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WAVE ATLAS IN FRENCH POLYNESIA: APPLICATION ON WAVE ENERGY INTEGRATION INTO THE ELECTRICAL MIX

Corinne Dubois[1], Marie Peniguel[2], Hélène Chabbert[2], Vetea Vitrac[3], Mauna Reveil[4]

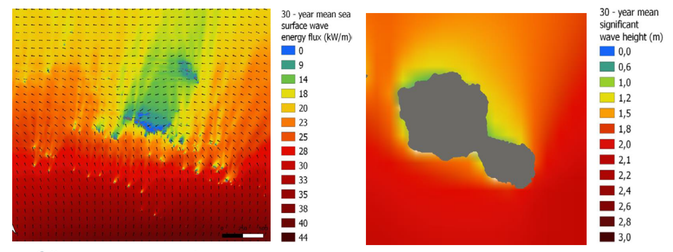
[1] Are Uira, [2] Meteolien, [3] TEP, [4] Ys Polynésie

A new wave energy atlas database for French Polynesia

Based on Météo-France's MFWAM model at 0.05° resolution, with a spatial resolution of 5 km, a three-hourly step, and a temporal depth of 30. Better modelling of islands than existing reanalysis, leading to better estimates of wave conditions and propagation. Spectral significant wave height (VHM0), wave period at spectral peak (VTPK), spectral moments (-1,0), wave period (VTM10), sea surface wave energy flux (J), mean wave direction from (VMDR) are now available from 1993 to 2022.

TEP available production data sets were only on year 2023. So, it was necessary to extend this period to 2023 by a redistribution of ERA-5 2023, on the meshes of the wave atlas with a focus on Tahiti, the domain of this study.

Wave atlas of French Polynesia - 2024

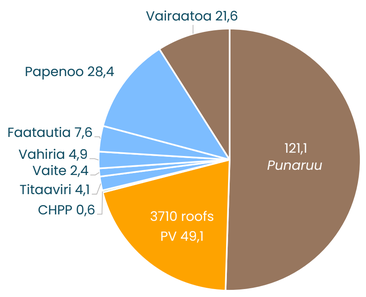


30-year mean J map *Focus on Tahiti for VHM0*

Made by meteolien METEO FRANCE Financed by RÉPUBLIQUE FRANÇAISE ADEME Ys Énergies Marines Développement Direction Polynésienne de l'Énergie

Integration of 10 MW & 20MW wave energy in Tahiti grid

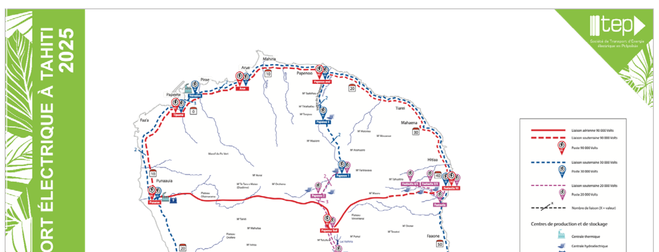
Sea state data from the wave atlas extended to 2023 were used as input for simulating the production of 10 MW & 20MW wave energy systems. These simulations were carried out for integration into the Tahitian power grid at 4 different injection points and considering existing electricity production TEP & EdT registered in 2023.



Installed capacities in 2023 in MW

In 2025, Tahiti presents an electrical mix of 55 % Oil, 37% Hydro, 8% PV (plants+ roofs), and a battery set has been installed to allow better future adjustments for renewable energies.

But all simulations were performed on the base of available 2023 data sets.



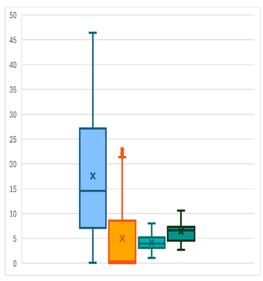
Comparison of the numbers of friction points following wave capacity

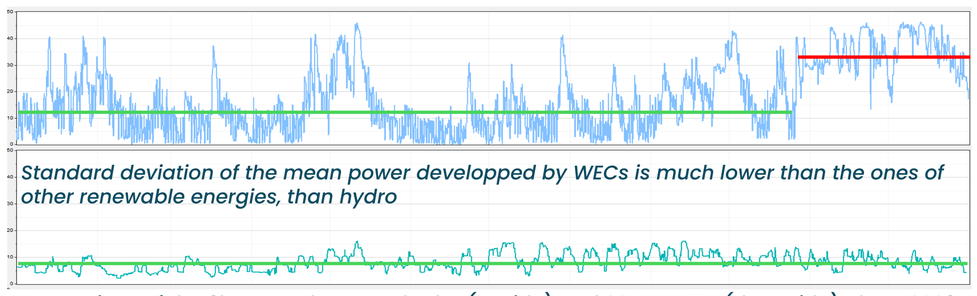
Comparison of the durations (num of 3h slots) of the friction points following wave capacity

The target is that wave energy replaces thermal and does not interfere with other renewables.

Analysis reveals the challenging seasonality of hydropower which production is quite low between June and July and high (~x3) between November and December. These periods being at the inverse for austral waves in the southern coast, it is a global good point for wave energy and reveals very few issues with 10MW WEC, with a maximum of ~2MW during less than 3h (our min time slot as per the model). Nevertheless, increasing to 20MW reveals the multiplication of issues, in the middle of the night in (Tahitian) winter and sometime also during the day in (Tahitian) summer, with a maximum overlap of ~8MW in May 2023 during around 9hrs.

X = REN Mean:
Hydro: 17,6MW / PV: 5,0MW
WEC 10MW: 4,1MW / WEC 20MW: 8,2MW
_ : Median power

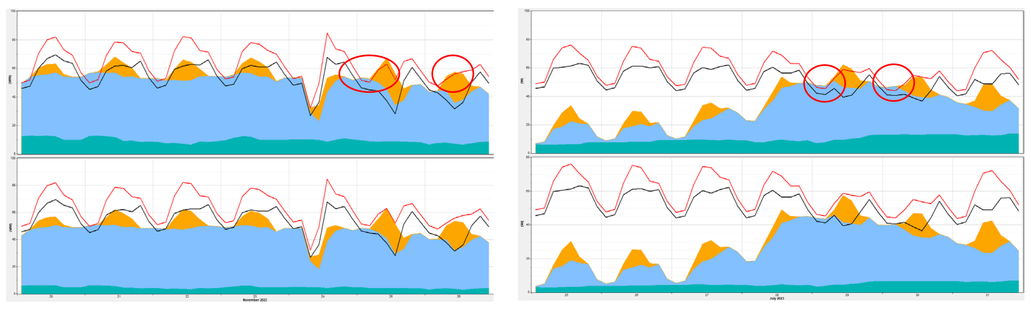




Standard deviation of the mean power developped by WECs is much lower than the ones of other renewable energies, than hydro

Comparison of the 3h curves between hydro (upside) and 20MW WEC (downside) along 2023, with seasonnality highlighted for hydro compared to relative steadiness for waves

Focus on a week with frictions in summer from Mon.20/11 to Sun. 26/11 with 10MW (downside) and 20MW (upside)



Focus on a week with frictions in winter from Tue.25/07 to Mon. 31/07 with 10MW (downside) and 20MW (upside)

Conclusions and openings

Wave atlas allowed to model the easy future integration of wave energy into the electrical mix. As, for wave energy, standard deviation around the mean power is very low, wave electricity production does not challenge the grid usual balance with the first 10MW. But, by simulating 20MW, analysis reveals that, even if it would not create itself any friction, it could increase the risks on the existing weakness points. Furthermore, the share of PV jumped from 8% in 2023 to 19% in early 2025, due to the recent commissioning of 4 PV plants. As in 2023, PV variations was still managed by a compensation either by thermal power curtailment (which is virtuous) and/or by the new battery unit and/or by hydro power curtailment and/or by curtailment on the PV systems themselves.
So, the learnings from 2023 tend to prove that any Grid system (incl. batteries) designed to be able to face the high standard deviations of PV systems, are mathematically able to absorb the very low standard deviation of the wave energy systems. This shall be studied with more details in futures studies with 2025 data.

LEGEND OF THE DOCUMENT
Consumption — Wave — Hydro — PV — Thermal — Total prod

References
Axel Roy, Victoire Laurent (2023). Réanalyse du modèle de vagues MFWAM sur la Polynésie française (MFWAM_FR-POLYNESIA_005).
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Parution publique PF: Concession de distribution publique d'énergie électrique de Tahiti nord conclue entre la PF et la société Electricité De Tahiti rapport du délégataire du service public, Année 2023.