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A techno-economic analysis of floating photovoltaic systems, for southern European countries

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Introduction

In the last years new technical and environmentally friendly energy production technologies are beginning to emerge, which Floating Solar Photovoltaic (FSPV) systems are part. In this framework, southern European countries have excellent climate conditions for reinforcing the use of solar energy.

This research assess the existing Portuguese potential for floating PV systems and its integration in the power grid. A floating solar power plant of 1MW in Gouvães dam included in the Tâmega hydroelectric complex, under construction in northern Portugal was sizing and evaluated its energy potential.

Case study

In this case study will be sizing and evaluated the technical and economic conditions of a **1 MW** FSPV system that may be installed in the Gouvães dam reservoir currently under construction on the Tâmega River, belonging to Iberdrola company.

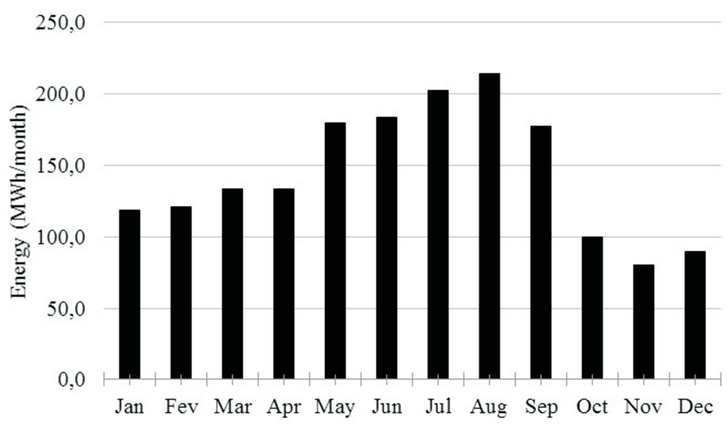

Fig.1 Expected monthly energy production.

The forecast of the monthly energy produced over a year, taking into account the local climate conditions are show in Fig. 1 and reachs an accumulated value of approximately **1.8 Gwh**. The CAPEX values tacked into account to evaluated the economic viability are presented in table I.

Table I CAPEX Direct Costs for a FSPV

Equipment	Value (USD/kWp)
Panels	300
Inverters	200
Floating structure	300
Anchoring	36
Electrical equipment/devices	100
Installation & Labour	150
Transport	20
TOTAL	**1106**

To account for the profits from the sale of the produced energy, the average reference tariffs practiced in 2020 were considered for the OMIE Price Of Energy (POE), which were around 40 €/MWh. Table II presents a summary of the main parameters used in the techno-economic project evaluation.

Table II Parameters Used in the Techno-Economic Evaluation

Parameter	Value
Project lifetime (n)	*25 years*
Yearly Energy/Electricity production	*1800 MWh*
Discount rate (i)	6%
O&M yearly costs	1% of initial investment
Yearly inflation rate (e)	2%
Energy price in first year	40 €/MWh
Initial investment costs	1000000 €/MW
Final Residual value (V_R)	15% of initial investment

The Portuguese case

According the Portuguese national plan for energy and climate, the dam reservoirs in Portugal will have new rules in order to encourage the increase of floating solar power plants. It is predicted that if 20% of the area of the 50 largest reservoirs is used to produce electricity from PV systems, therefore, Portugal could reach the power production target of **2.55 GW** from FSPV systems.

Methodology

This section describes the theoretical model used for sizing a grid-connected FSPV system and for further annual electricity production calculation. Therefore, these calculations are the basis of the developed study. The model used to calculate the maximum energy produced by a FSPV system as a function of irradiance and temperature at the site is based on equations (1-4)

➡ Maximum current as a function of irradiance (G):

$$I_{max} = I_{SC}^{STC}\frac{G}{G^{STC}} \qquad (1)$$

➡ Maximum voltage as a function of irradiance (G) and temperature (T):

$$V_{max} = mV_T ln\left[\frac{(I_{SC}^{STC} - I_{max}^{STC})\frac{G}{G^r}}{I_O^{STC}\left(\frac{T}{T^{STC}}\right)^3 e^{\frac{\epsilon}{m^r}\left(\frac{1}{V_T^{STC}}-\frac{1}{V_T}\right)}}\right] \qquad (2)$$

➡ Maximum power extrated for a panel :

$$P_{max} = V_{max} \cdot I_{max} \qquad (3)$$

➡ Energy produced by a panel during a given time interval Δt, affected by the inverter efficiency :

$$E = \eta_{inv}\sum_{i=1}^{n} P_{max}(G,T)\cdot \Delta t_i \qquad (4)$$

Considering the electricity is totally sale to the grid, Fig. 2 shows the investment will have a payback period around 14 years, which is considered high, for renewable energy projects. However, the project presents a positive NPV around 329235€ and a IRR about 5.8%.

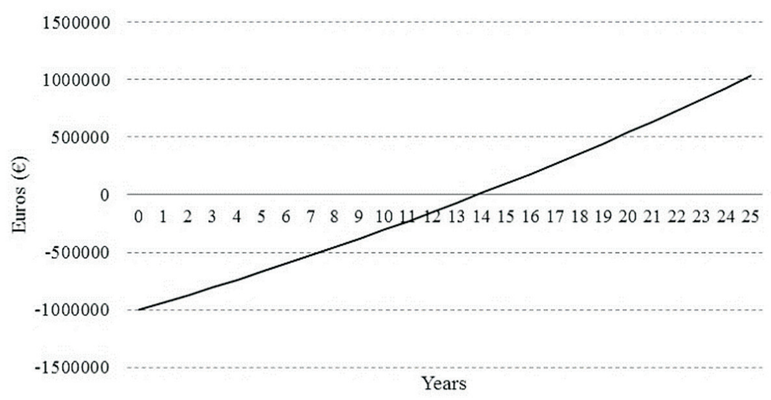

Fig.2 Amortization results over the project lifetime.

Results

Southern European countries have interesting potential for installing FSPV. These technology also have a large number of advantages over onshore systems. However, these plants require additional costs than traditional types of PV facilities. This research, shows that the payback period to amortize the investment rounds 14 years, which remains very high for renewable investments. Thus, while the investment costs do not decrease, its use is more suitable for supplying local and auxiliary systems, such as pumping stations, allowing a significant reduction in the energy bill.

Conclusions