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Importance of the fluctuations of the steel price in the economic feasibility of a hybrid offshore platform in the West of the Iberian Peninsula

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Abstract. Marine renewable energies are being implemented as basic energy sources of the Spanish energy system for various reasons, the first because the planet Earth is made up of 70% water, which makes marine resources very important when programming the production, the second because they are clean energies that do not emit greenhouse gases, necessary to comply with the European Green Deal and the third because this type of energy provides us with energy independence from third countries. But, despite the social benefits mentioned above, we also have to take into account economic factors that can make the economic profitability of this type of equipment less viable. For this, the wind resource, platform costs, etc. are analyzed. Within these factors, this research focuses on seeing how the variation in the price of steel (the main material used in this equipment) caused by the increase in the cost of electricity causes the main economic parameters to vary for a park made up of W2Power hybrid platforms. of 300 MW located on the Atlantic coast of the Iberian Peninsula.

Key words. Renewable energy, hybrid platforms, iron, Atlantic Area.

1. Introduction

Renewable energy sources come in many different forms [1]. One of the first classifications we can make is taking into account the type of renewable resource they use, which can be solar energy [2], wind energy [3], wave energy [4], tidal energy [5], etc. In order for these energies to be exploited, they need a medium, some of them, such as solar and wind power, can be located both on land and in the sea, but there are others, such as wave energy or tidal energy that can only be located in the sea. Since Earth is composed of 70% water, we can consider that the potential can be great. To carry out this work, a hybrid wave and wind platform has been used, such as Wave2power [6][7][8], which takes advantage of both the energy provided by the waves and the energy provided by the wind.

The structure of this platform is built of steel [9], and the price of this mineral has been in continuous movement since 2020, initially due to the pandemic caused by SARS-CoV-2, in the first moments of the pandemic the consumption of steel to the world level fell drastically causing a decrease in production and in some cases the temporary closure of the factories that produced it, at that time the price suffered a significant drop, but in the second half of 2020 the demand began to increase gradually and it was found with a very reduced supply which caused the increase in prices that continue today. Linked to this is the war in Ukraine, which is causing an unstoppable rise in electricity prices [10] and therefore the cost of the steel companies to produce steel is very high, causing them to go back to producing it and with it the steel price continues to rise. The increase in the price of steel is linked to the cost of electricity and the raw materials that make it up, the main component being iron, which has gone from values of 396 €/ton dollars in 2020 to values of 1,125 €/ton dollars in 2021 [11], that is, its price has increased in two years by almost 50%. Therefore, the objective of this work is to know how the price variations of this material can affect the economic viability of these wind farms.

The aim of the present paper is to analyze how the variation in the cost of raw materials, in this case steel, influences the economic profitability of a hybrid offshore renewable energy farm. The case study will analyze the Atlantic coast of the Iberian Peninsula, the W2Power hybrid offshore platform [7] and several costs of steel. Results will indicate the influence of steel cost in the main economic indicators in an offshore farm: Internal Rate of Return (IRR), Net Present Value (NPV) and Levelized Cost Of Energy (LCOE) [12], [13].

2. Method

The method proposed calculates the main economic indicators of a hybrid offshore renewable energy farm considering the cost diseggregation presented in a previous paper [14], where the total cost of a floating offshore renewable energy farm is dependent on the cost of the several phases of the life-cycle of the farm: the concept phase (C1), the development & design phase (C2), the manufacturing phase (C3), the installation phase (C4), the operation and maintenance phase (C5) and the dismantling phase (C6).

The present paper considers the influence of the steel cost ($\boldsymbol{C}_{\mathbf{steel}}$) in the main economic parameters. In this context, the presence of the steel cost is mainly presented in the cost of manufacturing (C3) and in the cost of dismantling (C4) the hybrid offshore renewable energy farm. Equation (1) and Equation (2) are shown these costs.

$$C3 = C31 + C32 + C33 + C34 + C35 \qquad (1)$$

$$C6 = C61 + C62 + C63 + C64 + C65 \qquad (2)$$

Being:

- $\boldsymbol{C31}$: cost of manufacturing the generators.
- $\boldsymbol{C32}$: cost of manufacturing the platforms.
- $\boldsymbol{C33}$: cost of manufacturing the moorings.
- $\boldsymbol{C34}$: cost of manufacturing the anchoring.
- $\boldsymbol{C35}$: cost of manufacturing the electric systems.
- $\boldsymbol{C61}$: cost of dismantling the generators.
- $\boldsymbol{C62}$: cost of dismantling the platforms.
- $\boldsymbol{C63}$: cost of dismantling the moorings and anchorings.
- $\boldsymbol{C64}$: cost of cleaning the offshore area of the farm.
- $\boldsymbol{C65}$: cost of removing the materials of the farm.

The subcosts that depend on the $\boldsymbol{C}_{\mathbf{steel}}$ are the following:

- $\boldsymbol{C31}$= f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C32}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C33}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C34}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C61}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C62}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)
- $\boldsymbol{C63}$ = f($\boldsymbol{C}_{\mathbf{steel}}$)

The main economic parameters taken into account in terms of considering the influence of the cost of steel in them are the following:

- Net Present Value (NPV).
- Internal Rate of Return (IRR).
- Levelized Cost Of Energy (LCOE).

Their equations are, respectively, as follows:

$$\boldsymbol{NPV = -I_0 + \sum_{n=1}^{N_{farm}} \frac{CF_n}{(1+r)^n}} \qquad (3)$$

$$\boldsymbol{0 = -I_0 + \sum_{n=1}^{N_{farm}} \frac{CF_n}{(1+IRR)^n}} \qquad (4)$$

$$\boldsymbol{LCOE = \frac{\sum_{n=0}^{N_{farm}} \frac{LCS_{FOREF_n}}{(1+r)^n}}{\sum_{n=0}^{N_{farm}} \frac{E_n}{(1+r)^n}}} \qquad (5)$$

Being:

- $\boldsymbol{I_0}$: initial investment of the hybrid offshore renewable energy farm.
- $\boldsymbol{CF_n}$: cash flow of the project in year $\boldsymbol{n}$.
- $\boldsymbol{r}$: discount rate.
- $\boldsymbol{N_{farm}}$: number of years of the life of the project.
- $\boldsymbol{E_n}$: energy generated in each year.
- $\mathbf{LCS_{FOREFn}}$**:** total life cycle cost of a floating offshores renewable energy farm in the year n

3. Case of study

The case of study will consider the W2Power platform [15], which is a hybrid floating offshore renewable energy platform, which is composed by 4 wave energy converters of 0,175 MW each and 1 offshore wind energy turbine of 3,6 MW. Therefore, the total power of 1 hybrid platform is 4,3 MW.

The total power of the farm is 300 MW, which represents 69 hybrid offshore wind platforms, with a total of 276 wave energy converters and 69 floating offshore wind turbines.

Moreover, the location selected to carry out the study is the Atlantic shore of the Iberian Peninsula, which comprises the countries of Spain and Portugal, as Fig. 1 is shown.

Fig. 1. Location selected (in yellow). Adapted from [16].

The electric tariff considered in the case of study is 200 €/MWh.

Finally, three different values of the cost of steel have been taken into account: 500 €/ton, 700 €/ton and 900 €/ton.

The life cycle of the farm is 20 years and the discount rate is 6%.

Results

Considering a farm of 300 MW and a steel price 1, IRR ranges from -181.68 % to 22.37 % (see Fig. 2), NPV ranges from -356.58 M€ to 405.06 M€ (see Fig. 3) and the LCOE ranges from 104.03 €/MWh to 520.45 €/MWh (see Fig. 4).

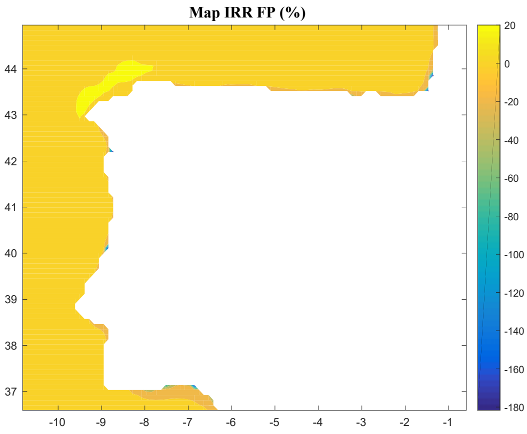

Fig. 2. IRR for a Farm with Steel price 1.

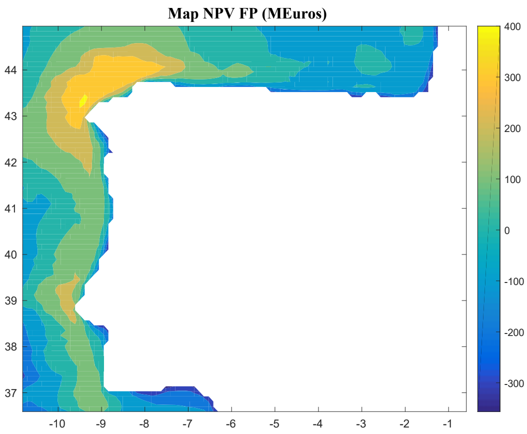

Fig. 3. NPV for a Farm with Steel price 1.

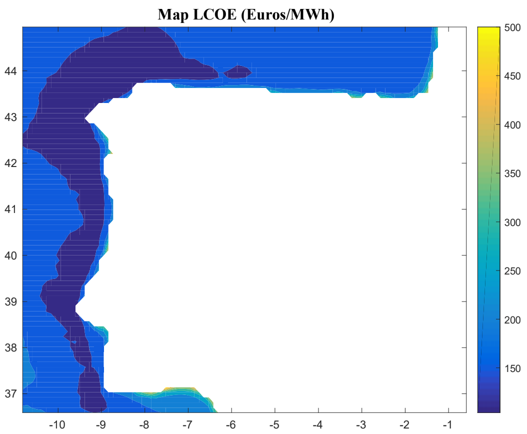

Fig. 4. LCOE for a Farm with Steel price 1.

Considering the steel price 1, IRR ranges from -181.40 % to 20.88 % (see Fig. 5), NPV ranges from -375.32 M€ to 385.93 M€ (see Fig. 6) and the LCOE ranges from 107.50 €/MWh to 539.11 €/MWh (see Fig. 7).

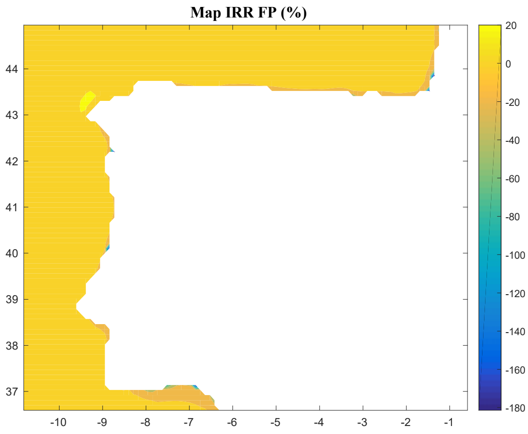

Fig. 5. IRR for a Farm with Steel price 2.

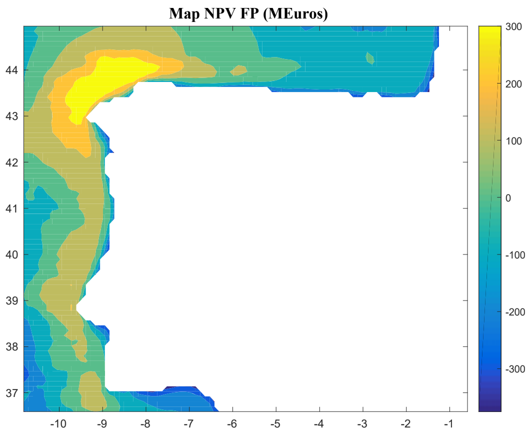

Fig. 6. NPV for a Farm with Steel price 2.

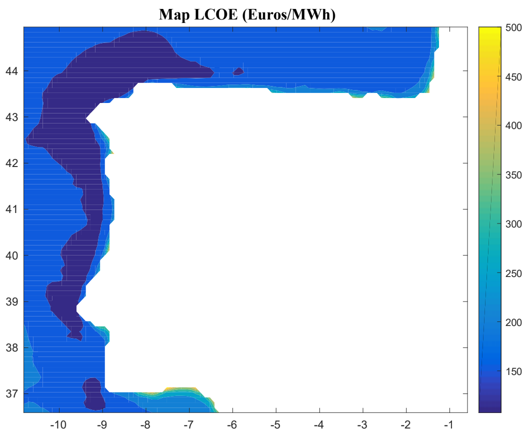

Fig. 7. LCOE for a Farm with Steel price 2.

Considering the steel price 1, IRR ranges from -181.14 % to 19.54 % (see Fig. **8**), NPV ranges from -394.04 M€ to 366.78 M€ (see Fig. **9**) and the LCOE ranges from 110.97 €/MWh to 557.75 €/MWh (see Fig. **10**).

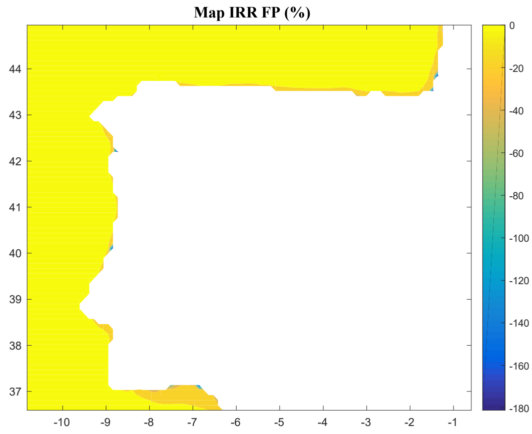

Fig. 8. IRR for a Farm with Steel price 3.

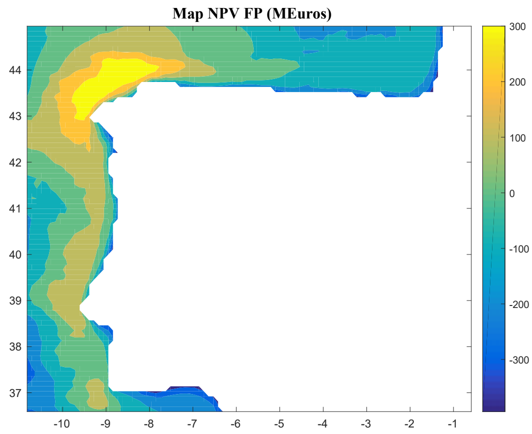

Fig. 9. NPV for a Farm with Steel price 3.

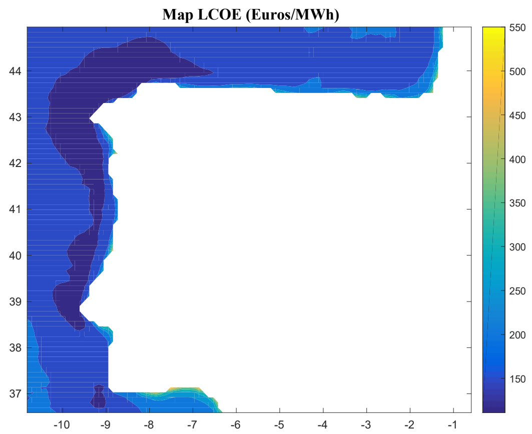

Fig. 10. LCOE for a Farm with Steel price 3.

Therefore, if the price of the steel increases a 40%, the best value for IRR will be reduced a 6.7%, the NPV will be reduced a 4.7% and the LCOE will be increases a 3.3%. On the other hand, if the price of the steel will increase a 80%, the best value of IRR will be reduced a 12.7%, the NPV will be reduced a 9.5% and the LCOE will be increased a 6.7% (see Table I).

Table I. – Variation of LCOE in hybrid offshore renewable energy farms depending on the variation of the price steel.

Price steel increases	40%	80%
IRR best	-6.7%	-12.7%
NPV best	-4.7%	-9.5%
LCOE best	3.3%	6.7%

4. Conclusion

The present paper has analyzed the influence of the steel cost on the economic feasibility of a hybrid offshore renewable energy farm.
The case study has taken into account the Atlantic coast of the Iberian Peninsula, the W2Power hybrid offshore platform and several costs of steel.
Results indicate the influence of steel cost in the main economic indicators in an offshore farm: Internal Rate of Return (IRR), Net Present Value (NPV) and Levelized Cost Of Energy (LCOE). The highest influence of the cost of steel is in terms of IRR, NPV and LCOE respectively.
These results are useful to analyze the future of these type of technologies in the case of the fluctuation of the price of its main component, whose value is changing daily in these uncertain times.

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