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BOOK OF ABSTRACT

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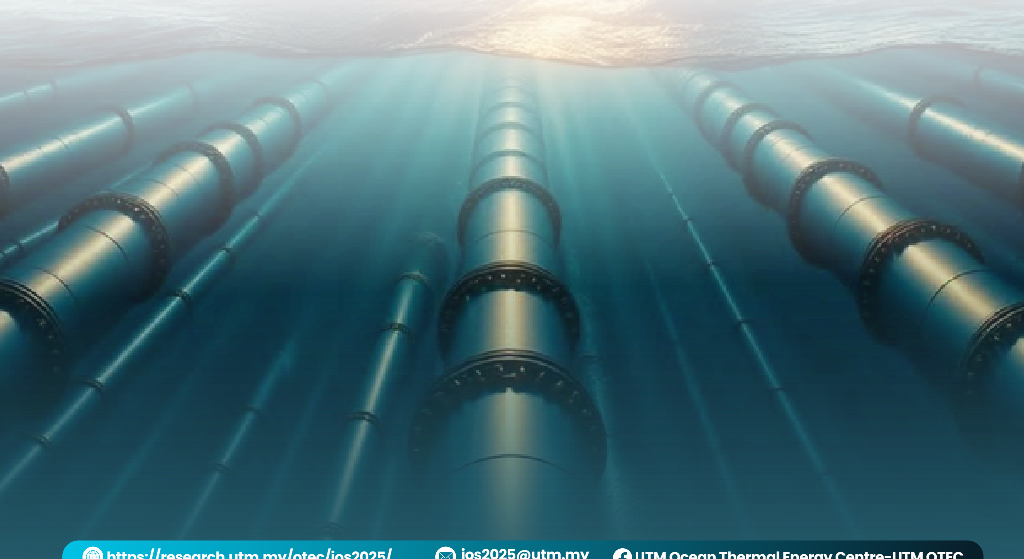

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ABSTRACT OF 11TH INTERNATIONAL OTEC SYMPOSIUM 2025

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11th International OTEC Symposium (IOS 2025)

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Foreword by the Chair of Ocean Thermal Energy Association (OTEA)

It is my profound honor, as President of the Ocean Thermal Energy Association (OTEA), to share these words at the opening of the 11th International OTEC Symposium (IOS2025). I extend my deepest respect and heartfelt appreciation to Universiti Teknologi Malaysia (UTM) and the organizing committee for their vision, dedication, and unwavering commitment. Under the banner "Sustainable Energy – Harnessing Power of the Ocean," this symposium stands as a beacon of possibility—where knowledge, passion, and purpose come together to shape a better future for our planet.

OTEA is the world's largest global community devoted to OTEC, uniting researchers, engineers, policymakers, and industry leaders who share a single conviction: that the ocean holds the power to transform our world. Today's global energy and environmental challenges are immense, but they are not insurmountable. Through OTEC and the multiple uses of deep ocean water, we hold the tools to address energy insecurity, freshwater scarcity, environmental stress, and the vulnerabilities faced by island and coastal societies everywhere. This is not merely technology—it is hope made tangible.

This year marks an extraordinary milestone. In January, the world's first advanced Hybrid-OTEC (H-OTEC) facility was inaugurated in Port Dickson, Malaysia, as UPM/UTM-OTEC. This achievement is more than a technological breakthrough; it is a symbol of what international collaboration, dedication, and belief in the future can accomplish. As OTEA President, I am deeply moved and proud that IOS2025 is being held in Malaysia, home to this pioneering and inspiring new global hub for next-generation OTEC innovation.

OTEC's ability to deliver constant, stable renewable power—day and night, in every season—offers a unique path toward global energy resilience. When combined with deep ocean water–based desalination, cooling, aquaculture, marine biotechnology, and tourism, the Multiple Use of Seawater model becomes a foundation for a flourishing Blue Economy. For many communities, especially island nations and coastal regions, these innovations represent not only solutions, but dignity, opportunity, and a new horizon of possibility.

OTEA's mission is guided by a simple but powerful belief: that by uniting academia, industry, governments, and local communities, we can create real and lasting change. We are committed to accelerating innovation, expanding real-world implementation, and ensuring that OTEC contributes meaningfully to a peaceful, sustainable, and hopeful global future.

May IOS2025 ignite inspiration in each of us. May it foster new partnerships, spark breakthrough ideas, and deepen our shared commitment to harnessing the ocean's power for humanity. And may this symposium help shape a world where future generations can live with security, prosperity, and harmony with our oceans.

Together, let us move forward with courage and belief. The ocean is calling us toward a brighter future—and together, we will answer.

Thank You.

Prof. Dr. Yasuyuki Ikegami
Chair
Ocean Thermal Energy Association (OTEA)

Foreword by the Chairperson
11th InternationalOTECSymposium (IOS2025)

Salam Sejahtera, Greetings everyone

It is my great pleasure to welcome all esteemed delegates, keynote speakers, participants and industry partners to the 11th International OTEC Symposium (IOS2025), proudly hosted by Universiti Teknologi Malaysia (UTM) through its UTM Ocean Thermal Energy Centre (UTM OTEC), Institute Future Energy (IFE), Universiti Putra Malaysia (UPM) and Universiti Malaysia Sabah (UMS) and supported by Ocean Thermal Energy Association (OTEA).

Since its inception, IOS has served as a vital annual platform for researchers, industry practitioners, and policymakers to engage in knowledge exchange and foster collaborations in the field of OTEC technology, projects, oceanography, Deep Ocean Water application and other OTEC spin off industries. This year, we are honoured to continue the legacy by bringing together experts from across the globe to deliberate on innovations, challenges, and opportunities that will shape the transition towards a renewable and sustainable future energy, here in UTM Kuala Lumpur.

The theme of IOS2025, “Sustainable Energy – Harnessing Power of the Ocean”, is timely and significant. It reflects the urgent need to accelerate the global agenda on carbon footprint, strengthen energy-water-food security, and drive sustainable development in line with the United Nations Sustainable Development Goals (SDG 2030).

I would like to extend my heartfelt appreciation to our partners, collaborators, and sponsors whose support has made this symposium possible. Special thanks to the organising committee for their dedication in ensuring the success of this international gathering. Great teamwork has
been your spirit for IOS2025.

Wishing everyone a productive, engaging and meaningful symposium experience.

Thank You.

Assoc. Prof. Dr. Sathiabama T. Thirugnana
Chairperson IOS 2025 & Director of UTM Ocean
Thermal Energy Centre, Institute of Future Energy
Universiti Teknologi Malaysia

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HEAT EXCHANGER OPTIMIZATION

IOS2025-005
Optimization of Sea Water Air Conditioning Systems through Experimental Analysis of Chilled-Water Temperature Regimes

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ABSTRACT

Sea Water Air Conditioning (SWAC) technology is emerging as a sustainable, resilient, and low-carbon solution to address the growing cooling demand in tropical coastal regions. By harnessing deep cold seawater to provide "free cooling," SWAC can achieve energy performance up to twenty times higher than conventional vapor-compression systems, while significantly reducing CO2 emissions and eliminating the use of refrigerants.

This study investigates the performance and optimization potential of[2] SWAC systems regarding their operating temperatures through a dedicated experimental campaign conducted with the Pilot'Clim test bench, an advanced experimental platform designed to reproduce real building conditions, including air distribution, internal heat gains, and humidity variations. This facility enables precise monitoring of thermal dynamics and operational stability, providing essential data for performance evaluation.

The research focuses on assessing system stability, coefficient of performance (COP), indoor comfort, and humidity control across different chilled-water supply temperature ranges (7–15 °C) under various climatic scenarios. The selection of the supply temperature range is shown to be a key design parameter, as it directly influences seawater intake depth and overall system configuration: lower supply temperature targets for the district cooling inlet (7–8 °C) require deep-water intake from 900 to 1000 m, increasing installation costs, whereas higher supply temperature ranges (11–16 °C) allow shallower intake from 300 to 500 m, thereby reducing initial investment costs. Moreover, adjusting the supply temperature range can also enable the integration of a post-OTEC cycle within a combined SWAC–OTEC configuration.

Experimental results highlight the critical importance of maintaining stable chilled-water temperatures. Thermal oscillations induced by fan coil unit control valves were found to significantly reduce COP and impair comfort regulation, while stable operation enhances both energy efficiency and indoor climate control. Preliminary analyses indicate that COP variations between the most and least efficient operating conditions can reach 25 to 30 %, emphasizing the potential benefits of optimized control strategies. Seasonal effects also influence performance, with humid conditions increasing cooling and dehumidification demand, while milder periods improve overall efficiency.

Although the assessment of chilled-water supply temperature ranges is still ongoing, preliminary findings confirm their pivotal role in SWAC system optimization. Several technical improvements have been implemented on the experimental test bench, including the integration of a three-way valve for precise temperature control, the addition of a 500 L buffer tank to emulate a realistic large-scale district cooling system and mitigate thermal fluctuations, and the development of an intelligent supervisory interface to enhance data management and analysis. These developments aim to deepen the understanding of chilled-water system dynamics and support the design of combined SWAC–OTEC setups as well as large-scale SWAC solutions, thereby paving the way for sustainable and resilient cooling strategies in coastal regions.

Keywords: Sea Water Air Conditioning (SWAC), High Temperature District Cooling (HTDC), Experimental Assessment, Sustainable cooling, Resilient cooling solutions

ACKNOWLEDGMENT

This work was supported by the French Environment and Energy Management Agency (ADEME), the University of Reunion Island through the OPTISWAC project.

IOS2025-011
Heat Exchangers Optimization In Ocean Thermal Energy Conversion (OTEC) System Using Response Surface Methodology and TRNSYS Simulation

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ABSTRACT

Heat exchanger components (evaporators and condensers) are the most vital and expensive elements, greatly determining the thermal efficiency and economic viability of Ocean Thermal Energy Conversion (OTEC) systems. OTEC systems operate at small temperature differences, so any improvement in heat exchanger performance is crucial to maximize the system's net power. This study aims to optimize the heat exchanger (HE) design parameters in a closed-cycle OTEC system to maximize clean power and exercise efficiency, as well as minimize system costs. The background of this research is to overcome the difficulties in predicting the optimal performance of OTEC under dynamic operational conditions and high investment costs. The integration of dynamic system simulation and multivariate optimization becomes a necessary solution. The method used is a hybrid approach between transient simulation and statistical optimization. Thermodynamic modeling of closed-cycle OTEC systems was carried out comprehensively using renewable energy simulation software TRNSYS (Transient System Simulation Program). TRNSYS was chosen for its ability to model the dynamic behavior of components, such as heat exchangers (Type 50 or Type 54), in scenarios of varying seawater conditions over time. The critical design parameters of the HE, i.e. the pinch-point temperature difference (ΔT_{pp}) in the evaporator and condenser, as well as the flow rate of the working fluid, are identified as the input variables. Experimental design and optimization are carried out using the Response Surface Methodology (RSM), implemented through Design-Expert software. We use multivariate experimental designs (e.g., Central Composite Design/CCD) to save the number of TRNSYS computational simulations and build accurate empirical models (response surfaces). This response surface model links design variables to objective functions (net power, efficiency, and total cost). Furthermore, numerical optimization in Design-Expert is applied to these models to determine the optimal combination of HE parameters that produce the highest clean power with acceptable cost constraints. The expected main result is a set of optimal values for the ΔTpp Evaporator, ΔTpp Condenser, and working fluid flow rate that results in the best design point. For example, it shows that a ΔTpp value of 3oC can produce the highest net power and efficiency. The main conclusion is that the integrated framework of TRNSYS and RSM (Design-Expert) provides an efficient tool for thermally and economically optimized OTEC heat exchanger designs. The contribution of this research is to provide quantitatively optimized HE design parameters that will accelerate OTEC's commercialization efforts by addressing the problem of key component inefficiencies.

Keywords: Response Surface Methodology (RSM), TRNSYS Simulation, Heat Exchanger, Multi-objective Optimization, Pinch-Point Temperature Difference (ΔT_{pp})

IOS2025-032
Research on Performance Evaluation of Evaporator-Condenser for Hybrid OTEC

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) is a type of power generation system that utilizes renewable energy. OTEC generates electricity by harnessing the temperature difference between warm surface seawater and cold deep seawater, offering the advantage of providing a stable power supply throughout the year. However, challenges remain, including the limited available temperature difference and the tendency for fouling to occur when seawater flows directly through heat exchangers, leading to reduced heat transfer performance. To address these issues, a hybrid cycle combining an open-cycle flash evaporation seawater desalination system with a closed-cycle OTEC has been proposed. This system, termed Hybrid OTEC (H-OTEC), enables simultaneous power generation and seawater desalination. In H-OTEC, a heat exchanger referred to as the Evaporator–Condenser (Eva-Con) is used. The Eva-Con employs flash-evaporated steam as the heat source and utilizes its condensation latent heat to evaporate the working fluid. Because phase change occurs on both sides, enhanced heat transfer performance is expected. Additionally, since seawater does not flow directly through the heat exchanger, lower-cost plate materials can be used. Previous studies have investigated the heat transfer performance of OTEC evaporators, and various estimation formulas have been proposed. However, the heat transfer performance of the Eva-Con, which simultaneously handles working fluid evaporation and heat source condensation, remains insufficiently understood. Moreover, while some studies have reported that condensation performance in flash evaporation seawater desalination is degraded by dissolved oxygen in seawater (i.e., non-condensable gases), the impact of non-condensable gases on H-OTEC remains unclear. Therefore, this study conducted performance tests on a plate-type Eva-Con for H-OTEC using ammonia as the working fluid. It quantitatively evaluated the impact of non-condensable gases on condensation heat transfer in the Eva-Con, using the dissolved oxygen (DO) concentration in warm seawater as a variable. Furthermore, to incorporate the effect of non-condensable gas concentration into the empirical equation for the water condensation heat transfer coefficient in the Eva-Con, the relationship between the Nusselt number and various dimensionless parameters of water vapor, both with and without non-condensable gases, was analyzed, leading to the derivation of a new experimental correlation. The results revealed that the concentration of non-condensable gases in the water vapor significantly affects condensation heat transfer.

Keywords: **Evaporator-Condenser，OTEC，H-OTEC，Plate heat exchanger，Desalination，Hybrid-cycle，Non-condensable gas**

ACKNOWLEDGMENT

Authors are grateful to acknowledge Science and Technology Research Partnership for Sustainable Development (SATREPS) funded by Japan Science and Technology (JST, JPMJSA1803) and Japan International Cooperation Agency (JICA) and Ministry of Education (MoE) of Malaysia for this Long-Term Research Grant Scheme (LRGS) grant with Vote number R.K130000.7856.4L894.

IOS2025-039
Optimisation Chlorine Dosing for Biofouling Mitigation in Closed-Cycle OTEC Warm-Seawater Intakes

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) is a promising baseload renewable-energy technology. However, the long-term performance of closed-cycle systems is constrained by biofouling on warm-seawater heat exchangers and intake pipelines. Even thin microbial biofilms can roughly halve heat-transfer efficiency and increase pumping power and maintenance frequency, threatening the techno-economic viability of large-scale deployment. Operational experience from OTEC plants and pilot facilities, particularly in tropical waters, has explored ozone, iodine, sodium hypochlorite and chlorine dioxide for biofouling control, with hypochlorite generally proving the most effective and operationally practical. This study aims to optimise chlorine dosing in the warm seawater intake pipeline of closed-cycle OTEC systems by identifying suitable dosing locations, initial concentrations and hydraulic conditions that achieve effective antifouling while complying with residual chlorine discharge limits. Using hydraulic design data representative of tropical closed-cycle OTEC intakes (pipe diameters on the order of 0.10–0.13 m and flow velocities of 0.63–1.26 m s^{-1}) and modelling chlorine residual transport with bulk and wall decay, chlorine concentration profiles are predicted along the pipeline for different velocities, pipe sizes and temperatures. Results indicate that an initial dose of 1.0–1.2 mg L^{-1} at the intake head can maintain 0.5–1.0 mg L^{-1} at the heat-exchanger inlet and outfall, consistent with typical regulatory constraints. Higher flow velocities ($\geq$ 0.9 m s^{-1}) and smaller diameters retain higher residuals, whereas elevated temperatures (> 320 K) significantly accelerate decay. The optimised dosing strategy is expected to reduce biofouling by approximately 80–90% reduction in biofouling, providing a quantitative basis for chlorine management in tropical closed-cycle OTEC intakes and supporting standardised, regulation-compliant maintenance protocols.

Keywords: Closed-cycle OTEC; Biofouling; Chlorine dosing; Residual chlorine decay; Reactive transport modelling.

ACKNOWLEDGMENT

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MULTIPLE USE OF SEAWATER BUSINESS MODELS

IOS2025-009
KOREA SDGs Activities through Ocean Thermal Energy Conversion and Discharged Ocean Water Application

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ABSTRACT

Climate change is intensifying meteorological variability and the risk of flooding, while shortages of essential resources such as food, energy, and water are threatening humanity's sustainable survival and health. The KOREA (Korea Ocean Renewable Energy Applying) SDGs (Sustainable Development Goals) Program is being promoted to share and support technologies secured for utilizing seawater resources, which enable circular regeneration while minimizing environmental impact, with island nations in the equatorial belt facing the climate crisis. This enhances the ability of target countries to develop, utilize, and manage their ocean environment and seawater resources (SDG#14) through ODA (Official Development Aids) project. Specifically, it improves food security (SDG#2), access to drinking water (SDG#6), and energy (SDG#7) in ocean thermal energy conversion (OTEC) and discharge ocean water application (DOWA) for coastal communities through education and practical training in SSUA (Sustainable Seawater Utilization Academy; SDG#4), thereby supporting climate action (SDG#13) to build sustainable communities (SDG#11). These initiatives have been implemented or are currently underway in Kiribati, the Marshall Islands, and Fiji. As a climate action program utilizing seawater resources, its widespread adoption could significantly help coastal nations achieve their Sustainable Development Goals.

Keywords: SDGs, ODA, OTEC, DOWA, Cascade Utilization, SSUA

ACKNOWLEDGMENT

Authors are grateful to acknowledge the ODA project support from the Ministry of Oceans and Fisheries of the Republic of KOREA (PGS5580).

IOS2025-017
Green Hydrogen Harvesting from Seawater

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ABSTRACT

The global transition toward clean energy has positioned green hydrogen as a critical vector for achieving net-zero emissions. However, conventional hydrogen production through freshwater electrolysis remains economically and environmentally constrained. Current processes consume approximately 9 litres of purified water for every kilogram of hydrogen produced, with a production cost of around $6 per kg, making large-scale adoption difficult. In addition, dependence on freshwater creates competition with human and agricultural needs, while grey hydrogen from fossil fuels continues to emit nearly 10 kg of CO_2 per kg of H_2. These challenges highlight the urgent need for a sustainable and cost-effective alternative that can utilize seawater—the Earth's most abundant resource. Direct electrolysis of seawater has long been limited by the formation of toxic chlorine gas at the anode, rendering it unsuitable under environmental regulations. To overcome this, Park Kadal Energy Pvt Ltd has developed a patented apparatus for harvesting hydrogen directly from seawater without chlorine evolution or desalination. The innovation lies in a specially designed electrochemical cell that selectively facilitates hydrogen and oxygen generation while suppressing chlorine formation. The system requires only an initial priming energy and then operates in a self-sustaining mode, utilizing part of the generated hydrogen to power the subsequent process. Laboratory-scale trials have successfully demonstrated hydrogen production at approximately 2 litres per minute from natural seawater, achieving Technology Readiness Level 4 (TRL-4). No chlorine emission was observed during continuous operation. The process also yields oxygen and distilled-quality freshwater as valuable by-products, addressing both energy and water scarcity simultaneously. The estimated hydrogen production cost is $3–3.5 per kg, with potential to reach $1–1.5 per kg at industrial scale, making it globally competitive with fossil-derived hydrogen. The proposed development pathway includes a pilot-scale demonstration plant (1 ton H_2 per day) in collaboration with research institutions and industry partners. Beyond energy generation, the technology supports decarbonisation in key sectors such as steel, cement, fertilizer, and transportation. Moreover, it offers a viable solution for coastal and island nations where freshwater is limited and renewable resources like solar and wind are abundant. This innovative seawater-based hydrogen production technology represents a transformative step toward clean, affordable, and sustainable hydrogen. It aligns with global climate objectives and national green hydrogen missions, providing a pathway to large-scale decarbonisation while conserving freshwater resources and eliminating chlorine pollution.

Keywords: Green Hydrogen, Seawater Electrolysis, Chlorine-free, Renewable Energy, Pilot Plant, Sustainable, Self-sustaining, Clean Fuel, Hydrogen Economy

IOS2025-022
Integrated Assessment Techniques for OTEC-Based Multi-Use Systems with DSWA

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ABSTRACT

This study aims to develop an evaluation method for assessing the overall performance of a combined deep ocean water application (DOWA) system cantered on ocean thermal energy conversion (OTEC), referred to as the D-OTEC system. OTEC is a renewable energy technology that generates electricity by exploiting the temperature difference between warm surface seawater and cold deep ocean water. Because it requires large volumes of seawater, its integration with other DOWA-based industries has drawn growing attention for improving resource efficiency and energy performance. For instance, on Kumejima Island in Okinawa, Japan, deep ocean water is already utilized for power generation, aquaculture, agriculture, and cosmetics, demonstrating the potential of multistage and sustainable marine resource use. However, a quantitative evaluation framework focusing on the energy performance of integrated OTEC systems has not yet been established.

In this study, district cooling, data centers, and sea grape cultivation were selected as representative examples of cascade utilization within the D-OTEC system. The utilization sequence was arranged according to temperature levels: OTEC power generation, district cooling (chilled water outlet 8–12°C), data center cooling (10–15°C), and sea grape cultivation (20–25°C). This configuration allows residual thermal energy from deep ocean water to be reused efficiently through multistage heat utilization.

To evaluate system efficiency, two objective functions were proposed, incorporating the heat transfer area (A_t) as a parameter. The analysis assumed surface and deep seawater inlet temperatures of 30°C and 4°C, warm and cold-water flow rates of 3000 and 2000 kg/s, and a generator output of 1200 kW. The overall heat transfer coefficients for the evaporator and condenser were set to 10.0 and 5.0 kW/m²K, respectively.

A comparative analysis between conventional district cooling and D-OTEC-integrated systems was conducted using these two objective functions. The D-OTEC system achieved over 90% CO_2 reduction compared with general cooling systems, indicating substantial environmental advantages. Lower chilled-water outlet temperatures resulted in greater CO_2 reduction, emphasizing the importance of thermal optimization. The optimal outlet temperature derived from the OTEC power consumption ratio was 8°C, while that obtained from the objective function was 9°C, showing that optimal conditions depend on evaluation criteria and system configuration.

The results confirmed that OTEC-integrated systems outperform conventional systems in both environmental and economic performance. For small-scale cases, one of the two objective functions was sufficient for effective evaluation, simplifying the analysis process. The proposed evaluation framework provides a practical and quantitative approach for assessing the performance of integrated D-OTEC systems and supports the future development of sustainable ocean energy utilization.

Keywords: Ocean Thermal Energy Conversion (OTEC), Deep Ocean Water Application (DOWA), objective functions, DOWA combination used with OTEC (D-OTEC), OTEC-Based Multi-Use Systems with DSWA

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OCEANOGRAPHY
&
SEAWATER QUALITY

IOS2025-001
Assessment of Thermal Resources for Ocean Thermal Energy Conversion (OTEC) Systems in the Caribbean Sea

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ABSTRACT

The Caribbean faces persistent energy challenges due to its heavy reliance on fossil fuels, especially in the Antilles, where over 80% of electricity comes from non-renewable sources and residential rates surpass USD 0.30/kWh. By contrast, Costa Rica and Belize have achieved higher renewable integration, while Mexico, with 22% renewables in its generation mix, maintains more competitive prices. Beyond this disparity, structural barriers, such as the lack of regional interconnection and the rising frequency of cyclones driven by climate change, highlight the urgency of resilient solutions. Ocean Thermal Energy Conversion (OTEC), which harnesses the thermal gradient between warm surface waters and cold deep waters, emerges as a promising renewable option for tropical regions, offering continuous baseload power.

This study evaluates the spatial and temporal variability of thermal resources across the Caribbean within 50 km offshore, a range enabled by recent advances in offshore wind technology. The analysis is based on bathymetric, surface, and subsurface temperature (~1000 m) data spanning 19 years, enabling a comprehensive assessment of thermal gradient (ΔT_m) and persistence (P), which indicates the percentage of days in which ΔT_m exceeds specific thresholds (18°C, 20°C, 24°C). The evaluation distinguishes between hurricane (June–November) and non-hurricane (December–May) seasons to capture potential seasonal variability.

Results show that annual ΔT_m ranges from 20.8°C to 24.4°C across the basin. High-gradient zones cluster around Cuba, Haiti, western Colombia, and from Panama to Mexico, while northern Venezuela and eastern Colombia exhibit lower gradients. Seasonal differences are marked: cyclone-prone regions like Cuba and Grand Cayman display variations above 3°C, whereas Nicaragua, Costa Rica, and Panama remain below 1°C. Persistence analyses reveal robust conditions: $\Delta T \geq 18$°C in more than 94% of the basin, $\Delta T \geq 20$°C in over 96%, and $\Delta T \geq 24$°C locally in thermal "hotspots," though generally for less than half the year.

Importantly, the similarity of spatial distributions across hurricane and non-hurricane seasons indicates that OTEC could sustain continuous operation under standard conditions ($\Delta T \geq 20$°C). This basin-wide characterization highlights the Caribbean's strong and resilient thermal resource base for OTEC deployment. By mapping areas with favorable gradients and persistence, the study provides critical insights for guiding site selection and supporting the transition to low-carbon energy systems in one of the world's most vulnerable regions.

Keywords: Ocean thermal assessment, OTEC, Caribbean

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IOS2025-002
High-resolution global dataset on deep ocean water accessibility for SWAC applications

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ABSTRACT

The worldwide demand for cooling is rising at an unprecedented pace, particularly in tropical and subtropical regions where air conditioning already represents a major share of peak electricity demand. Meeting this growing demand with conventional vapor-compression systems will significantly increase greenhouse gas emissions and electricity consumption, especially in insular and coastal territories highly dependent on imported fossil fuels. Sea Water Air Conditioning (SWAC) offers a promising alternative by harnessing naturally cold deep ocean water (DOW) as a renewable cooling source. However, the feasibility of SWAC projects strongly depends on local bathymetry and seawater temperature profiles, which determine both the length of the intake pipeline and the associated investment costs. Until now, this dependency has limited large-scale evaluations of SWAC potential to coarse datasets and localized studies.

To overcome this gap, we introduce a new high-resolution global dataset specifically designed to assess DOW accessibility for SWAC applications. The dataset combines three complementary sources: (i) the GEBCO 2021 bathymetry (30 arc-second resolution), (ii) the GLORYS ocean temperature reanalysis (1/12° horizontal resolution, 50 depth levels, climatology 2000–2020), and (iii) the ERA5-Heat thermal comfort index, used here to characterize regions with significant demand for air conditioning. Intake depths required to reach seawater temperatures between 5°C and 15°C are systematically identified within a 15 km offshore limit, corresponding to the current technical feasibility of drawing pipelines. By cross-referencing with UTCI-based heat stress indicators, the dataset highlights priority coastal zones where cooling needs and DOW accessibility overlap.

The results demonstrate that the conventional 5°C design restricts feasible sites mainly to intertropical islands and steep continental shelves, often requiring pipeline lengths of 5–10 km. In contrast, allowing higher intake temperatures (9-12°C) not only reduces pipeline length and cost but also dramatically expands the number of eligible coastal locations, including parts of South America, southern Africa, and even temperate regions such as Portugal, the UK, and New Zealand. This finding highlights the importance of considering High Temperature District Cooling (HTDC) regimes (up to 14/22°C), which remain compatible with indoor comfort standards while significantly improving techno-economic feasibility.

By providing spatially explicit and openly accessible information, this dataset constitutes a unique decision-support tool for researchers, engineers, and policymakers. It enables rapid screening of potential SWAC sites, supports pre-feasibility analyses, and contributes to long-term planning of sustainable cooling strategies under climate change. Ultimately, this work facilitates broader deployment of SWAC, helping coastal regions transition towards low-carbon, resilient cooling infrastructures.

Keywords: Sea Water Air Conditioning (SWAC), Deep Ocean Water (DOW), Bathymetry and seawater temperature, Global resource assessment, High Temperature District Cooling (HTDC), Sustainable cooling

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IOS2025-006
OTEC and exchange of CO2 in the ocean

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ABSTRACT

The principle of OTEC, Ocean Thermal Energy Conversion, is to extract energy from heat exchange between warm surface water and cold deep water. OTEC plants should work to produce renewable energy with no og only small emissions of CO2 and thus contribute efficiently to climate change mitigation efforts. As will be shown in the presentation, OTEC plants can also co-operate with CDR to stimulate sequestration of captured CO2 in the deep ocean. OTEC operation implies raising large amounts of deep water, warming it and discharging near the surface, as colder-than-ambient water, as a form of artificial upwelling. The deep water will carry upwards dissolved constituents such as certain amounts of nutrients and gases. When considering deploying large OTEC plants, the impacts og such vertical transport must be assessed, especially to what extent the impacts stimulate or inhibit natural uptake of CO2 from the atmosphere to the ocean and reducing the ocean's capacity as a sink for anthropogenic CO2. The depth of OTEC deep water intake may in some ocean regions coincide with the intermediate commonly found low-oxygen layer, which usually holds elevated concentrations of dissolved CO2 gas. Bringing this gas to the surface may lead to the nearfield ocean becoming not a sink, but a source of CO2 to the atmosphere. Additionally, the warming of the used deep water will, independent of deep water concentrations, stimulate outgassing of CO2 and other gases. On the other hand, nutrient-rich water brought up to the upper euphotic layers near the OTEC plant can stimulate blooming of phytoplankton that absorbs CO2 from the water, thus lowering its concentration there and enabling more influx from the atmosphere. Thus, OTEC operation can in principle work both ways, regarding atmosphere-ocean flux of CO2. The presentation will point at the issues and concerns raised here and suggest approaches to find the best locations for OTEC plants and optimal intake depth, relative to the prevailing oceanographic conditions.

Keywords: OTEC, Siting optimization, Ocean-atmosphere CO2 flux, Oceanography, dissolved gases

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IOS2025-010
Exploring OTEC Opportunitiesin Australia's Maritime Domain

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ABSTRACT

Australia's geographic position provides unique opportunities for Ocean Thermal Energy Conversion (OTEC), a renewable energy technology that harnesses the temperature difference between warm surface waters and cold deep waters to generate electricity. Situated at the southern edge of the tropical belt, Australia's northern regions in particular experience high sea surface temperatures and have water depths that may be suitable for OTEC deployment. To assess future potential, Geographic Information Systems (GIS)-based numerical modeling techniques were used to assess water column temperature properties and depth across Australia's Exclusive Economic Zone (EEZ), identifying areas with sufficient thermal differentials to support OTEC system deployments. This analysis utilized the CSIRO Atlas of Regional Seas (CARS) dataset, which provides gridded fields of seasonal ocean water properties derived from a quality-controlled archive of historical subsurface ocean property measurements collected primarily by research vessel and autonomous profiling buoys. Using this dataset, a detailed spatial and temporal evaluation of temperature gradients at suitable depths was performed, alongside additional analysis of seasonal variability across the EEZ study area. Results indicate that some regions in northern Australia exhibits promising conditions for OTEC, with thermal gradients exceeding the minimum threshold required for efficient energy conversion, however the more populated southern coastline regions offer little to no OTEC potential due to the cooler surface water conditions. Site selection was further refined by considering proximity to existing energy grid infrastructure and energy demand. These findings highlight the opportunities offered by OTEC technologies in Australian maritime domain, supporting the expansion of ocean-based renewable energy solutions and contributing to the diversification of Australia's energy mix.

Keywords: Ocean Thermal Energy Conversion (OTEC), Resource Assessment, Australia, Ocean Marine Energy (ORE)

ACKNOWLEDGMENT

The authors acknowledge the foundational contributions of previous research through the *Marine Spatial Planning for a Blue Economy* project funded by the Blue Economy Cooperative Research Centre (CRC) Program, grant number CRCXX000001 (previously 20180101).

IOS2025-025
Comparative Assessment of Water Quality Between Seagrass and Non-Seagrass Coastal Sites

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ABSTRACT

This study aimed to compare marine water quality between seagrass and non-seagrass coastal habitats to evaluate the influence of seagrass presence on key physico-chemical and microbiological parameters. Surface seawater samples were collected from ten coastal sites along Melaka and Negeri Sembilan, comprising five seagrass-associated sites (Teluk Pelanduk, Pulau Perjudi, Pulau Konet, Tanjung Bidara, and Kem Terendak) and five non-seagrass sites (Pantai Padang Kamunting, Pengkalan Balak, Lexis, Teluk Kubur, and Pulau Mengkudu). In situ measurements included dissolved oxygen (DO) and pH, while laboratory analyses determined ammonia (NH_3), phosphate (PO_4), nitrate (NO_3), total suspended solids (TSS), and fecal coliform (FC). Water quality was evaluated against the Malaysian Marine Water Quality Standards (DOE, 2021, Class 2). Results showed no substantial improvement in compliance at seagrass sites compared to non-seagrass sites. DO concentrations were critically low across all sites (2.8–3.3 mg/L) and below the 5.0 mg/L threshold, indicating widespread oxygen depletion. Nutrient enrichment was evident, with nitrate (1.8–2.4 mg/L) and phosphate (0.08–0.14 mg/L) exceeding permissible limits, while TSS remained high (54–78 mg/L) in both site categories. Only fecal coliform levels showed partial improvement at seagrass sites (120–160 MPN/100 mL) relative to non-seagrass sites (280–350 MPN/100 mL). Overall, the findings suggest that while seagrass meadows may provide localized water quality benefits, they are insufficient to offset the broader effects of nutrient loading, organic enrichment, and sediment stress in coastal waters influenced by anthropogenic inputs.

Keywords: Eutrophication, Nutrient enrichment, Coastal pollution, Marine water quality regulation, Environmental monitoring

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This research was funded by Yayasan PETRONAS for Seagrass Mapping and Community-Based Programme in Peninsular Malaysia except Johor. This programme/research was also implemented in collaboration with the Department of Fisheries, Malaysia.

IOS2025-026
Comparative Assessment of Marine Carbonate Parameters in Seagrass and Non-Seagrass Habitats of Port Dickson Indicating the Buffering Role of Seagrass Meadows

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ABSTRACT

This study assessed the variation of marine carbonate chemistry between seagrass and non-seagrass habitats in the coastal waters of Port Dickson, Negeri Sembilan, to evaluate the role of seagrass meadows in moderating local seawater conditions. Sampling was conducted at five locations, namely Teluk Pelanduk and Pulau Perjudi (seagrass habitats) and Lexus, Teluk Kubur, and Pulau Mengkudu (non-seagrass habitats). Each site consisted of three sampling stations positioned along a nearshore to offshore gradient ranging from 50 to 590 metres from the shoreline. Measured parameters included pH, total alkalinity (TA), dissolved inorganic carbon (DIC), partial pressure of carbon dioxide (pCO_2), and calcium carbonate saturation states (ΩCa and ΩAr). Data were tested for normality and homogeneity before statistical analysis. Independent samples t-tests were used to compare seagrass and non-seagrass habitats, while one-way ANOVA assessed spatial variation among sampling sites and distances from shore. Statistical significance was determined at $p < 0.05$. The results showed that seagrass habitats had significantly higher TA (1975–2372 µmol/kg), DIC (1801–2218 µmol/kg), and pH (7.74–7.78) with mean ΩCa and ΩAr values of 2.81–3.31 and 1.86–2.19 respectively. In contrast, non-seagrass habitats displayed lower TA (1826–2106 µmol/kg) and ΩAr (1.45–1.97), accompanied by elevated pCO_2 levels reaching up to 1076 µatm, particularly at nearshore stations. ANOVA results indicated that carbonate parameters also varied significantly with distance from shore, where nearshore waters had higher DIC and TA due to benthic respiration and terrestrial carbon input, while offshore waters exhibited higher pH and saturation states due to greater mixing. Overall, the findings confirm that seagrass meadows in Port Dickson enhance carbonate buffering capacity and maintain a more stable and less acidified environment. These habitats function as local biogeochemical refuges that may help mitigate the impacts of ocean acidification in coastal ecosystems.

Keywords: Carbonate buffering capacity, Coastal biogeochemistry, Dissolved inorganic carbon dynamics, pCO_2 variability, Blue carbon ecosystem

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Authors are grateful to acknowledge Yayasan PETRONAS as the funder of the Seagrass Mapping and Community-Based Programme in Peninsular Malaysia except Johor, and the Department of Fisheries, Malaysia as the Programme Strategic Partner.

IOS2025-027
Assessment of Seawater Quality Variation Before and After H-OTEC Surface Water Extraction Based on the Malaysian Marine Water Quality Index (MMWQI)

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ABSTRACT

This study aims to determine the variation in seawater quality parameters before and after the surface water extraction activity of the Hybrid Ocean Thermal Energy Conversion (H-OTEC) pilot plant located at the Institute of Aquatic Sciences (I-AQUAS), Port Dickson. Surface seawater samples were collected at 9 coastal sites situated in front of the H-OTEC facility during high tide at six different stages of plant operation between April and November 2024. Sampling events represented distinct operational phases, namely a day and a week after ammonia transfer (25 April and 10 May), before and during testing and commissioning (9–15 October), and one month after continuous testing (15 November). The Malaysian Marine Water Quality Index (MMWQI) was computed using six key parameters as outlined in the Department of Environment (DOE, 2020) guidelines. Results showed significant temporal variations between sampling events but not between sampling sites. The average MMWQI of surface seawater in May 2024, representing a week after ammonia transfer, was classified as Poor (MMWQI < 49), largely influenced by elevated phosphate (PO_4^{3-}) concentrations (mean: 1680 µg/L). Phosphate enrichment is likely linked to anthropogenic sources such as detergents and sediment runoff. Similarly, the surface water tank (SFW) sample on 15 October 2024, a week after testing and commissioning, exhibited Poor classification due to high Escherichia coli counts (816.4 MPN), attributed to unsterilized piping materials. Overall, these findings suggest that while the spatial variability of seawater quality remained minimal across the study area, temporal changes were strongly influenced by operational and maintenance phases of the H-OTEC system, highlighting the need for improved pre-commissioning sterilization and regular effluent monitoring.

Keywords: H-OTEC, seawater quality, MMWQI, phosphate, *E. coli*, temporal variation, Port Dickson

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IOS2025-038
Estimating Tropical Upper-Ocean Heat Storage from Satellite-Derived SST

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ABSTRACT

Sea surface temperature (SST) and the associated thermal potential of the upper ocean play crucial roles in regulating air–sea interactions, upper-ocean stratification, and coastal climate dynamics. In tropical systems, short-term variations in solar heating, atmospheric conditions, and tidal forcing strongly influence the ability of surface waters to accumulate and store heat. This study examines the day-to-day and tidal variability of SST and the resulting changes in thermal potential off the coast of Kalumpang, Malaysia, using MODIS satellite observations collected from January to December 2025.. The results reveal marked differences between daytime and nighttime SST. Daytime heating increases SST and enhances the thermal potential of the surface layer due to strong solar radiation and limited vertical mixing. The formation of a shallow warm layer during midday indicates a heightened capacity of the near-surface ocean to store thermal energy. In contrast, nighttime conditions show reduced SST variability and lower thermal potential, driven by radiative heat loss and enhanced mixing processes that distribute heat downward or release it to the atmosphere. Tidal variability further modulates SST and thermal potential. High-tide phases are characterized by relatively cooler SST due to the inflow of deeper or offshore waters with reduced thermal energy content. Conversely, low-tide periods, especially when occurring during daylight hours, display elevated SST and increased thermal potential because of decreased water depth and intensified solar heating of shallow waters. The highest thermal potential values were observed during midday low-tide events when solar forcing and reduced depth act simultaneously to intensify surface warming. Seasonal patterns also influence the magnitude of daily warming and thermal potential variability, with clearer skies and calm-wind periods amplifying surface heating. These findings underscore the importance of integrating both day-to-day and tidal processes when interpreting satellite-based SST datasets in tropical coastal environments. This study demonstrates that SST and thermal potential in the coastal waters off Kalumpang exhibit short-term variability driven by solar heating and tidal dynamics. Incorporating thermal potential into SST analyses provides improved understanding of coastal heat storage, energy redistribution, and the implications for marine ecosystems, climate assessments, and coastal resource management.

Keywords: SST, Thermal Potential, Solar Heating, Tidal Dynamics

OTEC
BUSINESS MODELS

IOS2025-008
Use of cold-water agriculture (ColdAg) technology for the growth of cabbage (*Brassica oleracea* var. *capitata* L.)

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ABSTRACT

The OTEC system not only allows us to generate electricity but can also be used to obtain secondary byproducts such as drinking water, air conditioning, aquaculture, and cold-water agriculture, among others. In the case of agriculture, climate change is increasing the frequency of extreme heat events, exacerbating their negative impact on plant development and agricultural yield. However, most experiments designed to study plant adaptation to heat stress apply high, uniform temperatures to both shoots and roots without examining potential effects through the thermal gradient due to temperature variability in the soil and environment.

Therefore, the objective of this research was to analyse the potential physiological impacts that the thermal gradient can have on cabbage (Brassica oleracea var. capitata) under two treatments: those with soil cooling to 20°C and a controlled temperature in the environment of 35°C (cold-water agriculture), and those where the temperature was 35°C without soil cooling. The results showed that, with cold-water agriculture technology, cabbages showed improved development and growth in variables such as root length, stem length, number of leaves, and leaf area, as well as greater accumulation of fresh and dry biomass. According to this, this technology could be of great help in combating food poverty and developing projects to boost crop production and yield in the medium and long term.

Keywords: ColdAg, thermal gradient, physiological stress, cabbage, climate change, thermomorphogenesis

ACKNOWLEDGMENT

The authors would like to thank the Secretariat of Science, Humanities, Technology and Innovation (SECIHTI) for the financial support for this work and the Postgraduate College Montecillo campus for providing facilities for conducting the experiments.

IOS2025-016
Applying Circularity Concepts in offshore OTEC Applications

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ABSTRACT

Extending harvesting of electricity via OTEC from coastal regions as of today to the full hurricane free band around the equator in the future will boost the potential of green electricity production to values exceeding the total primary energy demand of the world by a 2-digit number. In order to avoid lossy and costly transport of electricity to land the better choice is offshore conversion of electricity via water electrolysis on what we call "UGE-Platforms" into Hydrogen and Oxygen, followed by synthesis of Hydrogen with CO2 or Nitrogen into green molecules like Methanol or Ammonia. An other option is to store Hydrogen in Metal-Powders like an Iron-Titan powder as Metal-Hydrid. Both options have the charme that in contrast to Hydrogen they can be easily transported and stored, thus solving all the problems related to the Hydrogen value chain.

In both cases circularity concepts shall be applied. This means that in case of Methanol the CO2 needed for synthesis is supplied from hard to abate sectors like steel and cement industry using Oxygen from UGE-electrolysis for performing Oxyfuel combustion, which is a prerequisite for making Carbon sequestration energy and cost efficient. The captured Carbon is returned to the UGE-plants. In case of Metal powders, the dehydrated powder is shipped to UGE-plants, where it is reloaded with Hydrogen like in a battery, while the released heat is used for superheating of the evaporated working fluid for efficiency improvement.

Green Methanol and probably also Me-Hydrids will be "The base chemicals of the future" for use in "Refineries of the Future", which have to replace until 2045 fossil energy carriers like coal and natural gas by green molecules for realization of the so called "Molecular transition". This terminus has been selected in order to differentiate from the "electricity transition" happening right now.

UGE is expected to be successful and economic by the following reasons: (1) Elimination of OTEC-typical problems like cost of water pipes, low efficiency as well as corrososion and biofowling in the evapoaror, (2) Expected production cost of Methanol in the range of Bio-Methanol today will undercut that of grey Methanol in 2050, (3) Valueable by-products of desalinated water and Oxygen and (4) Generation of Carbon Credits.

Keywords: Offshore OTEC, Green Molecules and Metal-Hydrides, Refineries of the Future and Molecular Transition, By-products water and Oxygen, Circular Carbon Economy, Efficiency improvement.

IOS2025-021
Site Suitability and Resource Demand Assessment for 10 MW Hybrid OTEC Systems in Sabah, Malaysia

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ABSTRACT

The Hybrid Ocean Thermal Energy Conversion (H-OTEC) system is a next-generation marine renewable energy technology that simultaneously produces electricity, desalinated freshwater, and nutrient-rich deep seawater (DSW) for applications such as aquaculture and cooling. This paper details the site suitability and resource demand assessment that guided the technical selection of two simulated 10 MW H-OTEC deployment locations in Sabah, Malaysia: an on-island system at Layang-Layang Island and an offshore system near Kalumpang Island. The methodology ensured sites minimized infrastructural and operational costs while optimizing energy output. The primary technical criterion for H-OTEC operation is the thermal gradient, requiring a minimum temperature difference of 20∘C between warm surface water and cold deep seawater for efficient performance. Swallow Island was selected as the on-island setup primarily for its superior thermal resource, exhibiting an average temperature gradient of 24.62∘C. Further technical viability was confirmed by the discovery that a greater than 20∘C differential is achievable at just 700 m depth, which significantly reduces infrastructure complexity compared to the typical ≥1,000 m depth requirement. Kalumpang Island was selected for offshore deployment due to its favourable thermal gradient of 23.17∘C and its strategic location, offering a relatively short distance (1.96 km) to nearby communities, thereby enhancing the potential for socio-economic benefits and efficient resource distribution. The analysis confirms that the multi-output nature of H-OTEC directly addresses critical resource deficits across Sabah. Sabah faces a significant challenge in maintaining energy security, operating with only a 5% electricity reserve margin, far below the 20% target. The H-OTEC system's net power output of 2.45 MW is designed to contribute to increasing this insufficient reserve margin and supporting rural electrification goals. In addition, due to logistical challenges and inconsistent network expansion, 31% of Sabah's rural population (181 million liters/day) lacks access to treated water. The H-OTEC plant's desalinated water output of 558 m3/hr (13,392 m³/day) can support up to 7.4% of this rural freshwater deficit, providing a sustainable, decentralized supply solution. Moreover, deep seawater demand (DSW), valued for its low temperature and high nutrient content, is vital for Sabah's aquaculture sector, which contributes 56% of the nation's total output. DSW enhances resilience against disease and warming surface waters. Demand is concentrated in two clusters: the Swallow Cluster, encompassing 429.02 hectares of aquaculture and 8 hectares of seaweed cultivation; and the Kalumpang Cluster, which serves as a key utilization hub with a substantially larger demand footprint, covering 954.72 hectares of aquaculture area and 2,997 hectares of seaweed cultivation. This combined assessment confirms the strong technical feasibility and strategic necessity of deploying H-OTEC, driven by the critical alignment between the system's multi-outputs and Sabah's acute deficits in energy, water, and aquaculture sustainability.

Keywords: Hybrid Ocean Thermal Energy Conversion, Ocean renewable energy, Techno-economic analysis, Desalinated Water Production, Deep seawater utilization

ACKNOWLEDGMENT

This work was supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program entitled 'Development of Advanced Hybrid Ocean Thermal Energy Conversion (OTEC) Technology for Low Carbon Society and Sustainable Energy System: First Experimental OTEC Plant of Malaysia' funded by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA), and Ministry of Higher Education Malaysia (MoHE) and led by the Institute of Ocean Energy Saga University (IOES) of Japan, and UTM Ocean Thermal Energy Centre (UTM OTEC), Universiti Teknologi Malaysia (UTM). Registered Program Cost Centre: #R.K130000.7809.4L887, Project [Cost Centre #R. K130000.7855.4L890].

IOS2025-029
OTEC in Context: A Strategic Comparison with Geothermal and Microreactors

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ABSTRACT

Ocean thermal energy conversion (OTEC) shares many characteristics with advanced geothermal and microreactor technologies: firm power generation without continuous commodity supply, low emissions, site-specific challenges, lack of consensus on optimal technical configurations, and decades of unfulfilled plans for imminent commercialization. Yet while geothermal and nuclear startups have captured billions in public and private funding over the last decade—and positioned themselves as central to future clean grids—OTEC remains relatively obscure to many decisionmakers.

This presentation invites the OTEC community to critically reflect on how the geothermal and nuclear sectors have navigated commercialization hurdles over the past 10–15 years. We'll explore shared challenges—such as permitting, supply chain maturity, public perception, and financeability—as well as divergent paths, including policy advocacy efforts, the evolving relationship between startups and large corporations, early-stage capital recruitment (via private investors and government grants), signaling from prospective anchor customers (notably the U.S. Department of Defense), and the creation of institutional support structures that have accelerated progress in other sectors.

Through a lightly interactive format, attendees will assess how perceived environmental risks and benefits, technology readiness, profitability, and total addressable market shape external interest and investment readiness for emerging energy technologies like OTEC. The goal is to surface strategic gaps and share ideas on how the community might benefit from bolder coordination, clearer messaging, and alignment with—or creation of—influential public-sector priorities.

Keywords: OTEC, nuclear, geothermal, commercialization, advocacy, policy, innovation, economics

IOS2025-035
Accelerating OTEC Commercialization: Lessons from Fragmented Efforts and a Roadmap to 2030

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) continues to hold long-term promise as a clean energy solution for tropical and subtropical island states, where diesel-generated electricity remains costly and logistically burdensome. Historical techno-economic studies from as far back as the the 1970s demonstrated credible cost projections, yet commercial deployment has remained elusive.

This presentation revisits the potential for multi-product OTEC systems to reduce the levelized cost of energy (LCOE) to competitive levels by integrating co-production of desalinated water, hydrogen, ammonia, and other value-added products. These configurations not only improve energy and resource efficiency but may also enable power purchase agreements (PPAs) and investment models with more favorable rates of return.

Recent proposals, including those targeting the U.S. military and various island utilities, often focus solely on electricity, overlooking the integrated value streams that multi-product OTEC could offer. Drawing from prior design reports, published techno-economic analyses (TEAs), and updated Pro Forma modeling assumptions, this analysis highlights current technical and economic gaps and lays out the opportunity for targeted engineering and financing efforts to close them.

Finally, while commercialization remains a challenge, we briefly introduce the concept of building an international consortium to advance design-ready, investment-grade multi-product OTEC demonstration projects by 2030. This would draw on technical experts, island stakeholders, and prospective private and public investors to de-risk first-of-a-kind deployments and chart a path to broader adoption.

Keywords: OTEC, desalination, hydrogen, multi-product, TEA, commercialization

POLICY & SUSTAINABILITY

IOS2025-020
Evaluation of Hybrid OTEC Implementation on Fernando de Noronha Archipelago Through Brazil-Japan Collaboration

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ABSTRACT

FFernando de Noronha archipelago, 354 km off Brazil's coast, depends on ecotourism for 95% of its economy. In 2024, it had over 131,000 visitors, with a permanent population exceeding 3,000 and 4,000 temporary workers. From 2018 to 2024, surveys show the island primarily uses diesel generators, consuming up to 25,000 liters daily to produce about 5 MW of power, with weekly fuel shipments from Recife and Natal. Diesel storage is 210,000 liters. To cut CO_2 emissions, two solar plants have been installed. Faced with water scarcity, 65% of drinking water is produced via energy-intensive seawater desalination at 72 m^3/h. Due to its equatorial location, traditional split-type air conditioning is widely used.

Fernando de Noronha Archipelago is considered perfect for OTEC – Ocean Thermal Energy Conversion deployment due to its tropical location and temperature differences between surface and deep water is higher than 20oC and it remains quite stable whole year. Nowadays, OTEC technology is considered a mature technology, however, CAPEX stills quite high, but on islands, according to many studies the cost per kWh is quite competitive compared to thermoelectric plant using diesel as fuel on the archipelago. Successful implementation will provide continuous, fuel-free energy 24 hours per day for 7 days per week, and becomes the baseload. So, this technology can reduce fossil fuel dependence, improve water security through Low-Temperature Thermal Desalination (LTTD) process with minimum maritime environment impact due to use less than 2% of surface seawater, and can boost the local economy through new businesses such aquaculture, cosmetics production, hydrogen generation, superfoods. Furthermore, the cold seawater can also be used for air conditioning through SWAC technology. This evaluation examines the benefits and challenges of OTEC of 1 MW to 2 MW taking into consideration an established memorandum of understanding (MOU) between Brazilian Universities and IOES – Institute of Ocean Energy, Saga University, Japan. The Memorandum of Understanding (MoU) signed between UFPE and IOES on August 5th, 2024 represents a significant step forward in the quest for sustainable energy solutions and innovative marine applications. This collaboration is expected to yield groundbreaking research, human resource development, technological advancements, and tangible benefits for both Brazil and Japan. By harnessing the power of OTEC and DOW applications, the island of Fernando de Noronha can move towards a more sustainable and prosperous future, benefiting from the expertise and experience of Japan's leading research institute.

Keywords: OTEC, LTTD, SWAC, Fernando de Noronha archipelago, Brazil-Japan as One Team

IOS2025-028
Laboratory Evaluation of Cold-Water Discharge Strategies for Sustainable H-OTEC Operation Under Wave-Driven Mixing

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ABSTRACT

This study aims to develop recommendations for sustainable cold-water release from Hybrid Ocean Thermal Energy Conversion (H-OTEC) systems by examining how outlet depth, outlet design, and wave conditions influence mixing efficiency. The objective is to identify discharge configurations that minimize cold-water intrusion and surface cooling, therefore reducing ecological impacts while supporting long-term OTEC operations. Experiments were conducted in a controlled laboratory flume at Universiti Putra Malaysia (UPM). A mechanical wave generator simulated surface wave conditions. Cold water (7–10 °C) was released at two depths: bottom discharge and hanging (30 cm above the floor) and through two outlet designs: a single-hole outlet and a multi-hole outlet. Surface temperature changes were captured using a thermal imaging camera, while vertical temperature distribution at increasing distances from the outlet was recorded using a temperature acquisition module. Wave action consistently enhanced mixing, elevating minimum temperatures and reducing the extent of cold-water pooling. Single-hole bottom discharge without waves produced the strongest cold-water signature (lowest observed temperature: 8.6 °C). Introducing waves increased the minimum temperature to 15.65 °C, indicating rapid dilution. Hanging outlets further reduced cold-water intrusion, with the lowest temperatures recorded at 24.89 °C (with waves, single hole). Multi-hole outlets improved lateral and vertical mixing, especially under wave conditions; the warmest minimum temperature (25.10 °C) occurred with the hanging multi-hole outlet under wave action, indicating minimal cold-water impact. Overall, mixing was most effective when waves combined with multi-hole discharge configurations. The combination of wave action and multi-hole outlet design produces the most environmentally compatible discharge, minimizing cold-water accumulation and reducing potential stress to marine ecosystems. Hanging outlets positioned above the seafloor further enhance dilution. These findings support the recommendation that future H-OTEC systems adopt elevated, multi-port diffusers in areas with natural wave activity to ensure sustainable long-term operation with minimal ecological disturbance.

Keywords: Diffuser design, Multi-hole outlet, Outlet depth, Temperature stratification, Marine environmental impact

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OTEC PROJECT
&
SYSTEMS

IOS2025-003
Design of a OTEC Laboratory for Offshore Applications

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ABSTRACT

The paper presents aspects of the design of a new OTEC (Ocean Thermal Energy Conversion) facility to be installed at the Federal University of Rio de Janeiro's (UFRJ) campus in Rio de Janeiro, Brazil. OTEC harnesses the thermal gradient between warm surface seawater and cold deep seawater to generate renewable electricity, offering a sustainable alternative in tropical regions like Brazil's Blue Amazon, where surface temperatures exceed 26°C and deep waters at 700-1,000m depths remain around 4-5°C. This technology not only produces baseload power but also supports co-products such as desalinated water, aquaculture, and cooling for offshore installations. The laboratory aims to advance OTEC research amid growing global demand for decarbonized energy solutions. The facility is engineered to support comprehensive feasibility studies for both on-shore and floating offshore OTEC systems. Central to its design is a 30kW OTEC pilot plant, scaled to simulate various thermal cycle configurations, including closed-cycle Rankine systems using ammonia or other working fluids, and hybrid open-closed cycles. This setup enables realistic mimicking of fluid dynamics, heat transfer efficiencies, and energy exchanges between a floating OTEC platform and adjacent offshore structures, such as oil production platforms (FPSOs) or FLNG units. By integrating OTEC with existing hydrocarbon infrastructure, the lab explores synergies like utilizing excess cold water for platform cooling or power supplementation, potentially reducing operational costs and emissions in Brazil's Campos and Santos Basins. Beyond thermal cycles, the laboratory incorporates advanced simulation capabilities for hot and cold water flows. This includes modeling intake pipes from deep-sea collection points to heat exchangers, allowing precise assessment of hydraulic head losses, frictional resistances, biofouling impacts, and thermal inefficiencies. Drawing from prior Joint Industry Projects (JIPs) on cold water pipes (CWPs), the design incorporates large-diameter (up to 4m) HDPE or composite risers, tested for vortex-induced vibrations (VIV) and fatigue under extreme conditions like 100-year cyclones. Small-scale flume tests at LOC and large-scale basin experiments at LabOceano will validate numerical models using software like Orcaflex, ensuring compliance with standards such as API17N and IEC OTEC guidelines. A key innovation is the simulation of dynamic aspects, including platform motions (heave, pitch, roll) and associated control strategies for electrical loads. This encompasses grid integration with variable demands from connected assets, such as submarine equipment or remote islands like Fernando de Noronha, where OTEC could enable sustainable development through Deep Ocean Water Applications (DOWA). Control algorithms will address power fluctuations, employing AI-driven optimization for stability and efficiency. This facility positions UFRJ as a hub for OTEC innovation in Latin America, bridging academic research with industrial applications to accelerate deployment in offshore environments. Future expansions may include field trials in the Brazilian Blue Amazon, advancing Technical Readiness Levels (TRL) from lab simulations to operational prototypes.

Keywords: OTEC,Offshore Engineering, Experimental facilities

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IOS2025-004
Identification of site location for OTEC and SWAC in Reunion Island based on GIS data analysis

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ABSTRACT

Reunion Island is a french department with tropical climate in the Indian Ocean that reached a renewable share of 92.4% in its energy mix in its efforts towards energy transition to help tackling climate change. However, 61.2 % of this renewable energy – bio-fuel and wood pellet – is imported, increasing both its price and carbon footprint. Moreover in Reunion Island, the building sector accounts for 80 % of the electric consumption, half of which is used for air conditioning. The combination of Ocean Thermal Energy Conversion (OTEC) technology that uses the thermal gradient of the sea to generate electricity, and the Sea Water Air Conditioning (SWAC) technology, supplying cooling from deep sea water, allows for the simultaneous production of cold and electricity, among others, making it a highly relevant solution to improve the energy mix, and reduce the electric consumption. This work uses Geographic Information System (GIS) data to assess potential sites for OTEC and SWAC in Reunion Island. First, relevant data such as high cooling demand buildings, protected or risky areas, seafloor composition, and parcel data are gathered and analyzed to reveal suitable sites and possible cooling network setups. Then, 10 years of deep sea water and surface seawater temperatures data are collected from WINDS and GHRSST, respectively, and analyzed together with bathymetric data. From these two analysis, a classification of the site is done, accounting for the relevance for cooling demand, the length and height of on-land pipe, as well as the ease of access to the resource. In addition to sites suitable for OTEC and SWAC, sites suitable for only SWAC are highlighted as well as they can operate at higher deep sea water temperatures. Finally, for OTEC sites, maps showing the achievable temperature difference divided by the length of the pipe to reach said temperature difference is computed, while for SWAC only sites, the required submerged pipe length is computed for different temperature targets. While the offshore analysis is still on-going, preliminary results show six sites for which the cooling load would justify the installation of a SWAC coupled with a potential OTEC facility with various distance to the resource. Among these six sites, the required on-land cooling network is less 3 km for one site, between 3 to 5 km for four sites and around 10 km for the last one. Four more sites are highlighted, but they either represent a smaller load, such as a single small size hospital, or would require a special authorization for pipe construction through a protected area.

Keywords: OTEC/SWAC site selection, GIS-based analysis, resource assessment, Reunion Island

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Opportunities and Challenges of Developing OTEC and SWAC for a Pacific Island

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ABSTRACT

The potential for OTEC and SWAC development has been assessed for the island of Guam in the Marianas Island chain of the western Pacific Ocean. Like many islands, Guam depends on imported diesel fuel to generate electricity, augmented by solar photovoltaics and a small amount of onshore wind. Located in the typhoon zone, Guam is subject to frequent typhoons such as Category 4 Typhoon Mawar which devasted the island in May 2023. In addition to extensive damage to infrastructure, businesses, and residences, the Guam grid was damaged, resulting in lengthy repair work that kept electricity and other essential services offline in parts of the islands. Guam is actively looking for renewable energy sources that can be used to stabilize and augment the electricity grid, provide power for new and emerging industries, and bring down electricity costs long term.

Guam is close to deep water of the Marianas Trench. This project has examined the waters surrounding Guam for potential year-round thermal resources to support OTEC and SWAC, with the ability to reach deep ocean water within a few kilometres off shore. Siting studies have assessed the proximities to electrical loads and to identify potential landfall sites for OTEC and SWAC plants that could meet bathymetric, geological, environmental, cultural, and grid entry criteria. Coordinating with Guam Power Authority (the local electrical utility that supplies all of Guam), favourable site locations for SWAC and OTEC systems have been identified. Discussions with Guam governmental authorities indicate the feasibility of meeting regulatory needs, with additional studies needed to assure compliance and minimal impact to coastal environment and the economy. Initial requirements for powering new aquaculture facilities on the island have been examined.

As in all small communities, acceptance and support for OTEC and SWAC on Guam is extremely important. A series of townhall meetings, university-led surveys, presentations at local events and conferences, and individual consultations have presented the potential, opportunities, and challenges of OTEC and SWAC for Guam. It appears that the community, while cautious about potential effects on coral reefs and nearshore areas, are optimistic about the potential for OTEC and SWAC to increase resilience and support sustainability for the island.

Keywords: OTEC and SWAC; remote islands; community acceptance

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IOS2025-012
Site selection of Ocean Thermal Energy Conversion (OTEC) plants for Barbados

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ABSTRACT

Barbados, a small island developing state in the Caribbean, has committed to becoming a 100% renewable energy island with carbon neutrality by 2030. To achieve this goal, alternative fuel sources must be identified to replace the island's dependence on imported fossil fuels for energy generation. The Barbados Public Sector Smart Energy Program and, more recently, the Barbados Investment and Development Corporation have expressed interest in ocean thermal energy conversion (OTEC), commissioning studies to explore its potential to increase the island's renewable energy capacity and efficiency. Barbados' tropical climate provides ideal year-round marine thermal gradients that meet the operational requirements for OTEC systems. This study, therefore, assesses Barbados' OTEC resources and their viability at several locations around the island. The island's coastline was divided into four quadrants, with four proposed plant locations selected within each quadrant based on the shortest distance to the coast. These locations were ranked using a multi-criteria decision analysis that combined the AHP–TOPSIS methodology. Each criterion was weighted using the Analytical Hierarchy Process (AHP), and the four plant locations were then ranked using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The criteria selected for the analysis included: thermal difference; shortest distance from the coast to the proposed plant location; shortest distance to the Port of Barbados; shortest distance to the nearest electrical substation; coastal features/infrastructure; coastal space use; and fishing areas.

The results of the analysis ranked the east coast site the highest. This area features steep bathymetry, providing the necessary depths close to shore, minimal economic or recreational activity, and no significant coastal infrastructure. Conversely, the west coast was found to be the least suitable for OTEC development, primarily due to longer distances and the high density of economic and recreational uses along that coast. Avoiding densely populated areas with significant economic and recreational activity is advisable to minimize potential negative impacts during construction and maintenance, as well as to prevent adverse public perceptions among both residents and tourists.

Barbados aims to position itself as a leader in the Caribbean through its aggressive policies promoting a transition to 100% renewable energy, and OTEC is among the promising avenues under consideration. The findings of this study serve as a foundation for further OTEC development, marine spatial planning, and investment on the island. With a detailed and robust site selection process completed, OTEC development can now progress to in situ data collection and technical planning.

Keywords: Ocean thermal energy conversion (OTEC); Renewable energy; Site selection; Multi-criteria decision analysis; Caribbean; Barbados

IOS2025-013
Annual Performance Analysis of a Mid-Scale OTEC System under Constant and Daily Optimized Flow-Rate Scenarios

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) offers a reliable and continuous renewable energy source by harnessing the temperature difference between warm surface water and deep cold seawater. Despite this reliability, commercial-scale deployment remains limited by high capital costs. Since OTEC plants exhibit strong economies of scale due to mooring, power cable, installation and design costs, increasing plant size can substantially reduce the cost per unit of energy. However, the achievable system size is constrained by the largest commercially available high-density polyethylene (HDPE) pipelines, currently limited to approximately 3.5 m in diameter.

This study investigates the performance of a mid-scale closed-cycle floating OTEC system designed around a 3-pipe bundle of 3.5 m-diameter pipelines, representing the largest configuration feasible with existing components. A numerical model of the system was developed to evaluate performance under varying ocean temperature and flow rate conditions. The model incorporates the energy balances of the evaporator, condenser, turbine, and pumps, while accounting for heat-transfer limitations and hydraulic losses to determine the net electrical power.

Two operational strategies were evaluated in this study. In the first scenario, the system operated with constant warm and cold water flow rates selected to maximize net output power based on the annual mean temperature difference. In the second scenario, seawater and working fluid flow rates were optimized daily to maximize daily net power, and the resulting daily values were integrated to estimate the total annual output power. Daily ocean temperature data were sourced from the HYCOM reanalysis dataset for two representative tropical sites in the Caribbean: one situated approximately 40 km north of Little Cayman Island (20.04° N, 80.00° W) and the other 13 km south of Puerto Rico (17.84° N, 67.20° W). Each site was analysed at multiple cold water intake depths over a year to capture both temporal and spatial variations in ocean thermal conditions.

Results demonstrate that daily flow rate optimization enhances annual net power generation compared to constant seawater flow operation. Increasing the intake depth improves the thermal gradient but also raises pumping power, revealing a trade-off between available ΔT and hydraulic losses. Overall, this work illustrates that a mid-scale OTEC system, constrained by commercially available 3.5 m pipelines, can improve performance through adaptive operational control. The findings provide insights into power prediction and lay the groundwork for future studies focused on cost optimization and techno-economic assessment of mid-scale OTEC systems.

Keywords: OTEC,Powerprediction, Long-Term Performance Assessment, Flow rate optimization.

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Comparing a "20" Megawatt Ocean Thermal Energy Model for Two Locations

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ABSTRACT

Ocean Thermal Energy Conversion (Otec) uses warm tropical surface seawater and deep cold seawater to drive turbine-generators that produce baseload continuous electricity. With the support of Florida Atlantic University and the United States' Department of Energy, PCCI Inc. have developed an Otec Rankine numerical model and hull conceptual design for a mid-size (~20 megawatts) floating power plant. The plant's cost model includes distance from its construction yard to its operating site, plus the plant's hydraulic and thermal performance parameters.

PCCI's study will compare the net annual energy production and levelized cost of electricity for two notional plants. One plant is modeled as being built at the USA's Gulf Coast and operating near The Bahamas at latitude 25°N. The second plant will be modeled as being built at Johor in Malaysia and operating in the ocean north of Sabah at 7°N latitude.

The Symposium presentation will present an overview of the Rankine model, the hull arrangement, cold water and discharge water pipes, crew manning, notional installation method and plant economics for the two sites.

Keywords: OTEC, Ocean Thermal Energy, cell spar, agru HDPE, ammonia Rankine, LCOE

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IOS2025-015
Demonstration of 3 kW Hybrid Ocean Thermal Energy Conversion System in UPM UTM OTEC Centre

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) is a power generation system that utilizes the temperature difference between surface and deep ocean layers. Due to the natural phenomena, where seawater temperature remains stable under varying weather conditions, OTEC operates continuously and produces stable power generation throughout the year. However, the available temperature difference is small, around 20°C, and the heat exchanger performance is critical in producing the power output. When surface seawater is directly circulated through the heat exchanger, heat transfer performance and power output is reduced because of biofouling on the heat transfer surfaces. The fouling condition depends strongly on the geographical and environmental conditions. In recent years, the Hybrid Ocean Thermal Energy Conversion (H-OTEC) system, which utilizes spray-flash-evaporated steam generated from surface seawater as the warm heat source, has attracted increasing attention as an effective approach to prevent fouling on heat exchanger surface and producing fresh water. In an H-OTEC system, the spray-flash-evaporated steam from surface seawater is condensed in the Evaporator–Condenser (Eva-Con) unit to produce desalinated water while simultaneously generating electricity. Since H-OTEC system involves phase change, it can enhance the overall heat transfer coefficient and reduce the size and cost of the heat exchanger. In 2024, a 3 kW H-OTEC experimental plant was installed at the UPM–UTM OTEC Centre in Port Dickson, Malaysia. This facility represents the world's first H-OTEC pilot plant. The experimental apparatus employs actual seawater as the warm heat source and cooling water from a refrigeration unit as the cold heat source allowing evaluation of the performance of the key component, the Eva-Con, in H-OTEC. This configuration enables evaluation of system performance under various conditions and with the direct use of seawater into the H-OTEC plant. This study presents detailed experimental results obtained from the 3 kW H-OTEC system in UPM–UTM OTEC Centre, using R134a as the working fluid. Continuous operation was conducted to investigate the effects of warm surface seawater temperature condition on the Eva-Con performance, the theoretical power output and thermal efficiency of the cycle. As a result, the plant demonstrated stable operation with an average thermal efficiency of 2.7%. The cycle efficiency ranged from approximately 1.5% to 3.0% when the temperature difference between the warm and cold heat sources was 20–23 K. The findings presented in this study provide a comprehensive evaluation of the system design and characteristics of the 3 kW Hybrid Ocean Thermal Energy Conversion system in UPM-UTM OTEC Centre.

Keywords: OTEC, Hybrid cycle, H-OTEC, Desalination, Spray flash evaporation, Plate-type heat exchanger

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IOS2025-18
Prospective Utilization of Machine Learning for OTEC System Enhancement: Learning from Researches on Other Ocean Renewables and Typical Thermal-Based Power Generation

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ABSTRACT

The energy transition toward low-carbon systems requires improved efficiency and optimization of sustainable power generation technologies. Ocean Thermal Energy Conversion (OTEC) offers long-term potential as a stable, clean, and multifunctional ocean energy technology, providing a continuous energy supply thanks to the stable thermal gradient of tropical oceans throughout the year. However, implementing OTEC requires a deep understanding of the system and supporting structure design to reduce the levelized cost of energy and improve its technological readiness level. Considering these conditions, the present study explores the prospective application of machine learning (ML) to enhance OTEC systems, based on studies conducted on other ocean renewable technologies (such as ocean current and wave energy) and thermal-based power generation systems (such as geothermal and coal-fired power plants). This study follows a Kitchenham-style methodology to identify and synthesize current literature on ML applications, aiming to provide useful insights for improving the efficiency and optimization of OTEC systems.

In the context of ocean energy, the applications of ML and deep learning have shown significant progress, particularly in predicting ocean conditions, optimizing wave energy converter designs, and enabling adaptive control of power take-off systems. For ocean current energy, ML has been used to predict tidal current velocity and estimate power potential. Similarly, in the coal and geothermal sectors, ML has been applied to improve operational efficiency, reduce fuel consumption, and optimize reservoir control and combustion processes. Although wave and ocean current energy share similar energy sources with OTEC, while coal and geothermal systems share thermal mechanisms based on temperature differences, OTEC has unique characteristics. These include the temperature gradient between deep and surface seawater, the use of a Rankine cycle with working fluids such as ammonia, and complex thermohaline dynamics. These characteristics necessitate advanced optimization strategies to improve efficiency and reliability. The application of ML in OTEC systems holds great potential to support more accurate simulations, optimize operational parameters, predict performance under seasonal and ocean condition variations, evaluate integration feasibility with other renewables, and provide adaptive control under disturbances. Therefore, ML can help reduce failure rates, increase clean energy output, and accelerate OTEC’s commercial readiness in tropical regions, including Indonesia.

In conclusion, OTEC systems stand to gain significant benefits from an integrated ML framework that incorporates digital twins, thermal cycle optimization, ocean condition adaptation, and predictive maintenance. This study recommends the development of local tropical ocean datasets, the integration of in-situ sensing, and the combination of physical and ML models to further enhance the accuracy and reliability of OTEC systems.

Keywords: Machine Learning (ML), Ocean Thermal Energy Converter (OTEC), Energy, Prediction, Optimization

IOS2025-019
Theoretical Study of OTEC Plant Optimization: Reuse of Indonesian Post-Operation Offshore Oil/Gas Pipelines as a Cold-Water Pipe

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ABSTRACT

This work is part of a theoretical study that models an OTEC (Ocean Thermal Energy Conversion) plant, a technology that aims to exploit the temperature gradient between warm surface waters and cold deep waters to generate electricity. The main objective of the study was to model, compare, and optimize different OTEC plant configurations (closed and open cycles) in order to evaluate their thermodynamic performance and feasibility in the context of an Indonesian industrial project to reuse existing offshore pipelines.
The methodological approach consisted of constructing complete numerical models of OTEC cycles, studying the influence of the main parameters (pressures, temperatures, flow rates, and enthalpies) and the working fluids used (ammonia, R22, R134a, R410A, propane). The calculations made it possible to determine the power produced, the power consumed, and the net power of the system, while integrating the physical constraints associated with seawater pumping and heat transfer in the exchangers. Parametric simulations and sensitivity analyses were then carried out to identify the optimal operating conditions and the minimum power required to achieve a positive energy balance.
The results obtained highlighted the major impact of the heat exchangers, pumped water flow rates, and fluid selection on the overall efficiency of the plant. An improved approach, taking into account a two-phase fluid at the turbine outlet, significantly increased the simulated net power. The study as a whole yielded a methodology for the thermodynamic evaluation and optimization of OTEC systems, providing a basis for future studies on sizing and technical and economic feasibility analysis.

Keywords: Optimization, CC-OTEC, OC-OTEC, Net power, Ammonia, Propane, R22, R134A, R410A

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Optimizing Double-Stage Hybrid Cycle Ocean Thermal Energy Conversion Designs for Power and Desalinated Water Generation

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) is an attractive renewable technology for coastal and island regions that face growing demands for clean electricity and freshwater. Its hybrid cycle configuration, which simultaneously generates power and produces desalinated water, offers a valuable solution for areas where both resources are limited. However, OTEC performance is fundamentally restricted by the small available temperature difference (ΔT) between warm surface seawater and deep cold seawater. This limited (ΔT) leads to low thermodynamic efficiency and challenges in utilizing the remaining thermal energy after the first stage of evaporation and condensation. Enhancing the extraction and recovery of this limited energy resource remains a major engineering priority for improving the future viability of OTEC systems. Despite increasing interest in multistage OTEC concepts, there remains a notable gap in the systematic study of double-stage hybrid cycle OTEC (D-H-OTEC) configurations focused for simultaneous electricity and desalinated water production. Limited attention has also been given to how different entry points for deep seawater may affect performance distribution between stages. To address this gap, the present study proposes and evaluates a D-H-OTEC configuration with two designs, namely v1 and v2, and optimizes them using two objective functions, γ_1 and γ_2. γ_1 maximizes net power output, while γ_2 represents a combined objective that accounts for both power generation and desalinated water production. A detailed thermodynamic model was developed to simulate system and analyse the performance across ΔT values from 19 °C to 29 °C. The results reveal that the D-H-OTEC system can significantly enhance total energy water output within limited thermal conditions. Under γ_2 optimization, v2 achieves up to 13,000 kW of net electricity and approximately 26,000 t/day of desalinated water, supported by higher surface seawater flowrates and a large total heat-transfer area. v1, on the other hand, demonstrates stronger thermal efficiency, better deep seawater utilization, and higher heat-transfer coefficients in the first stage. Exergy analysis indicates that v2 reaches efficiencies up to 15.5%, while heat-transfer evaluation confirms that deep seawater is the dominant thermal resistance. These findings imply that double-stage configurations can substantially strengthen OTEC's multi-generation capability. Furthermore, the advantages of v1 and v2 highlight the importance of matching system configuration to project goals, which v1 is more suitable for compact designs whereas v2 is preferable for prioritizing maximum power and water output. Overall, this study provides performance insights and optimization guidelines for hybrid OTEC facilities, supporting the United Nations Sustainable Development Goals (SDGs), particularly Goal 7 (Affordable and Clean Energy) and Goal 6 (Clean Water and Sanitation) in coastal and island communities.

Keywords: Double-stage, hybrid cycle, OTEC, desalination, renewable energy

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IOS2025-024
Building Data Servers for Ocean Thermal Energy Resource Assessment

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ABSTRACT

Even though the temperature is the key variable for Ocean Thermal Energy Conversion (OTEC) assessment, an OTEC project involves both land and ocean infrastructure that can bring conflicts of land use and of marine spatial planning. The process of assessing the potential for OTEC relies on gathering the relevant data, which mostly consists of temperature profile and bathymetry data. Additional information on the ocean environment will also be necessary, including biogeochemical profiles, physical oceanography data, marine biodiversity catalogues, atmospheric conditions, among others. This data will be useful for ocean modelling, feasibility assessment, and environmental impact assessment. There is a wide range of options of data by different providers and several public datasets. Moreover, there is a diversity factor which expands the available options and the user might face difficulties finding, obtaining, and analyzing different types of data. There can be an information gap between the scientific community and users from varying backgrounds when it comes to data access due to unfamiliarity with scientific data formats, as well as data access protocols. Our group has established three data servers to facilitate the process of downloading and visualizing data, under Japanese and Malaysian domains. Our process includes collecting, documenting, and distributing scientific data through a THREDDS data server (TDS), a Live Access Server (LAS), and an ERDDAP server, enabling easy access and visualization of data for ocean thermal energy assessment.

Keywords: OTEC, Data Servers, Oceanographic Data, Data Access, Resource Analysis

IOS2025-030
From Analysis to Engineering: Decades of Progress Toward Deploying OTEC at Kwajalein

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ABSTRACT

Ocean Thermal Energy Conversion (OTEC) has long been considered a promising solution for remote tropical islands—particularly those burdened by the high cost of petroleum-fuel-based electricity. Among the most compelling global sites is the U.S. Army Garrison Kwajalein Atoll (USAG-KA), where steep ocean temperature differentials and high diesel dependency make OTEC both technically and economically attractive. However, decades-long interest in advancing a first-of-a-kind (FOAK) OTEC facility at Kwajalein has been tempered by its extremely remote location, the Army's stringent reliability standards, limited land availability, and ongoing disagreement over whether a floating or land-based design is more viable.

Our team first contributed to this conversation in 2007 by responding to a Request for Information (RFI) with a techno-economic feasibility study for a 10-MWe land-based OTEC facility serving Kwajalein and Roi-Namur. That analysis highlighted favorable conditions but also underscored uncertainties around long-term costs, construction methods, and whether coproduction opportunities (e.g., hydrogen, cooling) could enhance viability. Despite compelling findings, some of which will be presented, no project moved forward.

Fast forward to the 2020s: after years of stakeholder engagement, and a broader military push for resilient energy systems, new studies evaluated alternative energy options for USAG-KA. One published outcome concluded that a floating concrete OTEC platform could offer significant cost savings—laying the groundwork for the first committed investment in design-phase OTEC engineering. In early 2025, a contract for $3.5M was announced to support engineering design and cost estimation for an OTEC facility, as part of a larger initiative funded by the Department of Defense to enhance the readiness and energy security of USAG-KA.

Having served as the proposal coordinator and project manager for this OTEC design project through early 2025, I will not be speaking to the project's current status. Nevertheless, I will share insights into the pathway that led to this milestone, including lessons from earlier studies, the role of evolving defense energy priorities, the importance of persistent stakeholder engagement, and challenges likely to arise in future project development efforts.

Keywords: OTEC, first-of-a-kind (FOAK), energy resilience, island power, public-private partnerships, commercialization, defense energy

IOS2025-031
A Nobel Approach for Predicting Performance of Open Cycle OTEC Using Long Term Measurements from Deep Sea Moored Buoy

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ABSTRACT

National Institute of Ocean technology (NIOT) has designed an open cycle Ocean Thermal Energy Conversion (OTEC) plant for Kavaratti, Lakshadweep Island and the plant is under construction. To carry out OTEC resource assessment and understanding the local sub-sea environment for OTEC process, a deep-sea moored surface buoy observatory system was deployed off Kavaratti, Lakshadweep by NIOT. This article discusses in-situ measurements using a uniquely designed deep-sea moored surface-buoy observatory and estimation of power performance of an Open cycle OTEC plant being implemented by NIOT. The buoy system comprises of a surface buoy anchored in 1200 m water depth to the seabed through a novel single point deep water station keeping system. The station keeping consists of taut induction cable with subsea sensors connected to it at different depths. Subsea sensors provide in situ measured data which are transmitted in real time for assessment of oceanographic parameters useful in design of components for a ocean thermal gradient based power plant and desalination. The data received is logged and processed onto a onboard logger and communicated through wireless mode (IoT) and also through various redundancy systems using Radio Frequency communication and on board logging for real time data monitoring. The oceanographic profile data for temperature, depth and pressure received from the system is helpful for OTEC plant design and site selection. The system has successfully collected and transmitted data for an over of two years, providing valuable insights for oceanographic research and OTEC resource assessment. Based on this data collection various oceanography aspects were studied for application of OTEC process as. The studies carried out on water temperature profile, current speed, current direction and temperature difference between surface and deep waters. Based on this data performance of Open cycle OTEC plant model was studied. A sensitivity analysis for power and water generation was carried out. It is observed that OTEC plant performance is deeply influenced by temperature variation due to seasonal changes. Variation in temperature difference between surface and deep sea at 1000 m depth measured over a year data collection. A system for long term assessment of sub-sea environment using deep sea moored surface buoy has been developed for resource mapping and design of OTEC plant being executed by NIOT. Further AI-based forecasting and digital twin applications are being planned for plant operation, automation, and control in order to optimize OTEC power.

Keywords: Open cycle OTEC, Ocean thermal gradient, Desalination, Resource assessment, Data buoy

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IOS2025-033
Optimization-Driven Feasibility Analysis of Standalone Hybrid Renewable Energy Systems for Remote Communities in Sabah

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ABSTRACT

Remote communities in Sabah face persistent energy poverty due to rugged terrain, dispersed settlements, and the prohibitive cost of grid extension. Many existing standalone hybrid renewable energy systems are designed with simplified techno-economic assumptions that neglect long-term component degradation, electrical losses, storage diversity, and governance realities, leading to optimistic cost estimates and uncertain reliability. This research addresses this gap by assessing the feasibility of optimization-driven standalone hybrid systems for remote Sabah communities. The objectives are to (i) identify suitable hybrid architectures and storage options for Sabah-like conditions, (ii) synthesise recent advances in techno-economic and multi-objective optimization of standalone and microgrid-based systems, and (iii) develop a feasibility and design framework tailored to remote settlements in Sabah. The method combines a structured synthesis of recent techno-economic and energy management studies on standalone and hybrid systems with PV, wind, micro-hydro, diesel, and multiple storage options (batteries, pumped hydro, hydrogen), together with analysis of rural electrification case studies in comparable regions. Special attention is given to models that explicitly incorporate degradation, cable and transformer losses, long-duration storage, demand-side management, and governance or business-model considerations. These insights are then organised into a comparative mapping of system configurations, optimization approaches, and performance indicators, from which a Sabah-specific feasibility framework and indicative design guidelines are derived. The results show that hybrid architectures with diversified storage and advanced optimization algorithms consistently achieve higher renewable fractions, lower diesel dependence, and reduced lifecycle cost compared with single-source or battery-only designs, while maintaining stringent reliability targets. Evidence from similar contexts indicates that including degradation and losses in the optimization process slightly increases the calculated energy cost but yields more realistic sizing and more resilient long-term performance. The analysis also highlights the strong sensitivity of feasibility to resource variability, discount rate, component cost trajectories, and economies of scale, as well as the critical role of governance quality, regulatory support, and community participation. The main research output is an optimization-driven feasibility framework and set of design guidelines for standalone hybrid systems in remote Sabah, including recommended resource combinations, storage strategies, and modelling requirements. The research outcome is a decision-oriented basis for planners, policymakers, and practitioners to design and deploy realistic, cost-effective, and socially robust hybrid renewable energy systems that can accelerate sustainable electrification of remote communities in Sabah.

Keywords: Hybrid Renewable Energy Systems, Off-Grid Electrification, Energy Storage Integration, Rural Energy Access, Sabah Remote Communities

IOS2025-034
Status of OTEC in the Philippines and Way Forward

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ABSTRACT

This document presents a brief review of past studies, conceptual design, efforts for collaboration, and plans for commercial OTEC in the Philippines. Recent initiatives to promote OTEC and other Ocean Energies, form collaboration with institutions (government, academe) are described and a Road Map for OTEC in the Philippines is presented. The presentation includes: 1) excerpts from "Conceptual design of OTEC power plant in the Philippines" study at Saga University, presented at the Joint PSME-JSME conference in 1987 and published in the Journal of Solar Energy, 1988, 2) Plans for Commercial OTEC, Wave energy and Tidal current, 2016, a collaboration of Energy Island Bell Pirie Ltd., UK and (Philippine National Oil Co.) PNOC Renewables Corp., 3) Revival of OTEC Initiatives, establishment of OTEA, Philippine delegation joining OTEA, 2019, 4) OTEA Philippines General Assembly and mini OTEC Symposium, August 2025 with following topics: a) present Status of OTEC technology, Kumejima model applied to the Philippines, b) main OTEC equipment for 5 MW OTE, c) latest in SWAC technology, d) OTEC and Desalination in India, e) Cold Water Pipe (CWP), 5) Collaboration with Institutions, Academe (University of San Carlos), government (Dept. of Science and Technology), 6) Planned research initiatives at the University of San Carlos (USC), 7) Road MAP for OTEC in the Philippines

Keywords: OTEC, ocean energy, conceptual design, collaboration, road map

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Ocean Thermal Energy Can Be Economical Today

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ABSTRACT

Ocean thermal energy conversion (OTEC) has been recognized since the late 1800's, as a very large, practically infinite source of solar energy, captured and stored in the ocean and capable of being tapped. Many studies prove this possibility, and numerous small experimental models and plants have been built since the 1930's which certainly prove that this source of heat can physically be harnessed. OTEC is potentially the best and only "green" source of energy which is truly base load or continuous. That means no storage system, batteries and converters are needed.

Today, almost universally, engineers agree on OTEC science but have differing approaches to engineering for practical plants. Pure and solely OTEC thermal efficiency is not the overall key to a successful plant model. The best use of pumped water, warm and cold, to maximize the kilowatts per quantity of water pumped, together with the minimization, cost of materials, manufacture, and installation methods used in constructing and installing the plant, will ultimately lead to the best solutions for making an OTEC plant competitive with fossil fuels. The western Pacific, South China sea, and Indian Ocean basin are among the most impactful areas using this technology, for the world's population.

This paper describes how an OTEC plant, designed by Sea Solar Power, can be constructed in an economical way. The result is a floating OTEC plant that will provide lower levelized cost of electricity than can be obtained using diesel oil delivered through tankers for diesel generators. The 25,000 KW net commercial plant, a small, robust, but economical prototype, described in this paper, can be built today with present innovative technology and provide massive savings for the countries and industries who will install it first. Larger capacity plants will provide even lower cost electricity. This plant will provide an ideal match for supplying completely clean and green continuous power year-round for the coming AI growth in the world. It is the only economical "green" base load, continuous electric producer available today.

Keywords: Ocean Thermal Energy, OTEC, Ocean Thermal Energy Conversion, Sea Solar Power, green, base load, economical

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Cooling Data Centre Servers using Cold Deep Seawater Discharged from OTEC Condensers

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ABSTRACT

Malaysia's intensifying demand for resilient, energy-efficient digital infrastructure underscores the urgency of developing sustainable cooling strategies for high-density data-centre environments. This study evaluates the conceptual and thermodynamic basis for integrating an Ocean Thermal Energy Conversion (OTEC)–derived deep-seawater cooling system into Malaysia's emerging data-centre ecosystem, directly contributing to SDG 7 (Affordable and Clean Energy) and SDG 9 (Industry, Innovation and Infrastructure). As highlighted in the technical documentation, OTEC plants continuously draw deep seawater at temperatures of 4–8 °C from depths of approximately 700–1,000 m. After serving as the condenser coolant for the working fluid, this water is discharged at roughly 10 °C—still sufficiently cold for direct heat-exchange cooling of data-centre secondary loops without exposing IT equipment to seawater intrusion. Multiple peer-reviewed studies referenced in the file reinforce these findings, documenting potential annual energy savings approaching 79% relative to standard mechanical cooling under favourable bathymetric and hydraulic conditions. A critical parameter in evaluating the applicability of such systems is the thermal performance of deep seawater as a cooling medium. The file includes a first-principles calculation to determine the quantity of 10 °C seawater required to cool 1 m^3 (≈1000 kg) of water from an initial temperature of 40 °C to 18 °C. Removing this 22 K thermal load requires approximately 92,400 kJ of heat extraction. If deep seawater is permitted an 8 K temperature rise (10 °C → 18 °C), the required mass of seawater is about 2.9m3 is required per 1 m^3 of source water to achieve the desired temperature drop. This ratio has direct implications for pipeline sizing, pump power, and diffuser design in an OTEC-integrated data-centre deployment. Nonetheless, Malaysia's geological constraints remain significant. Much of the nation rests on the broad Sunda Shelf, where depths exceeding 700 m typically occur far offshore, making cold-water access costly and logistically complex. More favourable bathymetry exists near Sabah's Sulu–Celebes Sea margins, yet even these regions often necessitate offshore or floating infrastructure with extended power and fibre transmission distances—factors that elevate capital expenditure and operational risk. Despite these constraints, the integration of OTEC and deep-sea cooling represents a transformative opportunity for Malaysia. It offers a pathway toward low-carbon, thermodynamically stable data-centre operations while leveraging the national sustainability commitments and global SDG priorities. Additionally, hybrid configurations that combining OTEC deep-seawater discharge with seawater-condenser cooling or district-cooling heat recovery has provided adaptable models that align with Malaysia's broader sustainability strategy and its pursuit of technologically advanced, environmentally responsible digital infrastructure.

Keywords: Deep-seawater cooling, data-centre thermal management, bathymetry, energy-efficient, green cooling system.

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Engineering Evaluation of Fixed Jacket Platforms for Ocean Thermal Energy Conversion in Malaysian Waters

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ABSTRACT

Recent technological developments have substantially improved the feasibility of ocean thermal energy conversion (OTEC) as a viable renewable baseload energy option for Malaysia. OTEC systems operate by exploiting the natural thermal gradient between warm surface water and cold deep water, requiring a cold-water intake pipeline extending to about 700 m. In Malaysian waters, these depths are only reachable approximately 20 km from shore due to the shallow continental shelf, resulting in a substantial increase in capital expenditure (CapEx) for offshore deployment. Current cost assessments indicate that platform and mooring systems account for more than 25% of total development costs, underscoring the need for offshore structural solutions that reduce both fabrication and installation complexity. Although existing OTEC plants worldwide have been deployed either onshore or on floating platforms, fixed offshore platforms well established in the oil and gas sectors represent a mature and structurally reliable alternative with minimal additional manufacturing constraints for OTEC adaptation. However, implementing a fixed platform for OTEC introduces challenges not present in conventional offshore applications. The most critical of these is the integration of a large-diameter cold-seawater intake pipe, which increases hydrodynamic loading, affects overall mass distribution, and modifies the global stiffness of the platform. These effects influence the dynamic characteristics of the structure, including natural frequencies, global mode shapes and susceptibility to dynamic amplification under wave–current–wind interactions. Furthermore, deeper offshore deployment exposes the facility to harsher met-ocean conditions and complicates energy delivery logistics. This proof-of-concept study evaluates these challenges through an integrated approach combining numerical structural analysis, scaled laboratory testing and techno-economic assessment. Using the Structural Analysis Computer System (SACS), detailed structural models of both a conventional jacket platform and an OTEC-adapted jacket system incorporating a Rankine-cycle plant layout are developed. These models undergo in-place and dynamic analyses using site-specific Malaysian environmental conditions, enabling a direct comparison of platform performance with and without the OTEC intake pipeline system. Overall, the preliminary findings demonstrate that a well-optimised fixed offshore platform can offer a cost-effective alternative to floating OTEC systems. The results provide an engineering basis for future OTEC development in Malaysia and outline design strategies that can be immediately applied to upcoming offshore projects.

Keywords: Ocean Thermal Energy Conversion (OTEC); Fixed Offshore platform; Structural Integrity; Rankine Cycle OTEC system, Seawater OTEC Pipeline.

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