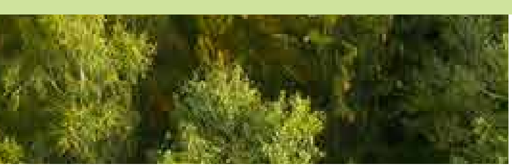
DATAMETRICS RESEARCH AND INFORMATION CENTRE

https://daresearch.com.my

# A Comparative Analysis of Renewable & Sustainable ENERGY Platforms in Malaysia

# Table of Contents





# Abstract

**'A Comparative Analysis of Renewable and Sustainable Energy Platforms in Malaysia'** aims to clarify the complex distinctions between renewable and sustainable energy and provides an overview of Malaysia's current energy landscape, focusing on renewable sources. The study delves into key policy frameworks such as the National Energy Transition Roadmap (NETR) and National Energy Policy (NEP) that are guiding Malaysia's renewable strategy, along with assessing the five cross-cutting renewable energy enablers crucial for the transition to a green economy. The report performs an economic analysis, evaluating the costs, benefits, and ROI of green energy investments and measuring their environmental impact in terms of carbon offset and other eco-benefits. Furthermore, it identifies challenges and opportunities in renewable and sustainable energy platforms such as solar, wind, hydro, geothermal, biomass, co-generation (Cogen) and waste heat recovery (WHR). Finally, it offers targeted strategies to help achieve Malaysia's goal of 70% renewable energy by 2050. The report concludes with a call-to-action, emphasising the urgent need for innovative solutions and offering policy recommendations for sustainable practices in line with Malaysia's renewable energy goals.

**Keywords:** renewable energy, sustainable energy, Malaysia, energy transition, climate crisis, policy frameworks, green technology financing, energy efficiency, social equity, environmental responsibility, economic viability, co-generation, waste heat recovery, renewable energy enablers.

1

# Executive Summary

Malaysia is at a pivotal moment in its journey towards sustainable energy. Driven by the urgent global need to mitigate climate change and capitalise on unique geographical and economic opportunities, Malaysia is setting ambitious targets for renewable energy and carbon reduction. By 2050, Malaysia aims to achieve 70% renewable energy, a commitment that has earned it a commendable ranking of 35th in the World Economic Forum's 2023 Energy Transition Index[1] and the highest score amongst ASEAN countries at 61.7%.

The cornerstone of this transformative agenda is the National Energy Transition Roadmap (NETR), launched on 27 July 2023[2]. Designed to align with the Twelfth Malaysia Plan (2021–2025), NETR is a comprehensive strategy targeting net-zero emissions by 2050. It encompasses 10 flagship projects across six key levers: energy efficiency, renewable energy, hydrogen, bioenergy, green mobility, and carbon capture utilisation and storage (CCUS). This strategic roadmap builds upon the National Energy Policy introduced in September 2022, which aims to transition Malaysia to a low-carbon economy by 2040.

According to Economic Minister Rafizi Ramli, the first phase of NETR has already attracted significant interest, securing RM25 billion in investments. It projects the creation of 23,000 jobs and aims to reduce carbon emissions by 10,000 gigagrams annually. This introduction serves as an overview of Malaysia's ambitious yet achievable plans as the nation is poised for a sustainable energy transformation.

**Table 1:** An Overview of Malaysia's NETR: Key Levers, Flagship Initiatives, and Cross-cutting Enablers for a Sustainable Future.

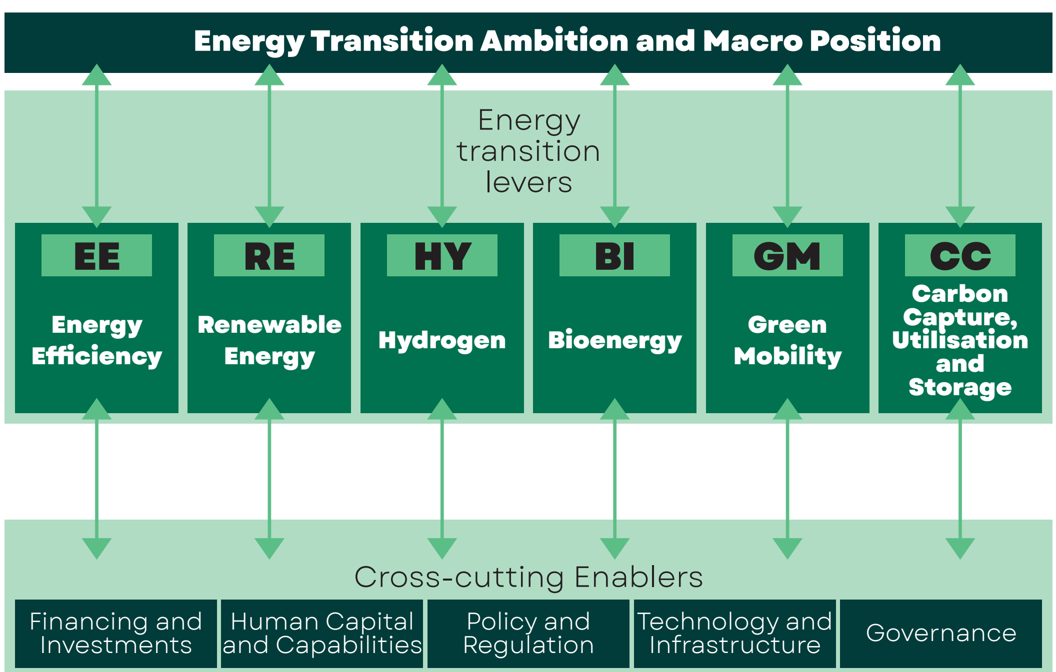
NETR Part 1

Identify flagship catalyst projects and initiatives

| 6 Energy Transition Levers | 10 Flagship Catalyst Projects |
|---|---|
| Energy Efficiency (EE) | Energy Switch |
| Renewable Energy (RE) | Renewable Energy Zone (RE Zone) |
| | Energy Storage |
| | Energy Secure |
| Hydrogen | Green Hydrogen |
| | Hydrogen for Power |
| Bioenergy | Biomass Demand Creation |
| Green Mobility | Future Mobility |
| | Future Fuel |
| Carbon Capture, Utilisation and Storage (CCUS) | CCS for Industry |

NETR Part 2

Establish low-carbon pathway, energy mix and emission target reduction for the energy sector

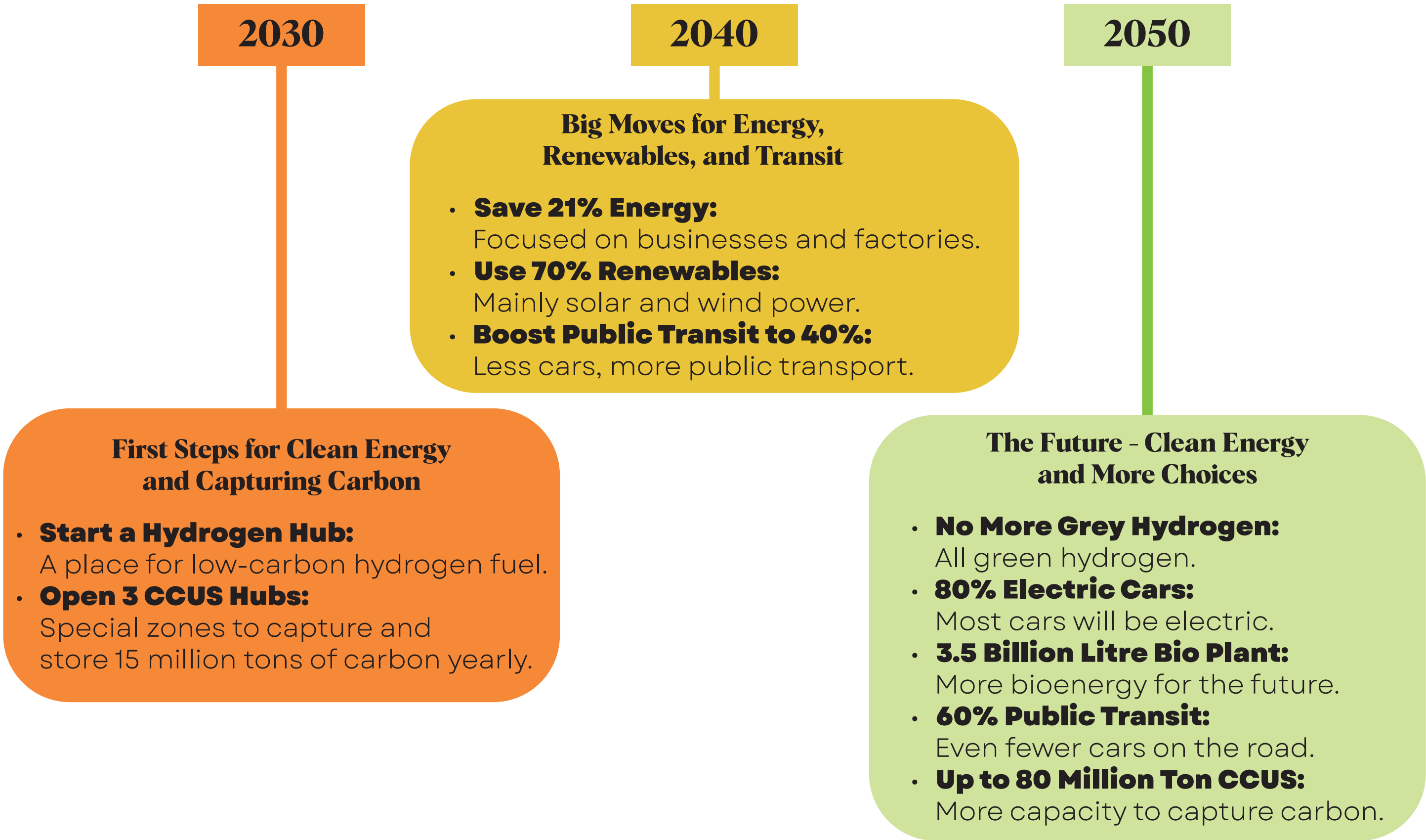



***Source:*** *Ministry of Economy, Malaysia*

Following the successful conclusion of the NETR Phase 1, Malaysia unveiled Phase 2 on 28 August 2023. Prioritising initiatives such as biomass, waste-to-energy utilisation, carbon capture, energy storage, and hydrogen integration, this phase emphasises an actionable, forward-thinking approach.

Dato' Ir. Ts. Abdul Razib Dawood, CEO of the Energy Commission, stressed the need to boost renewable energy capacity. While solar remains the most practical energy option in the country, other renewable sources are still developing and require further study.[3] In the accompanying infographic (figure 2), a concise timeline visually illustrates Malaysia's progressive steps from 2030 to 2050, highlighting pivotal energy and environmental milestones in the nation's pursuit of a greener future.

**Figure 2: Visualising Malaysia's Commitment: A Decade-by-Decade Roadmap to Sustainable Energy from 2030 to 2050.**




See how we're doing from 2030 to 2050, step by step, towards a greener future.

***Source:*** *Skrine*

However, the terms 'renewable' and 'sustainable' are frequently used interchangeably but carry different meanings. This paper therefore seeks to clarify the distinction, drawing on actionable data and credible sources. Further, the report offers insight into Malaysia's renewable and sustainable energy platforms, including solar, wind, hydro, and bioenergy. The report also considers energy solutions widespread beyond Malaysia, such as Cogen and WHR, and discusses the benefits and challenges of these sources, providing a comprehensive perspective on their applications.

The Malaysian government's proactive approach is evident in its establishment of financial incentives. Schemes like the Green Technology Financing Scheme (GTFS), Green Investment Tax Allowance (GITA), and Green Income Tax Exemption (GITE) have been pivotal in incentivising corporate investments in renewable energy and waste management. These schemes have improved financial outcomes and promoted the use of green technology, with the government offering credits of up to 60% through the Credit Guarantee Corporation (CGC) and a 2% subsidy on interest and profit rates.

This report is a guide to Malaysia's path towards sustainable energy, essential for policymakers, investors, industries and corporates, and all those interested in the energy transformation in Malaysia. We closely examine key initiatives, evaluate their impacts, and suggest strategies in line with Malaysia's 2050 sustainability objectives for industries and corporates.

# 2

# Overview

In 1999, Malaysia identified renewable energy (RE) as its 'fifth fuel'[4], setting the stage for a long-term strategy to combat climate change. Key policies, such as the NETR and the NEP, guide this journey towards a more sustainable future. These policies set ambitious targets: transforming Malaysia into a low-carbon nation by 2040 and achieving net-zero emissions by 2050.

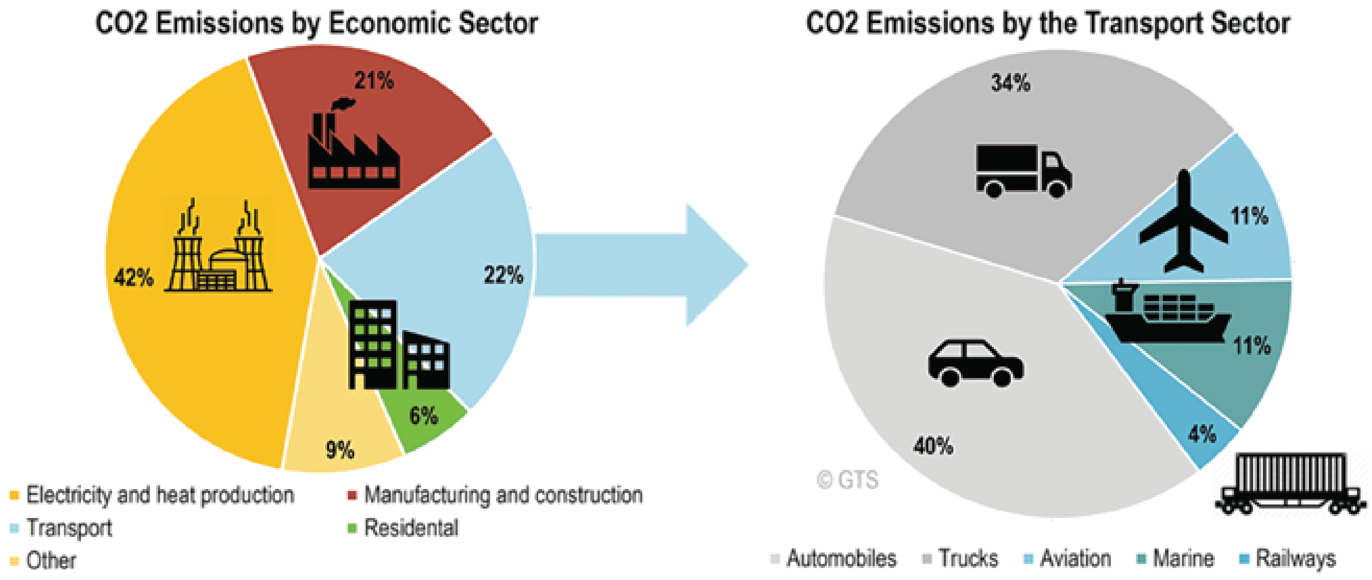
To accomplish these objectives, the NETR specifically prioritises flagship renewable energy projects. These are designed not only to accelerate the nation's transition to cleaner energy but also to drive profitable ventures. As the data below illustrates, the energy sector is the primary contributor to the country's emissions, followed by manufacturing and construction.[5]

In tandem with Malaysia's strategic transition towards renewable energy, a deeper dive into the nation's CO2 emissions provides striking insights. Figure 3 below, "Balancing Economics and Ecology: Industry CO2 Contributions vs. Renewable Goals," showcases the major industry players in terms of their contributions to CO2 emissions, juxtaposed against the backdrop of the 2050 renewable targets.

At a glance, the significance of electricity and heat production as the dominant contributors is evident, while the transportation sector delineates its emissions into various modes, revealing the areas that require urgent sustainable interventions. As we examine this visual data, the pathway towards achieving the set renewable goals becomes clearer, with each sector presenting distinct challenges and opportunities.

**Figure 3:** Balancing Economics and Ecology: Industry CO2 Contributions vs. Renewable Goals

Unveiling the economics behind Malaysia's ambition for a cleaner, greener future. These pie charts illustrate the major industry contributions to CO2 emissions in the context of our 2050 renewable targets.




Global Greenhouse Gas Emissions by the Transportation Sector

***Source:*** *The Geography of Transport Systems, Global Greenhouse Gas Emissions by the Transportation Sector*

**Analysis:**

- Electricity and heat production: Highest contributor but also the sector with the most potential for renewable implementation.
- Transport: Progressing towards sustainability through the adoption of electric vehicles (EVs) and subsidies, which have been effective in reducing emissions, but further actions are necessary.
- Railways: Lower contributors but opportunities for sustainability exist.

***Source:*** *Datametrics Research and Information Centre (DARE)*

With energy accounting for 28% of Malaysia's Gross Domestic Product (GDP), the economic stakes are high. The country's strong position in the Global Energy Transition Index[6] underscores its potential to benefit from the global shift towards sustainability—a market that could be valued at $10.3 trillion by 2050.

While the NETR's target of deriving 70% of energy from renewables by 2050 is commendable, a diverse energy strategy is crucial for a smooth transition. This diversified approach offers the dual benefits of risk management and cost-effectiveness. Moreover, it enhances grid resilience, therefore contributing to the nation's economic stability and energy security. In doing so, it aligns perfectly with the NETR's broader vision for the country.

Beyond the primary objective of achieving net-zero emissions, the NETR's emphasis on a diverse energy approach brings multifaceted advantages to businesses and the nation as a whole. For industries, especially the energy-intensive manufacturing sector, this strategy ensures uninterrupted energy supply, guarding against the risks of a single-source dependency. It paves the way for consistent operations, potential long-term cost savings, and shields businesses from the unpredictable nature of fossil fuel prices.

At a national level, diversifying the energy portfolio does more than just contribute to ecological sustainability. It strengthens Malaysia's energy security, diminishes import reliance, and positions the country at the forefront of the renewable energy transition. This approach not only promises environmental stewardship but also fosters economic growth, attracts investments in the green sector and creates job opportunities, in line with the NETR's broader vision.

**However, the necessity of exploring alternative sustainable energy solutions in Malaysia is underscored by several compelling factors, as presented in Table 4**

**Table 4:** Challenges and Considerations for Malaysia's Renewable Energy Transition

| Factor | Reason |
|---|---|
| Technological Constraints: | While solar and wind energy have their merits, they are contingent on weather and geographical conditions. Malaysia should expand its focus to include hydroelectric, geothermal, and emerging technologies. |
| Economic Considerations: | A diversified energy portfolio could offer superior risk management and potentially lower long-term costs, aligning with Malaysia's economic goals. |
| Grid Robustness: | An integrated approach to energy sourcing can enhance the resilience and reliability of the national grid. |

***Source:*** *Datametrics Research and Information Centre (DARE)*

## 2.1 Expanding the Horizon of Energy Solutions

Following our in-depth research at DARE, which included strategic analysis and advocacy in key economic sectors and an exploration of various alternative energy solutions, it became apparent that Malaysia could greatly benefit from expanding its technological scope beyond established renewable energy sources. Cogen systems and WHR technologies, for example, have been gaining attention on a global scale.[7] By exploring these alternative pathways, Malaysia could optimise its existing strategy and meet the ambitious objectives set for the sustainable energy landscape by 2050. Case in point, Cogen supplies 30% of Berlin's electricity and 70% of its heating demand, demonstrating its significant role in a diversified energy portfolio[8]. In Japan and the U.S., WHR is actively implemented across various industries, from the 'Top Runner Programme' in Japan[9] aimed at reducing factory energy consumption, to a Texas refinery that meets nearly 30% of its energy requirements through WHR.

## 2.2 Objectives and Scope

This research aims to provide a holistic examination of Malaysia's journey towards a sustainable energy future by 2050. Our approach encompasses:

| | |
|---|---|
| **Current Energy Overview:** | Provide a summary of Malaysia's existing energy mix, focusing on renewable sources. |
| **Renewable vs. Sustainable Energy:** | Clarify what makes Renewable Energy different from Sustainable Energy. |
| **Policy Insights:** | Examine key frameworks like NETR and NEP that guide Malaysia's renewable strategy. |
| **Technological Assessment:** | Analysis of the efficiency and scalability of renewable platforms, such as solar and wind, as well as emerging alternatives. |
| **Economic Analysis:** | Evaluate costs, benefits, and ROI for green energy investments. |
| **Environmental Metrics:** | Assessment of carbon offsetting and additional ecological benefits of each energy platform. |
| **Challenges & Opportunities:** | Identification of key issues and growth vectors for renewable platforms. |
| **Case Studies:** | Highlight real-world sustainable energy applications, exploring the feasibility of Cogen and WHR, among other technologies. |
| **2050 Target Strategies:** | Actionable recommendations aimed at achieving Malaysia's 70% renewable energy goal by 2050. |

Realising Malaysia's ambitious 2050 target necessitates more than a piecemeal approach. This framework must incorporate comparative evaluations, technological innovation, policy coherence, and cross-sectoral collaboration.

# 2.3
# Focus on Sustainable Energy Planning

Malaysia's pursuit of a sustainable energy future is closely tied to the nation's economic and environmental goals. Emphasising innovative alternatives are key to this vision. While challenges are present in technology adoption and integration, they can be overcome with the aid of a specialised or skilled workforce.

## 2.3.1 - Leveraging Alternative Technologies for Efficiency

**To reiterate, based on DARE's research and observations in the field of renewable energy, it is evident that as Malaysia strives for a more sustainable energy future, Cogen and WHR technologies present a compelling opportunity to meet the country's energy efficiency needs and requirements.** These underexplored technologies repurpose waste heat generated from industrial activities, aligning well with the NEP and NETR. To reach its lofty goal of 70% renewable energy by 2050, Malaysia could greatly benefit from a targeted adoption strategy for these technologies. Such a strategy should be coherently integrated into the national agenda, melding technological innovation with cohesive policy-making and cross-sectoral collaboration, thereby reinforcing Malaysia's commitment to a diversified and sustainable energy landscape.

# 3

# Unpacking Renewable VS. Sustainable Energy

## 3.1 Renewable Energy: A Step Forward

**The terms "renewable" and "sustainable" are often mixed up in environmental discussions, especially when it comes to energy. However, they have different meanings.** "Renewable" refers to energy from sources that won’t run out, like solar, wind, and hydro power, seen as alternatives to fossil fuels to reduce greenhouse gas emissions. However, being renewable doesn't mean an energy source is always sustainable.

## 3.2 The Bigger Picture: Sustainable Energy

Meanwhile, "sustainable" energy considers the bigger picture, balancing today's energy usage with the needs of future generations. It also takes into account the full process of energy production, aiming to reduce environmental harm and ensure social fairness.

In the following sections, we explore the distinctions between renewable and sustainable energy, aiming to provide a clearer understanding for better decision-making in environmental policies and long-term energy planning.

## 3.3 Malaysia's Journey Through the Renewable Energy Spectrum

Malaysia is advancing in renewable energy through innovative measures, establishing itself as a regional leader in sustainable practices and the adoption of clean, efficient power. Over the past five years, Malaysia has cut its greenhouse gas emissions by an admirable 20%[10]. This is not accidental. It's the result of an intentional focus on diversifying energy resources, encompassing everything from solar and wind to biomass and hydroelectric power.

Although mitigating climate change is a significant benefit, pivoting to renewable energy is also a strategic move to reduce dependence on less sustainable sources like fossil fuels. As we delve into the specifics, we will highlight how each renewable energy sector contributes to this larger mission. Ultimately, we'll examine the multi-pronged approaches that are setting Malaysia on a path towards a genuinely sustainable energy future[11].

### 3.3.1 - Solar

Solar energy is often the focal point of renewable energy discussions, and for good reason. In analysing Malaysia's solar sector, one cannot overlook its substantial untapped potential–269 GW to be precise. However, as we move through 2023, only 1.07 GW has been utilised[12]. It's worth noting that this isn't an issue of cost. Solar panel prices are clearly falling. However, the bottleneck occurs at the average investment of RM3.50 per watt-peak for 2023, along with a limiting 18% solar capacity factor.

Evidently, the investment opportunity seems promising, but the high initial costs and modest returns are making investors think twice. That said, the landscape does offer encouraging signs. The Large Scale Solar (LSS) scheme[13] functions as a significant facilitator in this sector. Designed to simplify the initiation and implementation of impactful solar projects, this government-supported scheme comes with financial perks meant to attract investor involvement. It acts much like a business accelerator for renewable energy, spotlighting and endorsing projects that show the most promise in cost efficiency.

The LSS has instituted a competitive bidding framework, designed to prioritise cost-effective solar projects. This measure is steadily breaking down financial and operational barriers, providing an incremental yet undeniable push towards reaching our ambitious solar targets. By facilitating this, the LSS scheme not only aids in the immediate adoption of solar energy but also serves as a promising bridge to future possibilities.

In contrast, the Corporate Green Power Programme (CGPP) adopts a different approach, employing a willing-buyer willing-seller model. This initiative allows corporate consumers to virtually purchase solar energy from developers through Virtual Power Purchase Agreements (VPPAs), aiming to promote green energy adoption among corporate entities in Malaysia. Unlike the LSS's competitive bidding process, the CGPP's model encourages a broader range of participants by maintaining application limits to ensure equitable distribution and support diverse renewable energy development[14]. This strategic variation in model underscores the multifaceted approach Malaysia is adopting to boost its renewable energy sector.

### 3.3.2 - Wind

Wind energy, much like solar energy, holds a compelling narrative in Malaysia's quest for renewable sources. As of 2023, Malaysia has tapped into only 23 MW, which is a fraction of the potential 100 GW waiting to be harnessed[15]. Major projects like the Bukit Kayu Hitam Wind Farm and the upcoming Gebeng Industrial Park Wind Farm indicate that Malaysia is making significant progress. However, let's be clear, the costs remain high, reaching RM10 million per megawatt when considering a 30% capacity factor[16].

Further, wind conditions in Malaysia are diverse. The nation experiences average annual wind speeds of around 2 m/s, and these can rise to 15 m/s in some coastal areas during the monsoon season. A single windmill, operating at half its efficiency, could generate about 4,309 W. For perspective on the strategic scale, fulfilling only 10% of Malaysia's estimated electricity demand for 2020 would require approximately 6% of the country's total land area and a substantial investment of around RM1.4 billion.

So where does this leave Malaysia in terms of wind energy? While wind energy is promising in certain areas, it is not a one size fits all solution. Malaysia is exploring the potential to generate between 500 and 2,000 MW, which would cover roughly 3.5% to 14% of its electricity demand, based on 2020 data. Wind energy could even prove to be more cost-effective than solar energy, but it's essential to remember that its utility is limited by where and when the wind blows[17]. In short, wind energy has a role to play, but realising its potential will require smart planning and investment.

### 3.3.3 - Biogas

Biogas in Malaysia has some strong numbers behind it, with a robust potential of over 3 GW. This energy comes from diverse sources like agricultural waste, municipal waste, and landfill gas. Noteworthy initiatives in the sector are the 2 MW Kluang Landfill Gas Power Plant and the 1 MW Nibong Tebal Palm Oil Mill Biogas Plant[18].

Adding to this momentum, biomethane production in Malaysia saw its highest levels in 2016, thanks in part to an abundance of organic materials ripe for biogas generation. Specifically, the potential for power from Palm Oil Mill Effluent (POME) is not to be overlooked, estimated at a hefty 2376 GWh[19].

The industry landscape has been evolving, too. A mere 18 biogas plants existed in 2017, but by 2023, the country is witnessing a proliferation of biogas projects. This growth aligns well with efforts to bolster Malaysia's renewable energy portfolio.

In a nutshell, biogas in Malaysia is on an upward trajectory, offering a diverse and substantial contribution to the nation's renewable energy ambitions. But like any emerging industry, it has its challenges that need to be managed for full-scale implementation. Also worth mentioning is the untapped tidal energy potential of 1 GW, a resource that could add another dimension to Malaysia's renewable energy mix[20].

## 3.3.4 - Biomass

Biomass energy in Malaysia isn't just a footnote in the country's energy playbook. It's a chapter waiting to be fully written. With a staggering 3.6 GW of untapped potential and 419 MW already in use as of 2023, this renewable resource is gaining traction[21]. The energy is primarily sourced from agricultural waste and forest residues, making it an appealing and sustainable option.

However, harnessing biomass energy comes with its own set of challenges. In 2020, biomass combustion accounted for 10% of Malaysia's particulate emissions and 5% of its nitrogen oxide emissions[22]. In addition, biomass crops currently occupy about 1% of the nation's agricultural land[23], which raises questions about sustainable land use.

Interestingly, Malaysia's climate is practically tailor-made for biomass energy development. This offers dual benefits: it provides a renewable energy source and aids in reducing greenhouse gas emissions. Nevertheless, the country's ongoing reliance on fossil fuels remains a significant hurdle, guiding the conversation toward the necessity of diversifying into renewables like biomass.

In this regard, the National Biomass Strategy 2020 serves as a proactive blueprint. It focuses on palm biomass as a key economic growth driver. However, this focus comes with its own set of complexities, including emissions from biomass combustion and land allocation for crops. Therefore, while biomass energy offers substantial promise for Malaysia, it's not without challenges. These hurdles must be tackled head-on to fully unlock the benefits of this renewable resource.

## 3.3.5 - Hydropower

Hydropower is a significant component of Malaysia’s energy landscape, with 1.7 GW already in operation and a potential for up to 16 GW[24]. Facilities such as the Bakun, Kenyir, and Murum Dams are leading contributors, but it’s essential to note they also account for 5% of the country’s greenhouse gas emissions and have environmental implications.

In a broader context, hydropower represented 15% of Malaysia’s total power generation in 2021 and is on a trajectory to grow by 4.82% each year through 2028. This makes it a critical part of the nation’s energy and climate objectives.[25]

However, there are other lurking challenges to consider. Environmental effects, particularly habitat disruption, are a concern, and with CO2 emissions rising by an average of 4.09% annually since 1999, a balanced approach to hydropower is necessary. In summary, while hydropower holds promise for Malaysia, it’s not without its complexities that require thoughtful solutions for optimal benefits.

### 3.3.6 - Geothermal

Geothermal energy in Malaysia remains more of a promise than a reality, with a potential of 229 MW but no operational plants as of 2023. The landscape is set to change with the anticipated 50 MW Ulu Slim Geothermal Power Plant expected to be operational in 2024[26].

Significantly, geothermal energy has potential in Malaysia, especially with new developments on the horizon. Yet, challenges remain, not least of which is realising the untapped possibilities in other renewable sectors like tidal energy.

## 3.4
## Profitable Sustainability: Malaysia's Renewable Energy ROI

All things considered, Malaysia is making good progress in renewable energy, a crucial step both for the country and global sustainability efforts. Notably, Malaysia has reduced its reliance on fossil fuels and increased its clean energy capacity by 23%, equating to a total of 8.45 GW[27].

The solar industry in Malaysia is indeed growing rapidly, with an additional 1,000 MW coming from large projects and another 500 MW from rooftop installations. These figures are bolstered by an extra 188 MW from other renewable sources, as outlined by SEDA[28]. This growth not only diversifies Malaysia's energy mix but also positively impacts the economy.

Government initiatives such as net metering and feed-in tariffs are accelerating the country's transition to cleaner energy. Financial incentives are rendering Malaysia a more attractive market for renewable technologies, thus bringing the country closer to its sustainability objectives.

Government backing further confirms Malaysia's commitment to a sustainable future. The country's accomplishments could serve as practical examples for other nations, contributing to worldwide efforts to combat climate change.

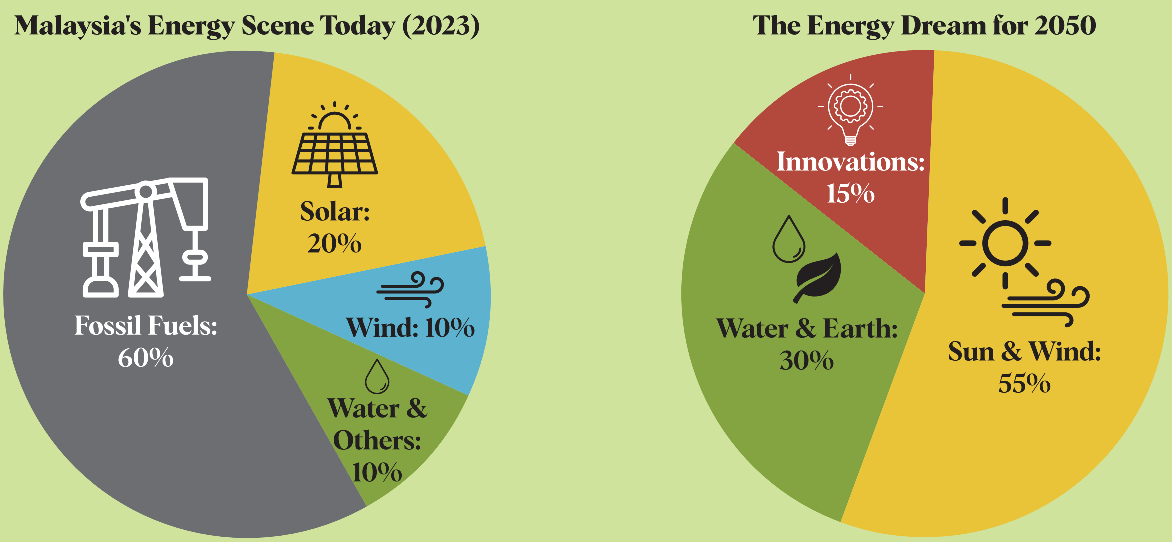
As Malaysia continues its exploration of renewable energy options, the nation emerges as a valuable model, illustrating the practical benefits and viability of long-term sustainability plans.

**Figure 5:** A Balanced Energy Future for Malaysia: The 2050 Vision for Renewable, Sustainable, and Clean Energy.

*More Than Just Sun and Wind: Crafting Malaysia's Diverse Energy Roadmap*

*Why put all our energy eggs in the solar and wind basket? Malaysia needs a diversified energy approach for a greener, cleaner future.*

**Quick Facts:**
- Time to move away from heavy fossil fuel use.
- Aiming for 70% green energy by 2050.
- Diversity in energy sources is not just good—it's a must.




**Takeaways:**
- Relying exclusively on solar and wind energy can be risky due to climate and geographical factors.
- There is untapped power in water and biomass.
- Co-generation (Cogen) and Waste Heat Recovery (WHR) are proven, reliable energy-efficient technologies that are poised to significantly complement our national renewable energy systems.

***Sources:***
*https://www.st.gov.my/*
*https://www.seda.gov.my/*
*https://www.nrel.gov/*
*https://www.irena.org/*

Exploring the advantages of renewable energy is essential for Malaysia's sustainable growth strategy. From reducing greenhouse gas emissions to fostering technological innovation and achieving energy independence, renewables can serve as a strategic asset for the nation's energy portfolio.

# 3.5
# Key Advantages of Renewable Energy

### 3.5.1 - Lowering Greenhouse Gas Emissions:

Renewable energy sources such as solar, wind, and hydropower have a significantly lower carbon footprint compared to traditional fossil fuels[29]. While burning fossil fuels releases carbon dioxide, methane, and other harmful pollutants into the atmosphere, renewable energy sources produce minimal to almost no emissions. For instance, the combustion of coal and natural gas releases a substantial amount of CO2, contributing to the greenhouse effect and climate change. On the contrary, harnessing solar or wind energy produces no pollutants - making these renewable sources crucial for a cleaner environment.

### 3.5.2 - Encouraging Technological Innovation:

The renewable energy space has seen remarkable technological advancements in recent years. Innovations in solar panel efficiency, wind turbine design, and energy storage solutions have greatly enhanced the feasibility and cost-effectiveness of renewable energy systems. For instance, the development of perovskite solar cells promises to significantly boost solar panel efficiency while reducing manufacturing costs. Similarly, the advent of larger and more efficient wind turbines has enabled the harnessing of wind energy even in areas with lower wind speeds. These technological strides are continually driving down the costs of renewable energy - creating it as a more competitive alternative to replace traditional fossil fuels.

### 3.5.3 - Fostering Energy Independence:

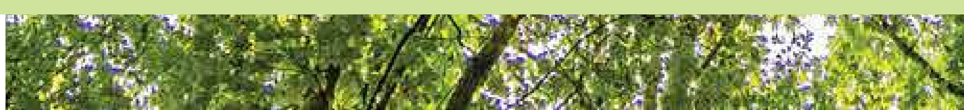
Utilising local renewable resources significantly reduces a nation's dependence on imported energy, thus enhancing national security. By investing in domestically available renewable energy sources, Malaysia can achieve a greater degree of energy self-sufficiency, insulating the nation from potential supply disruptions and volatile international energy prices. Moreover, the decentralisation of energy production that renewables facilitate can also contribute to a more resilient energy infrastructure, capable of withstanding or quickly recovering from adversities. In Malaysia's context however, harnessing its abundant solar, wind, and biomass resources could play a pivotal role in fostering energy independence - stimulating local economies, and creating job opportunities within the green technology sector.

## 3.6
## Overcoming Obstacles for a Sustainable Tomorrow

At its core, sustainability is a comprehensive concept that includes the environmental, social, and economic impacts of energy production and consumption. This involves implementing practices such as using renewable energy sources, promoting energy efficiency, and encouraging responsible consumption to minimise environmental harm. Additionally, it encompasses fostering social equity and economic development that supports communities without depleting natural resources. This concept is fundamental to sustainable development, which is about meeting today's needs without compromising the ability of future generations to meet theirs.

Case in point, a strategic shift towards renewable energy sources like solar, wind, and hydropower, which currently constitute 23% of the nation's energy mix has already taken place in Malaysia. This transition not only supports Malaysia's goal of achieving net-zero emissions but also promises significant economic benefits. By 2050, Malaysia could save between USD 9 billion and USD 13 billion annually in avoided energy costs, climate change impacts, and other related expenses by adopting renewable energy[30]. This shift is also crucial for reducing greenhouse gas emissions, therefore aligning with the global climate action goals and fostering a sustainable future for the nation[31].

Despite the country’s wealth of renewable energy resources, Malaysia grapples with various challenges on its path to sustainability. Obstacles, from the high installation costs of solar and wind energy to environmental concerns associated with biomass and hydropower, necessitate well-planned solutions. The government's proactive approach, underscored by incentives and research investments, showcases its dedication to navigating these hurdles. As such, the government has outlined initiatives such as the development of a Third-Party Access (TPA) framework and financial assistance for green projects. The legislative foundation for the TPA framework is rooted in the Gas Supply Act of 1993, along with its associated regulations, rules, and orders. Oversight of the TPA framework is provided by the Energy Commission[32]. Energy efficiency measures, as discussed in the NETR, are also part of these initiatives.



To elaborate on some of the government's key initiatives, the TPA framework is designed to allow multiple players in the energy market to have fair and equitable access to gas infrastructure. This not only promotes competition but also aids in more efficient utilisation of the country's energy resources. Alongside the TPA, NETR has set an ambitious goal to achieve 22% energy savings for the industrial and commercial sectors by 2040[33]. Technologies like WHR are in perfect alignment with NETR's energy efficiency pillar, offering a promising avenue for meeting these targets.

Additionally, the Malaysian government's proactive approach is evident in its establishment of financial incentives designed to spur investment in sustainable technologies. Schemes like the Green Technology Financing Scheme (GTFS), Green Investment Tax Allowance (GITA), and Green Income Tax Exemption (GITE) have been pivotal in incentivising corporate investments in renewable energy and waste management. Through these schemes, companies can realise improved financial outcomes while also contributing to a greener future. Specifically, the government offers credits of up to 60% through the Credit Guarantee Corporation (CGC) and provides a 2% subsidy on interest and profit rates[35].

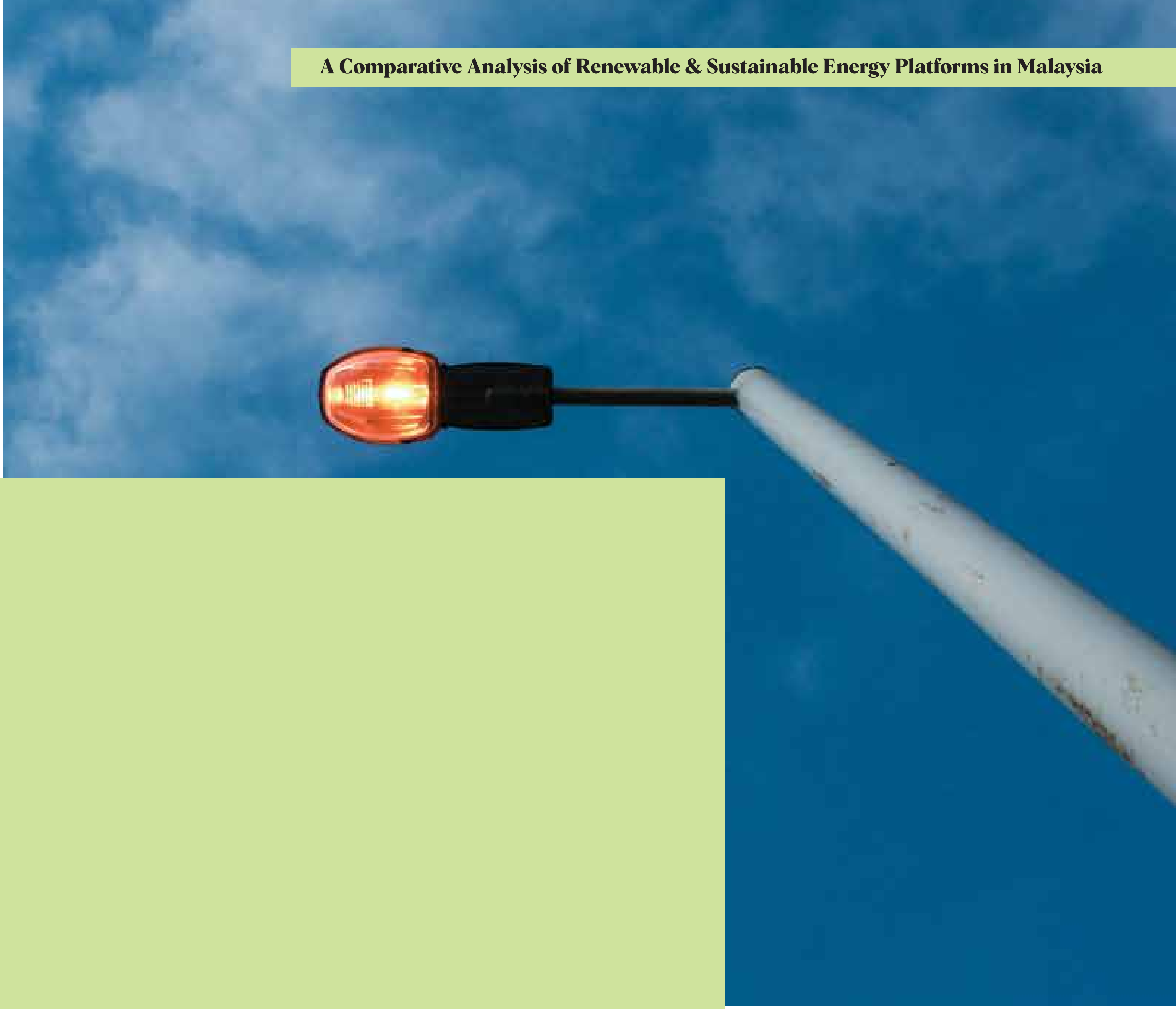
Another noteworthy initiative is the MySDG Trust Fund, a multi-donor funding platform that supports projects contributing to the Sustainable Development Goals (SDGs). This fund is especially significant for projects related to green technology and sustainable development, making it another attractive financial option for companies looking to invest in sustainability.

In summary, financial assistance for green projects refers to a diverse range of subsidies, grants, and low-interest loans provided by the government. These financial instruments are strategically crafted to lower the initial capital required for green projects, thereby accelerating Malaysia's transition to a more sustainable energy landscape. All of this serves to ensure that Malaysia's ongoing efforts in renewable energy are in line with the global shift toward sustainability, even in the face of challenges. Through a variety of initiatives, the country is not only striving to achieve its own sustainability goals but is also making a valuable contribution to global environmental stewardship.

# 3.7
# Key Components of Sustainable Energy

The transition towards sustainable energy is underscored by a holistic approach that encompasses environmental, social, and economic dimensions. Governed by the Sustainable Energy Development Authority (SEDA), a government agency under the Ministry of Energy, Green Technology and Water, its mission is to promote, develop and regulate the sustainable energy sector in Malaysia. It's imperative to evaluate sustainable energy platforms for their broader impact on society and the economy. The following three components have been identified as the key in assessing the true sustainability of energy sources, providing a well-rounded framework for evaluation:

| 3.7.1 - Lifecycle Assessment | 3.7.2 - Societal Impact: | 3.7.3 - Economic Viability |
|---|---|---|
| • **Comprehensive Environmental Evaluation:** A Lifecycle Assessment (LCA) is a technique to assess the environmental impacts associated with all the stages of a product's life from cradle to grave (from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling)[34]. It evaluates the full environmental cost of energy production, including resource extraction, energy generation, and waste disposal, providing a complete picture of the environmental footprint. | • **Community Involvement and Benefit:** The societal impact of sustainable energy encompasses the benefits it brings to local communities, including job creation, skills development, and improved quality of life.<br><br>• **Health and Wellbeing:** Sustainable energy sources have a lesser impact on air and water quality, which in turn contributes to better public health outcomes. By reducing pollutants in the atmosphere, renewables contribute to cleaner air and water, promoting overall community health and wellbeing[35]. | • **Long-term Cost Effectiveness:** Evaluating the economic viability of renewable energy involves assessing the long-term operating costs and comparing them to the benefits. Renewable energy sources often have lower operating and maintenance costs than fossil fuel-based energy sources.<br><br>• **Market Scalability and Industry Opportunities:** Sustainable energy platforms also have the potential for market scalability, support job continuity and provide access to gaining knowledge, education and experience in a specific area of expertise. Enhancements in industry competence and scalability can drive economic growth, foster innovation, and cultivate a skilled workforce for the future. |



In today's eco-conscious world, finding truly sustainable energy involves a multi-dimensional assessment that considers its entire environmental impact, societal effects, and economic feasibility. Beyond just being "green", energy sources must benefit communities, be economically viable, and offer long-term scalability and valued job opportunities. To this end, renewable energies should be assessed for true sustainability using comprehensive criteria such as the LCA, social impact studies, and return on investment (ROI) analysis. The recommended approach is to employ a sustainability index that combines these metrics for a holistic evaluation.

## 3.8 Diverse Mix of Platforms

One size doesn't fit all, especially when it comes to implementing and integrating the optimal energy solutions for varied geographical and economic landscapes. Beyond the conventional solar and wind power, the emergence of a range of other platforms is observed. Each with their unique advantages and applications. Renewable solutions such as bioenergy, hydroelectricity, and even sustainable energy solutions such as Cogen and WHR are garnering interest as potential players in a diversified energy mix.

### 3.8.1 - Innovative Approaches: Cogen and WHR

In the quest for a diversified energy mix, Cogen and WHR have emerged as innovative approaches that promise significant contribution[37]. Unlike conventional renewable energy platforms like solar, wind, or hydroelectricity, which primarily focus on generating electricity, these approaches harness the full spectrum of energy available, enhancing overall system efficiency for almost any type of mixed-energy architecture.

## Cogen

Cogen simultaneously produces electricity and useful thermal energies from the same energy source, usually through natural gas, biomass, or coal. The primary benefit of Cogen is its ability to capture and utilise the heat that would otherwise be wasted during electricity generation, significantly improving the energy efficiency of the system. By doing so, Cogen reduces the overall greenhouse gas emissions and lowers the operation costs, making it a cost-effective solution for industrial and commercial energy users.

## Waste Heat Recovery

WHR involves capturing and reusing the heat generated during industrial processes or electricity generation that would typically be lost to the environment. Unlike Cogen, WHR does not generate electricity but instead recovers waste heat which can be utilised for other purposes such as heating, cooling, or even generating additional electricity using a steam turbine. The implementation of WHR systems significantly enhances energy efficiency, reduces greenhouse gas emissions, and can lead to substantial cost savings over time.

In this context, through our study on sustainable energy solutions in Malaysia, DARE has identified **Kinergy Advancement Berhad** as a noteworthy early adopter of the Organic Rankine Cycle (ORC) system[38]. As a provider of holistic sustainable energy solutions, Kinergy Advancement Berhad's innovation in waste heat recovery aligns with the broader industry trend towards energy sustainability. This development, known for its simplicity and versatility, is widely adaptable in various use-cases. It has resonated well with larger energy trends abroad, and bodes well for global efforts underway to realise more efficient and environmentally responsible energy solutions.

These innovative approaches, although not renewable in the traditional sense, play a pivotal role in creating an integrated, efficient energy system. By optimising the use of energy and reducing waste, Cogen and WHR contribute to the broader goals of energy sustainability and environmental responsibility. The application of these technologies, especially for industrial and commercial use, will facilitate businesses in establishing sustainable practices. Their application in Malaysia's energy landscape can offer unique advantages, aligning with the nation's ambitious targets towards achieving a cleaner and more sustainable energy future. As countries like Malaysia aim for ambitious renewable targets, it is crucial to remember that the global energy transition is a shared journey.

Effective technological innovation, policy frameworks, and economic considerations are the three pillars that must hold this global endeavour up. And within this complex ecosystem, versatile platforms like Cogen and WHR can offer unique advantages, further strengthening the case for a robust and diversified approach to sustainable energy. The challenge is not just to meet energy demands but to do so in a manner that is environmentally conscientious and socially equitable. Whether it's leveraging the Cogen of electricity and thermal energy or exploring the potential of marine turbines, Malaysia's energy landscape is becoming a crucible for experimentation and adaptation. Each of these platforms brings unique advantages that can be tailored to the country's diverse geographical and economic contours, offering a mosaic of solutions for a sustainable energy transition.

**Table 6:** Analysing Renewable and Sustainable Energy Sources for Malaysia's 2050 Goals

**Introduction:** As the world grapples with the imperative to transition towards more sustainable forms of energy, understanding the different types of renewable and sustainable energy sources becomes increasingly crucial. This table offers an overview of various energy sources, evaluating them on four key criteria: Renewability (Energy Output vs Input), Sustainability (Long-term Ecological Impact), Societal Impact (Ease of Implementation and Scalability), and Impact on Earth (Environmental Considerations).

| Energy Source | Renewability (Energy Output vs Input) | Sustainability (Long-term Ecological Impact) | Societal Impact (Ease of Implementation and Scalability) | Impact on Earth (Environmental Considerations) |
|---|---|---|---|---|
| Solar | ●●●●○ | ●●●●● | ●●●○○ | ●●●●● |
| Wind | ●●●●● | ●●●●● | ●●○○○ | ●○○○○ |
| Hydro | ●●●●● | ●●●○○ | ●●●●● | ●●●○○ |
| Biomass | ●●●○○ | ●●●○○ | ●●●○○ | ●●●○○ |
| Tidal Wave | ●●●○○ | ●●●●● | ●●○○○ | ●○○○○ |
| Geothermal | ●●●●● | ●●●●● | ●●○○○ | ●○○○○ |
| Co-generation | ●●●●● | ●●●●● | ●●●●● | ●●●●○ |
| Waste Heat Recovery | ●●●●● | ●●●●● | ●●●○○ | ●○○○○ |

***Source:*** *Datametrics Research and Information Centre (DARE)*

# 4

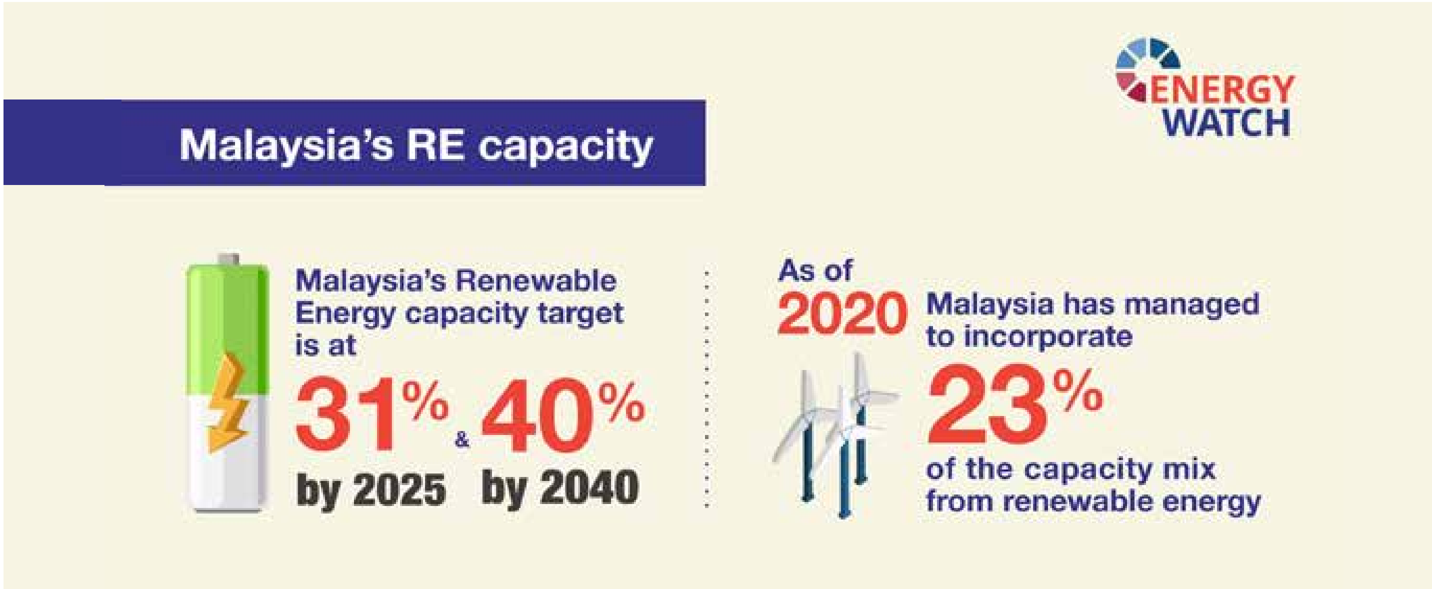
# Malaysia's Aspiration in the RE Space

## 4.1 Beyond the Horizon: Malaysia's Untapped Potential in Pioneering Green Technologies

Malaysia's ambition in the renewable energy sector has been a carefully orchestrated progression over the years. The Malaysia Renewable Energy Roadmap (MyRER) initially set a target of having renewable energy constitute 31% of the nation's energy needs by 2025, and 40% by 2035.

Later, recognising the urgency of climate change and the economic opportunities tied to renewable energy, Malaysia revised its goal to 70% renewable energy by 2050. This significant increase from its previous target of 40% by 2035 is emblematic of Malaysia's deepening commitment to a sustainable future.

**Figure 7:** Malaysia's Progress and Future Goals in Renewable Energy Capacity




***Source:*** *Datametrics Research and Information Centre (DARE)*

To highlight Malaysia's progress in the renewable energy sector, the infographic illustrates Malaysia's Renewable Energy (RE) capacity in recent years. By 2020, Malaysia had successfully integrated 23% renewable energy into its overall energy capacity mix, demonstrating its dedication to sustainable energy practices. This achievement aligns with the nation's set objectives. Although the journey thus far has been noteworthy, it also indicates the challenges and efforts that remain to meet the nation's ambitious renewable energy goals.

Malaysia's forward-thinking attitude has room to integrate under-the-radar but highly effective technologies such as WHR and Cogen into its NETR. The importance of these technologies is amplified when considering the sizable workforce reliant on Malaysia's energy sector. If Malaysia intends to reach net-zero greenhouse gas emissions by 2050, a strategic approach is needed to decrease dependence on fossil fuels, especially in significant sectors like transportation and industry, which will be crucial in meeting the 2050 targets of 70% renewable energy. Meanwhile, globally, Cogen and WHR have proven to be effective solutions.

# 4.2 Global Implementation of Cogen and WHR Technologies

In Germany, Cogen supplies up to 30% of Berlin's electricity and 70% of its heating needs[39]. Japan's 'Top Runner Programme' promotes WHR solutions that reclaim heat from manufacturing, reducing overall energy consumption[40] . In the U.S., sectors from cement production to chemical manufacturing use WHR, as seen in a Texas petroleum refinery where WHR powers nearly 30% of its energy needs[41].

Additionally, at DARE, as we compiled this research report, our findings indicate a widespread adoption of WHR and Cogen technologies in various industries and countries, largely due to their efficiency and effectiveness. WHR captures and reuses heat from industrial processes, improving energy efficiency and reducing emissions. Similarly, Cogen optimises fuel source utilisation, enhancing the resilience of the energy sector, a key principle of NETR. These aren't just novel solutions. They are evidently mature technologies with years of research, implementation, and application backing them.

## 4.2.1 Secondary Energy

Clearly, the global success and integration of WHR and Cogen technologies highlight the importance of innovative energy management strategies. This brings us to the crucial role of secondary energy, which is a pivotal element in the overall energy landscape, especially in the context of transforming primary energy sources for practical and sustainable use.

Secondary energy refers to the energy embodied in commodities such as electricity, gasoline, or other fuels that are produced through the transformation of primary energy sources like coal, natural gas, or sunlight. This transformation process, driven by human technology and innovation, is essential for turning natural energy sources into practical forms that are more readily usable in everyday applications. Ensuring the efficient and sustainable use of these transformed energy forms is as crucial as harnessing the primary energy sources themselves.

This includes a focused approach towards managing not just the direct harvesting of these resources but also the efficient and sustainable transformation of these resources into secondary forms of energy that are vital for modern consumption.

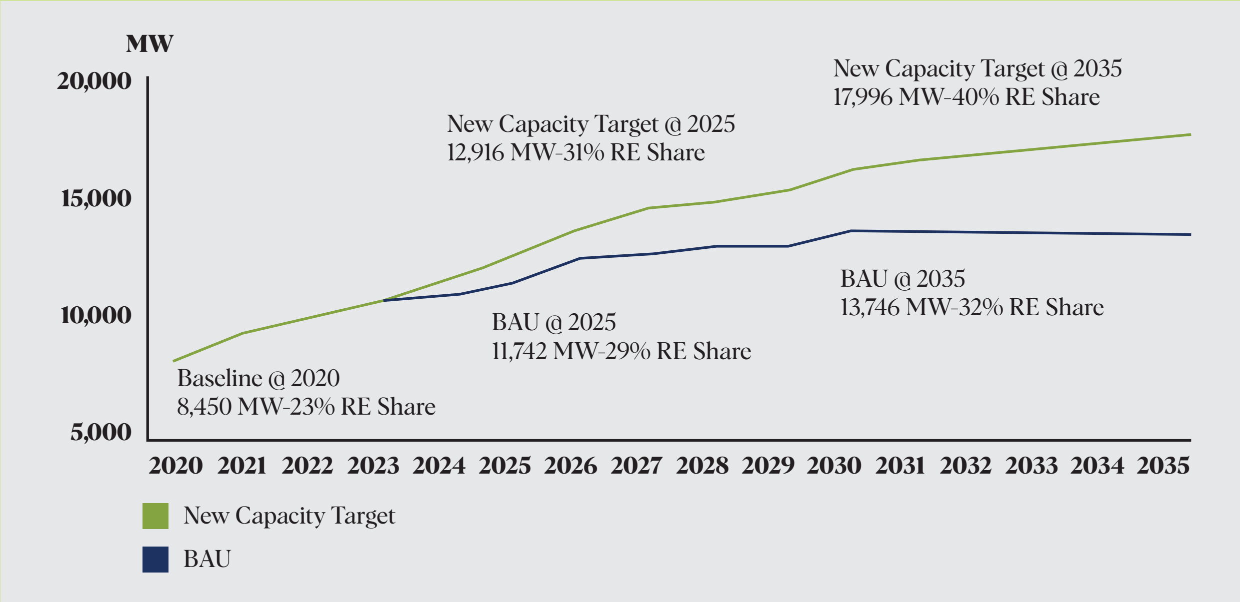
Incorporating these technologies can complement Malaysia's existing strategies, fitting into the roadmap's areas like energy efficiency and renewable energy. Through these initiatives, it enables Malaysia to address the pressing concerns of today, including shaping a more sustainable future for coming generations. However, they remain relatively under-recognised in Malaysia. On that note, it does suggest great potential for alignment opportunities with global best practices.

This potential opportunity would indeed necessitate a comprehensive and actionable framework to drive the transition forward. It should detail the steps and measures needed across different sectors to ensure a structured approach towards meeting Malaysia’s 2050 targets. A significant aspect of this framework involves managing the preservation of secondary energy.

# 4.3
# Policy Milestones

Key policy initiatives have acted as the catalysts in this journey, driving the nation towards its renewable energy goals. The introduction of Renewable Energy (RE) as the "fifth fuel" in 1999 was a precursor to more substantial moves. The Twelfth Malaysia Plan (2021-2025) further cemented the nation's commitment to achieving net-zero emissions by 2050. In September 2022, the NEP was launched with an aim to make Malaysia a low-carbon nation by 2040. As we have discussed earlier, in practice, NETR is designed not only to accelerate Malaysia's transition to renewable energy but also to make the energy sector more robust and resilient.

**Figure 8:** Malaysia's Renewable Energy Trajectory: Current Trends and Ambitious Goals for 2050




**Projecting the Future of Malaysia's Renewable Energy**

Charting the Course: Future Projections for Malaysia's Renewable Energy and Carbon Reduction

If Malaysia hits its 2050 goal of 70% renewable energy, carbon emissions could drop by 60%. A win-win for a greener future, these projections suggest Malaysia could even set new global standards in renewable energy.

**Analysis:**

- Dual Benefits: Increasing renewable energy generation directly correlates with a decrease in carbon emissions.
- Key Milestones: Pay attention to 2030 and 2040, pivotal years for both renewable energy and carbon reduction.
- 2050 Vision: Achieving the 70% renewable energy target can result in unprecedented carbon reduction.

***Source:*** *Sustainable Energy Development Authority (SEDA)*

# 4.4
# Malaysia's Renewable Energy: Beyond Trends, Towards Technological Leadership

Malaysia's energy transformation has been about more than just percentages and policy–it's been fundamentally technological. Recognising the global shifts in renewable energy, Malaysia has taken an elaborate, technology-driven approach to its energy transition. The evolution from solely relying on solar and hydro to exploring emerging technologies such as hydrogen fuel cells, bioenergy, and initial explorations into the feasibility of carbon capture and storage is noteworthy. This technology-first approach is evident in the 10 flagship catalyst projects under NETR, which seek to advance innovative solutions and technologies that can make the transition to renewable energy not just feasible but efficient and cost-effective.

This commitment, however, has not gone unnoticed. To reiterate, it has earned Malaysia a commendable ranking of 35th in the World Economic Forum's 2023 Energy Transition Index and the highest score among ASEAN countries at 61.7%[42].

Malaysia's evolving targets, policy milestones, and technology-driven initiatives highlight a comprehensive and dynamic approach to renewable energy. These aren't just aspirational targets set to appease global expectations, but rather they represent a strategic vision that is both aggressive and achievable. By combining ambitious goals with robust policy frameworks and technological innovation, Malaysia is not just following the renewable energy trend but is poised to become a leader in defining how nations should approach a sustainable energy future, with a clear roadmap towards achieving 70% renewable energy by 2050.

# 5

# Renewable Energy Platforms Available and Viable for Malaysia : A Comprehensive Evaluation

## 5.1 Malaysia's Energy Evolution: Multi-Billion Ringgit Investment and Global Collaborations Targeting Sustainable Growth by 2040

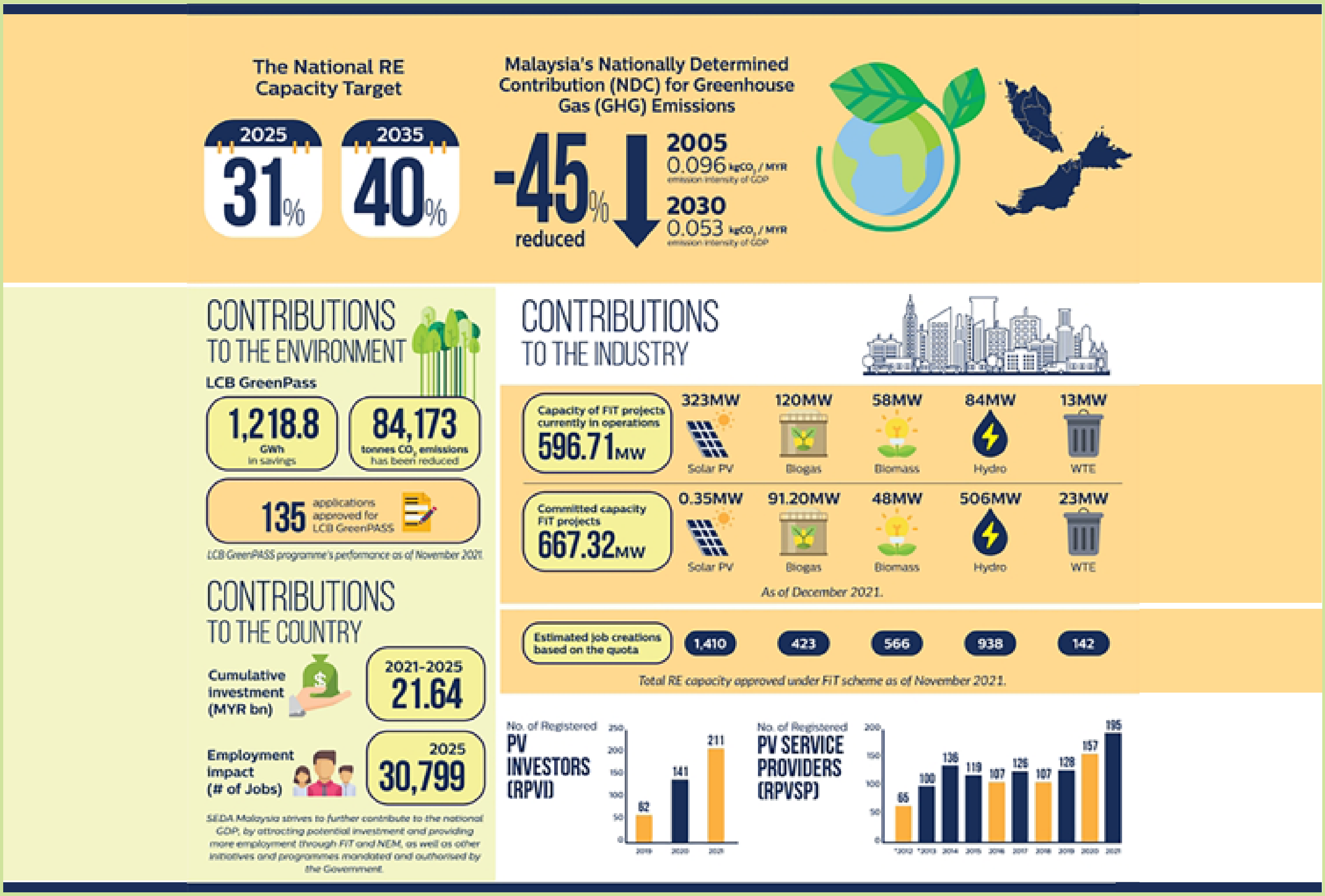
In a recent development, as highlighted in the National Industrial Master Plan (NIMP 2030) and reported by The Edge, Malaysia is planning to invest up to RM13 billion by 2040 for energy efficiency, targeting 21% energy savings as outlined in the NETR[43]. This includes RM7 billion for retrofitting government buildings and RM2 billion each by 2030 for smart devices and building retrofits. This transition aligns with the goals of the New Industrial Master Plan (NIMP) 2030, which aims to bolster a robust industrial sector as a cornerstone for socioeconomic prosperity. The shift from a sectoral-based approach to a mission-based approach under NIMP 2030 accentuates the importance of sustainable growth, which is intrinsically tied to energy efficiency and renewable energy investments.

By 2040, energy savings goals are set at 15% for the residential sector and 22% for commercial and industrial sectors, up from 10% and 11%, respectively. The forthcoming Energy Efficiency and Conservation Act will introduce mandatory energy audits, green building codes, and an Energy Service Company (ESCO) platform. Recently, Prime Minister Datuk Seri Anwar Ibrahim visited Masdar City in Abu Dhabi, leading to an MoU between MIDA and Masdar to develop 10GW of renewable energy projects in Malaysia worth US$8 billion, as covered by various news outlets[44]. Other supporting policies and financial commitments like the RM2 billion facility for energy transition and the US$430 million fund for green energy projects have been launched as part of Malaysia's decisive steps towards a sustainable energy framework.

Transitioning from the extensive investment plans Malaysia has for a sustainable energy future, let's delve into the various renewable energy platforms that are both available and viable for the nation. These platforms, each with their unique advantages and challenges, serve as the backbone of Malaysia's commitment to a greener and more sustainable energy landscape.

In our detailed examination, it is essential to emphasise that solar power is a primary renewable energy source in Malaysia. The tropical climate of Malaysia serves as a fitting catalyst for this renewable resource. Over the years, technological improvements have contributed significantly to establishing solar energy as a reliable and cost-effective option. These advancements include more efficient photovoltaic cells, more affordable solar panels, and innovative energy storage solutions.

**Figure 9:** Malaysia's Green Energy Impact across Environment, Industry, and Nation




**Source:** *The Star*

## What are the RE Platforms Available and Viable for Malaysia? Types of Platforms, Pros and Cons:

**Table 10:** Malaysia's Renewable Energy Roadmap: Platforms, Contributions, and Considerations for a Sustainable Future.

| Category | Source | Pros | Cons |
|---|---|---|---|
| **Clean Energy** | Solar Energy (see page 14, Section 3.3.1) | • Abundant availability due to Malaysia's tropical climate.<br>• Technologically mature, with various deployment options (rooftop, utility-scale, solar farms). | • Intermittency issues;<br>• Questions about sustainability of solar panel production. |
| | Wind Energy (see page 14, Section 3.3.1) | • Zero emissions during operation.<br>• Technology is becoming increasingly efficient. | • Not ideal for all geographic locations in Malaysia;<br>• Large land footprint. |
| | Hydrogen Fuel Cells (see page 45, Section 6) | • Zero-emission energy source;<br>• Highly efficient. | • Expensive technology;<br>• Production may require fossil fuels. |
| **Renewable Energy (RE)** | Hydroelectric Power (see page 25, Section 3.8.1) | • Highly efficient;<br>• Provides grid stability. | • Ecological impact on rivers and aquatic life;<br>• High upfront cost. |
| | Bioenergy (see page 25, Section 3.8) | • Makes use of organic waste;<br>• Can provide a constant energy source. | • Potential for deforestation;<br>• Energy yield can vary. |
| **Energy Efficient** | Co-generation (CHP) (see page 26, Section 3.8.1) | • Efficiency up to 90%; cost savings;<br>• Reduced emissions. | • High initial cost;<br>• Specialized expertise for installation and maintenance required. |
| | Waste Heat Recovery (WHR) (see page 26, Section 3.8.1) | • Reuses 'waste' heat, enhancing energy use.<br>• Less need for extra fuel lowers emissions.<br>• Boosts overall operational efficiency. | • Limited applicability, best suited for industries with large amounts of waste heat.<br>• Implementation challenges include complexity and cost in retrofitting existing systems. |

***Source:*** *Datametrics Research and Information Centre (DARE)*

# 5.2 The Conundrum of Solar Sustainability

Solar energy began gaining prominence in Malaysia's energy landscape in the early 2000s. The tropical climate of Malaysia serves as a fitting catalyst for this renewable resource. Over the years, technological improvements have contributed significantly to establishing solar energy as a reliable and cost-effective option in Malaysia. These advancements include more efficient photovoltaic cells, more affordable solar panels and innovative energy storage solutions[45].

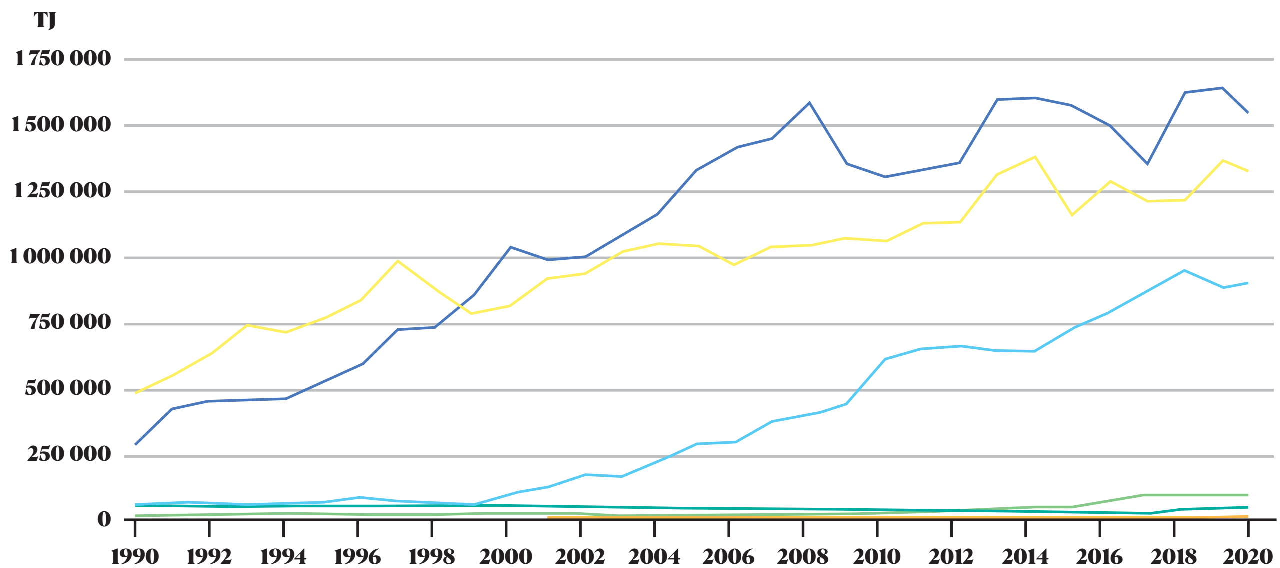
Given the urgency of global climate issues, the diversification of energy sources in Malaysia has risen to a level of critical importance. While solar energy offers a promising avenue, challenges remain. These include the prospect of generating up to 78 million tonnes of waste by 2050 and environmental concerns related to the manufacturing of solar panels. These are issues that pose grave consequences if not addressed in a timely manner[46].

In the Malaysian context, the abundant sunshine makes solar energy an increasingly cost-effective choice. A 300-watt solar panel in Malaysia is capable of generating around 1.0 to 1.5 kWh per day, compared to the average household consumption of 20 to 30 kWh daily[47].

Nevertheless, the process of manufacturing solar panels is fraught with complexities. From the mining of raw materials like quartz and metals to the final assembly, each step requires significant amounts of energy and water. Furthermore, materials such as cadmium telluride and gallium arsenide, essential for solar panel production, present environmental risks[48]. By-products of the manufacturing process, including toxic substances like silicon tetrachloride, pose challenges for waste disposal.

As the global impetus to transition away from fossil fuels gains momentum, it becomes critical for Malaysia to evaluate alternative energy options diligently. The aim is to ensure that the transition to renewable energy sources like solar does not inadvertently result in a new, albeit lesser, set of problems[49].

**Figure 11:** Malaysia's Energy Supply by Source: Key Trends






Coal · Natural Gas · Hydro · Biofuels and waste · Oil · Wind, solar, etc.

| | Coal | Natural Gas | Hydro | Biofuels and Waste | Oil | Wind, Solar, etc. | Units |
|---|---|---|---|---|---|---|---|
| **1990** | 56747 | 284744 | 14360 | 51986 | 480488 | | TJ |
| **1995** | 67516 | 517237 | 22399 | 52210 | 762165 | | TJ |
| **2000** | 96628 | 1035354 | 25078 | 52710 | 812310 | | TJ |
| **2005** | 288381 | 1334340 | 18688 | 45097 | 1042297 | 4 | TJ |
| **2010** | 611311 | 1306073 | 23299 | 34223 | 1060541 | | TJ |
| **2015** | 733410 | 1571662 | 50126 | 27947 | 1155566 | 983 | TJ |
| **2020** | 907663 | 1504618 | 94382 | 47360 | 1304279 | 8415 | TJ |

The data reveals a dynamic shift in Malaysia's energy landscape over the last three decades. Coal usage has surged from 56,747 TJ in 1990 to 907,663 TJ in 2020, marking a significant increase. Meanwhile, natural gas remains the dominant source, although its usage slightly dipped to 1,504,618 TJ in 2020 from its 2015 peak.

Hydroelectric power and renewables like wind and solar are making inroads. Hydro grew 556% from 1990 to 2020, and although wind and solar started small in 2005, they've risen sharply to 8,415 TJ by 2020.

Oil remains a steady contributor, reaching 1,304,279 TJ in 2020 from its 1990 supply of 480,488 TJ. Biofuels and waste have had variable contributions over the years, settling at 47,360 TJ in 2020.

In summary, Malaysia's energy supply reflects an increasing reliance on coal, consistent usage of oil and natural gas, and a growing focus on renewable sources.

***Source:*** *International Energy Agency*

# 5.3 Balancing Innovation with Sustainable Choices in Malaysia's Green Transition

As Malaysia shifts towards sustainability, five key renewable energy sources emerge: solar, wind, hydropower, geothermal, and biomass. Their full potential, however, hinges on strategic technological advancements.

Transitioning isn't simple; energy generation, transmission, and storage challenges vary by platform. High installation and maintenance costs, often due to specialised materials and technology, can deter adoption, especially given rising global energy prices. Depending on the renewable type, new transmission methods might be necessary. Moreover, platforms like solar and wind generate power intermittently, necessitating advanced storage solutions, which can add costs.

To enhance the integration of renewable energies in a cost-efficient way, Malaysia must focus on increasing its system's flexibility. This requires ambitious, forward-thinking strategies to address current grid integration issues and enhance grid flexibility. Consequently, in Malaysia's strategy for energy transition, investments in the power sector and grid improvements represent a significant portion, over 70%, of the total investment needs. This amounts to a minimum of USD 375 billion[50].

These financial considerations become even more pressing as the world grapples with rising energy costs, making it crucial to weigh the economic viability of adopting renewable energy. Adopting renewables can position Malaysia as a green technology leader, but it requires targeted research, public-private partnerships, and policy support. Breakthroughs in battery storage might address intermittency issues in solar and wind energy.

In turn, the New Industrial Master Plan 2030 (NIMP 2030) envisions a mobilised financing ecosystem and a strengthened investor journey to facilitate ease of doing business, which can significantly impact the advancement of battery storage technologies in Malaysia[51]. By aligning with the NIMP 2030's mission-based approach, battery storage is a crucial aspect of ensuring the reliability and efficiency of renewable energy systems, especially solar and wind energy.

By storing excess energy produced during peak production times, energy can be dispatched during periods of low or no energy generation. This significantly improves the energy system's reliability, making renewables a more viable option. In Malaysia, companies and government initiatives are investing in developing advanced battery storage solutions to overcome the intermittency challenges associated with renewable energy sources. This includes exploring various battery technologies and improving the existing infrastructure to accommodate large-scale energy storage systems.



## 5.4
## Malaysia's Corporate Push for a Sustainable Future

Malaysian companies are leading the way in investing in green solutions and developing innovative energy solutions. Top Glove Corporation, Petronas, Tenaga Nasional Berhad, the Malaysian Palm Oil Board, Sime Darby Plantation, and Petronas Gas Berhad are just a few examples of companies that are taking action to reduce their environmental impact and promote sustainable energy use.

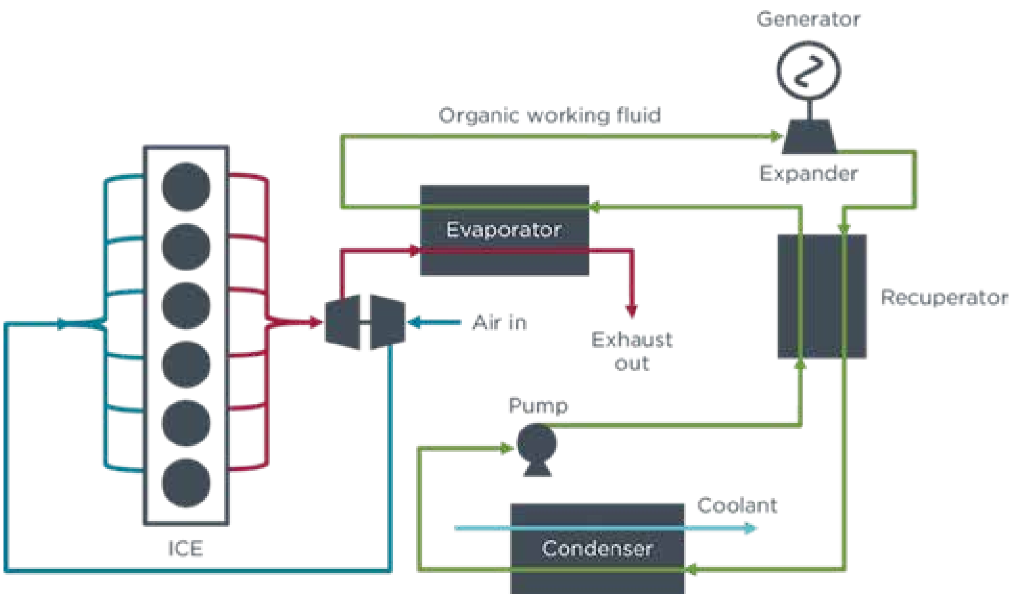
**Top Glove Corporation**, the world's largest rubber glove manufacturer, is investing RM1 billion in solar energy, with plans to install 100 MW of solar panels at its manufacturing facilities. This is expected to reduce the company's electricity costs by 15% and greenhouse gas emissions by 100,000 tonnes per year[52].

**Petronas**, the national oil and gas company of Malaysia, has set a target to reduce its greenhouse gas emissions by 30% by 2030[53] and to achieve net zero emissions by 2050. The company is investing in a range of green projects, including carbon capture and storage, renewable energy, and energy efficiency. In 2022, Petronas announced a RM16 billion investment in renewable energy, with plans to develop 10 GW of renewable energy capacity by 2030 .

**Tenaga Nasional Berhad (TNB)**, the national electricity utility of Malaysia, is investing RM10 billion in renewable energy by 2025, with a target to source 30% of its power from renewables by 2030[54]. The company is developing a range of renewable energy projects, including solar, wind, and biomass.

**The Malaysian Palm Oil Board (MPOB)** and **Sime Darby Plantation** have introduced Cogen systems in their palm oil mills, enhancing the efficiency of electricity and heat production[55]. This initiative has significantly reduced energy consumption and greenhouse gas emissions[56]. As per an MPOB study titled 'The Need to Reduce National Greenhouse Gases Emissions: Oil Palm Industry's Role', Cogen has the potential to decrease energy consumption in palm oil mills by up to 30%. Additionally, the research indicated that cogeneration could diminish greenhouse gas emissions by up to 60%.

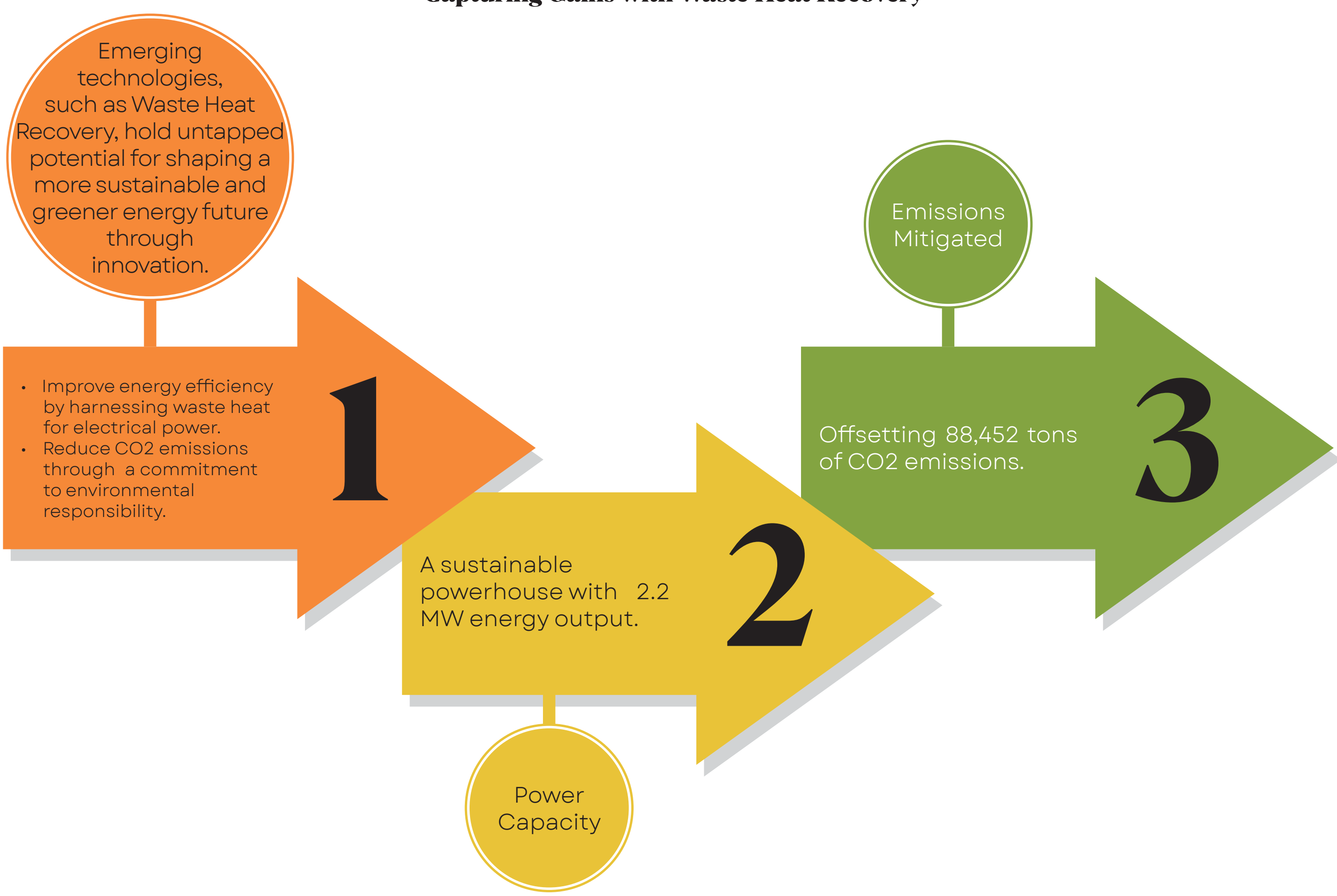
**Figure 12:** Optimising Energy: The Waste Heat Recovery Process in Aerospace and Its Benefits




**Pioneering Sustainable Energy Solutions in Aerospace**

Waste Heat Recovery: The Implementation Process for Energy Efficiency in Industrial Operations

**Capturing Gains with Waste Heat Recovery**




***Source:*** *Datametrics Research and Information Centre (DARE)*

Petronas Gas Berhad is harnessing WHR at its Pengerang Integrated Complex to produce electricity. Before implementing WHR, the electricity generation was 200 MW, but after its introduction, it increased to 300 MW[57]. This enhancement has also led to a 20% reduction in natural gas consumption, translating to substantial energy savings. Moreover, the adoption of WHR has resulted in a decrease of 100,000 tonnes of CO2 equivalent emissions per year, underlining the significant reduction in greenhouse gas emissions.

Cogen and WHR systems epitomise efficient energy use, minimising waste and emissions. In navigating its renewable energy journey, technological innovation is paramount for Malaysia. By investing in research and development, Malaysia can turn renewable energy challenges into transformative solutions for both the economy and the environment.

The Malaysian government is supporting technological innovation in the renewable energy sector through a number of initiatives, including the *Renewable Energy Technology Development Fund, the Sustainable Energy Development Authority (SEDA) Innovation Hub, and the Malaysia Green Technology Corporation (MGTC) Green Technology Innovation Commercialisation Programme.* These initiatives are helping to accelerate the development and deployment of new renewable energy technologies in Malaysia. The NIMP 2030, acting as a catalyst, anticipates a Compound Annual Growth Rate (CAGR) of +6.5% in the manufacturing sector between 2022-2030[58], driven partly by the adoption of renewable energy, which supports the development of sophisticated industries while ensuring environmental sustainability. The interdependence between sectors as emphasised in NIMP 2030 suggests that successful implementation of renewable energy strategies will benefit various sectors either directly or indirectly, contributing to the nation's long-term economic complexity and sustainability.

**Figure 13:** Elevating Malaysia's Clean Energy Landscape with Cogen & WHR

### Exploring Cogen & WHR as Sustainable and Clean Energy Options Beyond Solar and Wind

Cogen and WHR are innovative technologies that could revolutionize Malaysia's industrial sectors by offering efficient and eco-friendly energy solutions.

### What Are Cogen & WHR?

Cogen: Dual energy (electricity & heat) from a single source.
WHR: Reuse of industrial waste heat for efficiency.

### Why Cogen & WHR?

## COGEN

- High Efficiency: 90%
- Significant emissions reduction
- Long-term cost savings
- Versatile & Reliable: Suitable for all facility sizes and adds resilience

## WHR

- High Efficiency: 50%
- Long-term cost savings
- Versatile & Reliable: Suitable for all facility sizes and adds resilience

**Industries:**

COGEN:

- Manufacturing
- Automotive
- Textiles
- Pharmaceuticals
- Chemical Processing
- Data Centers

WHR:

- Food Processing
- Textiles
- Pulp and Paper
- Metal Production
- Oil Refining
- Glass Manufacturing

**Policy Support:**

COGEN:

- Eligible for Government Incentives
- Energy Efficiency Grants
- Carbon Offset Programs

WHR:

- Potential for Tax Benefits
- Research and Development Credits
- Custom Tariff Exemptions

**Impact on Malaysia**

- Efficiency: Boost industrial operations.
- Environment: Reduced emissions.
- Economy: Lower costs and job creation.

Cogen and WHR offer untapped, sustainable and clean energy solutions that can serve as valuable additions to Malaysia's renewable energy portfolio.

***Source:** Datametrics Research and Information Centre (DARE)*

# 6

# Recommendations to Accelerate RE Aspirations

As Malaysia steers towards a more sustainable energy future with a target of 70% renewable energy by 2050, policy interventions are crucial in accelerating this transition. This section outlines a brief policy direction that includes incentives for emerging technologies, proposals for lifting the renewable energy export ban, and support for advanced systems like Cogen and WHR.

To effectively correlate these interventions with Malaysia's renewable energy goals, it's essential to adopt a comprehensive approach that emphasises investment in both emerging and established renewable sectors. While emerging technologies such as hydrogen fuel cells and advanced bioenergy show great potential for a sustainable future, the key lies in integrating these innovations with substantial investments in established renewable sectors like solar and wind energy. According to International Renewable Energy Agency (IRENA), hydrogen demand in Malaysia is expected to grow significantly, up to 1.5 million tonnes of clean hydrogen by 2050[59]. Thus, this dual focus ensures a balanced development of new and reliable energy sources, catering to both immediate and future energy needs.

Additionally, deploying energy storage solutions and smart grid infrastructure is critical. Energy storage solutions like batteries are integral for managing the

intermittent nature of renewable energy sources, ensuring a consistent supply of power during low production periods. Similarly, investing in smart grid infrastructure is fundamental for optimising the distribution and utilisation of renewable energy, enhancing grid reliability, and enabling real-time monitoring and management of energy resources.

These established technologies - solar and wind energy, not only provide immediate solutions for energy generation but also serve as a foundation upon which emerging technologies can build. The integration of cutting-edge technologies with time-tested renewable energy sources and modern infrastructure creates a robust framework that can adapt to evolving energy needs. A comprehensive strategy should encompass these diverse elements to ensure a well-rounded energy portfolio for the nation. By cultivating a synergy between emerging technologies, established renewable sectors, energy storage solutions, and smart grid infrastructure, Malaysia can not only enhance individual sector efficiencies but also collectively create a sustainable and resilient energy system. Together, these measures will directly support Malaysia's strategic shift towards a green economy. By focusing on both renewable and sustainable energy platforms, the country can achieve a balance between environmental stewardship and economic growth, ultimately propelling Malaysia towards its 2050 vision of a 70% renewable energy mix.

# 6.1 Incentives for Emerging Technologies

## 6.1.1 - Recommendation 1: Tax Incentives and Subsidies

To encourage research, development, and deployment of emerging technologies like hydrogen fuel cells and advanced bioenergy, the government should introduce targeted tax incentives and subsidies. Companies investing in these technologies should be eligible for a Green Investment Tax Allowance.

Companies investing in these technologies, including SMEs and start-ups focusing on innovative renewable energy solutions, should be eligible for a Green Investment Tax Allowance (GITA). This allowance could be structured to offer benefits based on the level of innovation and the potential environmental impact of the technology.

Additionally, subsidies could be offered to support pilot projects and prototypes, facilitating real-world testing and development. By promoting a supportive fiscal environment, these measures could accelerate Malaysia's transition to a diverse and robust renewable energy sector, enhancing energy security and contributing to national sustainability goals.

## 6.1.2 - Recommendation 2: Public-Private Partnerships (PPP)

The government should establish partnerships with private companies to jointly invest in research and pilot projects. This collaborative effort will speed up the technological advancement necessary for a broader rollout of emerging energy solutions, but also build a conducive ecosystem for innovation and commercialisation.

Such partnerships can facilitate a knowledge transfer, reduce risks, and accelerate the adoption of advanced systems like Cogen and WHR technologies. The synergy between public and private sectors is crucial for overcoming the technological and financial barriers that impede the progress towards a sustainable energy landscape. Beyond regulatory mandates, a concerted dialogue to identify priority sectors and align the objectives of all stakeholders is paramount.

## 6.2
## Lifting the Renewable Energy Export Ban

| 6.2.1 - Recommendation 3: Gradual Lifting with Quotas | 6.2.2 - Recommendation 4: Bilateral agreements |
|---|---|
| To foster an environment where renewable energy can be a significant export product, a gradual lifting of the current ban with set quotas can be a viable first step. This would allow Malaysia to meet its domestic needs while also profiting from international markets. | To ensure a steady and reliable export market, the government should engage in bilateral agreements with countries that have high renewable energy demand but low production capabilities. These agreements can set the groundwork for a long-term, mutually beneficial relationship. |

## 6.3
## Support for Sustainable Energy Solutions

### 6.3.1 - Recommendation 5: Sector-specific incentives for sustainable energy solutions

Industries such as manufacturing and petrochemicals, which stand to benefit most from sustainable energy solutions like Cogen and WHR, should be targeted with sector-specific incentives. These incentives might include big tax cuts, rewards for using sustainable practices, faster approval processes, and direct financial help for upgrading to energy-saving technologies.

For example, a tax credit scheme could be introduced for industries investing in Cogen and WHR systems, proportionate to the amount of reduced carbon emissions. Additionally, a streamlined permitting process would encourage quicker adoption and implementation of these technologies.

Tailoring incentives to specific sectors represent a sophisticated approach to driving the adoption of energy-efficient technologies. This is not only beneficial for the industries in terms of cost savings and efficiency gains but also aligns with the National Energy Policy's objective of reducing carbon emissions and promoting sustainable industrial practices. Such targeted interventions can serve as the linchpin of a more resourceful, less wasteful industrial landscape. These sector-specific programmes are not a mere afterthought, but a carefully calibrated strategy aimed at fast-tracking the deployment of energy-efficient solutions where they can make the most impact.

Building on this momentum, Bank Negara Malaysia (BNM) has also stepped in to support smaller-scale enterprises in embracing sustainable practices. BNM's Low Carbon Transition Facility (LCTF) is established to support SMEs in adopting sustainable and low carbon practices[60]. The LCTF is open for SMEs in all sectors that are committed to transform their business operations towards low carbon operations. This includes improving energy efficiency, increasing use of sustainable material for production, and obtaining sustainability certification.

LCTF is a financial facility designed to motivate and assist SMEs in adopting sustainable strategies to ensure their business resilience. The LCTF provides funding for capital expenses and working capital, aiming to kickstart or support the shift towards low-carbon and sustainable business operations. This facility covers a range of activities, such as:

- Gaining sustainability certification.
- Boosting the utilisation of sustainable materials in production.
- Enhancing the energy efficiency of buildings and appliances.
- Setting up on-site renewable energy generation equipment.

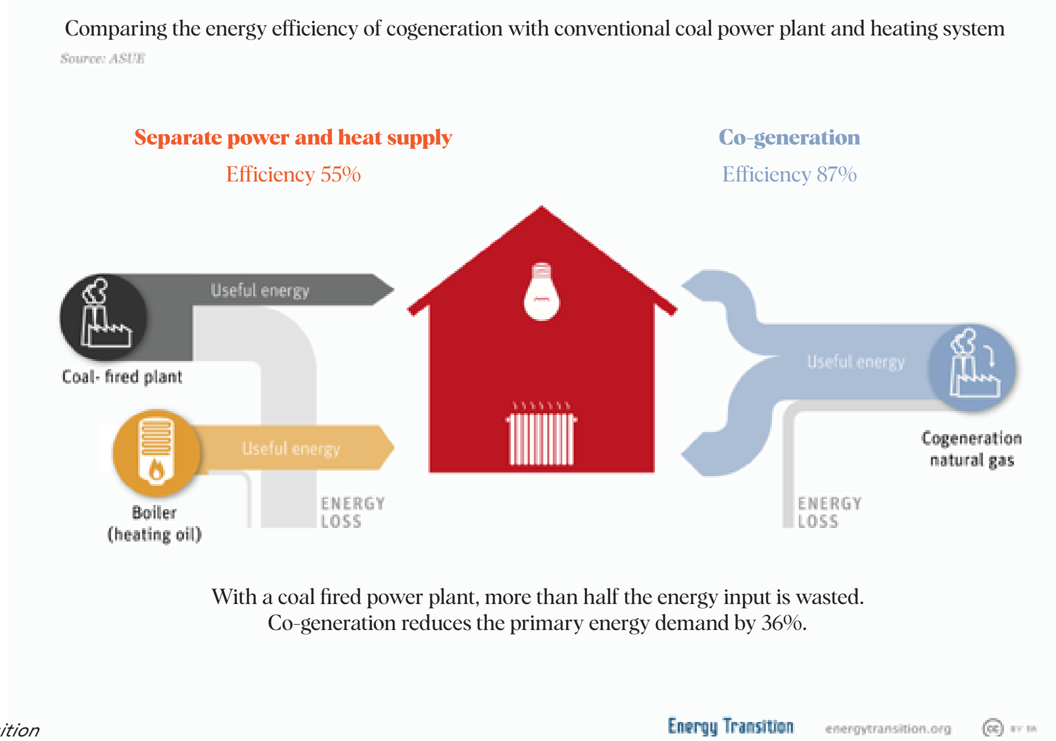
As Malaysia explores various renewable energy options, it's important to recognise the role of alternative yet underexplored technologies like Cogen and WHR in this landscape. Malaysia has a diverse set of options when it comes to renewable energy platforms, each with its own pros and cons. But Cogen and WHR offer particularly intriguing possibilities for increasing energy efficiency, benefitting from long-term energy optimisation and reducing environmental impact. As Malaysia continues its journey towards a 70% renewable energy target by 2050, these technologies could play a crucial role in achieving those goals.

# 6.4
# Recommendation 6: Standards and Certification

National standards and certification processes should be developed to ensure that innovative technologies and effective sustainable energy solutions like Cogen and WHR technologies are properly recognised. This includes considering the high initial capital expenditures (Capex) required, the long-term operational and maintenance costs, and the potential for government subsidies or tax incentives. Furthermore, the environmental impact and energy efficiency of these technologies should also be key factors in their evaluation. Companies that meet and practice these standards should be eligible for additional incentives.

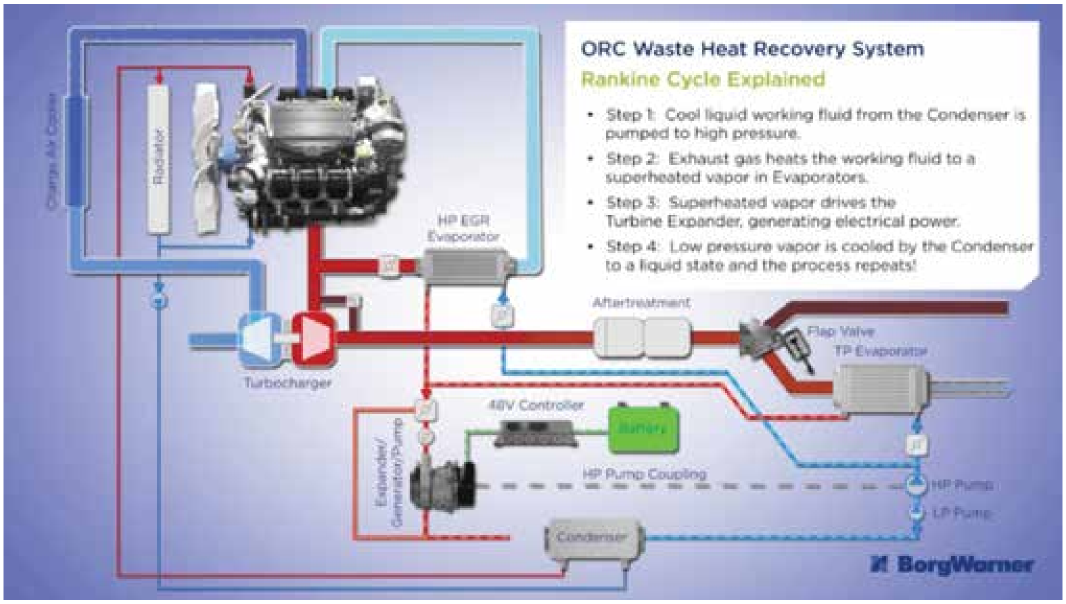
Indeed, a comparative analysis anchored in real-world applications adds weight to the case for immediate action. Figure 14 illustrates why Cogen is more efficient than conventional coal power plants, further emphasising the potential of these technologies. Take, for instance, the case of Safran Group, which operates in the aerospace and defence industries. At their WHR facility situated in Sendayan, Seremban, they have reported savings of 168,000,000 kWh over a concession duration of 10 years, as documented on 20 Dec 2021[61]. Refer to Figure 15 for an illustration of the ORC system, a technology prevalent in developed countries for energy transition, and locally championed by solutions providers like Kinergy Advancement Berhad. **Safran Group** successfully integrated such systems into its operations, yielding not only environmental gains but also a robust return on investment. Such a case study serves as a compelling blueprint for Malaysia, underscoring that the application of existing technologies–like Cogen and WHR–can be immediate and profoundly impactful.

**Figure 14:** Why Cogen is more efficient than conventional coal power plants




***Source:*** *Energy Transition*

**Figure 15:** The Rankine Cycle Process Breakdown




***Source:*** *BorgWarner*

## 6.5
## Recommendation 7: Utility buyback programs

For Cogen systems that produce excess energy, utility companies should offer buyback programmes at competitive rates. This not only provides an additional revenue stream for companies investing in Cogen systems but also adds to the national grid, thereby improving overall energy availability and stability.

Through the strategic implementation of these policy recommendations, Malaysia can make substantive strides not only in reaching its ambitious 2050 renewable energy targets but also in catalysing economic growth, fostering technological innovation, and establishing itself as a global leader in sustainable energy solutions. This proactive approach, emphasising the adoption of emerging technologies and offering robust support for systems like Cogen and WHR, will further Malaysia's position at the forefront of the global transition towards a more sustainable and eco-friendly energy paradigm.

# Conclusion 7

As Malaysia embarks on an audacious journey towards a future largely defined by renewable energy, the stakes could not be higher. This report therefore provides an in-depth look at Malaysia's current energy landscape, its aspirations for the future, and the policy mechanisms that could help realise these ambitions.

While various renewable energy options have their merits and limitations in Malaysia, the consideration of innovative clean energy generation solutions like Cogen and WHR have shown their worth throughout this report, particularly for energy-intensive work sites. These technologies can improve energy efficiency and enhance sustainability practices by capturing waste heat from industrial processes for electricity and/or heating generation. Although they complement other renewable energy forms, they have a role in a balanced, sustainable energy strategy.

These technologies are a valuable complement to solar and wind energy, offering their own forms of innovation and efficiency. They enrich the overall energy portfolio by utilising thermal energy from industrial processes for electricity and/or heating. By doing so, they not only augment the country's energy capabilities but contribute meaningfully to a truly circular energy economy. Herein lies an untapped wellspring of potential that could catalyse Malaysia's quest for energy sustainability, while concurrently offering robust economic dividends.

Our policy recommendations offer a well-rounded strategy designed to catalyse Malaysia's transition to cleaner energy sources. By incorporating tax incentives, encouraging public-private partnerships, and lifting the renewable energy export ban, Malaysia can ensure a cohesive and effective energy policy. These initiatives are not just proposals but prerequisites for a more sustainable future, underlined by a compelling economic rationale.

Let's not forget the importance of backing up big goals with concrete actions. That's why we need specific tax breaks and support programmes to make sustainability solutions more appealing for businesses. With the right financial incentives, we can encourage companies to invest in these underused technologies. In turn, this helps Malaysia not just to be sustainable but also to save money, creating a win-win situation for everyone involved.

Moreover, by adopting a technology-driven approach, Malaysia can leapfrog traditional barriers that often plague energy transitions. The integration of emerging technologies like hydrogen fuel cells, advanced bioenergy, and smart grids can offer more than just incremental improvements; they promise revolutionary changes in how we generate, distribute, and consume energy. These technologies are not the outliers of tomorrow but the mainstay innovations that will underpin Malaysia's energy sector in the coming years.

In addition to existing technologies, the potential for even greater energy savings and operational efficiency cannot be overstated. Implementing alternative technologies alongside conventional renewable sources can unlock avenues for greater energy optimisation. By focusing on operational efficiency through data analytics, smart metering, and real-time monitoring, Malaysia can enhance its energy utilisation strategies. These steps have been proven to generate increased energy savings, while streamlining the entire energy infrastructure, optimising resource allocation and reducing operational costs.

Ultimately, the vision for Malaysia's energy future holds considerable hidden potential. It is a vision that sees the country not just reaching its goal of 70% renewable energy by 2050 but also emerging as a global leader in the realm of sustainable energy solutions. It envisions a nation where energy is not merely a commodity but shared resources that power possibilities, opportunities and aspirations for growth of its people and prosperity of its planet. It sees a world where Malaysia stands at the forefront of the global energy transition, guided by forward-thinking objectives, policies and innovations.

The sustainable energy metamorphosis that Malaysia is poised to undergo will set a benchmark for nations around the world. Through meticulous planning, strategic investment, and collective will, this vision is not just attainable; it is within our grasp in view of having it managed timely and strategically. As we close this report, we remain hopeful that the insights and recommendations provided herein will serve as a valuable roadmap for policymakers, industry leaders, and all stakeholders in Malaysia's energy sector.

Embracing sustainable energy enables Malaysia not only to utilise resources but also to maximise their usage. This shift promises a significant reduction in carbon emissions, while stimulating economic growth and ensuring business and job continuity. The transition to sustainable energy sources will considerably bolster our nation's energy security and resilience, safeguarding a more robust environment against future energy-related challenges.

May it guide us towards a future where sustainable energy is not just an option but a defining characteristic of our national identity.

# References 8


1. Source: World Economic Forum. Energy Transition Index 2023. 2023. Information derived from the document "Energy Transition Index 2023"
2. Source: Ministry of Economy, Malaysia. National Energy Transition Roadmap (NETR). 27 July 2023. Information derived from the document "National Energy Transition Roadmap (NETR)"
3. Source: Ministry of Energy and Natural Resources, Malaysia. National Energy Policy 2022-2040. September 2022. Information derived from the document "National Energy Policy 2022-2040".
4. Source: Malaysia Renewable Energy Roadmap 2035. Information derived from the document "Malaysia Renewable Energy Roadmap 2035".
5. Source: Department of Statistics Malaysia. Environmental Statistics 2021. 2022.
6. Source: World Economic Forum. Global Energy Transition Index 2023. 2023.
7. Source: Bulletin, Monthly Labor Review, December 2022.
8. Source: International Energy Agency (IEA), World Energy Outlook 2022.
9. Source: Japan Ministry of Economy, Trade, and Industry (METI), Top Runner Programme.
10. Source: Renewable Energy Policy Framework (REPF), Ministry of Energy, Green Technology, and Water Malaysia (KeTTHA), 2019. Information derived from the document "Renewable Energy Policy Framework (REPF) 2019".
11. Source: Malaysia's Third Biennial Update Report to the United Nations Framework Convention on Climate Change (UNFCCC), KeTTHA, 2019. Information derived from the document "Malaysia's Third Biennial Update Report to the UNFCCC".
12. Source: Solar Energy Potential in Malaysia, Sustainable Energy Development Authority (SEDA), 2022. Information derived from the document "Solar Energy Potential in Malaysia".
13. Source: Large Scale Solar (LSS), SEDA, 2023. Information derived from the document "Large Scale Solar (LSS)".
14. Source: Business Today Malaysia, 2023. Information derived from the article 'Samaiden Wins Big in Latest CGPP, Kenanga Maintains Outperform' available at https://www.businesstoday.com.my/2023/11/10/samaiden-wins-big-in-latest-cgpp-kenanga-maintains-outperform/.
15. Source: Ministry of Energy and Natural Resources Malaysia, Malaysia Energy Statistics 2022 (Putrajaya, 2022). Information derived from the document "Malaysia Energy Statistics 2022".
16. Source: Malaysia Renewable Energy Roadmap 2035 and SEDA. Information derived from the document 'Malaysia Renewable Energy Roadmap 2035' and SEDA's annual report 2023.
17. Source: Asia Wind Energy Association. Information derived from the document available at "https://www.asiawind.org/research-data/market-overview/malaysia/.
18. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 12.
19. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 12.
20. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 11.
21. Source: Ministry of Energy and Natural Resources Malaysia, Malaysia Energy Statistics 2022 (Putrajaya, 2022). Information derived from the document "Malaysia Energy Statistics 2022".
22. Source: Malaysia Department of Environment and Malaysian Palm Oil Council. Information derived from the Malaysia Department of Environment's air quality report 2023 and the Council's agricultural land use report 2023.
23. Source: Malaysia Renewable Energy Roadmap 2035 and SEDA. Information derived from the document 'Malaysia Renewable Energy Roadmap 2035' and SEDA's annual report 2023.
24. Source: Sustainable Energy Development Authority Malaysia (SEDA), Annual Report 2022 (Putrajaya, 2022). Information derived from the document "Annual Report 2022".
25. Source: Ministry of Energy and Natural Resources Malaysia, Malaysia Energy Statistics 2022 (Putrajaya, 2022). Information derived from the document "Malaysia Energy Statistics 2022".
26. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 10.
27. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 13.
28. Source: SEDA Malaysia, "Renewable Energy in Malaysia: 2023 Report" (2023), p. 13.
29. Source: Malaysia Renewable Energy Roadmap 2035. Information derived from the document 'Malaysia Renewable Energy Roadmap 2035'.
30. Source: International Renewable Energy Agency (IRENA). Information derived from the report 'Renewables Are the Solutions to Malaysia’s Sustainable Future and Renewed Climate Ambition'

31. Source: Malaysia Renewable Energy Roadmap 2035. Information derived from the document "Malaysia Renewable Energy Roadmap 2035"
32. Source: Malaysia Renewable Energy Roadmap 2035. Information derived from the document "Malaysia Renewable Energy Roadmap 2035".
33. Source: National Energy Efficiency Roadmap (NETR).
34. Source: Credit Guarantee for Green Technology (CGGT).
35. Source:International Organisation for Standardisation (ISO), "ISO 14040:2006 Environmental management - Life cycle assessment - Principles and framework," (2006).
36. Source: World Health Organisation (WHO), "Ambient air pollution: A global assessment of exposure and health effects," (2016).
37. Source: United Nations Industrial Development Organisation (UNIDO), "Waste Heat Recovery: A Practical Guide," (2018).
38. Source: International Renewable Energy Agency (IRENA). (2021, August). Organic Rankine Cycle (ORC) technology brief. https://www.mdpi.com/1996-1073/16/5/2329: https://www.mdpi.com/1996-1073/16/5/2329.
39. Source: Berlin Senate, "Berlin to Become Climate-Neutral by 2045," press release, March 8, 2022, https://www.berlin.de/en/senate/press-office/press-releases/2022/03/08/berlin-to-become-climate-neutral-by-2045/. (4.2)
40. Source: Ministry of Economy, Trade and Industry, "Japan's 'Top Runner Programme'," https://www.meti.go.jp/english/policy/energy_environment/energy_efficiency/top_runner/index.html.
41. Source: U.S. Department of Energy, "Waste Heat Recovery: Texas Petroleum Refinery Powers Nearly 30 Percent of Its Energy Needs," https://www.energy.gov/eere/amo/articles/waste-heat-recovery-texas-petroleum-refinery-powers-nearly-30-percent-its-energy-needs.
42. Source: World Economic Forum's 2023 Energy Transition Index. Information derived from the report 'World Economic Forum's 2023 Energy Transition Index'.
43. Source: The Edge. "Malaysia to invest RM13 billion in energy efficiency by 2040". Published on September 28, 2023. Accessed on November 2, 2023. https://theedgemalaysia.com/node/680614
44. Source: Free Malaysia Today. "Masdar signs MOU with Malaysia to develop up to 10GW of renewable energy projects". Published on October 15, 2023. Accessed on November 2, 2023. https://www.zawya.com/en/press-release/companies-news/masdar-signs-mou-with-malaysia-to-develop-up-to-10gw-of-renewable-energy-projects-pqtav43e
45. Source: Malaysia Energy Outlook 2022. Energy Commission of Malaysia, 2022.
46. Source: Solar Energy in Malaysia: A Review. Renewable and Sustainable Energy Reviews, vol. 97, 2019, pp. 446-459.
47. Source: Malaysia Renewable Energy Roadmap 2035. Sustainable Energy Development Authority (SEDA) Malaysia, 2021.
48. Source: The Environmental Impacts of Solar Energy. International Journal of Life Cycle Assessment, vol. 25, no. 3, 2020, pp. 543-559.
49. Source: The Global Transition to Renewable Energy: A Review of Challenges and Opportunities. Renewable and Sustainable Energy Reviews, vol. 118, 2020,pp. 109587-109607.
50. Source: IRENA website. Information derived from the document 'Renewables Are the Solution to Malaysia's Sustainable Future and Renewed Climate Ambition' on the IRENA website.
51. Source: Malaysian Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). National Integrated Mobility Plan (NIMP) 2030. Information derived from the document "National Integrated Mobility Plan (NIMP) 2030."
52. Source: Top Glove Corporation. Top Glove Corporation Invests RM1 Billion in Solar Energy. Information derived from the press release "Top Glove Corporation Invests RM1 Billion in Solar Energy."
53. Source: Petronas. Petronas Sets Target to Reduce Greenhouse Gas Emissions by 30% by 2030. Information derived from the press release "Petronas Sets Target to Reduce Greenhouse Gas Emissions by 30% by 2030."
54. Source: TNB Sustainability Report 2022
55. Source: Sime Darby Plantation Sustainability Report 2022
56. Source: MPOB Annual Report 2022
57. Source: Petronas website. Information derived from the document "Sustainable Development" on the Petronas website.
58. Source: Malaysian Investment Development Authority (MIDA). Launch of the New Industrial Master Plan 2030 (NIMP 2030). Information derived from the webpage "Launch of the New Industrial Master Plan 2030 (NIMP 2030) - MIDA"
59. Source: IRENA website. Information derived from the document 'Renewables Are the Solution to Malaysia's Sustainable Future and Renewed Climate Ambition' on the IRENA website.
60. Source: Bank Negara Malaysia's Low Carbon Transition Facility (LCTF).
61. Source: Kinergy Advancement Berhad. 'Kinergy Advancement - Company Information'. Information derived from the PDF document available at 'https://cdn.kinergyadvancement.com/xCQhH1775.pdf'.

A Comparative Analysis of Renewable & Sustainable Energy Platforms in Malaysia

DARE
DATAMETRICS RESEARCH
AND INFORMATION CENTRE