

Evaluation of a floating wave energy converter for Sipora Island, Mentawai, Indonesia: wave resource, annual energy production and levelized cost of energy

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I. INTRODUCTION

Indonesia has set a target for new and renewable energy to supply at least 23% of the national energy mix by 2025 [1]. For ocean wave energy, a potential of 17,989 MW has been reported, of which 0.3 MW, or 0.0017%, was installed [1]. Ribal et al. [2] reported a mean wave power of 15 to 20 kW/m for the waters of the Mentawai Islands, which face the Indian Ocean. A mean wave power above 15 kW/m has been given as one criterion for a good wave energy site [3, Chs. 2–4]. In remote villages of the Mentawai Islands Regency, electricity has been available only in the evening, for about six hours a day [4], and supply relies on nine diesel power plants operated by the state utility on the islands of Siberut, Sipora, North Pagai and South Pagai.

This study aimed to choose a potential site for wave power and the area to be supplied, to compute the wave characteristics and the wave energy potential at the chosen site, to evaluate the potential of several existing wave energy converters there, and to evaluate the economics of the selected converter. The wave data were modelled data from the European Centre for Medium-Range Weather Forecasts, the energy production was estimated with the power matrix and scatter table method, and the regional cost of electricity supply was taken from a ministerial decree [5].

II. STUDY SITE AND DATA

A. Site

The study point lies in the waters west of Sipora Island in the Mentawai Islands Regency, West Sumatra Province, and faces the Indian Ocean directly. The point

is at 2.05° S, 99.4° E, about 16.5 km from the coast of North Sipora district (Fig. 1). The site was chosen from the wave energy resource map of Ribal et al. [2], and Sipora Island was chosen as the area to receive the electricity. Water depth at the point is 120 m below mean sea level, taken from the Indonesian national bathymetry (BATNAS) at 6 arc-second resolution and processed in Global Mapper. Bottom contours between the point and Sipora Island are not gentle, which may complicate the installation of a subsea export cable. The BATNAS data were accessed in December 2023; their version was not recorded.

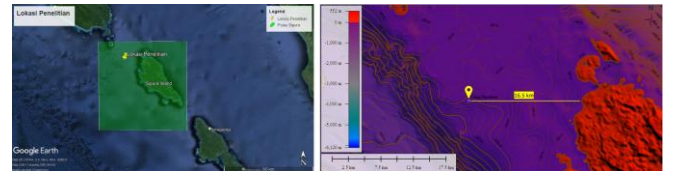


Fig. 1. Study point west of Sipora Island and bathymetry. Source images: thesis Gbr 3.2 and Gbr 3.4 (Google Earth imagery; BATNAS).

B. Wave data

Hourly significant wave height, peak wave period and mean wave direction for 2022 were taken from the ERA5 dataset of the European Centre for Medium-Range Weather Forecasts [6], giving 8,760 records. The data were downloaded in December 2023 from the Copernicus Climate Data Store dataset reanalysis-era5-single-levels on its 0.5° grid, using the variables swlh, pp1d (peak_wave_period) and mwd (mean_wave_direction) at the nearest grid node, and the time stamps are in UTC, as ERA5 is distributed. One year of data was used to represent annual energy production, on the assumption stated in the thesis that wave conditions are similar from year to year. The mean wave direction was measured

clockwise from true north, and the wave roses were drawn for the direction from which waves arrive.

C. Electricity supply and demand

The Mentawai Islands are not connected to the Sumatra grid and are supplied by isolated systems with nine diesel plants and three biomass plants. The diesel plants had a peak load of 3.06 MW against a total capacity of 10.137 MW. Electricity customers in the regency rose from 12,793 in 2019 to 19,295 in 2023 [7]. Electricity consumption in the Mentawai service area of the state utility rose from 16,539 MWh in 2019 to 21,241 MWh in 2023 [8]. From these data the thesis projected a consumption of 23,395 MWh for 2025. This consumption, which covers the whole Mentawai service area, is taken as the demand of Sipora Island because most of the population and of the diesel generation of the service area are on Sipora. The regional cost of electricity supply of the state utility for the Mentawai Islands, set by Decree of the Minister of Energy and Mineral Resources No. 169.K/HK.02/MEM.M/2021, was Rp2,319.00/kWh [5].

III. METHODS

A. Wave power

The wave power per unit crest length in deep water, where the depth h exceeds half the wavelength λ , is [9]

$$P = \rho g^2 H_s^2 T_e / (64\pi) \quad (1)$$

where P is the wave power (kW/m), ρ the density of water (kg/m^3), g the acceleration due to gravity (m/s^2), H_s the significant wave height (m) and T_e the energy period (s). The thesis does not state the values of ρ and g ; this study uses the coefficient $\rho g^2 / (64\pi) = 0.4740 \text{ kW}/(\text{m}^3 \cdot \text{s})$ implied by the bin powers tabulated in the thesis. The energy period is the ratio of the spectral moment of order -1 to the zeroth spectral moment, $T_e = m_{-1}/m_0$ [10]. Because the dataset provides the peak period T_p , the energy period was obtained from $T_p = 1.12 T_e$, the ratio for a JONSWAP spectrum with peak enhancement factor $\gamma = 3.3$ [10]. Occurrences were counted in bins of 0.5 m in H_s and 0.5 s in T_e , both for all directions and for the dominant direction sector of 191.25° to 213.75° . The wave power of each bin was multiplied by the number of hours in that bin to give the wave energy per metre of crest for the year. Each bin is represented here by the H_s and T_e at its centre. The thesis evaluated each bin at its lower H_s and T_e edges, which biases its tabulated wave power low. Because the deep-water condition holds at 120 m only for periods below about 12.4 s, the power of each bin was multiplied by the ratio of the group velocity at $h = 120 \text{ m}$ to its deep-water value, using the intermediate-depth group velocity given in the thesis and linear dispersion with $g = 9.81 \text{ m/s}^2$. This factor is 1.017 at $T_e = 12.25 \text{ s}$ and rises to 1.174 at $T_e = 18.75 \text{ s}$.

B. Annual energy production

Annual energy production was estimated with the power matrix and scatter table method, recommended in IEC TS 62600-100 [11] and described in [3, Chs. 2–4], in which the absorbed power of each bin of a device power matrix is multiplied by the hours of occurrence of that bin and summed. Three floating devices were evaluated: the Pelamis attenuator with a hydraulic power take-off rated at 750 kW, the Wave Dragon, an overtopping device that the thesis classes as a terminator [12], with water turbines rated at 5,900 kW, and the OE Buoy floating oscillating water column with an air turbine rated at 2,880 kW. The power matrix of the OE Buoy was taken from Babarit et al. [13]. The Pelamis and Wave Dragon power matrices were taken from Veigas et al. [14]; the thesis also names Carballo and Iglesias [15] as the source of the power matrices. Production was computed from the occurrences in the dominant sector of 191.25° to 213.75° only, with the device oriented towards that sector. Each bin was assigned the matrix value at its lower H_s and T_e edges, and the matrices begin at $H_s = 1 \text{ m}$; the matrices were read against the energy period, as in the thesis (Section V-D). The power matrices are labelled with the peak period in the device chapter of the thesis and were applied against the energy period. The number of devices needed was the 2025 consumption divided by the annual energy production of one device.

C. Capture width ratio

The capture width ratio of each bin was computed as

$$\text{CWR} = P_{aBs} / (P B) \quad (2)$$

where P_{aBs} is the absorbed power of the device (kW), P the wave power (kW/m) and B the effective width of the device (m). The effective widths were 180 m for the Pelamis, 300 m for the Wave Dragon and 24 m for the OE Buoy. For the Pelamis and the Wave Dragon the effective width is the device length, chosen because of the arrangement of their power take-off. The thesis summarised each device by the mean of its non-zero bin ratios; for the Wave Dragon it printed 43.2%, which divides the sum of the 24 non-zero ratios by 25, and the corrected mean is 45.0%. This study reports instead the annual capture width ratio: the annual energy production divided by the product of the effective width and the annual incident wave energy per metre in the dominant sector, 32,719 kWh/m as tabulated in the thesis. Both terms are evaluated at the lower bin edges, so device power and wave power are read at the same matrix nodes.

D. Device selection

The device was selected by annual energy production, rated power and estimated cost of the number of units needed to meet the 2025 consumption. The estimated cost per device was £19,500,000 for the Pelamis [16], £15,271,843.20 for the Wave Dragon [17] and £6,699,420 for the OE Buoy [18]. The £19,500,000 for the Pelamis and

the £13,104,000 that the thesis used for the Wave Dragon in the selection equal the US\$25,000,000 and US\$16,800,000 given by Astariz and Iglesias [16] multiplied by 0.78; the thesis does not state this exchange rate.

E. Costs and financial model

The economic evaluation was made for one Wave Dragon unit with a project life of 25 years, starting in year 0 (2024) and decommissioned in year 26 (2050). The device cost was £15,271,843.20 per unit [17], covering the power take-off, generator, floating structure and electrical systems, but not installation, mooring or export transmission. The cited report gives US\$10–12 million for a single 4 MW prototype unit, and the thesis does not state how this was converted to £15,271,843.20 for the 5.9 MW unit. Because there were insufficient sources of cost data for wave energy installations, the other cost categories used the per-megawatt rates of a 450 MW floating offshore wind farm in the United Kingdom at 100 m depth, scaled to 5.9 MW [19]. Mooring was costed at £354 per tonne for 2,000 t. The mooring mass of 2,000 t is an assumption taken from the same floating offshore wind cost guide [19]. Costs were converted at £1 = Rp20,037, the latest Bank Indonesia transaction rate as of 10 March 2024 [20]. Annual operation and maintenance costs and the decommissioning cost were escalated at 4.13%, the mean annual inflation rate for 2013–2023 [21], and cash flows were discounted at 4.59%, the mean Bank Indonesia policy rate for 2016–2022 [22]. Revenue was the annual energy production of 3,382,126 kWh sold at the regional supply cost, with constant production, all energy sold and a constant selling price over the project life. The economic chapter of the thesis used 3,382,182 kWh per year, which differs from the production computed in its Chapter IV. The net present value was computed as

$$NPV = PV_{in} - PV_{out} = \sum_n (FV_{in,n} - FV_{out,n}) / (1 + i)^n \quad (3)$$

where PV_{in} and PV_{out} are the present values of income and expenditure, $FV_{in,n}$ and $FV_{out,n}$ the income and expenditure in year n , summed from 2024 (the capital expenditure) to 2050 (the decommissioning cost), and i the discount rate; the summation sign is added here, as the thesis prints a single-year term. The levelized cost of energy was defined as

$$LCOE = [CapEx + PV(OpEx) + PV(Dec)] / PV(AEP) \quad (4)$$

where $CapEx$ is the capital expenditure, $OpEx$ the operation and maintenance expenditure, Dec the decommissioning cost and AEP the annual energy production, with the capital expenditure counted at the start of the project. Costs and energy were both discounted by $(1.0459)^n$, n being the number of years after 2024, as (4) defines. Recomputing the worked calculation of the thesis shows that it instead divided the cost of every year by 1.0459 once and summed the energy without discounting, which gave Rp9,311.95/kWh. The operation and maintenance cost of year n was escalated by $(1.0413)^{n-1}$, as in every yearly value of Table 5.8 of the

thesis and in every year but 2049 of its Table 5.7, and the decommissioning cost, incurred in 2050, by $(1.0413)^{25}$ under the same convention. Table 5.7 of the thesis for 2049 and its worked example for year 25 use $(1.0413)^n$ instead; with that convention, and the decommissioning cost escalated by $(1.0413)^{26}$, the levelized cost would be Rp12,595/kWh and the net present value –Rp510,610,158,418. The decommissioning cost in 2050 is therefore Rp47,471,644,357.43. The thesis gives three other values: Rp49,432,223,269.39 in its Table 5.7, the year-0 cost escalated by $(1.0413)^{26}$ as its text writes; Rp51,473,774,090.42 in its text; and Rp58,622,819,509.94 in its Table 5.8, whose present value equals the cumulative balance for 2049 in its Table 5.9. With these values the levelized cost would be Rp12,438/kWh, Rp12,450/kWh or Rp12,495/kWh.

IV. RESULTS

A. Wave climate

In 2022 the significant wave height ranged from 0.61 m on 3 January to 2.33 m on 16 November. The peak period ranged from 6.12 s on 19 January to 20.96 s on 2 July (Fig. 2).

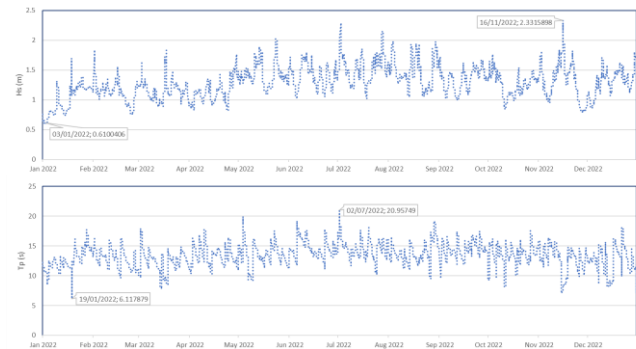


Fig. 2. Hourly significant wave height (top) and peak period (bottom) at the study point in 2022. Source: thesis Gbr 3.5 (reused as image).

Waves arrived mainly from 191.25° to 213.75° , for 5,194 h or 59.3% of the year, followed by 213.75° to 236.25° for 2,223 h or 25.4% (Table I and Fig. 3; the thesis text rounds these to 58% and 26%).

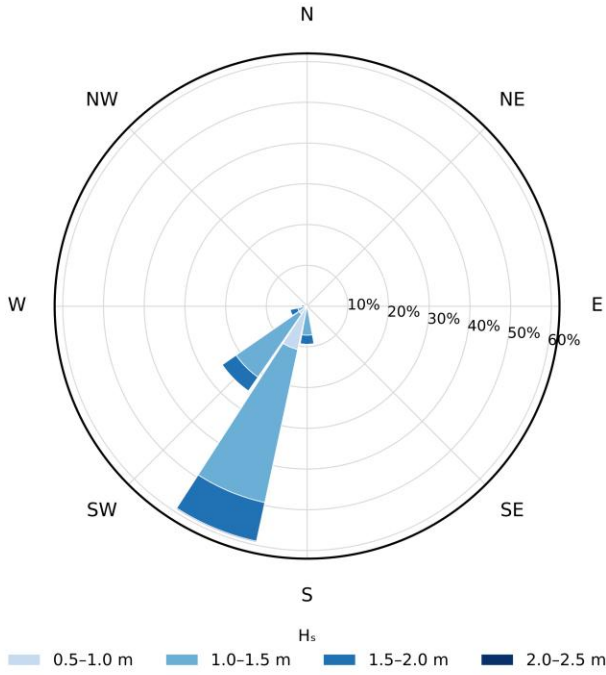


Fig. 3. Wave rose for 2022 at the study point: share of hours by direction from which waves arrive (22.5° sectors) and significant wave height class. Redrawn from the hourly ERA5 series; the sector counts equal Table I (thesis Gbr 3.6 and Tabel 3.2).

TABLE I. HOURS OF OCCURRENCE IN 2022 BY DIRECTION SECTOR AND SIGNIFICANT WAVE HEIGHT CLASS. SOURCE: THESIS TABLE 3.2 (IMAGE).

Direction sector (°)	0.5–1 m	1–1.5 m	1.5–2 m	2–2.5 m	Total
168.75–191.25	27	600	196	0	823
191.25–213.75	954	3,367	851	22	5,194
213.75–236.25	208	1,649	363	3	2,223
236.25–258.75	0	206	166	8	380
258.75–281.25	0	26	92	18	136
281.25–303.75	0	4	0	0	4
All directions	1,189	5,852	1,668	51	8,760

No hours occurred below 0.5 m, at or above 2.5 m, or from the other direction sectors (Table I). The thesis judged the variation of wave direction at the site to be not very large, which it regarded as fairly favourable for a wave energy converter.

B. Wave resource

For all directions, energy periods ranged from 5 s to 19 s and significant wave heights from 0.5 m to 2.5 m, and the most frequent bin was H_s 1–1.5 m with T_e 11.5–12 s, with 1,005 h. In the dominant sector the same bin was the most frequent, with 662 h (Fig. 4a). The mean wave power was 10.2 kW/m over all 8,760 h of 2022 and 10.0 kW/m over the 5,194 h of the dominant sector. In deep water, as the thesis assumed, the bin-centre means were 9.9 kW/m for all directions and 9.7 kW/m for the dominant sector. The thesis reported a mean of 10.32 kW/m over all hours of 2022; it lies closest to the all-direction value with the depth correction, which the thesis did not apply. The largest bin wave power in the dominant sector was 43.6 kW/m, in the bin H_s 2–2.5 m with T_e 16–16.5 s, and the most frequent bin had 8.8 kW/m (Fig. 4b). The thesis gave 30.3 kW/m for the largest bin; evaluating that bin at its centre gives 39.0 kW/m in deep water, and the depth correction adds the remainder.

The wave energy available in 2022 was 89,576 kWh/m for all directions and 51,817 kWh/m for the dominant sector, against 32,719 kWh/m tabulated in the thesis for the dominant sector (Fig. 4c). Most of the energy, 78% in the dominant sector, came from bins with H_s of 1–2 m and T_e of 10–14.5 s.

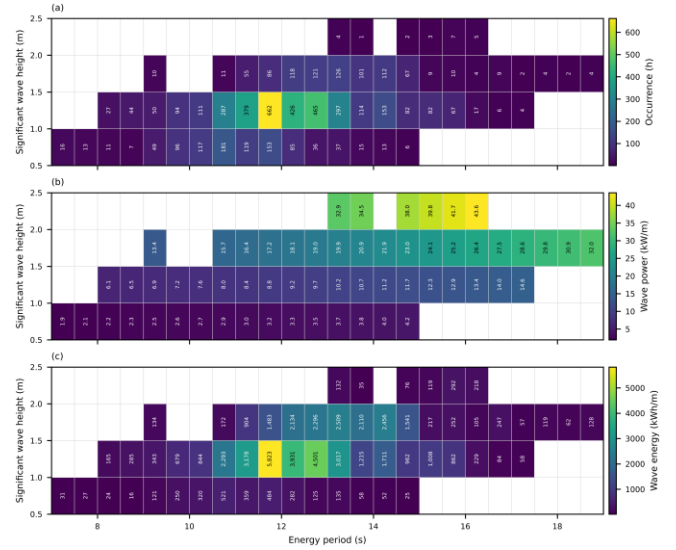


Fig. 4. Dominant sector 191.25°–213.75°, 2022: (a) hours of occurrence, (b) bin wave power (kW/m) and (c) bin wave energy (kWh/m) at bin centres with the depth correction, by significant wave height and energy period. Counts from thesis Gbr 4.2; power and energy computed as in Section III-A.

C. Device performance

To reach rated power, the Pelamis needs significant wave heights above 5 m and the Wave Dragon above 3.5 m, whereas the largest significant wave height at the site was 2.33 m. The OE Buoy power matrix reaches its rated power of 2,880 kW only at H_s = 7 m and a period of 9 s, far outside the conditions at the site. The annual energy production in 2022 was 62,925 kWh for the Pelamis, 3,382,126 kWh for the Wave Dragon and 220,051 kWh for the OE Buoy (Table II). For all three devices the largest contribution came from the bin H_s 1–1.5 m with T_e 11.5–12 s: 13,902 kWh for the Pelamis, 575,940 kWh for the Wave Dragon (Fig. 5) and 27,804 kWh for the OE Buoy.

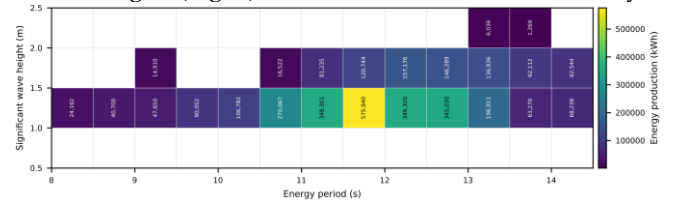


Fig. 5. Energy production of one Wave Dragon by bin in 2022 (kWh), dominant sector only. Redrawn from the values printed in thesis Gbr 4.10.

The annual capture width ratio was 1.07% for the Pelamis, 34.5% for the Wave Dragon and 28.0% for the OE Buoy; the means of the non-zero bin ratios were 3.1%, 45.0% and 31.3%. The bin capture width ratio of the Wave Dragon was highest, at 80%, for H_s 1–1.5 m with T_e 8–8.5 s. The capacity factor of one Wave Dragon, not reported in the thesis, follows from these values as 6.5%.

TABLE II. DEVICE PARAMETERS AND RESULTS FOR THE STUDY POINT IN 2022; THE ANNUAL CAPTURE WIDTH RATIO IS COMPUTED AS IN SECTION

III-C THE NUMBER OF DEVICES IS THE 2025 CONSUMPTION DIVIDED BY THE ANNUAL ENERGY PRODUCTION OF ONE DEVICE, UNROUNDED AS IN THE COST ROW (THE THESIS PRINTS 372, 7 AND 106); THE WAVE DRAGON MEAN OF NON-ZERO BIN RATIOS IS CORRECTED FROM THE 43.2% PRINTED IN THE THESIS (SECTION III-C). SOURCES: THESIS TABLE 2.3–2.5, §4.2–4.4 AND TABLE 4.2.

Quantity	Pelamis	Wave Dragon	OE Buoy
Type	Attenuator	Overtopping	Floating oscillating water column
Rated power (kW)	750	5,900	2,880
Effective width (m)	180	300	24
Annual energy production (kWh)	62,925	3,382,126	220,051
Annual capture width ratio (%)	1.07	34.5	28.0
Mean of non-zero bin ratios (%)	3.1	45.0	31.3
Estimated cost per device (£)	19,500,000	15,271,843.20	6,699,420
Devices for 23,395,000 kWh (unrounded)	371.8	6.9	106.3
Cost of devices (£)	7,249,940,40524	105,639,107.37	712,257,298.99

D. Device selection and layout

The Wave Dragon was selected because it had the largest annual energy production and the lowest cost for the number of units needed (Table II). Seven Wave Dragon units would be needed to supply the projected 2025 consumption of 23,395,000 kWh, since $23,395,000 \text{ kWh} / 3,382,126 \text{ kWh} = 6.92$. The thesis rounds the counts to 372, 7 and 106; for the OE Buoy this rounds down, and 106 units would produce 23,325,406 kWh, slightly less than the projected 2025 consumption. The units were placed in a line facing the dominant direction, and this layout was not optimised for wave capture by more than one unit.

E. Costs

The estimated expenditure for one Wave Dragon unit, with one year of operation and maintenance, was £21,905,508.20 (Table III). The device accounted for 70% of this total.

TABLE III. ESTIMATED EXPENDITURE FOR ONE WAVE DRAGON UNIT. SOURCES: THESIS TABLE 5.1–5.6 (IMAGES) AND §5.4.

Category	Share (%)	Cost (£)	Cost (Rp)
Development and project management	4	862,285.00	17,277,604,545.00
Device (Wave Dragon)	70	15,271,843.20	306,001,922,198.40
Balance of plant	12	2,627,860.00	52,654,430,820.00
Installation and commissioning	9	1,865,580.00	37,380,626,460.00
Operation and maintenance (per year)	2	416,540.00	8,346,211,980.00
Decommissioning (year-0 prices)	4	861,400.00	17,259,871,800.00
Total		21,905,508.20	

The rupiah value in Table III for development and project management is the pound value multiplied by the exchange rate, because the corresponding thesis text value differs (Section V-C). The balance of plant follows Table 5.3 of the thesis, £2,627,860.00; the thesis cash flow used £2,519,860.00 from its Table 5.1. The capital expenditure in 2024 was Rp413,314,584,023.40, against

Rp411,150,588,023.40 in the thesis with the Table 5.1 balance of plant. The annual operation and maintenance cost started at Rp8,346,211,980.00 in 2025 and was escalated each year to Rp22,045,007,568.48 in 2049 (Table 5.8 of the thesis; its Table 5.7 gives Rp22,955,466,381.06 for that year).

F. Net present value at the regional supply cost

With 3,382,126 kWh sold each year at Rp2,319.00/kWh, the annual revenue was Rp7,843,150,194.00, less than the operation and maintenance cost of every year. The net present value over the project life was -Rp502,180,975,934, so the regional supply cost does not recover the costs of the project. The thesis reported -Rp259,146,743,307.35, a value that cannot be reproduced from its printed inputs.

G. Levelized cost of energy

The present value of the costs was Rp617,411,012,198 and the present value of the energy was 49,689,537 kWh, giving a levelized cost of energy of Rp12,425/kWh. If the electricity were sold at this price, the cumulative discounted cash flow would become positive in 2047 and return to zero in 2050, after the decommissioning cost (Fig. 6).

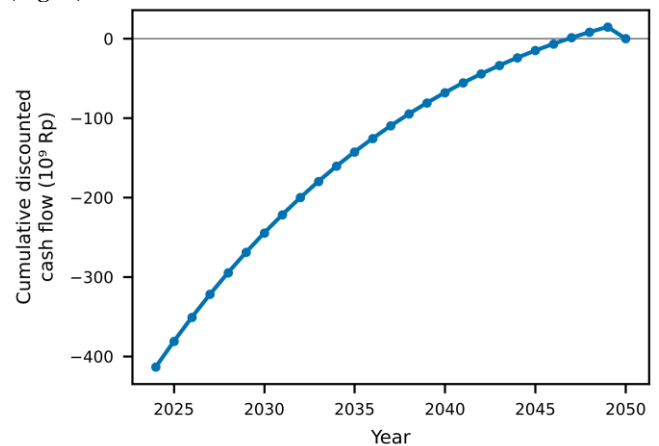


Fig. 6. Cumulative discounted cash flow of one Wave Dragon unit if the electricity is sold at the levelized cost of energy, 2024–2050. Computed from the thesis cost inputs as in Section III-E.

The cost of energy from diesel generators, obtained in the thesis with the levelized cost of electricity calculator of the Institute for Essential Services Reform [23], was Rp4,677/kWh to Rp7,795/kWh; the calculator inputs are not stated in the thesis.

V. DISCUSSION

A. Resource

The mean wave power of about 10 kW/m at the study point is below the 15 kW/m criterion cited in Section I [3, Chs. 2–4] and below the 15 to 20 kW/m reported for the Mentawai waters by Ribal et al. [2]. The thesis does not discuss this difference. The binned wave energy of the thesis corresponds to only 6.30 kW/m over the dominant-sector hours, far below its reported mean of 10.32 kW/m. Evaluating the same bins at their centres gives 9.7 kW/m

in deep water, which shows that the binned tables, evaluated at the lower edges, rather than the mean were biased low. The depth correction raises the all-direction mean from 9.9 kW/m in deep water to 10.2 kW/m, because long-period waves at 120 m carry more power than the deep-water expression gives.

B. Device selection

Under the conditions at the site none of the three devices reaches its rated power. The Wave Dragon produced the most energy and, with seven units, had the lowest cost of the three configurations.

C. Economics

At the regional supply cost of Rp2,319.00/kWh, a floating wave power plant using the Wave Dragon is not feasible, and the levelized cost of Rp12,425/kWh is above the diesel range of Rp4,677/kWh to Rp7,795/kWh. The thesis reached the same conclusion with its value of Rp9,311.95/kWh. The difference has two parts: discounting each year by its own factor lowers the present value of the costs from the Rp787,368,128,813.09 of the thesis to Rp617,411,012,198, which alone would give Rp7,302/kWh, while discounting the energy as (4) requires lowers the energy term from 84,554,550 kWh to 49,689,537 kWh and raises the cost to Rp12,425/kWh. The thesis concluded that the Wave Dragon cannot yet be chosen as a generator for the energy transition in Indonesia, and that lower costs of installation, power take-off and structure, and higher efficiency, are needed. The development and project management cost printed in the thesis text, Rp346,191,362,268,165.00, equals the pound value multiplied by the exchange rate twice; the cash flow uses the correct value of Rp17,277,604,545.00, so this error does not affect the results. With the £2,519,860.00 of Table 5.1, which the thesis cash flow used, the levelized cost would be about Rp43.6/kWh lower.

D. Limitations

The ERA5 reanalysis wave data were not validated against measurements, and validation against data from trusted institutions is needed. Only one year, 2022, was used, and the similarity between years assumed in Section II was not demonstrated. The annual energy production counts only the 5,194 h of the dominant sector, 59.3% of the year, and assigns no production to the 954 h in that sector with H_s below 1 m or to the hours with energy periods beyond the range of each power matrix: 867 h for the Pelamis, 386 h for the Wave Dragon and 31 h for the OE Buoy. The source power matrices are indexed by the peak period, as their labels in the device chapter of the thesis state, but were read against the energy period; reading them at $T_p = 1.12 T_e$, taking the matrix column at or below that value, would lower the annual energy production by 60% for the Pelamis, 33% for the Wave Dragon and 11% for the OE Buoy, and raise

the levelized cost of the Wave Dragon to about Rp18,493/kWh. The depth correction was applied to the wave resource only; the device power matrices were used as printed. The annual capture width ratios use lower-edge values for both production and incident energy. With the bin-centre, depth-corrected incident energy of Section IV-B as denominator, while production still uses the lower-edge lookup, they would be 0.67%, 21.8% and 17.7%; these mix two conventions and are lower bounds rather than estimates. The cost estimate is borrowed from floating offshore wind, the device price dates from 2004 and was not escalated, only one of the seven units needed was costed, and actual data on interest rates, inflation and device prices are needed. The 2025 consumption of 23,395 MWh is for the whole Mentawai service area of the state utility, not for Sipora Island alone. Assigning each bin the power matrix value at its lower H_s and T_e edges also affects the annual energy production, in a direction that depends on the shape of each matrix. The thesis used £13,104,000 per Wave Dragon unit in the device selection and £15,271,843.20 in the cost model; this study uses £15,271,843.20 in both, which does not change the selection. Production was assumed constant over 25 years with all energy sold at a constant price, transmission losses in the export cable were not applied to the energy production, the difficulty of cable installation on the bottom slope towards Sipora Island was not reflected in the generic per-megawatt installation rates, and the layout of the seven units was not optimised. Newer wave energy converters with higher efficiency and lower cost may change both the energy production and the cost of energy.

VI. CONCLUSION

A point 16.5 km west of North Sipora district, at 120 m depth, was evaluated as a site for a floating wave power plant to supply Sipora Island, using one year of modelled wave data. Waves arrived mainly from 191.25° to 213.75°, and over the whole year significant wave heights ranged from 0.61 m to 2.33 m and peak periods from 6.12 s to 20.96 s. Evaluated at bin centres, the mean wave power was 9.7 kW/m to 10.2 kW/m, depending on the hours included and on the depth correction, close to the 10.32 kW/m reported in the thesis and below the 15 kW/m given in [3, Chs. 2–4] as one criterion for a good site. Of the three devices, the Wave Dragon produced the most energy, 3,382,126 kWh in 2022, and was selected. The regional supply cost of Rp2,319.00/kWh does not make the plant feasible, and the levelized cost of energy computed as defined in (4) is Rp12,425/kWh, above the range given for diesel generation.

ACKNOWLEDGEMENT

Thanks Prof. Harman Ajiwibowo and Lurohman Mamin Masturi, supervisors of the undergraduate thesis on which this article is based, for their guidance.

DECLARATIONS

Funding: this work received no specific funding.

Competing interests: the author declares no competing interests.

Data availability: the hourly wave data and calculation files are held by the author and the thesis supervisors and are not publicly available. The ERA5 data are free to use and can be obtained from the Copernicus Climate Data Store [6].

Prior publication: this article is based on the author's undergraduate thesis in Ocean Engineering at Institut Teknologi Bandung (2024), available from the ITB digital library: https://digilib.itb.ac.id/gdl/view_data/studi-evaluasi-pembangkit-listrik-tenaga-gelombang-laut-di-perairan-pulau-sipura-kepulauan-mentawai-sumatera-barat/

Use of AI: the English text of this manuscript was drafted with an AI system (Claude, Anthropic) from the author's undergraduate thesis. The AI system was also used to recompute and verify values derived from the thesis data, check numerical consistency and look up reference metadata. The author reviewed all content and takes full responsibility for it.

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