EU's Renewable Energy Targets. An Economic Analysis of Floating Photovoltaic Plants on Inland Waters in Romania

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Abstract: *The European Union's (EU) imperative for its Member States to achieve climate neutrality has elevated the role of photovoltaic (PV) parks in the renewable energy landscape. However, the proliferation of photovoltaic (PV) plants presents sustainability challenges, notably in terms of land requirements for installation. This puts a strain on the allocation of the available land, leading to competition with vital economic sectors like agriculture and industry. In response to that challenge, this article proposes an analysis of the viability of the installation of photovoltaic (PV) panels on floating platforms on Romanian lakes. Employing a comprehensive methodology, this study evaluates key metrics including capital expenditure (CapEX), operational expenditure (OpEX), and the levelized cost of energy (LCOE). By examining the profitability and broader implications of floating photovoltaic (PV) installations, this research aims to contribute to the discourse on sustainable energy solutions amidst land scarcity. It underscores the potential of leveraging water surfaces to meet the EU's renewable energy targets, while alleviating pressure on land resources, and informing policymakers and industry stakeholders on the feasibility and benefits of adopting innovative approaches to green and clean energy generation.*

Keywords: *Renewable energy, floating photovoltaic installations, land scarcity, Romania.*

JEL classification: *O13, P18, P48, Q42.*

Introduction

The reform of the energy sector, fundamental to all economic activities, is vital for the transition to a circular and eco-friendly economy. This transition requires gradually replacing conventional energy sources with renewable ones, while also improving their profitability and accessibility. Enhancing energy efficiency is crucial in ensuring a smooth transition without negative impacts on investors and consumers.

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While the evolution of renewable energy technologies and the decline in their costs support the EU's envisioned transition, **the targets set by European leaders sometimes appear too ambitious for the proposed timeframes.** As investments in new energy production technologies are gaining momentum, negative externalities of their use and new challenges arise, fuelling concerns within the business community about the viability of the clean economy model.

For the last two decades, the European Union has been the main promoter of renewable energy worldwide. Especially relevant in this sense was the promulgation of Directive 2001/77/EC, at the proposal of the European Commission, which supported the promotion of the use of renewables throughout the Union. That moment marked the beginning of the decarbonisation process of the energy sector and of the economy. Later, the legislative framework in this field was supplemented and clarified by Directive 2009/28/EC, Directive (EU) 2018/2001, and Directive (EU) 2023/2413, which ensured an efficient and prompt adaptation of the European regulations to the reality of the market.

The paradigm shift in the European Union has created new opportunities, but also new challenges from the economic and legislative points of view. The implementation of green energy production projects has not been uniformly done in the community space, as Member States differ in terms of their promotion capacity. To counter the potential distortions of the energy market triggered by these differences, the European Parliament issued Regulation 2024/1735, one of its objectives being the standardisation of the way in which the authorities regulate the development of energy production from renewable sources (European Parliament, 2024).

Under these conditions, it is vital to identify solutions to improve the efficiency of green investments and reduce their negative effects (e.g., the harsh competition for extra-urban land that might be used for the development of photovoltaic parks). A solution currently promoted in the academic environment is the installation of photovoltaic (PV) panels on floating pontoons to harness the lake water gloss. This method allows to cut back on costs for the purchase or rental of land dedicated to PV. In addition, in the case of reservoirs, the short distance to the electricity transmission infrastructure considerably reduces the costs of connecting the park to the grid.

Despite the international trend that promotes floating photovoltaic parks, there is little research focused on testing their viability on Romania's lakes. Simulations are necessary due to the strategic importance of the agricultural sector (which competes for land with the renewable energy producers) and due to the fact that many lakes are in mountainous areas, where shading and meteorological phenomena can significantly impact the panels' productivity.

In Europe there are already power generation companies that have built or designed floating photovoltaic plants. For example, Q Energy has started the construction of such a solar plant with a capacity of 74.3 MW (134,649 panels) in the Haute-Marne region of north-western France. It will be put into operation in 2025, on the site of a former quarry (Q Energy, 2023). ECOwind has also carried out a similar project north of the town of Grafenwörth, Austria, with an installed capacity of 24.5 MW, which will be able to supply 7500 households (BayWa r.e., 2023).

The main purpose of this article is to analyse the profitability of such investments in Romania, based on a case study in a mountainous area. The work also aims to ascertain the probability of costs increasing due to unforeseen factors or circumstances – changes in the legislation, rising prices of raw materials and construction services – that cannot be accounted for in a preliminary analysis of the investment and, thus, to formulate recommendations to address these challenges.

After an overview of the most relevant studies that tackle the possible installation of floating photovoltaic panels, we describe the research methodology used to calculate the levelized cost of electricity (LCOE) and to analyse the results obtained. Subsequently, we present our opinions on the research carried out, the study's limitations, some recommendations for future research, and finally, the conclusions that can contribute to the development of the photovoltaic energy sector in Romania.

Literature review

At the end of 2023, during the United Nations Conference on Climate Change in Dubai, the need for a global emissions reduction of 43% until 2030 and of 60% until 2035, relative to figures from 2019, was reiterated as critical in order to limit global warming to 1.5 degrees Celsius. Moreover, the leaders of the participating states agreed that by 2030 they will triple the production of energy from renewable sources and double energy efficiency (European Commission, 2023). Even before COP28, EU's Member States had proposed, through the European Green Deal, that by 2030 they would reduce greenhouse gas emissions by 55%, increase energy efficiency by 32.5%, and ensure that at least 32% of the final energy consumption comes from renewable sources. In response to the disruption of the global energy market caused by Russia's invasion of Ukraine, the European Commission launched the REPowerEU Plan (2023), which, among other measures, comes with a more ambitious target for renewables (i.e., 45% by 2030), designed to reduce substantially the dependence on classical fossil fuels and pave the way to climate neutrality by 2050.

How realistic the previously set targets are (Institute for Energy Research, 2023) is hard to determine, but the significant technological progress of the last decades is unquestionable. If less than 20 years ago, renewables were not competitive, they have recently become not only profitable, but also extremely attractive to investors. This transformation is largely due to anti-pollution measures promoted globally by the EU (Miciuła *et al.*, 2020; Włodarczyk *et al.*, 2021).

The developed states, adhering more or less willingly to the global energy goals established to combat pollution, are looking for solutions to replace with renewables the conventional energy that has been ensuring their economic growth over the past two centuries (Kammen, 2004). The most illustrative example of this transition is the rise in the global production of photovoltaic energy, from 100 GW in 2012, to 1000 GW in 2022. This market's growth is just beginning, with an estimated production of 2300 GW in 2025 (Guchhait *et al.*, 2023).

The construction of onshore photovoltaic and wind farms could rapidly increase the percentage of renewable energy in the European energy mix. However, this would require large areas of land that are equally necessary for other economic activities, such as agriculture, industry, or biodiversity conservation (Tölgyesi *et al.*, 2023). Therefore, if European states want to achieve the objectives mentioned in the European Green Deal (and, subsequently, climate neutrality), without affecting other land-intensive economic sectors, they should identify other solutions onshore or offshore, and increase the profitability of the renewable power plants (Lee *et al.*, 2014; Ramasamy and Margolis, 2021).

The installation of offshore wind turbines has already become a global trend because their efficiency is higher than that of the onshore ones (Chen *et al.*, 2022). However, the popularity of offshore photovoltaic plants varies due to the high costs of construction and installation. Thus, offshore photovoltaic islands are still in the testing stage, but there are good chances for their development in the coming years, provided the existing technology evolves so that the marine environment no longer represents a danger for them (Wang *et al.*, 2022). On the other hand, the reduction of prices for photovoltaic panels and the evolution of available technologies make floating photovoltaic parks a very effective solution for fresh and calm waters (Cazzaniga *et al.*, 2018).

Among the renewables, the photovoltaic energy has the cheapest production costs, which is reflected by its attractiveness to European investors. According to Kougias *et al.* (2021), the EU's photovoltaic energy market must grow 5 times, compared to 2020, to meet the targets proposed for 2030. During 2023, an additional 56 GW of photovoltaic energy production capacity was installed in Europe – of which 14.1 GW in Germany, 8.2 GW in Spain, 4.8 GW in Italy and 4.6 GW in Poland (SolarPower Europe, 2023). At the end of 2023, the installed photovoltaic energy production capacity in the European Union was roughly 260 GW, of which only 1.9 GW were generated in Romania. Although it has a larger territory than its neighbouring states that are EU members, Romania has much smaller photovoltaic energy production capacities than them, i.e. Hungary produced 5.8 GW in 2023, and Bulgaria 2.9 GW, whereas Ukraine, which is not yet an EU member, generated 8 GW that same year (International Renewable Energy Agency, 2024). The latter have developed their energy sector more than Romania.

The main benefit of installing photovoltaic panels on water is the fact that the costs with land purchase, which sometimes represent more than half of the money invested in photovoltaic farms, are largely reduced. Moreover, covering with floating panels a significant part of lakes also contributes to reducing evaporation during dry periods (Mittal *et al.*, 2017, Ferrer-Gisbert et *al.*, 2013).

Micheli and Talavera (2023) demonstrated that projects of this type in Turkey, Romania, Italy, Spain, Bulgaria, and Greece would be profitable. Besides, the installation of floating PV panels brings further benefits to the investors, as the surface temperature of fresh and calm waters is quite constant and thus diminishes the wear and tear of the installation, improving not only its lifetime but also its efficiency (Skoplaki and Palyvos, 2009; Kamuyu *et al.*, 2018; Dörenkämper *et al.*, 2021). Reducing the temperature of the installation and the amount of dust deposited on the the panels increases the efficiency of the entire photovoltaic farm and, implicitly, its productivity (Tina *et al.*, 2021).

Jamal and Muaddi (1992) demonstrated that if PV panels are covered with a thin layer of water, their lifetime and efficiency increase due to water cooling. However, this might not apply for PV panels in maritime areas because salty water is particularly corrosive and therefore substantial investments in materials and resistance structures are needed (Ghigo *et al.*, 2022).

Methodology

Data Collection:

The authors of this paper consulted analyses conducted by Romania's power transport and system operator Transelectrica, to assess the available capacity of the national network. Additionally, the Global Solar Atlas software was used to determine key characteristics of the photovoltaic energy production in the selected location.

Analysis:

The analysis involved calculating monthly and annual panel production, as well as total production over a 25-year lifetime. This calculation considered the equipment's efficiency and wear based on the manufacturer's specifications.

Calculations

The **LCOE** formula was used to estimate the cost, with components including capital expenditure (CapEX), operational expenses for the year t (OpEXt), annual electricity production (P_{el}), and a discount rate (r):

where: CapEX: capital expenditures on fixed assets necessary to realise the photovoltaic park, OpEXt: operational expenses for each year, P_{el}: annual

$$LCOE = \frac{CapEX + \sum_{t=1}^{n} \frac{OpEX_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{P_{el}}{(1+r)^t}} \quad (1)$$

electricity production, and r: discount rate (assumed as 0 for this study).

Estimation of components

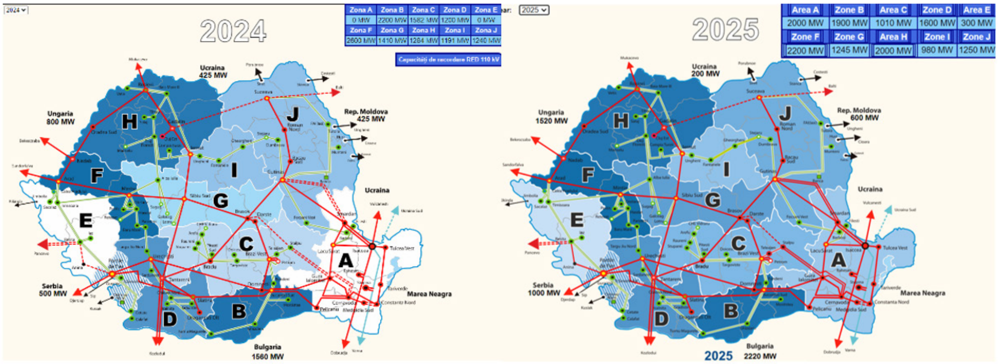
CapEX was determined by analysing online market offers for materials used for platform structure, panels and installation components (screws, cables, and inverters). Estimates from previous studies, available in the specialised literature, were used to determine the costs of the anchoring systems and of the equipment installation services. Operational expenses were estimated at 15 euros/kW/year, with an additional annual depreciation of 0.2%, based on wear analysis for photovoltaic parks in Spain (Micheli, 2021). Due to the proximity of the envisaged installation project to the water's edge and the normal weather conditions, maintenance costs were presumed to be similar to those of the land-based parks.

Results

Available Capacity Analysis:

The available capacity to accommodate electricity production in the Romanian grid was examined in collaboration with Transelectrica, as depicted in *Figure 1*.

Figure 1. Available capacity to take over electricity production in the Romanian grid in 2024 and 2025



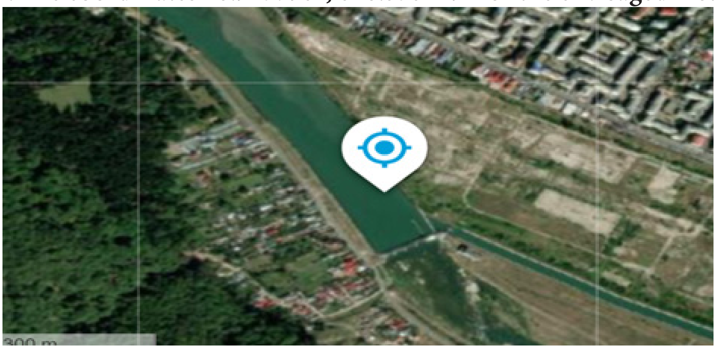
Source: www.transelect rica.ro.

According to the planning carried out by the Romanian power transport and system operator, represented in *Figure 1*, in the North-East region (marked with the letter J) there is sufficient capacity to absorb the electricity produced in the system, both in 2024 (1240 MW) and in 2025 (1250 MW).

Location Selection Process

The location for the installation was determined based on a solar radiation analysis conducted using the Global Solar Atlas software. *Figure 2* displays the chosen coordinates (46.917793°, 026.373119°) within the region J (*Figure 1*), which benefits from favourable solar radiation levels conducive to competitive photovoltaic park performance. Furthermore, the site is not designated as a protected area and this fact simplifies the approval process for PV panel installation without incurring additional environmental documentation costs.

Figure 2. The coordinates 46.917793°, 026.373119° for the envisaged installation



Source: www.globalsolaratlas.info.

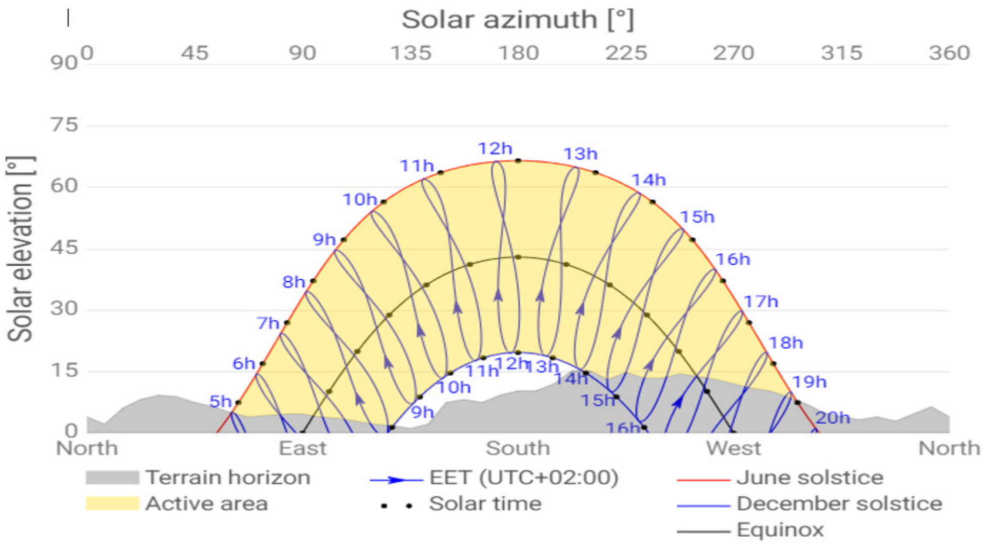
Simulation Results

To conduct the simulation, the chosen installation site, depicted in *Figure 2* and situated in region J, was selected. This location was deemed optimal due to favourable solar radiation levels, as evidenced by the analyses presented in *Figure 3*,

Figure 4, and *Table 1*. Moreover, the absence of protected status for the lake would ensure streamlined approval processes for solar project development, minimising the associated environmental documentation costs.

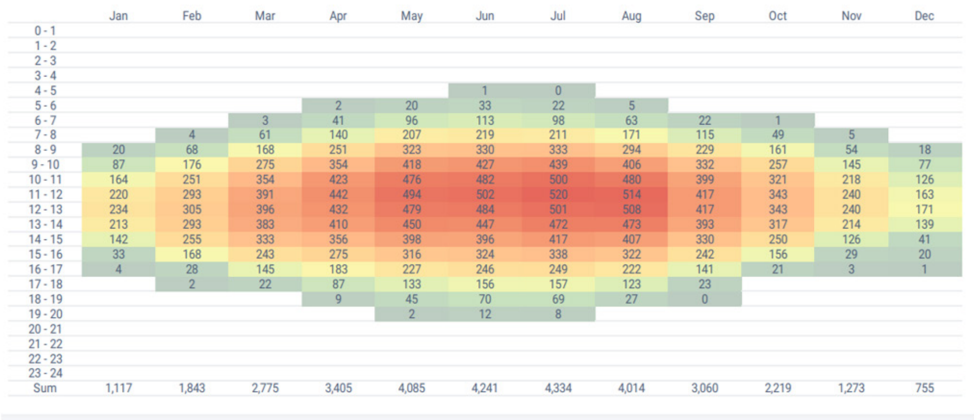
The solar azimuth, solar elevation angles depicted in *Figure 3*, and the total photovoltaic power output (*Figure 4*) were analysed to assess their impact on panel performance. Previous studies – including those carried out by Yang *et al.* (2011), Stanciu *et al.* (2016), and Hafez *et al.* (2017) – have already highlighted the importance of the solar azimuth and solar elevation angles for photovoltaic farms. The terrain horizon is also illustrated in *Figure 3*, because it determines the hours of the daily exposure of PV panels to solar radiation. The horizon line plays a very important role in photovoltaic energy production, as it influences the exposure of solar panels to sunlight. High landforms, forests or tall buildings, can block sunlight during the day, especially at sunrise and sunset – when the sun is lower, reducing the period of exposure to sunlight and implicitly the energy production (Vega-Garita *et al.*, 2023). These calculations were performed using the Global Solar Atlas software for the coordinates referenced in *Figure 2*.

Figure 3. Solar azimuth and solar elevation



Source: www.globalsolaratlas.info.

Figure 4. Total photovoltaic power output (kWh) of the envisaged installation



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5						1	0					
5 - 6				2	20	33	22	5				
6 - 7			3	41	96	113	98	63	22	1		
7 - 8		4	61	140	207	219	211	171	115	49	5	
8 - 9	20	68	168	251	323	330	333	294	229	161	54	18
9 - 10	87	176	275	354	418	427	439	406	332	257	145	77
10 - 11	164	251	354	423	476	482	500	480	399	321	218	126
11 - 12	220	293	391	442	494	502	520	514	417	343	240	163
12 - 13	234	305	396	432	479	484	501	508	417	343	240	171
13 - 14	213	293	383	410	450	447	472	473	393	317	214	139
14 - 15	142	255	333	356	398	396	417	407	330	250	126	41
15 - 16	33	168	243	275	316	324	338	322	242	156	29	20
16 - 17	4	28	145	183	227	246	249	222	141	21	3	1
17 - 18		2	22	87	133	156	157	123	23			
18 - 19				9	45	70	69	27	0			
19 - 20					2	12	8					
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	1,117	1,843	2,775	3,405	4,085	4,241	4,334	4,014	3,060	2,219	1,273	755

Source: *www.globalsolaratlas.info*.

Figure 4 illustrates the monthly production structure of the analysed photovoltaic island, segmented by hours throughout the year. It reveals that the peak production period is from May to August, and coincides with the dry season when energy output, especially from hydroelectric plants, declines.

Table 1 summarises key site characteristics, including irradiance levels and panel specifications. For the selected location, each 1,000 kWp capacity could generate 1,009 GWh annually.

Table 1. Site characteristics

Site analysis indices	Value
Direct Normal Irradiance (DNI)	1153.8 kWh/m^2
Global Horizontal Irradiance (GHI)	1240.8 kWh/m^2
Diffuse Horizontal Irradiation (DIF)	591.9 kWh/m^2
Global tilted irradiation at an optimum angle (GTI_{opta})	1459.1 kWh/m^2
Optimum Angle (OPTA)	38/180°
Temperature	9.3 °
Elevation	303 m
Total photovoltaic power output for 1000 kWp	1.009 GWh/year
Global tilted irradiation	1335.6 kWh/m^2 per year
Panel's tilt	10°
Panel's azimuth	180°

Source: www.globalsolaratlas.info

Panel Characteristics

The Aiko N-Type ABC Black Hole Series PV Module was chosen for its high efficiency and cost-effectiveness. *Table 2* outlines its specifications. Each panel is capable of producing 615W at an efficiency of 23.8%.

Table 2. Panel characteristics

Aiko N-Type ABC Black Hole Series PV Module	Value
Rated power	615 W
Efficiency	23.8%
Width	1,134 mm
Height	2,278 mm
Occupied area	2.583252 m^2
Mass	28.3kg
TEMP coefficient	-0.29%
Annual degradation from second year	0.35%
Minimum product warranty	15 years
Price	110 euro per piece

To achieve the desired capacity of 1,037 MW, a total of 1,632 Aiko N-Type ABC Black Hole Series PV Module panels are required. With this configuration, the system would produce an estimated 1,047 GWh annually.

CapEX Analysis

The total capital expenditure (CapEX) for the installation (including the materials for the platform structure, the photovoltaic panels, and associated components) was calculated. *Table 3* details the breakdown of costs, totalling €705,173.

Table 3. CapEX

		Total costs (euro)
Materials used for the structure of the platform		
Aluminium 5005 structure		41,600
Aluminium 6061 plates		27,487
Stainless Steel 301 rectangular bars		11,365
HDPE floating docks		17,219
Total		97,671
Photovoltaic panels		
Aiko N-Type ABC Black Hole Series PV Module		179,520
Clamping screws		9400
Connection cables		12515
Invertors	200 euro/kW	207,400
Installation & labour	139.5 euro/kW	144,661
Anchor system	33.48 euro/kW	34,718
Transport	18.6 euro/kW	19,288
Total		607,502
CAPEX		**705,173**

Structural Design and Material Requirements

The installation area required for the panels is calculated at 2.583252 m^2 per panel, including an additional 0.567 m^2 for maintenance access. Therefore, 1,632 installed panels would occupy a total area of 5141 m^2. Structural materials include aluminium bars (5005 alloy) and stainless-steel bars (301 alloy) for support and anchoring, as well as corrugated aluminium sheets (6061 alloy) for access ways. Detailed quantities and costs of these materials are outlined in *Table 3* and more detailed calculations for material requirements and costs are provided in *Appendix A*.

Floating Platform Design

The floating platforms supporting the panels are designed to withstand the weight of installation. Each platform has a floating capacity of 360 kg per square meter, with an area of 0.25 m^2. Thus, 805 high-density polyethylene (HDPE) floating docks are required to support the entire system.

Fastening System and Electrical Components

Screws and fastening systems are used to secure the panels to the aluminium structure and platform. Additionally, electrical components such as cables are required for connecting the panels. Detailed lengths and costs of these components are provided in *Table 3*.

Labour and Installation Costs

According to Baptista *et al.* (2021), the costs of installation and labour - converted from US dollars to euros at the time of this analysis - were estimated at 139.5 euros/kW, those of transportation at 18.6 euros/kW, and those of anchoring the system at 33.48 euros/kW. These costs are crucial for determining the overall investment required for the project.

OpEX and LCOE Calculation

The OpEX for the floating PV farm were estimated at 15 euros/kW/year. The operational costs are similar to the calculations made by Micheli (2021) for photovoltaic plants in Spain because the operation and maintenance of panels on inland waters are light activities (similar to those for onshore PV parks) due to the proximity to land and the favourable weather conditions. The above-mentioned costs increase by 0.2% every year due to the natural wear and tear of the panels. The lifetime of the installation was estimated at 25 years, with an annual production reduction of 0.35%, according to the characteristics provided by the manufacturer. Hence, for that period, the **total OpEX would be 498,231.3 euros.**

The total production, with a reduction of 1% in the first year and 0.35% /year starting from the second year, would amount to 24,947.9 MWh. In this context, the LCOE for the analysed installation is 48.237 euros/MWh. The result of the calculation proves that the photovoltaic island would be cost-effective for the European market, where the LCOE of photovoltaic installations varies between 20 and 60 euros/MWh and the electricity market prices vary between 200 and 650 euros/MWh (International Energy Agency, 2023).

Discussion

The case study's findings show a competitive LCOE of 48.237 euros/MWh, better than the European average of 56 euros/MWh in 2023 (Schmela *et al.*, 2023). This outcome underscores the viability of the PV park project within the Romanian energy landscape. It's noteworthy that the forecasts for 2030 indicate that the average LCOE for solar energy in Romania will range from 54 euros/MWh to 58.6 euros/MWh, and the average LCOE for wind energy will range from 52.6 euros/MWh to 54.4 euros/MWh (Deloitte, 2019). Additionally, the inclusion of storage capacities raises the LCOE to 111.6 euros/MWh. As technology continues to advance, global LCOE values are expected to dip below 30 euros/MWh by 2050 (Det Norske Veritas Group, 2023).

However, the study has **certain limitations** owing to the evolving legal framework in Romania. Notably, it is difficult to estimate the costs associated with the concession procedure and the investor royalties without receiving further clarifications from authorities. Moreover, determining the royalties payable to the National Administration "Romanian Waters" for installing PV facilities on water bodies presents a similar challenge. Other costs might be triggered by the possible requirement to reconfigure or resize the electricity transmission network in some areas. Such costs are usually minimal when the photovoltaic park is located on reservoirs, considering the short distances to the network connection point. However, proactive engagement with the regulatory authorities and stakeholders can mitigate these uncertainties and streamline the project development processes.

On the other hand, cost optimisation strategies play a pivotal role in the economic viability of such projects. Thus, possible discounts from suppliers for the wholesale purchase of equipment can significantly reduce project costs. Furthermore, securing financing from European funds represents a viable avenue for these investments. The RePowerEU programme, initiated by the EU under the Next Generation EU facility, allocates approximately 200 million euros for new renewable energy production capacities in Romania (Ministry of Investments and European Projects, 2023). Leveraging such funding opportunities can alleviate financial burdens associated with project implementation and enhance overall project feasibility.

The profitability of renewable energy investments is boosted by their inherent versatility. Renewable energy sources offer greater flexibility in power generation, as they can be switched on and off much more easily than conventional ones. Moreover, they enable producers to capitalise on peak demand periods and command higher prices in the balancing market. Renewable energy producers can participate in the balancing market when they can reserve a quantity of their energy output to balance the system in line with the orders issued by the transmission operator. For example, the solar and wind energy can balance the deficit of hydropower during dry periods, wind power plants can compensate for the lower energy output of photovoltaic plants during cloudy periods, just as the high productivity of photovoltaic installations can sometimes balance a low energy production of wind power plants. In Romania, this practice is not yet common, as the operator of the electricity transmission network generally relies on conventional energy sources, due to their stability. However, this situation will certainly change with the growth of renewable energy sources and storage capacities. The adaptability not only enhances profitability but also contributes to improving LCOE values, making renewable energy projects increasingly competitive within the energy market landscape.

Conclusions

As this study argues, the competing demands for land necessitate innovative solutions for expanding the renewable energy infrastructure. By capitalising on underutilised water bodies, such as lakes and reservoirs, the floating PV installations offer a promising avenue for addressing land scarcity while concurrently enhancing renewable energy capacity. Our research underscores the viability of the floating PV farms, offering a sustainable alternative to traditional land-based solutions.

The low investment costs of floating PV farms, in terms of LCOE, prove their economic feasibility. This solution appears to be a strategic alternative to traditional land-based installations because it eliminates the need for land acquisition and it capitalises on the proximity to existing electricity transmission networks. The potential royalties payable to surface water management authorities are insignificant in comparison to the costs associated with land acquisition.

This floating PV parks are a niche sector that could bolster Romania's renewable energy portfolio. However, it is imperative to introduce simplified procedures for obtaining permits and to have standardised royalty frameworks to catalyse investment and foster industry growth.

Looking ahead, future research endeavours should delve into cost comparative analyses of floating photovoltaic parks in diverse geographic contexts. Furthermore, investigating long-term performance metrics will be pivotal in optimising the efficiency and sustainability of floating PV installations.

In conclusion, by harnessing the power of water surfaces and through concerted efforts to streamline regulation and incentivise investments, Romania could position itself as a front-runner in the burgeoning field of floating PV farms and thus contribute significantly to the EU transition towards cleaner energy.

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Appendix A

The installation area required for the panels is calculated at 2.583252 m^2 per panel, including an additional 0.567 m^2 for maintenance access. Therefore, 1,632 installed panels would occupy a total area of 5141 m^2. Structural materials include aluminium bars (5005 alloy) and stainless-steel bars (301 alloy) for support and anchoring, as well as corrugated aluminium sheets (6061 alloy) for access ways.

In this context, 1632 installed panels would occupy 5141 m^2. One panel weighs 28.3 kg, which means that 1632 will weigh approximately 46.2 tons. Each panel requires 3 horizontal aluminium bars 5005 (AlMg1) each measuring 1,134 m long to which they must be fixed and one vertical aluminium bar 2,278 m long. In total, for the whole island, rectangular aluminium bars (width 40 mm, height 60 mm, thickness 4 mm) with a length of 9270 m are required. Similar bars with lengths of 1224 m (0.25 m x 2 for the high part and 0.125 m x 2 for the middle part) are needed to achieve the 10% slope of the panel installation. Thus, in total, rectangular aluminium bars with a length of 10,494 m are required. The presented rectangular pipes have a specific mass of 1.98 kg/m, resulting in a total mass of 20.8 tons/platform. Their price at the time of the analysis is 2 euros/kg. This results in a cost of 41,600 euros for the entire aluminium structure of the island.

For the construction of the access bridge for maintenance, 301 stainless steel bars in "L" profile (2 for each aisle, with a width of 0.04 m, a height of 0.06 m and a thickness of 4 mm) with a length of 3,702 m are also required. They have a specific mass of 3.07 kg/m, resulting in a requirement of 11,365 tons/platform. The cost for these is 1 euro/kg, which means a total of 11,365 euros/platform.

To make the access ways, 1,851 m of corrugated aluminium sheet (aluminium 6061) with a width of 0.5 m and a thickness of 0.5 cm is also needed. The specific mass of this sheet is 6.75 kg/m, so 12,494 tons are needed. The price at the time of the analysis was 2.2 euros/kg. Thus, it results in a price of 27,487 euros/platform.

According to the specifications of the chosen floating pontoons, the floating capacity is 360 kg/m^2, so a pontoon, which has an area of 0.25 m^2, can support 90 kg and costs 21.39 euros. The total weight of the platform is 70.1 tons. An additional mass of 5% of the mass of the panels was considered for cables and screws, resulting in an additional 2.31 tons. Thus, the pontoon must support 72.41 tons, requiring 805 HDPE floating docks. At the time of this analysis, such a dock costed 21.39 euros, so the total price was 17,219 euros/platform.

The price of the screws needed to fasten the aluminium bars to the platform was estimated at 0.77 euros/piece, according to the average price on the market, resulting in a cost of 7,540 euros. For fastening the panels to the aluminium bars, the price of the necessary systems was considered 0.19 euros/piece, resulting in a cost of 1,860 euros/platform. In total, the cost of fastening the system amounts to 9,400 euros. The length of the necessary electric cables was considered similar to that of the rectangular bars on which the panels are attached, namely 9,270 m, to which 50% was added for flexibility, resulting in 13,905 m. The average price for these is 0.9 euro/m, so the total cost is 12,515 euros/platform.