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Spanish Facilities For Developing Photovoltaic Offshore Energy

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Abstract. This paper aims to create a list of possible shipyards and ports located within Spanish territory with the capability to build offshore solar platforms and the ability to store, prepare and move these structures once built, respectively. As such, a set of characteristics will be identified with each port and shipyard that will help recognize which is more suitable for any given scenario of installation site and platform. This will assist future projects in its development as a guiding resource that will help attract and facilitate the growth of this industry in Spanish marine territory.

Key words. Port; Shipyard; Photovoltaic; Solar; Offshore; Energy

1. Introduction

The energy transition towards systems based on renewable energy sources is one of the major technological, economic, and logistical challenges of the 21st century [1]. In this context, marine solar energy, including both floating photovoltaic installations and solar infrastructure associated with coastal and offshore environments, is emerging as a strategic alternative to diversify the energy mix, reduce pressure on land use, and harness the high solar potential of maritime and coastal areas [2]. However, the large-scale deployment of this type of infrastructure depends not only on technological advances in energy generation but also on the existence of robust and efficient logistical systems that enable its manufacturing, assembly, transport, installation, operation, and maintenance [3].
Ports and shipyards play a central role within this logistical value chain [4]. Traditionally linked to maritime trade, shipbuilding, and the offshore industry, these infrastructural nodes are undergoing a functional transformation to adapt to the new demands associated with marine renewable energy. In particular, ports act as multifunctional logistics platforms that concentrate key activities such as the storage of large components, the pre-installation and assembly of solar systems, and the coordination of specialized maritime transport to the installation sites. Shipyards, for their part, contribute critical industrial capabilities related to the construction, adaptation, and maintenance of floating structures, support vessels, and specific technical solutions necessary for the implementation of solar energy projects in marine environments.

The efficient integration of ports and shipyards in marine solar energy logistics not only helps reduce operating costs and execution times but also increases the reliability and safety of projects, aspects that are especially relevant in maritime environments characterized by complex environmental conditions. Furthermore, this integration generates opportunities for regional economic development, fosters technological innovation, and reinforces the role of port systems as key players in the sustainable energy transition [5].

Although marine solar energy is still at an early stage globally, several ports have already begun to experiment with floating photovoltaic systems, illustrating their growing logistical and technological relevance. European facilities such as Rotterdam or Antwerp-Bruges have hosted pilot platforms within port basins, using their infrastructure for assembly, testing, and maintenance. Similar initiatives have emerged in Singapore and Portugal, where ports are assessing their capacity to support offshore solar pre-assembly. In Spain, although large-scale offshore solar projects have not yet been deployed, ports such as Valencia, Ferrol, and Las Palmas have conducted preliminary studies and shown interest in integrating renewable-energy–related activities—including floating PV prototypes and multipurpose logistics for offshore technologies—taking advantage of existing synergies with the offshore wind and shipbuilding sectors. These developments highlight an incipient but clear trend toward the involvement of Spanish port infrastructures in future marine solar supply chains.

This study seeks to identify and evaluate shipyards and ports within Spanish territory that have the capacity to construct offshore solar platforms, as well as the facilities required to store, prepare, and transport these structures after construction. To this end, a set of key characteristics will be defined for each port and shipyard, enabling the assessment of their suitability for different installation scenarios and platform types. The results are intended to support future projects by providing a reference framework that facilitates development, attracts investment, and promotes the growth of the offshore solar industry in Spanish marine waters.

2. Methodology

In this section, both the methodology and the resources used in order to define the characteristics of shipyards and ports will be explained.

The methodology adopted in this study is designed to provide a systematic and comparable assessment of the suitability of Spanish ports and shipyards for the construction, handling, and deployment of offshore solar platforms. To achieve this, the approach integrates multiple data sources, technical criteria, and analytical procedures that allow both infrastructures to be evaluated not only in terms of their physical characteristics but also according to their potential operational roles within the offshore solar value chain. The analysis follows a structured sequence that includes data compilation, verification and harmonisation, definition of evaluation parameters, and the categorisation of facilities according to their logistical and industrial capacity. This comprehensive framework ensures that the assessment reflects the real conditions under which ports and shipyards would be used in future offshore solar deployment scenarios.

A. Ports

Ports are defined by law [6] as a set of land areas, maritime waters and installations which are located on the seashore or estuaries, that meet the physical, natural or artificial and organisational conditions which allow port traffic operations to be carried out, and which are authorised by the competent Administration for the development of these activities.

The National Geographical Institute (IGN) [7] provides access to information on the location, shape and status of Spanish ports. The ports documented include those located in the Iberian Peninsula, the Balearic Islands, Ceuta, Melilla and the Canary Islands, although it should be noted that not every port [8] contains the same information. Note that data such as the port's draft and the available surface area may not be available in most cases.

However, when considering the already mentioned Royal Decree 2/2011 of 5 September [6], it is important to note some further distinctions. Firstly, the minimum water surface area required for a port is half a hectare, a space which is sufficient when evaluating most of the currently available offshore solar platforms. Furthermore, these platforms may only require port call operations in these areas, as the construction process must be conducted in shipyards, thereby minimising its impact on regular activities. Secondly, these operations can only be conducted in non-marinas and non-fishing ports, as the primary function of these areas is to provide the necessary services for private small-scale vessels and fishermen.

The 2023 Statistical Yearbook of the State-Owned Port System [8] is another reliable source of information regarding Spanish ports. This publication provides detailed data on the infrastructure of every port under the jurisdiction of the state.

These ports are considered important assets for the Spanish economy due to their size, location or infrastructure. Therefore, they can be regarded as the ports most capable of providing the services needed for the transportation of offshore solar platforms. While these ports may have the capacity to offer repair and construction services, this analysis will not delve into that aspect for the sake of simplicity.

This report provides essential information for both ports and port authorities. Ports are described by their location in longitude and latitude, the main winds affecting the area, both the highest wave height and maximum tide race, the limits of entrance of the canal in width and draft, the limits of entrance of the mouth of the canal in width and draft and controlled water currents in the area. Port authorities are described by their water areas, available private and public quays and their use, land areas, number and capacity of dry and floating docks, slip ways and shipyards, types and capacity of available cranes, both public and private, and tugs.

B. Shipyards

Shipyards are facilities specialised in the construction, repair or dismantling of ships or floating structures. Consequently, they will be the sites responsible for manufacturing any offshore solar platform. This will necessitate sufficient clear space for the storage and manufacturing of the platforms, as well as the necessary resources, such as cranes or dedicated workshops.

The shipyards under consideration for this analysis are primarily included in the 4th Quarter Report of 2024 [9] provided by the Ministry of Industry and Tourism. Additionally, other shipyards were considered, primarily located on the east coast of Spain, as they were not included in this report despite having been considered by the port authority.

The characteristics considered include the calculation of the area belonging to the shipyard, the analysis of the amount and type of cranes available to the shipyard, as well as the number and capacity of slipways, docks and quays. In instances where the necessary information was not available on the shipyard's webpage, a combination of a Geographic Information System (GIS) program, Google Maps and Google Earth was utilised to derive an estimated value for comparison.

3. Results

In this section, a general overview of the results obtained from both ports and shipyards will be given, explaining mainly the relevant characteristics of said sites.

A. Ports

As previously mentioned, the IGN cartographic information [7] serves as a starting point for this project. A total of 322 ports will be considered at the initial stage of the project. Of these, 30 are designated as marina ports, with 6 allocated for fishing. This leaves a total of 284 ports available for general use as shown in **Fig. 1**.

Fig. 1. Location of Spanish ports.

With reference to the five Spanish marine subdivisions as set out in the maritime spatial plan [10], the following distribution of ports is observed. The North Atlantic subdivision comprises 118 ports, the South Atlantic subdivision 18, the Strait and Alboran subdivision 19, the Levantine-Balear subdivision 96, and the Canary subdivision 33.

If only those ports overseen by state authorities are taken into consideration, the total number of ports is significantly reduced to 52, as illustrated in **Fig. 2**. The distribution of ports according to the POEM (Plan de Ordenación del Espacio Marítimo – MSP, Maritime Spatial Planning) is as follows: the North Atlantic subdivision comprises 13 ports, the South Atlantic subdivision 6, the Strait and Alboran subdivision 7, the Levantine-Balear subdivision 14, and the Canary subdivision 11. Please refer to **Table I** for a detailed description of the characteristics of these ports.

Fig. 2. Location of State Authority Ports.

B. Shipyards

A combination of both the 4th Quarter Report of 2024 [9] provided by the Ministry of Industry and Tourism and the data publicly available in the Spanish Observatory of Transport and Logistics (OTLE) [11] was used to establish a minimum number of shipyards to consider. Thirty-three shipyards were considered in total, of which six are in the public sector. Their locations are indicated in Fig. 3.

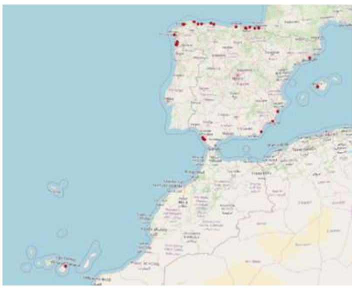

Fig. 3. Location of State shipyards analysed.

When evaluating the capabilities of shipyards, it is important to note that only 13 of them have the resources to undertake this type of project. It is possible to categorise other five shipyards as capable, provided that some significant modifications are carried out. The remaining shipyards are unable to complete the project due to a lack of available space for construction, the necessary workshops, or a specialisation in yachts or repairs. This is further explained in **Table II**.

Although this prospect is promising, currently there are only two shipyards who produced offshore renewable energy structures. These include Navantia shipyard located in Fene, which was tasked with the production both fixed (monopiles and jackets), submersible and floating (spar) structures [12] for offshore wind, and Astican shipyard located in Las Palmas de Gran Canaria, which produced other smaller offshore wind protypes [13].

4. Conclusions

Spain currently possesses the resources needed for the manufacturing and transportation of offshore solar platforms. However, as this technology continues to evolve, its capacity may become inadequate.

Despite the fact that Spanish ports are well spread across the Spanish coastline, Spanish shipyards are different since more strict measures need to be considered whenever evaluating its validity for manufacturing offshore solar platforms. Specifically, the absence of shipyards in the Strait and Alboran subdivision, and in the north of the

Levantine-Balear subdivision, represents a notable disadvantage. Similarly, only shipyards with access to the Atlantic Ocean were able to produce offshore energy platforms, completely disregarding the high energy resource and available surface located in the Mediterranean Sea. Furthermore, a discrepancy becomes apparent when considering port location and its distribution on the five Spanish marine subdivisions described in the POEM. It should be noted that the location of ports is more dependent on the length of the coastal region than its total surface area. However, this difference must be considered when planning the widespread installation of solar offshore technology. Additionally, not all of these ports have a draft deep enough to allow the storage or transportation of some offshore solar platforms, which further limits the selection.

Consequently, the selection process becomes highly contested near the Iberian Peninsula. If the objective is to reduce transportation and dismantling costs, the energy production through the life cycle of the platform will decrease, and vice versa. In contrast, the Canary Islands do not face this issue, as one of their shipyards has already demonstrated its capacity to undertake such projects, and their port infrastructure is sufficiently robust to support these processes. However, it should be noted that the available area of installation on the Canary Islands is considerably smaller than that of the Spanish coast, and their energy requirements are also lower.

Despite these considerations, it is important to note that these conclusions should not be viewed as a deterrent, as Spain is well-positioned for solar offshore development and installation, given its existing infrastructure and strategic location. While further investment may be required, the potential benefits of solar offshore energy are significant, making it a worthwhile investment prospect.

Overall, the results of this study provide a practical decision-making framework for identifying the most suitable Spanish ports and shipyards for offshore solar development. In practice, the findings can be used by port authorities, shipyard operators, project developers and policymakers to prioritise upgrades, optimise logistical planning and anticipate infrastructural bottlenecks during future deployment phases. The analysis largely meets the initial expectations by confirming that Spain already has a solid industrial and logistical base to support offshore solar expansion, while also highlighting the geographic imbalances and technical limitations that must be addressed to ensure large-scale feasibility. These insights open several avenues for future research, including a more detailed techno-economic assessment of platform transport and assembly routes, the integration of offshore solar with existing offshore wind or aquaculture infrastructures, and scenario-based simulations that consider climate, regulatory and market uncertainties. As offshore solar technologies mature, periodic updates of this assessment will be essential to track infrastructural evolution and guide strategic investment decisions.

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Table I. - Some relevant characteristics of each port overseen by state authority.

PORT AUTHORITY	PORT	GENERAL CONDITIONS									SURFACE	
		Wind		Maximum Wave Height (m)	Maximum Tide Range (m)	Entrance Conditions: Channel		Entrance Conditions: Mouth		Recorded Current (knots)	Not Used (m2)	Total (m2)
		Prevailent	Dominant			Width (m)	Depth (m)	Width (m)	Depth (m)			
A Coruña	A Coruña	S	SSW	10,43	4,5	600	23,5	800	21	0	1680366	3307305
	A Coruña (Outer port Langosteira)	NE	SW	12,54	4,35	400	22,5	520	22,5	0,43		
Alicante	Alicante	E7ºS	E7ºS	6,82	—	500	15	350	15	—	1083245	1624347
Almería	Almería	SW	SW	4,75	0,63	200	13	300	13	—	757619	1335665
	Carboneras Holcim (Spain) S.A.	SW	SW	7,1	0,385	—	—	320	17	—		
	Carboneras Endesa Generación S.A.	W/SW	EN	7,1	0,385	—	—	490	19	—		
Avilés	Avilés	NW	NW	9,03	4,6	82	12,75	223-103	12,75	2,25	34628	608417
Bahía de Algeciras	Bahía de Algeciras	NW	SE	3,88	1,26	—	—	665	16	3	1624015	5815913
Bahía de Cádiz	Tarifa	NW y E	NO y E	3,66	1,62	185	10	100	7	—	915971	4365083
	Cádiz	E/SE	E/SE	—	3,67	250	13	300	11,5	2		
	Zona Franca	E/SE	E/SE	—	3,67	150	9	160	8,5	2		
	Cabezuela - Puerto Real	E/SE	E/SE	—	3,67	250	13	—	—	—		
	El Puerto de Sta. María	WSW y WNW	E/SE	5	3,67	80	3	100	3	2		
Baleares	Palma de Mallorca	S y SW	S y SW	5,94	0,8	—	—	790	16	—	1037907	1993774
	Alcudia	S	E	6,25	0,8	—	—	220	7	—		
	Mahón	SW	NE	5,3	0,8	180	15	180	15	—		
	Ibiza	W	SE	6	0,8	—	—	220	8,5	—		
	La Sabina	W	SE	4,36	0,8	—	—	150	5	—		
Barcelona	Barcelona	SW	NE	3,81	—	926	50	520	16	—	3614003	11488829
Bilbao	Bilbao	NW	SW	19	—	375-500	14-30	500	30	—	233305	4141926
Cartagena	Cartagena	SSW	SSE	8	0,95	—	—	250	11,5	—	1590608	2406441
Castellón	Castellón	N/NW	N/NE	3,63	0,7	400-735-376	17	346	17	—	1655515	2771586
Ceuta	Ceuta	E	SE	3,7	1,14	—	—	300	18	—	534583	830445
Ferrol-San Cibrao	Ferrol (Inner Port)	ENE	W	7,79	4,46	160	11,3	546	20	—	2144138	3162706
	Ferrol (Outer Port)	ENE	W	7,79	4,46	—	—	546	20	—		
	San Cibrao	E	W	4,88	4,63	546	16,7	305	20	—		
Gijón	Gijón (Musel)	SW/NE	NW	5,92	4,36	490-1080	>20,00	840	25	—	1860942	4034357
Huelva	Huelva	NW	SW	4,42	3,6	200-300	13	300	13	5	14988594	17821556
Las Palmas	Las Palmas	NW	NE a NW	14,9	3	745	30	500	23	<1,00	1073284	5017234
	Arrecife	NW	NE a NW	7,9	3	—	—	150	14	<1,00		
	Puerto Rosario	NW	NE a NW	11,12	3,15	—	—	400	25	<1,00		
	Salinetas	NW	NE a NW	—	3	—	—	—	15	<1,00		
	Arinaga	NW	NE a NW	—	3	—	—	—	15	<1,00		
Málaga	Málaga	SE/SW	SE	4,67	0,8	—	—	345	17	—	382962	1190723
Marín y Ría de Pontevedra	Marín y Ría de Pontevedra	S/SSW	NNE	8,85	3,81	—	—	5500	60	2	470923	769991
Melilla	Melilla	NW	NE	7,32	0,96	—	—	515	12,5	—	225741	274646
Motril	Motril	W	E/SE	4,64	0,7	259	14	250	14	—	137881	905040
Pasaia	Pasaia	W/NW	W/NW	9	5	80-120	10	180	20	0,5	72997	646118
Santa Cruz de Tenerifa	Santa Cruz de Tenerife	NE	SW	2,44	—	100-400	40-120	127-675	6-55	2,7	861869	2227552
	Los Cristianos	NW	SE	—	—	200	20	300	10	1		
	San Sebastián de la Gomera	NE	SW	—	—	400	30	240	18	2,5		
	Santa Cruz de la Palma	NE	SE	2,7	2,5	750	40	350	20	1		
	La Estaca	NE	SW	—	—	150	25	150	20	1,5		
	Granadilla	NE	NE	—	2,36	200	24	315	26	—		
Santander	Santander	W/NW	NW/S-SW	—	—	150-400	11,5-12	1700	18	0,29	1293170	2644819
Sevilla	Sevilla	S/SW	S/SW	—	3,7	100	7,2	39	11	—	5218645	6864680
Tarragona	Tarragona	NW	NW	—	—	—	20,00-25,00	570	20,00-25,00	2	983004	3991036
Valencia	Valencia	SE	NE 1/4E	4,63	0,76	500	18,5	260	18,5	—	1530366	7673215
	Sagunto	SE	NE 1/4E	3,93	0,48	180	17,5	350	17,5	—		
	Gandía	SE	NE 1/4E	5,45	0,72	75	11	130	10	—		
Vigo	Vigo	SW	W/SW	1,75	4	740	38-23	2222-2037	38-23	3	49131	1024949
Vilagarcía	Vilagarcía	N y SW	N,WNW y SW	5,76	4,21	110	9	200	9	1	185433	571891

Table II. - Some relevant characteristics of each port overseen by state authority.

Shipyard	Validity	Comment
Armon Navia	Yes	It has sufficient open area, although it needs some refurbishment in order to be able to build certain platforms.
Armon Burela	No	Its entire surface is covered, so it would not be able to build most platforms.
Armón Vigo	No	It lacks the necessary features, with almost everything being covered.
Armón Gijón	Yes	Spacious shipyard with sufficient open space.
Armon Ría de Vigo	Yes	It has both sufficient surface area and the structures to assemble it.
Gondán Castropol	Yes	There is enough space available, although it would be necessary to adapt the area of the stands for the construction of the platforms or to make some accessible land available.
Murueta Erandio	No	It has sufficient surface area, but it would be mandatory to adapt the stands to the construction of the platforms.
Murueta Bilbao	Yes	It has both available open space and the resources to build it.
Zamakona Bilbao	No	Almost the entire surface is occupied by stands.
Zamakona Pasaia	Yes	It would need some restructuring for the construction of platforms, although it has sufficient surface area.
RepNaval Las Palmas	No	Almost the entire surface is occupied by stands.
Ría de Avilés	Yes	It has both available open space and the resources to build it.
Cardama Vigo	No	Its entire surface is covered or occupied by stands.
Balenciaga Zumaia	Yes	It would need some restructuring for the construction of platforms, although it has sufficient surface area.
Astilleros de Mallorca La Palma	No	Its entire surface area is occupied by stands and it specialises in yachts.
Astilleros de Mallorca Reparación	No	Despite having sufficient surface area, only yacht and boat repairs are carried out.
Astilleros de Mallorca / Freire Vigo	No	Its entire surface area is occupied by stands or halls, although it may have sufficient surface area if it is restructured.
Astander Santander	Yes	Its surface area is sufficient and it has the resources.
Astican Las Plamas	Yes	Similar structures have already been built.
Metalships and Docks Vigo	Yes	Its surface area is sufficient and it has sufficient resources.
Nodosa Marín	No	Its surface area may be very limited, although it can be utilised if the yard is restructured.
Blascar Ferrol (La Graña)	No	Its entire surface is covered or occupied by stands.
Navantia Ferrol	Yes	Its surface area is sufficient and it has sufficient resources.
Navantia Fene	Yes	Similar structures have already been built.
Navantia Cádiz	Yes	Its surface area is sufficient and it has sufficient resources.
Navantia Puerto Real	Yes	Its surface area is sufficient and it has sufficient resources.
Navantia San Fernando	Yes	Its surface area is sufficient and it has sufficient resources.
Navantia Cartagena	Yes	Its surface area is sufficient and it has sufficient resources.
Astilleros San Enrique Vigo	Yes	It has sufficient surface area, although it currently has only a small usable area.
Astilleros y Varaderos Lago Abeijon La Coruña	No	Not enough usable area.
Astondoa Santa Pola	No	It specialises in yachts.
Astillero y varadero de Carboneras	No	It does not have sufficient surface area.
Isonaval Barcelona	No	It has the surface area, but lacks the resources. Moreover, they specialise in yachts.