CASE STUDY FOR FUTURE WAVE ENERGY EXPLOITABILITY (2027 - 2050) IN THE BELGIAN CONTINENTAL SHELF

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I. OVERVIEW

Given the continuing greenhouse gas emissions and energy market developments, predicted wave forecast data over the Belgian Continental Shelf (BCS) are used to estimate the wave energy potential and its possible exploitation through various wave energy converters (WECs) In this study, an evaluation on the wave power resource based on the wave modelled data from 2027 to 2050 and the assessment of several WECs were performed from technical and economic points of view.

II. METHODOLOGY

Over the whole domain

- Wave numerical model from 2027 to 2050 by using the SWAN model . CORDEX regional climate model data [1] was employed, from 2027 to 2050 with a spatial and time resolution of 0.11° x 0.11° and 6 hours, respectively.
- Wave power (P_W), in kW/m, was estimated through the Equation (1) and the monthly and seasonal variability was defined (Equation (2) and (3), respectively).

$$P_W = \frac{1}{2}\,\rho\, g\, H_{m0}{}^2\left(1+\left(\frac{2kh}{\sinh(2kh)}\right)\right)\frac{\omega}{k} \quad \textbf{(1)}$$

$$MV = \frac{\overline{P_{W\,highest\,M.}} - \overline{P_{W\,lowest\,M.}}}{\overline{P_W}} \quad \textbf{(2)} \qquad ; \qquad SV = \frac{\overline{P_{W\,highest\,S.}} - \overline{P_{W\,lowest\,S.}}}{\overline{P_W}} \quad \textbf{(3)}$$

At the six selected locations

- The estimation of wave power trends throughout the assessed years was done, including the directionality analysis.

- WEC performance indexes as CF and $SIWED_{30}$ [4] were estimated.
- WEC scaling, was performed based on the Froude similarity law [5].
- The economic indicators CapEx, COE, and LCOE were estimated [6, 7].

Table 1. Wave energy converter features employed in the assessment [2,3].

Device	WEC type	Nominal rated power [kW]
F2HB	Point absorber	1000
Pelamis	Attenuator	750
SeaPower	Attenuator	3587
Pontoon	Point absorber	3619
AWS	Point absorber	2470
OEBuoy	Attenuator	2880
Aquabuoy	Point absorber	250
Langlee	Terminator	1500
Sparbuoy	Point absorber	139

III. RESULTS

WAVE POWER FORECASTING ↣ WAVE ENERGY CONVERTERS PERFORMANCE ↣ WAVE SCALING AND ECONOMIC INDICATORS

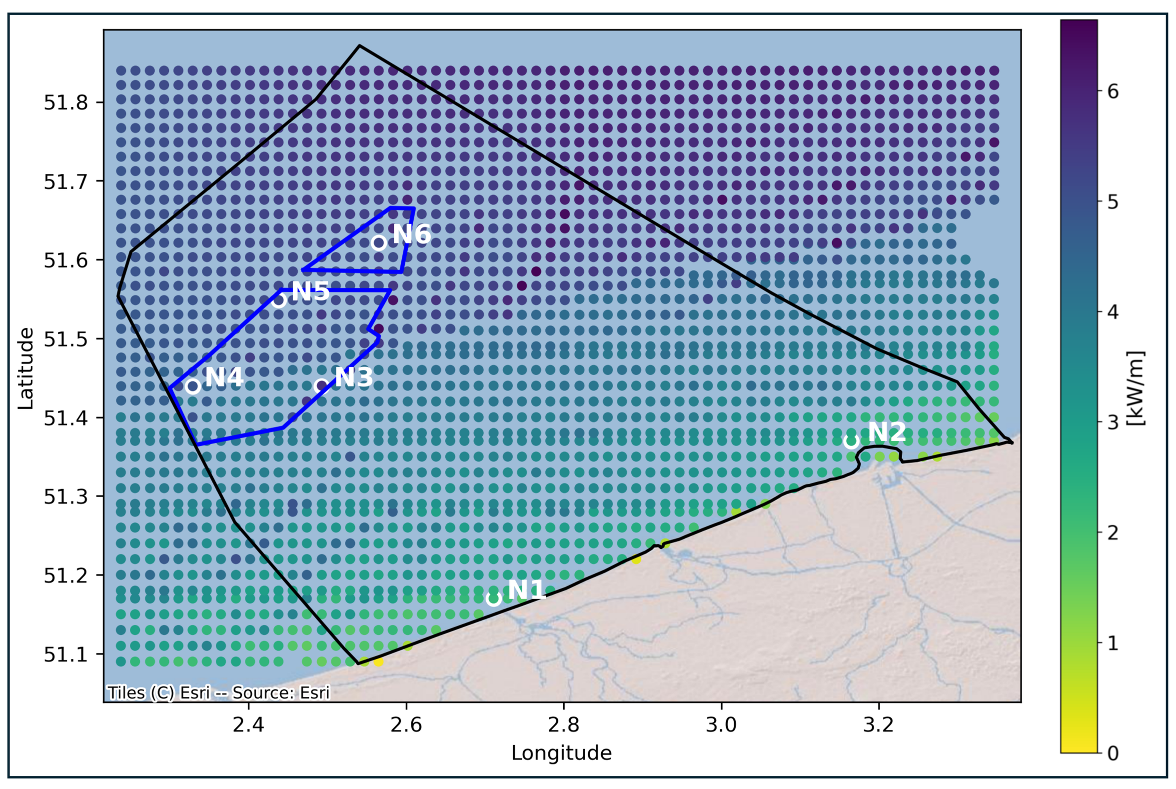

Figure 1. Mean anual wave power over the BCS and marine energy exploitable regions (2027-2050). The black contour indicates the BCS, whereas the blue frames indicate the regions earmarked by the Belgian authorities for marine energy exploitation.

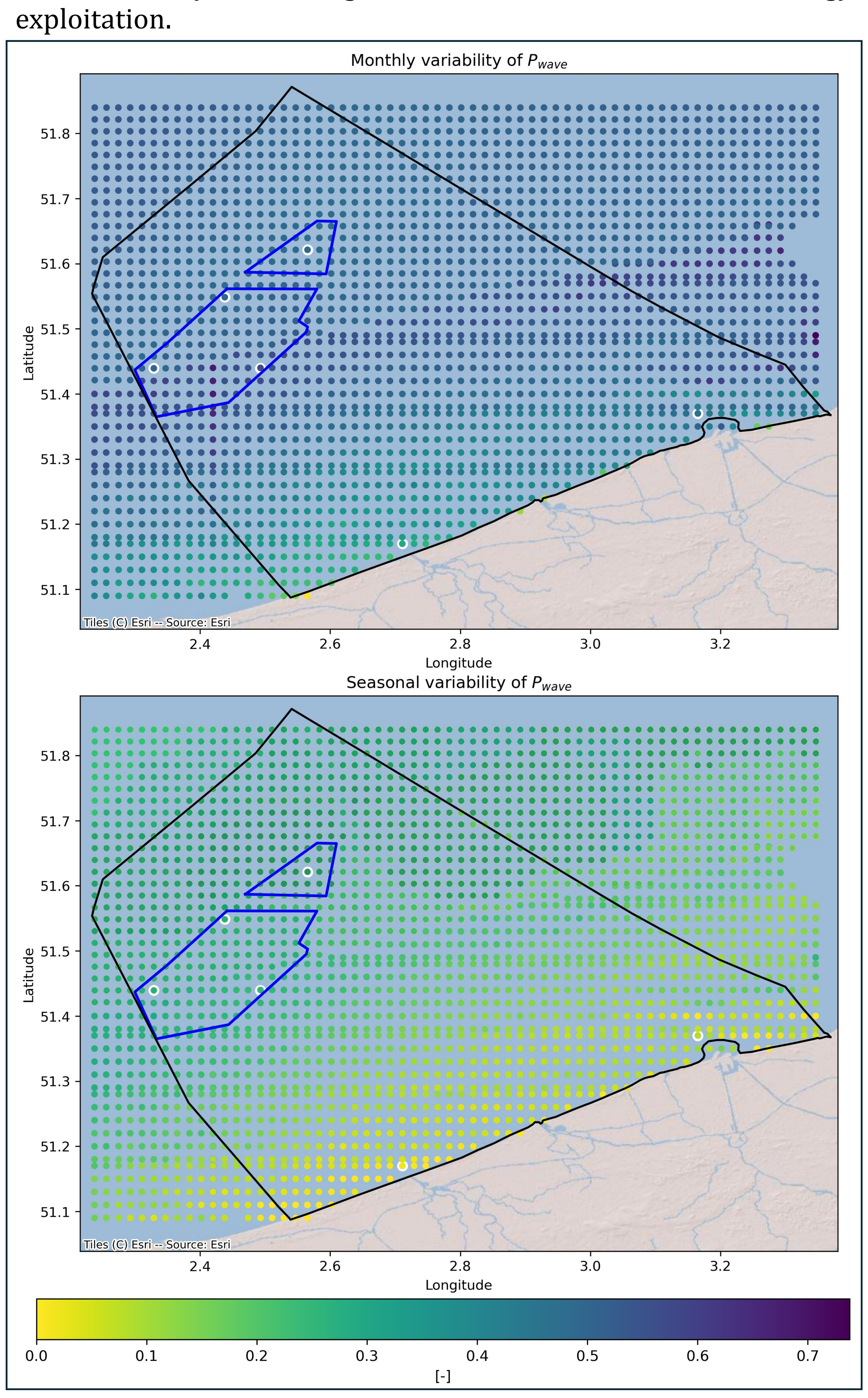

Figure 2. Monthly (MV) and Seasonal (SV) variability over the BCS.

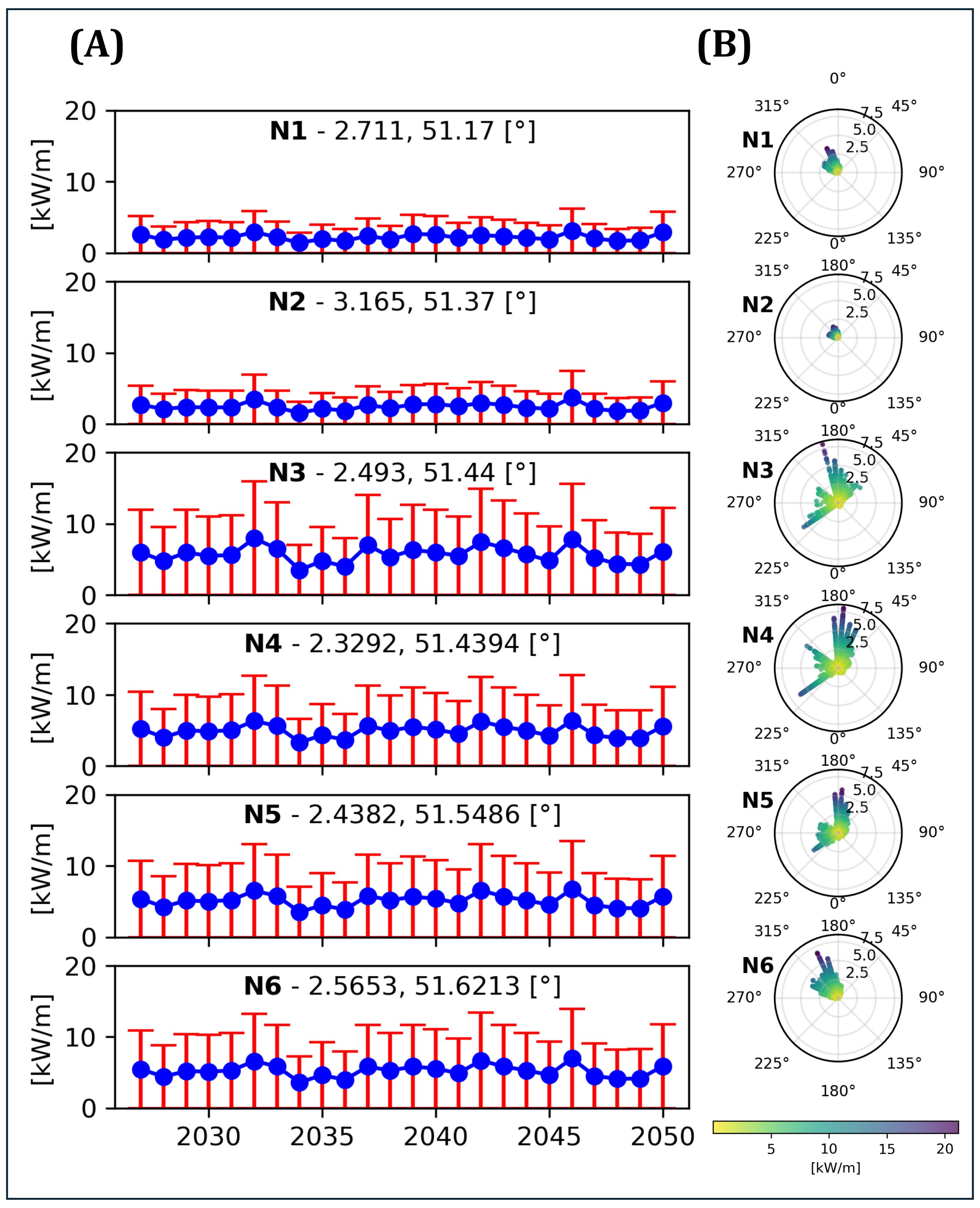

Figure 3. (A) Annual mean P_W (blue dots), and standard deviation (red whiskers) over the period 2020-2050; and (B) Wave power directional distribution , and over the six assessed locations.

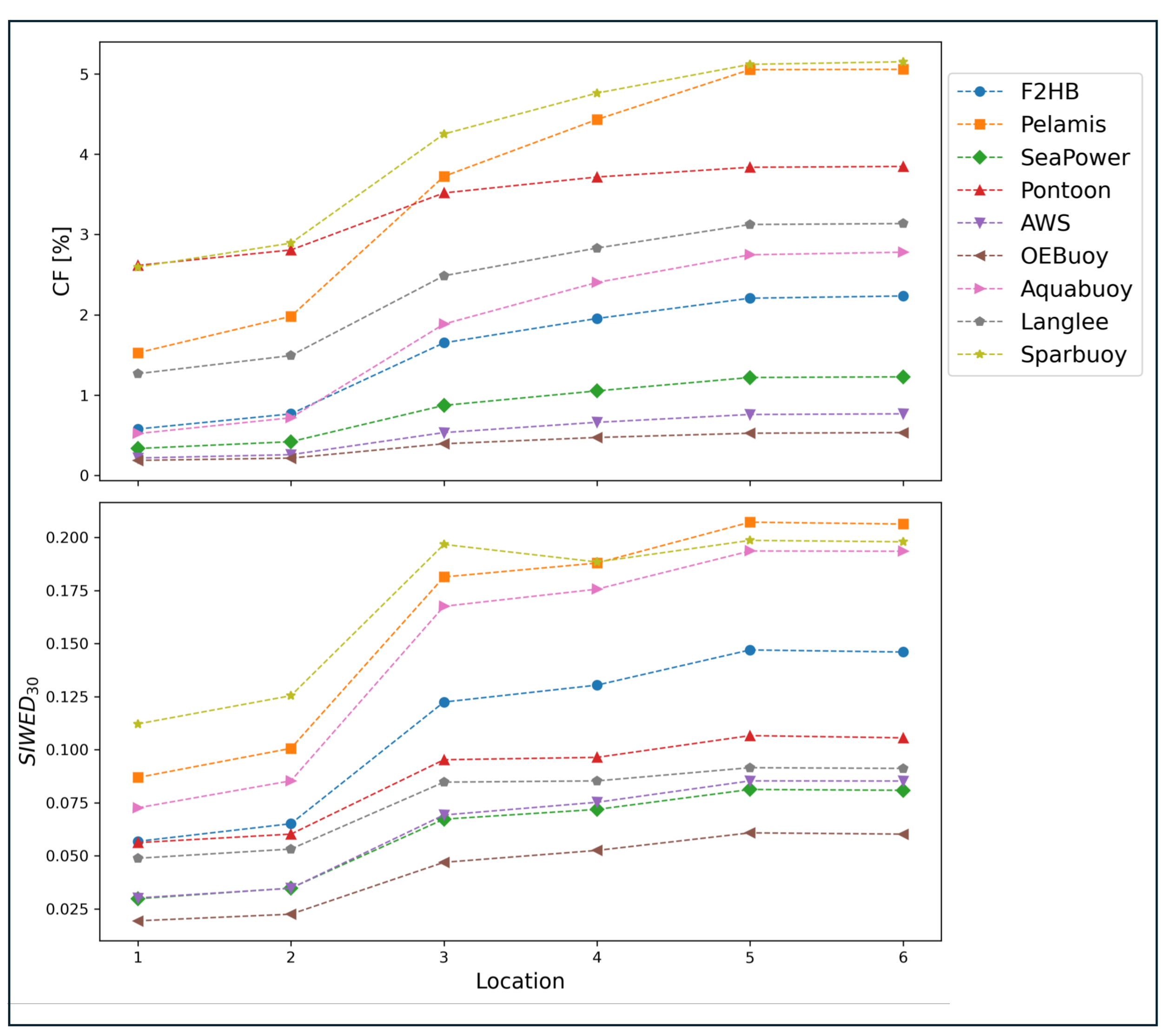

Figure 4. CF and $SIWED_{30}$ over the six assessed locations.

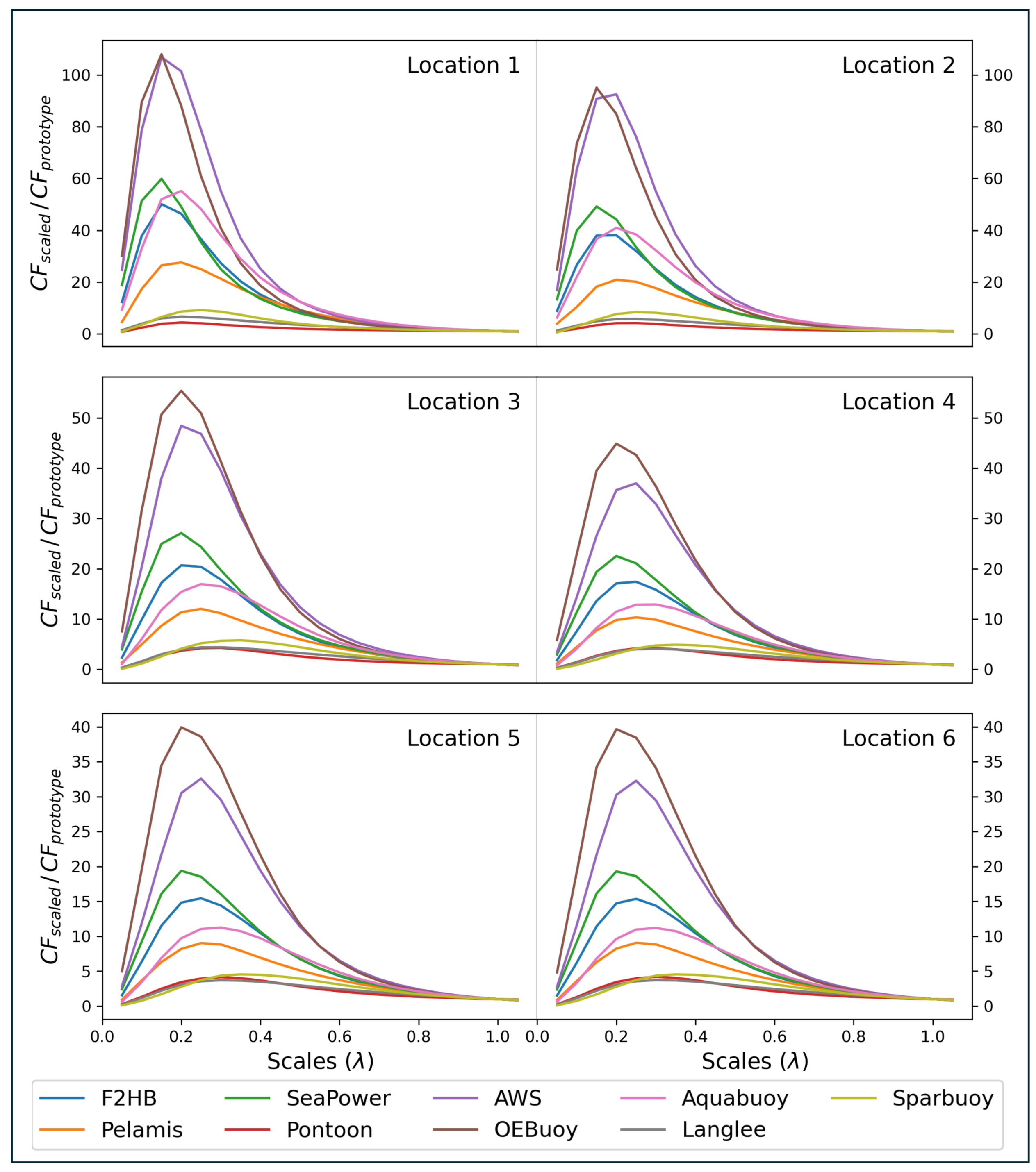

Figure 5. $CF_{Scaled}/CF_{prototype}$ over the six assessed locations.

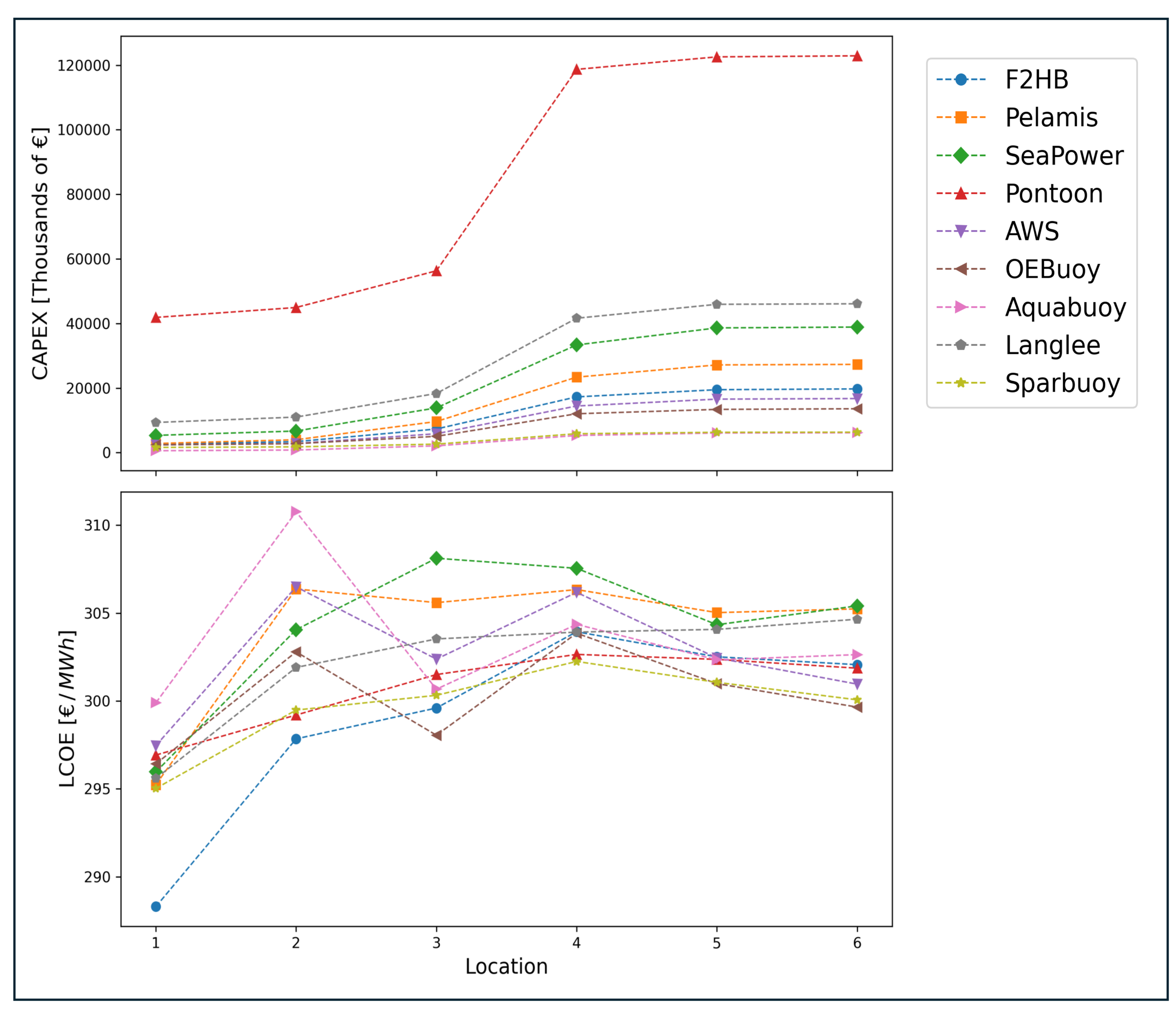

Figure 6. CapEx and LCOE for all WECs over the six assessed locations.

VI. FINAL REMARKS

- The six locations evaluated present a relevant annual variability of wave power. Such variability is lower for locations 1 and 2, which are placed close to the coasts. The most energetic years are 2032 and 2046.
- The three most efficient converters over the assessed locations are Pelamis, Sparbuoy and Aquabuoy, based on $SIWED_{30}$.
- The evaluated converters need to be adapted to the local wave conditions over the BCS to increase their efficiency. The converters which would benefit most due to WEC scaling are OEBuoy and AWS.
- The highest CapEx over the all assessed locations corresponds to Pontoon converter. LCOE costs oscillate between 285 and 315 €/MWh over the six locations.

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