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How important are ports for the offshore wind industry?: the case of Spain

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Abstract. Offshore wind is becoming a new technology to develop a better sustainable world. Its progress is linked to the use of port facilities, where the offshore wind farms can be stored or pre-installed. The aim of this paper is to analyse the storage space availability for ports in terms of being used for the new offshore wind sector. The case of study will be focused on analysing the port facilities in Spain, country with a great offshore wind resource in some specific areas. Results indicate the ports that can be used for the development of offshore wind in Spain. This work is important in order to establish a roadmap of the offshore wind business in Spain, which can repair the economic and social damaged due to SARS-CoV-2 pandemic.

Key words. offshore wind, offshore renewable energies, port, crane, surface.

1. Introduction

In the 90s there was an interest in the analysis of atmospheric pollution, trying to quantify and reduce the gases that modified the greenhouse effect. These gases are known as Greenhouse Gases (GHG) that cause global warming of the planet. In order to avoid global warming caused by anthropogenic causes, the well-known Kyoto Protocol was created in 1997 in Kyoto (Japan) [1]. This protocol has achieved that the governments that joined it established laws and policies to meet environmental objectives, that companies take the environment into account when making investment decisions and promote the creation of the carbon market, whose purpose is to achieve the reduction of emissions at the lowest cost. This was the starting point for GHG reduction [2,3], which was followed by numerous protocols and agreements. The last agreement was carried out in 2016 in Paris [4] and it was agreed that the increase in the temperature of the planet could not exceed 1.5º and for this in 2030 the GHG reductions should be 45% lower than in 2010 and in 2050 to achieve zero net emissions.

To achieve these objectives it is necessary to modify the way of obtaining energy, going from the use of fossil fuels to the use of renewable energies [5].

In this context, renewable energy sources have been used on the planet for different uses during centuries: agriculture, livestock, etc., but always in small farms. Nowadays, this use of renewable and inexhaustible energy needs to be done through power plants that supply energy in a great way.

This transition towards an energy system based on renewable technologies will have very positive economic effects for the global economy and development. According to IRENA (International Renewable Energy Agency) [6], reaching the Paris Agreement [4] requires doubling the share of renewable energy in electricity generation to 57% worldwide by 2030. This requires increasing annual investments in renewable energy from 330 billion dollars today up to 750 billion dollars, with

the consequent boost to job creation and growth linked to the green economy [7].

Within renewable energies, one of the ones that is taking the largest market is wind energy and as it is known, 70% of our planet is water, so it is not a mistake to think that most of the development of wind energy will take place through offshore wind farms.

This energy source has been introduced to the market through modern wind turbines in the 1980s [8], and the energy generated by each turbine has ranged from 450kW in the world's first wind farm (Towards 2000 [9]) in the United States to General Electric's Haliade X wind turbine with 12MW power [10].

This increase in the power of the turbines is associated with the sizes of all associated equipment: rotor, nacelle and substructure, reaching today heights of 260 m for the Haliade-X12MW, with rotor sizes of 220 m and a swept area of 36,000 m^2 [10].

Due to the sizes mentioned, these megastructures need to be manufactured in locations where road transport is minimal or null, since the most common way of transporting equipment for offshore installation is via barges, tugboats and other special vessels.

Regarding the development of offshore wind installation and maintenance, characteristics of ports and shipyards should be studied.

The layout of the installation port is an important issue in the offshore wind industry [11–13]. In this sense, several authors explain some aspects about it [14]. Akbari et al. [15] explain that the storage space availability, as part of a port's layout, as an importance of 0.289 under 1 regarding the criteria to select an installation port. They have analyzed several parameters related to ports and offshore wind to be installation port or maintenance port, such as: seabed suitability, component handling, quay length, quay load, port's depth, distance to offshore site, distance to key component supplier, distance to road, potential for expansion, component laydown area availability, storage and component fabrication facility. The storage space availability is crucial for the case of an installation port. Therefore, the aim of this paper is to analyze the storage space availability for the Spanish ports in terms of being used for the new offshore wind sector.

2. Methodology

The proposed method will be developed in the following steps:

- Calculate the number of offshore wind platforms of each type that can fit in each port.
- Analyze the most representative ports in Spain.
- Calculate the useful surface of the ports.
- Calculate the area occupied by each of the wind turbines.
- Divide the useful area of the port between the area of the wind turbines, taking into account the necessary spaces for their handling.

To calculate the surface of the platforms it has been simplified as follows: WindFloat and Zhizin Zhao Design have been simplified as a circle and for the NREL Spar and DTU as a rectangle

The work scenarios are as follows:

- Scenario 1 (S1): Semi-submersible WindFloat Platform with 5MW NREL turbine
- Scenario 2 (S2): NREL Spar platform with 5MW NREL turbine
- Scenario 3 (S3): ZHIZIN ZHAO DESIGN Semi-submersible platform with 10MW DTU turbine
- Scenario 4 (S4): DTU Spar platform with 10MW DTU turbine

Table I. Areas of platforms and turbines

S	platform AREA (m^2)	TURBINE AREA (m^2)	+50% maneuve-rability (m^2)
S1	4.536	858	2.697
S2	1.128	858	993
S3	9.840	1.931	5.885
S4	1.440	1.931	1.685

Considering Table I, the total Surface in m2 is shown in Table II.

Table II. Total area

SCENARIO	TOTAL AREA (m^2)
S1	8.092
S2	2.979
S3	17.656
S4	5.056

Figure I shows the Spanish ports considered for this study.

Figure I. Spanish ports.

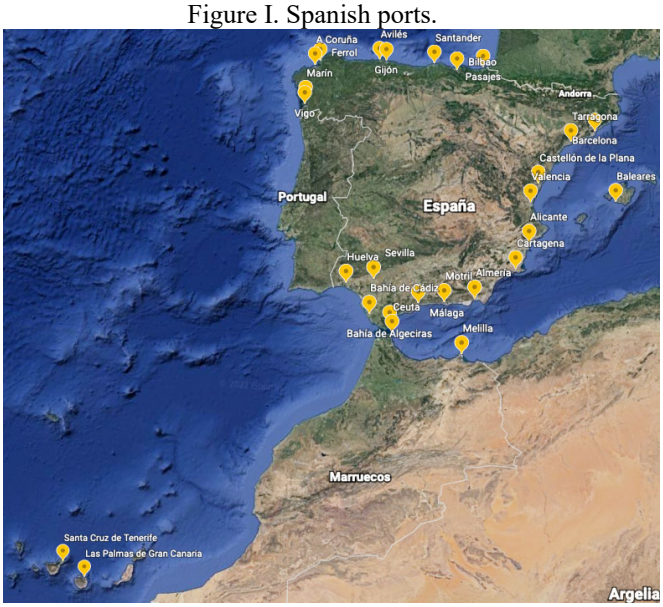


Table III shows the main Spanish ports with their main characteristics (location and uncovered area) [16–18].

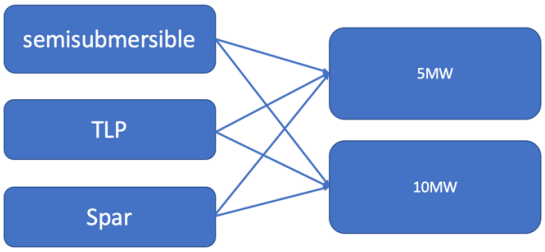
Table III. Port areas [16,17]

N	NAME	LOCATION	UNCOVERED AREA (m^2)
1	A Coruña	A Coruña	150.255
2	Alicante	Alicante	80.795
3	Almería	Almería	45.805
4	Avilés	Avilés	93.155
5	Bahía de Algeciras	Algeciras	241.390
6	Bahía de Cádiz	Cádiz	223.000
7	Baleares	Palma de Mallorca	247.687
8	Barcelona	Barcelona	554.965
9	Bilbao	Bilbao	201.420
10	Cartagena	Cartagena	119.495
11	Castellón	Castellón	135.500
12	Ceuta	Ceuta	34.770
13	Ferrol- San Cibrao	Ferrol	168.580
14	Gijón	Gijón	211.060
15	Huelva	Huelva	857.870
16	Las Palmas	Las Palmas de GC	251.765
17	Málaga	Málaga	59.535
18	Marín y Ría de Pontevedra	Marín	37.620
19	Melilla	Melilla	13.730
20	Motril	Motril	45.240
21	Pasaia	Pasaia	26.500
22	Santa Cruz de Tenerife	Santa Cruz de Tenerife	111.375
23	Santander	Santander	131.415
24	Sevilla	Sevilla	425.000
25	Tarragona	Tarragona	198.760
26	Valencia	Valencia	382.110
27	Vigo	Vigo	26.815
28	Vilagarcía de Arousa	Vilagarcía de Arousa	28.670

3. Case of study

Spain is a country with an important wind resource and a large coastal area. It has 28 main ports [16,17], being a country with great potential for the development of offshore wind energy. The platforms chosen for the study are the semi-submersible, the TLP and the spar in two different rated power: 5MW and 10MW, as shown in Figure II.

Figure II. Study alternatives



4. Results

Table IV, Table V, Table VI and Table VII show that the best four ports in terms of uncovered surfaces are: Huelva, Barcelona, Sevilla and Valencia.

Table IV. Number of floating offshore wind platforms and turbines in Scenario 1.

N	S1
15	106
8	68
24	52
26	47
16	31
7	30
5	29
6	27
14	26
9	24
25	24
13	20
1	18
11	16
23	16
10	14
22	13
4	11
2	9
17	7
3	5
20	5
12	4
18	4
21	3
27	3
28	3
19	1

Table V. Number of floating offshore wind platforms and turbines in Scenario 2.

N	S2
15	239
8	155
24	118

26	106
16	70
7	69
5	67
6	62
14	59
9	56
25	55
13	47
1	42
11	37
23	36
10	33
22	31
4	26
2	22
17	16
3	12
20	12
18	10
12	9
28	8
21	7
27	7
19	3

Table VI. Number of floating offshore wind platforms and turbines in Scenario 3.

N	S3
15	40
8	26
24	20
26	18
5	11
7	11
16	11
6	10
9	9
14	9
25	9
1	7
13	7
11	6
23	6
10	5
22	5
4	4
2	3
3	2
17	2
20	2
12	1
18	1
21	1
27	1
28	1
19	0

Table VII. Number of floating offshore wind platforms and turbines in Scenario 4.

N	S4
15	141
8	91
24	70
26	62
16	41
7	40
5	39
6	36
14	34
9	33
25	32
13	27
1	24
11	22
23	21
10	19
22	18
4	15
2	13
17	9
3	7
20	7
18	6
12	5
21	4
27	4
28	4
19	2

5. Conclusion

Offshore renewable energies, such as offshore wind, are becoming a new technology to develop a better green world.

Its growth is associated to the use of port facilities, where the offshore wind farms can be stored or pre-installed.

The objective of this paper was to study the storage space availability for ports in terms of being used for the new offshore wind industry.

The case of study has analysed the port facilities in Spain, country with a great offshore wind resource in some specific locations.

Results indicate that the ports of Huelva, Barcelona, Sevilla and Valencia are the most adequate in terms of storage space availability for developing offshore wind. However, it is important for future research analysing if these ports are close to shipyards and if they are located in areas with a great offshore wind resource.

This paper is important in order to carry out a roadmap of the offshore wind sector in Spain, which can repair the economic and social damaged due to SARS-CoV-2 pandemic.

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