SAGE

Selangor Agenda for Green Economy 2025 - 2035

VOLUME 1 :
CLEAN ENERGY

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Foreword

As the economic engine of Malaysia, Selangor is proud to present the Selangor Agenda for Green Economy (SAGE) 2025–2035, a bold and forward-looking blueprint for a sustainable, inclusive, and resilient future. This clean energy-focused series serves as the cornerstone of SAGE's comprehensive agenda, highlighting our enduring commitment to a green and prosperous economy.

SAGE lays out our vision to build a low carbon economy, transition to a predominantly sustainable and renewable energy mix by 2045, and cement Selangor's position as a hub for green innovation in Southeast Asia. At the core of this agenda is our commitment to a just transition, ensuring that no community or worker is left behind as we navigate the shift toward a low-carbon economy. SAGE also aligns with our mission to strengthen Selangor's economic growth, energy independence, and global competitiveness, while creating an enabling environment for public and private leadership through supportive policies, incentives, and robust ESG-aligned frameworks.

SAGE is not merely an environmental strategy, it is a vital component of our broader development vision, reinforcing the aspirations of the Malaysia MADANI framework and the Rancangan Selangor Pertama (RS-1). Both frameworks underscore the importance of sustainable development, inclusivity, and innovation, values that SAGE embodies and advances. SAGE unlocks new sources of economic growth through clean energy, green industry, and environmental innovation.

This transition will create jobs, attract international investment, reduce dependency on electricity imports, and reposition Selangor as a leader in sustainable economic development. It is an invitation to reimagine the state's growth trajectory, one that integrates environmental responsibility with social progress and economic resilience.

I am confident that SAGE will serve as a unifying call to action for every stakeholder in Selangor. Let us move forward together with conviction and collaboration, and build a Selangor that is not only prosperous but future-ready, equitable, and truly sustainable for generations to come.

YAB Dato' Seri Amirudin bin Shari

YAB DATO'S MENTERI BESAR SELANGOR

Foreword

The Selangor Agenda for Green Economy (SAGE) 2025–2035 is a strategic and timely response to the specific environmental, social, and economic dynamics faced by our state. With pride, we introduce the first of many concerted efforts within the SAGE framework. It sets the foundation for a broad and enduring economic transition toward sustainability across all sectors.

As Malaysia's most urbanized and industrialized state, Selangor faces a complex energy landscape. We consume over one-third of the country's electricity, yet our generation capacity remains disproportionately low. Our reliance on coal and imported electricity exposes us to economic, environmental, and energy security risks. Addressing these vulnerabilities is not just necessary; it is urgent.

The development of SAGE has been shaped through inclusive and extensive engagement with a wide range of stakeholders. Local authorities across Selangor, key federal ministries, regulatory bodies, and strategic institutions were all consulted. This collaborative approach ensures that SAGE is both practical and responsive to the state's evolving needs. These dialogues have reinforced our commitment to a whole-of-government and whole-of-society approach. We aim to bridge policy intent with local realities, fostering seamless coordination across sectors and levels of governance.

The State Secretary's Office is fully committed to leading the implementation of SAGE through institutional alignment, strategic planning, and capacity building. This is a collective journey that requires the commitment of every community, every business, and every resident in Selangor. Together, we can shape a future where Selangor continues to thrive: an economically vibrant, environmentally resilient, and socially inclusive.

YB Dato Dr Ahmad Fadzli bin Ahmad Tajuddin

YB STATE SECRETARY OF SELANGOR

Foreword

Around the world, economies are accelerating their shift toward low-carbon growth models, driven by the urgency of climate change, energy security concerns, and evolving global trade regulations. Malaysia, too, is charting its course through the National Energy Transition Roadmap (NETR), which outlines clear targets such as achieving 70% renewable energy in the power sector by 2050. As the nation's most industrialized and populous state, Selangor must take decisive steps to align with and lead this national momentum.

In response, the Selangor State Economic Planning Unit (UPEN) has developed the Selangor Agenda for Green Economy (SAGE) 2025–2035, a long-term strategy to redefine Selangor's economic and energy future through sustainability, innovation, and inclusivity. As the foundational phase in a series of strategic endeavors under the SAGE framework, this clean energy-focused roadmap exemplifies Selangor's leadership in advancing a sustainable and innovative economic future. The first phase of SAGE is designed around four strategic levers that shape the energy transition. These include the optimization of brown energy sources such as natural gas, the development of sustainable energy through waste-derived feedstocks, the expansion of renewable energy, and the deployment of energy storage technologies and these levers are supported by seven key enablers.

By 2035, SAGE targets the achievement of a clean energy mix comprising 35% of total power generation. The ambitious targets are underpinned by a suite of strategic initiatives, including five flagship catalysts, GAPS for solar energy, SHORE for hydrogen development, SelGas for natural gas optimization, ISWM for circular solid waste management, and SEL-Hydro for harnessing small-scale hydropower, among other key programs.

SAGE is a reflection of Selangor's proactive approach to building a future-proof economy. It emphasizes long-term planning, inter-agency collaboration, and measurable impact. We call on all stakeholders, public and private, local and global to work hand in hand with us in realizing this vision. Only together can we secure Selangor's place as a national and regional leader in sustainable growth, technological innovation, and environmental stewardship.

YBHG Dato' Johary bin Anuar

DIRECTOR OF SELANGOR STATE ECONOMIC PLANNING UNIT (UPEN)

Executive Summary

Executive summary

Selangor, Malaysia's economic powerhouse and most populous state, plays a pivotal role in advancing the nation's green transition agenda. Home to over 20% of the national population and a major contributor to GDP, Selangor is uniquely positioned to align with and accelerate Malaysia's commitments under national and international climate frameworks. As global momentum for decarbonization intensifies, Selangor stands at a critical juncture to shape its own low-carbon future while supporting Malaysia's broader sustainability goals.

The Selangor Agenda for Green Economy (SAGE) is the state's flagship framework to guide its energy transition over the next decade. It reflects Selangor's strong commitment to becoming a greener, lower-emission state through structured, coordinated, and inclusive action. SAGE sets ambitious, yet achievable targets, aiming to build 7,414 MW of clean energy capacity by 2035, achieve a 35% clean energy share in power generation, and mobilize RM 34 billion in investments to support this transformation.

To realize these outcomes, SAGE is structured around four strategic levers and seven key enablers, each supported by actionable initiatives that cover power generation, energy use, and system resilience. Together, they form an integrated roadmap to transition Selangor from a coal-reliant energy landscape to one that is diversified, resilient, and clean. SAGE also introduces five flagship catalysts, GAPS, SelGas, SHORE, ISWM and SEL-Hydro, each targeting a key area of the energy transition. These initiatives focus respectively on solar energy, natural gas, hydrogen, waste management and hydropower, serving as high-impact drivers to diversify Selangor's energy mix and strengthen system resilience.

Beyond technical targets, SAGE embodies a broader vision for the state: to achieve carbon neutrality, maintain clean energy dominance, become a regional green innovation hub in Southeast Asia, and ensure a just and inclusive transition that benefits all communities. This document is not merely a policy guide, it is a call to action and a shared blueprint for government, industry, and citizens alike to drive Selangor's transformation toward a sustainable and prosperous future.

SELANGOR'S AGENDA

A decade long plan to lead the transition towards a sustainable and carbon neutral future

SECTION 1

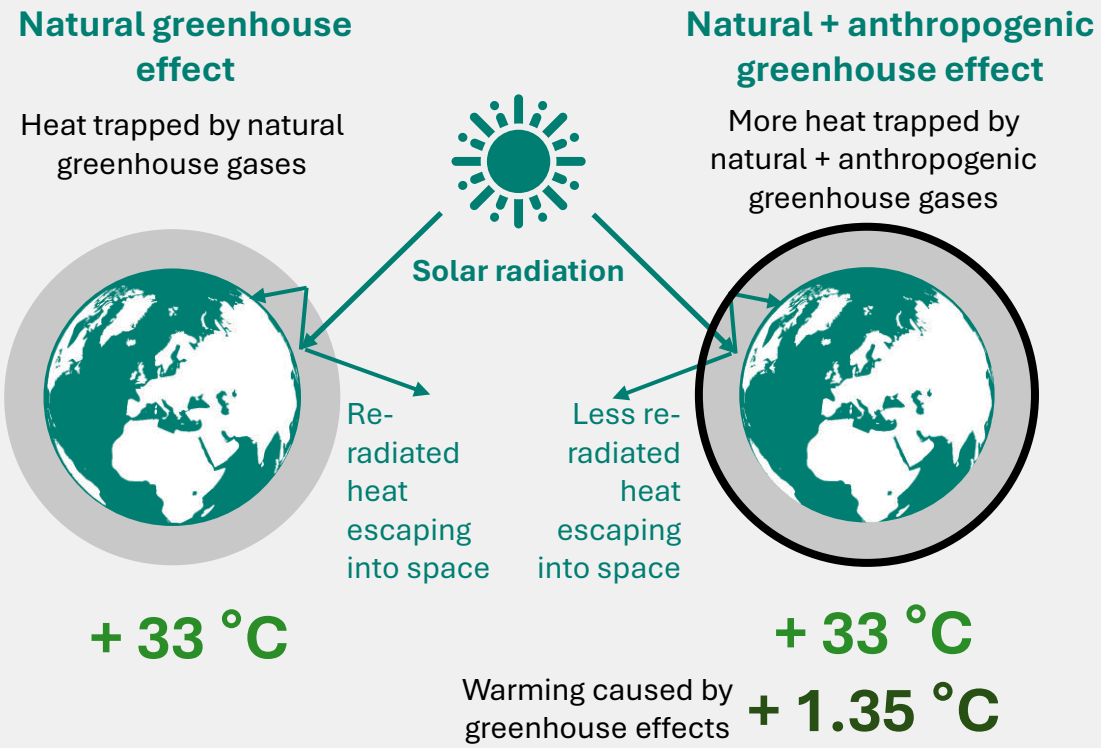
Introduction

SECTION 1

Introduction

1.1 Global efforts toward carbon neutrality

Over the past century, the Earth's atmosphere has experienced an unprecedented rise in greenhouse gas concentrations, largely driven by human activity. Activities such as burning of fossil fuels, deforestation, large-scale agriculture, industrial processes etc. have intensified the release of greenhouse gases, particularly carbon dioxide (CO_2), methane, and nitrous oxide. This is known as the anthropogenic greenhouse effect, causing an additional warming of the Earth of 1.35 °C above pre-industrial average (1850-1900), with carbon dioxide levels surpassing 400 parts per million (ppm) in recorded history.



The natural greenhouse effect, driven by elements like water vapor and naturally occurring levels of CO_2, plays a crucial role in maintaining Earth's temperature, keeping it approximately 33 °C warmer than it would be otherwise. However, human activities, particularly the burning of fossil fuels, have intensified this effect. This anthropogenic greenhouse effect has led to an additional warming of approximately 1.35 °C above pre-industrial levels, contributing significantly to the current climate crisis.

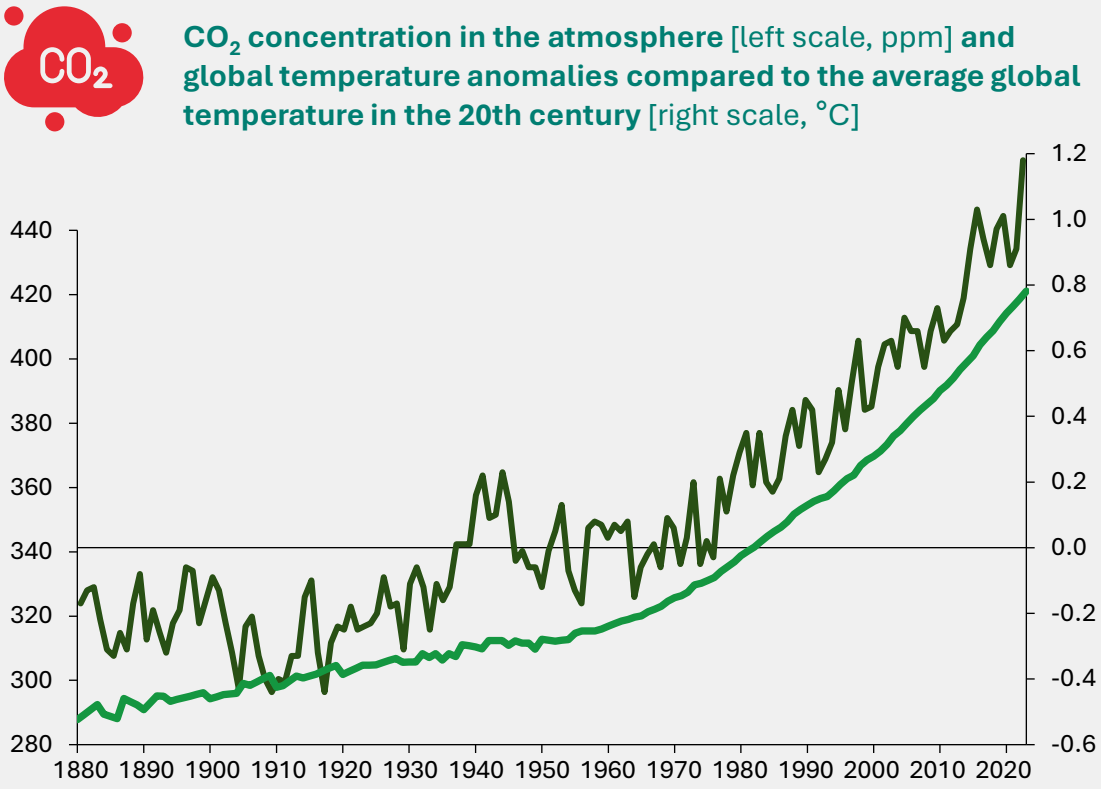


Figure 1.1: Illustrations of green house effect and CO_2/ temperature increase nexus

This trend is accelerating. Since the 1880s, CO_2 levels have risen significantly, but the steepest increases have occurred in the past six decades. In parallel, the Earth's average temperature today has climbed by 1.2 °C above the 20th-century average, a striking reminder of the growing urgency of the climate crisis.

In response to these alarming trends, the international community has mobilized through coordinated efforts to address climate change on a global scale. The Conference of the Parties (COP), held under the United Nations Framework Convention on Climate Change (UNFCCC), plays a central role in this global response. It serves as the primary forum where nations negotiate and commit to collective climate action, setting the direction for emission reductions, adaptation strategies, and financial support.

A defining milestone in this journey was COP21, held in Paris, France in 2015, which led to the adoption of the Paris Agreement. This landmark accord united countries in a shared commitment to limit global warming to well below 2 °C. As of 2023, approximately 138 countries, representing more than 70% of global CO_2 emissions, have pledged to reach net-zero emissions by 2050 or earlier.

Building on the Paris Agreement, COP26 in Glasgow, United Kingdom (2021) resulted in the Glasgow Climate Pact, which called for accelerated action to

Figure 1.2: Overview of COP and Paris Agreement

phase down coal power, reduce methane emissions, and increase climate finance for developing nations. Most recently, COP28 in Dubai, United Arab Emirates (2023) marked another turning point, with the first-ever agreement to explicitly call for a transition away from fossil fuels. It also established a global commitment to reduce greenhouse gas emissions by 43% by 2030, reinforcing the urgency and scale of action required.

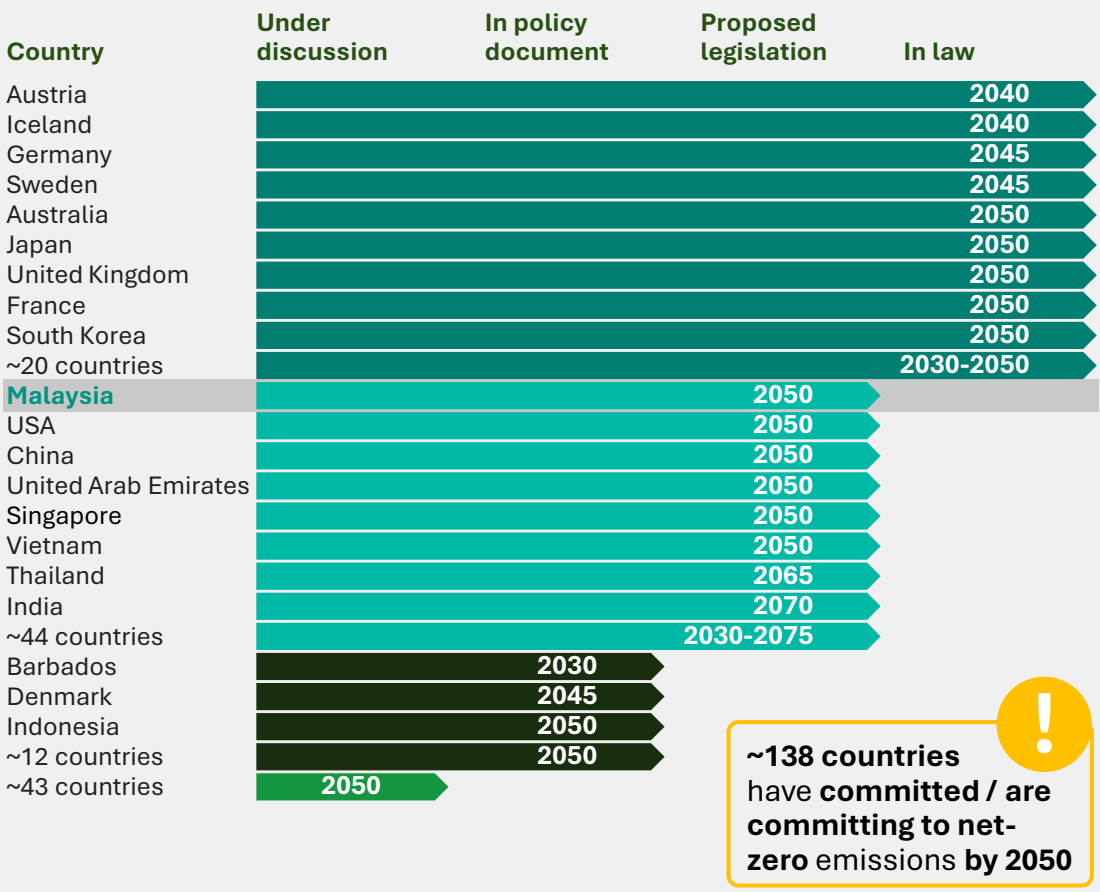


Figure 1.3: Net zero commitments by country

These commitments reflect a broader shift toward low-carbon development pathways, green technologies, and sustainable economic models. Not only are countries putting effort into combating climate change, but corporations around the world are also determined to take action.

The global push toward decarbonization is no longer optional, it is redefining how economies operate, trade, and grow. As countries and corporations commit to net-zero targets, the standards for market access, investment eligibility, and industrial relevance are rapidly evolving. For Selangor, keeping pace with this transition is essential to remain economically competitive and strategically positioned in the global landscape.

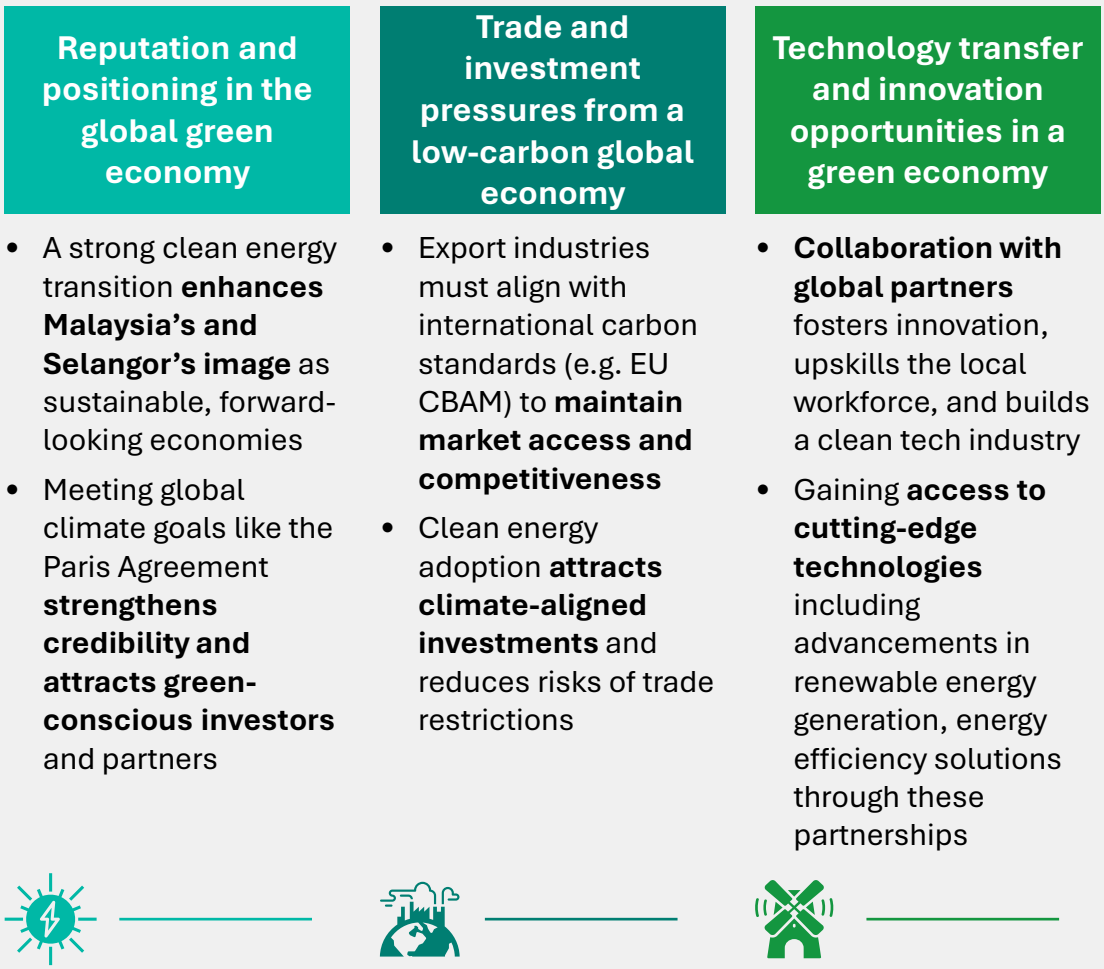


Figure 1.4: Implications of global green economy to Malaysia and Selangor

International climate commitments, such as the Paris Agreement, are setting new expectations for national and subnational actors. Inaction or delay risks reputational setbacks, while alignment with global sustainability trends demonstrates credibility, strengthens investor trust, and affirms Selangor's relevance in an increasingly climate-conscious world.

In addition to that, trade dynamics are shifting, with mechanisms like the EU's Carbon Border Adjustment Mechanism (CBAM) etc. requiring exporters to demonstrate lower carbon footprints. As a key contributor to Malaysia's industrial output and exports, Selangor must ensure its supply chains meet these new requirements to safeguard access to international markets and attract global buyers with net-zero mandates.

The global green transition is accelerating technological innovation. Regions that actively participate gain early access to clean technologies, financing, and knowledge transfer. For Selangor, this means that integrating renewable energy solutions and digital infrastructure is not just beneficial, it is necessary to keep pace with global developments and to build the capacity needed for a resilient, future-ready economy.

1.2 Selangor at a glance

Selangor stands as a key economic engine of Malaysia, contributing around RM 430 billion to the national gross domestic product (GDP) in 2024, which represents approximately 26% of the country's total GDP of RM 1.7 trillion and the state accounts for 34% of Malaysia's manufacturing GDP. This performance reflects a robust annual growth rate of 5.4%, higher than the national average of 5.1%, underscoring the state's critical role in driving national economic resilience. With a population of approximately 7.4 million in 2024, accounting for around 22% of Malaysia's total population, Selangor is not only the most populous state, but also among the most urbanized. Its urbanization rate is already higher than 95%, significantly exceeding the national average of 77% in 2024, and far ahead of the projected national rate of 85% by 2040.

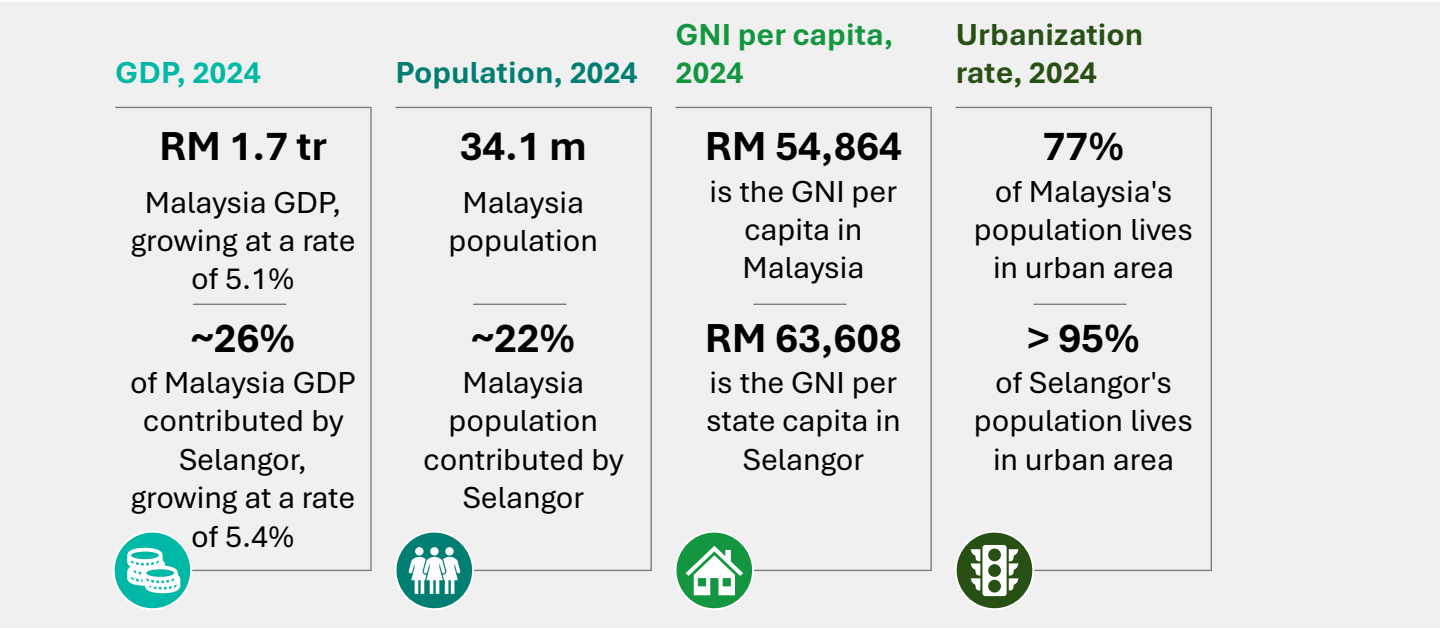


Figure 1.5: Key highlights of Malaysia and Selangor

As the most populous and urbanized state in Malaysia, Selangor plays a central role in driving the nation's economic transformation, from a resource-dependent economy to one rooted in advanced manufacturing, services, and innovation. Often referred to as Malaysia's "industrial state", Selangor hosts some of the country's most strategic economic zones and high-value sectors and has cultivated a strong value chain ecosystem that supports both local enterprises and international investments. Over the past five decades, this industrial strength has driven sustained growth in the state's manufacturing and services sectors, reinforcing its position as a key engine of national economic development. The state is now channelling this industrial strength toward the development of green industrial areas, low-carbon infrastructure, and future-ready sectors such as data centers and semiconductors.

At the same time, changing social dynamics, including rapid urbanization, digitalization, and evolving consumption patterns, are reshaping how communities live, work, and use energy. Building on these shifts, climate risks and environmental pressures add further urgency for a coordinated and inclusive energy transition. For Selangor, balancing economic growth with climate resilience is no longer a distant ideal, it is a strategic necessity for long-term competitiveness, livability, and sustainability.

1.3 Selangor's current energy landscape

Selangor's demographic and economic prominence has positioned it as one of the largest consumers of power in Malaysia. The state is home to a diverse and high-value industrial base, with strategic sectors including automotive, electronics, logistics, aerospace, and pharmaceuticals, etc. These industries are inherently energy-intensive and, when combined with the needs of a highly urbanized and densely populated population, contribute to Selangor's significant power demand.

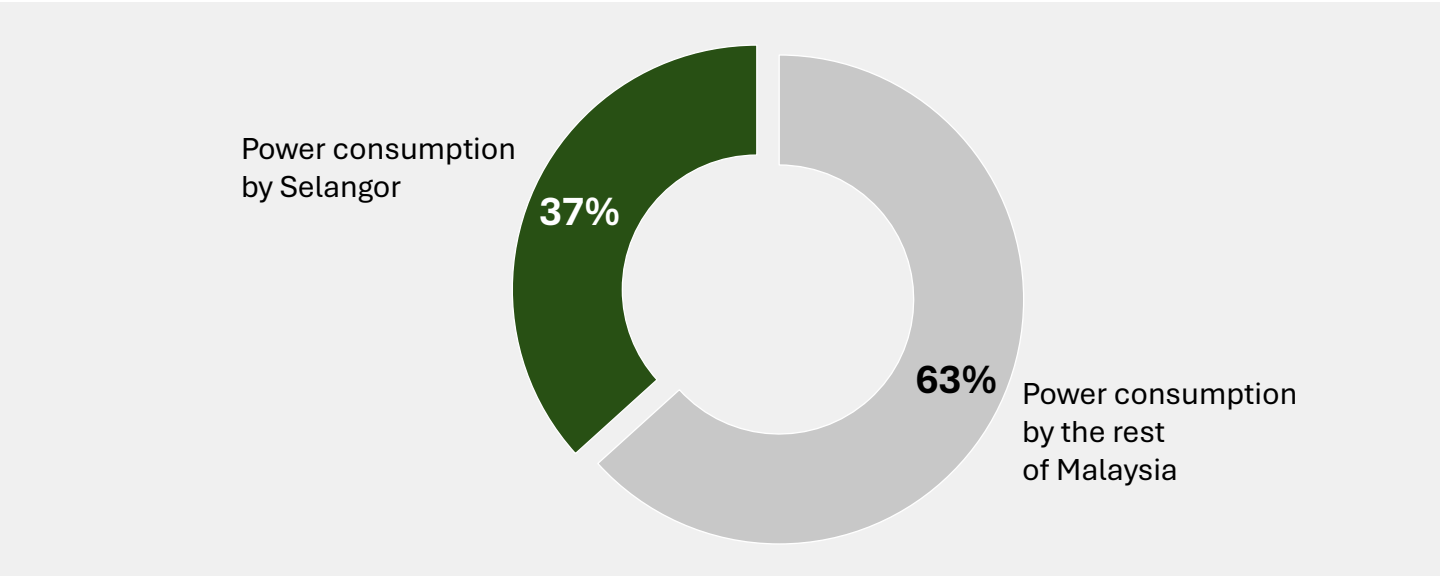


Figure 1.6: Power consumption in Malaysia, 2024 [%]

In 2024, Selangor accounted for approximately 37% of the country's total power consumption, equivalent to over one-third of Malaysia's 192 terawatt-hours (TWh) of annual energy demand, and represented nearly 78% of energy usage within the Klang Valley region. This upward trend in energy use is not only a reflection of economic and population growth, but also of the evolving patterns of urban living, digitalization, and increased demand for mobility and connectivity.

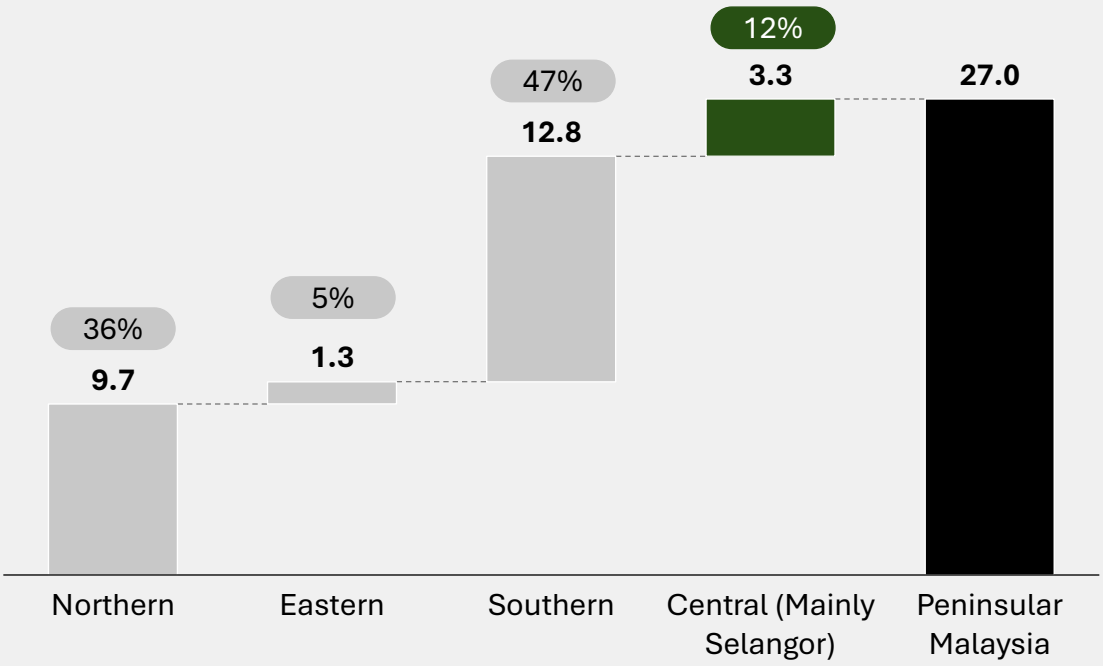


Figure 1.7: Total power generation capacity by regions, 2023 [GW; %]

Despite being Malaysia's economic powerhouse, Selangor remains energy-deficient at the local level. The central region generated only 3.3 GW of power, just 12% of Malaysia's total generation capacity of approximately 27 GW. In comparison, the southern region produced 12.8 GW, the northern region 9.7 GW, and the eastern region 1.3 GW. This mismatch between Selangor's high power consumption and limited local generation reveals a structural vulnerability in its power system, raising concerns over energy security, grid resilience, and supply efficiency. The persistent imbalance underscores the urgent need for strategic planning to enhance Selangor's energy self-sufficiency.

In terms of power mix, Selangor's power generation is significantly more carbon-intensive than the national average. Coal is dominating the state's power generation profile, making up approximately 91% of the mix,substantially higher than the Peninsular Malaysia's 55%. Natural gas is contributing just 8% in Selangor, compared to Peninsular Malaysia's 38%, while renewable energy is accounting for only 1%, well below Peninsular Malaysia's 6% share.

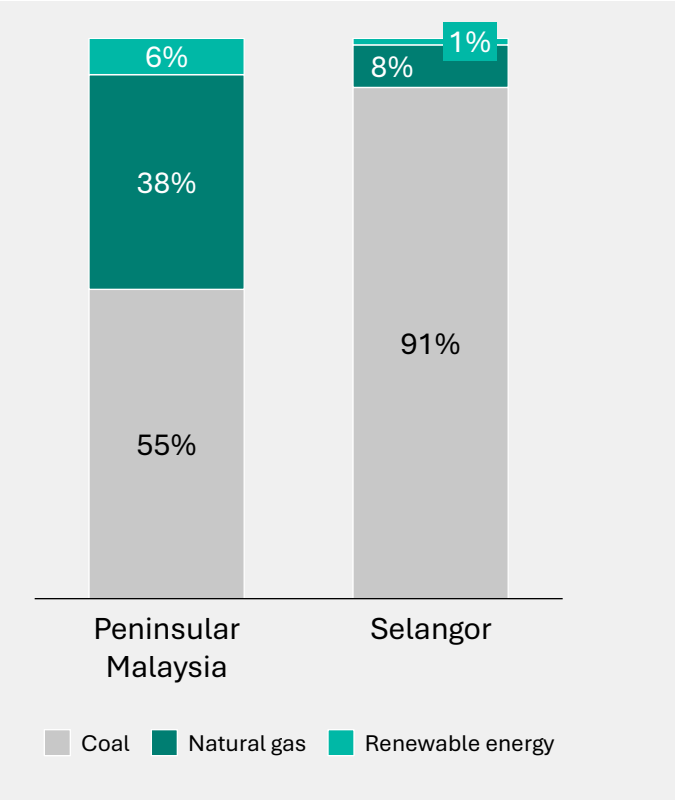


Figure 1.8: Power generation mix in Peninsular Malaysia and Selangor, 2024 [GWh]

This imbalance underscores a pressing need for diversification, particularly as Selangor continues to evolve as a key industrial and economic center. Continued dependence on coal may impede alignment with national and global decarbonization goals. Strengthening the share of renewables and cleaner energy sources in Selangor's future energy mix presents a critical opportunity to advance its green economy transition, enhance energy resilience, and support Malaysia's broader climate commitments.

SECTION 2

Case for Selangor’s clean energy development

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Case for Selangor's clean energy development

The government is actively working to transition Malaysia toward a clean energy-powered future and achieve its net-zero emissions target. Roadmaps such as National Energy Transition Roadmap (NETR) and initiatives include programs such as Large Scale Solar (LSS) and CRESS, which serve as actionable steps toward building a green economy.

Currently, the central region of Malaysia faces an energy deficit of approximately 33% and relies heavily on electricity imports from the northern and southern regions to meet demand, which will worsen as two power plants retire in 2026 and 2029.

In Selangor, coal accounts for around 91% of total power generation currently, contributing to an estimated 59.2 $MtCO_2e$ in annual carbon emissions.

At the same time, Selangor is attracting energy-intensive developments such as data centers, currently hosting around 50% of Malaysia's total which contribute to rising electricity demand. This demand is expected to grow even further with major upcoming projects, including a new port city and a business district. These developments are set to significantly accelerate the state's energy needs.

In light of these challenges and opportunities, Selangor's transition to cleaner energy is both timely and strategic, supporting economic growth, job creation, environmental sustainability, and long-term energy security.

2.1 Alignment with national agenda

Malaysia's transition toward a renewable energy future is anchored in a series of national policies, legislative frameworks, and economic instruments aimed at reducing emissions and promoting clean energy.

Foundational legislation

Environmental Quality Act 1974

Set standards for emissions for industrial processes, which directly contribute to decarbonization efforts

Renewable Energy Act 2011

Promotes the generation of clean energy through a feed-in tariff system, incentivizing companies to invest in renewable energy sources

Energy Efficiency and Conservation Act 2024 (Act 861)

Aims to improve energy efficiency, reduce energy waste, and support Malaysia's environmental goals

Strategic roadmaps

Malaysia Renewable Energy Roadmap (MyRER)

Outlines Malaysia's medium-term target — 31% of RE installed capacity by 2025 and 40% by 2035

National Energy Transition Roadmap (NETR)

Outlines Malaysia's strategy for achieving net-zero emissions by 2050

Future policies

Carbon Tax (2026)

Targeted at high emission industries; is designed to encourage companies to adopt cleaner energy

Scope 3 Emissions Reporting (2027)

To ensure accountability and enforce transparency; required disclosure of scope 3 emissions starting 2027

At the foundation is the Environmental Quality Act 1974 (EQA 1974), which sets the legal basis for environmental protection, including requirements for environmental impact assessments (EIAs) and pollution control. This ensures that all energy projects, including renewable ones, comply with environmental safeguards. Complementing this is the Renewable Energy Act 2011 (REA 2011), which promotes the adoption of renewable energy through mechanisms like the Feed-in Tariff (FiT), encouraging private sector investment in solar, biomass, and small hydroelectric power. Similarly, the

Figure 2.1: Malaysia's key policies and roadmaps focused on energy and environmental sustainability

Energy Efficiency and Conservation Act 2024 was introduced to improve energy efficiency, reduce energy waste, and support Malaysia's environmental goals, including achieving carbon neutrality by the year 2050. The Act targets major energy users in the industrial and commercial sectors, namely, companies and buildings that consume 21,600 gigajoules (GJ) or more of energy annually as well as selected buildings and energy-using products. To provide strategic direction, the Malaysia Renewable Energy Roadmap (MyRER) outlines clear targets and pathways to increase renewable energy capacity to 31% by 2025 and 40% by 2035. It focuses on expanding net energy metering, enhancing grid infrastructure, and supporting new business models such as corporate power purchase agreements. Building on MyRER, the National Energy Transition Roadmap (NETR) takes a broader approach. It elevates MyRER's goals within a wider framework that includes energy efficiency, green mobility, and emerging technologies such as green hydrogen and carbon capture. The NETR acts as an umbrella strategy, coordinating efforts across sectors and guiding legislative and investment reforms.

To further drive change, Malaysia plans to introduce a carbon tax in 2026, aimed at high-emission sectors. This measure is expected to channel funding into clean energy projects and support broader transition initiatives under the NETR. In addition, mandatory Scope 3 emissions reporting from 2027 will enhance corporate accountability by requiring businesses to disclose indirect emissions across their value chains. Together, these frameworks form a cohesive and

reinforcing system that supports Malaysia's path toward a low-carbon, climate-resilient energy future.

The development of the Selangor Agenda for Green Economy (SAGE) is in alignment with broader national and state-level planning frameworks. At the federal level, the Twelfth Malaysia Plan (2021–2025) serves as a key reference, with its emphasis on shared prosperity, inclusivity, and environmental sustainability. It outlines cross-cutting strategies such as advancing a low-carbon economy, strengthening green growth enablers, and building climate resilience, all of which directly inform SAGE's goals. Similarly, at the state level, Rancangan Selangor Pertama provides a strategic foundation for SAGE, particularly through its sustainability pillar that focuses on green economic growth, climate action, resource efficiency, and environmental conservation. These overarching plans ensure that SAGE is not developed in isolation, but is firmly rooted in Selangor's and Malaysia's broader long-term development and sustainability agenda.

Several national policies and roadmaps are also supporting Selangor's and Malaysia's broader energy transition efforts, including the Hydrogen Economy & Technology Roadmap (HETR), the upcoming CCUS Bill, and the National Biomass Strategy Action Plan 2023–2030. These initiatives reflect the government's strong commitment to achieving its environmental and climate goals.

Complementing these key policies and Malaysia's broader energy transition agenda are several strategic policy frameworks developed by various ministries, including:

- The Ministry of Natural Resources, Environment and Climate Change (NRECC) has developed key frameworks including the Nationally Determined Contribution (NDC) Roadmap, Long-Term Low Emissions Development Strategies (LT-LEDS), and the Malaysian Electricity Supply Industry (MESI) to guide the country's decarbonization path.
- The Ministry of Finance (MOF) has introduced a Carbon Pricing Instrument to incentivize emissions reductions.
- Under the leadership of Ministry of Investment, Trade and Industry (MITI), strategic documents such as the National ESG Industry Framework, New Industrial Master Plan (NIMP), and Chemical Industry Roadmap (CIR) aim to align industrial growth with sustainability goals.
- The Ministry of Science, Technology and Innovation (MOSTI) has charted the Hydrogen Economy and Technology Roadmap (HETR) to position Malaysia in the emerging global hydrogen economy.
- The Ministry of Plantation and Commodities (KPK) supports the bioeconomy through its National Biomass Action Plan.

In line with these national policies, the Malaysian government has introduced a range of targeted programs to accelerate the uptake of renewable energy across residential, commercial, and industrial sectors.

Residential

- **Net Energy Metering Scheme (NEM 3.0)**
  - Allowing consumers to install solar PV systems and offset their electricity bills by exporting excess energy to the grid
  - **NEM Rakyat**, which targets residential users has been allocated a total quota of 600 MW
- **Community Renewable Energy Aggregation Mechanism (CREAM)**
  - Maximizing **residential rooftop solar potential** by enabling homeowners to lease or rent out their rooftops to third parties for solar power generation

Commercial/ Industrial

- **Net Energy Metering Scheme (NEM 3.0)**
  - **NEM NOVA**, which targets commercial/ industrial sectors has been allocated a total quota of 1700 MW
- **Green Technology Financing Scheme (GTFS 4.0)**
  - Providing RM 1.0 billion in **financial support** for renewable energy producers and consumers, offering a 1.5% interest/profit rebate and a 60%–80% government guarantee on financing
- **Corporate Renewable Energy Supply Scheme (CRESS)**
  - Third-party access guideline that allows renewable energy developers to **sell power directly to commercial users** at negotiated tariffs

Policy applies to both residential and commercial/ industrial:

- **Large Scale Solar (LSS)**
  - Solar plants **generating electricity** that is fed into the national grid, contributing to Malaysia's overall RE capacity

Figure 2.2: Malaysia government's initiatives targeting residential and commercial/ industrial users

On the residential front, the Net Energy Metering 3.0 (NEM 3.0) scheme allows homeowners to install rooftop solar photovoltaic (PV) systems and offset their electricity bills by exporting surplus energy back into the grid. Under this scheme, NEM Rakyat is tailored specifically for residential users, with a total allocation of 600 MW, available until June 2025.

Supporting wider community participation, the Community Renewable Energy Aggregation Mechanism (CREAM) enables households without upfront capital to lease their rooftops to third-party solar developers, maximizing rooftop solar potential while creating new economic opportunities for homeowners.

In the commercial and industrial sectors, the NEM NOVA scheme facilitates self-generation and energy export for businesses, backed by a 1,700 MW quota allocation. To further drive private sector participation, the Green Technology Financing Scheme (GTFS 4.0) provides financial incentives for renewable energy projects and energy service companies, including a 1.5% rebate on interest or profit for the first five to seven years, along with 60 - 80% government-backed guarantees on approved financing. As of July 2023, GTFS 4.0 is supported by a RM 1 billion fund available through December 2025 or until fully utilized.

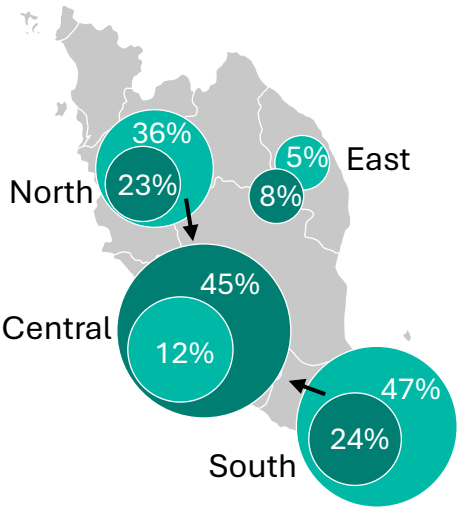
One of the most significant upcoming developments is the Corporate Renewable Energy Supply Scheme (CRESS). This mechanism introduces third-party access to the national grid, allowing renewable energy developers to contract directly with commercial end-users. Developers and buyers can negotiate energy prices independently, while the grid, operated by Tenaga Nasional Berhad (TNB), will be used to transmit the electricity under a regulated wheeling charge. CRESS represents a transformative shift in how clean electricity can be traded and delivered in Malaysia, paving the way for more flexible and market-driven energy procurement models.

Electricity generated from Large Scale Solar (LSS) projects ultimately flows to residential, commercial, and industrial end-users via the national grid. At the utility scale, the LSS program supports the development of solar farms that significantly boost Malaysia's renewable energy capacity. The latest round, LSS5, continues to drive this momentum by attracting private sector investment in clean power generation.

These national-level efforts create both external pressure and strategic urgency for Selangor to align with the country's clean energy trajectory. As Malaysia moves decisively toward a low-carbon economy, Selangor, being the nation's industrial and economic hub, faces increasing expectations to reduce its emissions footprint, modernize its energy systems, and remain competitive. National targets such as the 70% renewable energy share by 2050, along with upcoming regulations like carbon pricing and mandatory emissions reporting, will directly impact industries concentrated in Selangor. To stay ahead, the state must proactively transition its economy, infrastructure, and investment landscape toward greener, more sustainable models.

2.2 Over-reliance on import energy from the northern and southern regions

Malaysia's central region, which includes Selangor, currently faces an energy deficit of approximately 33%, which will worsen as two power plants retire in 2026 and 2029, increasing its heavy reliance on power imports from the northern and southern regions to meet its growing demand.



Share of generation installed capacity | Share of power demand | Power flow

Eastern

1. Pergau Power Station (PGAU)
2. S.J Ulu Terengganu (HTRG)
3. Sultan Mahmud Power Station (KNYR)

1.3 GW

Central

1. Kuala Langat Power Plant Sdn. Bhd. (KLPP) **expiring 2026**
2. Kapar Energy Ventures Sdn. Bhd. (PKLG) **expiring 2029**
3. TNB Connaught Bridge Sdn. Bhd. (CBPS) Not Dispatching
4. Pulau Indah Power Plant Sdn. Bhd. (PIPP) with 1.2 GW, to begin commissioning in 2025

3.3 GW

Northern

1. GB3 Sdn. Bhd. (SGB3)
2. Gelugor Power Station (GLGR)
3. Prai Power Sdn. Bhd. (SKSP)
4. S.J Bersia (BSIA)
5. S.J Chenderoh (CEND)
6. S.J Kenering (KNRG)
7. S.J Lower Piah (LPIA)
8. S.J Sultan Idris (SIHY)
9. S.J Sultan Yusof (SYHY)
10. S.J Temenggor (TMGR)
11. S.J Ulu Jelai (UJLI)
12. S.J Upper Piah (UPIA)
13. Segari Energy Venture Sdn. Bhd.
14. TNB Janamanjung Sdn. Bhd. TNB
15. Janamanjung Sdn. Bhd. TNB
16. Manjung Five Sdn. Bhd.
17. TNB Prai Sdn. Bhd. (NPRI)
18. Teknologi Tenaga Perlis Consortium Sdn. Bhd. (PLPS)

9.7 GW

Southern

1. Jimah East Power Sdn. Bhd. (JMHE)
2. Jimah Energy Ventures Sdn. Bhd.
3. Panglima Power Sdn. Bhd. (PGLA)
4. Pengerang (PCGP)
5. Tanjung Bin Energy Sdn. Bhd.
6. Tanjung Bin Power Sdn. Bhd. (TBIN)
7. Tunku Ja'afar Power Station
8. Tunku Ja'afar Power Station
9. Southern Power Generation S/B
10. Edra Energy Sdn Bhd (EMPP)

12.8 GW

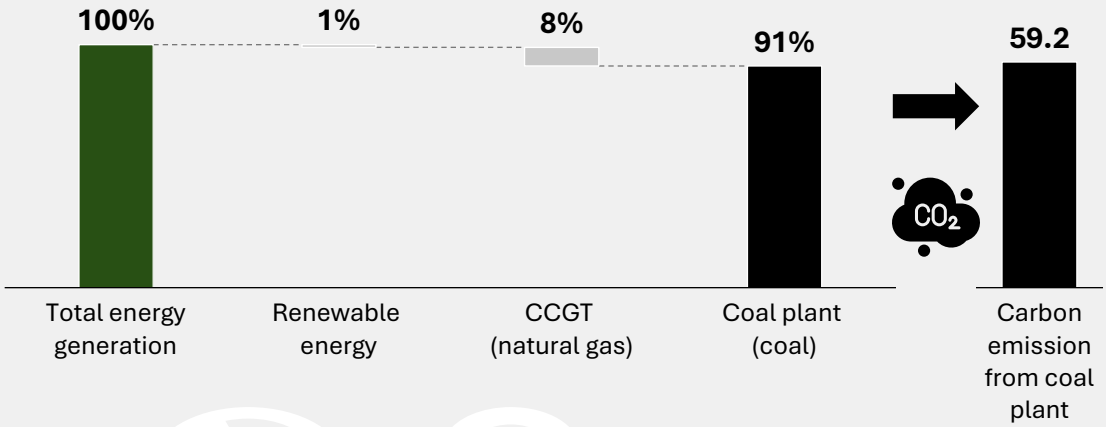
Total: 27.0 GW

Figure 2.3: Geographical distribution of energy demand and generation capacity in Malaysia

Although the central region accounts for nearly 45% of Peninsular Malaysia's electricity consumption, it holds only 12% of the country's total installed generation capacity, approximately 3.3 GW out of 27 GW and 2 of the main power plants in Selangor is expiring in 2026 and 2029. In contrast, the northern and southern regions, which consume just 23% and 24% respectively, host 36% and 47% of national generation capacity. This geographic imbalance underscores the urgent need for Selangor to strengthen its local energy supply. As industrial growth, urbanization, and large-scale developments continue to drive demand, building energy self-sufficiency, particularly through clean sources, will be essential to ensuring long-term energy security, grid resilience, and sustainable development.

2.3 Selangor's carbon footprint reduction

Selangor's power mix remains heavily dependent on coal, which is expected to account for approximately 91% of the state's power generation.



59.2 million tCO_2e emitted annually is equivalent to

~20% of Malaysia's carbon emission

or

Carbon emissions from **11 m** of ICE cars

Figure 2.4: Power generation mix and carbon emissions in Selangor, 2024 [%, $MtCO_2e$]

Cleaner sources such as solar panels, small hydro, and waste-to-energy, are contributing only 1% combined, while natural gas via combined cycle gas turbines (CCGT) is supplying around 8%. Based on this power mix and demand, Selangor's carbon emissions is around 59.2 $MtCO_2e$ which is equivalent to more than 20% of Malaysia's carbon emissions or annual carbon emissions from 11 million of cars. This high-emission outlook reflects the state's continued reliance on coal as the dominant baseload power source in Peninsular Malaysia. The data underscores an urgent need for a strategic pivot toward cleaner energy alternatives to significantly reduce emissions, enhance sustainability, and align with national and global decarbonization targets.

2.4 Energy-guzzler developments in Selangor

Selangor's role as Malaysia's leading industrial and digital hub is reflected in its concentration of high-energy developments.

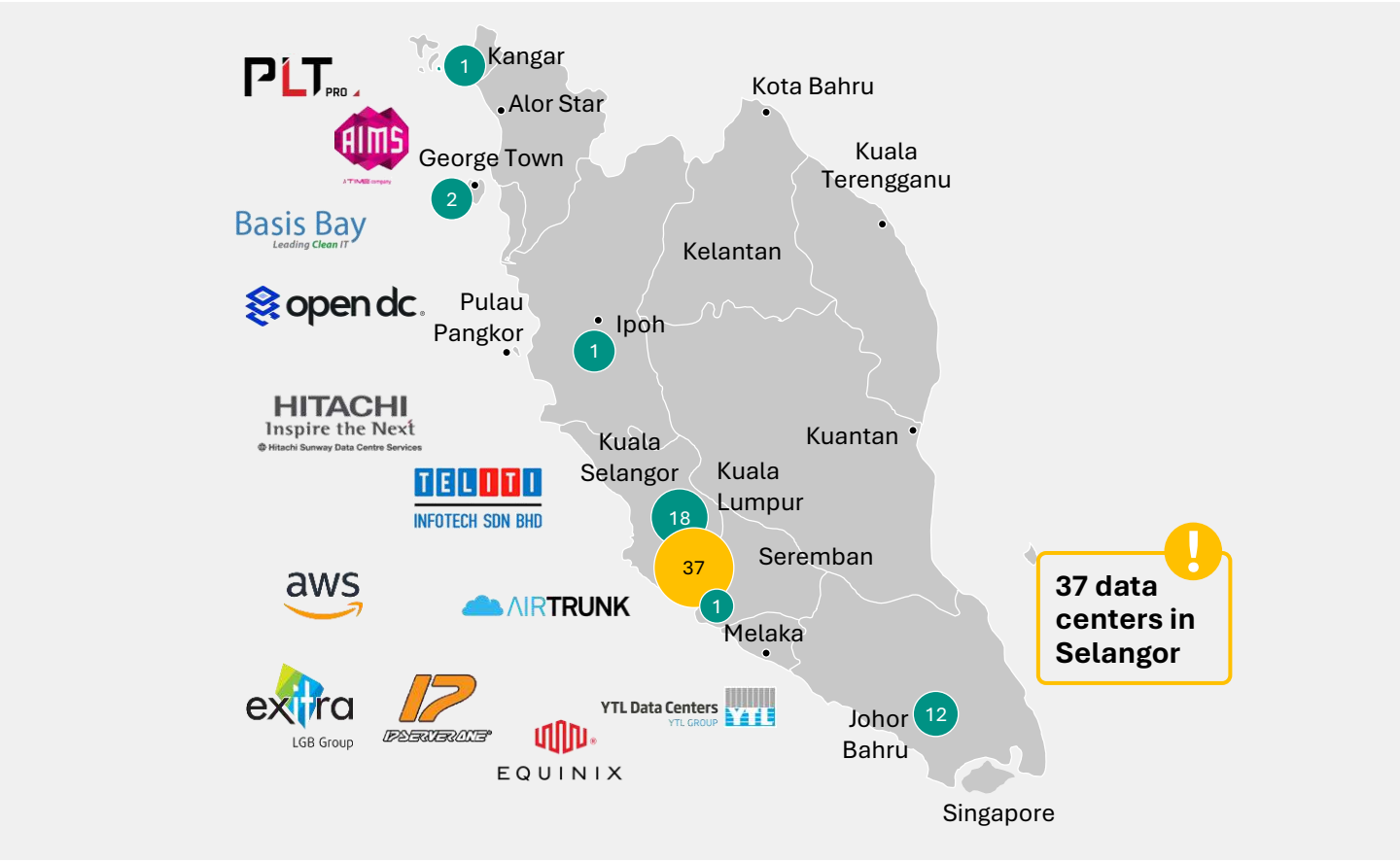


Figure 2.5: Geographic distribution of data centers across Malaysia

The state hosts 37 out of Malaysia's 73 data centers, making it the most data center-dense state in the country. Malaysia's appeal as a data center destination is underpinned by its stable electricity supply, strategic location, competitive costs, and availability of land. These advantages have attracted major players such as AWS, YTL, Princeton Digital Group, and Exabytes, who have already established a presence in Malaysia's data center landscape.

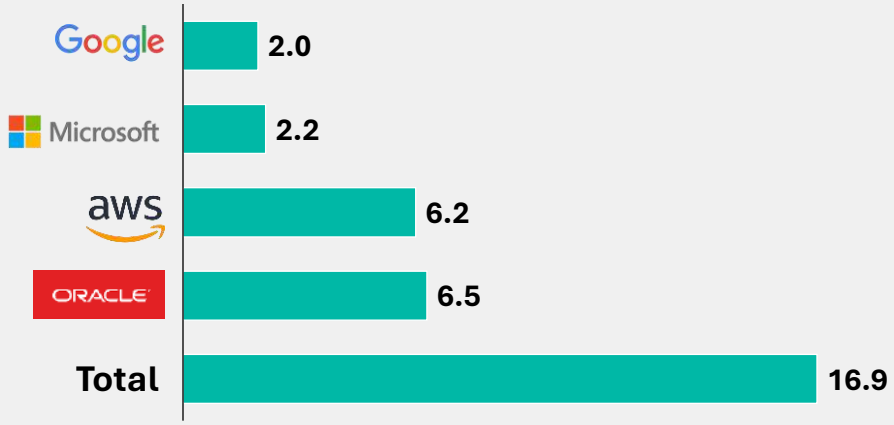


Figure 2.6: Investments by tech giants in data centers in Malaysia [USD bn]

In parallel, global tech giants including Google, Microsoft, Oracle, and AWS have pledged USD 16.9 billion in investments to expand their digital operations across the country.

Data centers are inherently energy-intensive, consuming large amounts of electricity to support continuous server operations, advanced cooling systems, and uninterrupted connectivity.

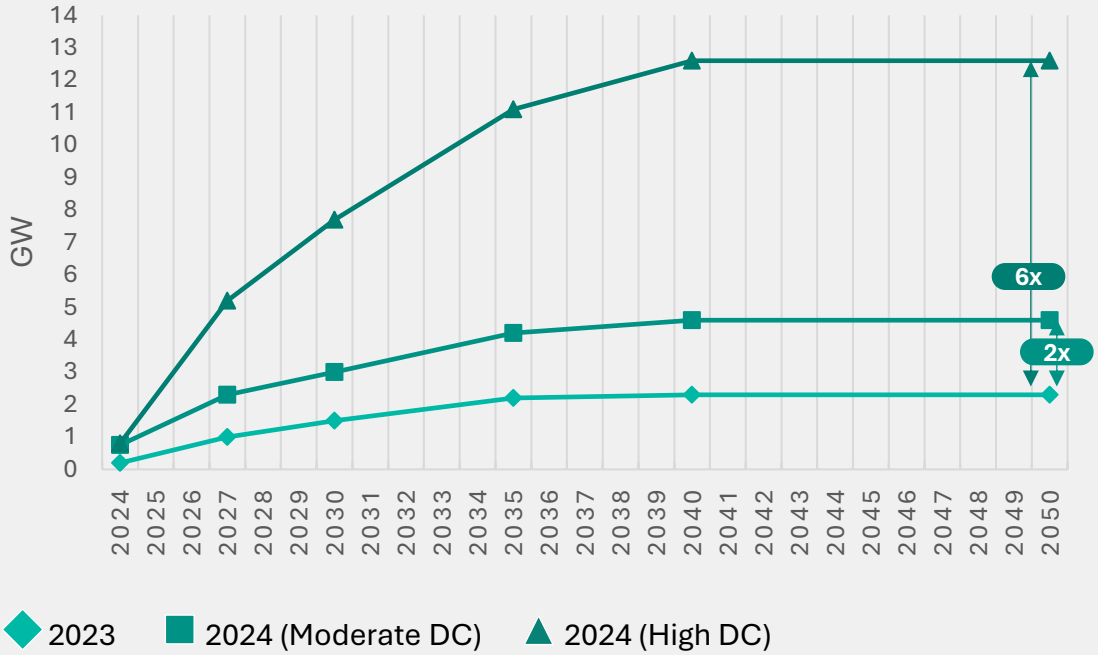


Figure 2.7: Power demand projection of Malaysia in different scenarios, 2024-2050

Key notes

- **Moderate Data Center** scenario is derived from TNB on data center demand (excluding pre-consult phase)
- **High Data Center** scenario encompassed all stages (pre-consult, supply application, ESA signed)
- Selangor is home to 37 out of Malaysia's 73 data centers, more than 50% of the total

Electricity demand from this sector could double under the moderate data center scenario, which exclude data centers at the pre-consultation stage. While the high data center scenario , includes all stages of development, from pre-consultation through to signed electricity supply agreements (ESAs), and indicates a potential sixfold increase in demand if all proposed projects become operational.

Beyond digital infrastructure, Selangor is pursuing several large-scale developments that are expected to significantly increase electricity demand.

Carey Port City

Heavy machinery & equipment, cold storage & warehousing, lighting & security systems 24/7 in operation

Shah Alam (SA) Sentral

High-rise buildings that require extensive HVAC (heating, ventilation, air conditioning), lighting, & elevator systems and office IT infrastructure

Figure 2.8: Other energy-guzzler developments in Selangor

One such initiative is the Carey Island mega port, a RM 28 billion project will require 24/7 power supply to support its operations. These include heavy-duty cranes and port machinery, extensive cold storage facilities, and warehouse logistics systems that demand constant energy to maintain optimal conditions and security.

Furthermore, Selangor is developing SA Sentral, a RM 3 billion business district in Shah Alam, which will be characterized by dense clusters of high-rise commercial buildings. These structures typically consume large volumes of electricity to power heating, ventilation, and air conditioning (HVAC) systems, elevators, extensive lighting, and digital infrastructure to support modern office operations. Collectively, these upcoming projects represent a substantial and sustained increase in baseline electricity consumption, underscoring the urgency for Selangor to build a resilient, low-carbon energy system capable of supporting its ambitious development agenda.

2.5 Benefits of energy transition for Selangor

Economic Growth

Transitioning to renewable energy enhances Selangor's appeal to multinational corporations and foreign investors, positioning it as a regional hub for green innovation. A cleaner energy profile enhances Selangor’s attractiveness to multinational corporations and foreign direct investors that prioritize Environmental, Social, and Governance (ESG) commitments. Embracing clean energy opens new markets in solar technology, electric mobility, and energy storage, diversifying Selangor’s economy and reinforcing its long-term resilience. As part of its vision to become Southeast Asia’s leading green innovation center, Selangor aims to attract sustainable businesses and foster a thriving ecosystem of climate-forward industries.

Job Creation

The shift toward a green economy is expected to generate significant employment opportunities across various sectors. Based on NETR's and MyRER's estimate on the job creation opportunities, the Selangor state government's efforts to build the capacity of the green workforce are expected to create approximately 26,000 jobs in the green economy transition. Roles are expected to emerge from industries directly and indirectly linked to the green transition. These opportunities will span installation, operations, maintenance, and technology development, supporting long-term upskilling and workforce transformation.

Environmental Impact

By reducing reliance on fossil fuels, particularly coal and Selangor’s clean energy transition supports significant reductions in greenhouse gas emissions. The state’s goal of achieving carbon neutrality by 2050 aligns with national and global climate commitments. With plans to fully phase out coal by 2045, Selangor is laying the groundwork for a cleaner, more sustainable environment. Renewable energy projects also tend to have a lower ecological footprint, helping to preserve ecosystems and promote biodiversity conservation.

Energy Security

Scaling up local renewable energy generation enhances Selangor’s energy security by decreasing dependence on electricity imports from other regions. Currently, Selangor contributes around 12% of Malaysia’s total power generation capacity, despite accounting for 45% of the national electricity demand. A more diversified and renewable-heavy energy mix will improve the stability of Selangor’s energy supply by reducing reliance on external sources, reduce exposure to fossil fuel price volatility, and provide a more stable foundation for long-term economic planning and energy resilience.

Summary of Benefits

1

Economic growth

- A cleaner energy profile enhances Selangor's attractiveness to multinational corporations and foreign direct investors that prioritize Environmental, Social, and Governance (ESG) commitments
- Clean energy opens new markets in solar, electric vehicles, and storage sectors

2

Job creation

- SAGE's clean energy transition is expected to create around 26,000 jobs from the spillover effects anticipated to generate direct and indirect employment opportunities across related sectors
- Green projects provide opportunities for upskilling and new long-term employment opportunities

3

Environmental impact

- Adoption of renewable energy reduce CO_2 emissions, helping Malaysia reach Net Zero by 2050
- Renewable energy has a lower environmental footprint, preserving ecosystems

4

Energy security

- Developing local renewable energy reduces reliance on power imports from other states
- A diverse energy mix strengthens the resilience of the grid
- Reduced dependency on fossil fuels lowers exposure to price fluctuations

Figure 2.9: Benefits of energy transition for Selangor

Selangor's transition to clean energy stands to deliver wide-ranging socioeconomic and environmental gains. By embracing cleaner energy sources, the state can attract greater investment, create tens of thousands of jobs, and reduce its carbon footprint while enhancing energy security. These outcomes will not only future-proof Selangor's economy but also position it as a leader in Malaysia's green growth journey.

Image by Afham Hamsyari

SECTION 3

Selangor Agenda for Green Economy (SAGE) Roadmap 2025-2035

SECTION 3

Selangor Agenda for Green Economy (SAGE) Roadmap 2025-2035

The Selangor Agenda for Green Economy (SAGE) is the state's strategic framework for advancing a sustainable, low-carbon future. Its vision focuses on building a low carbon economy, boosting the clean energy foundation, becoming a hub for green innovation, and ensuring a just and inclusive energy transition. Aligned with this vision, SAGE's mission is to drive Selangor's green economy development, with clean energy as the foundation, while maximizing its economic, environmental & social benefits. To guide implementation, SAGE is anchored by five core principles that ensure the transition is effective, efficient, just, and strategically directed.

SAGE outlines clear and measurable targets that support its state-level goals. By 2035, Selangor aims to achieve 7,414 MW of clean energy capacity, 35% of clean energy mix, and attract RM 34 billion in investment. SAGE's 2035 targets are generally aligned with, if not on track to achieve, Malaysia's overall energy transition goals. They represent a strong and proactive commitment to sustainable development and clean energy leadership.

These goals are operationalized through four strategic levers: brown energy, sustainable energy, renewable energy, and energy storage system.

- Brown energy refers to power derived from fossil fuels. Natural gas and green CCGT are key drivers within the brown energy supporting the energy transition. Selangor's contribution to the national energy transition includes developing a natural gas supply capacity of 3 MTPA by 2035, alongside the deployment of 5,775 MW of green CCGT capacity.
- Sustainable energy converts waste or by-products from human activities into energy. In Selangor, this involves WTE facilities with capacities of 158 MW, establishing anaerobic digesters with a capacity of 2.6 MW, operating POME biogas power plant with 30 MW capacity and deploying landfill gas engines with a generation capacity of 4.8 MW.
- Renewable energy in Selangor is being scaled across a mix of natural sources that are continuously replenished. The state's targets include 1,330 MW from solar PV systems, 36.6 MW from run-off-river hydropower ,15 MW from geothermal energy and 2 MW from wind power.
- For energy storage systems, Selangor plans to deploy a battery energy storage system with a capacity of 400 MWh and hydrogen production of 800 kg per day and a pumped storage system with a capacity of 60 MW.

Each of the four levers is supported by its own set of initiatives and projects that are designed to accelerate Selangor's energy transition. Together, they reflect a holistic and strategic approach to building an inclusive green economy, anchored in clear priorities and accountable action.

SAGE outlines seven key enablers, each designed to accelerate Selangor's low-carbon transition through targeted interventions across systems, sectors, and institutions.

- Green infrastructure serves as the backbone of the state's energy transition, covering critical systems such as CCUS technologies and advanced grid infrastructure.
- Selangor is also transforming its transport sector by promoting EV adoption, expanding charging networks, encouraging the use of alternative fuels, and increasing greener mobility options.
- Green workforce and literacy development focuses on cultivating a skilled, future-ready labor force while raising public awareness of sustainable practices.
  - With Selangor's workforce currently numbering around 4 million and growing at a 2% compound annual growth rate, SAGE is projected to generate approximately 26,000 green jobs, representing about 0.7% of the state's total labor force.
- Green optimization & energy efficiency reduces overall energy use by minimizing consumption, optimizing processes, and encouraging behavioral change.
- A robust and forward-looking green policy and incentives forms the foundation of Selangor's green economy agenda.
- Green reporting enhances transparency, strengthens accountability, and builds market confidence towards Selangor's green economy ambition.
- Finally, green finance and investment mobilize the capital required to scale renewable energy, boost energy efficiency, and deploy clean technologies.

Each project under the four strategic levers and seven enablers of SAGE will be implemented in three phases leading up to 2035.

3.1 Vision and mission

As outlined in Figure 3.1, SAGE's vision is to build a future-ready, low-carbon Selangor by becoming a leader in clean energy, green innovation, and inclusive economic development. This vision is anchored by four key ambitions: achieving carbon neutrality by 2050, transitioning to a predominantly clean energy mix by 2045, and reducing reliance on fossil fuels, especially coal. SAGE also aspires to establish Selangor as a green innovation hub in Southeast Asia, fostering a vibrant ecosystem of sustainable businesses and technologies. Just as importantly, it upholds the principle of a just transition, ensuring that vulnerable communities and workers in high-carbon sectors are not left behind, but instead supported with access to reskilling and new opportunities.

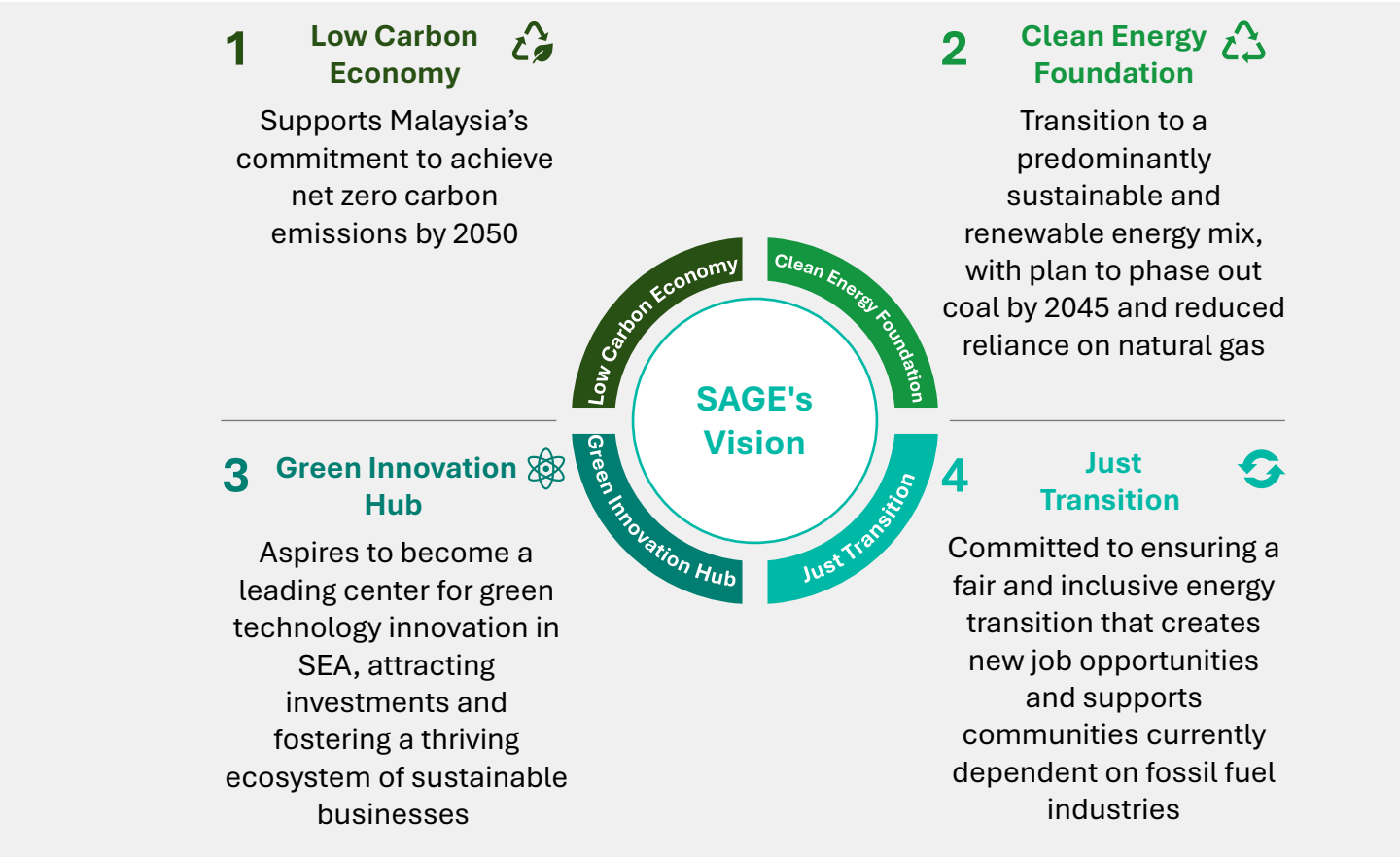


Figure 3.1: SAGE's vision

To realize this vision, SAGE's mission is focused on delivering real, lasting change through practical policy and coordinated action. It aims to enhance Selangor's economic growth and energy independence by promoting clean energy as a foundation for industrial development. The agenda aligns with the growing emphasis on Environmental, Social, and Governance (ESG) standards, recognizing that cleaner energy access is not only vital for climate action but also a key consideration for investors. SAGE promotes an enabling environment through robust regulatory frameworks and incentives, supporting both public initiatives and private sector leadership in renewable energy. In doing so, it accelerates the deployment of clean technologies across all levels of society, positioning Selangor as a model for sustainable progress in Malaysia.

The Selangor Agenda for Green Economy (SAGE) is a roadmap for the state's **green economy development, with clean energy as the foundation**, complementing the First Selangor Plan – It sets economic perspectives, goals, and action plans to achieve a low-carbon future

1	2	3	4	5
Aims to enhance economic growth and energy independence	Aligns with the increasing importance of Environmental, Social, and Governance (ESG) considerations for investors	Emphasizes access to cleaner energy, which is essential for combating climate change and reducing greenhouse gas emissions	Promotes a robust green economy outlook through targeted policies and frameworks	Facilitates the transition to clean energy across sectors, starting from clean energy sources, through both public and private initiatives

Figure 3.2: SAGE's mission

3.2 Guiding principles

SAGE is built on five guiding principles that shape its strategy and implementation. These principles reflect Selangor's commitment to a fair, effective, and forward-looking energy transition, aligned with national aspirations while rooted in local strengths and needs.

Strong Governance and Coordinated Action

Efficient enforcement, intra-state coordination, and alignment with national energy transition goals are key to accelerating Selangor's energy transition

Self-Sufficient Energy Supply

Producing sufficient clean energy to meet Selangor's growing demand, ensuring access to a reliable, stable, and self-reliant energy system

Just and affordable

Engaging all stakeholders in the energy transition to support equitable job transitions and maintain affordable energy access

Environmental Sustainability

Meeting Selangor's energy needs while managing environmental impact responsibly, ensuring long-term ecological balance and reduced emissions

Economic Growth and Opportunities

Attracting clean energy investments and fostering the development of clean energy industries to generate high-value job opportunities in Selangor

Figure 3.3: SAGE's guiding principles

The first guiding principle emphasizes the need for strong governance with coordinated intra-state efforts, aligned with national energy transition goals. Realizing SAGE's ambitions requires effective collaboration across departments and agencies within the state. From planning and infrastructure to finance and public engagement, each arm of government must work in sync to implement policies, mobilize resources, and track progress. This whole-of-state approach ensures that Selangor can translate the strategies into relevant outcomes.

The second principle focuses on reliable, stable, and self-reliant energy access. As Selangor continues to grow economically and demographically, ensuring a resilient energy system is essential. SAGE highlights the importance of generating sufficient clean energy within the state to meet rising demand especially for industry, transport, and urban development, while reducing dependence on fossil fuel imports from other regions. Building a self-sufficient energy supply not only strengthens energy security but also supports long-term sustainability.

The third principle is the commitment to a just and affordable energy transition for all. SAGE recognizes the socioeconomic impacts of the energy shift, particularly for communities and sectors currently reliant on high-emission sources. The agenda aims to maintain affordable energy pricing, protect vulnerable groups, and ensure that new opportunities, such as jobs, training, and access to technology are accessible to all. No one will be left behind as Selangor moves toward a cleaner energy future.

The fourth guiding principle underscores the importance of protecting the environment through sustainable energy practices. Selangor is committed to minimizing its carbon footprint by prioritizing clean energy technologies and embracing energy efficiency across sectors. This principle ensures that energy development is done with sensitivity to ecological balance, contributing to better air quality, healthier ecosystems, and a more livable environment for future generations.

The fifth and final principle focuses on driving economic growth and creating employment. The energy transition is seen not just as a climate necessity, but as an economic opportunity. By attracting green investments and nurturing a dynamic clean energy sector, SAGE aims to stimulate industrial growth and open up new employment pathways. The development of green jobs, local supply chains, and technological innovation will help position Selangor as a hub for the green economy in Malaysia.

These principles are operationalized through four strategic levers and the key enablers as illustrated in Figure 3.4 below.

Brown energy

- Natural gas supply
- Green combined-cycle gas turbine

Sustainable energy

- Waste-to-energy incinerator
- Anaerobic digester
- Landfill gas engine
- POME biogas power plant

Renewable energy

- Solar PV
- Run-off-river hydropower
- Geothermal power
- Wind power

Energy storage system

- Battery energy storage system
- Hydrogen production (incl. conversion into ammonia and methanol)
- Pumped hydro energy storage

Key enablers

- Green infrastructure
- Green mobility
- Green workforce and literacy development
- Green optimization & energy efficiency
- Green policies & incentives
- Green reporting
- Green finance & investment

Figure 3.4: 4 energy transition levers and key enablers of SAGE

3.3 SAGE's ambition

In supporting Malaysia's broader energy transition, the SAGE outlines a clear set of ambitious yet achievable goals to accelerate the state's shift toward clean energy and a low-carbon economy. Recognizing Selangor's pivotal role in national development, SAGE aligns closely with federal targets while tailoring its priorities to the state's unique energy landscape and economic profile. By setting quantifiable milestones, SAGE aims to drive impactful change across energy, industry, and society.

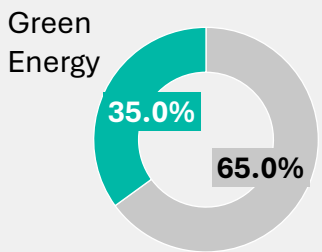
Key targets under SAGE by 2035 include:

- 7,414 MW of clean energy generation capacity across the state
- 35% of clean energy in energy generation mix, contributing to national decarbonization efforts
- RM 34 billion (approximately USD 8 billion) in projected energy investments, enabling a just and inclusive energy transition

7,414 MW

additional clean energy capacity by 2035[1)]

Clean energy mix target, 2035 [%]



RM 34 bn

or approximately

USD 8 bn,

in projected investments by 2035[1)]

Figure 3.5: SAGE's goals by 2035

1) This target reflects current projections and may increase as new projects are introduced and implemented throughout the roadmap period

Targets for SAGE's levers and enablers

Brown Energy

Green CCGT
With **hydrogen ready** capabilities
Capacity : 5,775 MW

Natural gas supply
Maintaining the security and reliability of the system to meet the demand
Capacity : 3 MTPA

Sustainable energy

Waste to energy incinerator
Greener way for waste management
Capacity : 158 MW

POME biogas power plant
Generates from landfill methane gas
Capacity : 30 MW

Landfill gas engine
Capacity : 4.8 MW

Anaerobic digester
Capacity : 2.6 MW

Renewable energy

Solar PV
Focusing on utilized land and water body
Capacity : 1,330 MW

Run-off river hydropower
As part water security agenda for Selangor
Capacity : 36.6 MW

Geothermal power
Capacity : 15 MW

Wind
Capacity : 2 MW

Energy storage

Battery energy storage system
Storing excess electricity for during high demands
Capacity : 400 MWh

Pump hydro energy storage
Minimizing social & environment impact
Capacity : 60 MW

Hydrogen production (incl. conversion into ammonia and methanol)
Capacity : 800 kg/ day

Key enablers

Green infrastructure (Carbon capture technology)
Capacity : 0.5 MTPA

Green mobility (EV charging stations)
Capacity : 550 units by 2035 (Average 50 units per year)

Green mobility (Hydrogen refueling station)
Are essential for the widespread adoption of hydrogen-powered vehicles
Capacity : 500 kg/ day

Green workforce
Total job expected to create
Capacity : 26,000 pax

Green optimization & energy efficiency
Project optimizations
Capacity : 44 sites

Green reporting
Once per two years
Capacity : 6 reports total

Figure 3.6: Targets for SAGE's 4 levers and enablers

These goals and targets demonstrate Selangor's commitment to staying in step with national ambitions.

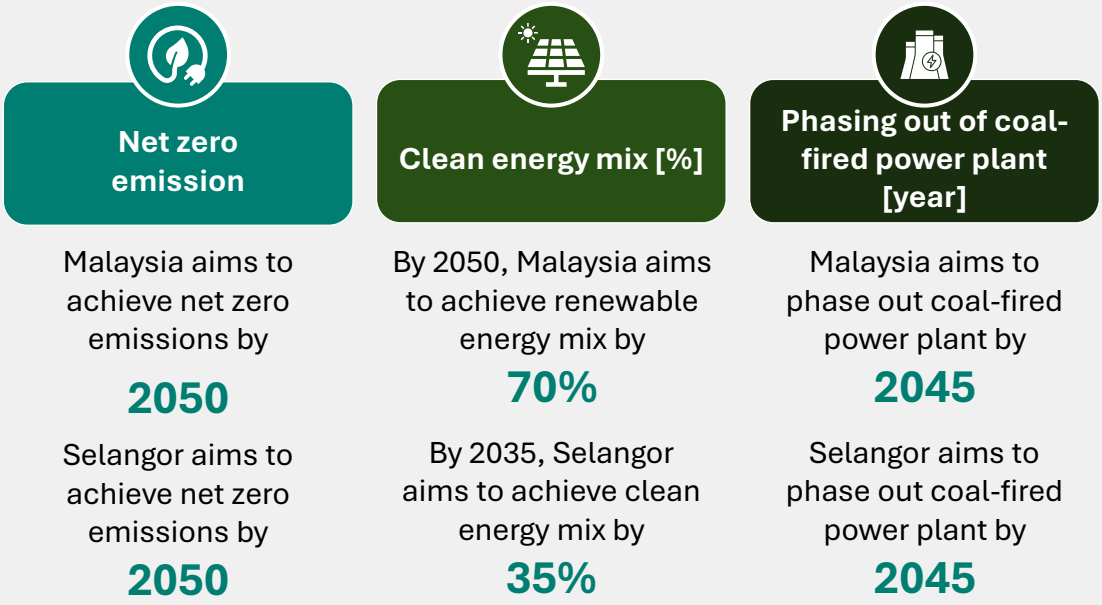


Figure 3.7: Comparison of Malaysia's and Selangor's energy transition targets

Malaysia is targeting net-zero emissions by 2050, a vision echoed in SAGE's own long-term roadmap. Malaysia's aspiration to achieve a 70% renewable energy share in installed capacity by 2050 is supported by Selangor's regional goal of reaching 35% clean energy mix by 2035. Furthermore, while Malaysia plans to fully phase out coal-fired power plants by 2045, Selangor has aligned with this national target, also committing to eliminate coal use by 2045 and significantly reduce its reliance on natural gas. These targets collectively reflect the state's determination to lead by example and contribute meaningfully to Malaysia's energy transformation.

3.4 Energy transition levers and key initiatives

Under the SAGE, the definition of clean energy excludes coal/oil-fired power generation and instead centers on four strategic levers: selected forms of brown energy, sustainable energy solutions, renewable energy sources, and energy storage systems. Each plays a vital role in reducing carbon emissions, strengthening energy reliability, and supporting Selangor's shift toward a resilient, low-carbon economy.

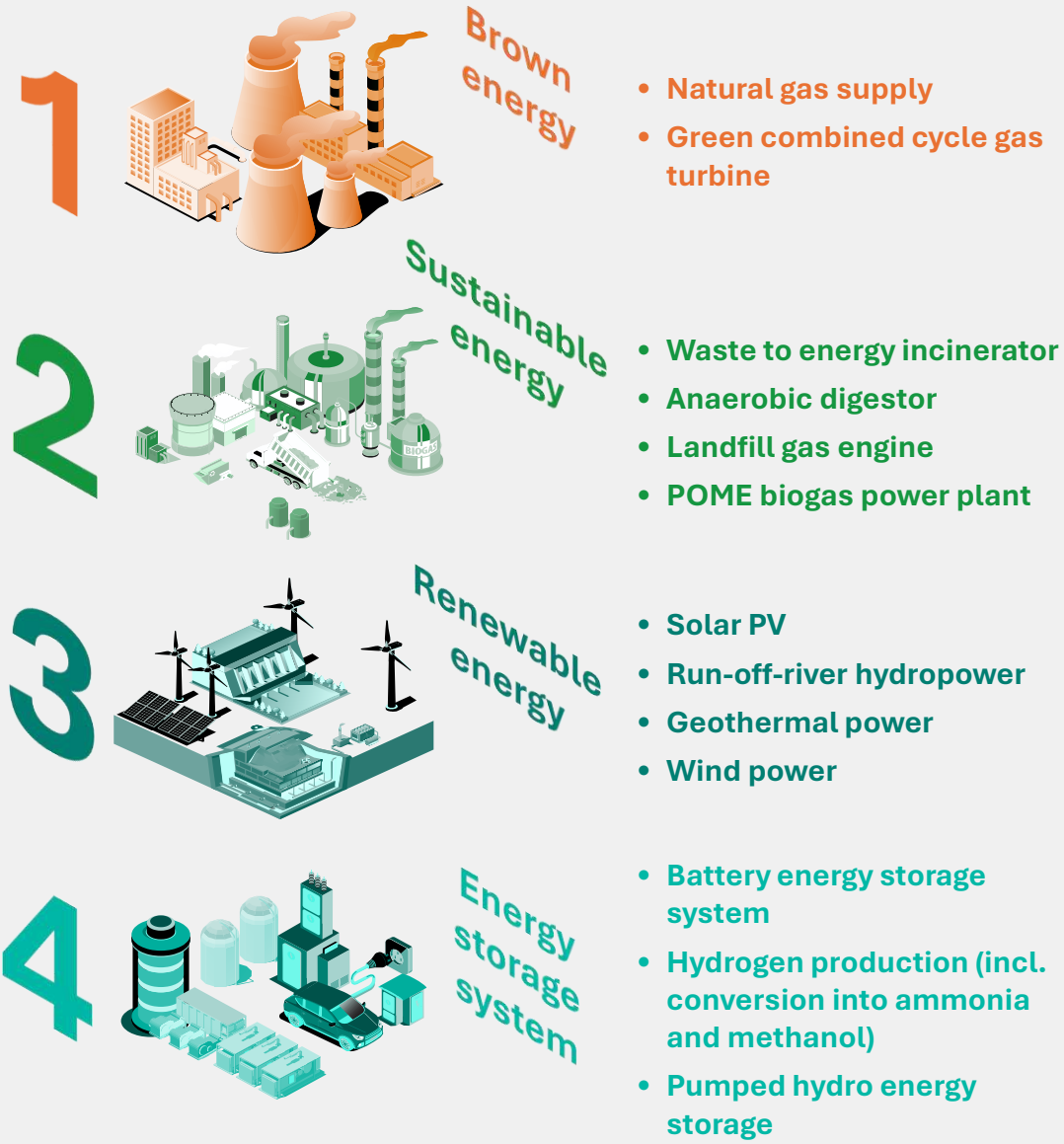


Figure 3.8: 4 key energy transition levers and enablers

Selected forms of brown energy, particularly natural gas, play a foundational role in Selangor's transition. As a cleaner-burning fossil fuel, natural gas emits significantly fewer greenhouse gases than coal, up to 50% less CO_2 per unit of electricity generated. Its efficiency, availability, and operational flexibility make it a practical and reliable option to support grid stability, especially during peak demand or when intermittent sources such as solar are unavailable. Technologies including combined cycle gas turbines (CCGT), liquefied natural gas (LNG), and emerging green gases like hydrogen or ammonia are expected to evolve further as carbon mitigation technologies advance.

Sustainable energy sources, such as waste-to-energy (WTE) systems and landfill gas engines, complement the brown energy mix by transforming municipal waste into usable electricity. These systems help reduce methane emissions from landfills while contributing to energy generation, aligning with circular economy principles and reducing environmental pressure from conventional waste disposal.

Renewable energy, led by solar photovoltaics and small hydropower, forms the cornerstone of Selangor's long-term energy sustainability. These sources offer zero emissions during operation and are increasingly cost-effective and scalable.

Energy storage systems, especially Battery Energy Storage System (BESS), are essential in enabling a stable and high-performing energy ecosystem. By storing surplus energy from intermittent sources like solar, BESS improves grid reliability, facilitates load balancing, and reduces dependency on traditional baseload power. These systems can be deployed across hybrid power plants, grid services, and commercial or industrial applications, playing a key role in realizing Selangor's ambitions for a future-ready, flexible energy system.

Together, these four levers form a robust, balanced framework to guide Selangor's clean energy journey, one that is environmentally responsible, economically viable, and aligned with the state's sustainability goals.

3.4.1 Brown energy

Overview

Brown energy refers to power derived from fossil fuels such as coal, oil, and natural gas. These sources, while historically central to Malaysia's electricity generation, are major contributors to greenhouse gas emissions and global warming. Fossil fuels are non-renewable resources formed from prehistoric organic matter, and their continued use places significant strain on the environment. As of 2023, Malaysia's power system remains predominantly reliant on fossil fuels, with coal and gas contributing a substantial share to national energy production. This underscores the pressing need for a transition towards cleaner alternatives that can support both sustainability and energy security. Natural gas and green CCGT are key drivers within the brown energy in supporting the transition to a green economy.

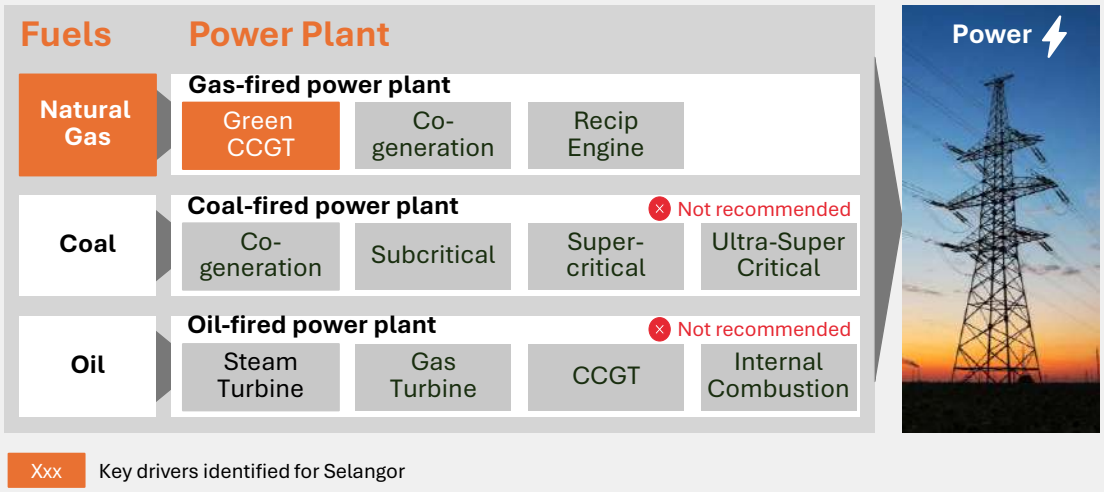


Figure 3.9: Brown energy overview

Key drivers

Natural gas supply

Natural gas plays a critical role in bridging the transition from high-emission fossil fuels to a cleaner energy system. It is a fuel that, when burned, produces significantly fewer greenhouse gas emissions compared to coal or oil , emitting up to 50% less carbon dioxide per unit of electricity generated. This makes natural gas one of the cleanest-burning fossil fuels currently available. In power generation, natural gas is typically combusted in turbines to produce electricity, and its flexible, fast-starting nature makes it ideal for balancing intermittent renewable energy sources such as solar and wind.

Green CCGT

Green Combined Cycle Gas Turbines (CCGT) represent a more efficient and lower-emission method of generating electricity compared to conventional fossil fuel power plants. These systems combine a gas turbine with a steam turbine to capture and utilize excess heat, significantly improving overall efficiency with performance levels in the region of 60% compared to 35% to 40% for conventional thermal power plants. While natural gas is the primary fuel used in CCGTs, the "green" designation refers to the use of cleaner-burning fuels and the ability to transition toward zero-carbon alternatives. Green CCGT infrastructure can be designed or retrofitted to accommodate low- or zero-carbon fuels such as green hydrogen, biogas, methanol, or ammonia. This fuel flexibility ensures that today's gas-powered generation can evolve into tomorrow's carbon-neutral systems. As such, green CCGTs play a key role in the energy transition by providing reliable, dispatchable power that supports grid stability, while offering a pathway to deeper decarbonization as cleaner fuels become more widely available.

Key targets

Malaysia has set a firm national target to fully retire all coal-fired power plants by 2045. Much of the displaced coal capacity is expected to be replaced by gas-fired power plants, which offer a comparatively lower-emission alternative. In line with this shift, Selangor plans to contribute through a natural gas supply capacity of 3 million tonnes per annum (MTPA) by 2035 with an investment of RM 5 billion by 2030. In parallel, the state targets the deployment of 5,775 MW of green Combined Cycle Gas Turbine (CCGT) capacity, backed by RM 15.45 billion in investments between 2024 and 2030. These developments signal a clear direction: while the long-term goal is a predominantly renewable energy mix, gas will remain an essential transitional fuel in the near to medium term.

Rural areas in Selangor play a critical role in this transition by providing strategic sites for regasification facilities and CCGT plants, which require ample land, safety buffers, and proximity to coastal or transmission infrastructure. Their involvement is poised to bring direct benefits through job creation in construction, operations, and logistics. Improved energy access and infrastructure in these regions can also stimulate broader rural economic development, enabling greater industrial activity, attracting new investments, and enhancing energy affordability and reliability for households and small enterprises.

Natural Gas Supply

(involves infrastructure expansion for improved supply security)

Capacity: 3 MTPA

Investment capacity: RM 5 bn (2030)

Deep dive on Figure 3.11.1

Green CCGT

Capacity: 5,775 MW

Investment capacity: RM15.45 bn (2024-2030)

Deep dive on Figure 3.11.2

Figure 3.10: Targets for brown energy on capacity and investment capacity

Key challenges

However, the reliance on natural gas is not without its challenges. Malaysia's domestic gas supply has faced curtailments in the past, as seen in 2011, where limited availability disrupted power sector reliability for nearly 50 days. Strategic investments, robust infrastructure planning, and coordinated state–federal action will be essential to manage this risk while maximizing the benefits of gas as a transitional fuel.

Ultimately, while brown energy will continue to contribute to Selangor's power needs in the near term, its role must be carefully calibrated within the broader clean energy transition. By leveraging natural gas for its lower carbon profile and adaptability, and simultaneously expanding other energy sources, Selangor can achieve a more balanced, secure, and environmentally responsible energy future.

Key initiatives

The key initiatives and projects for brown energy are shown in figure 3.11

4

LNG landing TPA via SelGas

Expansion of natural gas infrastructure to enhance gas security and supply diversity

Key project under SelGas

Figure 3.11.1: Key initiatives/ projects for natural gas supply

Under the SelGas initiative, Selangor is planning the development of a liquefied natural gas (LNG) landing and regasification facility to support the state's growing industrial energy needs. This aligns with efforts to diversify energy sources and strengthen local supply security. The facility will be equipped to manage the full LNG process, including importation, offloading, storage, regasification, and distribution to users across Selangor. It will operate within Malaysia's TPA framework to foster a more competitive and liberalized gas market. A new pipeline connection is planned to connect the terminal to the nearby city gate, offering a shorter and more direct route into Selangor's distribution network. This will serve as an alternative to the existing long-haul pipeline system and enhances supply reliability and overall system resilience. By enabling this infrastructure, it contributes to Selangor's long-term goal of building a more reliable, flexible, and sustainable energy ecosystem.

Figure 3.11: Key initiatives/ projects for natural gas supply

The key initiatives and projects for green CCGT are shown below.

1 3

Pulau Indah PP 1&2

Addition of modern combined cycle gas turbine (CCGT) will increase its capacity to 1.2 GW in phase 1 and to 1.05 GW in phase 2

Champion:
WHB

2 6

Kuala Langat PP

CCGT with Cogen power plant with planned capacity expansion of up to 675 MW in phase 1 and to 750 MW in phase 2

Champion:
Kuala Langat Power Plant Sdn Bhd (KLPP)

5

Kapar New PP

The new Kapar Power Plant will have a capacity of 2.1 GW

Champion:
TNB

Figure 3.11.2: Key initiatives/ projects for green CCGT

3.4.2 Sustainable energy

Overview

Sustainable energy sources are those that can meet current demands without depleting resources or causing long-term environmental harm. Unlike renewable energy, which derives power from naturally replenishing sources like wind, sun, or water, sustainable energy often utilizes waste products or by-products from human activities. These sources include technologies such as waste-to-energy (WTE) incineration, anaerobic digestion, POME biogas power plants and landfill gas engines. They offer sustainability by being healthy, safe, long-lasting, and self-replenishing. Together, these technologies exemplify Selangor's commitment to sustainable waste management and clean energy generation.

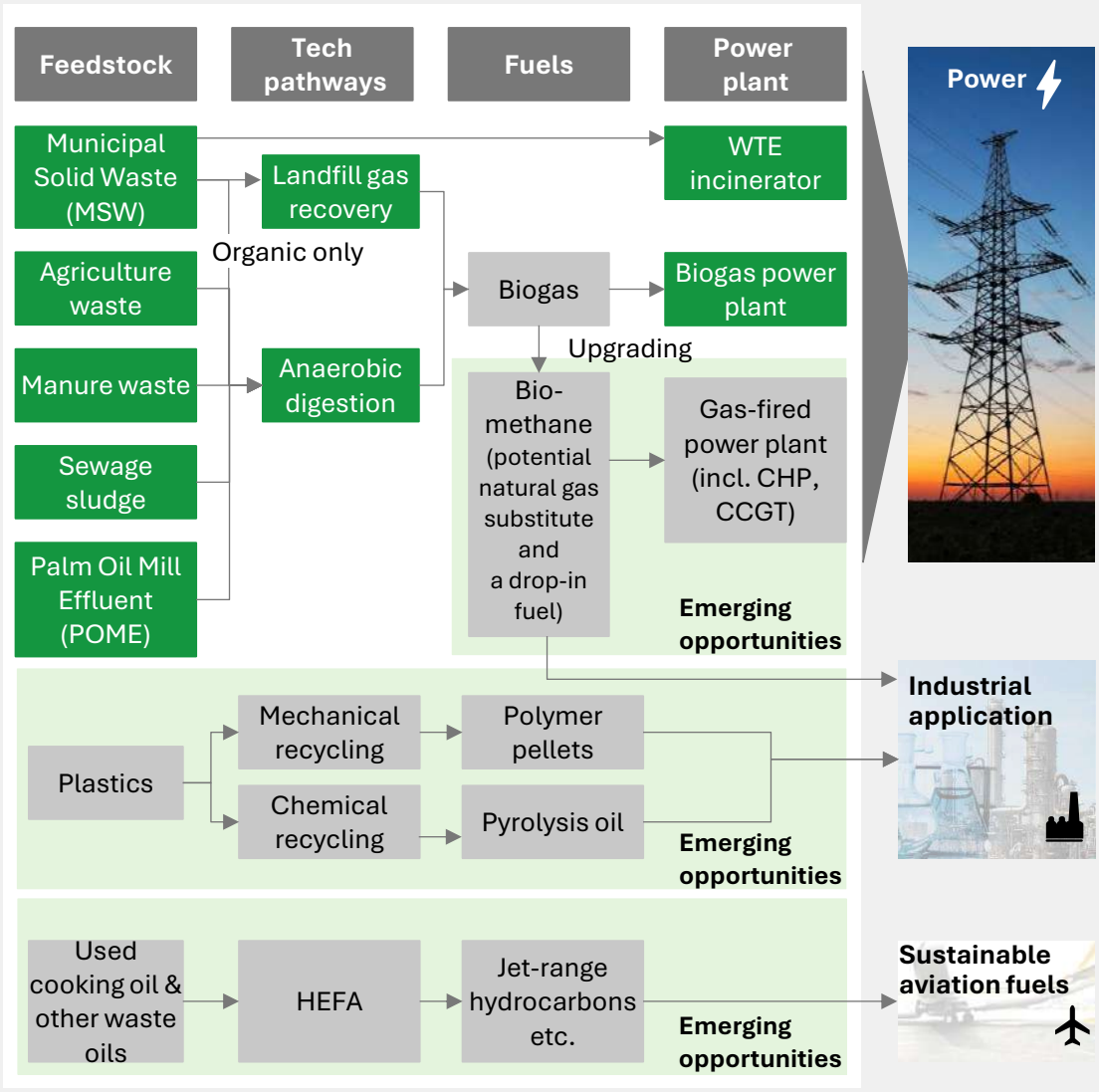


Figure 3.12: Sustainable energy overview

Key drivers

Waste-to-energy incinerator

Waste-to-Energy (WTE) incineration is a proven technology that transforms municipal solid waste into usable electricity. By burning waste at high temperatures, WTE facilities produce steam that drives turbines to generate power. This process significantly reduces landfill volumes, offering a dual benefit of waste management and energy recovery.

As urban areas like Selangor continue to generate increasing amounts of solid waste, WTE serves as a strategic solution for managing non-recyclable waste streams while contributing to the region's energy mix. To ensure environmental safety, modern WTE plants operate under stringent emission controls, making them a clean and efficient component of a green economy.

Anaerobic digester

Anaerobic digesters convert organic waste into energy through a natural biological process that occurs in oxygen-free environments. Common feedstock includes food waste, agricultural residues, and other biodegradable materials. As the waste breaks down, it releases biogas, a mixture rich in methane which can be used to generate electricity, produce heat, or be upgraded into biomethane for fuel applications. In addition to energy generation, this process produces nutrient-rich digestate that can be repurposed as organic fertiliser, supporting circular agriculture practices. Anaerobic digestion aligns with Selangor's goals of reducing landfill dependence and transforming organic waste into valuable, low-carbon energy sources.

POME biogas power plant

Biogas derived from Palm Oil Mill Effluent (POME) offers a compelling energy solution for Selangor, particularly given the state's strong agricultural base. POME, an organic wastewater from palm oil processing, is rich in biodegradable matter. The process begins with the collection and pre-treatment of POME, followed by its breakdown in an anaerobic digester where biogas is produced, a mixture primarily of methane and carbon dioxide. This biogas is then captured, cleaned to remove impurities, and used to fuel power plants for electricity generation. The energy produced can be used on-site at the mill or supplied to nearby communities. By turning agricultural waste into a valuable energy source, this system reduces fossil fuel dependence, cuts greenhouse gas emissions, and lowers the environmental impact of palm oil production.

Landfill gas engine

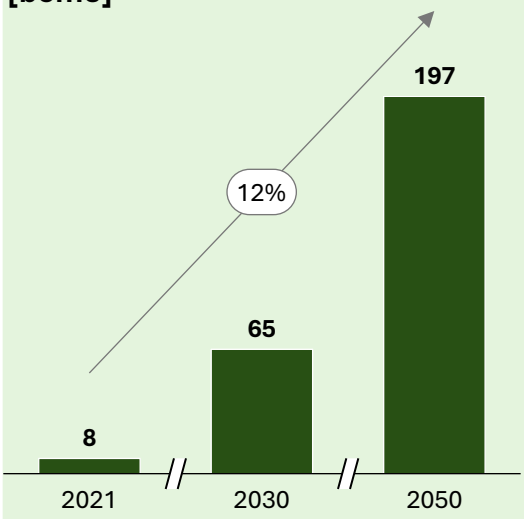
Landfill gas engines harness energy from methane, a potent greenhouse gas that is naturally emitted by decomposing waste in landfills. Rather than allowing this gas to escape into the atmosphere, gas collection systems capture it and route it to engines that convert it into electricity. This not only mitigates climate impact but also generates reliable power from an otherwise harmful emission. In the context of Selangor's energy strategy, landfill gas recovery represents a practical and scalable approach to managing legacy waste sites, transforming them into contributors to clean energy production. It reinforces the state's broader ambition to extract value from waste while advancing climate resilience.

Deep dive into emerging green opportunities:

1 Biogas upgrading to biomethane

With the global biomethane market projected to grow by approximately 12% annually through 2050, biomethane represents a timely opportunity for Selangor and Malaysia to decarbonize major sectors. Malaysia and Selangor in particular, has abundant sources of biogenic feedstock such as palm oil mill effluent (POME), livestock manure, agricultural residues, and municipal organic waste. Biomethane is produced by upgrading raw biogas generated from the anaerobic digestion of organic waste into high-purity methane through the removal of carbon dioxide and impurities. Tapping into these waste streams not only mitigates environmental impacts but enables the production of biomethane, which is chemically identical to natural gas. This opens the door for use in Malaysia's power, industrial, and transportation sectors, and creates an opportunity for export to markets like Singapore.

Global demand for biomethane [bcme]



Key drivers for biomethane in Malaysia:

- Demand for biomethane rises as **decarbonization efforts intensify**
- Enhancing **energy security** through domestic biomethane production
- **Exporting to Singapore** presents a short-term demand opportunity

Figure 3.12.1: Global demand for biomethane and key drivers for biomethane in Malaysia

2 Plastics recycling

With global plastic waste continuing to rise, advanced recycling solutions are becoming essential.

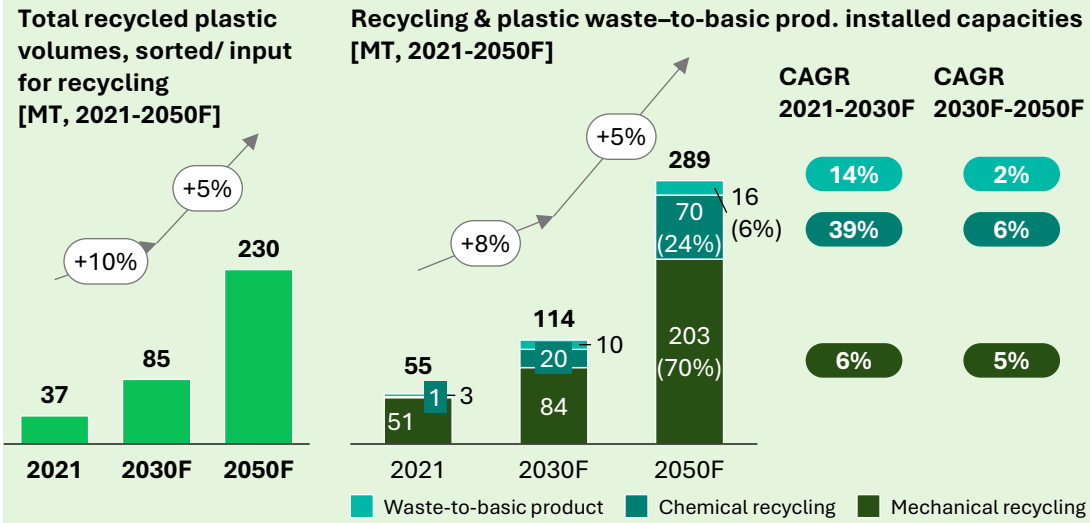


Figure 3.12.2: Total recycled plastic volume, sorted/ input for recycling and recycling & plastic waste–to-basic product installed capacities

While mechanical recycling is expected to remain the primary method handling 70% of all plastic recycling by 2050, chemical recycling technologies are seeing rapid growth, backed by a promising a feedstock in petrochemical and energy applications.

Plastic recycling relies on two main approaches:

- Mechanical recycling: Involves sorting, cleaning, grinding, and melting plastic into reusable pellets
- Chemical recycling: Breaks plastic waste down into chemical building blocks, which can be used as raw materials for new plastics or fuels

While mechanical recycling is the most developed recycling pathway, pyrolysis is the most promising amongst chemical recycling.

Mechanical recycling

Mechanical processes (e.g., grinding, washing, separating, drying, re-granulating and compounding)

Output

Polymer pellets

Pyrolysis

Plastics are broken down into basic hydrocarbons via 'cracking', i.e. **heating in absence of oxygen**

Output

Pyrolysis oil

Figure 3.12.3: Deep dives of mechanical recycling and pyrolysis

For Malaysia, adopting both technologies is key to minimizing landfill use, reducing environmental pollution, and developing a sustainable circular economy.

3 Upgrading used cooking oil to sustainable aviation fuels

In support of the shift towards sustainable aviation fuel (SAF), Malaysia has introduced progressive SAF blending targets, starting with a 1% blending mandate by 2025 under the National Energy Transition Roadmap (NETR), and aiming for 47% by 2050 as outlined in the Aviation Industry Sustainability Roadmap.

SAF blending targets set, 2025–2050 [%]

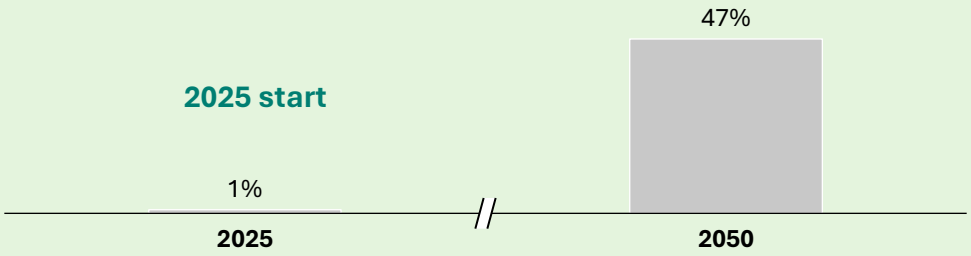


Figure 3.12.4: SAF blending targets set

Among the available technological pathways, Hydroprocessed Esters and Fatty Acids (HEFA) has emerged as the most cost-effective method for SAF production. Used cooking oil (UCO), in particular, is the most cost-competitive feedstock within the HEFA process, with levelized production costs as low as USD 0.90 per liter. Malaysia produces significant volumes of UCO and by capturing and refining UCO at scale, Selangor can contribute meaningfully to greener aviation and reduce reliance on fossil fuels.

Levelized production cost by feedstock [USD/ Liter]

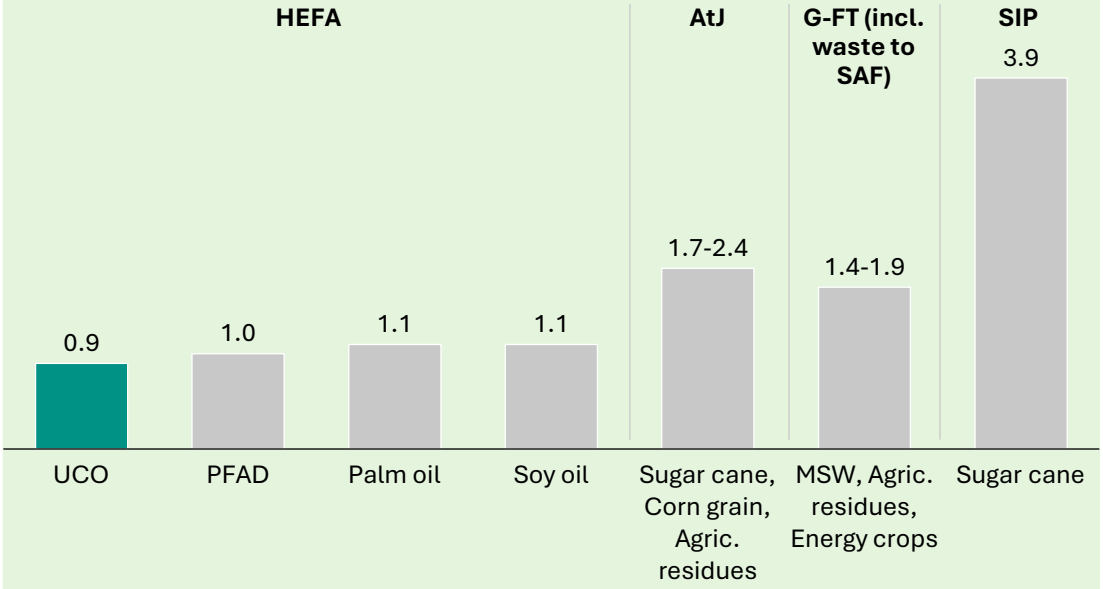


Figure 3.12.5: Levelized production cost by feedstock

Key targets

The state plans to process 6,800 tonnes of waste per day through WTE incinerators, while also developing anaerobic digesters capable of handling 200 tonnes per day of organic waste. Additionally, POME biogas power plant and landfill gas engines are expected to contribute 30 MW and 1.2 MW of electricity, respectively.

These efforts will rely in part on organic and agricultural waste streams sourced from rural areas, where palm oil operations and livestock activities are concentrated, creating new opportunities for rural stakeholders to supply feedstock and participate in the value chain. This creates opportunities for rural communities to participate in the green economy, generate new income streams, and contribute directly to the state's clean energy transition. To support these ambitions, expected investments of RM 3 billion for WTE development between 2025 and 2028, RM 50 million for anaerobic digesters from 2030 to 2032, RM 180 m for POME biogas power plant by 2030 and RM 3 million for landfill gas engine projects scheduled by 2026.

Waste-to-Energy Incinerator

Deep dive on Figure 3.14.1

Capacity: 158 MW

Investment capacity: RM 2.9 bn (2025-2028)

Anaerobic Digester

Capacity: 2.6 MW

Deep dive on Figure 3.14.2

Investment capacity: RM 50 m (2030-2032)

POME Biogas Power Plant

Capacity: 30 MW

Deep dive on Figure 3.14.3

Investment capacity: RM 285 m (2030)

Landfill Gas Engines

Capacity: 4.8 MW (To date)

Figure 3.13: Targets for sustainable energy on capacity and investment capacity

Key challenges

Despite the promising potential of sustainable energy sources, Selangor faces several challenges that must be addressed to ensure their successful implementation. One of the primary obstacles is the technological and operational complexity involved in deploying advanced systems like WTE incineration and anaerobic digestion. These technologies require significant expertise and infrastructure to operate efficiently and safely. Additionally, while WTE incineration offers a solution to waste management, it can produce emissions if not properly controlled, raising environmental and health concerns. To mitigate these risks, strict adherence to environmental standards and continuous monitoring is essential. Public perception and acceptance also pose a challenge, as effective communication about the benefits and safety of these projects is crucial for gaining community support.

Key initiatives

The key initiatives and projects for sustainable energy are shown in figure 3.14.

7

Jeram WTE 1&2

Aims to generate 58 megawatts (MW) of electricity

Champion:
WHB

8

Tanjung Duabelas WTE

Tanjung Duabelas sanitary landfill has a production capacity of 42 MW

Champion:
WHB

10

Sultan Idris Shah WTE

RM 1 billion WTE plant spanning approximately 245 acres of Rawang's landscape with capacity of 58 MW

Champion:
KDEB Waste Management

Figure 3.14.1: Key initiatives/ projects for WTE

11

Jeram anaerobic digester

It is co-located with the Jeram WTE facilities to optimize land use, streamline operations and enable a more efficient conversion of waste into energy with a capacity of 1.3 MW

Champion:
WHB

13

Tanjung Duabelas anaerobic digester

It is co-located with the Tanjung Duabelas WTE facilities to optimize land use, streamline operations and enable a more efficient conversion of waste into energy with a capacity of 1.3 MW

Champion:
WHB

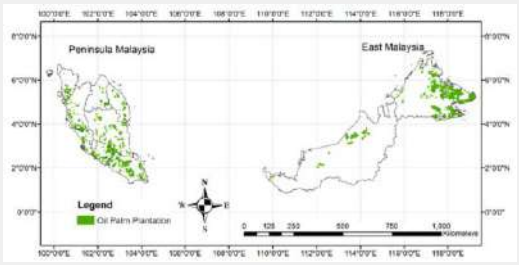
Figure 3.14.2: Key initiatives/ projects for anaerobic digester

12

POME biogas power plant

POME biogas power plants are currently undergoing feasibility studies to determine the most suitable locations and capacities for development with target capacities of 30 MW

Palm oil plantation in Malaysia



Palm oil mills in Malaysia

Palm Oil Mills Pre-Processing Facilities Main Processing Facilities

Further Processing 1 Facilities Further Processing 2 Facilities

Figure 3.14.3: Key initiatives/ projects for POME biogas PP

3.4.3 Renewable energy

Overview

Renewable energy is derived from natural resources that are replenished naturally and can be harnessed without depleting the planet's resources. The renewable energy sources offer a sustainable and low-emission alternative to traditional fossil fuels, contributing to the reduction of greenhouse gas emissions and the mitigation of climate change. In Selangor, the focus is on solar PV systems and run-off-river hydropower. While geothermal, wind energy, and ocean energy are still under exploration stage.

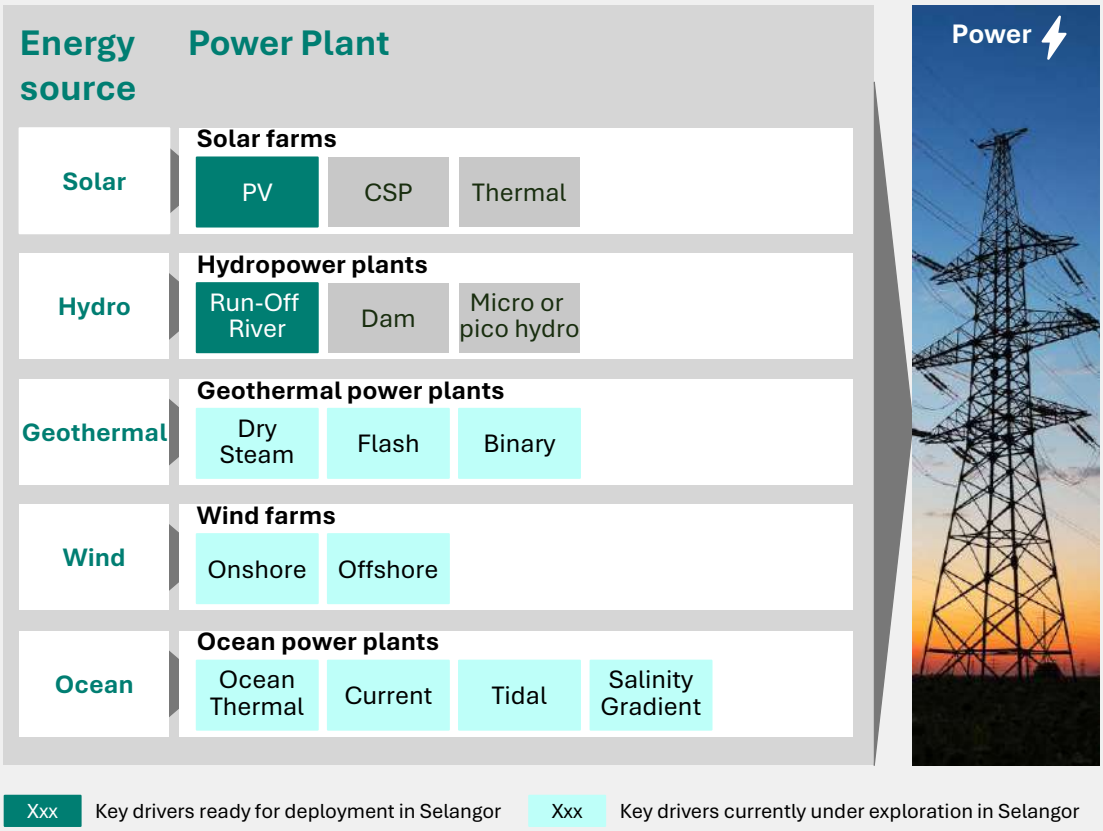


Figure 3.15: Sustainable energy overview

Key drivers

Solar PV

Solar energy, harnessed from the Sun's light and heat, can be converted into electricity or used for thermal applications through a range of technologies. These include active systems such as photovoltaic (PV) panels and concentrated solar power, as well as passive designs that optimize building layout and materials to naturally regulate temperature and lighting.

In Selangor, three main configurations are being explored to maximize solar adoption. Floating solar systems are deployed on water surfaces like reservoirs, helping conserve land and repurpose underutilized areas. Ground-mounted solar installations, typically set up on open land, support large-scale power generation for the grid. Meanwhile, rooftop solar panels make efficient use of existing building structures, enabling decentralized energy generation without the need for new land development. Together, these varied applications allow solar energy to be scaled flexibly across urban, industrial, and rural settings.

Run-off-river hydropower

Run-off-river hydropower is a renewable energy solution that generates electricity by utilizing the natural flow of rivers without the need for large-scale reservoirs or significant alterations to the river's course. This approach greatly minimizes environmental disruption, allowing aquatic ecosystems to remain largely intact and reducing the risk of flooding or displacement of local communities, common issues associated with traditional hydroelectric dams. The technology is particularly suited for regions like Selangor, where balancing energy development with environmental conservation is a priority. Its consistent energy output, driven by the predictable flow of water, makes it a reliable source of clean electricity that enhances energy security while reducing reliance on fossil fuels. Additionally, run-off-river plants are generally smaller in scale and less complex to construct, resulting in shorter development timelines and lower capital costs, making them a practical and cost-effective option for accelerating Selangor's transition to renewable energy.

Geothermal power

Geothermal energy harnesses the Earth's internal heat to produce electricity through power plants that tap into underground reservoirs of hot water or steam. This process offers a consistent and environmentally friendly energy supply, emitting minimal greenhouse gases compared to fossil fuels. As a renewable source, geothermal energy provides a reliable complement to variable renewables like solar and wind, helping to stabilize the energy grid. In Selangor, geothermal potential is still being explored to diversify the state's clean energy portfolio while reducing dependence on finite resources.

Wind power

Selangor's coastline presents a promising opportunity for wind energy development, with strong and consistent winds that are ideal for renewable energy generation. The state is actively exploring coastal wind projects to diversify its clean energy portfolio and contribute to national renewable energy goals. In addition to supporting Selangor's decarbonization agenda, these developments are expected to stimulate economic growth by creating green jobs and attracting private investment. Harnessing wind energy not only strengthens energy security but also reinforces Selangor's commitment to environmental sustainability and innovation in the energy sector.

Key Targets

By 2035, Selangor aims to achieve significant milestones in renewable energy generation. The state targets a solar PV capacity of 1,095 MW, with an investment of RM 7.3 billion between 2026 and 2033. Run-off-river hydropower is expected to contribute 35.5 MW, with RM 437 million investment from 2024 to 2028. Geothermal capacity of 15 megawatts (MW)is targeted, supported by RM 240 million in investment by 2034. Lastly, wind energy is targeted at 2 MW capacity, with RM 24 million investment by 2032.

Due to their physical and spatial requirements such as large surface areas for solar exposure, natural river flows for hydropower, or unobstructed wind currents, many renewable energy projects are best situated in areas with favorable natural conditions and lower development density. As such, a significant portion of these installations is expected to be located in rural regions, where land is more abundant, cost-effective, and rich in renewable resources. This creates tangible opportunities for rural communities to benefit through land leasing arrangements, local employment, and active participation in the clean energy supply chain. In doing so, Selangor's renewable energy transition becomes not only environmentally driven but also socially inclusive, ensuring that no community is left behind.

Solar PV

Capacity: 1,330 MW

Investment capacity: RM 7.345 bn (2026-2033)

Deep dive on Figure 3.17.1

Run-off-River Hydropower

Capacity: 36.6 MW

Investment capacity: RM 495 m (2024-2028)

Deep dive on Figure 3.17.2

Currently under exploration

Geothermal Power

Capacity: 15 MW

Investment capacity: RM 240 m (2034)

Wind Power

Capacity: 2 MW

Investment capacity: RM 24 m (2032)

Figure 3.16: Targets for renewable energy on capacity and investment capacity

Key challenges

Despite the promising potential of renewable energy, Selangor faces several challenges in its implementation. High initial costs for renewable energy technologies can be a barrier, especially for smaller players in the market. Access to the latest renewable energy technologies is often hampered by high costs or supply chain constraints . Additionally, integrating renewable energy into the existing grid requires significant upgrades and advanced grid technologies to address grid stability and management issues. Public awareness and understanding of renewable energy benefits are crucial for garnering support and encouraging adoption.

Key initiatives

The key initiatives and projects for renewable energy are shown in figure 3.17.

Solar projects in Selangor

LSS Payung 17

A RM 410 million joint venture project with 150 MW capacity projected

Champion:
TNB Renewables, WHB

SelCo LSS by Air Selangor 23

A RM 45 million joint venture project with 15 MW capacity projected

Champion:
Samaiden, Air Selangor

Malaysia's government-led initiatives supported by Selangor's government via Green Energy Aggregator Program for Selangor (GAPS)

Large Scale Solar (LSS) 20

Selangor government supported the open tender for solar farm launched by Malaysia government through GAPS and Selangor recently secured the largest floating solar project in SEA under LSS5, totaling 450 MW in capacity

LSS CRESS 21

The Corporate Renewable Energy Supply Scheme (CRESS) enables companies to purchase green electricity directly from RED via the national grid, with GAPS facilitating the process on behalf of the Selangor government

LSS ENEGEM 24

Energy Exchange Malaysia (ENEGEM) is a designated platform to facilitate sales of solar energy between Malaysia and neighboring countries in the region

Figure 3.17.1: Key initiatives/ projects for solar power

14

Batang Kali Hydropower

A small hydropower plant developed to supply 5.1 MW of electricity to the Ulu Yam substation

Champion:
WHB

15

Lower Sungai Kerling Hydropower

A small hydropower plant developed to supply 4.5 MW of electricity

Champion:
WHB

20

Sungai Bernam Hydropower

A small hydropower plant developed to supply 6 MW of electricity

Champion:
SEDA, Selangor and Perak State Ventures

16

Kuala Kubu Dam Hydropower

A small hydropower plant developed to supply 10 MW of electricity

Champion:
Air Selangor

17

Bernam Scheme Hydropower

A small hydropower project designed to collect and channel water from multiple rivers with capacity of 8.5 MW

Champion:
WHB

22

Ulu Pangsun Hydropower

A small hydropower plant developed to supply 2.1 MW of electricity

Champion:
WHB

Figure 3.17.2: Key initiatives/ projects for hydropower

3.4.4 Energy storage

Overview

Energy storage systems (ESS) are essential for balancing the intermittent nature of renewable energy sources like solar and wind. They capture excess energy produced during periods of low demand and release it during peak consumption times, ensuring a stable and reliable power supply. These systems are increasingly recognized for their role in integrating renewable energy into the grid, enhancing grid stability, and supporting the transition to a low-carbon energy future. In Malaysia, ESS technologies include Battery Energy Storage System (BESS), which use electrochemical solutions to store electricity; pumped hydro energy storage, which utilize gravitational potential energy; and other energy vectors such as hydrogen, ammonia and methanol are the key focus for ESS.

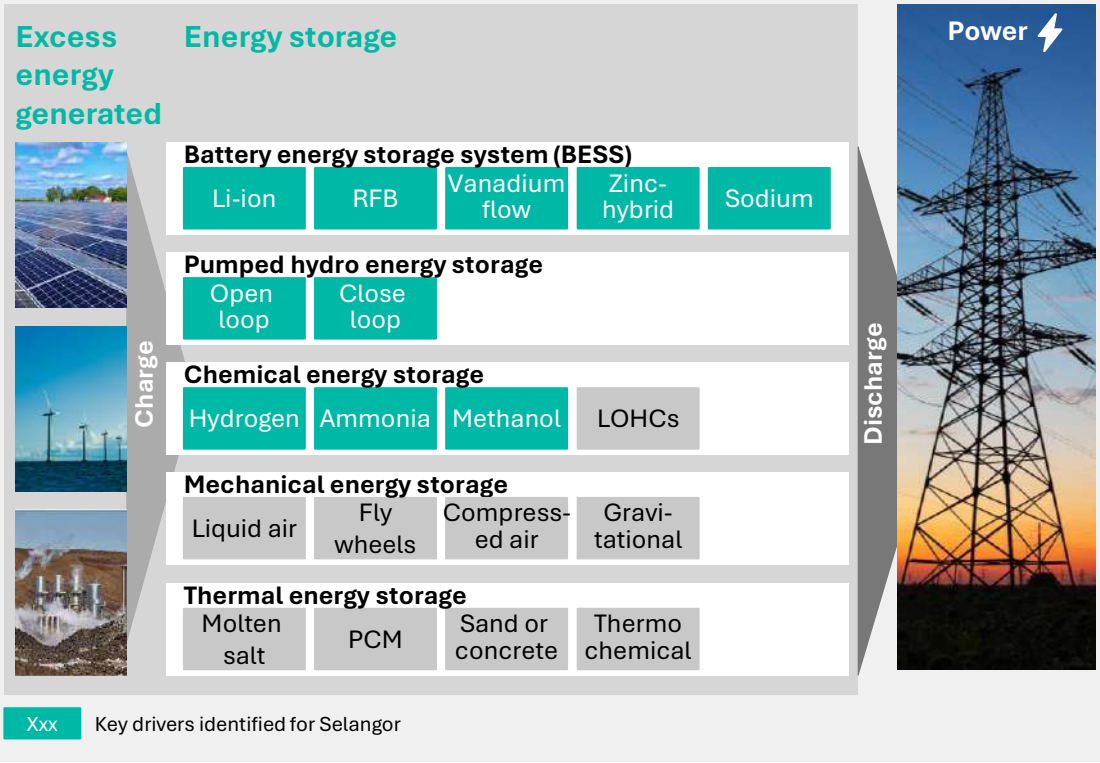


Figure 3.18: Energy storage overview

Key drivers

BESS

Infrastructure by providing fast, flexible, and efficient energy storage solutions. They store surplus electricity, often from renewable sources and release it during periods of high demand or grid instability, helping to stabilize voltage, support frequency regulation, and ensure uninterrupted power supply. BESS can be applied across the entire power system, from generation to transmission, distribution, and end use, making them suitable for integration with grid services, hybrid power plants, renewable energy sources, and commercial and industrial applications. This versatility makes BESS not just a storage solution, but a critical tool for a flexible, secure, and sustainable energy future.

As Selangor scales up its renewable energy capacity, battery storage will be instrumental in ensuring that green power remains both dependable and accessible across the state.

Pumped hydro energy storage

Pumped storage is a proven and efficient energy storage technology that plays a vital role in stabilizing the power grid. It works by using surplus electricity to pump water into an elevated reservoir, which is later released through turbines to generate electricity during periods of high demand. This process enables the state to store large amounts of energy and dispatch it when needed, ensuring a continuous and reliable power supply even when solar or wind output is low. Its ability to respond quickly to fluctuations in energy supply makes it an ideal complement to intermittent renewable sources. Recognizing its strategic value, Selangor is actively identifying suitable locations for developing pumped storage facilities to provide long-duration energy storage, reduce reliance on fossil fuels, and enhance overall grid resilience.

Hydrogen production (incl. conversion into ammonia and methanol)

Hydrogen serves as a highly versatile and efficient energy storage medium, particularly suited for supporting renewable energy integration. During periods of excess or off-peak electricity, energy is used to electrolyze water, producing hydrogen. This hydrogen can be stored in various forms such as compressed gas, liquefied hydrogen, metal hydrides, or carbon nanostructures depending on technical, economic, and environmental considerations. It can also be further converted into other energy carriers such as ammonia and methanol, enabling broader applications across sectors. When energy is needed, the stored hydrogen is either used in fuel cells or combusted together with natural gas to generate electricity. With its high energy density, long-duration storage capability, and ability to be transported and deployed across sectors, hydrogen offers a clean, scalable solution for balancing supply and demand while enhancing overall grid resilience.

Key Targets

Selangor aims to achieve significant milestones in energy storage by 2035. The state aim to achieve Battery Energy Storage System (BESS) capacity of 400 megawatt-hours (MWh), supported by RM 400 million of investment between 2027 and 2034. Selangor's government is also targeting hydrogen production with a capacity of 800 kg per day with an investment of RM 150 million by 2028. Additionally, a pumped storage system with a capacity of 30 megawatts (MW) is targeted, with an investment of RM 429 million anticipated by 2032.

Each of these systems comes with specific spatial and safety requirements that make low population density areas particularly important in their deployment. BESS, for example, can pose fire risks due to thermal runaway, requiring proper spacing and controlled environments that are typically easier to secure away from densely populated urban zones. Pumped hydro storage depends on significant elevation differences between reservoirs, a condition more readily found in hilly or mountainous rural landscapes. Similarly, storing hydrogen involves high-pressure containment and is highly flammable, necessitating regulated buffer zones that are more feasible in low population density industrial parks or remote locations. As such, low population density areas play a strategic role in supporting Selangor's energy transition by offering the physical conditions and safety margins essential for ESS infrastructure.

Battery Energy Storage System

Capacity: 400 MWh

Investment capacity: RM 400 m (2027-2034)

Hydrogen production (incl. conversion into ammonia and methanol)

Capacity: 800 kg/ day

Investment capacity: RM 150 m (2028)

Pumped Hydro Energy Storage

Capacity: 30 MW

Investment capacity: RM 429 m (2032)

Figure 3.19: Targets for energy storage on capacity and investment capacity

Key challenges

Despite the promising potential of energy storage systems, several challenges must be addressed to ensure their successful implementation in Selangor. High initial investment costs and limited grid infrastructure pose significant barriers to the widespread adoption of ESS technologies. Furthermore, the dependence on critical materials such as lithium, cobalt, and nickel for battery production creates supply chain risks. In Selangor, these challenges are compounded by the need for suitable land areas for large-scale installations and the integration of ESS with existing grid systems.

Key initiatives

The key initiatives and projects for energy storage systems are shown in figure 3.20.

27

Battery Energy Storage System

BESS is a critical complement to LSS & CRESS, helping to stabilize the grid by storing excess solar energy for use during peak demand or low generation periods

Champion:
Developers for LSS/ CRESS

28 29

Hydrogen production

A four-phase project led by the SHORE team under the SAGE aims to integrate hydrogen into power generation

Champion:
WHB

30

Pumped Hydro Energy Storage

Pumped hydro energy storage is currently undergoing feasibility studies, as it remains a relatively new concept and technology in Selangor's energy landscape

Champion:
SEDA

Figure 3.20: Key initiatives/ projects for energy storage

3.5 Key enablers for successful implementation

Under the SAGE, 7 strategic enablers have been identified to drive the state's transition towards a greener economy. These enablers serve as foundational pillars that support systemic transformation across sectors and align with broader national and global sustainability objectives. SAGE outlines 7 key enablers, green infrastructure, green mobility, green workforce & literacy development, green optimization and energy efficiency, green policies & incentives, green reporting, and green finance & investment, each designed to accelerate the state's low-carbon transition through targeted interventions.

1
Green infrastructure

Involves the deployment of technologies like carbon capture and advanced grid technologies to reduce emissions and enhance energy system efficiency

2
Green mobility

Focuses on electrifying public transport, expanding EV charging and hydrogen refueling infrastructure, and promoting low-emission transport solutions such as cycling and green logistics

3
Green workforce & literacy development

Aims to cultivate a green-literate population and a skilled workforce by strengthening education, training, and collaboration between government, industry, local groups and academia

4
Green optimization & energy efficiency

Reduces overall energy use by minimizing consumption, optimizing processes, and encouraging behavioral change through standards, retrofitting, and public engagement

5
Green policies & incentives

Establishes the rules, incentives, and standards needed to guide and support the energy transition at every level

6
Green reporting

Enables businesses to disclose their ESG performance through regulatory and voluntary frameworks, fostering transparency and accountability

7
Green finance & investment

Mobilizes funding for sustainable projects through mechanisms like green tech financing scheme green bonds, and public-private partnerships

Figure 3.21: The seven key enablers for SAGE

3.5.1 Green infrastructure

Overview

Green infrastructure forms the physical and technological foundation of Selangor's energy transition, enabling the state to decarbonize key sectors while modernizing its energy ecosystem. It includes critical systems such as carbon capture, utilization, and storage (CCUS) and advanced grid technologies that reduce emissions, improve energy efficiency, and support large-scale renewable integration.

Beyond environmental gains, these developments create skilled jobs in building and maintaining CCUS and advanced grid systems, while fostering local businesses in clean technology and energy management. For Malaysian SMEs, this infrastructure offers new avenues to enter green value chains such as renewable energy services, system integration, or component supply and benefit from more reliable, cost-effective energy enabled by advanced grid technologies. Enhanced energy stability and efficiency can lower operational risks and boost productivity for SMEs across both urban and rural areas. As Selangor advances toward a cleaner and more resilient energy future, these technologies will transform the industrial landscape. CCUS mitigates emissions from hard-to-abate sectors like cement and steel by capturing CO_2 for storage or industrial reuse. Advanced grid technologies enable real-time monitoring, automated demand response, and seamless integration of clean energy. Together, they reinforce Selangor's commitment to climate targets, energy security, and inclusive economic growth.

Key challenges

The large-scale development and deployment of green infrastructure in Selangor are not without challenges. Chief among them is the significant capital investment required to initiate and sustain such projects, particularly in emerging areas like CCUS and grid digitization. These technologies are complex, demand long lead times, and require specialized technical expertise, especially in designing and managing CO_2 transport and storage systems. The evolving regulatory framework also presents uncertainties, as existing standards may not yet fully address the technical and environmental considerations of new infrastructure solutions. Public understanding and acceptance, especially around the safety and permanence of CO_2 storage, remain limited, potentially affecting project feasibility. From the grid perspective, transitioning from legacy infrastructure to a modern, digital network involves extensive coordination across government, utilities, and private sector stakeholders, alongside investment in cybersecurity, workforce training, and data integration systems. Addressing these challenges will require proactive policymaking, targeted incentives, and institutional alignment to ensure that Selangor's green infrastructure can keep pace with its decarbonization ambitions.

Key initiatives

The key initiatives and projects for green infrastructure are shown in figure 3.22.

Implement advanced grid technologies

Deploy advanced digital systems across Selangor to optimize energy distribution and integrate renewable sources efficiently

Deploy carbon capture, utilization and storage (CCUS)

Capture CO_2 emissions from industrial sources and store or repurpose them to mitigate atmospheric release

Figure 3.22: Green infrastructure initiatives

To realize its green infrastructure goals, the Selangor state government is advancing a series of coordinated initiatives. The state will implement advanced grid technologies across the electricity network to enhance system efficiency, reduce transmission losses, and support the flexible integration of renewable energy. These upgrades will introduce real-time data management, automated controls, and demand-side response capabilities, creating a more adaptive and reliable power system. In parallel, Selangor is charting a strategy to develop its CCUS ecosystem. This begins with comprehensive feasibility studies to assess potential geological storage sites within and around the state, including deep saline formations and depleted hydrocarbon reservoirs. These assessments will evaluate technical viability, environmental safeguards, and long-term storage integrity. Building on this foundation, pilot-scale CCUS projects will be launched at selected industrial facilities to test capture technologies and refine cost and performance benchmarks. The state also plans to construct dedicated CO_2 transport infrastructure, such as pipelines, to efficiently connect emission sources with designated storage locations. All infrastructure development will be guided by a state-level regulatory framework that ensures safe operations, transparent monitoring, and public accountability. Through these initiatives, Selangor is laying the groundwork for a future-ready energy infrastructure capable of supporting its long-term transition to a low-carbon economy.

3.5.2 Green mobility

Overview

Green mobility is a cornerstone of Selangor's strategy to achieve a sustainable and low-carbon future. Transportation is a significant source of greenhouse gas emissions, contributing to urban air pollution and climate change. By transforming the transportation sector by promoting the adoption of electric public transports and vehicles (EVs), expanding charging infrastructure, integrating alternative fuels such as hydrogen and expanding greener transportation options.

This shift will generate new employment opportunities in EV manufacturing, infrastructure development, and maintenance services, while making transportation more accessible and affordable for all residents. Improved air quality will particularly benefit vulnerable communities, including children, the elderly, and those in densely populated areas. Together, these initiatives contribute to reducing emissions and elevating the overall quality of life for Selangor’s diverse population.

Key challenges

The shift towards green mobility in Selangor faces several challenges. The high initial costs associated with electrification and the development of new green fuel can be prohibitive for both consumers and businesses. Additionally, the existing transportation infrastructure may require significant upgrades to accommodate EVs, alternative fuel vehicles and to become bicycle friendly. Public awareness and acceptance of new technologies, such as hydrogen fuel cells, remain limited, necessitating comprehensive education and outreach efforts. Furthermore, coordinating efforts among various stakeholders, including government agencies, private sector partners, and the public, is essential to ensure the successful implementation of green mobility initiatives.

Key initiatives

Electrify public transportation systems

Transition Selangor's public bus fleet to electric vehicles to reduce urban air pollution

Promote green logistics networks

Promotion of electric and hydrogen-powered vehicles for goods transportation to reduce carbon emissions

Promote bicycle-friendly urban planning

Develop extensive cycling lanes and bike-sharing programs to encourage sustainable urban mobility

Develop micromobility infrastructure

Build dedicated lanes and supporting facilities to promote the safe use of e-bikes and e-scooters for short-distance travel

Expand electric vehicle charging stations

Increase the number of EV charging stations across Selangor to support the growing adoption of electric vehicles

Establish hydrogen refueling stations

Set up facilities to provide hydrogen fuel for vehicles, supporting the transition to clean transportation

Figure 3.23: Green mobility initiatives

To realize this transition, Selangor is implementing a comprehensive set of initiatives to accelerate the adoption of green mobility solutions. Efforts are underway to electrify public transportation, starting with the conversion of the state's bus fleet to electric vehicles, which is an essential step in reducing emissions and urban air pollution. In parallel, the state is promoting low-carbon logistics by encouraging the use of greener logistics options such as electric and hydrogen-powered vehicles for goods transport. To support active and sustainable urban mobility, bicycle-friendly infrastructure, including the development of dedicated cycling lanes and a bike-sharing program, is being developed. Complementing this, Selangor is also investing in micromobility infrastructure by building dedicated lanes and facilities to support the safe use of e-bikes and e-scooters for short-distance travel. Recognizing the importance of infrastructure in enabling this transition, the state is expanding its network of electric vehicle charging stations, with local councils facilitating this effort by providing land for the infrastructure through partnerships with EV charger providers. Additionally, groundwork is being laid for the establishment of hydrogen refueling stations to meet future demand. These coordinated measures underscore Selangor's commitment to delivering a cleaner, healthier, and more efficient transportation ecosystem for all.

3.5.3 Green workforce and literacy development initiatives

Overview

Green literacy development is a foundational enabler in Selangor's energy transition, encompassing both the cultivation of a skilled, future-ready workforce and the elevation of public awareness on sustainable practices. From engineers and technicians to policy analysts and clean energy entrepreneurs, a knowledgeable talent pool is essential to drive and sustain the transformation of Selangor's energy ecosystem. In parallel, fostering a society that is informed about energy conservation, renewable technologies, and climate responsibility is critical to building a culture of sustainability. To achieve this, Selangor is committed to advancing comprehensive education and training programs that reflect the latest developments in energy technologies and environmental science. These initiatives extend beyond the energy sector and into the public domain, empowering households, businesses, and communities to make responsible, energy-conscious decisions. Equally important is the role of collaboration: a robust, cross-sectoral network that connects government agencies, educational institutions, and industry stakeholders is vital to ensure that green literacy efforts are relevant, adaptive, and inclusive. Through this holistic approach, Selangor seeks to embed sustainability into the very fabric of its human capital development strategy.

Key challenges

The expansion of green literacy in Selangor faces a range of institutional and behavioral challenges. Developing high-quality training programs demands sustained investment in infrastructure, curriculum development, and skilled educators, resources that may be constrained by existing financial and administrative limitations. As the clean energy sector evolves at a rapid pace, training frameworks must continuously adapt to keep pace with emerging technologies, market demands, and international best practices. On the public side, awareness and engagement levels remain uneven, with many residents lacking accessible, credible information about the benefits of energy efficiency or the urgency of climate action. Encouraging behavioral shifts from adopting efficient appliances to supporting low-carbon mobility requires more than information alone; it calls for targeted outreach, culturally relevant messaging, and long-term community engagement. Additionally, effective collaboration across sectors can be hindered by misaligned priorities, limited coordination mechanisms, and the absence of shared accountability frameworks. Addressing these challenges is essential to ensure that Selangor's workforce and society are both equipped and motivated to support the energy transition.

Key initiatives

Initiatives focus on green workforce capacity building

Provide vocational training

Establish training centers to develop a skilled workforce for the clean energy sector

Introduce academic programs

Offer specialized courses in renewable energy and sustainability at Selangor's universities and technical schools

Facilitate recruitment of international green experts

Facilitate the targeted recruitment of experienced expats to fill key knowledge and skills gaps in Selangor's green transition

Develop green entrepreneurship & support scheme

Offer targeted program to support aspiring entrepreneurs in the green economy through grants, incubators, mentorship, and market access

Deep dive on next page

Launch public awareness campaigns

Educate Selangor's residents and businesses on energy conservation practices and the benefits of energy-efficient appliances

Foster research collaborations

Encourage partnerships between academic institutions and industry to advance energy transition research

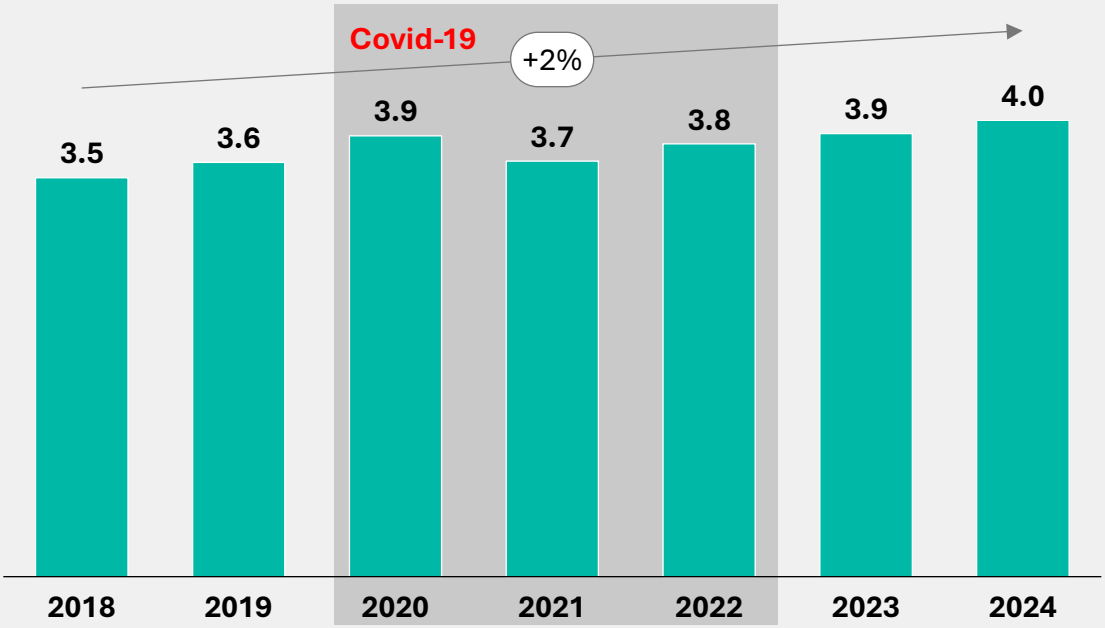
Engage communities in reforestation initiatives

Engage local groups in tree planting, habitat restoration, and stewardship to foster environmental awareness

Figure 3.24.1: Green workforce and literacy development initiatives

To overcome barriers and build a robust ecosystem of green literacy, the Selangor state government is implementing a comprehensive strategy for workforce capacity building and community engagement across the green economy This includes vocational training programs aimed at upskilling the existing labor force in practical clean energy competencies such as solar installation, sustainable construction, and energy efficiency management. Courses to train certified energy managers and energy auditors are being promoted to ensure compliance with regulatory requirements and improve energy performance across sectors. At the same time, academic programs in renewable energy and environmental sustainability are being introduced across institutions to prepare students with the technical and strategic expertise required for the green jobs in the near future. Selangor is also facilitating the recruitment of international green experts to support knowledge transfer and mentor local professionals, ensuring global best practices are shared at the local level. The state's green entrepreneurship and support scheme empowers startups and SMEs by providing resources and guidance to break into clean technology sectors. Together, these efforts span the entire talent pipeline, from students to experienced workers while positioning Selangor as a regional hub for green skills and innovation. Beyond capacity building, Selangor is advancing broader engagement through public awareness campaigns delivered via schools, digital platforms, and community events to promote sustainable living practices. Research collaborations between universities and industry are being strengthened to ensure academic and innovation efforts remain aligned with market needs. Additionally, the state is working to engage communities in reforestation initiatives, encouraging active participation in tree planting and ecological restoration. Collectively, they provide people across Selangor with particular impact in both urban and rural areas, access to better career prospects, entrepreneurial opportunities, and a meaningful role in building the state's green future.

Labour force in Selangor [million]



	Installed capacity targeted	Job creation projection
MyRER	18.0 GW	46,636
NETR	71.2 GW	310,000
SAGE	7.4 GW	26,000

Representing **~0.7%** of total workforce in Selangor

Figure 3.24.2: Deep dive on green workforce capacity building

As the energy sector currently employs approximately 25% of Malaysia's total workforce, and with Selangor's labor force continuing to grow at 2% compound annual growth rate, this strong baseline in energy-related employment, combined with a growing pool of workers, enables Selangor to lead in transitioning toward a green economy. Based on proportional estimates derived from the NETR and MyRER, using the average number of jobs created per GW from both reports, SAGE with its target of 7.414 GW of clean energy capacity, is projected with potential to generate up to 26,000 green job opportunities.

3.5.4 Green optimization & energy efficiency

Overview

Green optimization & energy efficiency is a key enabler in Selangor's energy transition, aimed at reducing overall energy consumption across buildings, industries, and households. At its core, optimization and energy efficiency is about using less energy to achieve the same or better outcomes, making it one of the most immediate and cost-effective strategies to lower emissions and reduce strain on energy systems. It involves three interlinked components: reducing unnecessary consumption, improving the performance of energy systems and processes, and fostering a culture of responsible energy use. Together, these efforts help lower operating costs, enhance energy security, and reduce the state's carbon footprint. Beyond technical upgrades, energy efficiency also reflects a broader shift in how energy is valued and used, placing equal emphasis on innovation, optimization, and public awareness. As Selangor charts a path toward a low-carbon future, improving energy efficiency will be critical to ensuring the sustainability and resilience of its energy ecosystem.

Key challenges

The advancement of green optimization and energy efficiency in Selangor faces a number of structural, financial, and behavioral challenges. Transitioning toward more efficient systems whether in homes, businesses, or public infrastructure often involves high upfront costs, particularly for technologies such as automation, building retrofits, and digital monitoring systems. While these investments yield long-term savings, the initial capital requirements can be a barrier for both public and private stakeholders. At the same time, energy efficiency depends heavily on user behavior, which cannot be changed overnight. Cultivating a widespread culture of energy-conscious living requires sustained education, long-term habit formation, and consistent public engagement. Many consumers still lack clear, accessible information about the practical benefits of energy efficiency or the tools available to achieve it. In industrial settings, outdated technologies and entrenched processes can further delay the adoption of optimized energy practices. Moreover, policy enforcement and inter-agency coordination are often uneven, limiting the reach and effectiveness of existing programs. Overcoming these challenges will require not only technical upgrades but also a deep shift in mindsets, governance mechanisms, and financing models to ensure inclusive and impactful progress.

Key initiatives

Enforce building energy codes

Implement strict energy efficiency standards for new constructions to reduce overall energy consumption

Mandate industrial energy audits

Require large industries to conduct energy audits to identify and implement energy-saving measures

Retrofit government buildings

Improve energy performance in public buildings through efficiency upgrades and modernization of systems

Implement smart township elements

Integrate digital infrastructure such as smart surveillance technologies to enhance energy efficiency and urban management

Introduce district cooling solutions

Centralize cooling systems at the district level to reduce energy consumption and improve operational efficiency

Increase energy saving awareness

Increase public awareness on energy conservation through targeted campaigns that inspire long-term behavioral change

Figure 3.25: Green optimization & energy efficiency initiatives

To overcome existing challenges and embed energy efficiency across all sectors, Selangor is implementing a comprehensive set of initiatives that target both infrastructure and behavioral transformation. A central measure is the enforcement of building energy codes, which introduce mandatory efficiency standards for all new developments. These regulations are designed to reduce long-term energy demand by ensuring that buildings are constructed with optimal design, materials, and technologies. In parallel, large industrial operations will be required to conduct regular energy audits, enabling them to assess consumption patterns, identify inefficiencies, and implement cost-effective solutions that enhance productivity while lowering emissions. In the public sector, Selangor is retrofitting government buildings to improve energy performance, prioritizing upgrades to insulation, lighting, and mechanical systems.

To advance urban-level efficiency, the state is rolling out Smart Township elements in partnership with developers. These include the integration of technologies such as energy-efficient street lighting, intelligent surveillance systems to optimize both energy use and urban functionality. At a broader systems level, district cooling solutions are being introduced in collaboration with Tenaga Nasional Berhad (TNB). By centralizing cooling infrastructure for large complexes and city blocks, this initiative can significantly reduce electricity demand, three such systems have already been implemented at key public buildings including the Royal Theatre, Selangor Museum, and Wisma MBSA. Recognizing the importance of public engagement, Selangor is also increasing energy-saving awareness through targeted campaigns aimed at educating residents and businesses on energy conservation practices, the use of efficient appliances, and long-term behavioral change. Taken together, these initiatives reflect a whole-of-society approach to energy efficiency, combining policy enforcement, technological innovation, and community participation to create a more sustainable Selangor.

3.5.5 Green policies & incentives initiatives

Overview

A comprehensive and forward-looking framework of green policies and incentives forms the backbone of Selangor's energy transition agenda. As the state positions itself to lead in sustainable development, it is crucial to establish regulatory clarity while also creating supportive mechanisms that encourage widespread participation. Well-defined legal instruments and enforcement frameworks will guide industry practices and provide long-term confidence for developers and businesses. At the same time, targeted incentives will help stimulate clean energy adoption, promote energy efficiency, and accelerate innovation. Together, these policies and incentives will ensure that Selangor's transition is effective, fair, and inclusive. This approach allows Selangor to stay aligned with national targets under the National Energy Transition Roadmap (NETR), while customizing solutions for the state's unique industrial structure and energy profile. By embedding sustainability into both regulatory and incentive structures, Selangor can foster broad collaboration, attract clean energy solutions, and drive meaningful decarbonization across sectors.

Key challenges

Despite strong ambition, the development and implementation of green policies in Selangor face several complex challenges. Foremost is the need to reform existing subsidy structures, which continue to favor fossil fuel consumption and hinder the competitiveness of low-carbon alternatives. These legacy subsidies distort market signals and delay the scale-up of clean technologies. Additionally, crafting effective policies requires substantial institutional capacity, cross-agency coordination, and continuous stakeholder engagement. Balancing regulatory ambition with economic pragmatism is also critical, particularly for energy-intensive sectors that operate in globally competitive markets. The absence of consistent data collection and reporting frameworks further complicates the enforcement of emissions-related regulations, while ongoing alignment with national and international standards introduces additional technical and legal complexity. Overcoming these barriers is essential to building investor confidence, unlocking green finance, and ensuring that the energy transition is both resilient and equitable.

Key initiatives

Facilitate Scope 3 emissions reporting compliance

Facilitate compliance with federal requirements on Scope 3 emissions reporting by guiding large corporations in Selangor to disclose supply chain emissions and strengthen accountability

Support implementation of carbon tax by 2026

Support the federal government's introduction of a carbon tax targeting high-emission industries by providing state-level guidance

Provide green technology incentives

Offer tax reliefs, rebates, and other benefits to encourage the adoption of green technologies across sectors

Offer EV purchase rebates

Provide tax rebates for electric vehicle purchases made through approved dealers in Selangor to accelerate EV adoption

Figure 3.26: Green policies & incentives initiatives

To address these challenges and foster a resilient policy environment, Selangor is implementing targeted green regulatory and incentive-based initiatives. A key measure is the state's support for the federal government's planned carbon tax by 2026, which will apply to high-emission industries such as energy production and cement manufacturing. Selangor will play an enabling role by engaging local businesses, providing technical guidance, and enhancing readiness to comply with this market-based instrument designed to encourage cleaner production and low-carbon investments. In parallel, the state will facilitate compliance with upcoming federal requirements on Scope 3 emissions reporting by assisting large corporations to accurately disclose supply chain emissions and improve transparency.

To further accelerate the adoption of sustainable technologies, Selangor will offer a range of green technology incentives, including tax reliefs, rebates, and other benefits across industrial and commercial sectors. In shaping these initiatives, inspiration can be drawn from successful federal programs such as the Energy Audit Conditional Grant, which helps companies identify energy-saving opportunities, and the Nikmat Untuk Rakyat (NUR@PETRA) Rebate Program, which provides targeted incentives to promote the adoption of energy-efficient technologies among smaller enterprises. These examples offer valuable frameworks that Selangor could adapt to suit local needs and further accelerate the transition to a low-carbon economy. Recognizing the importance of green mobility, some local councils also introducing targeted tax rebates for electric vehicle purchases made through approved dealerships in Selangor, reinforcing efforts to reduce transport-related emissions and support cleaner urban mobility. Through these measures, Selangor aims to align with national climate goals while strengthening local accountability, transparency, and market readiness for a low-carbon future.

3.5.6 Green reporting initiatives

Overview

Green reporting serves as a vital tool in Selangor's energy transition strategy by enhancing transparency, driving accountability, and fostering market confidence. As the state charts its course toward a low-carbon and resilient economy, consistent and credible reporting on environmental, social, and governance (ESG) performance is essential to track progress, identify gaps, and attract green investment. Green reporting enables both public and private sector actors to disclose their climate-related risks, emissions profiles, and mitigation efforts in a structured and comparable manner. For the Selangor state government, it also serves as a platform to track achievements, communicate policy outcomes, demonstrate leadership, and align with national frameworks such as the NETR.

Importantly, this initiative empowers the public with greater access to information, allowing citizens, community groups, and civil society to stay informed about how government and corporations are responding to climate challenges. It promotes more inclusive governance by enabling the people of Selangor to hold institutions accountable and participate meaningfully in the state's green development journey. Over time, widespread ESG adoption is expected to foster a culture of corporate responsibility, encourage ethical business practices, and build long-term public trust in Selangor's sustainable growth trajectory.

Key challenges

Despite growing awareness of sustainability issues, green reporting practices in Selangor remain uneven across sectors and institutions. Many corporations, particularly small and medium-sized enterprises, lack the technical capacity, resources, or knowledge to produce robust ESG disclosures. There is also an absence of uniform reporting standards, which leads to inconsistencies in the quality and comparability of sustainability data. Additionally, while regulatory ESG requirements are expanding globally, there is still limited enforcement or incentive mechanisms at the local level to drive comprehensive adoption, especially among state-owned enterprises and high-emission sectors. For the public sector, challenges include the integration of reporting frameworks across agencies, standardizing indicators for performance evaluation, and embedding sustainability metrics into planning and budgeting cycles. Addressing these gaps is crucial to ensure that reporting becomes a meaningful tool for decision-making, not just a compliance exercise.

Key initiatives

Establish dashboard tracking system

Build or enhance a central dashboard to track project progress and achievements under SAGE, with updates provided by responsible departments for transparency and coordination

Implement Selangor government green reporting

Implement biennial green reporting by the Selangor government to track progress, identify gaps under the SAGE Roadmap, and showcase achievements that strengthen investor confidence and promote green investment in the state

Require corporate green reporting

Require enterprises in Selangor to disclose their environmental, social, and governance (ESG) efforts, including outcomes from industrial energy audits and encouraging voluntary ESG disclosures to stakeholders to enhance transparency and accountability

Figure 3.27: Green reporting initiatives

The Selangor state government will establish a centralized dashboard tracking system as the main platform for departmental reporting and progress monitoring under the SAGE Roadmap. This system will enable agencies to update project data regularly, improving coordination and ensuring consistent, transparent reporting. The state will also implement biennial green reporting to institutionalize sustainability practices in public governance and track SAGE progress. These reports will present gap analyses, key milestones, and future targets to provide stakeholders with a clear view of Selangor's climate actions. To reinforce public sector leadership, all government-linked companies and state-owned enterprises will be required to conduct mandatory ESG reporting. Selangor will also promote voluntary ESG disclosures from private companies, especially in high-impact sectors, through strategic guidance, incentives, and capacity building. Together, these measures aim to embed a culture of sustainability and transparency aligned with global investor expectations and the state's long-term goals.

3.5.7 Green finance & investment

Overview

Green finance and investment are foundational to Selangor's energy transition, providing the capital necessary to drive the adoption of renewable energy, enhance energy efficiency, and scale up clean technologies. As the shift towards a low-carbon economy demands substantial upfront investment, the state government recognizes the urgency of establishing diverse, reliable, and innovative financing mechanisms that can unlock funding from both public and private sources. Strategic mobilization of green capital will not only accelerate the realization of green infrastructure and climate-aligned development but also stimulate job creation, attract ESG-conscious investors, and position Selangor as a leading hub for sustainable economic growth. In this context, the state is committed to building a robust green financial ecosystem that supports climate-resilient development and aligns with national commitments.

Key challenges

Despite increasing investor interest in sustainability, green finance in Selangor still faces several structural and market-related barriers. A key challenge is the perceived risk and limited commercial viability of certain clean technologies, such as carbon capture, hydrogen, and bioenergy that have yet to reach full maturity or scale. This often discourages institutional investors from participating in early-stage or unproven green projects. Furthermore, the absence of a deep pipeline of investment-ready projects hampers the flow of capital, as many proposals lack sufficient technical due diligence or fail to meet investors' thresholds for return and risk. Smaller initiatives, such as those focused on energy efficiency or community-scale renewables, frequently struggle to attract financing due to scalability constraints and high transaction costs. Additionally, the limited availability of structured green financial products and the need for regulatory clarity, particularly around carbon pricing and reporting further inhibit the growth of green capital markets in the state.

Key initiatives

Implement green technology financing schemes

Provide soft loans and financial support to enable the development of green technology projects

Facilitate public-private partnerships

Collaborate with the private sector to develop and implement energy infrastructure projects

Issue green bonds

Raise funds through green bonds to finance large-scale renewable energy projects

Figure 3.28: Green finance & investment initiatives

To strengthen Selangor's green financing ecosystem, the state government will implement green technology financing schemes aimed at enabling the development and scaling of sustainable projects. These may include soft loans and tailored financial support to foster broader participation in the green economy and accelerating the adoption of clean technologies. In parallel, the state will also promote public-private partnerships to bridge financing gaps and tap into private sector expertise for the development and operation of clean energy infrastructure. To mobilize capital for large-scale renewable energy and sustainable infrastructure projects, Selangor will prioritize the issuance of green bonds, enabling the pooling of resources for high-impact initiatives such as solar farms, energy-efficient transport systems, and grid upgrades. Collectively, these measures are designed to mainstream sustainability in the financial sector and accelerate the deployment of capital towards Selangor's clean energy future.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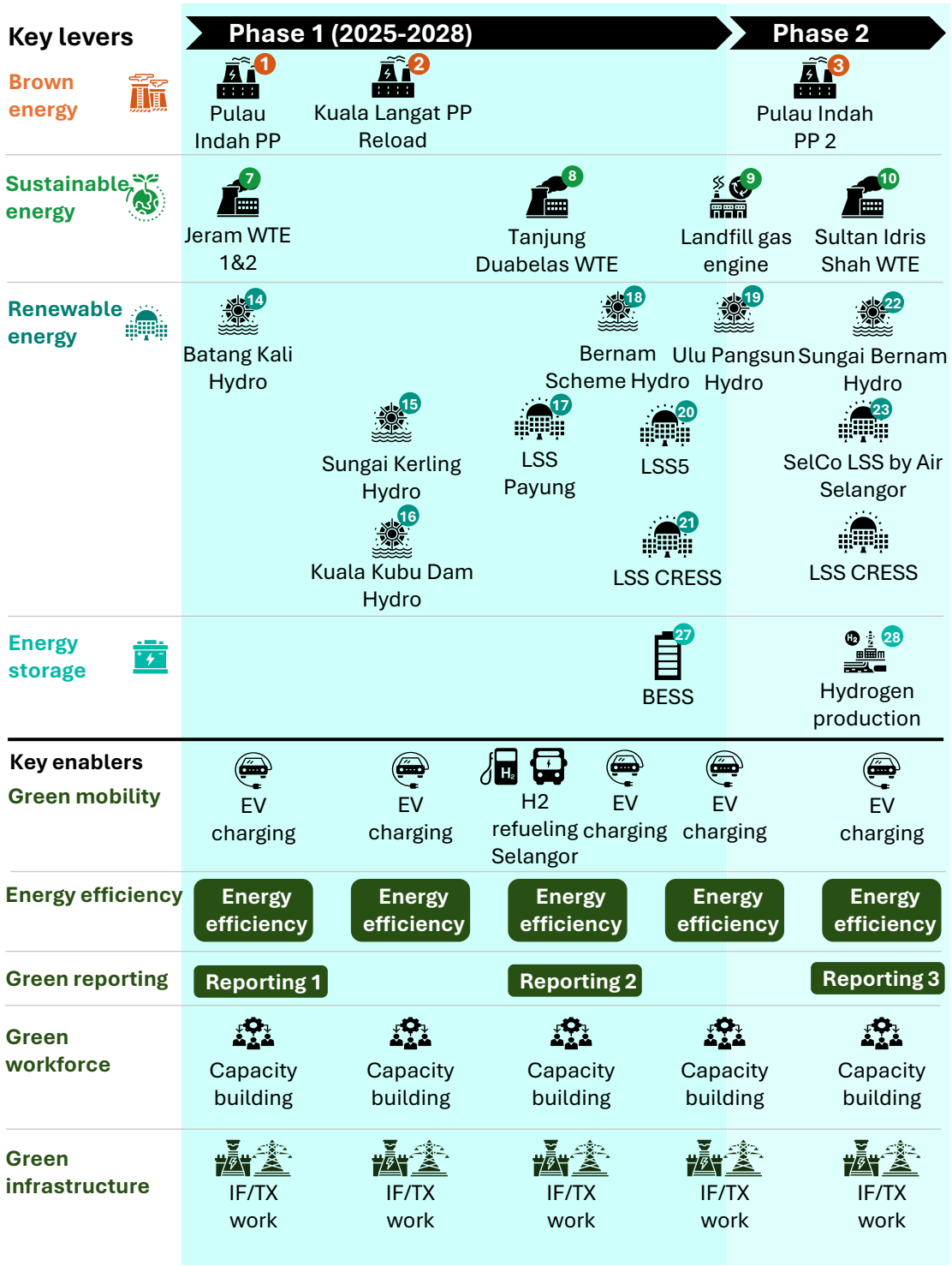
3.6 Overview of key initiative and implementation phases

To provide a clear roadmap for Selangor's energy transition, a detailed timeline has been developed outlining the key initiatives and projects under each of the four strategic levers as well as the key enablers. This timeline serves as a visual representation of the state's phased implementation approach, highlighting when specific projects will begin.



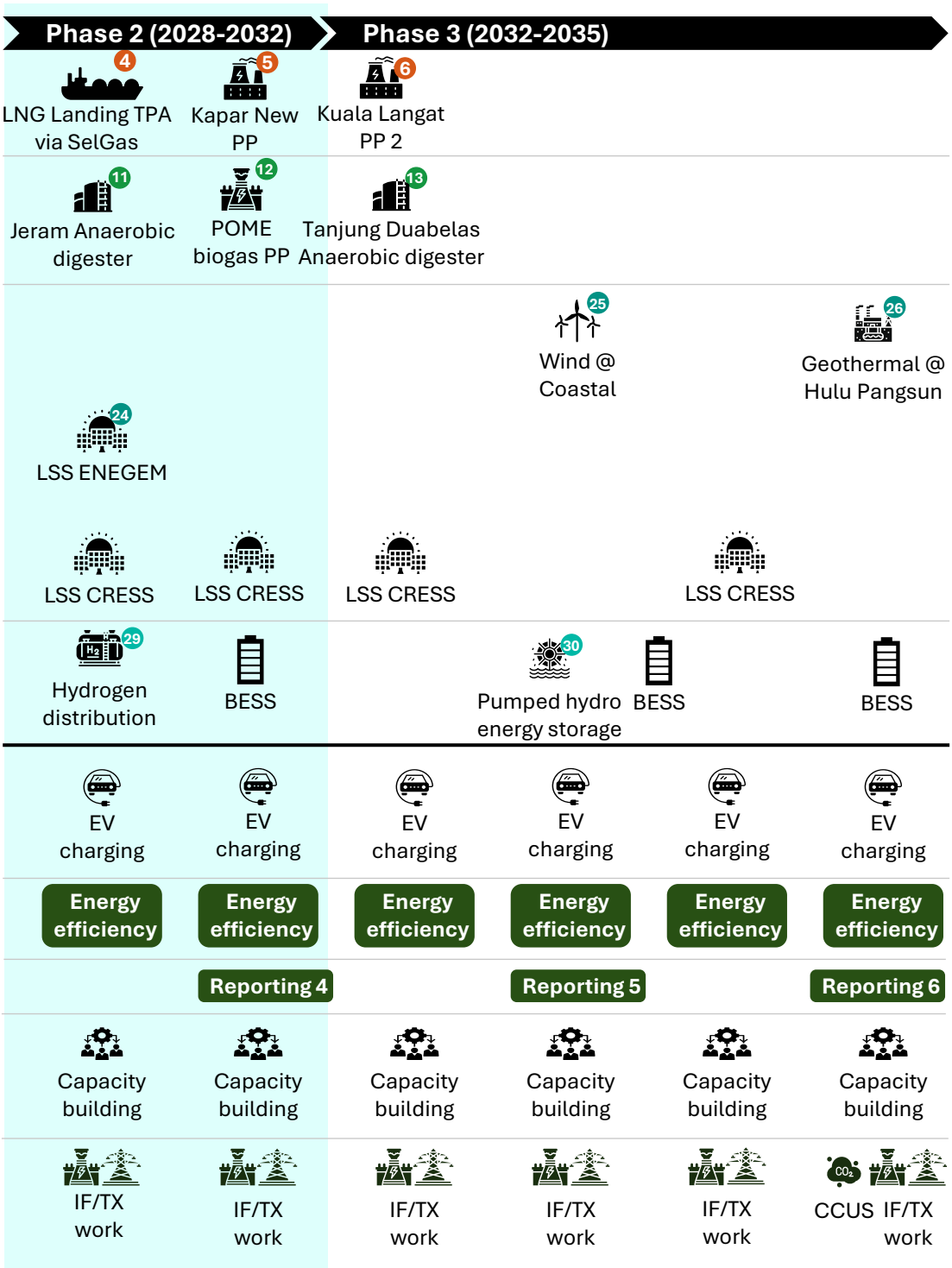


Figure 3.29: Selangor Green Economy Roadmap: Selangor's Green Future

SECTION 4

SAGE Flagship Catalyst

SECTION 4

SAGE Flagship Catalyst

SAGE has introduced five strategic subsets, GAPS, SelGas, SHORE, ISWM and SEL-Hydro to drive Selangor's transition to a green economy.

GAPS is a flagship initiative under SAGE that positions solar energy as a key driver of Selangor's clean energy transition. GAPS facilitates coordination across seven core areas to streamline engagement among stakeholders including customers, landowners, regulators, project developers, utilities, legal bodies, and financial institutions. It has identified 7,921 acres of land and 13,094 acres of water bodies, with solar generation potential of 2,707 MW and 4,364 MW respectively.

SelGas aims to build a resilient and future-ready natural gas ecosystem to position Selangor as Malaysia's leading natural gas hub. SelGas is developed in response to key challenges in Malaysia's natural gas sector, including declining production, price disparities, rising demand, and limited import infrastructure. Furthermore, SelGas follows a three-phase implementation plan that focuses on assessing current systems, improving infrastructure and then expanding the market, reducing transportation costs and infrastructure needs. SelGas' business model aims to ensure stable income while offering flexibility in gas delivery. While the sourcing strategy for SelGas is designed to ensure a reliable and cost-effective gas supply while remaining flexible to market conditions.

SHORE aims to establish Selangor's first green hydrogen production hub to introduce, scale, and commercialize hydrogen as a viable alternative energy source. SHORE's four-phase implementation strategy begins with hydrogen production for mobility, expands into power generation blending, and explores opportunities for export. The hydrogen production is based in Batang Kali, which has access to essential resources such as clean water, a stable energy supply, and is well-connected by major roads.

ISWM aims to reduce landfill dependency, lower greenhouse gas emissions, and enable clean electricity generation by transforming Selangor's waste management ecosystem into a sustainable, resource-efficient system.

SEL-Hydro serves as Selangor's dedicated initiative to explore and expand the state's hydropower potential as part of its broader clean energy transition under SAGE.

SAGE has developed a series of dedicated subsets to drive Selangor's transition toward a green economy, each strategically targeting key areas of the state's energy and environmental transformation.

Figure 4.1: The 5 flagship catalysts of SAGE

These flagship catalysts, GAPS, SelGas, SHORE, SEL-Hydro and ISWM, function as specialized implementation programs, each responsible for advancing specific components of the green economy. From aggregating renewable energy and optimizing natural gas usage to pioneering hydrogen development, expanding hydropower resources, and modernizing solid waste management, these initiatives ensure that the transition is both comprehensive and action-oriented. By aligning with SAGE's goals, these subsets are instrumental in unlocking new investment channels, enabling technology deployment, and ensuring that Selangor's shift toward sustainability is cohesive, measurable, and aligned with national and global commitments.

4.1 GAPS (Green-energy Aggregator Programs for Selangor)

Overview

GAPS aims to position solar energy as a cornerstone of the state's clean energy transition. As a program designed to streamline the entire solar energy value chain, from project development and approvals to energy generation, offtake, and adoption, GAPS acts as a central facilitator that brings together stakeholders across sectors. It functions as a key gateway for accelerating solar power development and investment, leveraging federal frameworks such as the recently launched Corporate Green Energy Supply (CRESS) mechanism introduced by the Energy Commission. Designed to unlock new revenue streams for Selangor, GAPS aligns renewable energy development with the state's broader economic ambitions by enabling strategic, large-scale solar deployment across suitable land parcels. The program is set to begin implementation in Q4 2024, with its inaugural project already shortlisted under the Large Scale Solar 5 (LSS5) scheme, a development poised to become the largest floating solar plant in Southeast Asia. Built on a third-party access (TPA) model, GAPS enables solar developers to secure their own offtakers, creating a streamlined pathway for private sector participation and expanding Selangor's role in the national solar energy landscape.

About GAPS

Green Energy Aggregator Program for Selangor ("GAPS") was established to overcome barriers, particularly the land availability and cost for solar power development and investment in Selangor, leveraging federal frameworks such as Corporate Green Energy Supply (CRESS), Large Scale Solar (LSS) mechanisms introduced by the Energy Commission

Objective

GAPS aims to act as a gateway for renewable energy investment in Selangor and to create new revenue stream for the state

Vision

- Enable a coordinated ecosystem for solar deployment that aligns land access, regulatory facilitation, and infrastructure planning
- Support the matching of corporate electricity demand with solar supply through CRESS, promoting private sector participation in renewable energy
- Streamline land identification, project approvals, and inter-agency coordination to reduce development barriers and accelerate project timelines
- Facilitate efficient grid connectivity by coordinating power evacuation infrastructure and resolving technical and regulatory constraints

Figure 4.2: Overview of GAPS

Core functions

GAPS is specifically designed to overcome barriers to solar energy development in Selangor, particularly the challenge of land availability and cost. Its primary function is to aggregate and mobilize suitable land in Selangor for solar photovoltaic (PV) projects. By identifying and activating strategic land parcels, including underutilized or idle lands, GAPS enables the state to monetize its land assets while supporting climate goals and enhancing energy resilience.

Beyond land facilitation, GAPS plays a central role in developing a comprehensive solar project ecosystem. This includes establishing land selection frameworks, minimizing environmental impact, increasing utilization of strategic land and curating a land source portfolio through state agency collaborations and public-private. GAPS also develops solar generation models that optimize financial returns for the state and provide scalable, bankable solutions for investors and developers.

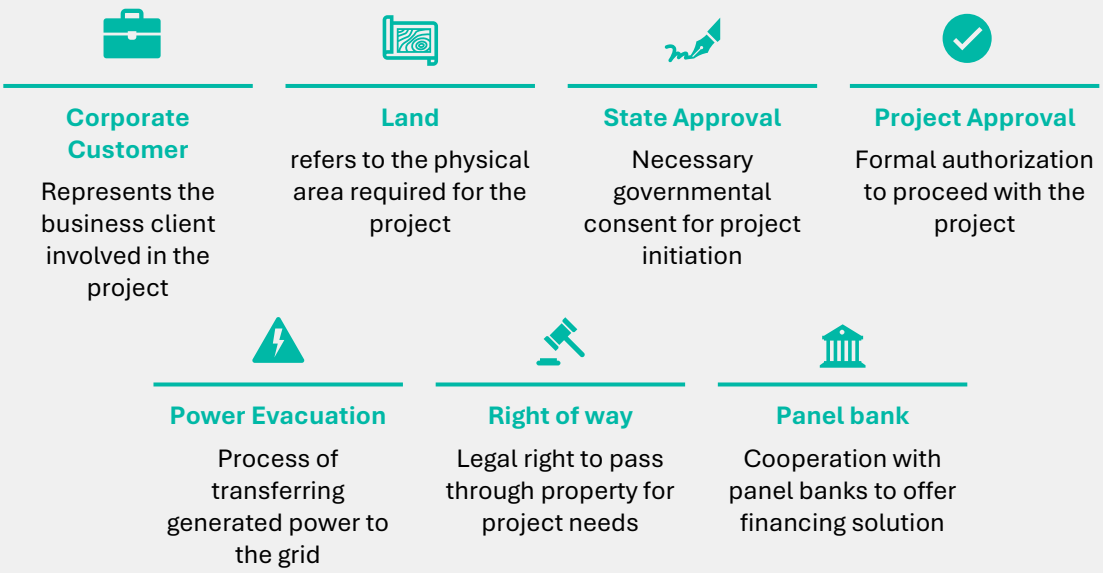


Figure 4.3: 7 core functions of GAPS

To operationalize its vision, GAPS functions across seven core areas:

1. Representing **corporate customers** in matching solar supply with demand under the CRESS mechanism;
2. Identifying and securing viable **land** parcels for solar project deployment based on technical and strategic value;
3. Facilitating **state-level approvals**, including land use permissions and inter-agency coordination;
4. Supporting formal **project authorization**, ensuring solar projects obtain necessary permits and licenses;

5. Coordinating **power evacuation** infrastructure, to connect solar plants efficiently to the national grid or direct offtakers;
6. Resolving **legal and regulatory**- related matters, such as land rights and right-of-way clearances;
7. Partnering with financial institutions, especially **panel banks**, to deliver customized green financing schemes to realize renewable energy projects efficiently.

By focusing mainly on solar power, GAPS is positioned to bridge policy intent with practical delivery, creating a unified platform that connects landowners, solar developers, technology providers, offtakers, and financiers. This integrated approach ensures that Selangor can meet rising energy demand sustainably while establishing itself as a leader in solar-driven economic growth and low-carbon development.

Deep dives:

To date, GAPS has identified a dedicated land bank comprising approximately 7,921 acres, with a projected solar generation potential of up to 2,707 MW in Selangor. In parallel, it is exploring floating solar opportunities, with a total waterbody area of 13,094 acres identified across the state, translating into an additional 4,364 MW of solar capacity. These figures highlight the untapped scale of solar generation that Selangor could harness through strategic site development and infrastructure planning.

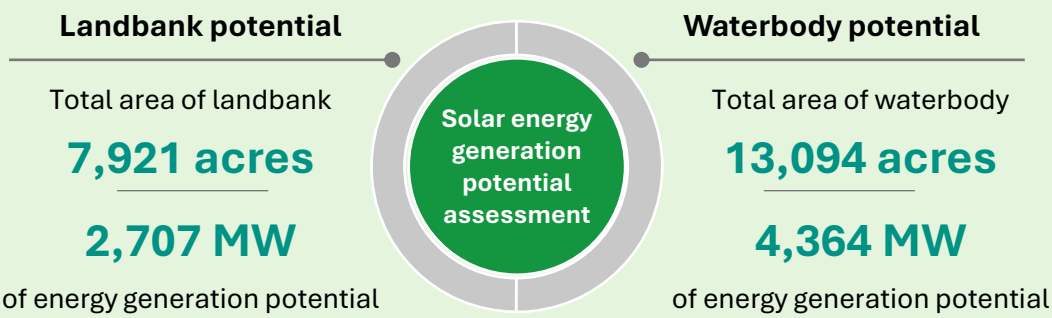


Figure 4.4: The identified solar energy generation potential in Selangor

The identified land parcels and water bodies are strategically distributed across multiple regions in Selangor, ensuring geographic diversity and enabling balanced development of solar energy infrastructure throughout the state

Sabak Bernam

Majlis Perbandaran Kajang
Total area : 138 acres
MW Potential : 46 MW

Kajang

Majlis Perbandaran Kajang
Total area : 325 acres
MW Potential : 108 MW

Klang

Majlis Perbandaran Klang
Total area : 849 acres
MW Potential : 283 MW

Kuala Selangor

Majlis Perbandaran Kuala Selangor
Total area : 1,234 acres
MW Potential : 472 MW

Majlis Perbandaran Kuala Selangor
Total waterbody area : 8,938 acres
MW Potential : 2,979 MW

Kuala Langat

Majlis Perbandaran Kuala Langat
Total area : 1,697 acres
MW Potential : 565 MW

Majlis Perbandaran Kuala Langat
Total waterbody area : 1713 acres
MW Potential : 571 MW

Hulu Selangor

Majlis Perbandaran Hulu Selangor
Total area : 1,452 acres
MW Potential : 550 MW

Majlis Perbandaran Hulu Selangor
Total waterbody area : 1,170 acres
MW Potential : 390 MW

Kuala Selangor

Majlis Perbandaran Sepang
Total area : 208 acres
MW Potential : 70 MW

Majlis Perbandaran Sepang
Total waterbody area : 1,265 acres
MW Potential : 421 MW

Figure 4.5: Locations of the identified solar energy generation potential areas in Selangor

Crucially, GAPS is also well aligned with the growing energy demands of Selangor's expanding digital economy. The state is rapidly emerging as a regional hub for data center development, with major international players such as Vantage Data Centers and Amazon Web Services (AWS) already making significant inroads. At least six industrial parks, ranging in size from hundreds to thousands of acres, have been earmarked specifically for data center investments. These developments present an ideal opportunity for GAPS to serve as a dedicated platform for connecting renewable solar generation to high-consumption users, facilitating direct green power supply arrangements under the CRESS mechanism.

4.2 SelGas (Natural Gas Roadmap for Selangor)

Overview

Natural Gas Roadmap for Selangor (SelGas) is a strategic project to develop an integrated gas infrastructure system anchored around the regasification terminal. It aims to strengthen the state's position as Malaysia's leading natural gas hub. Capitalizing on Selangor's status as the largest non-power gas consumer in the country, SelGas sets out a comprehensive roadmap that leverages key existing infrastructure, including the terminal and the power plants to create a resilient and interconnected gas supply ecosystem. The project addresses both near-term energy security needs and longer-term competitiveness within a rapidly evolving national gas market.

About SELGAS

The Selangor Gas (SelGas) initiative presents a timely strategic opportunity for Selangor to establish itself as Malaysia's gas hub by developing integrated gas infrastructure centered around the regasification terminal

Objective

SelGas aims to strengthen the state's position as Malaysia's leading natural gas hub by creating a resilient and interconnected gas supply ecosystem

Vision

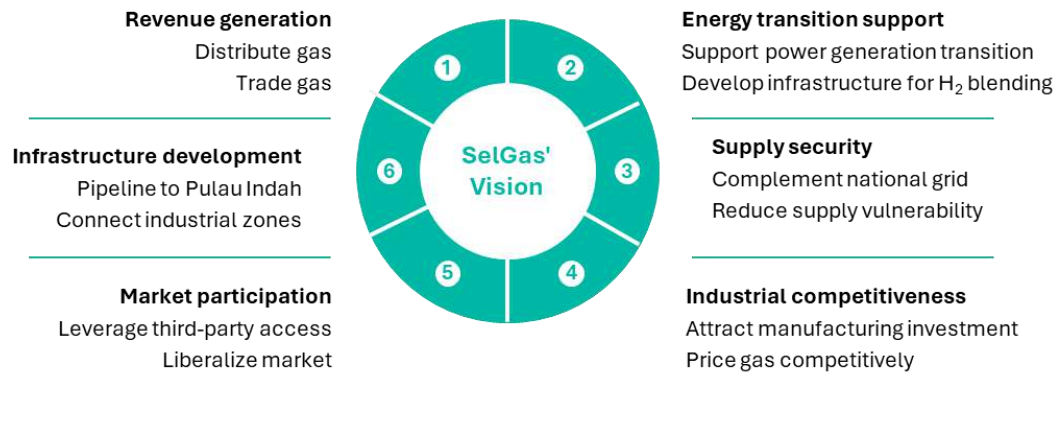


Figure 4.6: Overview of SelGas

SelGas is designed in response to a series of structural challenges currently confronting Malaysia's natural gas industry.

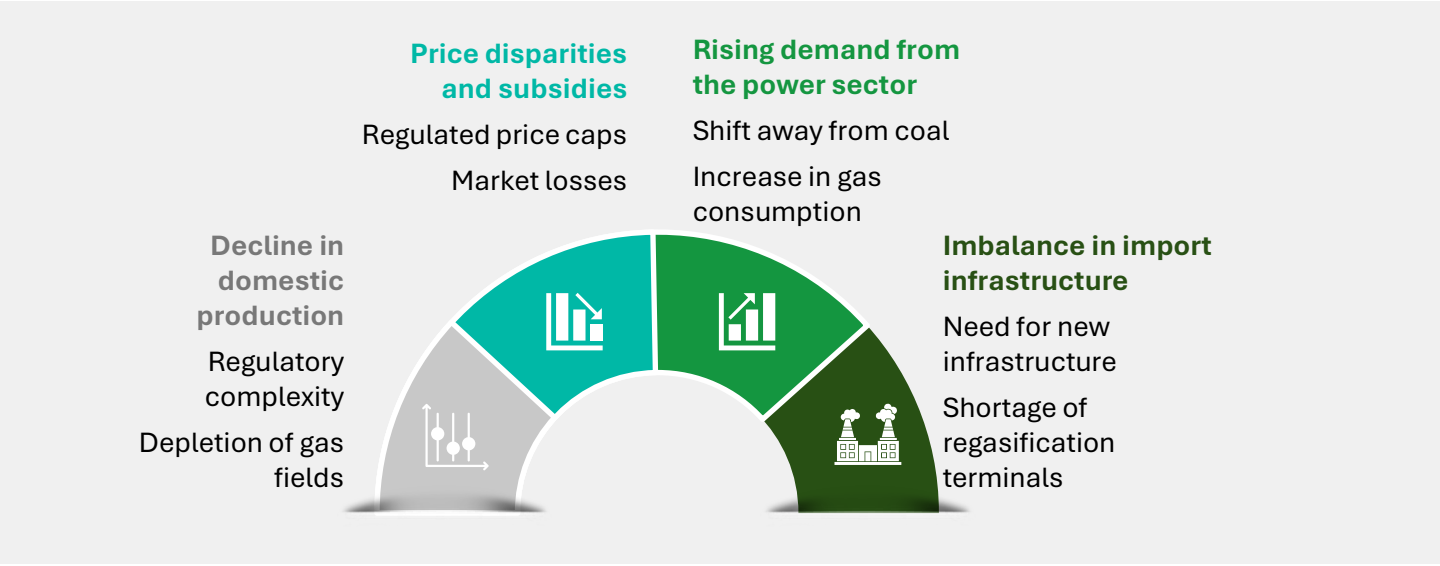


Figure 4.7: Challenges in Malaysia's natural gas industry

These include the decline in domestic production due to depleting fields and complex regulatory conditions, price disparities driven by subsidies and regulated pricing mechanisms, rising demand from the power sector amid coal phase-out efforts, and an imbalance in import infrastructure, particularly the limited number of regasification terminals across the peninsula. Against this backdrop, SelGas envisions establishing Selangor as the premier gas hub in Peninsular Malaysia by 2035, built on state-led infrastructure development, targeted investment attraction, and active market participation through mechanisms such as Third-Party Access (TPA).

At its core, SelGas aims to deliver energy supply security, support Malaysia's energy transition, stimulate revenue generation, and enhance industrial competitiveness in Selangor. Through the liberalization of the gas market, optimization of logistics, and facilitation of public-private infrastructure investment, SelGas is set to play a foundational role in positioning natural gas as a reliable, transitional fuel in Selangor's broader clean energy trajectory.

Core functions

SelGas is structured around a phased implementation plan designed to enable a systematic and future-ready transformation of the state's natural gas infrastructure. These core functions are organized across three distinct phases, each aimed at addressing key technical, commercial, and regulatory priorities while laying the foundation for Selangor to become a leading gas hub in Peninsular Malaysia.

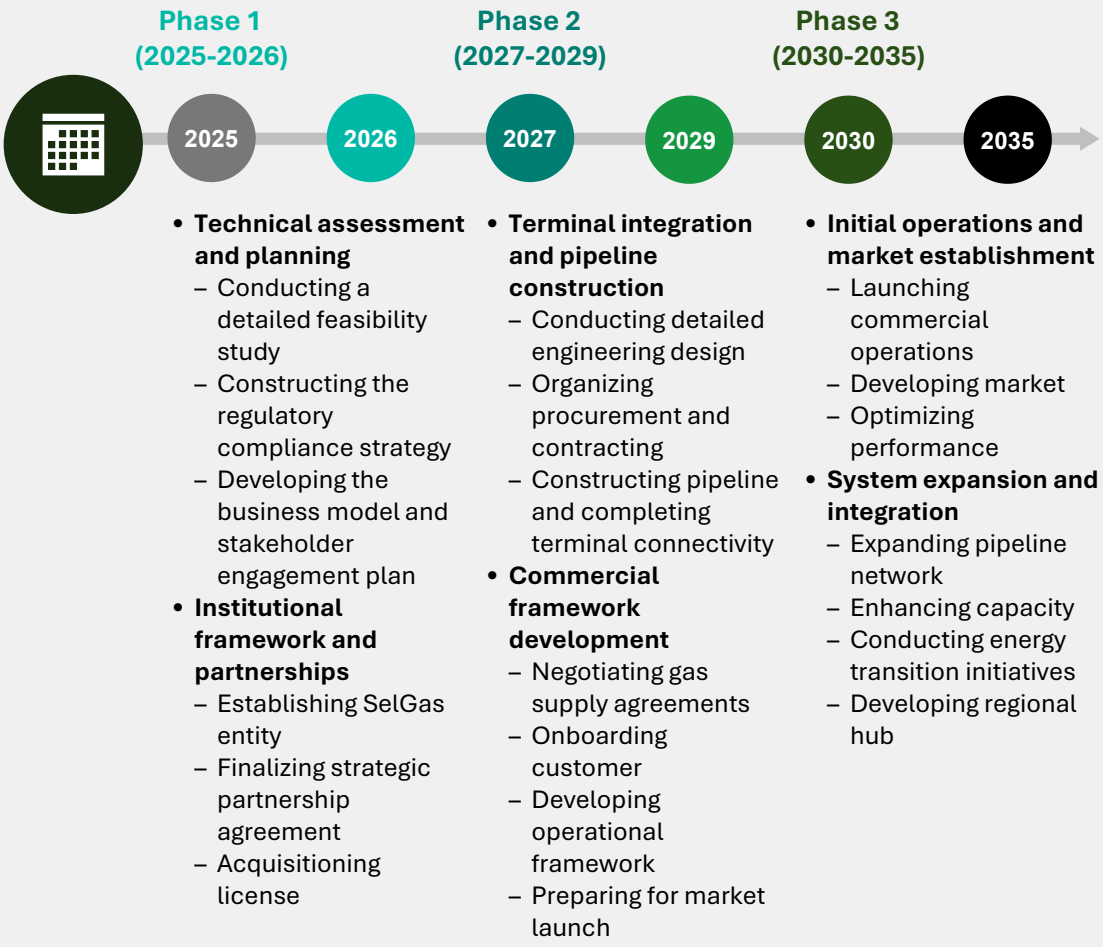


Figure 4.8: SelGas' 10-year plan

Phase 1: Feasibility and Preparation (2025–2026)

The initial phase focuses on conducting a comprehensive technical and regulatory assessment to establish the viability of the project. This includes a detailed feasibility study of the port and terminal facilities to evaluate infrastructure readiness, as well as the development of a regulatory compliance strategy to identify potential legislative barriers and define mitigation pathways. A robust business model will be formulated, alongside a targeted stakeholder engagement plan to align state, federal, and industry interests. Institutional mechanisms will also be put in place, including the establishment of a dedicated SelGas entity, the finalization of a strategic partnership agreement for terminal utilization, and the acquisition of necessary licenses to operate as a gas aggregator and distributor.

Phase 2: Infrastructure Development (2027–2029)

This phase marks the physical rollout of key infrastructure. Activities include the detailed engineering design, procurement, and construction of a dedicated pipeline network linking the terminal to industrial demand centers. Efforts will also be made to finalize terminal connectivity and operational readiness. In parallel, the commercial framework will be developed to support market entry, including securing gas supply agreements with diversified international sources beyond existing Australian supply routes. A customer onboarding strategy will be executed, and an operational framework will be established in preparation for the formal market launch.

Phase 3: Operations and Expansion (2030–2035)

Upon completion of construction, SelGas will enter the operational phase, commencing with commercial operations and market establishment, initially targeting anchor clients in Selangor's industrial base. Operational performance will be continuously assessed to optimize delivery, improve efficiencies, and expand customer reach. Pipeline network expansion will be pursued to serve additional industrial zones, emerging data center clusters, and semiconductor manufacturing hubs, with potential cross-border integration into neighboring states. Furthermore, capacity enhancement measures will be implemented to support growing demand and broaden supply flexibility.

As Selangor moves toward a cleaner energy future, this phase will also lay the groundwork for energy transition initiatives, including hydrogen blending, carbon capture, utilization and storage (CCUS), and biogas integration. Over time, these measures are expected to elevate Selangor's standing as a regional gas hub, reinforcing the state's long-term energy security, industrial competitiveness, and alignment with national low-carbon ambitions.

Deep dives:

SelGas' Business model overview

SelGas' business model revolves around several key revenue-generating streams aimed at ensuring stable income while offering flexibility in gas delivery. One of the primary mechanisms is throughput fees, which involves charging for the transportation of gas through its pipeline network. Additionally, SelGas provides storage and flexibility services, offering customers the ability to store gas and adjust delivery schedules based on fluctuating demand. The company also capitalizes on price arbitrage opportunities, exploiting market price gaps to purchase gas at lower rates and sell it at higher prices during peak demand periods. Another critical aspect of the business model is the margin on gas sales, where SelGas earns a retail margin above its procurement cost. Furthermore, SelGas offers value-added services, such as technical support and consulting, helping clients optimize their gas usage and infrastructure while enhancing overall service offerings.

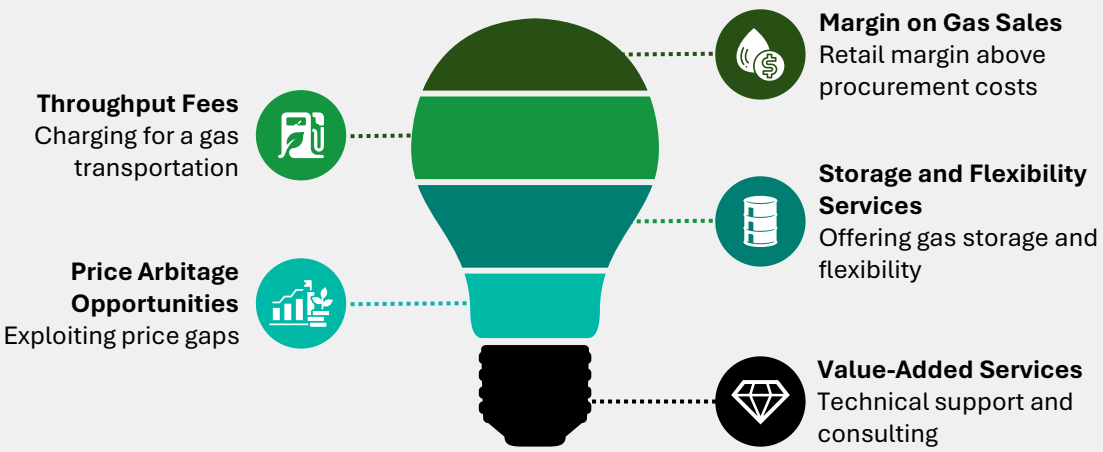


Figure 4.9: SelGas' business model

SelGas' gas sourcing strategy overview

The sourcing strategy for SelGas is designed to ensure a reliable and cost-effective supply of gas while remaining flexible to market conditions. A significant portion of the gas volume, approximately 60-70%, is secured through long-term contracts, ensuring a steady and predictable supply. In addition to these contracts, SelGas also engages in medium-term agreements, which provide flexibility by sourcing gas from regional suppliers, allowing the company to adapt to changing market conditions. To optimize costs and meet fluctuations in demand, SelGas also makes spot purchases, purchasing gas from the spot market when advantageous. The company ensures continuity of supply by maintaining strong connections with the Petronas network, which serves as a key domestic supply source. Lastly, SelGas is exploring partnerships with PETROS to diversify its supply sources, specifically investigating supply arrangements in Sarawak to further bolster its sourcing strategy.

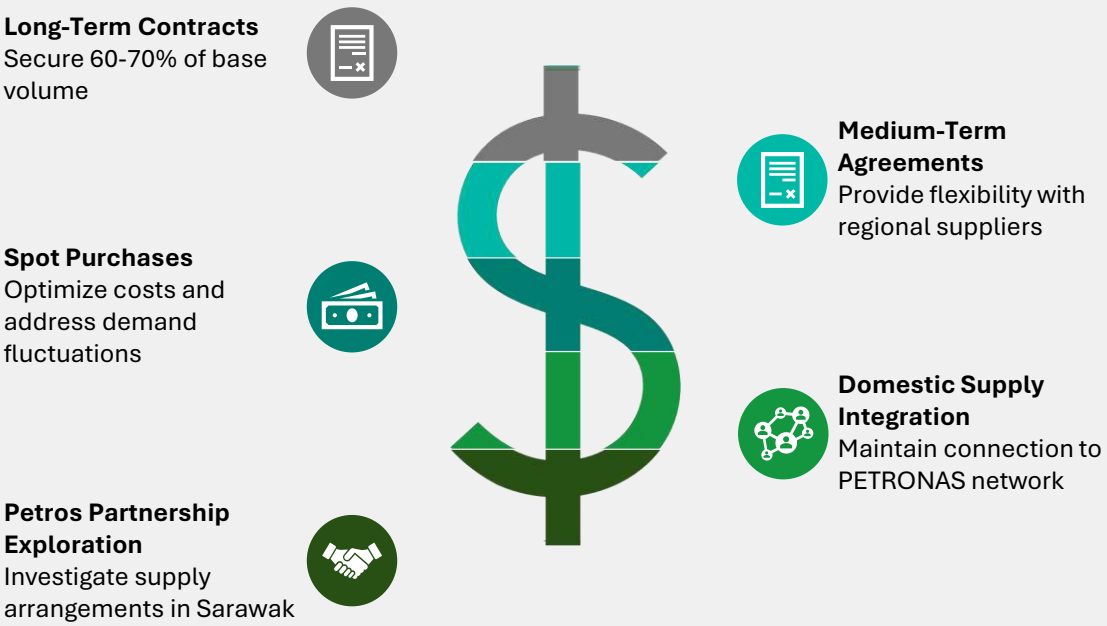


Figure 4.10: SelGas' sourcing strategy

4.3 SHORE (Selangor Hydrogen Oriented Resources)

Overview

SHORE aims to build a comprehensive hydrogen economy framework spanning the full value chain, from downstream applications to upstream production. SHORE isa project designed to enable the integration of hydrogen in Selangor by first introducing it for mobility, advancing green hydrogen production, embedding it into power generation, and ultimately expanding into export markets and other hydrogen-related technologies.

About SHORE

SHORE Selangor Hydrogen Oriented Resources

The Selangor Hydrogen Oriented Resources (SHORE) initiative is designed to introduce, scale, and commercialize hydrogen as a viable alternative energy vector within Selangor's energy landscape spanning the full value chain contributing to the diversification of clean fuel options in the state

Objective

SHORE aims to develop Selangor's first green hydrogen production hub for local mobility, industrial use and potential exports

Vision

- Establish Selangor as a leading hub for hydrogen innovation by building a full hydrogen value chain, from generation to end-use applications and exports
- Support energy system decarbonization through the phased deployment of clean hydrogen technologies, starting with transport and expanding into power and industrial sectors
- Enable domestic production of green hydrogen using renewable energy and electrolyzers, ensuring emissions-free fuel supply aligned with Selangor's energy transition goals
- Facilitate the integration of hydrogen into power generation and heavy industry, including hydrogen blending in gas turbines and adaptation of combustion systems

Figure 4.11: Overview of SHORE

On 15 October 2024, SHORE formalized a multi-party collaboration through a Memorandum of Understanding (MoU) with key stakeholders including Hydrexia, UNITEN, Uni10 Energy, and Worldwide Holdings, combining technological expertise, research capabilities, and infrastructure support. This partnership forms the operational and investment backbone of SHORE, enabling the project to concurrently initiate Phase 1 and Phase 2. SHORE's primary role spans project management, execution, and direct investment in the hydrogen value chain, with the goal of catalyzing new industrial opportunities while supporting energy system decarbonization.

Core functions

SHORE's implementation strategy is phased, designed to introduce, scale, and commercialize hydrogen as a viable alternative energy vector within Selangor's energy landscape.

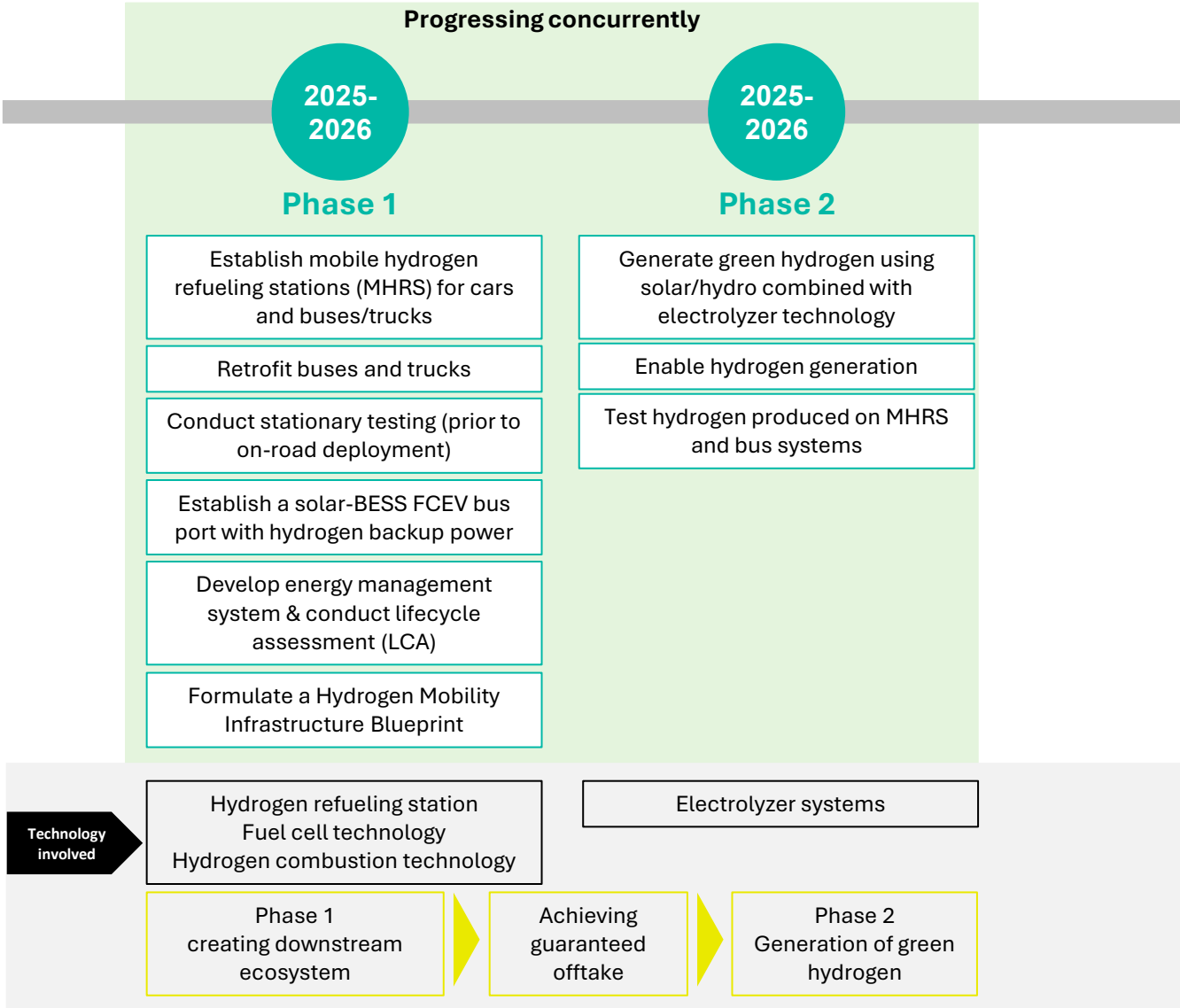


Figure 4.12: SHORE's hydrogen roadmap

- **Phase 1** centers on building Selangor's downstream hydrogen ecosystem, beginning with Mobile Hydrogen Refueling Stations (MHRS) for passenger and commercial vehicles, and retrofitting heavy fleets. This includes an off-grid Hydrogen Refueling Station powered by solar BESS and LTSS fuel cells, supporting a solar-BESS FCEV bus port. An optimized energy management system and lifecycle assessment will be developed for the integrated setup, alongside a Hydrogen Mobility Infrastructure Blueprint covering policy, regulation, and economic feasibility.
- **Phase 2**, which runs concurrently with Phase 1, targets green hydrogen generation using renewable energy sources such as solar and hydro power, coupled with electrolyzer technology. Locally produced hydrogen will also be tested on MHRS units and bus systems to validate performance and compatibility. This upstream component is crucial to ensure that the hydrogen produced is emissions-free and supports Selangor's broader energy transition efforts.

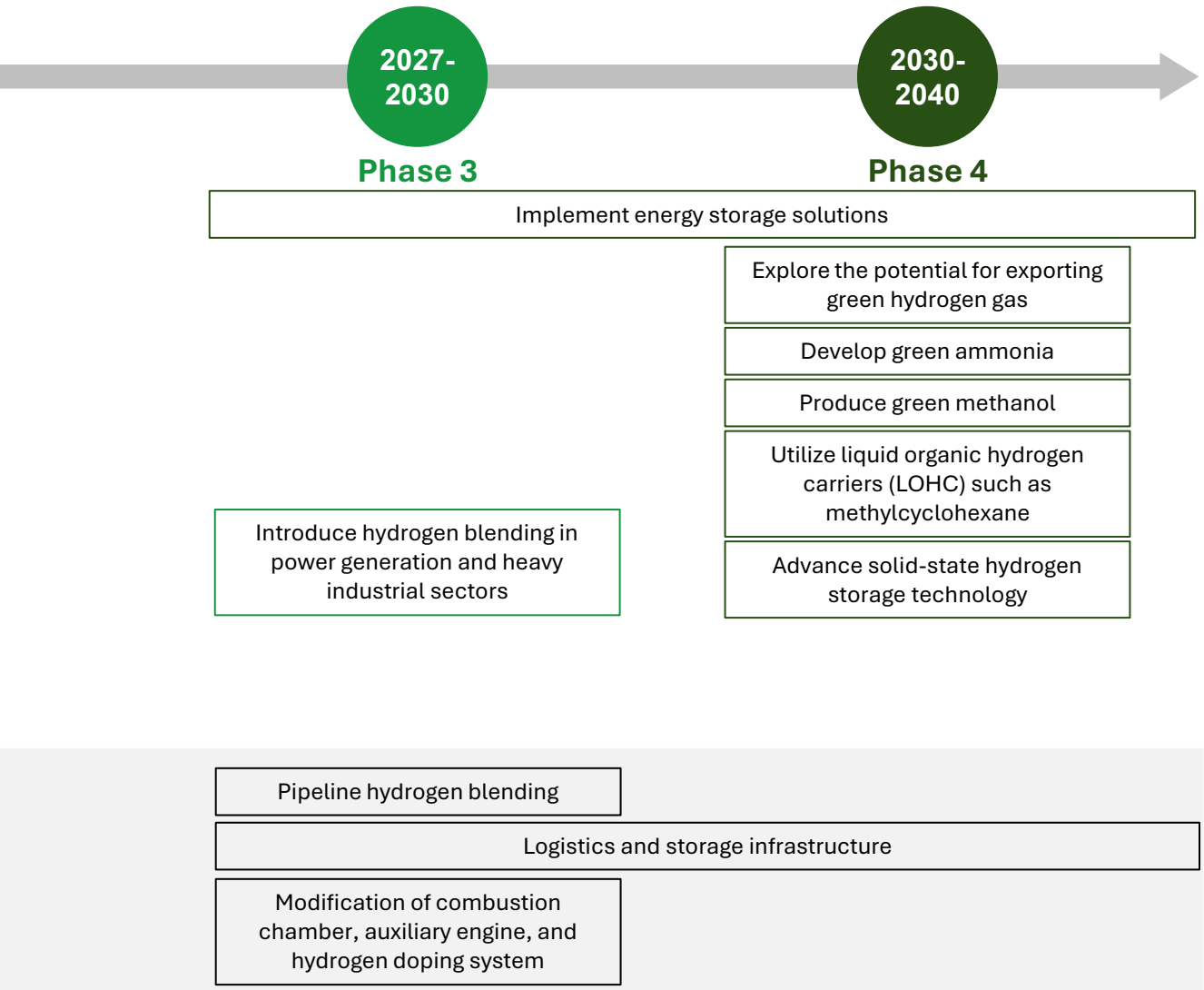


Figure 4.12: SHORE's hydrogen roadmap

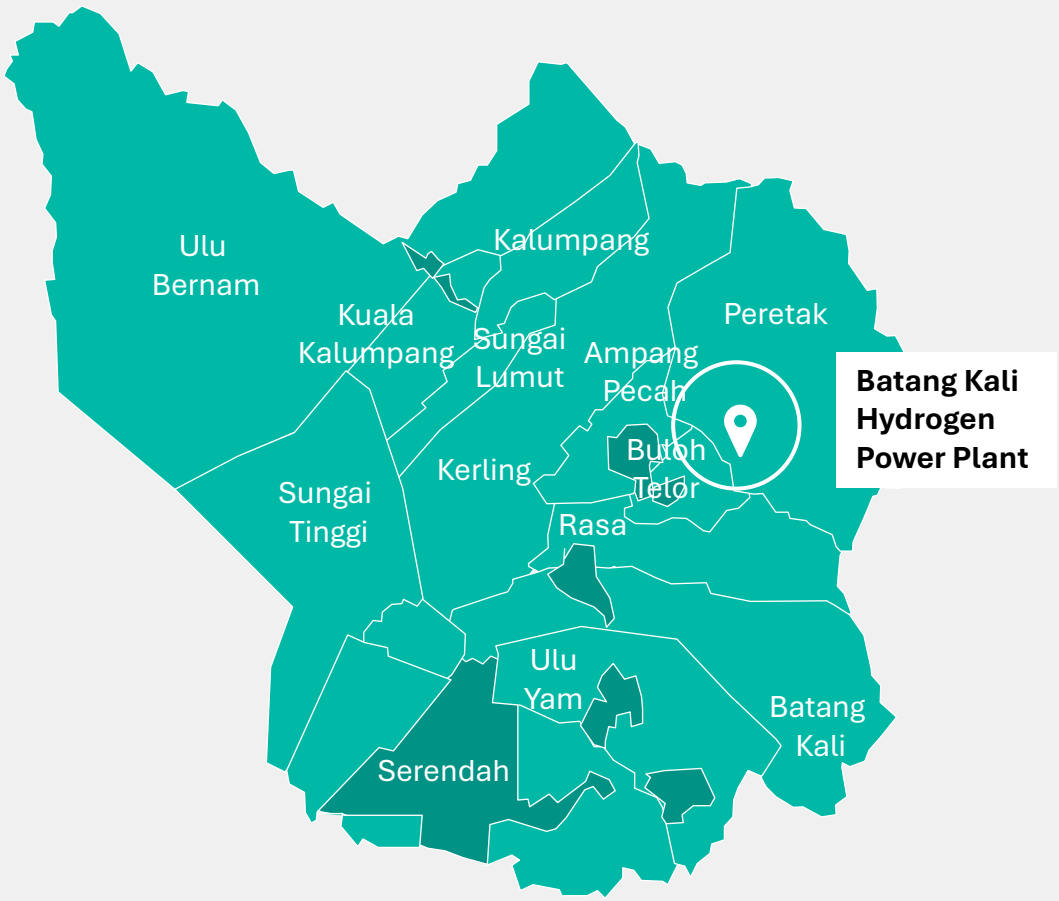


Figure 4.13: Location of SHORE's phase 2 development

Together, Phases 1 and 2 form the pilot stage, laying the technological foundation and ecosystem for hydrogen's integration into Selangor's green economy. These early stages are intentionally structured to attract further investment, build public confidence, and showcase the operational viability of green hydrogen.

The green hydrogen production facility of Phase 2 is strategically located in Batang Kali, occupying approximately 1.2 acres of land. The site benefits from direct access to clean water sources, essential for the operation of hydrogen production systems. It is positioned adjacent to a 5.1 MW small hydropower plant, which ensures a stable and renewable electricity supply to support green hydrogen generation. The location is well-connected by existing road networks to key surrounding areas, including Genting Highlands, Ulu Yam, Kuala Kubu Bharu, and Tanjung Malim, facilitating efficient logistics and accessibility. The facility is equipped with an electrolyzer system capable of producing green hydrogen, with a maximum power input capacity of 2 MW, reinforcing its role in advancing Selangor's renewable energy ambitions.

- **Phase 3** (2027–2030) aims to integrate hydrogen into power generation and heavy industry applications. This includes hydrogen blending into existing gas turbines, which aim to account for up to 5% of the total electricity generation mix. Key technologies in this phase involve pipeline blending systems, logistics and storage infrastructure, and modifications to combustion chambers and auxiliary engines, such as the adoption of hydrogen doping systems.
- **Phase 4** looks beyond domestic application to explore hydrogen export potential, focusing on the development of advanced hydrogen carriers including green ammonia, green methanol, Liquid Organic Hydrogen Carriers (LOHC) such as methylcyclohexane, and solid-state hydrogen storage technologies. This phase positions Selangor to tap into the growing global hydrogen economy while fostering downstream manufacturing and export-oriented industries.

Through its comprehensive, phased strategy, SHORE is poised to serve as Selangor's flagship platform for hydrogen innovation, setting a precedent for other states and reinforcing Malaysia's national low-carbon aspirations.

4.4 ISWM (Selangor Integrated Solid Waste Management)

Overview

The Selangor Integrated Solid Waste Management (ISWM) initiative is developed to transform the state's waste management ecosystem into a sustainable, resource-efficient system that aligns with Selangor's climate and energy goals. ISWM is a project designed to operationalize a strategic shift from conventional landfill-reliant practices to an Integrated Solid Waste Management center (ISWMC) model as a long-term solution to support the state's transition to a circular economy.

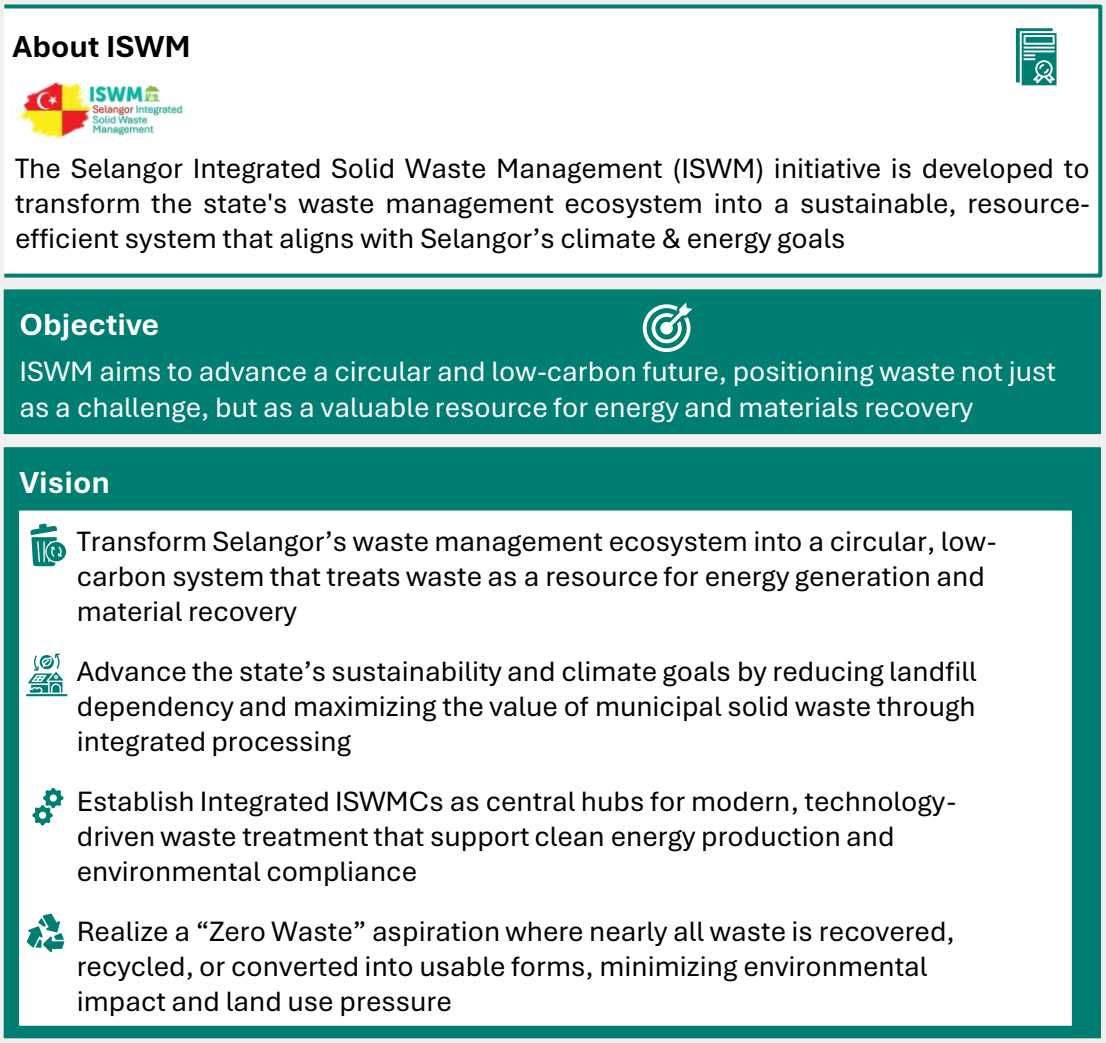


Figure 4.14: Overview of ISWM

With rapid urbanization and population growth, Selangor faces a steady rise in municipal solid waste (MSW), especially in dense urban zones. Current projections indicate an annual increase of 8–10% in daily waste generation, which places mounting pressure on land availability and renders traditional landfill-reliant methods unsustainable.

In response, the state is shifting towards an integrated model through the development of Integrated Solid Waste Management Centers (ISWMCs). These centers are designed to reduce landfill dependency, lower greenhouse gas emissions, and enable clean electricity generation from MSW, while supporting compliance with environmental regulations. ISWM also aims to maximize resource recovery through the adoption of modern technologies and operational efficiency. The initiative is supported by continued investment in innovation and automation, including the deployment of smart sorting systems and advanced emissions control technologies. Through ISWM, Selangor is laying the foundation for a resilient, circular waste-to-energy ecosystem that supports its broader sustainability ambitions.

Core functions

At the heart of the Integrated Solid Waste Management center (ISWMC) is the ambition to realize a "Zero Waste" aspiration, a system where all municipal waste generated in Selangor is either converted into energy or reintegrated into the economy through recycling and resource recovery. While this vision is ambitious, it reflects the state's unwavering commitment to sustainability, innovation, and environmental responsibility. The ISWMC operates as a comprehensive and technologically advanced ecosystem that consolidates several waste processing and treatment methods under one integrated system.

A central component of this ecosystem is the WTE facility, which converts non-recyclable municipal solid waste into electricity through thermal combustion. The heat produced in the process is used to generate steam, which then drives turbines to produce electricity, offering a projected generation capacity of up to 90 megawatts. Beyond energy production, this process also reduces reliance on landfills, with the resulting ash repurposed in construction and infrastructure applications, further closing the resource loop.

Complementing the WTE component are Material Recovery Facilities (MRFs), which serve as critical infrastructure for extracting recyclable materials such as plastics, paper, and metals. These recovered resources are reintroduced into industrial supply chains, reducing the demand for virgin materials and supporting the development of a circular economy.

To address organic waste, the ISWMC includes dedicated composting and anaerobic digestion facilities. These systems process food and green waste into high-quality compost for agricultural use or convert it into biogas, contributing to renewable energy production and nutrient recycling. This not only diverts organic waste from landfills but also supports local energy needs and soil restoration efforts.

The integrated system also includes modern landfill management components, designed to handle residual waste that cannot be recovered or repurposed. These engineered landfills are equipped to capture landfill gas, primarily methane, which can then be harnessed to generate electricity. This approach reduces harmful emissions while recovering additional energy from waste.

Deep dives:

The Integrated Solid Waste Management center (ISWMC) delivers tangible environmental and economic value to Selangor, reinforcing the state's broader goals for sustainability, climate action, and green growth. Key benefits include:

- Significant reduction in landfill dependency, with the ISWMC model enabling the diversion of up to 90% of municipal waste away from traditional disposal sites
- Clean energy generation from waste, which helps displace electricity derived from fossil fuels, thereby contributing to a more sustainable and resilient energy mix
- Lower greenhouse gas emissions, particularly through the reduction of methane, a potent climate pollutant typically released from unmanaged organic waste in landfills
- Enhanced material recovery, reducing the need for virgin resource extraction by reintroducing recyclable materials such as metals, plastics, and paper into the production cycle
- Support for green innovation and employment, as the adoption of advanced waste and energy technologies stimulates local industries and creates new job opportunities in the circular economy

Collectively, these core functions form a closed-loop waste management model that not only reduces environmental impact but also enhances energy security and resource efficiency for Selangor. The ISWMC stands as a model for sustainable urban infrastructure, demonstrating how innovative systems can turn waste into opportunity.

4.5 SEL-Hydro (Selangor Hydro Power Resources)

Overview

SEL-Hydro (Selangor Hydro Power Resources) is an ambitious initiative that harnesses the untapped potential of Selangor's river systems to generate clean, renewable hydropower. This initiative not only aligns with national climate strategies but also reinforces Selangor's leadership in driving inclusive green growth and environmental responsibility.

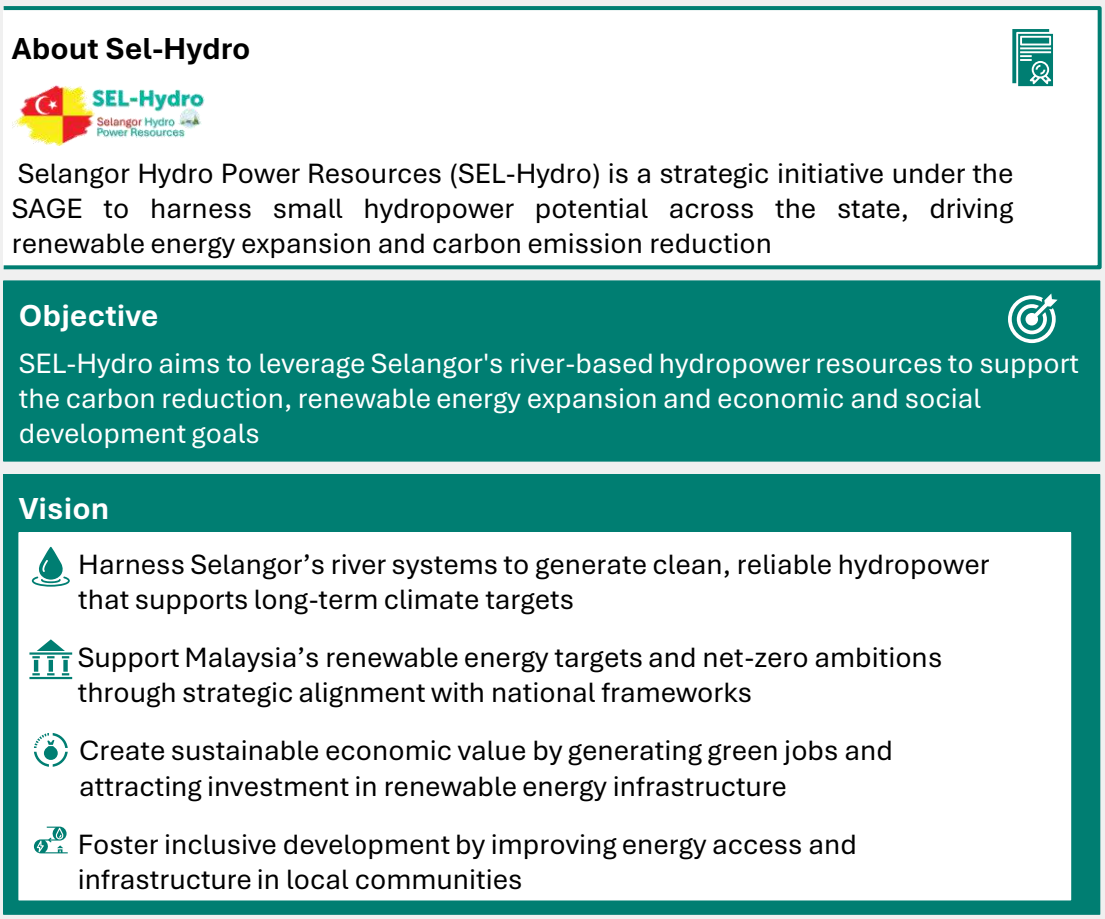


Figure 4.15: Overview of SEL-Hydro

SEL-Hydro supports three strategic objectives:

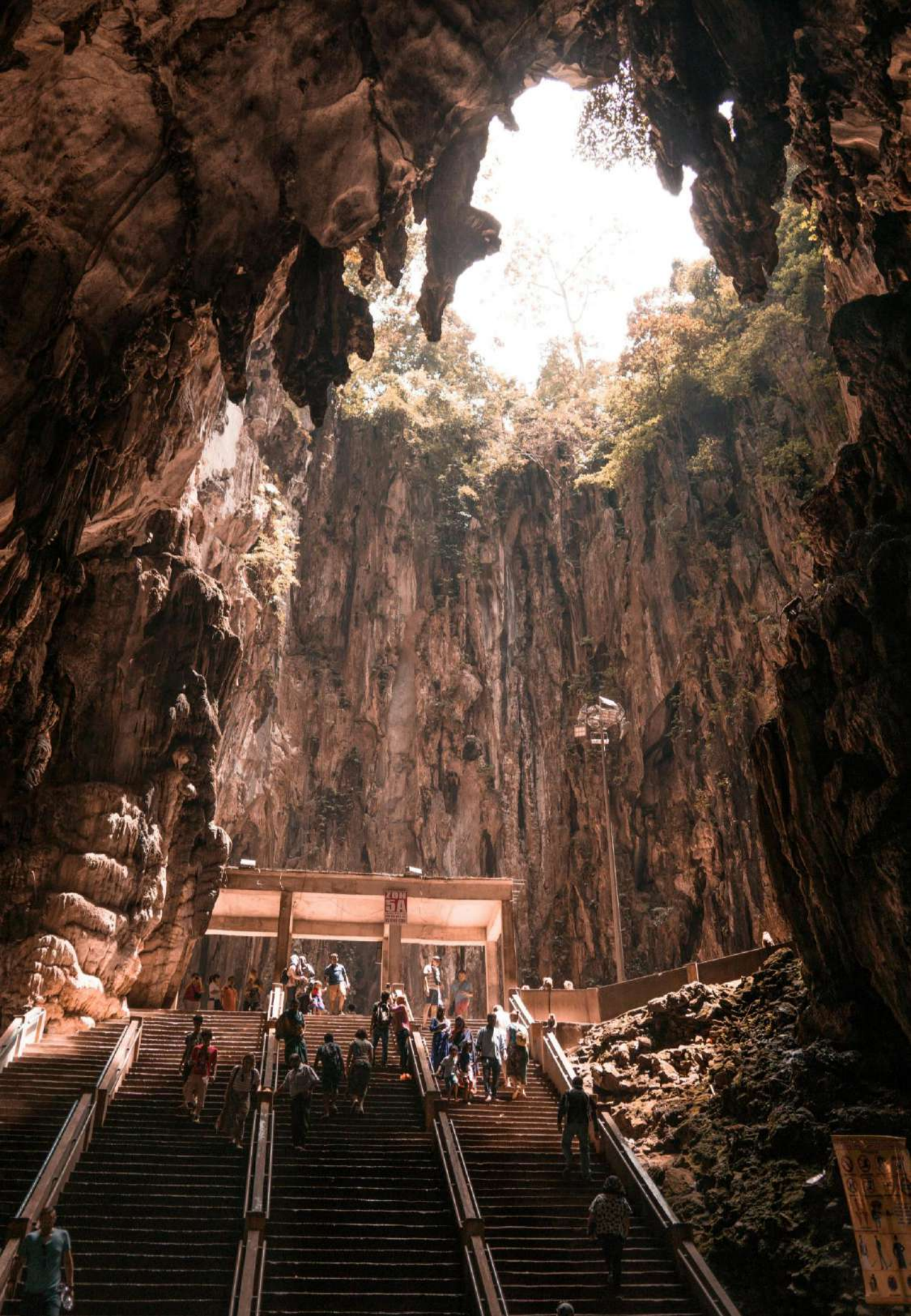
- First, it directly contributes to the state's carbon reduction goal, reinforcing Malaysia's national target of achieving net-zero emissions by 2050
- Second, it accelerates the expansion of renewable energy by increasing installed capacity in line with Selangor's goal of achieving 35% of renewable energy generation mix by 2035 and Malaysia's target which envisions 70% renewable energy share by 2050
- Third, the initiative serves as a catalyst for economic and social development by creating green jobs, stimulating local industries, and fostering sustainable growth across communities.

Core functions

The SEL-Hydro program is designed with clear technical and operational priorities to ensure impactful, scalable implementation. It is currently on track in securing projects to achieve its targeted installed capacity of 35.5 MW for small hydropower, which will be pursued under the Sustainable Energy Development Authority's (SEDA) Feed-in Tariff (FiT) mechanism. Key project sites include Batang Kali, which is already operational and was delivered a year ahead of schedule, along with Kerling Lower stream, Kuala Kubu Dam, Ulu Pangsun and Bernam Scheme. These locations have been strategically selected based on hydrological viability, low environmental impact, and optimal access to the state's grid infrastructure.

SEL-Hydro also demonstrates a high level of execution readiness and strategic planning. Early successes, such as the timely commissioning of the 5.1 MW small hydropower plant in Batang Kali, reflect the initiative's effective project delivery capabilities. This is supported by strong financial backing from the state budget, which ensures continuity and long-term stability for both ongoing and future developments. Streamlined regulatory processes, made possible through close collaboration with agencies like SEDA and the Energy Commission, further accelerate project timelines. Additionally, Selangor's investments in workforce training and partnerships with experienced engineers and local contractors enhance technical expertise and operational efficiency. A pipeline of future hydropower sites is also under evaluation, ensuring that the initiative can expand in step with the state's growing energy needs.

As an integrated component of the broader SAGE framework, SEL-Hydro reflects Selangor's forward-thinking commitment to sustainable development, energy diversification, and environmental stewardship. With each project milestone, the state not only advances its clean energy agenda but also strengthens its economy, uplifts communities, and sets a national example in responsible and inclusive growth.



SECTION 5

Conclusion

SECTION 5

Conclusion

SAGE represents a pivotal step in Selangor's transition toward a cleaner and more resilient energy future, marking a decisive move away from a coal-dependent generation mix toward a diversified, low-carbon energy portfolio. It reinforces the state's commitment to achieve 35% of clean energy mix target by 2035 and aligns with Malaysia's national target of achieving net-zero emissions by 2050.

Over the coming decade, SAGE will serve as a strategic guide to address Selangor's current energy generation gap by expanding domestic capacity. This will be driven by the integration of transitional low-carbon fuels, accelerated deployment of sustainable and renewable energy sources, and the development of energy storage solutions to support grid reliability and supply stability. These efforts will be underpinned by a comprehensive ecosystem of enablers, including green infrastructure, sustainable mobility, workforce upskilling, regulatory enhancements, sustainability reporting, and innovative financing mechanisms.

As a whole-of-state initiative, SAGE sends a strong signal to the market and industry stakeholders regarding Selangor's long-term direction in the energy sector. It underscores the state's emphasis on sustainability, energy security, and inclusive economic development. Beyond supporting environmental goals, SAGE is expected to enhance self-sufficiency, drive green economic growth, and generate broad socio-economic value through job creation, innovation, and improved quality of life for the people of Selangor.

Acknowledgements

We extend our sincere gratitude to all individuals and organizations whose invaluable contributions have shaped the development of the Selangor Agenda for Green Economy (SAGE) 2025–2035. This forward-looking agenda is the result of dedicated collaboration among a broad spectrum of stakeholders committed to advancing sustainable growth in Selangor. We offer special thanks to the members of the Working Committee and Steering Committee for their leadership, insights, and continued support throughout this process. We are also deeply grateful to all participants of the Go-Green Workshop, whose active engagement and thoughtful input were instrumental in refining the direction of this initiative. Their collective effort lays a critical foundation for Selangor's transition towards a resilient, inclusive, and greener economy in the coming decade.

Bibliography

Asian Transport Outlook (2024) Transport and Climate Profilehttps://asiantransportobservatory.org/documents/208/Malaysia-transport-and-climate-policy.pdf

City population (n.d.) Selangor. Retrieved from https://www.citypopulation.de/en/malaysia/admin/10__selangor/

Department of Statistics Malaysia (2023) Household Income & Expenditure. Retrieved from https://open.dosm.gov.my/dashboard/household-income-expenditure

Department of Statistics Malaysia (2024) Gross Domestic Product. Retrieved from https://open.dosm.gov.my/publications?page=1

Department of Statistics Malaysia (2024) Labour Force Survey Report. Retrieved from https://storage.dosm.gov.my/labour/lfs_qtr_2024-q4.pdf

Investor (2024) National grid third-party access guideline effective Friday. Retrieved from https://klse.i3investor.com/web/blog/detail/savemalaysia/2024-09-20-story-h469272212-National_grid_third_party_access_guideline_effective_Friday_says_Energy_

Malaysian Green Technology and Climate Change Corporation (2024) Green Technology Financing Scheme. Retrieved from https://www.gtfs.my/news/rm10-billion-fund-green-technology-financing-scheme-40

Our World in Data (n.d.) Malaysia: CO_2 Country Profile https://ourworldindata.org/co2/country/malaysia

ResearchGate (n.d.) Location map of oil palm plantation areas in Malaysia. https://www.researchgate.net/figure/Location-map-of-oil-palm-plantation-areas-in-Malaysia-Created-with-data-from-32_fig2_355830671

ScienceDirect(2024) Analysis of current state, gaps, and opportunities for technologies in the Malaysian oil palm estates and palm oil mills towards net-zero emissions. https://www.sciencedirect.com/science/article/pii/S2405844024067999

Sustainable Energy Development Authority (SEDA) Malaysia (n.d.) Net Energy Metering (NEM) 3.0. Retrieved from https://www.seda.gov.my/reportal/nem/

The Edge (2024) PKNS plans to develop Carey Island into a port city. Retrieved from https://theedgemalaysia.com/node/722579

The Malaysian Reserve (2024) PKNS launches SA Sentral to revitalise Shah Alam. Retrieved from https://themalaysianreserve.com/2024/09/07/pkns-launches-sa-sentral-to-revitalise-shah-alam/

The Star (2024) Selangor's GDP. Retrieved from https://www.thestar.com.my/news/nation/2024/07/03/mb-selangors-gdp-growth-reflects-trust-in-state-govt

The Star (2024) Selangor's GNI. Retrieved from https://www.thestar.com.my/news/nation/2024/07/31/selangor-new-high-income-state-according-to-world-bank-malaysia#goog_rewarded

TotalEnergies (n.d.) CCGTs: Flexible Facilities that Complement Renewable Energies and Contribute to the Stability of the Power Grid. Retrieved from https://totalenergies.com/news/news/ccgt-flexible-facilities-complement-renewable#:~:text=Firstly%2C%20CCGTs%20stand%20out%20with%20their%20superior%20energy,35%25%20to%2040%25%20for%20conventional%20thermal%20power%20plants.

United Nations Development Program (n.d.) Malaysia. Retrieved fromhttps://climatepromise.undp.org/what-we-do/where-we-work/malaysia

Utility Smart (n.d.) Does Natural Gas Produce More Carbon Dioxide Than Coal? Retrieved from https://www.utilitysmarts.com/gas/natural-gas/does-natural-gas-produce-more-carbon-dioxide-than-coal/

World Bank Group (n.d.) GNI per capita – Malaysia. Retrieved fromhttps://data.worldbank.org/indicator/NY.GNP.PCAP.PP.CD?locations=MY

World Bank Group (n.d.) Urban population - Malaysia. Retrieved from https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=MY

Acronyms & Abbreviations

BESS	Battery Energy Storage System	**GES**	Global Energy Storage
bn	Billion	**GHG**	Greenhouse Gas
CAGR	Compound Annual Growth Rate	**GNI**	Gross National Income
CBAM	Carbon Border Adjustment Mechanism	**GTFS**	Green Technology Financing Scheme
CCGT	Combined Cycle Gas Turbines	**GW**	Gigawatt
CCUS	Carbon Capture, Utilization and Storage	**HEFA**	Hydroprocessed Esters and Fatty Acids
CHP	Combined Heat and Power	**HETR**	Hydrogen Economy and Technology Roadmap
CIR	Chemical Industry Roadmap	**H_2**	Hydrogen
COP	Conference of the Parties	**ICE**	Internal Combustion Engine
CO_2	Carbon Dioxide	**ISWM**	Selangor Integrated Solid Waste Management
CREAM	Community Renewable Energy Aggregation Mechanism	**ISWMC**	Integrated Solid Waste Management center
CRESS	Corporate Renewable Energy Supply Scheme	**KPK**	Ministry of Plantation and Commodities
CSP	Concentrated Solar Power	**LOHC**	Liquid Organic Hydrogen Carriers
DC	Data center	**LSS**	Large Scale Solar
ESA	Electricity Supply Agreements	**LT-LEDS**	Long-Term Low Emissions Development Strategies
ESG	Environmental, Social and Governance	**m**	Million
ESS	Energy Storage Systems	**MESI**	Malaysian Electricity Supply Industry
EU	European Union	**MITI**	Ministry of Investment, Trade and Industry
EV	Electric Vehicle	**MOSTI**	Ministry of Science, Technology and Innovation
FiT	Feed-in Tariff	**$MtCO_2e$**	Million Tonnes of CO_2 Equivalent
GAPS	Green-energy Aggregator Programs for Selangor	**MTPA**	Million Tonnes Per Annum
GDP	Gross Domestic Product	**MW**	Megawatt

Acronyms & Abbreviations

MyRER	Malaysia Renewable Energy Roadmap
NDC	Nationally Determined Contribution
NEM	Net Energy Metering Scheme
NETR	National Energy Transition Roadmap
NIMP	New Industrial Master Plan
NRECC	Ministry of Natural Resources, Environment and Climate Change
POME	Palm Oil Mill Effluent
PP	Power Plant
ppm	Parts per Million
RM	Ringgit Malaysia
SAGE	Selangor Agenda for Green Economy
SelGas	Natural Gas Roadmap for Selangor
SEL-Hydro	Selangor Hydro Power Resources
SHORE	Selangor Hydrogen Oriented Resources
Solar PV	Solar Photovoltaic
TNB	Tenaga Nasional Berhad
TPA	Third-Party Access
TPD	Tonnes Per Day
USD	United States Dollar
WTE	Waste-to-Energy
°C	Degree Celsius


SAGE
Selangor Agenda for Green
Economy 2025 - 2035

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