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Potential for installation of floating photovoltaics on Spanish hydroelectric dams

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This study explores the potential for integrating floating photovoltaic systems into the reservoirs of Spanish hydroelectric dams. Using spatial analysis tools (GIS), the available surface area is evaluated considering a series of technical and operational constraints that are essential to ensure the viability and safety of these installations. The main objective is to identify suitable areas where the deployment of panels does not interfere with the core functions of the hydroelectric infrastructure, such as power generation or water management. The proposed methodology provides a preliminary, spatially explicit screening of the technical resource potential, identifying opportunities and key challenges for FPV deployment in Spanish hydroelectric reservoirs based on surface availability and proximity to existing hydropower infrastructure.

Keywords: hydropower; floating photovoltaics; GIS; potential

Potencial para instalación de fotovoltaica flotante en presas hidroeléctricas españolas

Este estudio explora el potencial para la integración de sistemas fotovoltaicos flotantes en los embalses de las presas hidroeléctricas españolas. Utilizando herramientas de análisis espacial (SIG), se evalúa la superficie disponible considerando una serie de condicionantes técnicos y operativos que son esenciales para garantizar la viabilidad y seguridad de estas instalaciones. El objetivo principal es identificar áreas aptas donde la implantación de paneles no interfiera con las funciones principales de la infraestructura hidroeléctrica, como la generación de energía o la gestión del agua. La metodología propuesta ofrece un análisis preliminar y espacialmente detallado del potencial técnico de los recursos, identificando las oportunidades y los principales retos para el despliegue de la energía fotovoltaica en los embalses hidroeléctricos españoles, basándose en la disponibilidad de superficie y la proximidad a las infraestructuras hidroeléctricas existentes.

Palabras clave: hidroeléctrica; fotovoltaica flotante; GIS; potencial

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1. Introduction

The global energy transition and the urgent need to reduce greenhouse gas emissions have accelerated the deployment of renewable energy technologies worldwide. Among them, photovoltaic (PV) solar energy has experienced rapid growth due to its scalability and decreasing costs (Hossain et al., 2024; Teske, 2019). However, the large land requirements of conventional ground-mounted PV systems create increasing competition with agriculture, urban development, and environmental conservation (Roy & Ghosh, 2017).

In this context, floating photovoltaic (FPV) technology has emerged as an innovative alternative that installs solar panels on water surfaces such as reservoirs and lakes. FPV systems avoid land-use conflicts while potentially improving PV performance through the cooling effect provided by the underlying water body (Khoja et al., 2025). Although reported efficiency gains vary depending on climatic and operational conditions, FPV systems can also provide important co-benefits, including reduced water evaporation and mitigation of algal growth (Mahmoudi Aznavah et al., 2026; Sahu et al., 2016).

Spain offers particularly favorable conditions for FPV deployment due to its high solar irradiation levels, extensive reservoir network, and ambitious renewable energy targets established in the National Integrated Energy and Climate Plan (NIECP). Many Spanish reservoirs are associated with hydroelectric or pumped-storage facilities, creating opportunities for hybrid hydro-solar systems that can share grid infrastructure and improve operational flexibility (Lee et al., 2020). Nevertheless, integrating FPV into active hydroelectric reservoirs also presents technical and operational challenges related to water level fluctuations, reservoir operations, environmental constraints, and infrastructure safety.

Despite growing international interest in FPV systems, studies specifically focused on hydroelectric reservoirs in Mediterranean environments remain limited. Existing large-scale assessments often overlook site-specific operational constraints and reservoir dynamics. To address this gap, this study develops a GIS-based methodology to evaluate the technical potential of FPV deployment in Spanish hydroelectric reservoirs while considering infrastructure proximity. The proposed framework aims to support future feasibility studies and strategic planning for FPV development in Spain.

2. Objectives

The primary objective of this study is to evaluate the technical potential for integrating FPV systems into Spanish hydroelectric reservoirs through spatial analysis. Specific objectives include:

1. To develop a GIS-based methodological framework that incorporates technical constraints for FPV site identification.
2. To assess the available surface area in Spanish reservoirs suitable for FPV deployment without interfering with hydroelectric operations.
3. To identify the main opportunities and challenges for FPV technology implementation in the Spanish context.
4. To provide preliminary estimates of the technical resource available and annual electricity generation for hybrid FPV systems.

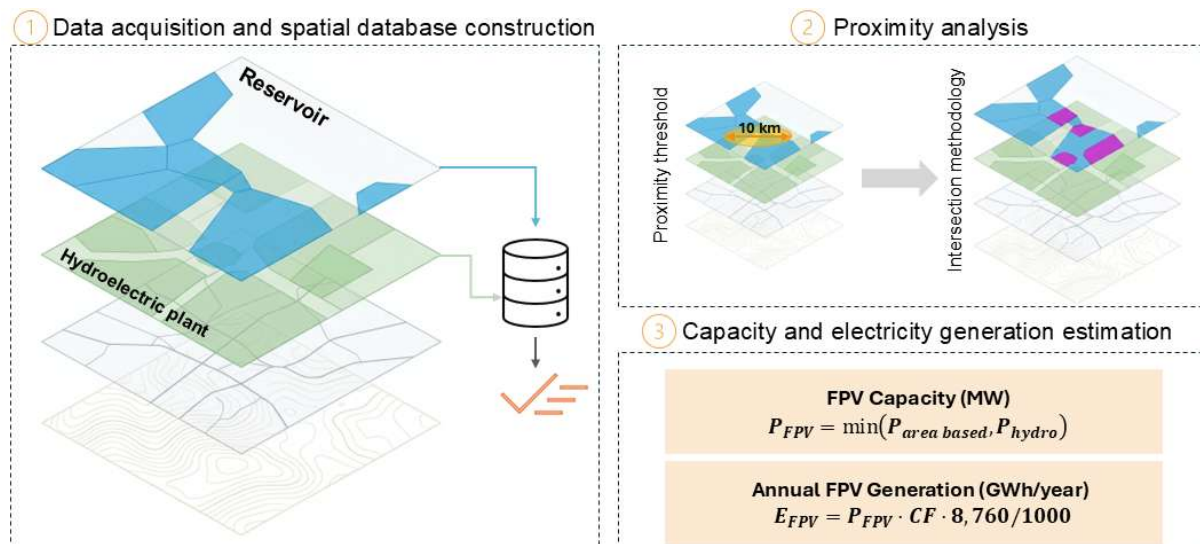
3. Methodology

The methodological framework developed in this study is designed to provide a systematic, reproducible approach for evaluating the technical potential of FPV systems in hydroelectric reservoirs. The framework is structured around a GIS-based analysis that integrates spatial

data with technical constraints. Unlike previous assessments focused only on available water surface area, this methodology considers proximity to existing hydropower infrastructure as an indicator of potential electrical integration. Since no GIS layer containing substation hosting capacity was available, the estimated FPV capacity for each reservoir was conservatively limited to the installed capacity of the associated hydropower plant (Real Decreto 1183/2020, de 29 de Diciembre, de Acceso y Conexión a Las Redes de Transporte y Distribución de Energía Eléctrica, 2020).

The analytical workflow is organized into three sequential stages (refer to Figure 1). First, a comprehensive spatial database is constructed from authoritative national sources, encompassing reservoir geometries and hydroelectric plant locations. Second, a proximity analysis is performed to identify reservoirs located within 10 km of existing hydroelectric facilities, using a threshold based on technical and economic considerations reported in the literature. Third, from the identified reservoirs, the potential installed power and electricity generation are estimated to create a filtered and classified list according to the size of the FPV. Since detailed GIS information on substation hosting capacity was not available, grid integration potential is approximated by conservatively limiting the estimated FPV capacity so that it does not exceed the installed capacity of the associated hydropower plant. This approach provides a preliminary assessment of FPV–hydropower integration opportunities while avoiding overestimation of deployable capacity. The analysis is conducted within the ArcGIS Online environment, which provides robust capabilities for spatial data management, geoprocessing, and visualization while facilitating collaboration and reproducibility. ArcGIS Online was selected for its compatibility with authoritative Spanish spatial data infrastructure, its capacity to handle large-scale datasets, and its suite of proximity analysis tools that enable precise distance-based associations between infrastructure features.

Figure 1: Overview of the proposed methodology



3.1 Data acquisition and spatial database construction

The foundation of this analysis rests upon the integration of two principal geospatial datasets, both obtained from official Spanish sources that ensure data quality, consistency, and authoritative attribution. The selection of data sources followed a rigorous evaluation of available spatial information, prioritizing datasets with documented metadata, regular update cycles, and alignment with national infrastructure registries.

- a) Reservoir layer: the reservoir layer represents the water bodies where FPV systems could potentially be deployed. This dataset was obtained from the National Geographic Information System of Spain (Sistema de Información Geográfica Nacional) and incorporates data from the Spanish Ministry for Ecological Transition and the Demographic Challenge (MITECO). The layer includes approximately 1,200 reservoirs, distributed across the diverse climatic and geographic regions of Spain. Each reservoir polygon is associated with attribute data including:
 - Official reservoir name
 - Geographic coordinates and administrative location
 - Maximum surface area (in ha) under normal operating conditions
 - Total storage capacity (in hm³)
 - Associated river basin authority (Confederación Hidrográfica)
- b) Hydroelectric plant layer: the hydroelectric plant layer identifies the locations of existing power generation facilities that represent potential grid connection points for FPV systems. This dataset was obtained from Red Eléctrica de España (REE, the transmission system operator of Spain). The layer distinguishes between different types of hydroelectric facilities:
 - Conventional hydroelectric plants (run-of-river and reservoir-based)
 - Pumped storage hydroelectric plants (PHS)
 Attribute information associated with each plant includes:
 - Plant name and operational status
 - Installed capacity (in MW)
 - Year of commissioning
- c) Data quality assurance: prior to analysis, both datasets underwent quality assurance procedures to verify spatial accuracy, attribute completeness, and temporal consistency. Spatial overlaps and topological errors were identified and corrected using additional informative tools. For hydroelectric plants, point locations were cross-referenced with satellite imagery to confirm positional accuracy relative to visible infrastructure.

3.2 Proximity analysis: intersection of reservoirs and hydroelectric plants

The core of the methodological framework is a proximity analysis designed to identify reservoirs that are strategically positioned to leverage existing electrical infrastructure from hydroelectric plants. This analysis recognizes that the cost of grid connection (including transmission lines, substations, and associated permitting) constitutes one of the largest capital expenditures for renewable energy projects. By co-locating FPV systems with existing hydroelectric infrastructure, these costs can be substantially reduced or eliminated, as the grid connection is already established and operational (Rodríguez-Gallegos et al., 2025).

- a) Selection of proximity threshold: a maximum distance of 10 km was adopted to identify reservoirs with potential access to existing hydropower electrical infrastructure. This threshold was selected based on technical and economic considerations reported in the literature (Aydin et al., 2013; Díaz, 2018; Nandi & Ghosh, 2010), as larger distances generally imply higher transmission costs and increased infrastructure requirements. In addition, Spanish energy regulations facilitate the administrative framework for generation facilities connected to existing substations within this range (Real Decreto 1183/2020, de 29 de Diciembre, de Acceso y Conexión a Las Redes de Transporte y Distribución de Energía Eléctrica, 2020). Therefore, the 10-km threshold represents a practical and conservative criterion for identifying potential FPV–hydropower integration opportunities. However, proximity should not be interpreted as a guarantee of grid connection availability, since actual feasibility depends on factors such as hosting capacity or network congestion.

- b) Intersection methodology: the proximity analysis was conducted in ArcGIS Online by generating 10-km buffer zones around hydroelectric plants and intersecting them with reservoir polygons. This procedure identified reservoirs potentially associated with existing hydropower infrastructure while preserving the attribute information of both datasets. Reservoirs linked to multiple hydroelectric plants retained all corresponding associations.
- c) Output generation: the proximity analysis produced two main outputs: (i) a GIS layer identifying reservoirs located within 10 km of hydroelectric facilities, and (ii) a relational database containing the associated reservoir and hydropower plant attributes, including reservoir surface area, plant type, and installed capacity. These outputs formed the basis for the subsequent estimation of FPV potential.

3.3 Capacity and electricity generation estimation

Following the identification and classification of suitable reservoirs, the potential FPV capacity was estimated using a simplified large-scale planning approach based on reservoir surface availability and the actual power of the hydropower plants P_{hydro} , and representative FPV capacity factor values reported in the literature.

According to the Spanish RD 1183/2020 (Real Decreto 1183/2020, de 29 de Diciembre, de Acceso y Conexión a Las Redes de Transporte y Distribución de Energía Eléctrica, 2020), a new generation plant (i.e., FPV) cannot increase the grid access capacity of an existing plant (i.e., hydropower). Consequently, the estimated FPV capacity P_{FPV} is given by the minimum value between the area-based physical potential $P_{area\ based}$ and the hydropower plant capacity P_{hydro} :

$$P_{FPV} = \min(P_{area\ based}, P_{hydro}) \quad (1)$$

where P_{FPV} is the estimated installed FPV capacity (MW), $P_{area\ based} = A_r \cdot C_r \cdot D_p$ is the area-based physical potential power (MW) (being A_r the total reservoir surface area (ha), C_r the assumed surface coverage ratio, and D_p the adopted FPV power density (MW/ha)), and P_{hydro} is the installed capacity of the existing hydropower plant (MW). In other words, if the physical potential $A_r \cdot C_r \cdot D_p$ exceeds the hydropower capacity, the FPV capacity is limited to P_{hydro} ; otherwise, the physical potential is used.

In addition to the installed capacity estimation, an indicative approximation of annual electricity generation was derived using representative FPV capacity factors (CF) for Spain. The annual electricity generation potential was estimated by using:

$$E_{FPV} = P_{FPV} \cdot CF \cdot 8,760/1,000 \quad (2)$$

where E_{FPV} is the estimated annual electricity generation (GWh/year), P_{FPV} is the installed FPV capacity (MW), CF is the assumed FPV capacity factor, and 8,760 represents the number of hours in one year.

These estimations should be interpreted as indicative large-scale technical potential rather than detailed production forecasts. The methodology does not incorporate hourly solar variability, reservoir-specific irradiation conditions, hydropower dispatch coordination, curtailment effects, shading losses, or detailed engineering constraints. Consequently, the resulting values represent preliminary planning-level estimates intended to support strategic screening and prioritization of reservoirs for future FPV feasibility studies.

4. Results

The application of the GIS-based proximity analysis resulted in a comprehensive dataset of more than 100 reservoir–hydropower associations across Spain. However, not all identified reservoirs present the same level of suitability for FPV deployment. It should be noted that the following estimates refer primarily to installed capacity as a technical potential indicator, not to effective electricity generation. Annual energy generation (GWh/year) is provided for illustrative purposes using average capacity factors, but does not account for hourly solar variability, dispatch coordination, or operational constraints. Therefore, these results represent preliminary capacity screening, not a production forecast.

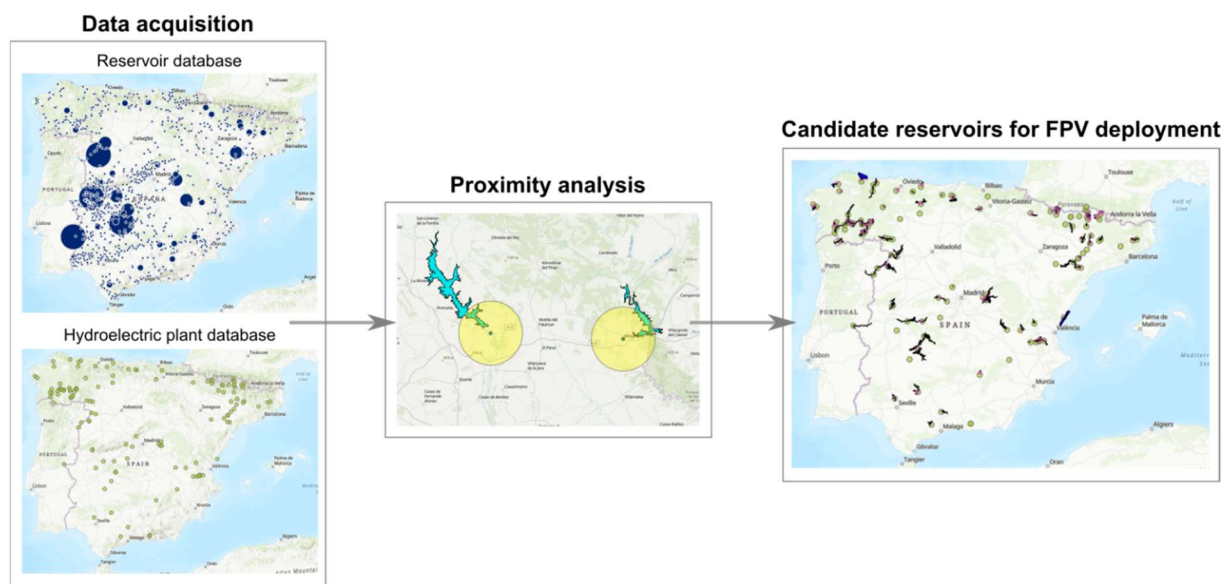
4.1 Selection criteria for quantitative assessment

To estimate FPV capacity in a consistent and technically meaningful way, a subset of locations was selected based on the following criteria:

- Minimum FPV capacity (> 50 MW): reservoirs with an estimated P_{FPV} (from eq. (1)) below 50 MW are considered unlikely to host utility-scale FPV plants, as the smaller scale would lead to poor economies of scale and disproportionately high installation costs per MW.
- Confirmed association with hydropower infrastructure: only reservoirs directly linked to hydroelectric plants (from the GIS intersection) were considered. This criterion was used as a preliminary indicator of potential infrastructure synergy and possible access to existing electrical assets, rather than as confirmation of actual grid connection availability.
- Data completeness: reservoirs with missing or inconsistent surface data were excluded from quantitative estimation.

Applying these criteria resulted in a subset of more than 40 reservoirs with potential for FPV deployment (see Figure 2).

Figure 2: Spatial datasets (reservoirs and hydroelectric plants) and an example of the proximity analysis (10-km buffers around hydroelectric plants, intersected with reservoir locations) to identify reservoirs with potential for FPV installation



4.2 Assumptions for FPV capacity estimation

The estimation of FPV area-based physical potential $P_{area\ based}$ was based on widely accepted assumptions:

- Surface coverage ratio: 10% of total reservoir area (Micheli, 2021; Ravichandran et al., 2022).
- Power density: a power density of 1 MW/ha was assumed, which lies within the typical range reported for FPV systems. Previous studies indicate that theoretical maximum densities may exceed 1.5 MW/ha under ideal conditions (Micheli, 2021), but practical deployments generally fall around 0.8–1.2 MW/ha when accounting for spacing, tilt, and maintenance requirements (Jin et al., 2023). The selected value therefore represents a realistic and conservative approximation for large-scale FPV installations.
- Capacity factor: for the annual electricity generation, the CF of FPV plants has been considered as 18.26%, which stands for the mean of the CF 's values across the different regions of Spain (López et al., 2022).

These assumptions reflect a balance between maximizing energy generation and minimizing environmental and operational impacts, particularly in active hydroelectric reservoirs. They are intentionally conservative and consistent with large-scale planning approaches, rather than site-specific optimized engineering designs. Therefore, the resulting capacity estimates represent a theoretical upper bound under spatial and operational constraints, but do not account for detailed engineering design, financial feasibility, or site-specific permitting conditions.

4.3 Estimated FPV capacity and energy generation by reservoir size class

Based on the estimated FPV capacity for each reservoir, projects were categorized according to typical utility-scale solar project size thresholds. Adopting the commonly used classification in the solar PV literature, three categories were defined. This classification provides a consistent framework for comparing the technical potential of FPV with existing hydropower plants.

- a) Large FPV projects ($P_{FPV} > 200$ MW): represent the largest mega-projects with maximum economies of scale. Table 1 summarizes the name, surface, FPV potential and annual electricity generation following the assumptions described in Section 0.

Table 1: Large FPV projects and electricity generation

Reservoir	P_{hydro} (MW)	P_{FPV} (MW)	E_{FPV} (GWh/year)
Alcátara	953.32	953.32	1,524.91
Almendra	850.88	850.88	1,361.05
Ricobayo	326.57	326.57	522.37
Valdecañas	247.17	247.17	395.37
Ribarroja	261.28	202.90	324.55
Subtotal		2,580.84	4,128.25

- b) Medium FPV projects (75 – 200 MW): these reservoirs provide the bulk of scalable opportunities, combining significant surface area with widespread geographic distribution. Table 2 summarizes the name, surface, FPV potential and annual electricity generation described in Section 0.

Table 2: Medium FPV projects and electricity generation

Reservoir	P_{hydro} (MW)	P_{FPV} (MW)	E_{FPV} (GWh/year)
Belesar	331.01	191.00	305.52
Azután	198.01	125.00	199.95
As Portas	268.02	118.30	189.23
Gabriel y Galán	110.4	110.40	176.59
Canelles	107.4	107.40	171.79
Torrejón Tajo	132	104.10	166.52
Portodomouros	88.12	88.12	140.95
Prada	88.12	88.12	140.95
Riaño	83.19	83.19	133.07
Bao (Puente Bibey 4)	312.41	82.00	131.17
Bao (Soutelo 2)	213.64	82.00	131.17
Guadalhorce	376.88	78.00	124.77
Iznajar	76.71	76.71	122.70
Mequinenza.	322.36	75.40	120.61
Subtotal		1,409.74	2,254.99

- c) Small FPV projects (50 – 75 MW): although smaller, these possible FPV projects are highly relevant due to their abundance and proximity to existing infrastructure. Table 3 summarizes the name, surface and FPV potential and annual electricity generation described in Section 0.

Table 3: Small FPV projects and electricity generation

Reservoir	P_{hydro} (MW)	P_{FPV} (MW)	E_{FPV} (GWh/year)
San Esteban	438.45	73.70	117.89
Salime	157.24	68.50	109.57
Mediano	66.97	66.97	107.12
Susqueda	88.55	66.00	105.57
Valparaíso	65.1	65.10	104.13
Prada	62.88	62.88	100.58
El Burguillo	61.95	61.95	99.09
Bárcena	61.15	61.15	97.81
Cedillo	495.18	59.00	94.37
Saucelle (Saucelle I)	525	58.90	94.22
Saucelle (Saucelle II)	516.39	58.90	94.22

Reservoir	P_{hydro} (MW)	P_{FPV} (MW)	E_{FPV} (GWh/year)
Camarasa	58.65	58.65	93.82
Castrelo	135.59	56.00	89.58
Serena	55.2	55.20	88.30
Orellana	55.2	55.20	88.30
Garcia de sola	55.2	55.20	88.30
C. de Guadalhorce	376.88	54.60	87.34
Buendía	54.45	54.45	87.10
Os peares (Grupo I)	200	53.50	85.58
Os peares (Grupo II)	181.02	53.50	85.58
Salas	52.82	52.82	84.49
Sau	55.56	52.78	84.43
Cijara (I)	50.4	50.40	80.62
Cijara (III)	50.4	51.70	82.70
Subtotal		1,407.05	2,250.68

4.4 Total estimated FPV potential and annual electricity generation

Aggregating the three categories, the total estimated FPV capacity for the selected reservoirs is approximately:

- Large FPV projects: 2.60 GW and 4,128 GWh/year
- Medium FPV projects: 1.40 GW and 2,255 GWh/year
- Small FPV projects: 1.40 GW and 2,250 GWh/year

This accounts for a total of 5.4 GW and 8,640 GWh/year, around 3.5% of the Spanish yearly electricity demand, which accounted for 256,086 GWh in 2025 (Red Eléctrica de España, 2026). Moreover, these values represent conservative technical potential and electricity generation, as it:

- Assumes only 10% surface coverage
- Excludes smaller projects (<50 MW)
- Does not yet incorporate optimized layouts or technological improvements

Despite this conservative potential, the results highlight several key insights:

- Strong concentration of potential: a relatively small number of very large reservoirs accounts for more than 50% of total capacity and electricity generation.
- Scalability through diversity: small and medium projects collectively contribute significantly, offering distributed deployment opportunities.
- Strategic alignment with existing infrastructure: all selected reservoirs benefit from proximity to existing hydropower plants.
- Geographical robustness: the identified potential is distributed across multiple river basins, enhancing system resilience at the national scale.

Overall, the findings confirm that Spain has a substantial and geographically diversified FPV resource base, with strong synergies between solar and hydropower systems. However, it should be noted that regarding electricity generation, it doesn't account for hourly hydropower coordination, curtailment, reservoir-specific shading, or operational dispatch constraints.

5. Discussion, limitations, and future works

The results highlight the strong potential synergies between FPV systems and existing hydropower infrastructure in Spain. Many of the identified reservoirs are associated with high-capacity hydroelectric facilities, which may offer advantages in terms of existing electrical infrastructure, operational expertise, and reduced land-use conflicts compared with conventional ground-mounted PV systems.

However, although the proximity analysis identifies reservoirs with strategic infrastructure advantages, spatial proximity alone should not be interpreted as a guarantee of effective grid connection feasibility. Actual connection viability depends on additional technical and regulatory factors that fall outside the scope of this study, including substation hosting capacity, transmission network congestion, access and connection procedures, and potential reinforcement requirements.

Similarly, the actual deployable FPV area within each reservoir may be affected by operational, hydrological, environmental, and technical constraints that were not explicitly integrated into the present large-scale GIS screening. Hydroelectric reservoirs serve multiple functions beyond electricity generation, including flood control, irrigation supply, navigation, and environmental management. Consequently, future reservoir-specific assessments should incorporate operational exclusion zones associated with dam structures, spillways, intake towers, penstocks, and navigation corridors to ensure safe operation and maintenance accessibility.

Technical feasibility may also be influenced by reservoir-specific physical conditions affecting mooring and anchoring systems. Factors such as water-level fluctuations can significantly affect the practically usable FPV area, installation costs, and long-term operational stability. Reservoirs with large seasonal drawdowns may require more complex floating anchoring configurations and adaptive cable management systems.

In addition, reservoir operational regimes in Spain can vary substantially depending on hydropower dispatch requirements, irrigation demand, flood-control strategies, and seasonal hydrological variability. These factors may influence the temporal compatibility between FPV generation and hydropower operation and should therefore be considered in future site-specific technical assessments.

Environmental aspects also require further investigation. Although FPV systems may provide certain environmental benefits, including evaporation reduction and partial mitigation of algal proliferation, their ecological impacts remain highly site dependent. Potential effects on thermal stratification, dissolved oxygen dynamics, aquatic habitats, and reservoir ecosystem functioning should therefore be evaluated in future studies. In particular, the integration of ecological sensitivity analyses, protected-area datasets, and Natura 2000 overlays would strengthen future FPV suitability assessments in Spain.

Consequently, the methodology proposed in this work should be interpreted primarily as a national-scale screening and prioritization framework intended to identify reservoirs with preliminary technical potential for FPV deployment. Detailed engineering design, hydrological modelling, environmental impact assessment, and electrical integration studies remain necessary before project implementation.

The principal limitations of the present study are summarized in Table 4.

Table 4: Limitations of the study and their potential effect

Limitation	Potential effect
No hourly dispatch modelling	Energy estimates remain indicative represented
No bathymetric dataset integration	Deployable area may be overestimated
No ecological sensitivity mapping	Environmental constraints not fully captured
No grid hosting capacity assessment	Grid integration feasibility remains preliminary
No reservoir-specific hydrological modelling	Operational water-level variability not represented

6. Conclusions

This study developed a GIS-based methodological framework to assess the technical potential for floating photovoltaic (FPV) deployment in Spanish hydroelectric reservoirs, using proximity to existing hydropower infrastructure as a key screening criterion. The main findings and contributions can be summarised as follows:

1. Identification of strategic reservoirs: the spatial analysis revealed more than 100 reservoirs located within 10 km of hydroelectric plants, representing a preliminary set of locations where FPV systems could potentially benefit from existing grid connection infrastructure. This proximity-based filtering provides a more targeted approach than previous area-only assessments.
2. Conservative capacity estimates: applying a 10% surface coverage ratio and a power density of 1 MW/ha, the total estimated FPV installed capacity for reservoirs with more than 50 MW of potential amounts to approximately 5.4 GW, with an indicative annual electricity generation of 8,600 GWh/year (around 3.5% of Spain's annual demand). Large reservoirs (>200 MW) account for nearly half of this capacity, while medium and small projects collectively contribute the remainder, highlighting a diversified deployment landscape. Moreover, these possible projects (with more than 50 MW of FPV) only represent 43 out of the more than 100 reservoirs initially determined.
3. Methodological contribution and limitations: the framework successfully integrates operational constraints (surface coverage, proximity threshold, capacity capping based on hydropower plant size) with spatial data. However, the results represent a first-level national screening, not a final feasibility assessment. Actual deployable capacity will depend on reservoir-specific factors such as water-level fluctuations, environmental sensitivities, bathymetry, grid hosting capacity, and regulatory procedures.
4. Strategic implications: the identified FPV potential is distributed across multiple river basins and coexists with active hydroelectric infrastructure, suggesting opportunities for hybrid solar-hydro operation, shared grid assets, and reduced land-use conflict. Nevertheless, proximity to hydropower plants does not guarantee grid availability, and future studies must incorporate substation hosting capacity and network congestion analyses.

In conclusion, Spain presents a substantial and geographically diverse FPV technical resource base that is worthy of further, more detailed feasibility assessments. The proposed GIS methodology offers a transparent, reproducible tool for prioritising reservoirs, but should be complemented by hydrological modelling, environmental sensitivity mapping, and electrical integration studies before project-level decisions are made.

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Use of Generative Artificial Intelligence

No generative artificial intelligence was used in preparing this communication.

Communication aligned with the Sustainable Development Goals

