

The background of the entire page is a dark blue field. It is filled with a complex pattern of wavy, vertical lines that originate from the bottom and fan out towards the top. The lines are primarily blue, but there are significant sections of red, particularly on the left side and in the lower half, creating a sense of depth and movement. The lines vary in thickness and curvature, giving the impression of a dynamic, fluid environment.

Position Paper on

**Ocean Thermal Energy-Driven
Development for
Sustainability (OTEDDS)**

Position Paper on Ocean Thermal Energy-Driven Development for Sustainability (OTEDDS)



Prepared by
Special Interest Group on Ocean Thermal
Energy-Driven Development
for Sustainability (OTEDDS)

2025

Position Paper on Ocean Thermal Energy-Driven Development for Sustainability (OTEDDS)

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Academy of Sciences Malaysia
Level 20, West Wing, MATRADE Tower
Jalan Sultan Haji Ahmad Shah off Jalan Tuanku Abdul Halim
50480 Kuala Lumpur, Malaysia

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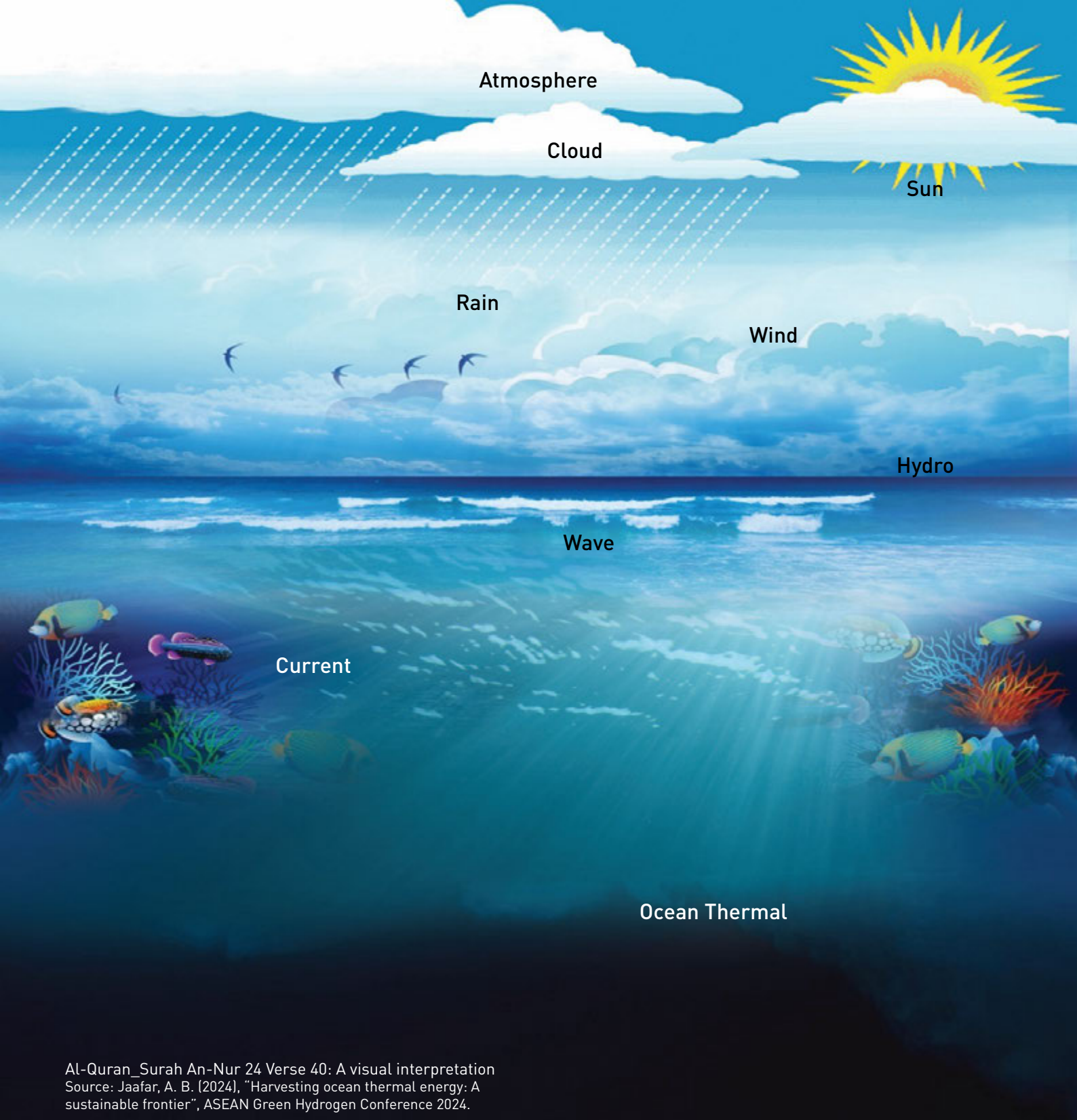
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LIST OF ABBREVIATIONS

10-10 MySTIE	10-10 MySTIE Framework
ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
BOT	Build-Operate-Transfer
CAPEX	Capital Expenditure
CoE	Centre of Excellence
DTN	Dasar Tenaga Negara 2022-2040
ECoS	Energy Commission of Sabah
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
FDI	Foreign Direct Investment
FIT	Feed-in tariffs
GW	Gigawatt
HETR	Hydrogen Economy and Technology Roadmap
IRENA	International Renewable Energy Agency
KETSA	Formerly known as Ministry of Energy and Natural Resources
KfW	Kreditanstalt für Wiederaufbau
KPI	Key Performance Indicators
LT-LEDS	Long-Term Low Emissions Development Strategies
MEL	Monitoring, Evaluation and Learning
MyRER	Malaysia Renewable Energy Roadmap
MW	Megawatt
NDC	Nationally Determined Contribution
NEP	National Energy Policy 2022–2040
NETR	National Energy Transition Roadmap
OTEC	Ocean Thermal Energy Conversion
OTEDDS	Ocean Thermal Energy-Driven Development for Sustainability
OTENAS	Ocean Thermal Energy Nasional Berhad
PPP	Public-Private Partnerships
PV	Photovoltaic
R&D	Research and development
RE	Renewable Energy
REO	Sarawak Renewable Energy Ordinance
RES	Renewable Energy Sources
SDG	Sustainable Development Goal
SEB	Sarawak Energy Berhad
SEDA	Sustainable Energy Development Authority
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change
UTM	Universiti Teknologi Malaysia



Al-Quran_Surah An-Nur 24 Verse 40: A visual interpretation
Source: Jaafar, A. B. (2024), "Harvesting ocean thermal energy: A sustainable frontier", ASEAN Green Hydrogen Conference 2024.

Darkness in the Depths of the Ocean

﴿أَوْ كَظُلُمَاتٍ فِي بَحْرٍ لُّجِّيٍّ يَغْشَاهُ مَوْجٌ مِّنْ فَوْقِهِ مَوْجٌ مِّنْ فَوْقِهِ سَحَابٌ
ظُلُمَاتٌ بَعْضُهَا فَوْقَ بَعْضٍ إِذَا أَخْرَجَ يَكَدُهُ لَمْ يَكْدِرْهَا ۖ وَمَنْ لَّمْ يَجْعَلِ اللَّهُ لَهُ
نُورًا فَلَا لَهُ مِن نُّورٍ﴾

"... or like darkness on a bottomless ocean spread with clashing billows and overcast with clouds: darkness upon darkness. If he stretches out his hand he can scarcely see it. Indeed the man from whom God withholds His light shall find no light at all."

The meaning of Al-Qur'an An-Nur 24:40.

Reference: Dawood, N. J. (Trans.). (2006). The Koran. Penguin Classics.



FOREWORD

Academician Datuk

Dr Tengku Mohd Azzman Shariffadeen FASc

President, Academy of Sciences Malaysia &
STI Advisor to the Prime Minister and the Nation

This report examines the potential of Ocean Thermal Energy Conversion (OTEC) to make a significant contribution to Malaysia's energy transition. It assesses the nation's technological readiness, environmental concerns, economic feasibility and governance pathways in responsibly adopting OTEC technology in Malaysia.

In common with countries around the globe, we face pressing climate change and energy transition challenges that demand innovative solutions that are both effective and sustainable. National aspirations call for a transformation in the way we power the needs of the citizens and the economy while safeguarding the environment. This has been outlined in the Twelfth Malaysia Plan (2021–2025) and further reinforced through recent initiatives under the National Energy Transition Roadmap, New Industrial Master Plan 2030, and Hydrogen Economy and Technology Roadmap.

As a maritime nation, our oceans hold strategic promise. OTEC leverages our ocean's natural temperature gradients to generate clean, continuous energy, while simultaneously opening additional economic opportunities such as desalination, aquaculture and cooling.

We invite policymakers, industry leaders, and researchers to consider OTEC's potential. These findings will hopefully encourage informed policy dialogue and evidence-based decision-making. Providing a diversified energy future for Malaysia will enhance national resilience and sustainable development.

The Academy of Sciences Malaysia is honoured to conduct this study on behalf of the nation as part of its thought leadership role. Yet beyond the technical findings, this report also carries a strong message: Long-term sustainability demands courage to explore new frontiers and the insight to proceed responsibly so that development benefits both people and planet.

The temperature gradient beyond our shores is a precious gift. It should be used wisely to advance human well-being while also protecting the environment that sustains us.

PREFACE

Professor Dato' Ir Dr A. Bakar Jaafar FASc

Chairperson, Special Interest Group (SIG) on Ocean Thermal Energy-Driven Development for Sustainability, Academy of Sciences Malaysia



The accelerating global transition towards low-carbon and climate-resilient energy systems calls for bold yet responsible exploration of innovative renewable energy pathways. For Malaysia, a maritime nation strategically located within equatorial waters, Ocean Thermal Energy Conversion (OTEC) presents a unique opportunity to harness the natural temperature gradient of the ocean as a continuous and predictable source of renewable energy. Recognising this strategic potential, the Academy of Sciences Malaysia (ASM) commissioned this study to evaluate the feasibility, opportunities, and systemic implications of OTEC development within the Malaysian context.

Resource assessments indicate that Malaysia's deep-water regions in the eastern part of Malaysia are particularly promising. Preliminary studies suggest that the deep waters off the State of Sabah possess a theoretical OTEC potential of up to 20,000 MW, while that of the State of Sarawak holds an estimated potential of approximately 6,000 MW. These figures represent long-term resource potential rather than immediately deployable capacity; nevertheless, they underscore the significant strategic value of those deep water regions of Malaysia in the immediate future ocean-based energy development. If responsibly and progressively developed, OTEC could strengthen regional energy security, support industrial growth, and catalyse sustainable economic opportunities in coastal and island communities.

This report provides a comprehensive and multidisciplinary assessment of OTEC technology, covering its scientific foundations, engineering requirements, environmental considerations, economic viability, and governance frameworks. In this regard, OTEC is examined not merely as a renewable power generation option, but as an integrated systems solution capable of supporting desalination, seawater air conditioning, cooling of data centres, sustainable aquaculture, and other energy-water-food nexus applications.

Additionally, this report adopts an evidence-based approach, drawing upon areas across oceanography, engineering, environmental science, economics, and policy analysis. Engagement with stakeholders at both federal and state levels ensured that the findings reflect technical realities as well as development priorities. While OTEC remains an emerging technology globally, the scale of Sabah and Sarawak's resource potential warrants strategic, phased exploration, anchored by pilot projects, environmental safeguards, technological validation, and sound economic planning.

It is important to emphasise that OTEC is not proposed as a standalone solution to Malaysia's energy transition. Rather, it represents a complementary and forward-looking pathway that may enhance energy diversification, strengthen resilience in the eastern part of Malaysia, and reinforce the nation's blue economy ambitions. Targeted research and development, regulatory clarity, financing innovation, and sustained collaboration between federal and state stakeholders will be critical enablers in translating potential into responsible implementation.

This report would serve as a foundation for informed decision-making and strategic planning as Malaysia evaluates the role of ocean thermal energy in advancing sustainable development, energy security, and long-term national resilience.

EXECUTIVE SUMMARY

Ocean Thermal Energy Conversion (OTEC) stands at the nexus of Malaysia's ambitions for a sustainable, resilient, and high-value renewable energy sector. Leveraging the temperature differential inherent in Malaysia's oceanic exclusive economic zone (EEZ), OTEC offers not merely a renewable electricity solution but an integrated platform for green hydrogen, desalinated water, climate-smart aquaculture, and advanced research and innovation.

Riding on the momentum generated by recent policies such as the National Energy Policy 2022–2040 (NEP), the Malaysia Renewable Energy Roadmap (MyRER), the Hydrogen Economy and Technology Roadmap (HETR) and the National Energy Transition Roadmap (NETR), Malaysia is uniquely positioned to take regional leadership in this emerging field. Yet, progress remains constrained by the lack of specific supporting legislation and dedicated institutional architecture.

This position paper, developed by the ASM Special Interest Group (SIG) on Ocean Thermal Energy-Driven Development for Sustainability (OTEDDS), provides a comprehensive assessment and detailed prescriptions to unlock OTEC's national potential.

Key recommendations include:

- The formal legal and policy recognition of OTEC within the Renewable Energy Act 2011 and related statutes.
- The establishment of Ocean Thermal Energy Nasional Berhad (OTENAS) as a "one-stop agency" to plan, coordinate, license and invest in national OTEC development, modelled on PETRONAS for the oil and gas sector.
- Strategic incentives and investment environments to catalyse both local participation and high-quality foreign direct investment.
- The enactment of an Ocean Thermal Energy Development Act to enable and regulate the sector.
- A phased development roadmap, beginning with pilot projects at high-potential sites in Sabah and Sarawak, scaling to gigawatt capacities and multi-product OTEC complexes by 2050.
- Robust governance and monitoring anchored in national priorities (*Dasar Tenaga Negara*, NETR, MADANI), international obligations (United Nations Framework Convention on Climate Change (UNFCCC), Sustainable Development Goals (SDGs), and climate justice principles.

With full implementation, OTEC can anchor over 1.5 million jobs, generate more than USD 39 billion in annual value, and serve as a technological, social and environmental beacon for Southeast Asia's blue economy development.

The tropical waters surrounding Malaysia represent an untapped source of clean, continuous renewable energy. By harnessing the natural temperature difference between warm surface seawater and cold deep seawater, Ocean Thermal Energy Conversion (OTEC) can provide reliable baseload electricity while supporting multiple value-added applications such as desalination, seawater cooling, aquaculture and green hydrogen production. As a multi-purpose ocean energy technology, OTEC offers significant potential to strengthen Malaysia's energy transition and advance the sustainable development of the blue economy.



CHAPTER 1:

INTRODUCTION

1.1

Background and Strategic Importance of Ocean Thermal Energy Conversion for Malaysia

Malaysia's energy sector is entering a new era amid mounting pressures: climate change, finite fossil reserves, rising energy demand, and evolving socioeconomic aspirations. In this context, the national imperative is clear—secure, clean, and sustainable energy for long-term prosperity, resilience, and environmental stewardship. Ocean Thermal Energy Conversion (OTEC) stands out as a promising, largely untapped resource particularly suited to Malaysia's tropical geography. The abundant and stable temperature gradients off Sabah and Sarawak, as well as portions of the peninsular exclusive economic zone, confer Malaysia a genuine strategic advantage.

Global and national urgency

Malaysia, like all nations, confronts the escalating threat of climate change—extreme weather, biodiversity loss, sea-level rise, and public health risks are not abstract projections, but everyday realities. Most greenhouse gas emissions to date are rooted in fossil-fueled energy production. The World Economic Forum's Global Risks Report 2024 identified extreme weather and the failures of climate action among the highest-impact global risks. Energy transition is therefore both a moral and economic necessity.

The blue economy and sustainable growth

For Malaysia, OTEC is not just an energy solution; it is a gateway to a wider blue economy—integrating sustainable offshore energy, freshwater production, aquaculture, and advanced biotechnology. Leveraging this resource secures Malaysia's place in the future global clean economy while bolstering domestic energy independence and job creation.

1.2

Purpose and Scope of the Position Paper

This position paper, prepared by the ASM Special Interest Group (SIG) on OTEDDS articulates:

- The technical, environmental, and economic basis for OTEC adoption in Malaysia.
- An assessment of OTEC's alignment with national policies (NEP, NETR, MyRER, HETR).
- The legislative and regulatory reforms needed to recognise and facilitate OTEC projects.
- The design of a centralised, dedicated agency—Ocean Thermal Energy Nasional Berhad (OTENAS)—to streamline OTEC investment, project development, and governance.
- Actionable recommendations for short-, medium-, and long-term adoption pathways for OTEC in national strategy, regulatory frameworks, and industry growth.

The scope covers federal and state (Peninsular, Sabah, Sarawak) regulatory environments, international policy alignment, stakeholder perspectives, and the implications of establishing OTENAS. The paper's recommendations are informed by technical studies, stakeholder consultations, and best practices in ocean energy policy.

1.3

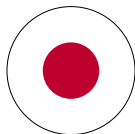
Science, Technology, Innovation and Economic Opportunities of OTEC

Concept of OTEC

OTEC exploits the temperature differential between warm surface seawater (often 25–30°C in Malaysia’s region) and cold, deep seawater (4–8°C available at ~700 meters depth). By using these gradients available year-round in Malaysia’s exclusive economic zone, the technology can run heat engines to generate continuous, “baseload” renewable electricity.

Global context and technology readiness:

First proposed in the 1880s by d’Arsonval, OTEC has advanced from concept to demonstration:



Japan’s Kumejima:
2 × 50kW closed-cycle
OTEC plants.



Hawaii:
105 kW R&D OTEC plant.



South Korea:
1 MW floating OTEC system (KRISO
project).

OTEC means:

“... a method of converting part of the heat from the Sun which is stored in the surface layers of a body of water into electrical energy or energy product equivalent.”
[Pub. L. 96-310, Sec. 9, July 17, 1980, 94 Stat. 946.]

This process typically employs a closed-cycle system, where a working fluid with a low boiling point (such as ammonia) is vaporised by warm surface seawater to drive a turbine connected to a generator. The vapor is then condensed by cold deep seawater and recirculated to complete the cycle. Figure 1.1 below illustrates the schematic diagram of the closed-cycle OTEC process, highlighting the heat exchange, turbine operation, and seawater intake and discharge flows sustained by the thermal gradient of ocean waters.

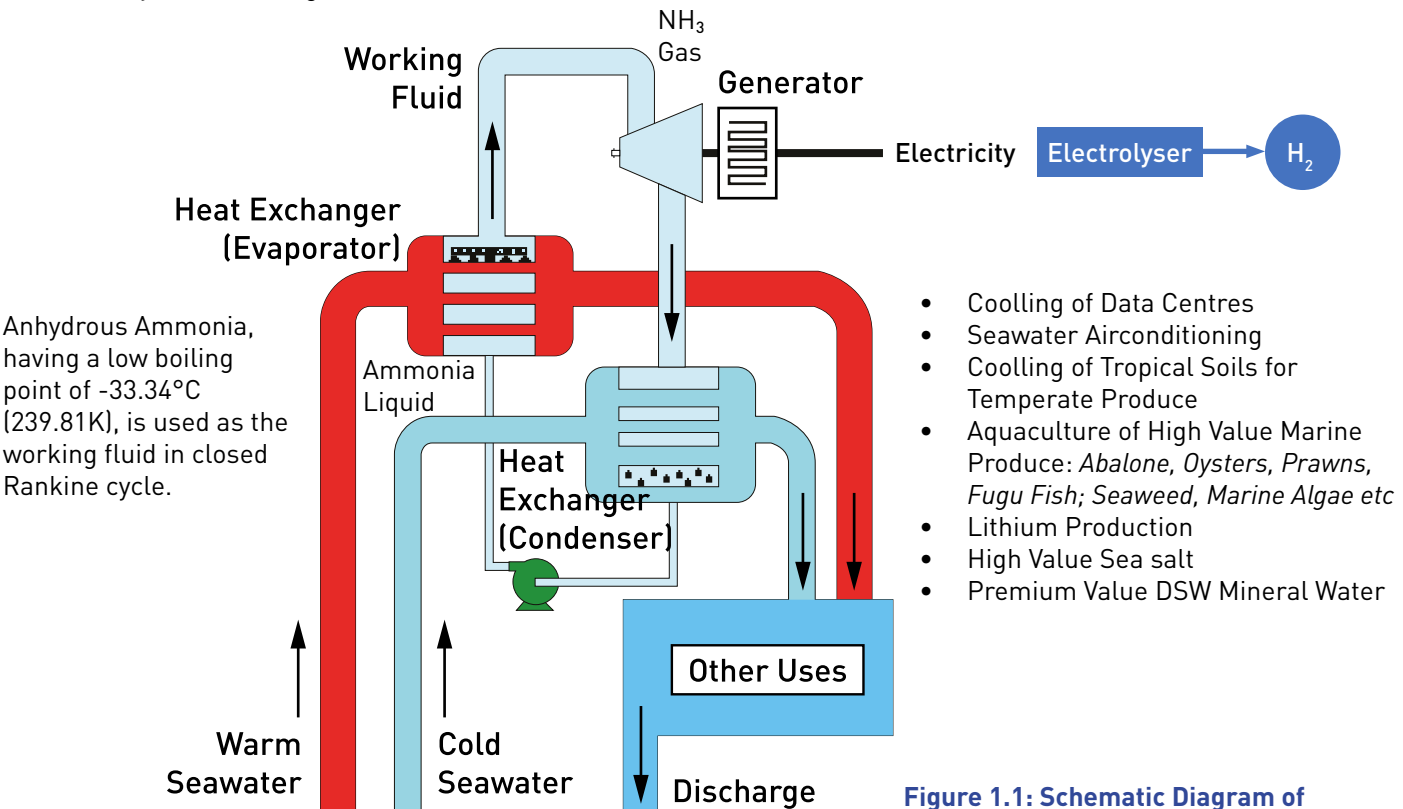


Figure 1.1: Schematic Diagram of Closed-Cycle OTEC Process
Adapted from M. Jadhav & R. G. Kale [2005]

1.4

Fundamentals of Ocean Thermal Energy Conversion (OTEC)

Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology that harnesses the natural thermal gradients of the ocean, specifically the temperature difference between the warm surface water and the cold deep seawater, to drive a heat engine which generates electricity. In Malaysia's tropical region, this temperature delta typically exceeds 20°C year-round, making it one of the most suitable locations globally for OTEC deployment.

Principles and Basic Cycles

The operational mechanisms of Ocean Thermal Energy Conversion (OTEC) are generally categorised into three basic cycles, each utilising the ocean's thermal gradient in distinct ways to generate electricity. These cycles, namely the closed-cycle, open-cycle, and hybrid-cycle, offer primarily in how they use the working fluid and handle the heat exchange process, offering unique advantages in terms of energy efficiency and by-product generation, such as freshwater.

closed-cycle OTEC

- Employs a working fluid (such as ammonia) with a low boiling point.
- Warm surface seawater vaporises the fluid to turn a turbine and generate power; cold seawater condenses the vapour back to liquid, completing the cycle.

open-cycle OTEC

- Warm seawater is flash-evaporated in a vacuum to produce low-pressure steam.
- The steam drives a turbine and is then condensed using cold deep seawater, often yielding desalinated freshwater.

hybrid-cycle OTEC

- Combines features of both, maximising power production and co-generating freshwater.

Key advantages: Predictable baseload renewable energy; 24/7 operation in equatorial regions; significant ancillary benefits such as desalinated water and nutrient-rich deep seawater for aquaculture.

1.5

Comparative Value and Transformative Potential of OTEC

When considering the transition to renewable energy, it is essential to evaluate potential technologies not only on their environmental merits but also on their technical reliability, economic viability, and capacity to contribute beyond mere electricity generation. Ocean Thermal Energy Conversion (OTEC) offers a distinct set of advantages that complement and in some aspects, surpass more established renewable energy sources, such as solar photovoltaic (PV) systems.

Unlike solar PV, which is intermittent and dependent on daylight and weather conditions, OTEC provides a continuous, stable baseload power source capable of operating 24/7 due to the consistent ocean thermal gradients available in tropical regions like Malaysia. Its offshore installation minimises land usage, which is a critical consideration for countries balancing energy development with conservation and land competition.

Moreover, OTEC plants produce valuable co-products including desalinated water, cooling services, and enable aquaculture opportunities that support the emerging blue economy. These multifunctional capabilities widen OTEC’s impact beyond electricity supply, offering integrated solutions for energy, water, food security, and industrial cooling.

However, these benefits come with relatively higher capital expenditure (CAPEX) and moderate operational complexity compared to solar PV, which enjoys lower upfront costs and simpler maintenance. Understanding these trade-offs is key to positioning OTEC within Malaysia’s diversified renewable energy portfolio, emphasising its transformative potential as a clean, sustainable, and multipurpose technology. The comparative analysis between OTEC and solar PV is summarised in the following Table 1.1 and Figure 1.2.

Table 1.1: Comparison of OTEC vs Solar Energy

Criteria	OTEC	Solar PV
Resource stability	Baseload, 24/7	Daytime, weather-dependent
Land use	Offshore, <0.1 km²/MW	Large: ~1.2 km²/100MW
GHG emissions	Negligible	Negligible (ops only)
Co-products	Water, cooling, aquaculture	None
CAPEX	High	Moderate
O&M	Moderate	Low

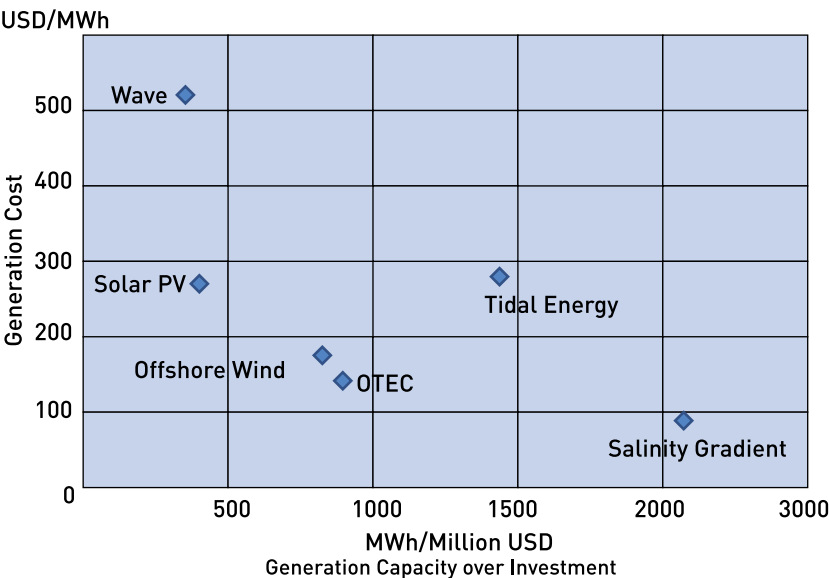


Figure 1.2: Comparative Analysis Diagram

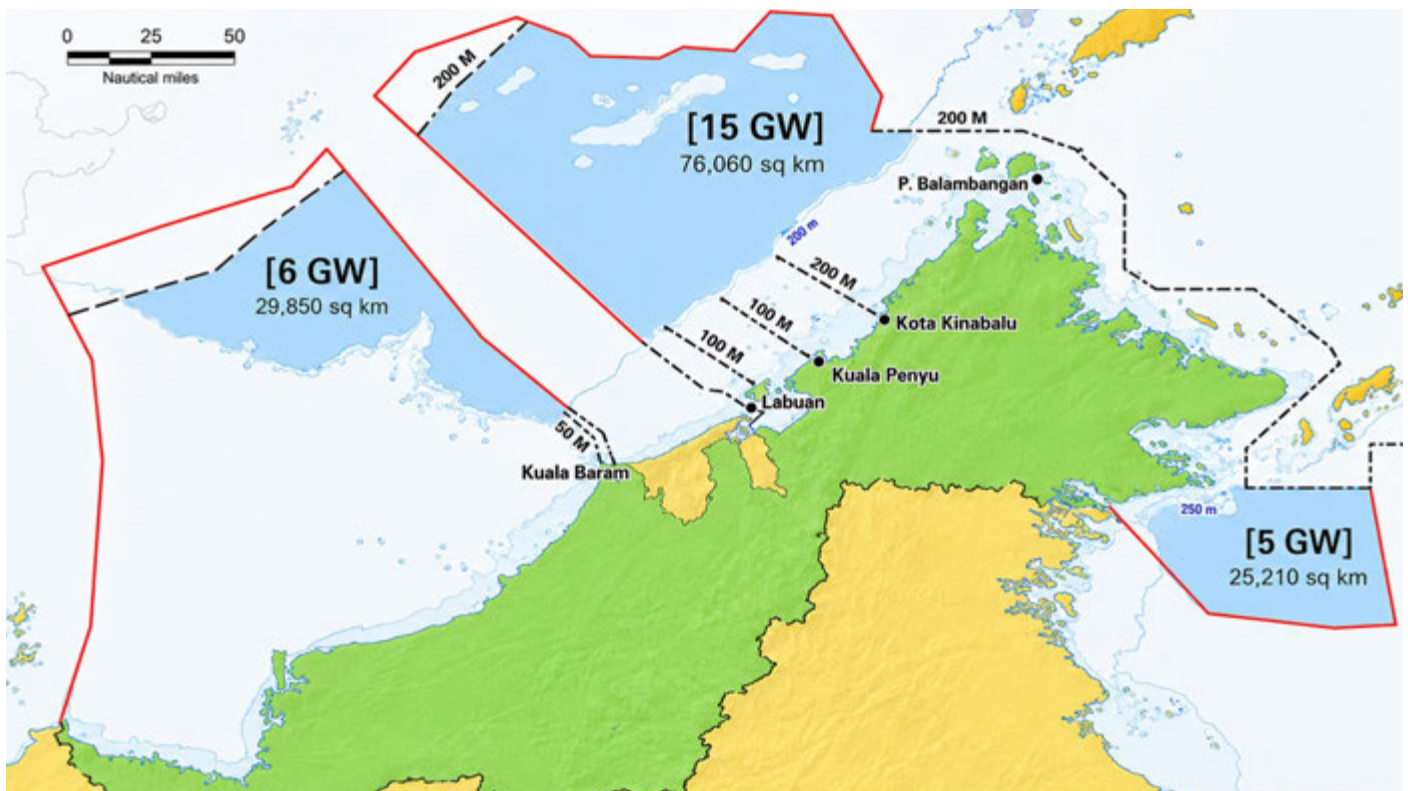


Figure 1.3: Malaysia's OTEC Resource Map - potential zones and estimated capacity

Note:

- The areas in blue @700m deep or deeper = 131,120 km²
- The deep waters are beyond 60km [32 nautical miles] from the coastlines, except the eastern part of Sabah

Globally, OTEC's theoretical capacity exceeds 5,000GW. For Malaysia, recent assessments estimate a national technical potential of 26GW, the largest in the ASEAN region, primarily along Sabah's west/east and Sarawak's coasts.

Multi-product value chains

Beyond power generation, OTEC systems support:

- Freshwater production via open/hybrid cycles (a 2MW OTEC facility could provide ~4,300 m³/day of desalinated water)
- Cold-water aquaculture; deep seawater is rich in nutrients (aquaculture for abalone, oyster, lobster, spirulina, etc.)
- Air conditioner and chilled-soil agriculture (OTEC-supplied cold water)
- Significant reduction in greenhouse gas emissions and land/wildlife impact, compared to traditional energy

1.6

OTEC Development in the Malaysian Policy Context

Renewable energy ambitions:

Renewable Energy Sources (RES) are at the heart of global decarbonisation. The main forms, which are solar, wind, biomass, hydro, etc., have limits (e.g. land, intermittency, ecological footprint). Ocean energy's predictability and abundance near the equator make OTEC uniquely robust.

Malaysia's policy framework:

A suite of forward-looking national policies and strategic roadmaps underpins Malaysia's transition to a sustainable energy system. These frameworks reflect the government's recognition of the need to accelerate renewable energy deployment, diversify its energy mix, and position the country as a regional leader in innovation and the emerging hydrogen economy. OTEC stands out in this framework, not only as a source of reliable, baseload power but also as a strategic enabler for broader economic and environmental targets. Below are the key policy pillars affirming OTEC's relevance and national priority:

- **National Energy Policy (NEP) 2022–2040**

Elevates diversification and the integration of high-potential, future-facing resources. Specifically, Action Plan 9 calls for aggressive exploration and scaling of nascent renewables with OTEC highlighted as a promising candidate for long-term resilience and energy security.

- **Malaysia Renewable Energy Roadmap (MyRER) 2021**

Cites OTEC as a strategic, emerging technology that can help Malaysia achieve its ambitious renewable energy targets—more than 23 GW installed capacity by 2050. The roadmap acknowledges OTEC's unique value as a stable, 24/7 generator and its role in supporting multi-sectoral benefits including water, cooling, and blue economy development.

- **National Energy Transition Roadmap (NETR) 2023**

Recognises OTEC as a critical next frontier in Malaysia's journey to net-zero. While other renewables (like solar and wind) have driven early gains, OTEC is now positioned for future contributions particularly in baseload generation and as a catalyst for hydrogen-linked renewable projects.

- **Hydrogen Economy and Technology Roadmap (HETR) 2023**

Malaysia has set a strategic goal to achieve 80GW of hydrogen production capacity by 2050. OTEC is recognised as a significant contributor to this target, with integrated OTEC and hydrogen systems potentially delivering up to 26GW, which is about one-third of the national goal, by utilising OTEC's continuous offshore renewable power for electrolytic hydrogen production.

Together, these policy instruments create a strong mandate for OTEC commercialisation, embed it within national clean energy and industrial strategies, and provide a robust enabling environment for accelerating project development, innovation, and investment. Despite alignment, OTEC remains absent from the Renewable Energy Act 2011, which presently recognises only biogas, biomass, solar PV, and small hydropower.

International and regional alignment

Malaysia is a signatory to the United Nations Convention on the Law of the Sea (UNCLOS), which affirms the country's rights to exploit and develop ocean resources, including energy, within its territorial waters and Exclusive Economic Zone. National implementation of these rights is based on the following:

- Territorial Sea Act 2012 [Act 750]: Sovereignty rights up to 12 NM from the baseline.
- Exclusive Economic Zone (EEZ) Act 1984 [Act 311]: Sovereign rights over living and non-living resources up to 200 NM, including energy extraction. Section 4 specifically grants the right for "production of energy from the water, currents, and winds".

National and State Legal and Institutional Frameworks

National level

While OTEC sits within the remit of Malaysia's maritime rights under EEZ and UNCLOS, legal and policy gaps at the federal level impede project bankability and regulatory certainty:

- Renewable Energy Act 2011 does not legally define OTEC as a renewable resource, precluding access to incentives and standard regulatory pathways.
- There is no dedicated, clear legislation or regulatory body for ocean energy/Ocean Thermal Energy.

State level (Sabah and Sarawak)



Sabah

The Energy Commission of Sabah (ECoS, 2024) now exercises regulatory authority for all forms of renewable energy (RE), including new ocean energy projects. Key OTEC pilot sites, including Pulau Layang-Layang and Pulau Kalumpang, are located in Sabah's waters. New water column concession procedures are currently being developed to facilitate investment from private, public, and international stakeholders.



Sarawak

Sarawak's Renewable Energy Ordinance references "ocean energy" as an eligible technology, but to date, the state's focus has remained on hydropower. Legal accommodation of OTEC is possible, but regulatory mechanisms are underdeveloped.

Federal–state coordination:

Malaysia's federal–state structure demands clear alignment and jurisdictional clarity. Major OTEC projects, especially in the EEZ (beyond 12 NM), will require harmonised policy and licensing between federal (Ministry of Economy, KETSA, SEDA) and state authorities (ECoS, Sarawak Energy).

1.8

Stakeholder Mapping and Role Assignment for OTEC Development

Identifying the full spectrum of stakeholders, their roles, interests, and influence is critical to the governance and operational success of OTEC development. Malaysia's complex administrative structure involving federal and state levels, diverse industry sectors, and varied community groups necessitates a clear and structured stakeholder engagement framework.

The stakeholder mapping process should categorise stakeholders into:

- **Government**

Ministries (economy, energy, environment, science & technology), regulatory bodies (SEDA, ECoS, Sarawak Energy), local governments, and inter-agency committees

- **Academic and research institutions**

Universities, research centres (e.g., UTM-Ocean Thermal Energy Centre), and technical institutes contributing R&D and workforce training

- **Local communities and indigenous groups**

Particularly those residing near potential OTEC sites, whose livelihoods and environments may be affected.

- **Industry players**

Developers, technology providers, investors, utilities, and blue economy enterprises spanning aquaculture, desalination, and hydrogen

- **Civil society and NGOs**

Environmental groups, community organisations, indigenous rights advocates, and consumer groups

Role assignment and participation mechanisms:

- Clarify decision-making authority vs advisory roles for each stakeholder category.
- Assign lead responsibility for project approval, monitoring, and conflict resolution.
- Establish inclusive participation platforms to integrate diverse voices, particularly marginalised groups.
- Promote transparent communication channels and feedback loops to ensure responsiveness and accountability.

A successful OTEC development initiative in Malaysia requires coordinated efforts across multiple government ministries and agencies. Each plays a distinct yet complementary role in areas ranging from policy formulation, regulatory oversight, and resource management, to sustainable energy promotion. Close collaboration among these bodies ensures streamlined planning, approval processes, and alignment with national energy transition and environmental sustainability goals. Key ministries and agencies involved in OTEC governance and operationalisation include the following:

Ministries & agencies

- Ministry of Energy Transition and Water Transformation (energy resources and efficiency)
- Ministry of Natural Resources and Environmental Sustainability (environmental sustainability)
- Ministry of Economy (policy oversight)
- Sustainable Energy Development Authority, SEDA (RE incentives/policy)
- Energy Commission of Sabah, ECoS (Sabah, regulatory)
- Sarawak Energy (state agency)
- Prime Minister's Department (proposed OTEC Planning Unit; for OTENAS establishment)

Industry, academia & communities

- UTM Ocean Thermal Energy Centre
- Power utilities and hydropower operators
- Aquaculture, biotechnology, and desalination industry players
- Rural and island communities (beneficiaries, site hosts)



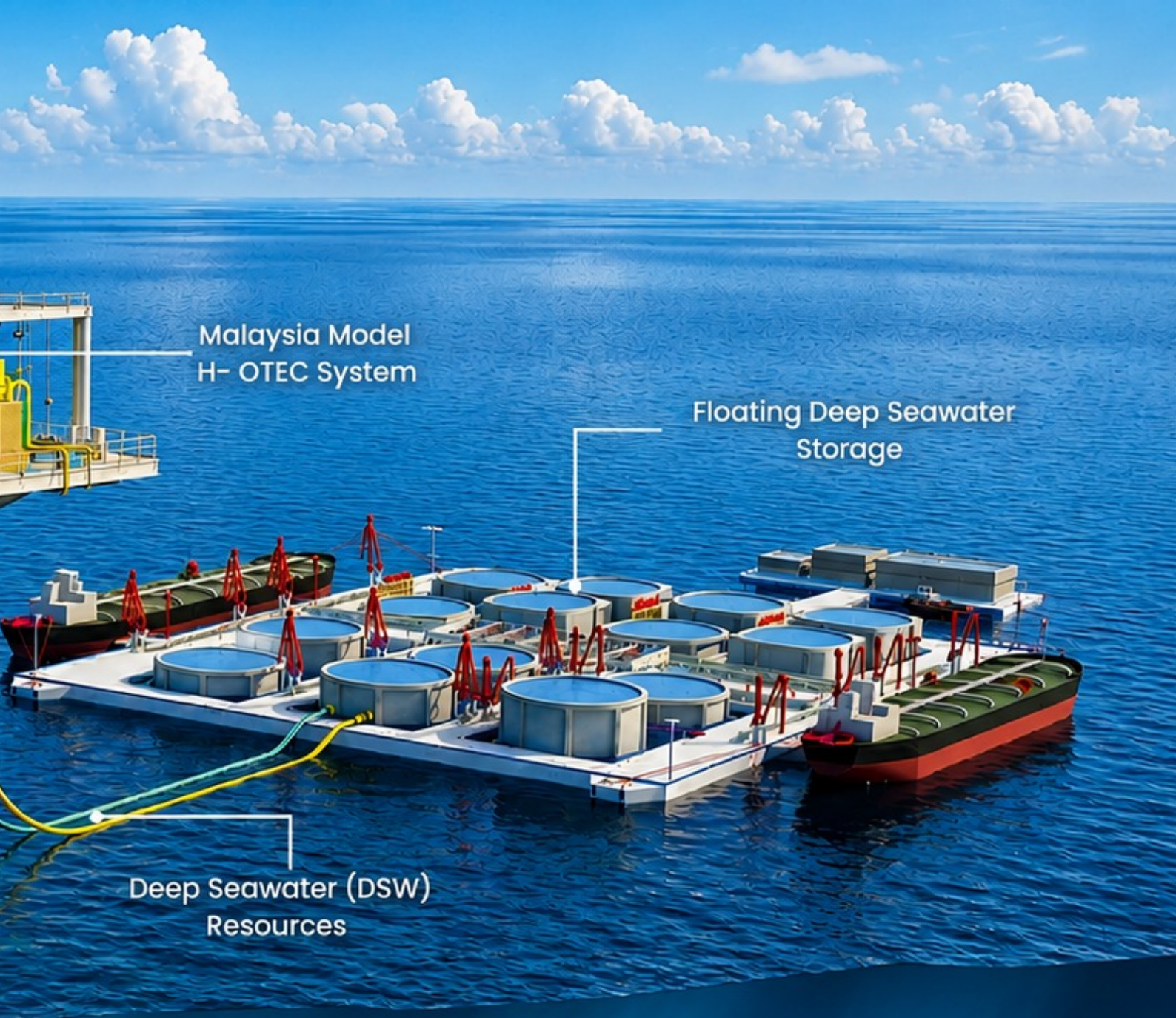
Marine Algae Farming

Fixed Offshore Platform

Deep Seawater Intake

Conceptual Illustration of a Fixed Offshore H-OTEC Platform with Floating Deep Seawater Storage and Marine Algae Farming

The conceptual fixed offshore Hybrid Ocean Thermal Energy Conversion (H-OTEC) platform illustrates Malaysia's proposed integrated use of ocean thermal resources and deep seawater. The platform combines H-OTEC power generation with deep seawater intake, floating storage and marine algae cultivation, demonstrating how OTEC infrastructure could support multiple outputs beyond electricity, including freshwater production, aquaculture, marine biotechnology and other high-value blue economy applications. This integrated approach is commonly referred to as the **"Malaysia Model"**, under which H-OTEC development is linked with the productive use of deep seawater to improve the overall economic viability of the technology.



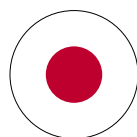
CHAPTER 2:

GLOBAL OUTLOOK AND SCIENCE, TECHNOLOGY, INNOVATION AND ECONOMY CONSIDERATIONS

2.1

Global Technology Benchmarks

OTEC technology has seen varied levels of development and demonstration globally, reflecting diverse geographic, climatic, and policy contexts. Several countries and regions have led pioneering efforts to explore and validate OTEC's potential as a reliable renewable energy source. These initiatives range from small-scale pilot plants to larger demonstration projects, each contributing valuable technical insights and operational experience. Understanding these global benchmarks provides important lessons and reference points as Malaysia advances its own OTEC development strategy within the broader ASEAN and international green energy landscape.



Japan

Kumejima Island: 2 × 50 kW closed-cycle demonstration plants; pilot-scale deep cold seawater-based industry (cooling, aquaculture, microalgae production)



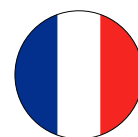
United States

Hawaii Natural Energy Institute operated a 105 kW open-cycle pilot plant in the 1990s



South Korea

Korea Research Institute of Ships and Ocean Engineering (KRISO) launched a 1MW floating OTEC barge off South Tarawa



France, the Caribbean, the Pacific Islands

Consortium-led studies and limited pilots in French islands, Martinique, and Pacific nations



ASEAN nations

Indonesia and the Philippines are exploring OTEC but are behind Malaysia in resource mapping and policy focus. Global OTEC interest is rising in small island developing states (SIDS) that lack large land-based RE options.

Table 2.1 presents a comparative overview of selected international case studies on Ocean Thermal Energy Conversion (OTEC) deployment, highlighting key experiences, challenges, and best practices that offer valuable insights for Malaysia's OTEC development journey.

Table 2.1: Country Case Studies

Country/Region	Capacity & Status	Key Lessons
Japan (Kumejima)	2 × 50 kW, on-land	Industry cluster catalysis, multi-use demonstration
Korea (KRISO)	1MW floating	Marine platform engineering, scale-up pathways
Hawaii, USA	105 kW (historic)	Tech feasibility, grid integration challenges
Martinique, France	Feasibility study, pilot planned	Political and financial barriers
Pacific Islands	Resource assessment	Importance of energy self-sufficiency

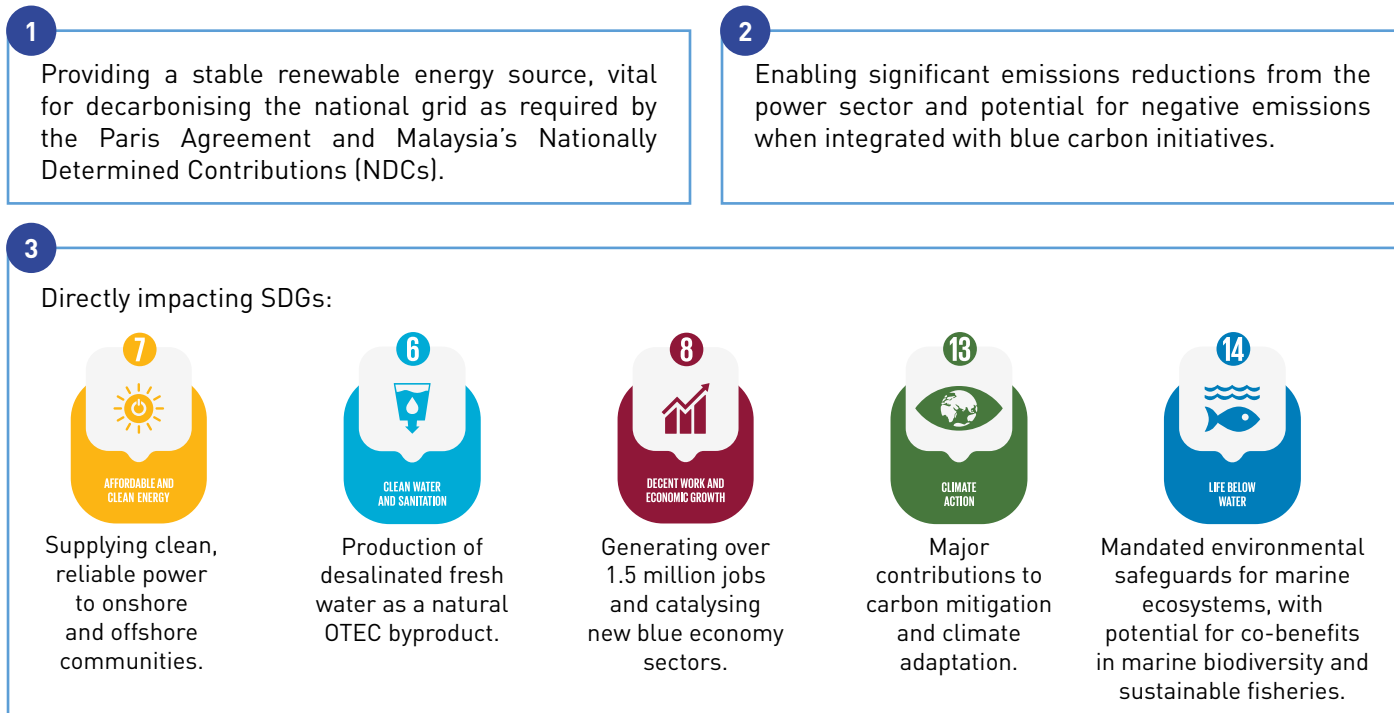
Key takeaways:

- Policy consistency and dedicated agencies (e.g., Saga University IOES in Japan) accelerate deployment.
- Private-public partnerships are vital for overcoming high initial capital costs.
- Exportable OTEC expertise/technology is a growing sector in Asia-Pacific nations.

Net-Zero and Sustainable Development Goal (SDG) Commitments

Malaysia has firmly pledged to achieve net-zero greenhouse gas emissions by 2050, a national commitment articulated in key energy, climate, and sustainable development strategies. OTEC directly contributes to these ambitions by offering baseload renewable energy, green hydrogen, and freshwater while minimising ecological footprint and supporting equitable economic growth.

OTEC supports Malaysia's international and national obligations by:



OTEC supporting All the 17 UN Sustainable Development Goals (SDG) [@ 1MW of OTEC Plant]



Figure 2.1: UN Sustainable Development Goals (SDGs)

International and Regional Collaboration

Active and strategic international engagement is crucial for fully leveraging the advantages of OTEC and satisfying global reporting and compliance obligations. Key approaches include:

- Participation in prominent global renewable energy and climate platforms, such as IRENA and Ocean Energy Europe.
- Establishing bilateral and multilateral partnerships focused on financing, technology transfer, and the exchange of best practices, particularly with countries like Japan, South Korea, the United States, and Pacific Island nations.
- Aligning technical, safety, and environmental standards with internationally accepted frameworks, including UNCLOS and IMO regulations, to enhance project financing prospects and instil investor confidence.

Policy Roadmap for Global Alignment

To effectively integrate OTEC into Malaysia's broader climate and sustainable development agendas, it is essential to establish a clear policy roadmap that aligns national efforts with global standards and initiatives. Institutionalising OTEC reporting within key climate frameworks will enhance transparency, accountability, and measurable progress tracking. Aligning OTEC development milestones with Malaysia's NDCs and SDGs ensures coherence with international commitments. The formation of a dedicated entity such as OTENAS will centralise coordination and position Malaysia as a leader in international OTEC collaboration and the regional blue economy. Furthermore, actively engaging in ASEAN and Asia-Pacific clean energy agendas will capitalise on Malaysia's first-mover advantage, while pursuing global climate finance mechanisms will provide critical funding to accelerate OTEC adoption and innovation. To operationalise this policy roadmap and ensure effective global alignment, the following key actions are proposed:

- Institutionalise OTEC reporting within all relevant national climate change and sustainability frameworks.
- Link progress on OTEC projects to Malaysia's NDCs and SDGs target reports.
- Establish OTENAS as a lead national engagement point for international OTEC cooperation and as Malaysia's representative in global blue economy initiatives.
- Advocate for the inclusion of OTEC in ASEAN and Asia-Pacific clean energy planning, leveraging Malaysia's first-mover advantage.
- Monitor international funding opportunities under global climate finance and green recovery programmes to support OTEC growth.

2.2

Science, Technology, Innovation and Economy Consideration

The 10-10 MySTIE Framework (Figure 2.2) is a tool to transform Malaysia into a knowledge-intensive economy by design, linking STI priorities to the economy in the hope of creating a collaborative ecosystem to move Malaysia up the global innovation value-chain and become a high-tech nation.

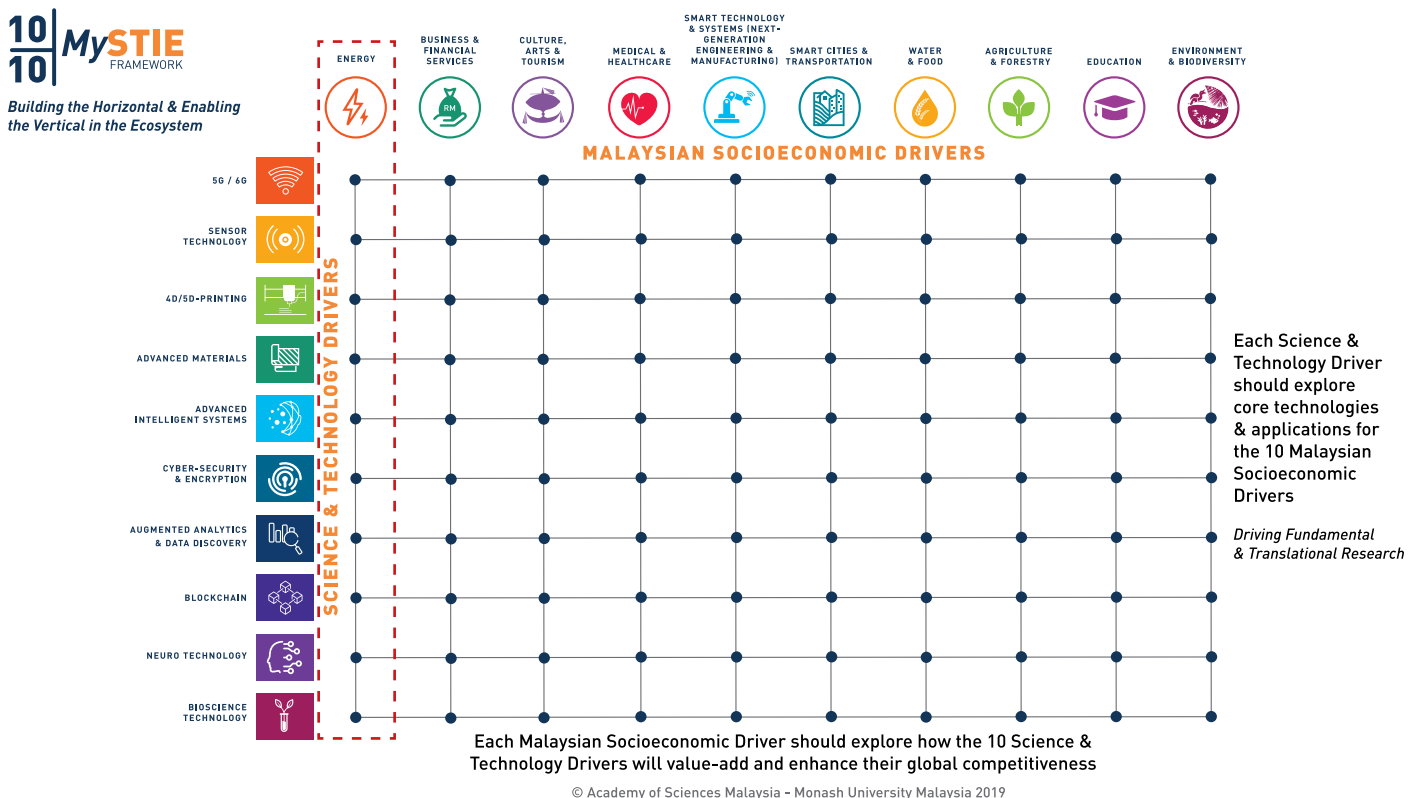


Figure 2.2: 10-10 MySTIE Framework
Academy of Sciences Malaysia, 2020

This framework can be applied to the energy sector, including OTEC, by integrating the 10 key socioeconomic drivers with 10 global science and technology drivers to foster innovation, sustainability, and competitiveness in energy production and management.

Specifically for OTEC in the energy sector, this framework can enable the following:

- Multi-stakeholder collaborative platforms involving government, industry, researchers, and communities to develop and commercialise advanced energy technologies like OTEC.
- Utilisation of emerging technologies such as advanced sensor networks, data analytics, and 5G/6G connectivity to optimise OTEC systems' efficiency and operational reliability.
- Creation of Centres of Excellence (CoE) dedicated to sustainable energy R&D that combine fundamental, applied, and translational research aligned with the socioeconomic demands of cleaner and renewable energy.
- Leveraging innovation ecosystems to improve the knowledge-intensive aspects of OTEC technology, enhancing economic competitiveness and environmental sustainability in line with Malaysia's national priorities.
- Integration with environmental and biodiversity drivers to ensure OTEC development supports sustainable ecosystem management alongside energy production.

Thus, the 10-10 MySTIE Framework serves as a systematic approach to transform OTEC from a technology concept into a commercially viable, innovative, and sustainable energy solution aligned with national socioeconomic goals and global technology trends.

Future-Proofing Malaysia's Blue Economy

Future-proofing involves integrating OTEC into broader marine and industrial policies, ensuring Malaysia remains resilient against climate, market, and technological uncertainties.

Strategic directions:

- Positioning Malaysia as a regional hub for OTEC technology, components, and expertise, opening new export markets in ASEAN, Pacific SIDS, and beyond.
- Leveraging OTEC synergies with green hydrogen, aquaculture, and desalinated water to drive blue economy clusters.
- Continuously monitoring trends in global carbon markets, renewable technology, and maritime regulations to update policies and maintain competitiveness.
- Fostering international research and industry collaborations for ongoing technology transfer and innovation.

Technology Status and Innovations

The field of OTEC technology has witnessed significant progress in recent years, driven by ongoing research and development efforts aimed at overcoming technical challenges and enhancing overall system performance. Innovations in design, materials, and multi-functional applications have broadened OTEC's potential, making it a more viable and attractive solution for sustainable energy generation and complementary uses. The following highlights some of the most notable recent advancements shaping the current state of OTEC technology.

• Floating platforms

Modular, moored OTEC barges allow deployment in deeper waters, reducing environmental and coastal impacts.

• Multi-product OTEC

Integrated systems capable of delivering power, large volumes of desalinated water, aquaculture feedstock, and direct-use cooling for coastal industries.

• Technological maturation

Advances in heat exchanger design, corrosion management, and marine engineering have significantly improved efficiency and lifespan.

Environmental Impacts and Sustainability

OTEC presents a promising pathway for sustainable energy generation with a notably low environmental footprint. As with any marine-based technology, understanding both the environmental benefits and potential ecological impacts is essential to ensure responsible development and long-term sustainability. The following explores the positive environmental contributions of OTEC, as well as key considerations and mitigation strategies necessary to minimise adverse effects on marine ecosystems and coastal communities.

Benefits

- **Minimal greenhouse gas emissions:**
OTEC operations emit almost no greenhouse gases during power generation.
- **Low land use:**
Offshore location minimises competition for productive land compared to solar or terrestrial wind energy.
- **Coastal ecosystem support:**
Deep cold seawater discharge can stimulate local fisheries and support marine biodiversity when managed appropriately.

Considerations and Mitigation

- **Seawater intake and discharge:**
Must be designed to avoid thermal pollution, mixing of water layers, and harm to marine organisms.
- **Biodiversity impact:**
Detailed environmental impact assessments (EIA) are mandatory for siting and operation.
- **Co-location with existing maritime activities:**
Ensuring compatibility with shipping lanes, fisheries, and oil and gas installations.

Potential for Malaysia's Adoption

Malaysia stands at a strategic inflexion point to harness OTEC as a transformative renewable energy and blue economy opportunity. Recognising the country's unique equatorial geography, favourable ocean thermal gradients, existing scientific expertise, and emerging policy support, this section explores the technical viability of OTEC deployment in Malaysia. It identifies value chain opportunities that can drive economic growth, job creation, and climate resilience.

Technical Viability

Malaysia's tropical EEZ offers persistent thermal gradients and sufficiently deep waters to support efficient OTEC operations. These natural conditions are foundational, as OTEC systems rely on the temperature difference between warm surface seawater and cold deep seawater, which needs to be stable and significant for optimal energy conversion.

Feasibility studies confirm the suitability of several strategic sites within Malaysian waters, notably Pulau Layang-Layang and Pulau Kalumpang in Sabah. These locations provide access to deep ocean waters within close proximity to shore, which substantially reduces the costs associated with cold water pipeline deployment and electricity transmission infrastructure.



Figure 2.3: The First Two Potential OTEC Sites in Malaysia

Other factors highlighting Malaysia's technical readiness include:

- The availability of stable year-round temperature differentials of approximately 20°C, providing a reliable, continuous baseload power supply.
- Proximity to deep waters less than 15 kilometres offshore, minimising capital-intensive marine infrastructure.
- Existing research and development infrastructure, such as the UTM Ocean Thermal Energy Centre, which supports pilot testing and technology refinement.
- Favourable environmental conditions with preliminary assessments indicating manageable ecological impacts when appropriate safeguards are applied.

However, challenges like high initial capital expenditure and specialised offshore engineering requirements remain to be addressed. With concerted capacity building, technology transfer, and international collaboration, Malaysia is positioned to demonstrate the viability of commercial-scale OTEC over the coming decade.

Value Chain Opportunities

OTEC development offers a multifaceted value chain that not only encompasses clean electricity generation but also delivers significant co-products and enables new economic sectors aligned with Malaysia's blue economy objectives.

- **Electricity**
OTEC provides stable, renewable baseload power, critical for grid stability and reducing reliance on intermittent renewables.
- **Desalinated water:**
As a byproduct of the process, OTEC plants can supply desalinated water, offering an innovative solution for water-stressed islands and rural communities.
- **Blue economy:**
The cold nutrient-rich deep seawater used in OTEC processes supports aquaculture, sustainable marine biotechnology, and chilled soil agriculture, contributing to food security and economic diversification.
- **Hydrogen production:**
Integrated with electrolysis systems, OTEC's continuous baseload power facilitates low-carbon, green hydrogen production, supporting Malaysia's ambitions outlined in the Hydrogen Economy Roadmap for up to 80GW of hydrogen capacity by 2050.

Additional value chain components include technology manufacturing, project construction, operations and maintenance, and environmental monitoring services, all of which will stimulate local employment and industrial capabilities.

By leveraging these integrated opportunities, Malaysia can maximise economic benefits, promote sustainable resource utilisation, and drive innovation, thereby positioning itself as a regional leader in ocean thermal energy and its associated sectors.

Barriers and Enablers for OTEC Technology Uptake

OTEC represents a promising renewable technology for Malaysia, but like any emerging technology, its widespread adoption faces several challenges. Addressing these barriers effectively requires a clear understanding of the technical, regulatory, financial, and market constraints currently limiting OTEC scaling in Malaysia. Conversely, the presence of strong enablers, such as supportive policies, institutional frameworks, research capabilities, and international collaborations, can accelerate uptake and position Malaysia as a regional leader in ocean energy technologies. A balanced appraisal of both hurdles and facilitators is critical to formulate practical interventions and optimise Malaysia's OTEC deployment strategy.

Barriers

- **High upfront capital expenditure (CAPEX):**
The construction of large offshore OTEC infrastructure entails significant initial investments, including deepwater cold water pipelines, floating platforms, and power generation systems, which pose financial risks and deter private investors. However, it promises significantly higher returns over the long term compared to many other renewable energy sources. This is because OTEC provides stable, continuous baseload power, multiple valuable co-products such as desalinated water and green hydrogen, and strong potential for blue economy integration, all of which contribute to diversified revenue streams and robust economic viability.
- **Legal and regulatory gaps:**
OTEC currently lacks formal recognition under Malaysia's Renewable Energy Act 2011. This absence limits access to established renewable energy incentives and creates uncertainties around licensing, permitting, and revenue frameworks.
- **Limited local supply chain and technical expertise:**
Malaysia's industry and workforce currently have limited experience in the specialised engineering, construction, and maintenance required for large-scale offshore OTEC plants, increasing dependency on foreign technologies and contractors.

Enablers

- **Policy inclusion:**
OTEC has gained policy visibility and is included within the National Energy Policy (NEP) 2022–2040, Malaysia Renewable Energy Roadmap (MyRER), and Hydrogen Economy and Technology Roadmap (HETR), providing an essential policy foundation for future support and investment facilitation.
- **Dedicated research and development capacity:**
The UTM Ocean Thermal Energy Centre (UTM-OTEC) serves as Malaysia's leading R&D hub, offering technical expertise, testing facilities, and innovation support that underpins national capacity building and project piloting.
- **Institutional support through OTENAS:**
The proposed establishment of Ocean Thermal Energy Nasional Berhad (OTENAS) is a pivotal institutional enabler, expected to centralise governance, streamline regulatory processes, coordinate stakeholder engagement, and mobilise investment for OTEC commercialisation.
- **International partnerships:**
Malaysia benefits from active collaborations with established OTEC nations and technological leaders such as Japan, Korea, and the United States. These partnerships facilitate technology transfer, joint research, financing mechanisms, and the sharing of best practices, which are crucial for accelerating domestic OTEC deployment.

2.3 Overview of National Policy Landscape

Malaysia's commitment to a more resilient, diversified, and sustainable energy sector is anchored by a series of major national policies, roadmaps, and action plans launched over the past decade. These frameworks collectively aim to accelerate renewable energy deployment, ensure energy security, and align with global climate goals, while creating new opportunities for economic growth and technological innovation.

MADANI Development Framework Alignment

The MADANI framework, Malaysia's guiding principle for sustainable and inclusive development, emphasises sustainability, equity, good governance, and innovation. OTEC aligns with each pillar:

- **Sustainability:**
Provides renewable, low-impact energy while enabling long-term blue economy opportunities.
- **Care and compassion:**
Addresses energy and water poverty in underserved regions.
- **Respect and equity:**
Ensures community participation, benefit-sharing, and just energy transition.
- **Innovation and prosperity:**
Ensures community participation, benefit-sharing, and just energy transition.
- **Good governance and trust:**
Promotes transparent institutional arrangements via OTENAS and robust stakeholder engagement.

National Energy Policy (NEP) 2022–2040

Purpose: Provides a comprehensive blueprint for managing the country's energy transition over nearly two decades.

Key features:

- Sets a target for renewables to reach 40% of the national power mix by 2035, ramping up to 70% by 2050.
- Action Plan 9 specifically highlights the need to explore high-potential, nascent energy sources, explicitly listing OTEC alongside other innovative solutions.

Implementation: Overseen by the Ministry of Economy, with multi-agency coordination to ensure policy integration across sectors.

Malaysia Renewable Energy Roadmap (MyRER) 2021

Purpose: Lays out granular targets, strategies, and enablers for RE development up to 2050.

Targets:

- Raise RE installed capacity to 18.4GW by 2040 and further to 23GW by 2050.
- RE share of the electricity mix to rise to 31% by 2025 and 40% by 2035.

Relevance to OTEC: Identifies 'emerging and strategic technologies' including ocean energy; points to OTEC's unique base-load advantage and multi-product value (hydrogen, desalinated water, aquaculture).

Gaps: OTEC is referenced but not yet included in incentive/implementation schemes due to pending legislative amendments and regulatory frameworks.

National Energy Transition Roadmap (NETR) 2023

Purpose: Provides a roadmap for decarbonising the national power system, driving a net-zero pathway by 2050.

Key highlights:

- Accelerates RE deployment with a focus on large-scale, low-carbon energy projects across Peninsular Malaysia, Sabah, and Sarawak.
- While OTEC is not expressly featured in the immediate implementation phase, the roadmap's call for innovative base-load technologies and green hydrogen aligns with OTEC's potential.

Complementary measures: The NETR is implemented alongside policy tools such as carbon pricing instruments, a green finance taxonomy, and the integration of energy equity and climate justice principles.

Hydrogen Economy and Technology Roadmap (HETR) 2023

Purpose: Establishes Malaysia's ambition to become a regional champion for green hydrogen by 2050, targeting up to 80GW installed capacity for green hydrogen, with strong export potential.

OTEC contribution:

- Technical studies suggest OTEC-based hydrogen production could contribute up to 26GW, more than a third of the total target, due to its continuous, non-intermittent supply and offshore integration benefits.

Integration challenge: While HETR recognises the potential, pilot-scale OTEC-to-hydrogen projects will require legislative recognition and strong institutional backing to move forward.

Supporting Plans: NDCs Roadmap, LT-LEDS, MADANI, Future-Proofing MESI

Nationally determined contributions (NDCs) roadmap and long-term low emissions development strategies (LT-LEDS): Articulate Malaysia's Paris Agreement commitments, targeting peak national emissions by 2040 and net-zero by 2050.

MADANI framework: Embeds sustainability, inclusivity, and governance reforms as the core of national development—including energy transition.

Future-proofing MESI: Prepares the country's energy sector for global competitive trends, ESG standards, and industrial decarbonisation.

2.4

Regional Regulatory Approaches and State Planning

Given Malaysia's federal system and diverse geography, energy regulation and planning reflect different state-level priorities and statutory frameworks.

Peninsular Malaysia

Regulatory framework: Governed by the Renewable Energy Act 2011 and the Sustainable Energy Development Authority (SEDA) Act 2011.

Status for OTEC:

- OTEC is currently not listed as a renewable resource under existing legislation.
- Project approvals depend on amendments to the federal legal definition of renewable energy and further empowerment of SEDA or new agencies.

Maritime legislation: The Territorial Sea Act 2012 and the EEZ Act 1984 give Malaysia sovereign rights for energy production within territorial waters and EEZ, supporting future OTEC deployment.

Sabah

State-level reforms: The Energy Commission of Sabah (ECoS), established in 2023–2024, holds primary authority over licensing, regulating, and incentivising RE projects, including ocean energy.

OTEC readiness: Key sites identified (Pulau Layang-Layang, Pulau Kalumpang); new water column concession protocols are being designed, creating a clearer path for OTEC pilot projects.

Bidding process: ECoS is positioned to launch competitive concession bidding for suitable OTEC zones, streamlining investment and regulatory approvals.

Sarawak

Legislation: Sarawak Renewable Energy Ordinance provides the legal basis for RE development, including ocean energy, but is operationally focused on hydropower.

OTEC potential:

- Offshore resource zones have high potential, but many lie in contested waters and face investment risk.
- Sarawak's policy focus remains on biomass and hydrogen production via established methods, but OTEC remains a strategic option for long-term diversification.

Institutional arrangement: Sarawak Energy Berhad leads state-level energy projects; specific frameworks for OTEC will require further amendments or supplementary guidelines.

2.5

Current Progress in Relation to OTEC Development

National

- NETR Phase 1 and Phase 2 implementation is underway, with detailed sectoral roadmaps and state consultations.
- MyRER and HETR are both subject to ongoing technical and stakeholder review, with industry workshops proposing future inclusion of ocean and emerging RE technologies.
- The Ministry of Economy and the Ministry of Natural Resources and Environmental Sustainability jointly drive the integration of climate, energy, and industrial policies.

State

- **Sabah:** ECoS is developing mechanisms for OTEC concessions, with recommendations submitted to the State Chief Minister and regulatory instruments under committee review.
- **Sarawak:** Ongoing investments in biomass and hydrogen infrastructure; feasibility work for ocean energy, including OTEC, is in early scoping stages, focusing on legal clarity and international partnerships.

Industry and Research

- UTM Ocean Thermal Energy Centre continues to lead national research and international technical cooperation on OTEC.
- Several private Malaysian and international investors have expressed interest in pilot OTEC plants, contingent on streamlined licensing and incentives.
- Cross-sector initiatives have been launched, including hydrogen-powered transport pilots (Sarawak) and new R&D funds for advanced marine renewables.

2.6

Malaysia's International Policy Commitments

- **Paris Agreement:** Malaysia is a signatory, with obligations to reduce greenhouse gas emissions and periodically increase ambition in line with NDCs and LT-LEDS.
- **UNCLOS:** Confers sovereign rights for the exploration and exploitation of marine energy resources within territorial seas and the EEZ.
- **SDGs:** OTEC projects are aligned with targets for affordable and clean energy (Goal 7), climate action (Goal 13), clean water (Goal 6), sustainable economic growth (Goal 8), and sustainable management of marine resources (Goal 14).

Table 2.2 summarises the alignment between key national and state policies and the development of OTEC in Malaysia, highlighting areas of current support and opportunities for regulatory and strategic enhancements.

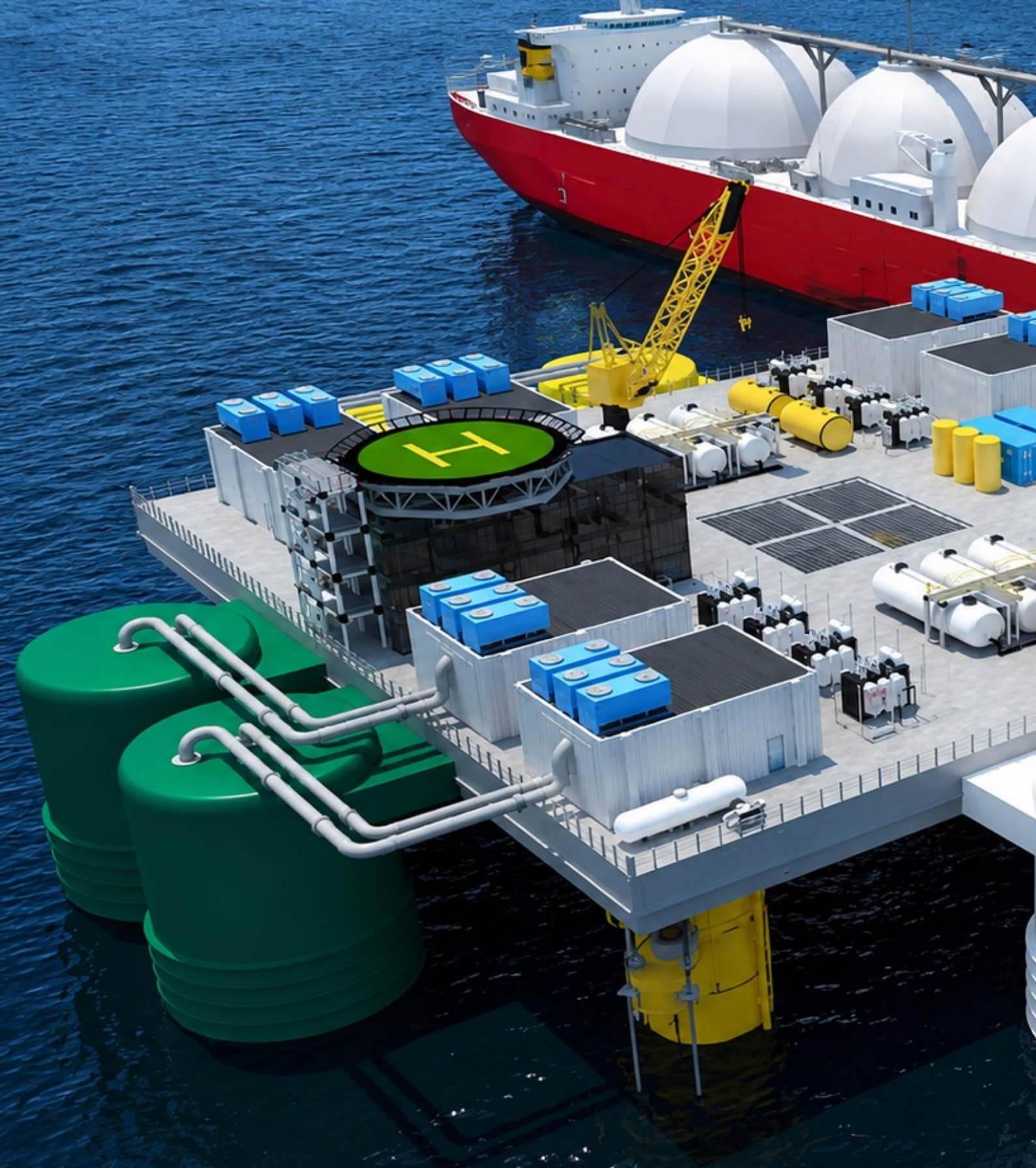
Table 2.2: National & State Policies Alignment with OTEC Development

Policy/Plan	OTEC Status	Responsible Body	Key Actions/Targets
NEP 2022–2040	Strategic focus	Ministry of Economy	Action Plan 9; 40–70% RE share
MyRER 2021	Emerging RE	SEDA	18.4GW by 2040, 23GW by 2050
NETR 2023	Implied, not explicit	Ministry of Economy	Accelerate low-carbon RE
HETR 2023	Recognised; up to 26GW possible	MOSTI	80GW of hydrogen by 2050
Sabah (ECoS, 2023–2024)	Concession-ready	ECoS	OTEC pilot licensing under review
Sarawak Renewable Energy Ordinance	Eligible, not implemented	Sarawak Energy/State Gov	Focus on hydro, some ocean energy
Territorial Sea Act 2012, EEZ Act 1984	Authorises	Federal Government	Sovereign rights for ocean energy
UNCLOS	Authorises	Federal Government	International law on marine resources

2.7 Way Forward

Achieving the full potential of Ocean Thermal Energy Conversion (OTEC) in Malaysia hinges on a comprehensive and coordinated approach that integrates legal, policy, and institutional frameworks at both the federal and state levels. This requires embedding OTEC explicitly within national renewable energy legislation and ensuring clear delineation of roles and responsibilities among government entities. Enhancing existing policies, especially during ongoing reviews of the Renewable Energy Act and evolving state legislations such as those in Sabah, presents a timely opportunity to position OTEC as a strategic priority. Malaysia’s ambition to lead regionally in ocean energy technology can be realised by aligning national roadmaps like MyRER, NETR, and climate commitments with the demonstration and scale-up of multi-megawatt OTEC projects. Furthermore, active engagement in regional and international renewable energy forums will be vital to securing technology partnerships, financing mechanisms, and skilled expertise, ensuring Malaysian OTEC developments remain competitive and sustainable in a global context. To realise this vision, focused actions are required across several key areas that address legislative inclusion, policy enhancement, regional positioning, and international cooperation, as outlined below:

- **Integration needed:** OTEC’s full deployment depends on statutory inclusion in national law, with federal and state roles clearly defined.
- **Policy enhancement:** Current reviews of the Renewable Energy Act, as well as evolving state-level legislation (especially in Sabah), present opportunities to incorporate OTEC as a strategic priority.
- **Regional leadership:** By aligning MyRER, NETR, and NDC/LT-LEDS implementation with pioneering multi-megawatt OTEC pilots, Malaysia can emerge as the regional hub for ocean energy technology.
- **International collaboration:** Continued participation in ASEAN, Asia-Pacific, and global renewable energy platforms will advance access to finance, technology, and talent for Malaysian OTEC projects.



Offshore OTEC-powered green hydrogen production

The platform shown is an offshore OTEC facility where continuous electricity generated from the ocean thermal gradient powers seawater desalination and electrolysis to produce hydrogen. The hydrogen is then liquefied or compressed and transferred directly to specialised carriers (shown in the background) for transport to international markets. This concept addresses one of OTEC's traditional limitations—its distance from major electricity demand centres—by converting renewable electricity into a transportable energy carrier. In addition to hydrogen production, the platform can support desalinated water production, cold seawater applications and offshore industrial activities, positioning OTEC as a contributor to the emerging global hydrogen economy. While the concept remains at the feasibility and engineering design stage, it demonstrates the growing potential of OTEC to diversify beyond electricity generation and serve as an offshore renewable energy hub for future low-carbon fuel production.



CHAPTER 3:

RESOURCE POTENTIAL AND SITE ASSESSMENTS FOR OTEC IN MALAYSIA

3.1

National OTEC Resource Potential: Current Knowledge and Mapping

Malaysia is exceptionally well-positioned for large-scale OTEC due to persistent, strong temperature differentials across its extensive EEZ. Technical studies estimate up to 26GW of OTEC potential, with the most promising capacity concentrated along the western and eastern coasts of Sabah (~20GW combined) and another significant zone offshore Sarawak (~6GW). Malaysian waters also feature suitable depths and relatively short distances from shore, reducing the need for long pipelines and optimising site economics.

Technical Resource Mapping

- **Sabah’s West Coast:** Deep waters (>700m) begin within 60km of the coastline, especially off Pulau Layang-Layang. This zone holds up to 15GW of potential.
- **Sabah’s East Coast:** Areas near Pulau Kalumpang identified for ~5GW, with 800m depths accessible within 15km of land.
- **Sarawak:** Waters off Kuala Baram feature an estimated 6GW, though many areas are farther offshore and, in some cases, within contested EEZ boundaries.
- **Peninsular (lesser potential):** While the coastlines are extensive, suitable deep water is generally much farther from shore, increasing costs and logistical complexity.

Table 3.1: Estimated OTEC Potential by Region in Malaysia

Region	Estimated Capacity	Main Candidate Sites	Distance to Deep Water
Sabah (West)	15GW	Pulau Layang-Layang	3–60km
Sabah (East)	5GW	Pulau Kalumpang, Tawau	10–15km
Sarawak	6GW	Off Kuala Baram	60–80km

3.2

Site-Specific Feasibility Studies and Environmental Assessment

Pulau Layang-Layang (Sabah)

- **Technical feasibility:** Depths of 700–1,000m accessible within 3–5km; year-round surface temperatures average 28°C with deep seawater at 4–6°C
- **Marine conditions:** Stable for offshore structures, but intensive marine biodiversity requires robust environmental management.
- **Grid proximity:** No significant mainland grid, but suitable for self-contained generation or hydrogen production targeted at export.

Off Kuala Baram (Sarawak)

- **Resource quality:** Consistent thermal gradients and suitable seabed topography.
- **Investment risks:** Offshore zones are further from shore and face ongoing territorial disputes in some regions, complicating permitting and long-term investment planning.
- **Pilot readiness:** Early stages; ideal for long-term site planning and future expansion post-pilot demonstration elsewhere.

Pulau Kalumpang (Sabah)

- **Site features:** Ideal for near-shore development, with 800m depth, as close as 15km from shore—a practical distance for large water intake/discharge pipes.
- **Community and development opportunities:** Current use as a diesel-powered outpost provides a local decarbonisation case; potential as a showcase for integrating power, desalination, and aquaculture.

Environmental Impact Assessment (EIA) Highlights

- **Ecosystem sensitivity:** All sites are in or near ecologically important areas, necessitating comprehensive baseline studies prior to project approval.
- **Mitigation needs:** Deep cold water return should be routed below the thermocline to avoid negative impacts on native biota.
- **Stakeholder engagement:** Monitoring and engagement plans are essential to address fisheries, tourism, and local community concerns.

3.3

Technical Considerations and Innovations in the Malaysian Context

System Design Adaptations

- **Platform approach:** Floating and moored OTEC platforms suitable for deeper waters, enabling flexible siting and reduced environmental footprint.
- **Intake/outfall infrastructure:** Malaysian EEZ bathymetry supports cost-effective deep-water intake within manageable distances.
- **Grid integration:** Remote/island or “offshore-to-hydrogen” models are immediately viable; grid-tied projects will require significant new transmission investment, especially in Sabah and Sarawak.

Lessons from Existing Regional Pilots

- International pilots (Japan–Kumejima, Korea–KRISO) demonstrate the importance of modular design, robust marine engineering standards, and a multi-product value proposition (power, water, aquaculture).

3.4

Socioeconomic Impact Assessment

Macro-Economic Projections

- **Direct value added:** If realised at full scale, OTEC could generate up to USD39 billion annually for Malaysia through energy exports, natural hydrogen, desalinated water, and multipurpose blue economy activities.
- **Employment:** Projections indicate more than 1.5 million jobs created by 2050, spanning engineering, manufacturing, operations, aquaculture, research, and downstream industries.

Regional Economic Development

- **Sabah and Sarawak:** OTEC deployment can revive and diversify local economies, with a focus on rural electrification, water security, and new value-chains (cooling, aquaculture, biotech).
- **Peninsular:** Limited direct OTEC deployment, but potential spillover innovation and supply chain opportunities.

Energy Equity

- OTEC holds promise for energy equity and climate justice by delivering stable, 24/7 electricity and clean water to underserved or off-grid island communities, in line with Malaysia’s just transition and MADANI visions.

Table 3.2: Summary Resource Potential and Site Assessment of OTEC Development in Malaysia

Site/Region	Technical Readiness	EIA Status	Development Priority	Pilot/Flagship Potential
Pulau Layang-Layang	High	Baseline	Immediate	Flagship (Sabah)
Pulau Kalumpang	High	Ongoing	Immediate	Demonstration (local grid)
Off Kuala Baram	Medium	To initiate	Medium-term	Feasibility (export)
Port Dickson	Existing 3kW Hybrid-OTEC R&D Facility	n/a	For Upscaling up to 250kW+	For deployment in deep waters

3.5

Recommendations for Site Prioritisation

Effective site prioritisation is crucial for accelerating the commercialisation of OTEC technology in Malaysia, while ensuring sustainable and inclusive development. A strategic focus on high-potential locations will enable the timely demonstration of OTEC's technical and economic viability, build investor confidence, and establish replicable models for broader adoption. Given Malaysia's vast maritime zones, targeted efforts are required to identify, evaluate, and develop sites that offer favourable oceanographic conditions alongside legal clarity and community support.

The following recommendations outline a pragmatic approach to prioritising OTEC sites, balancing expedited action on proven opportunities with methodical preparatory work in emerging areas. This phased approach aims to catalyse early project success while enabling long-term expansion within well-regulated, environmentally responsible frameworks.

- Fast-track pilot and flagship OTEC facilities at Pulau Layang-Layang and Pulau Kalumpang, where pre-feasibility studies have confirmed excellent thermal gradients, water depths, and infrastructure feasibility, providing ideal conditions for early demonstration projects.
- Launch comprehensive feasibility and EIA studies for prospective sites off Sarawak, emphasising legal and investment certainty to mitigate risks and attract diverse stakeholders for project development.
- Develop an integrated pipeline for foreign direct investment coupled with national supply chain participation, designed to maximise local content and economic benefits while leveraging international expertise and capital.
- Ensure that all site development activities adhere strictly to robust environmental management practices and inclusive stakeholder engagement protocols, safeguarding marine ecosystems, respecting community interests, and fostering transparency.

By implementing these recommendations, Malaysia can establish a robust foundation for a sustainable OTEC industry that balances rapid advancement with responsible stewardship and inclusive growth.



Shimizu Corporation's GREEN FLOAT concept

A visionary floating environmental city designed for deployment in equatorial waters. The concept proposes a self-sufficient, carbon-negative urban platform combining residential areas, food production, waste recycling, ecosystem restoration and renewable energy. OTEC forms part of a diversified energy system alongside solar, wind and wave power, using the temperature difference between warm surface seawater and cold deep seawater to provide continuous electricity and support cooling and other marine-based services. Rather than depicting a dedicated OTEC plant, the image illustrates how OTEC could function as enabling infrastructure within a larger floating-city ecosystem, supporting energy security, water and food self-sufficiency, and climate-resilient urban development.

In practice, GREEN FLOAT remains a **future-city concept rather than a constructed development**. Shimizu first introduced it in 2008 and later advanced related floating-structure research through GREEN FLOAT II, which received Approval in Principle from ClassNK in 2017. Since 2024, Shimizu has also participated in the Netherlands-led Floating Future research consortium, which is studying the technical, ecological and governance requirements for feasible large-scale floating cities. These activities show continued progress in floating-structure engineering, but the complete OTEC-powered city depicted in the image has not yet been realised.



CHAPTER 4:

LEGISLATIVE, REGULATORY LANDSCAPE, AND POLICY LINKAGES FOR OTEC IN MALAYSIA

4.1

Overview of Legislative and Regulatory Landscape

Malaysia's ocean energy governance spans complex intersections between federal authority, state legislation, marine jurisdiction, and international law. The successful advancement of OTEC is contingent on comprehensive legal frameworks that recognise, regulate, and incentivise the development of ocean-based renewables.

Enabling National Legislation

Renewable Energy Act 2011 [Act 725]

- The cornerstone federal law governing renewable energy incentives, licensing, and inclusion in the national energy mix.
- **Shortfall:** OTEC is not included in the First Schedule, which currently recognises biogas, biomass, solar PV, and small hydro.
- **Implication:** Projects face regulatory uncertainty and are unable to access national incentive mechanisms.

Sustainable Energy Development Authority (SEDA) Act 2011 [Act 726]

- Empowers SEDA to administer RE feed-in tariffs (FiT), quota allocation, and project registration.
- **Shortfall:** OTEC is not mandated within SEDA's current operational jurisdiction.

Territorial Sea Act 2012 [Act 750] & Exclusive Economic Zone (EEZ) Act 1984 [Act 311]

- Grant Malaysia sovereign rights for energy production—including ocean thermal, current, and wind—within 12 nautical miles (territorial sea) and up to 200 nautical miles (EEZ).
- Section 4, EEZ Act: Explicitly authorises energy production from water, currents, and winds.

Recent National Energy Policies

National Energy Policy 2022–2040 (NEP)

- Action Plan 9: Mandates exploration of “high potential” alternative energy, directly naming OTEC.

Malaysia Renewable Energy Roadmap (MyRER) 2021

- References ocean energy as an “emerging technology”; yet, policy implementation awaits legal recognition.

National Energy Transition Roadmap (NETR) 2023

- Calls for expansion of innovative energy technologies; mentions OTEC in supporting materials, but lacks a detailed chapter on ocean energy.

4.2

State Legislation and Regional Regulatory Landscape

Peninsular Malaysia

- **Regulatory framework:** Governed federally under the Renewable Energy Act 2011 and the SEDA Act; SEDA is the implementing authority.
- **Current status:** OTEC remains outside the legal framework. Permitting, incentives, and investment certainty for OTEC are not available until statutory inclusion is achieved.

Sabah

Sabah State Energy Enactment 2023 and Amendment 2024

- Energy Commission of Sabah (ECoS) is the primary licensing and regulatory body for electricity supply and renewable energy on state land and waters.
- Three Conditional Letters of Approval (CLOA) have been issued by ECoS to three private companies since 15 October 2024 to start the exploration and development of their respective OTEC Projects. Sabah has the potential to attract 17 more companies @1,000 MW.
- Legal gaps have been closed; the definition of “renewable energy” now includes “ocean thermal energy” as contained in the Amendment of 2024 to the Energy Enactment of Sabah, 2023.

Sarawak

Sarawak Renewable Energy Ordinance (REO):

- Provides the legal framework for renewable resource exploitation, including ocean energy.
- Operational reality: State policy focus remains on hydropower and biomass; OTEC is referenced as a future candidate, with legal clarity required for project permitting and state incentive access.

Sarawak Energy Berhad (SEB):

- Primary state-owned utility and development agency; has begun exploratory assessments of OTEC as part of long-term diversification strategies.

Inter-jurisdictional Coordination

OTEC development, particularly in waters spanning state and federal jurisdictions or within the EEZ, necessitates well-defined cooperative mechanisms among federal bodies, state agencies, and maritime authorities. The absence of harmonised standard operating procedures delays project realisation and creates investment uncertainty.

4.3

International Treaties and Best Practice Benchmarks

United Nations Convention on the Law of the Sea (UNCLOS)

- Confers sovereign rights to Malaysia over marine resource development within the EEZ and territorial seas.
- Ensures Malaysia can regulate, license, and enforce environmental protocols for offshore energy installations such as OTEC.

Case Study: U.S. Ocean Thermal Energy Conversion Act (1980)

- Established one-stop federal licensing under the National Oceanic and Atmospheric Administration (NOAA).
- Integrates EIA, navigation safety, stakeholder coordination, and eligibility for federal financial support.
- Serves as an international best practice for comprehensive OTEC legislation, facilitating commercial development through streamlining and clarity.

IRENA and Global Ocean Energy Governance

- International Renewable Energy Agency (IRENA) urges OTEC-eligible nations to set clear legal definitions for ocean energy, develop national standards, and harmonise with local environmental and safety laws.
- IRENA (2014), in its publication on Ocean Thermal Energy Development, cited that Malaysia is proposing a new law on ocean thermal energy development (Bakar Jaafar, 2013).

4.4

Identified Legal and Policy Gaps

National:

- OTEC's absence from the Renewable Energy Act (2011) and SEDA jurisdiction.
- No dedicated OTEC Act or administrative agency.
- Absence of tailored incentives, feed-in tariffs, or state investment mechanisms.

State:

- Sabah and Sarawak are in the process of modernising their respective RE laws; OTEC is only referenced, not explicitly included.
- Operational procedures for licensing, impact assessments, and revenue sharing are yet to be standardised.

Cross-cutting:

- Lack of a "single window" or one-stop agency for OTEC project development, as proposed with OTENAS.
- Insufficient legal frameworks for joint federal-state ventures in EEZ and overlapping waters.

4.5

Recommendations for Legal and Regulatory Reform

National Legal Actions

Amend Renewable Energy Act 2011: Include “ocean thermal energy” in the definition of renewable energy resources in the First Schedule.

Draft and Enact Ocean Thermal Energy Development Act: Comprehensive, stand-alone omnibus legislation to:

- Establish OTENAS as the statutory lead agency.
- Define project licensing, revenue, concession management, public-private and international partnership protocols.
- Integrate environmental and safety protections, project decommissioning, and local content requirements.

State and Regional Actions

- **Sabah and Sarawak:** Amend respective Enactments and Ordinances to include OTEC, with protocols aligned to federal law for smooth concession bidding, EIA, and joint oversight.
- **Sabah ECoS and Sarawak Energy:** Formalise OTEC as a strategic sector in state energy and economic blueprints.

Governance and Institutional Arrangements

- Establish an Ocean Thermal Energy Planning Unit (Prime Minister’s Department) to coordinate technical, legal, and regulatory drafting.
- Mandate joint operating agreements for EEZ and multi-jurisdictional projects, clarifying ownership, resource rights, and revenue allocations.

Align with International Best Practices

- Engage with IRENA, ASEAN, and other platforms on legislative and regulatory guidance.
- Establish technical working groups with international OTEC agencies (e.g., Institute of Ocean Energy, Saga University (IOES), Japan; National Oceanic and Atmospheric Administration (NOAA), the USA; and Korea Research Institute of Ships and Ocean Engineering, South Korea (KRISO)).

Table 4.1: Legal and Policy Landscape at a Glance

Law/Policy	Scope/Authority	OTEC Inclusion	Proposed Reforms
Renewable Energy Act 2011	Federal	Not included	Amend to include OTEC
SEDA Act 2011	Federal	Not included	Empower SEDA for OTEC
Territorial Sea Act 2012	Federal (12NM)	General authorisation	Explicit OTEC provisions
EEZ Act 1984	Federal (200NM)	General authorisation	Detailed OTEC licensing regime
Energy Commission of Sabah Enactment 2023	State	Definition of “Renewable Energy” already amended to include “ocean thermal energy” ¹	[Note: Ocean Thermal Energy Conversion (OTEC) Enactment 2024, and Energy Commission of Sabah Enactment (Amendment No. 2) 2024 on Thursday. Approved by Sabah State Legislative Assembly on 25 April 2024]
Sarawak RE Ordinance	State	Eligible, not active	Implement OTEC protocols
UNCLOS	International	Authorised	Adopt best practices (EIA, safety)

¹ Ocean Thermal Energy Conversion (OTEC) Enactment 2024, and Energy Commission of Sabah Enactment (Amendment No. 2) 2024 on Thursday. Approved by Sabah State Legislative Assembly on 25 April 2024

4.6

Forward Strategy: Timing and Sequencing

National Legal Actions

A strategic and phased approach is crucial to effectively advance OTEC development in Malaysia. This forward strategy outlines key timing and sequencing to align legislative reform, institutional establishment, project deployment, and international engagement. Prioritising immediate actions such as amending existing laws and forming preparatory bodies will lay the necessary groundwork. Subsequent short- and medium-term steps focus on enacting dedicated legislation, launching governance agencies like OTENAS, and initiating pilot projects to demonstrate feasibility. Ongoing efforts will maintain alignment with global standards and promote continued collaboration and technology transfer, ensuring Malaysia’s leadership in sustainable ocean energy development.

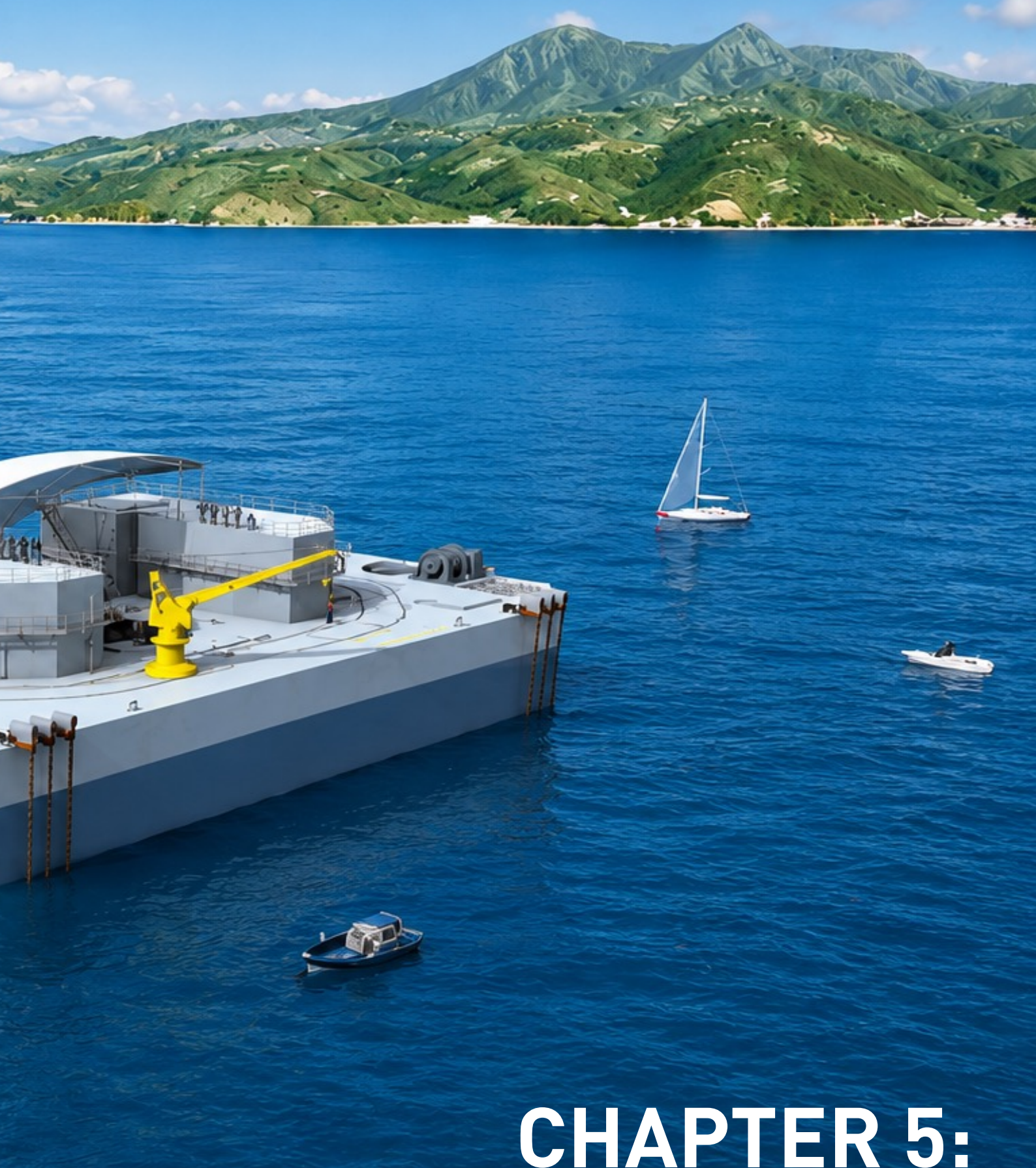
To realise this vision, focused actions are required across several key areas that address legislative amendments, institutional setup, project implementation, and international cooperation as outlined below:

Immediate	Short-term (1–3 years)	Medium-term (3–5 years)	On-going
Table amendments to the Renewable Energy Act and state enactments; establish preparatory committees.	Draft and enact Ocean Thermal Energy Development Act; launch OTENAS and Ocean Energy Planning Unit.	Harmonise licensing, develop pilot projects under revised laws, monitor and adapt regulatory performance.	Interface with international energy and maritime conventions to ensure compliance and facilitate collaboration and technology transfer.



DCNS – NEMO Project

The NEMO (New Energy for Martinique and Overseas) Project, led by DCNS (now Naval Group) and Akuo Energy, represented one of the world's first commercial-scale Ocean Thermal Energy Conversion (OTEC) initiatives. Conceived as a 16 MW floating offshore power plant supplying continuous renewable electricity to Martinique, the project demonstrated the technical maturity and engineering feasibility of large-scale OTEC systems. Supported by €72 million in funding under the European Commission's NER300 programme, the project advanced through detailed engineering and technology development but was ultimately not implemented due to financing challenges, high capital costs and changing renewable energy market economics. Nevertheless, the NEMO Project remains an important international reference, highlighting that while commercial-scale OTEC is technically achievable, wider deployment will require stronger policy support, innovative financing mechanisms and integrated business models to improve long-term economic viability.



CHAPTER 5:

KEY RECOMMENDATIONS & ACTION PLAN

5.1

High-level Recommendations

This position paper culminates in a series of overarching, strategic recommendations essential to unlock the full potential of OTEC in Malaysia. These recommendations address the legal, institutional, policy, financial, and technical dimensions, ensuring a coherent and actionable framework to support Malaysia’s energy transition, economic development, and leadership in ocean renewable energy.

1	2	3
Acknowledge OTEC as a feasible energy source	Provide legislative recognition and framework	Establish Ocean Thermal Energy Nasional Berhad (OTENAS)
To consider OTEC’s potential in executing initiatives from complementary policies such as the Malaysia Renewable Energy Roadmap (MyRER), Hydrogen Economy and Technology Roadmap (HETR), and National Energy Transition Roadmap (NETR).	- Amend the Renewable Energy Act 2011 to formally include OTEC as a recognised renewable energy resource. - Enact a standalone Ocean Thermal Energy Development Act to establish the legal basis for OTEC development, regulation, and incentives.	- Create a dedicated national statutory agency modelled after PETRONAS to coordinate, invest in, and regulate OTEC projects. - Empower OTENAS with clear powers for licensing, concession management, stakeholder coordination, and revenue oversight.

4

Enable integrated policy support and incentives

- Develop comprehensive incentive programmes (tax, grants, tariff structures) tailored specifically for OTEC and associated blue economy value chains.
- Ensure alignment of OTEC policy with existing frameworks such as the National Energy Policy (NEP), Renewable Energy Roadmap (MyRER), National Energy Transition Roadmap (NETR), and Hydrogen Economy Roadmap (HETR).

5

Enhance research, development and capacity building

- Prioritise sustained R&D investments in OTEC technology innovation, environmental management, and multi-product integration.
- Strengthen human capital development programmes to build a skilled OTEC workforce.

6

Ensure comprehensive stakeholder engagement and inclusive governance

- Institutionalise collaborative governance involving federal and state governments, industry, academia, local communities, and civil society.
- Integrate transparent and participatory decision-making processes to support social license and equitable benefits sharing.

7

Mandate environmental sustainability and risk management

- Mandate rigorous environmental impact assessments and adaptive management frameworks.
- Promote best international practices for ecological safeguards and climate resilience.

5.2

Short, Medium, and Long-Term Action Plans

To ensure clear direction and accountability, this section proposes phased, specific action plans that are mapped to both immediate priorities and longer-term strategic goals.

Short-Term Actions (2025–2027)

- Formally set up the Ocean Thermal Energy Planning Unit within the Prime Minister’s Office.
 - Begin drafting and consult widely on the Ocean Thermal Energy Development Act.
 - Amend the Renewable Energy Act 2011 to incorporate OTEC.
 - Incorporate OTENAS as a statutory corporation with initial operational capacity.
 - Identify and designate pilot project sites (e.g., Pulau Layang-Layang, Pulau Kalumpang).
 - Launch first pilot demonstration projects with public-private partnerships.
 - Initiate stakeholder engagement forums at the federal and state levels.
-

Medium-Term Actions (2028–2029)

- Scale up OTEC projects to commercial sizes (50–500MW capacities) at prioritised locations.
 - Roll out dedicated incentive schemes, feed-in tariffs, and procurement policies supporting OTEC.
 - Establish local supply chains and enhance workforce through education/training programmes.
 - Expand multi-product OTEC applications, including green hydrogen and aquaculture.
 - Implement integrated environmental monitoring programmes aligned with international protocols.
-

Long-Term Actions (2030–2040)

- Develop national OTEC clusters and “blue economy” zones contributing significantly to grid stability, industrial growth, and export capacity.
 - Position Malaysia as a regional pioneer in OTEC technology development, innovation, and export.
 - Achieve integration of OTEC with national net-zero and sustainable development goals.
 - Continuously update and refine regulatory frameworks, incentives, and governance based on emerging technologies and feedback from deployment experience.
-

5.3

Proposed Legislative & Institutional Framework for OTEC in Malaysia

Rationale for New OTEC Legislation

The successful deployment of OTEC projects in Malaysia is hindered by the absence of an integrated legal and institutional framework. Current laws inadequately recognise ocean energy, resulting in regulatory uncertainty, fragmented approvals, and limited investor confidence. A stand-alone legislative approach through a dedicated Ocean Thermal Energy Development Act is needed for the following reasons:

- Legal certainty: Ensures OTEC is formally recognised as a renewable energy resource eligible for incentives and well-defined regulatory processes.
- Investor confidence: Reduces risk by clarifying resource rights, licensing protocols, and the roles of federal and state authorities.
- Comprehensive scope: Goes beyond electricity generation to cover hydrogen, desalinated water, cooling, and blue economy products that OTEC technology can enable.
- Alignment with national priorities: Supports NEP 2022–2040, NETR, MyRER, and HETR, driving Malaysia’s climate, energy, and economic targets.

Key Provisions of the Proposed Ocean Thermal Energy Development Act

The proposed Act should be an omnibus legislation establishing clear, actionable governance across all aspects of OTEC commercialisation in Malaysia:

Definitions and Scope

- Clearly define “ocean thermal energy,” “OTEC facility,” “plantship,” “OTENAS,” and eligible ancillary products (hydrogen, desalination, etc.).
- Specify geographic applicability (territorial waters, EEZ, and contiguous zones).
- Alignment with national priorities: Supports NEP 2022–2040, NETR, MyRER, and HETR, driving Malaysia’s climate, energy, and economic targets.

Institutional Authority: Ocean Thermal Energy Nasional Berhad (OTENAS)

Legal status: Incorporated as a government-linked corporation under the Act, directly answerable to the Prime Minister’s Department.

Exclusive functions:

- Management and allocation of water column concessions.
 - Project licensing, technical vetting, and compliance oversight.
 - Facilitation of foreign and domestic investment, including joint ventures.
 - Revenue collection and distribution (royalties, tariffs, concession fees).
 - R&D, technology transfer, and capacity building.
 - Coordination with state agencies for overlapping jurisdictions, notably ECoS (Sabah) and Sarawak Energy.

Powers: To issue, revoke, and monitor licenses; enforce technical and environmental standards; mediate disputes; and act as a trustee for Malaysia’s maritime RE assets.

Licensing and Resource Allocation

- **Concession regimes:** Transparent, competitive bidding for 1,000MW water column “blocks” (as piloted in Sabah); provisions for project duration, renewal, and transferability.
- **Environmental safeguards:** Mandatory EIAs, continuous monitoring, and public consultation consistent with global best practice.
- **Priority areas:** Fast-track procedures for high-potential sites (e.g., Pulau Layang-Layang, Pulau Kalumpang).

Revenue Sharing and Incentives

- Define royalty structures, profit-sharing models with the federal/state governments, and local content requirements.
- Provide explicit tax incentives, import duty waivers, and R&D grants for OTEC investments.
- Dedicated innovation funds for Malaysian companies and R&D consortia.

Stakeholder Participation and Governance

- Representation in OTENAS Board for federal, state, academia, and industry partners.
- Public and community stakeholder engagement chapters to ensure social license to operate.

5.4

Amendments to Existing Legislation

Parallel to the new Act, the following amendments are proposed:

- **Renewable Energy Act 2011:** Add “ocean thermal energy” and “OTEC” as recognized resources in Schedule 1, enabling SEDA to extend incentives and initiative coverage to OTEC projects.
- **Sabah and Sarawak Enactments:** Amend state laws to align with federal provisions, recognizing OTEC and smoothing cross-jurisdictional projects.
- **Sustainable Energy Development Authority Act 2011:** Empower SEDA to coordinate with OTENAS on policy, incentives, and data collection for OTEC.

5.5

Institutional Linkages and Federal-State Coordination

To ensure the successful development and implementation of Malaysia’s OTEC initiative, strong institutional arrangements and clear federal-state coordination are essential. Given the multi-jurisdictional and cross-sectoral nature of the project, governance mechanisms should be established early to define roles, streamline decision-making, and support effective collaboration among the relevant ministries, agencies, and state authorities.

Prime Minister’s Office and OTENAS

- Prime Minister’s Office (PMO) to house an Ocean Thermal Energy Planning Unit i.e. “OTENAS” in coordinating the overall planning and implementation of OTEC during the initial 3–5 years. This includes phased rollout, setting the national technical standards, and facilitating inter-ministry coordination, ensuring alignment with broader energy and development priorities.

Federal-State Joint Operating Agreements

- Clarify and codify joint licensing, revenue-sharing, and operational oversight between OTENAS, ECoS (Sabah), and Sarawak Energy/Sarawak State government.
- Provide mechanisms for joint project steering committees, shared data platforms, and conflict resolution.

Multi-Ministry and Cross-Sector Collaboration

Strong institutional collaboration forms the backbone of Malaysia’s OTEC initiative. The Academy of Sciences Malaysia (ASM) and its advisory body, STIPAC, provide critical scientific and policy guidance, facilitating evidence-based decision-making and consensus-building. Collaboration efforts should focus on:

- Ministry of Economy (KE), Ministry of Sciences, Technology and Innovation (MOSTI), Ministry of Investment, Trade and Industry (MITI), Ministry of Energy Transition and Water Transformation (PETRA), National Security Council (MKN), Ministry of Natural Resources and Environmental Sustainability (NRES), Ministry of Finance (MOF), Department of Survey and Mapping Malaysia (JUPEM), regulatory authorities (SEDA, etc), state agencies (ECoS, Sarawak Energy), and others to be represented in working groups to ensure harmonised policy, investment flows, and technology transfer.
- Aligning inter-ministerial activities to integrate OTEC goals within national energy, environmental, and industrial strategies.

5.6

Fostering Academia-Industry-Government Partnerships

To accelerate the maturation and adoption of OTEC technology, fostering effective partnerships among academia, industry, and government is essential. These tri-sector collaborations drive innovation, build capacity, and ensure that policy supports market and technical realities.

Key components include:

1	2	3
Joint research projects	Technology transfer	Workforce development
• Collaborative initiatives between universities like Universiti Teknologi Malaysia (UTM) and industry stakeholders to advance OTEC engineering, environmental impact assessment, and integrated blue economy applications.	• Mechanisms for moving innovations from academic labs to commercial ventures, including incubation, licensing, and entrepreneurship support.	• Academia provides tailored training and certification programmes while industry offers internships and real-world experience; governments facilitate scholarships and funding.
4	5	6
Policy-research nexus	Innovation clusters	International collaboration
• Government funding programmes aligned with research priorities identified by academia and industry to ensure relevant, demand-driven R&D.	• Establishing OTEC-focused clusters or technology parks that combine research facilities, pilot projects, manufacturing hubs, and business incubation.	• Leveraging global partnerships to exchange expertise and co-develop advanced OTEC technologies.

Mutually beneficial partnerships should be formalised through memorandums of understanding (MoUs), joint steering committees, and public-private innovation funds to sustain long-term collaboration.

5.7

Institutional Blueprint: Structure and Mandates of OTENAS

Organisational Structure

- Members: Chaired by the Prime Minister with representation from relevant ministries/agencies, states, academia, industry, and civil societies.
- Divisions: Licensing/Compliance, Investment & Partnerships, R&D & Technology, Sustainability/Stakeholder Engagement, Operations & Safety.

Functions and Powers

- Manage national OTEC strategy, knowledge repositories, and capacity-building programmes.
- Implement national and international partnership programmes.
- Oversee the awarding and monitoring of OTEC water column concessions.
- Enforce technical and EIA protocols.

Transparency and Monitoring

- Annual reporting to Parliament and State assemblies.
- Public disclosure of concession awards, environmental monitoring, and financial performance.

Table 5.1: Roadmap for Legal and Institutional Implementation

Stage	Milestone	Lead Agency	Timeline
Pre-Legislation	OTENAS concept proposal to the Cabinet	PMO/SIG OTEDDS	Immediate
Drafting Legislation	Ocean Thermal Energy Development Act drafted	Attorney General's Chambers, PMO	Year 1
Act Tabling & Enactment	Parliamentary readings and enactment	Parliament/PMO	Year 2
OTENAS Corporation Set-up	Incorporation and Board appointments	PMO	Year 2
Concession Framework Finalisation	Issue first round pilot site licenses	OTENAS/ECoS/Sarawak	Year 3
Federal-State MOUs	Execution of joint operating agreements	PMO, Sabah, Sarawak	Year 3
Incentive Schemes Operational	Launch of tax, grants, and local incentives	SEDA/MOF/OTENAS	Year 3–4
Full Governance Roll-out	Ongoing monitoring, adaptive improvement	OTENAS/Stakeholders	Year 4+

5.8

Summary: Transformative Impact

The following outlines key considerations and strategic directions essential to advancing the successful development and deployment of OTEC technology in Malaysia. These focus areas address critical aspects, such as legislative reform, institutional capacity, project implementation, environmental sustainability, and stakeholder engagement. A comprehensive and phased approach is necessary to ensure that OTEC is positioned effectively within the national energy and economic landscape, maximising its transformative potential while managing risks and building the enabling environment.

To operationalise this framework and achieve tangible progress, specific actions are needed across several strategic domains as detailed below:

- Legally entrench OTEC as a pillar of Malaysia's renewable and blue economy.
- Attract and safeguard both domestic and FDI for OTEC development.
- Establish OTENAS as a PETRONAS-type "national champion" for ocean energy.
- Align federal and state efforts, reducing duplications, delays, and conflicts.
- Unlock billions in clean energy and industry value, fulfilling strategic national policy and global climate commitments.

Effective governance is crucial for coordinating multiple actors, managing complex inter-jurisdictional issues, and safeguarding the public interest.

- **OTENAS Board of Directors:** Comprising representatives from the Prime Minister's Department, KE, state governments (Sabah, Sarawak), academia, civil society, and industry.
- **Clear mandates:** OTENAS is accountable for licensing, project management, environmental oversight, and financial governance.
- **Inter-Agency coordination:** Facilitated through a steering committee involving SEDA, ECoS (Sabah), Sarawak Energy, NRES, and relevant security bodies.
- **Public reporting:** Mandated transparency through annual reports to Parliament and state assemblies detailing project status, finances, and environmental performance.
- **Stakeholder advisory panels:** Provide ongoing advice and feedback to OTENAS and the government on social, technical, and economic matters.
- **Dispute resolution mechanisms:** Clearly defined protocols to resolve conflicts between federal-state interests or among investors and communities.

5.9

Technology Development and Deployment Roadmap

OTEC Technology Roadmap for Malaysia

OTEC technology has matured globally; however, its commercial-scale adoption in Malaysia requires a tailored roadmap that takes into account local oceanographic conditions, the policy landscape, and economic objectives. A deliberate, phased approach is essential to transition from pilot projects to full-scale commercial deployment and integration with Malaysia's energy system and blue economy sectors. The following are the key aspects of Malaysia's OTEC Technology Roadmap.

Phase 1: Pilot and Demonstration Projects (2025–2030)

- Site selection and validation at high-potential zones (e.g., Pulau Layang-Layang and Pulau Kalumpang).
 - Installation of 1–10MW pilot plants to demonstrate technical and environmental feasibility.
 - Integration of multipurpose outputs — electricity, fresh water, cold-water aquaculture.
 - Close monitoring and data gathering to refine technical parameters and operational protocols.
-

Phase 2: Scale-Up and Commercialisation (2031–2040)

- Expansion to utility-scale plants (50–500MW) with improved system efficiencies.
 - Establishment of local manufacturing and maintenance capabilities.
 - Development of supply chains, workforce training, and stakeholder partnerships.
 - Co-deployment with green hydrogen production and desalination systems.
-

Phase 3: National Integration and Export Leadership (2041–2050 and beyond)

- Large-scale OTEC clusters supporting grid stability and industrial demand, including export-oriented green hydrogen.
 - Building Malaysia's regional leadership in ocean thermal technology and associated blue economy industries.
 - Promotion of technological innovation, export of expertise, and participation in international collaborative projects.
-

The roadmap is designed to be adaptive, leveraging pilot learnings and emerging technologies to optimise cost, efficiency, and environmental outcomes.

R&D, Piloting and Demonstration Projects

R&D, coupled with well-planned piloting, form the backbone for successful OTEC deployment in Malaysia. These activities reduce technical risks, validate concepts, and foster investor confidence.

Important considerations and initiatives:

Research and Development Focus:

- Optimisation of heat exchangers and fluid dynamics specific to Malaysian tropical ocean parameters.
- Sustainable marine engineering solutions to minimise ecological impact.
- Development of hybrid OTEC systems to boost freshwater and hydrogen co-production.
- Advanced monitoring systems for performance and environmental safeguards.

Pilot and Demonstration Projects:

- Identify and prioritise sites with optimal temperature gradients and environmental sensitivity.
- Secure funding through public-private partnerships and international grants.
- Employ modular, scalable designs to facilitate technology learning.
- Undertake comprehensive environmental impact assessments (EIA) and stakeholder consultations.
- Deploy pilot plants with full monitoring regimes for operational data collection.

Knowledge and Capacity Building:

- Collaboration with global OTEC centres of excellence (e.g., Japan, Korea, the USA).
- Incorporation of pilot learnings into national standards and best practice guidelines.
- Development of intellectual property and human capital pipelines through academia-industry partnerships.

Human Capital & Workforce Development

A skilled and adequately trained workforce is critical for pioneering OTEC deployment, ensuring operational excellence, innovation, and sustainable growth within Malaysia's clean energy sector.

Key human capital development strategies include:

- Designing specialised education programmes at universities and technical institutes focused on OTEC engineering, marine technologies, and blue economy management.
- Introducing dedicated training modules and certifications for OTEC system operation, maintenance, and environmental compliance.
- Facilitating industry-led internships, apprenticeships, and technical exchange programmes, especially involving overseas OTEC projects.
- Encouraging interdisciplinary programmes linking oceanography, environmental science, and renewable energy engineering.
- Promoting scholarship schemes and research funding that target young Malaysian talent in OTEC fields.
- Developing retraining programmes for workers experienced in oil & gas, power generation, and maritime sectors to transition into OTEC careers.

Policy Advocacy and Public Awareness

Effective stakeholder engagement starts with robust policy advocacy and public awareness campaigns. For OTEC to gain widespread support and smoothly integrate into Malaysia's energy ecosystem, policymakers, industry players, communities, and the general public must be adequately informed and engaged about the technology's potential, benefits, and challenges.

Strong advocacy efforts cultivate political will, reduce misunderstandings, and promote inclusivity in decision-making. Public awareness programmes should leverage multiple platforms such as traditional media, social media, workshops, and community forums to disseminate accurate info national energy transition, environmental sustainability, and socio-economic development.

Key strategies include:

- Launching nationwide outreach campaigns to raise awareness of OTEC technology, its benefits, and its role in addressing energy and water security.
- Producing accessible educational materials explaining OTEC's science, socioeconomic advantages, and environmental safeguards.
- Engaging local leaders, opinion makers, and community groups as ambassadors to build trust within vulnerable or often overlooked populations such as rural and indigenous communities.
- Coordinating with national and regional media to ensure consistent, evidence-based messaging about OTEC's place in Malaysia's renewable energy portfolio.
- Hosting periodic public consultations and hearings to gather inputs, dispel myths, and improve transparency during project planning and implementation phases.

Engagement with Local Communities and Indigenous Groups

Successful OTEC projects must foster strong relationships and collaboration with local coastal communities and indigenous groups. Addressing social, cultural, and economic dimensions enhances project acceptance and delivers equitable benefits. Recommended engagement practices include:

- Early and transparent communication regarding OTEC project plans, impacts, and opportunities.
- Inclusion of local knowledge and concerns in environmental and social impact frameworks.
- Development of benefit-sharing mechanisms such as employment quotas, local enterprise participation, and revenue sharing.
- Support for community-led initiatives leveraging OTEC co-products (e.g., aquaculture, freshwater provision).
- Continuous dialogue platforms to address grievances, adapt project plans, and reinforce trust.
- Capacity-building programmes tailored for indigenous groups to enhance participation in OTEC value chains.

Risk Management and Environmental Safeguards

Managing the inherent risks associated with offshore, large-scale deployments is vital for a sustainable OTEC development and maintaining public and investor confidence.

Risk management and environmental safeguard priorities include:

- Conducting rigorous environmental and social impact assessments per international best practices prior to project approvals.
- Designing intake and outfall systems that minimise impacts on marine ecosystems, including thermal pollution and entrainment of marine organisms.
- Implementing continuous environmental monitoring through sensors and independent audits.
- Establishing emergency response protocols for operational hazards (e.g., structural failures, extreme weather events).
- Integrating adaptive management approaches to respond dynamically to unforeseen environmental or technical issues.
- Coordinating with regulatory authorities and maritime agencies to ensure compliance with navigation, fishing, and biodiversity regulations.
- Developing financial and operational risk mitigation tools such as insurance schemes, phased investment structures, and contingency funds.

5.10

Investment Strategies and Economic Opportunities

Market Outlook: Domestic and Export Potential

Malaysia's abundant ocean thermal gradients position it as a strategic hub for OTEC development, offering a robust domestic market and significant export opportunities. As the country accelerates its renewable energy ambitions aligned with its net-zero 2050 goal, OTEC is poised to contribute substantive baseload power, green hydrogen, and freshwater to national grids and industries.

Domestically, Malaysia's demand for clean, reliable power continues to grow, especially in East Malaysia (Sabah and Sarawak), where remote and island communities face energy accessibility challenges. OTEC's continuous 24/7 generation capability offers a turnkey solution to meet this demand. Additionally, integrating OTEC with hydrogen production aligns with Malaysia's Hydrogen Economy and Technology Roadmap (HETR), opening domestic industrial applications and energy export prospects. Furthermore, OTEC development supports the special emphasis on elevating Sabah and Sarawak as Malaysia's competitive national regional hubs for sustainable energy, focusing on clean energy development, including renewable energy and low-carbon technologies (MoF, 2025).

On the export front, Malaysia's early investment and commercialisation of OTEC technology, as well as its production of green hydrogen and desalinated water, can position it as a regional supplier, especially within ASEAN and broader Asia-Pacific markets. The global push for green hydrogen exports, combined with growing water scarcity in nearby countries, adds to the attractiveness of Malaysian OTEC-based commodities.

Key points:

- Strategic location with high technical potential (estimated 26GW capacity by 2050).
- Rising domestic electricity demand, particularly in off-grid and island communities.
- Emerging regional green hydrogen demand and water scarcity.
- Growing interest from global investors and technology providers.

Incentives for Local and Foreign Investors

To realise this potential, Malaysia must offer a conducive incentive environment that attracts quality local and foreign investments while fostering technology transfer and domestic industry growth.

Incentive strategies should encompass:

- **Fiscal incentives:** Investment tax allowances, import duty exemptions on relevant equipment, corporate tax holidays for early-stage OTEC projects, and accelerated capital allowances.
- **Financial support:** Grants and viability gap funding for pilot and demonstration projects to mitigate first-mover risks.
- **Regulatory certainty:** Clear licensing processes via OTENAS, streamlined environmental approvals, and guaranteed grid access or long-term power purchase agreements.
- **Market access support:** Preferential procurement or quota systems favouring local suppliers and startups within the OTEC value chain.
- **R&D incentives:** Funding schemes for academic and industry R&D to improve cost-effectiveness and operational efficiency.
- **Foreign investment facilitation:** One-stop services under Invest Malaysia and OTENAS for investor support, visa facilitation, and intellectual property protection.

Business Models (Public, Private, PPPs, Concessionaires)

Given the capital-intensive and long-horizon nature of OTEC projects, a mix of business models will be essential to mobilise resources, balance risks, and harness competencies.

Key business models include:

- Public sector-led projects: OTENAS, as a government-linked corporation, could initially lead flagship projects to demonstrate technology viability and catalyse market confidence.
- Private sector engagement: Encouraging private utilities and technology firms to develop, own, and operate OTEC plants under regulated frameworks.
- Public-private partnerships (PPP): Structuring co-investment arrangements that share operational risks, financial burdens, and innovation responsibilities.
- Concession and licensing models: OTENAS manages water column concessions through competitive bidding, granting time-limited operational rights, and ensuring regulatory compliance.
- Build-operate-transfer (BOT): Where private developers finance and operate projects temporarily before transferring ownership to the national agency or utility.
- Community or cooperative models: Particularly for smaller-scale, remote OTEC applications benefiting local island or coastal communities.

Value-Added Products and Services (Hydrogen, Desalinated Water, Aquaculture)

OTEC facilities can generate multiple high-value co-products beyond electricity, enhancing project economics and aligning with Malaysia's blue economy objectives.

Hydrogen production

- Continuous baseload energy from OTEC plants offers an ideal power source for electrolysis-based green hydrogen, critical for industrial decarbonisation and export markets.
- Estimated potential contribution of 26GW hydrogen capacity by 2050 under HETR, positioning Malaysia as a regional green hydrogen producer.

Desalinated water

- Open and hybrid-cycle OTEC systems naturally produce desalinated freshwater, with potential to address water scarcity in islands and coastal zones.
- This freshwater can be supplied to communities, agriculture, and industry, or potentially offered as a commercially tradable commodity.

Aquaculture

- Cold nutrient-rich deep seawater extracted by OTEC plants provides an excellent environment for high-value cold water aquaculture (e.g., abalone, oyster, lobster, spirulina farming).
- Development of integrated multi-use OTEC complexes supporting sustainable food production, local livelihoods, and bio-resource industries.

Other services

- Chilled-air or seawater cooling for data centres and industrial processes, reducing energy consumption and expanding economic activity.
- Research platforms for marine science, biotechnology, and climate adaptation technologies.

Funding Mechanisms and Green Finance Options

Financing OTEC's upfront capital and operational costs demands innovative mechanisms and access to green finance to leverage public and private capital.

Key mechanisms include:

- Green bonds and sustainability-linked bonds: Issued by government agencies or private corporations, these instruments attract institutional investors seeking ESG-compliant assets.
- Concessional loans and grants: From multilateral development banks (e.g., ADB, KfW, AIIB), climate funds (Green Climate Fund), and bilateral donors supporting pilot and capacity-building projects.
- Blended finance: Combining concessional funding with private equity or commercial debt to improve risk-return profiles.
- Carbon pricing and credits: Leveraging Malaysia's carbon market and international carbon markets to monetise emissions reductions from OTEC operations.
- Public sector guarantees and risk-sharing: Governmental guarantees to alleviate political and project risks, reducing the cost of capital.
- Green finance taxonomies: Integration of OTEC under national green finance classifications to unlock dedicated funding sources.
- Equity crowdfunding and impact investing: Mobilising retail investors and dedicated impact funds aligned with Malaysian sustainable development goals.

5.11

Monitoring, Evaluation, and Adaptive Management

Given the evolving nature of OTEC technology and its economic environment, a robust monitoring, evaluation and learning (MEL) system is necessary to track progress and enable continuous improvement.

Key performance indicators (KPIs):

- Energy generation capacity and efficiency
 - Economic impact metrics (investment, revenue, job creation)
 - Environmental health parameters (marine biodiversity, emissions)
 - Social outcomes (community benefits, participation)
 - Regulatory compliance and governance effectiveness
-

Performance audits and reviews:

- Independent audits every 3–5 years.
 - Mid-course evaluations to reassess technical and policy assumptions.
 - Public dissemination of findings to enhance accountability.
-

Feedback and adaptive management:

- Establish mechanisms to adapt regulatory and investment frameworks based on monitoring results.
 - Foster innovation adoption by incorporating lessons learned into technology and policy updates.
 - Promote stakeholder feedback integration.
-

5.12

Timelines and Key Milestones (2025–2050)

A clear and structured timeline is essential to guide the phased development and deployment of OTEC in Malaysia from 2025 to 2050. This timeline identifies key milestones that reflect the progressive stages of legislative reforms, institutional establishment, pilot project demonstration, commercial scaling, and full integration into the national energy and blue economy sectors. By setting strategic targets and measurable outcomes across the short, medium, and long term, Malaysia can ensure coordinated actions among stakeholders, optimise resource allocation, and track progress against national and international clean energy commitments. The following Table 5.2 summarises these critical milestones, serving as a comprehensive roadmap to realise the transformative potential of OTEC over the next quarter-century.

Year	Milestones
2025	Formation of Ocean Thermal Energy Planning Unit; commencement of drafting the Ocean Thermal Energy Act.
2026	Parliamentary passage of the Ocean Thermal Energy Development Act; amendment of the Renewable Energy Act.
2027	Establishment and operationalisation of OTENAS; launch pilot OTEC sites in Sabah (Layang-Layang, Kalumpang).
2030	Completion of initial pilot and demonstration projects with documented performance and impact assessments.
2032	Implementation of dedicated incentive programmes and regulatory procedures; expanded R&D funding.
2035	Scale-up to first commercial-scale OTEC installations (50–100MW); workforce development milestones met.
2040	Operational multi-GW OTEC clusters with integrated hydrogen and aquaculture production.
2045	Malaysia recognised as regional leader in OTEC technology; export capabilities begin.
2050	Achievement of national net-zero targets substantially supported by OTEC; sustained blue economy growth.



KRISO-OTEC Energy Island

The image illustrates KRISO's (Korea Research Institute of Ships & Ocean Engineering) **concept of a self-sustaining floating artificial island powered by Ocean Thermal Energy Conversion (OTEC)**. In this model, OTEC serves not only as a source of continuous renewable electricity but also as the central enabling infrastructure for an integrated offshore development. The use of warm surface seawater and cold deep seawater can support complementary activities such as seawater desalination, district cooling, aquaculture, marine biotechnology, food processing, research facilities and offshore logistics. The concept demonstrates how OTEC can be developed beyond a stand-alone power-generation technology into a multipurpose **energy island and blue economy hub**, where energy, water, food production, research and marine industries are co-located to improve resource efficiency, economic viability and long-term sustainability.



CHAPTER 6:

CONCLUSION

Ocean Thermal Energy Conversion (OTEC) represents a transformative opportunity for Malaysia in both renewable energy and the blue economy. The nation's abundant ocean thermal gradients, combined with its strategic policy direction towards net-zero emissions and sustainable development, place Malaysia among the world leaders poised to commercialise this promising technology.

However, realising this potential demands coordinated policy frameworks, comprehensive legislative action, and the institutionalisation of a dedicated agency namely, Ocean Thermal Energy Nasional Berhad (OTENAS) to govern, regulate, and catalyse OTEC development. With clear governance, innovative financing, stakeholder engagement, and robust technology deployment roadmaps, Malaysia can mobilise over USD39 billion in annual economic value, generate over 1.5 million employment opportunities, and significantly contribute to the nation's clean energy and climate goals.

As Malaysia undertakes the necessary institutional reforms, legislative enactments, and investment mobilisations, the path is clear for OTEC to become a cornerstone of the nation's future energy system and blue economy. Strong collaboration among governmental bodies, industry players, academia, local communities, and international partners will be essential to overcome challenges and accelerate deployment.

The following summarises key takeaways:

1

Acknowledge OTEC as a Feasible Energy Source

Malaysia has substantial resources to make OTEC both economically and technically viable, as referenced by feasibility studies that have identified potential sites, such as Pulau Layang-Layang and Pulau Kalumpang in Sabah.

- To consider OTEC's potential in executing initiatives from complementary policies such as the Malaysia Renewable Energy Roadmap (MyRER), Hydrogen Economy and Technology Roadmap (HETR), and National Energy Transition Roadmap (NETR).

2

Legislative Gaps and Required Interventions

The absence of a comprehensive legislation for OTEC is a key barrier. It is proposed to:

- Draft a new Ocean Thermal Energy Development Act to establish the Ocean Thermal Energy National Berhad (OTENAS).
- Amend the Renewable Energy Act 2011 to include OTEC as a recognised renewable energy resource.

3

Establishment of a Dedicated Agency (OTENAS)

A dedicated corporation, Ocean Thermal Energy National Berhad (OTENAS), modelled after PETRONAS, is essential for the systematic management of OTEC projects. OTENAS would oversee investments, licensing, and revenue generation while facilitating Malaysia's transition to a sustainable energy future. It is recommended to:

- Set up an Ocean Thermal Energy Planning Unit under the Prime Minister's Department to initiate the legislative process.
- Define OTENAS' functions, powers, and operational guidelines under the proposed new legislation.

4

Enhance Incentives for OTEC Development

To position Malaysia as a leader in OTEC technology, leveraging its unique geographical advantages while promoting sustainable economic growth, it is essential to establish a comprehensive policy framework that includes:

- **Incentives for local stakeholders:** Develop and implement targeted incentives to support local players within the OTEC ecosystem, encouraging innovation and participation in this emerging sector.
- **Attracting foreign direct investment (FDI):** Create a conducive environment that not only attracts foreign investments but also ensures that these investments yield substantial economic benefits for Malaysia. This involves streamlining regulatory processes, providing financial incentives, and facilitating partnerships between local companies and foreign technology providers.

By focusing on these areas, Malaysia can strengthen its OTEC policy framework, encourage local industry participation, and attract strategic FDI that supports technology transfer, economic development, and long-term sectoral growth.

5

Governance Framework and Stakeholder Collaboration

A robust governance framework should outline clear mandates for stakeholders and provide actionable timelines. This includes:

- Assigning roles and responsibilities to OTENAS for coordinating OTEC development.
- Aligning efforts with the Secretariat of the National Security Council (MKN), the Ministry of Economy, and other relevant entities.

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ASM Special Interest Group on Ocean Thermal Energy-Driven Development for Sustainability (OTEDDS)

Chairperson

Professor Dato' Ir Dr A. Bakar Jaafar FASc

Technical Writer

Dr Su Wai Mon

Team Members

Professor Dato' Dr Aishah Bidin FASc

Professor Dr Aziz Arshad FASc

Professor Dato' Dr Kamaruzzaman Sopian FASc

Emeritus Professor Ir Dr Masjuki Hassan FASc

Dr Mazlan Madon FASc

Emeritus Professor Dr Phang Siew Moi FASc

Professor Ir Dr Siti Kartom Kamarudin FASc

Ir Dr Suzana Yusup FASc

Professor Dato' Ir Dr Wan Ramli Wan Daud FASc

Professor Ts Dr Shahrina Md Nordin FASc

Dr Mohd Shahwahid Haji Othman FASc

Mr Jia Yaw Kiu FASc

Professor Ir Denny Ng Kok Sum (Sunway University)

Datu Dr Muhammad Abdullah Zaidel (Jabatan Premier Sarawak)

Datuk Thomas Logijin (Ministry of Industrial Development & Entrepreneurship Sabah)

Datuk Ir Abdul Nasser Abdul Wahid (Energy Commission of Sabah)

Dato' Sr Dr Azhari Mohamed (Royal Institution of Surveyors Malaysia)

Ir Jason Yeo (Sarawak Energy)

Mr Nik Aznuddeen Husain (Ocean Thermal Energy Services Sdn Bhd & Semarak Renewable Energy Sdn Bhd)

Ts Dr Sathiabama T Thirugnana (Universiti Teknologi Malaysia)

ASM Management

Hazami Habib, Chief Executive Officer

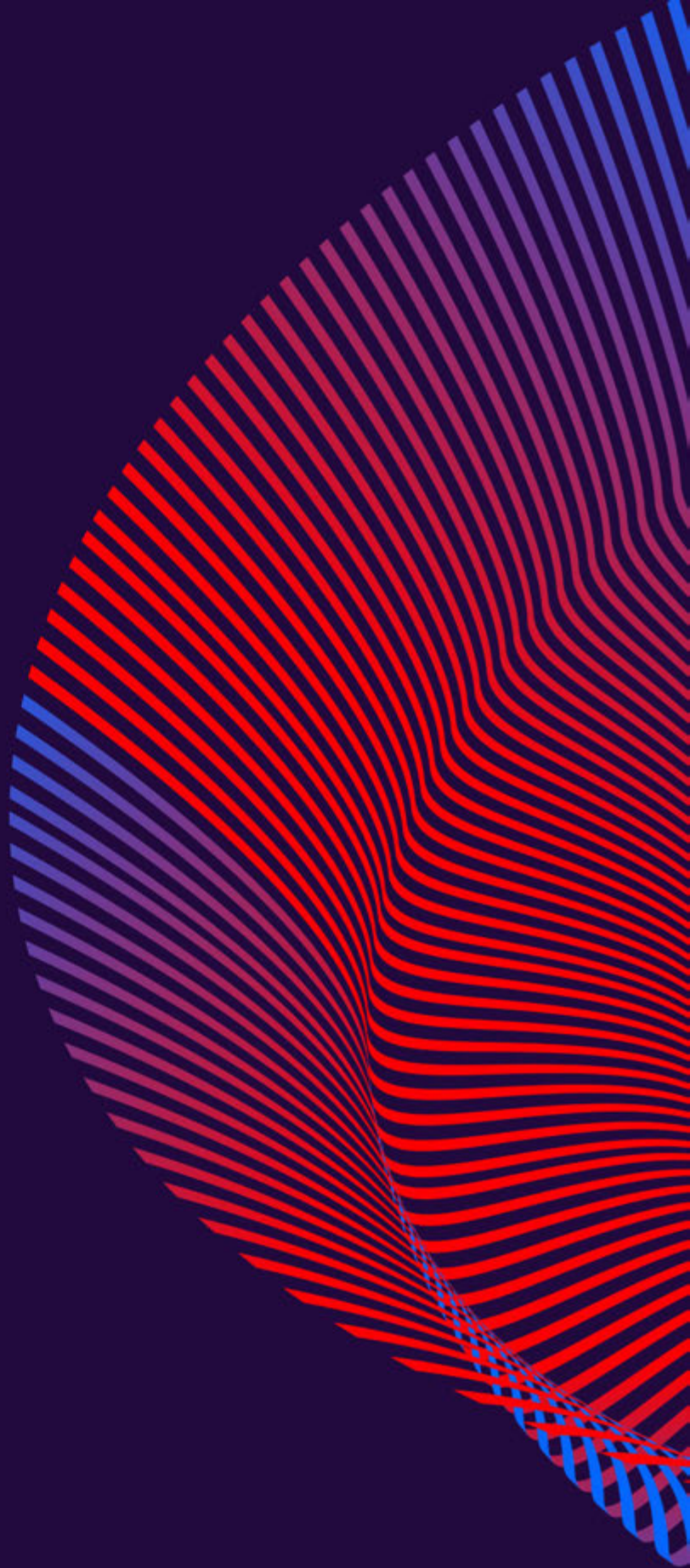
Nitia Samuel, Chief Strategy Officer

Ratnamalar Rajasingam, Senior Analyst

Norsyahira Shakri, Analyst

Naina Afifi Rosly, Graphic Designer

Ilham Raudhah Syazwani Mohd Razman, Editor



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