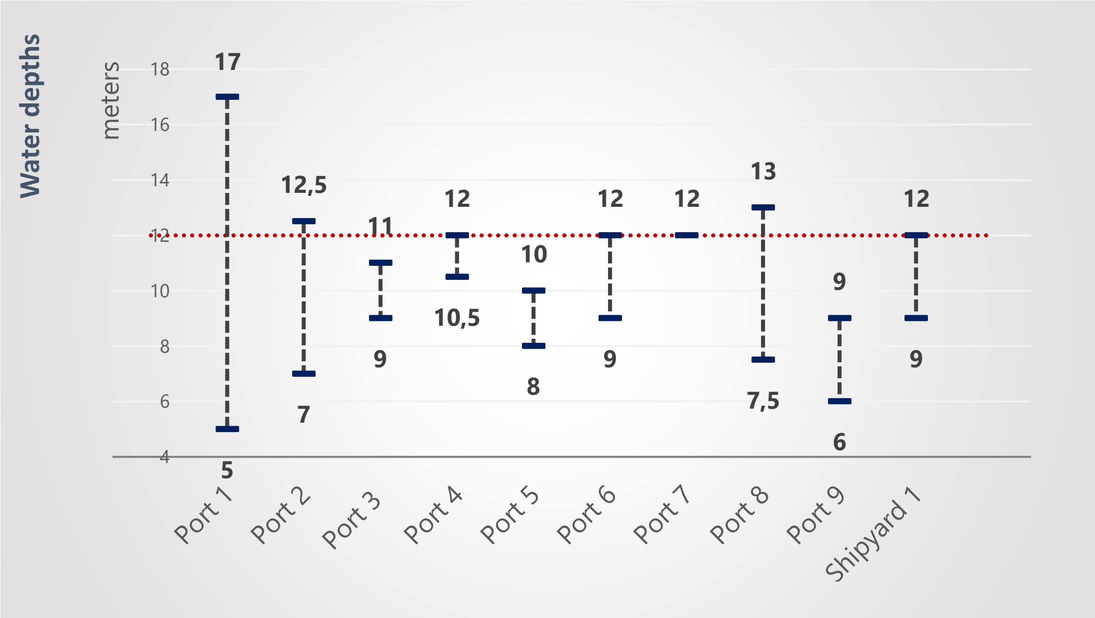
The availability of port space for staging needs, is portrayed in Figure 8:

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



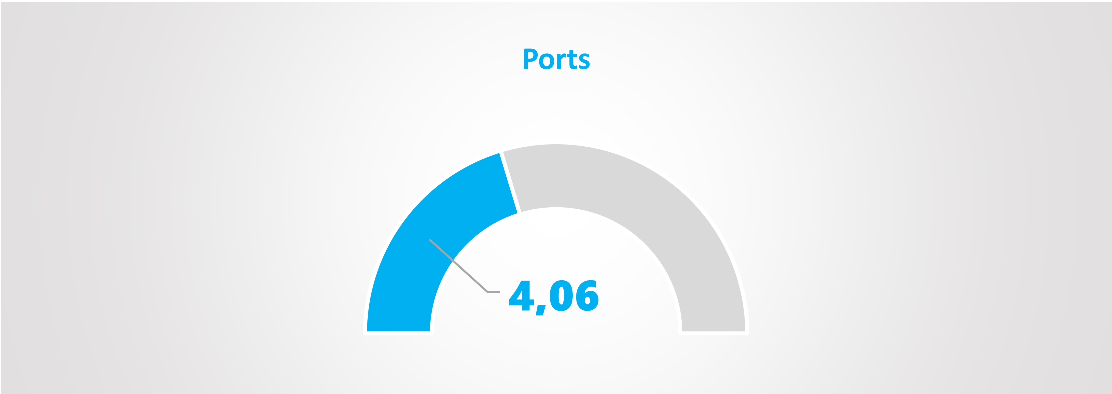
Finally, regarding the soil bearing capacity, most ports are not aware of it. This means that for the staging of the Offshore Wind Turbines to take place in the ports, geotechnical studies will have to be performed, before making any ground reinforcement works.

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:

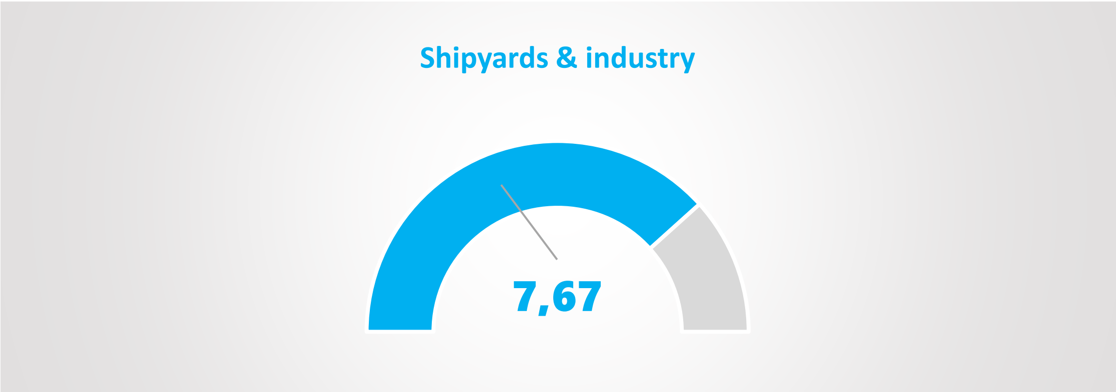
- Port authorities are currently focused on other, existing activities, which will compete with their involvement in the offshore wind industry, mainly due to limited space.
- In the ports that are under privatization there is uncertainty about the future, as the commercial strategy of the port will 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.

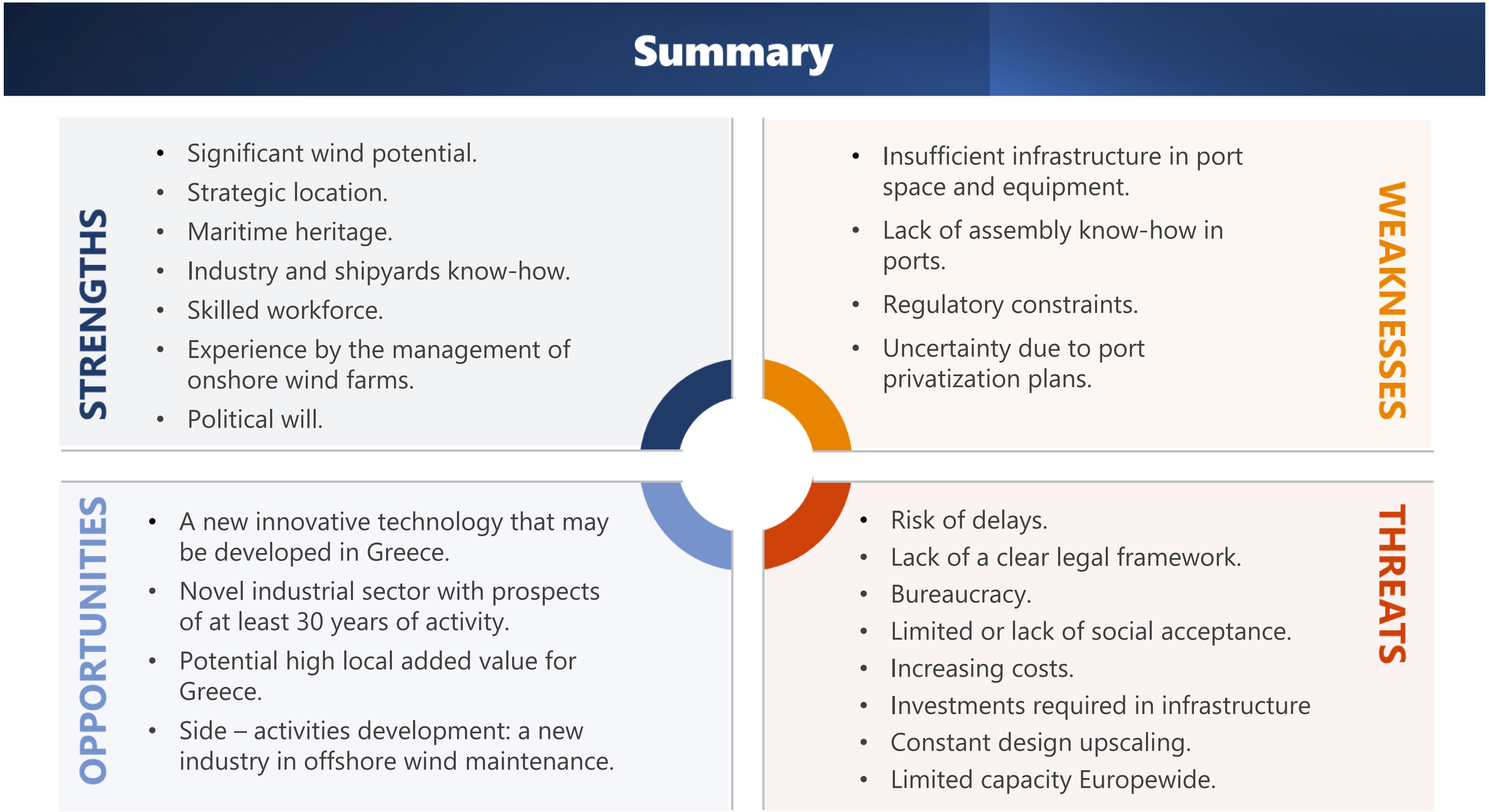
They recognize the significant opportunities to be active in the sector, as it concerns an innovative technology that domestic industry can support, with prospects for activity in the next 30 years and the potential for strong locally added value. In addition, there is also the possibility of developing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



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