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Location feasibility of a floating photovoltaic plant in inland waters. The case study of Lago de As Pontes in Spain.

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Abstract. The progressive closure of coal-fired power plants driven by decarbonisation policies is increasing the need to identify low-carbon alternatives that can be rapidly deployed. In this context, floating photovoltaic systems in inland bodies represent a solution because they can make use of lakes and reservoirs, minimising land-use conflicts. This study evaluates the suitability of a lake as a potential FPV location through analysis legislative, technical, sociopolitical and environmental factors for the project. The results determined that Lago de As Pontes is a good location for a floating solar farm in Galicia. Future work will involve sizing the plant and studying its technical and economic feasibility.

Key words. Floating photovoltaic, FPV, inland waters, onshore renewable energy, solar farm

1. Introduction

The European Union decided to close numerous power plants in order to reduce emissions by 45% by 2030 and achieve net zero by 2050 [1]. These targets are set out in the Paris Agreement of the 2015 United Nations Climate Change Conference (COP21).

The Paris Agreement states that the energy sector is currently responsible for three-quarters of greenhouse gas emissions [1] and 90% of CO2 emitted into the atmosphere [2]. As a solution, it establishes replacing energy production with fossil fuels (coal, gas, and oil) with renewable energy systems, such as wind and solar [1], which emit little or no pollutants into the atmosphere and do not come from exhaustible sources [2].

As a result, failure to meet the objectives of the Paris Agreement will lead to the following climate impacts: rising temperatures; droughts and floods; forest fires; sea level rise; freshwater scarcity; changes in biodiversity and soil composition; acidification of seas and oceans; and changes in ocean currents and wind patterns [3]. As a result, we are seeing more extreme weather events that threaten life on Earth as we know it today.

That is why it is necessary for all countries to move in the same direction until their energy production comes entirely from clean and renewable sources. This is the priority of the 29th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP29), held in November 2024 in Azerbaijan. The conference addressed the issue of financing for countries to ensure that they have the appropriate means to carry out the necessary measures to mitigate the global climate crisis [4].

The purpose of this study is to evaluate the suitability of each lake as a site for installing floating photovoltaic farms and to contribute to the introduction of floating solar energy in inland waters as part of Galicia's energy transition.

2. Methodology

To determine the feasibility of the location, an analysis will be carried out to determine whether the selected area is located in an exclusion zone, and various technical and socio-political factors that influence the choice of site will be studied. Subsequently, the impact of the location on the viability of the project will be determined.

1) *Determination of exclusion zone or not.*
First, it is examined whether the lake is classified as an exclusion zone for the installation of a floating photovoltaic plant. The analysis takes into account environmental, cultural, legislative, and technical aspects.

2) *Site assessment.*
After concluding that it is not classified as an exclusion zone, the suitability of planning an FPV plant in that location is assessed. The analysis is based on the criteria established in [5].

The technical assessment of the photovoltaic plant's location includes key aspects such as the conditions of the water body, proximity to logistics and electricity distribution infrastructure, and the potential of the energy resource. The location of the farm must take into account its proximity to both an electrical substation and transport infrastructure, as both factors have a significant impact on the costs and logistical feasibility of the project. Specifically, proximity to a terrestrial substation reduces the amount of cabling required to evacuate the plant.

Sociopolitical factors are fundamental in selecting the location of a floating renewable energy facility. In this regard, community perception and institutional commitment directly influence the viability of the project.

3) *Impact of location on the project.*
Finally, the impact of each of the above criteria on the project is determined. The impact will be classified as determined Table I.

Table I. – Impact categories. Source: authors' own elaboration based on [6].

IMPACT	DESCRIPTION
Positive	The aspect studied favors the choice of the lake as location.
Potentially negative	The variable is outside the standards, so it may have a potentially negative impact on the project.
Negative	The criterion negatively affects the photovoltaic plant.
Insufficient information	Specific studies are needed to determine the impact on the farm.

3. Case study: Lago de As Pontes floating photovoltaic farm

The application to Lake As Pontes responds to the objective of compensating for the loss in energy production suffered by the Galician community as a result of the closure of the thermal power plant in the Eume region.

Lake As Pontes, created from the controlled flooding of the former coal mines of the municipality's thermal power plant, has taken on a new role since the closure of the power plant in 2023. It was closed because, in 2018, the As Pontes thermal power plant ranked 17th in the European Environment Agency's ranking of the most polluting companies in Europe and first in Spain [7].

This natural setting (see Fig. 1) not only offers opportunities for designing floating photovoltaic platforms, but in recent years has also been transformed into a recreational space that attracts tourism and boosts the local economy.

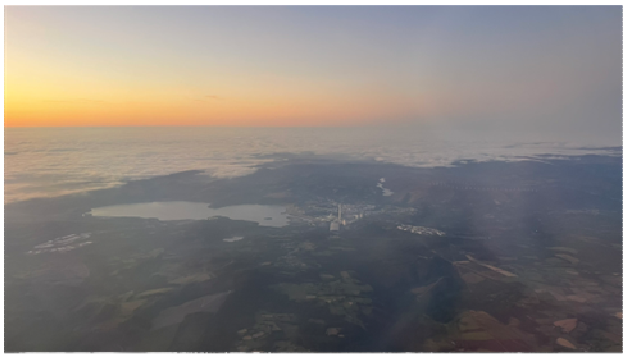

Fig. 1. Overview of Lake As Pontes. Source: authors' own elaboration.

Located in the municipality of As Pontes in the north-west of the province of A Coruña (see Fig. 2), it is one of the largest artificial lakes in Spain by surface area. It covers approximately 865 hectares and has a storage capacity of over 547 hm^3 [8]. Table II shows its most significant characteristics.

Fig. 2. Location of the lake. Source: authors' own elaboration based on [9].

Table II. – Summary table of the most significant characteristics of Lago de As Pontes. Source: authors' own elaboration based on [8].

VARIABLE	VALUE
Perimeter	18 km
Surface	8,65 km^2
Maximum depth	205 m
Volume of water	547 hm^3

The history of the lake dates back to the Paleolithic period, 30 million years ago, when this area was a lagoon in which plant and organic material accumulated, eventually becoming a lignite deposit [10,11]. Over time, it became the largest open-pit mine of this type of coal in Galicia [12]. The mine was used to extract lignite, a type of fossil coal that fueled the As Pontes thermal power plant.

Mining began in the 1940s with the Empresa Nacional Calvo Sotelo [6], and with the challenge of boosting its economic performance, Endesa took control in 1972 [10]. It remained in operation until 2008 due to the tightening of European regulations on emissions reduction, at which point it was decided to transform the site into a biological reserve [10].

Studies carried out in recent years have revealed that there are more than 205 species of vertebrates and 200 species of plants [13]. This makes Lake As Pontes a vast natural area where the lake's aquatic ecosystem coexists with the ecosystem of the surrounding mountains and meadows [8].

This rehabilitation demonstrates that it is possible to achieve the sustainable transformation of an industrial environment if it is approached in a planned manner and with a focus on protecting the environment [10].

The floating photovoltaic plant will be located within the lake in the area shown in Fig. 3, whose coordinates are listed in Table III. This region was chosen because it is the furthest from the town center and the beach, as well as being the deepest part of the lake. It will have a capacity of 2 MW.

Fig. 3 – Location of the photovoltaic farm. Source: authors' own elaboration.

Table III. – Coordinates of the photovoltaic farm location. Source: authors' own elaboration.

POINT	COORDENATES
P1	43° 28' 16.159'' N – 07° 53' 38.058'' O
P2	43° 28' 28.184'' N – 07° 54' 07.561'' O
P3	43° 28' 19.092'' N – 07° 54' 26.556'' O
P4	43° 28' 01.786'' N – 07° 53' 55.436'' O

4. Results

First, it was examined whether Lago de As Pontes is classified as an exclusion zone for the installation of a floating photovoltaic plant. The analysis takes into account environmental and cultural, legislative, and technical aspects. Table VI shows the results.

Table VI. – Classification of the site as a non-exclusion zone. Source: authors' own elaboration.

	YES	NO
Legislative aspect		X
Environmental and cultural aspects	X [(1)]	
Technical aspect		X
[(1)] *Permission must be sought from the competent environmental agency.*		

After concluding that Lake As Pontes is not classified as an exclusion zone, the factors that assess the suitability of designing a FPV plant in that location are analyzed.

The results of the technical criteria studied are:

- Conditions of the body of water. According to the longitudinal profile of the lake, there are areas where the depth reaches 205 meters [14], so despite being an artificial body of water, it has a considerable depth that must be taken into account when installing the floating platforms and carrying out the electrical installation of the plant. As mentioned in section 3, the available water surface area is approximately 8 km^2, making it feasible to install a 2 MW photovoltaic farm. It is also important to note that at this site, the effect of corrosion on the floating platform, as well as on the rest of the plant's components, caused by salt water and biofouling, is not as significant because it is a freshwater lake.
- Energy resource potential. The location of As Pontes is classified as an area with very low photovoltaic resources compared to the national average [15]. However, it is important to note that there are specific climatic factors that significantly influence the efficiency of photovoltaic panels: average temperature [16,17] and wind speed. In terms of average temperature, As Pontes has low values in both summer (16°C [18]) and winter (9°C [19]). With regard to wind speed, the location on Lago de As Pontes provides moderate wind conditions (6 m/s [20]). These values favor the natural cooling of the modules. Additionally, the floating nature

of the installation introduces an extra benefit: passive cooling provided by the water. This feature not only helps to reduce the temperature of the panels but also prevents them from becoming dirty and increases their efficiency.

- Proximity to logistics and electrical infrastructure. From an electrical standpoint, Red Eléctrica España has a substation in As Pontes with a 400 kV line [15]. In terms of logistics, the lake is strategically located in relation to the Port of Ferrol and the Navantia shipyard. The Seanergies division of the aforementioned public company contributes to the construction of components for offshore wind farms, so its experience in the sector can be used to manufacture components for floating solar platforms. If foreign materials are required or the platform is not locally built, As Pontes has a direct connection to the Outer Port of Ferrol via the N-655 and AG-64 roads. These infrastructures are suitable for the transport of large special loads, as they were used by Gamesa to transport the wind turbine blades it manufactured in As Somozas to the Outer Port of Ferrol.

The results of the socio-political criteria studied are:

- Social acceptance. This project represents an opportunity to revitalize the local economy in a context marked by the closure of the thermal power plant and could contribute significantly to the creation of direct and indirect employment. This concern, together with growing awareness of the global energy transition, suggests that the local population will support the project. The most controversial aspect lies in the visual impact that the floating platforms may have on the lake environment. However, the project takes this problem into account and, in the plant design process, a location was selected that reduces the impact by placing it in the area furthest from the neighboring population centers. In addition, the plant must be sized to comply with current regulations governing the percentage of lake surface area occupied by the PFV plant based on the eutrophic condition of the lake [21].
- Political aspects. There are solid policies at the state and regional levels that promote the installation of renewable energies, such as the PNIEC, the Roadmap for Offshore Wind and Marine Energy, and the Axenda Enerxética de Galicia 2030. All these measures are aligned with the climate objectives of the United Nations and the European Union. However, as noted at COP29, the lack of funding is a significant obstacle, hindering the development of floating photovoltaic energy projects in inland waters.

Table V summarizes all the criteria studied regarding the location and determines their impact on the project.

Table V. – Impact of location on the project. Source: authors' own elaboration.

TECHNICAL CRITERIA	IMPACT [1]
Energy resource potential	
Potential	
Average temperature	
Wind speed	
Proximity to logistics and electrical infrastructure	
Logistical proximity	
Proximity to the electrical grid	
Water body conditions	
Depth	
Corrosion	
Available water surface area	
Bed conditions	

SOCIOPOLITICAL CRITERIA	IMPACT [1]
Social acceptance	
Benefits to the local economy	
Visual impact	
Conflict with tourism and recreational activities	
Social awareness	
Politics	
Government policies	

[1] *Classification of impacts: positive, potentially negative, negative and insufficient information available.*

4. Conclusion

Based on the criteria analyzed, it is concluded that the implementation of a floating photovoltaic farm on Lago As Pontes is feasible from a location standpoint, although it requires specific administrative and technical considerations. As it is a protected wetland according to the classification of the Xunta de Galicia, authorization from this institution is required for the project to go ahead.

However, the environment does not present any conditions that would make it an exclusion zone for reasons of danger, as no significant risks associated with extreme winds, significant waves, or high seismicity have been identified.

On the other hand, given that Lago As Pontes is currently oriented towards tourism and recreational uses, the main challenge focuses on the compatibility of uses. To address this, it is proposed to integrate the plant as a support infrastructure (for example, acting as a jetty for water activities) and as an educational resource through educational visits, reinforcing its role as a pioneering sustainability project in Galicia.

As future work, we propose studying the technical and economic feasibility of the plant and comparing its results with other lakes. The objective will be to identify the lakes with the greatest solar resource potential and the most economically competitive ones. To do this, the solar

resource must be calculated and based on this, its electrical components will be dimensioned. Finally, the plant's energy production will be estimated, and its economic feasibility can be concluded. Another future line of research is to determine the environmental impact of floating photovoltaic plants installed in inland waters.

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