



March 2021

REPORT ON PENINSULAR MALAYSIA GENERATION DEVELOPMENT PLAN 2020 (2021 – 2039)



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1. Introduction

- 1.1. *Jawatankuasa Perancangan dan Pelaksanaan Pembekalan Elektrik dan Tarif* (JPPPET) was established on 14 November 1997 with the aim to plan, coordinate and identify electricity supply requirements to meet electricity demand in Peninsular Malaysia through an annual committee meeting. The committee is currently chaired by YB Datuk Seri Dr Shamsul Anuar bin Hj. Nasarah, Minister of Energy and Natural Resources and comprises of representatives from relevant ministries, agencies and utilities.
- 1.2. The Cabinet has agreed with the Peninsular Malaysia Generation Development Plan approved by JPPPET on 20 October 2020. The key consideration of the plan is not only limited to projection of demand and generation capacity, but also to monitor the progress of the implementation of transmission projects and to support the Government's policies in achieving 31% RE capacity by 2025 for Malaysia (decided by the JPPPET meeting held on 20 October 2020).
- 1.3. The objectives of this report are as follows:
 - To provide projection of electricity demand growth with the consideration of the economic parameters, taking into account the COVID-19 pandemic impact, emerging trends and disruptive technology.
 - To provide projection of generation capacity requirement to meet demand and ensure adequacy and security of supply.
 - To address the energy trilemma by balancing the trade-offs between energy security (to enhance the reliability and efficiency of electricity supply to meet the demand), affordability (to ensure electricity supply is reasonably priced for the long-term benefit of both consumers and producers) and environmental sustainability (to address carbon emission in the power sector).

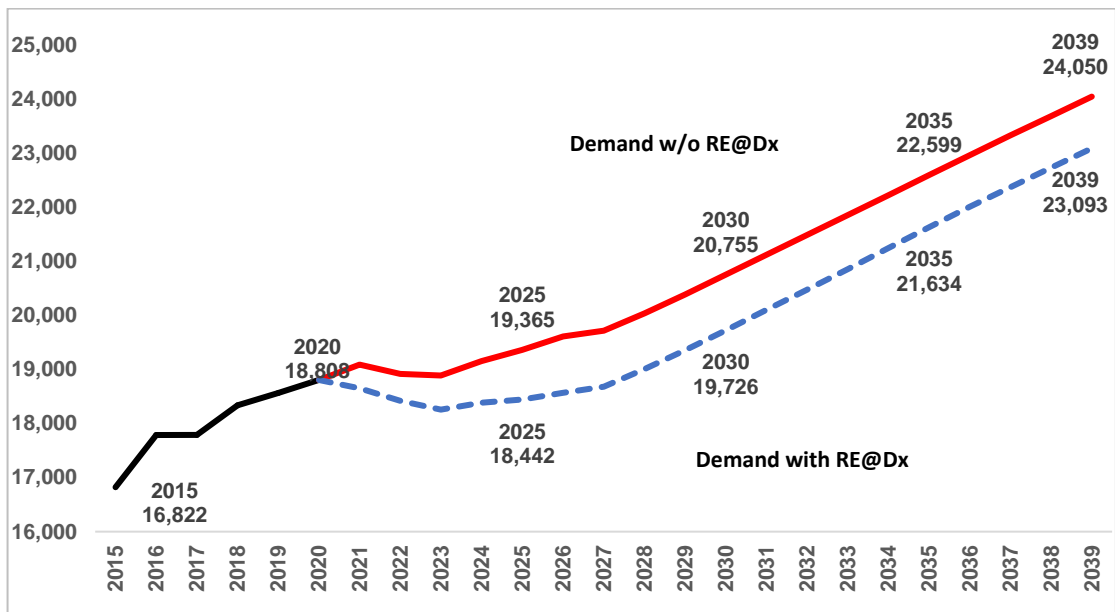
2. Demand Outlook

- 2.1. Demand forecast is reviewed annually at the start of the year where input from relevant stakeholders is gathered and deliberated through the Load Forecast Working Group (LFWG), chaired by Single Buyer. The proposed demand outlook is presented and endorsed by the Demand Forecasting Committee (DFC), chaired by Suruhanjaya Tenaga (ST) and includes representatives from the ministries, consumer's association, utilities and research institutions.
- 2.2. Demand forecast projection for capacity planning is the "net demand" as seen at the transmission or grid level. At the distribution level, there are several demand-side resources that are existing in the system and expected to become more significant in the future. These resources will generally reduce the overall demand seen at the grid level. They can be categorised into two, namely Behind-the-Meter and Distributed Generation (DG):
 - Behind-the-Meter sources considered are Energy Efficiency (EE) and self-consumption resources (such as rooftop solar and co-generation). These resources are expected to reduce future electricity consumption from the consumer end due to consumer's ability to self-generate for their own use (prosumer) as well as adoption of more energy efficient equipment.
 - Distributed Generation (DG) are mostly RE sources that are connected at distribution network such as biomass, biogas, mini hydro, waste-to-energy etc. Since these resources are connected directly at the distribution network, which is closer to demand, they reduce the need for electricity to be supplied by centrally dispatched generators connected at the grid level.
- 2.3. In the year 2020, the uncertainty of the Malaysian economy due to the impact of the COVID-19 pandemic had presented a challenge in forecasting the electricity demand. The moderate recovery scenario was selected as forecasted Gross Domestic Product (GDP) growth as it provides the middle view on the short-term GDP outlook which incorporate the uncertainties impacted by COVID-19 and the dynamics of economic data from various

agencies. This forecasted GDP growth is comparable with the international rating agencies.

- 2.4. Historically, the growth of demand from 2015 to 2020 is 16,822MW to 18,808MW, or at 2.3% annually. The COVID-19 pandemic had significantly reduced the overall demand in 2020. However a new peak demand was recorded on 10 March 2020, just a week prior to the imposition of Movement Control Order on 18 March 2020. For the year 2021-2030 and 2030-2039, demand is projected to grow by 0.9% p.a. and 1.7% p.a. respectively (**Figure 1**).
- 2.5. After deducting the projected resources at the distribution network (Dx), the net demand is projected to grow by 0.6% p.a. for 2021-2030 and 1.8% p.a. for 2030-2039. This net demand will be used for supply planning at the transmission side. COVID-19 is expected to cause a temporary decline in demand, but from 2023 onwards the growth is projected to normalise in line with the economic recovery.

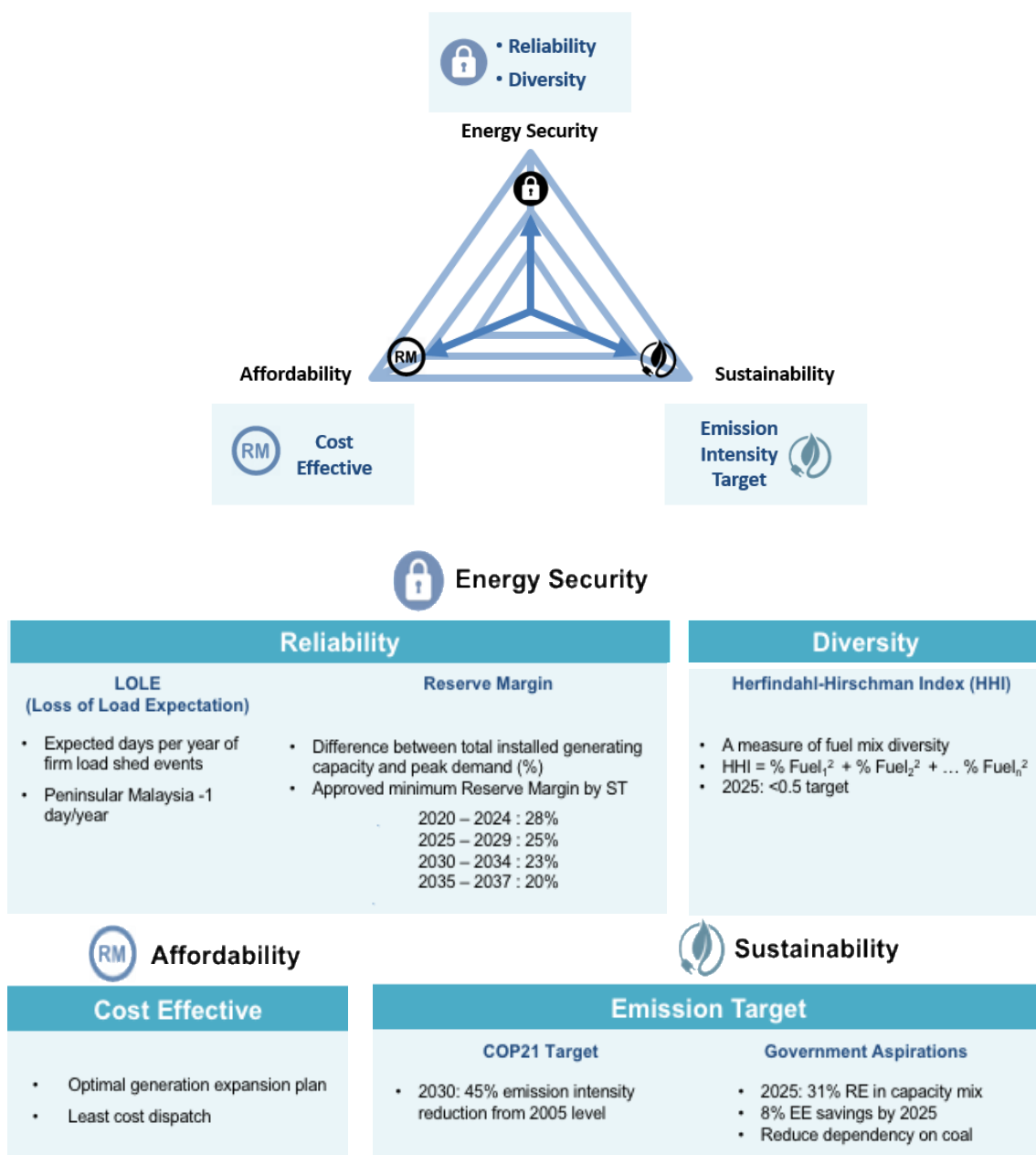
Figure 1: Peak Demand Actual 2015-2020 and Projection 2021-2039



3. Supply Outlook

3.1. In managing the energy trilemma under the long-term supply outlook, the Government has set several policies and planning criteria as illustrated under **Figure 2**. The energy security is managed through the diversification of fuel mix with a target to maintain a Herfindahl-Hirschman Index (HHI) of below 0.5 by 2025 and provide enough reserve margin and spinning reserve for the day-to-day generation and system balancing.

Figure 2: The Energy Trilemma



- 3.2. At the 21st Conference of Parties (COP21) in 2015, Malaysia pledged to reduce its carbon emission intensity per GDP by 35% in 2030 relative to the 2005 level, or 45% with support from developed countries. This Nationally Determined Contribution (NDC) was ratified at the Paris Agreement and overwhelmingly adopted by the United Nations (UN) member states to counter the damaging impacts of climate change.
- 3.3. Reinforcing the COP21 commitment, the Government has revised the national RE capacity mix target from 20% to 31% by 2025 for Malaysia. The Government has also included large hydro resources as part of RE definition for Malaysia, consistent with practices adopted by other countries internationally. Current large hydro capacity in Malaysia stands at 5,684MW with Peninsular Malaysia contributes about 2,232 MW.
- 3.4. In achieving the 31% RE capacity mix target for Malaysia by 2025, a total of 1,178MW¹ of new RE capacities will be developed in Peninsular Malaysia from 2021 onwards. The additional RE capacities consist of 1,098MW of solar and 80MW of non-solar (**Figure 3**). With variable RE (vRE) i.e., solar, being the dominant source of RE in the system, it is important to ensure that intermittent generation from solar PV will not jeopardise the overall electricity supply system in providing undisrupted and continuous power supply.
- 3.5. Hence, to effectively manage the integration of vRE with the projected supply and demand of electricity, the penetration limit for grid connected solar PV is set at 24% of the estimated peak demand. The solar penetration limit is derived from the common convention for solar threshold computation, which is the relative of total grid connected solar capacity (at both the distribution and transmission networks), compared to the annual forecasted peak demand. Such preventive measures are aimed at ensuring continuity of electricity supply in unexpected circumstances and to cope with generation uncertainty and availability from vRE. This is vital in safeguarding the stability and security of the grid system without incurring additional ad-hoc infrastructural costs for grid balancing and stability, due to the excessive penetration of vRE in the system. This, in the long run, will ensure affordable tariffs for all electricity consumers.

¹ Inclusive of Net Energy Metering (NEM) 3.0 solar program (500MW) announced in January 2021

- 3.6. The RE capacity mix for Malaysia is projected to increase to the 40% level by 2035. An additional 2,414MW of RE capacity would be developed in Peninsular Malaysia from 2026 to 2035 to support the country’s long-term national commitment (**Figure 4**). The grid infrastructure would be further strengthened and enhanced with the much-needed technical enablers such as energy storage systems to support such strategic intent. The solar penetration is expected to reach 30% of the projected peak demand in 2035.
- 3.7. With more vRE from solar being integrated into the electricity supply system, there is a need to attain a full grasp of the underlying costs and technical requirements of having higher shares of vRE in the power system. Therefore, the Energy Commission and the Grid System Operator (GSO) will be undertaking a study to further examine and identify the flexibility and threshold of vRE penetration in the system. The study will determine the limitations as well as the challenges and the possible enabling solutions to overcome these limitations and challenges. All this is to ensure the continuous, reliable, and cost-effective electricity generation in a high-vRE penetration scenario.

Figure 3: New RE Requirement to Meet 31% RE Capacity Mix by 2025 (Peninsular Malaysia)

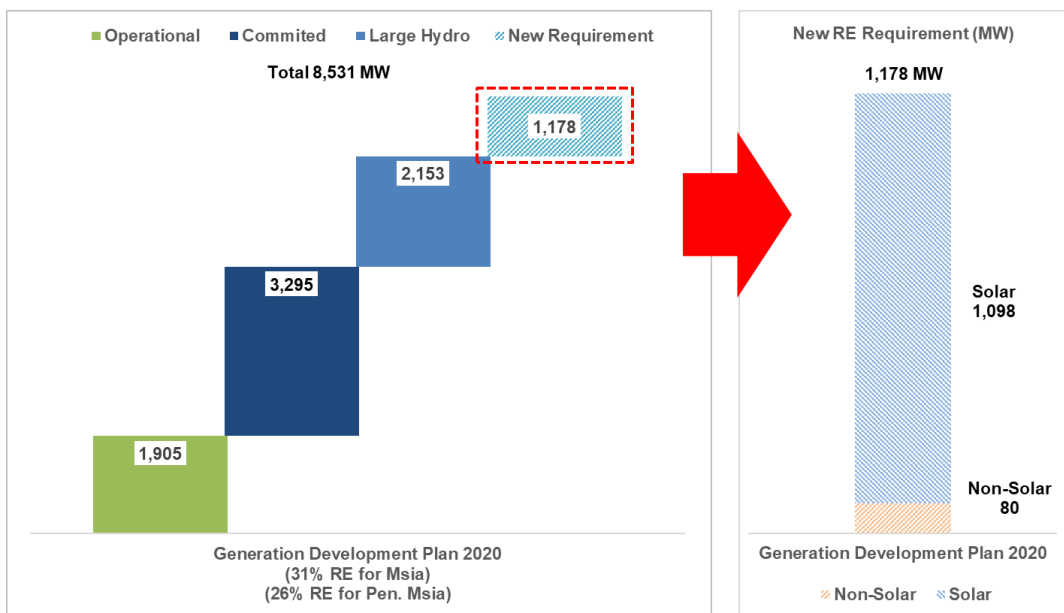
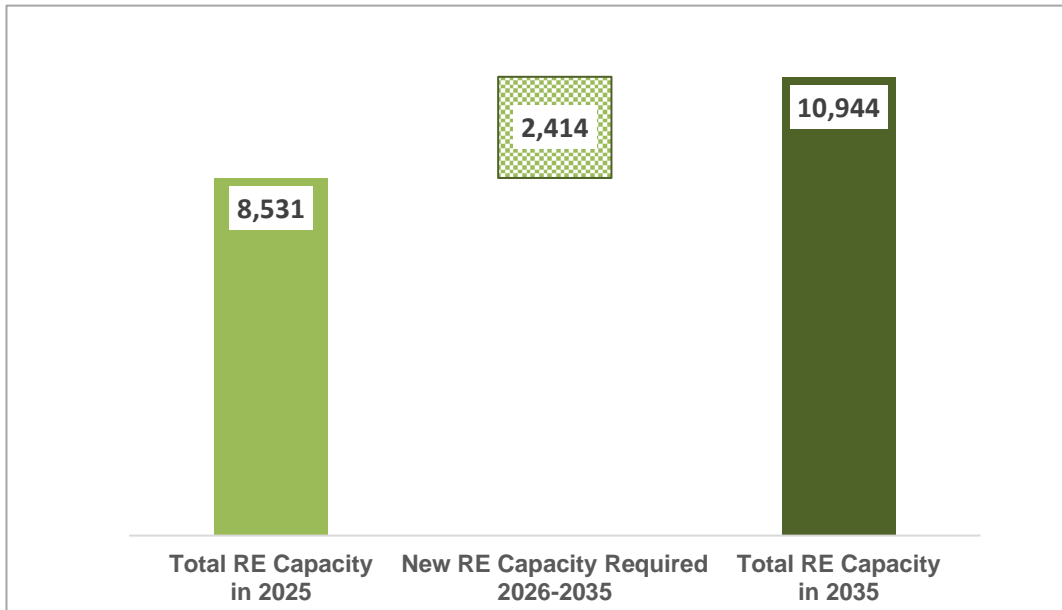
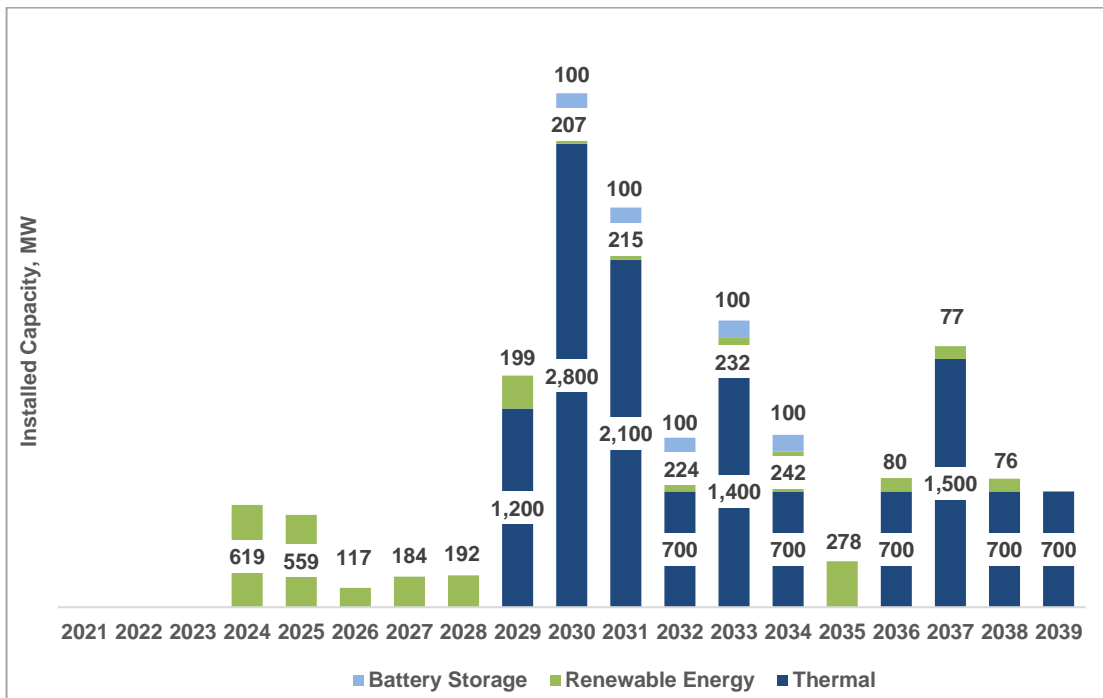


Figure 4: New RE Requirement (2026-2035) to Meet 40% RE Capacity Mix by 2035 (Peninsular Malaysia)



- 3.8. By the end of 2030, the system is projected to require 6,077MW of new capacity (Thermal and RE) to meet the demand growth, maintain the optimum reserve margin for system reliability and replace retired plants (**Figure 5**).
- 3.9. Beyond 2030, the system may require 9,924MW of additional capacity (Thermal and RE) by 2039 for the same purpose.

Figure 5: New Capacity Projection (MW) (2021-2039)



(Note: Battery storage is used to stabilize the system and will not be considered in the capacity mix)

- 3.10. Based on the approved Generation Development Plan (**Table 1**), the earliest new thermal plant (Combined Cycle Gas Turbine - CCGT) of 1,200 MW is required in 2029.
- 3.11. In the following year, 4 units of new CCGT plant will be required by the system due to substantial capacity retirement and higher electricity demand.

Table 1: Generation Development Plan (2021-2030)

Year	Generation Capacity (31% RE Capacity Mix for Malaysia)	Retiring Plants
2021	Edra Energy (CCGT) (3x747 MW) RE (860 MW)	YTL Power (CCGT) (585 MW)
2022	RE (652 MW)	TNB Pasir Gudang (CCGT) (275 MW) GB3 (CCGT) (640 MW)
2023	RE (663 MW)	Panglima (CCGT) (720 MW)
2024	TADMAX (CCGT) (2x600 MW) RE (855 MW)	SKS Prai CCGT (341 MW) TTPC (CCGT) (650 MW) TNB Gelugor (CCGT) (310 MW)
2025	RE (818 MW)	TNB Putrajaya GT4 & GT5 (OCGT) (249 MW)
2026	THB (CCGT) (2x600 MW) RE (117 MW)	KLPP (CCGT) (675 MW)

Year	Generation Capacity (31% RE Capacity Mix for Malaysia)	Retiring Plants
2027	Nenggiri (Hydro) (300 MW) RE (184 MW)	Segari Energy Ventures (CCGT) (1,303 MW)
2028	RE (192 MW)	TNB Tuanku Jaafar PD1 (CCGT) (703 MW)
2029	CCGT (1x700 MW) CCGT (1x500 MW) RE (199 MW)	KEV Gas U1 & U2 (Thermal Gas) (578 MW) KEV Coal U3-U6 (Coal) (1,474 MW)
2030	CCGT (4x700 MW) RE (207 MW) BESS (1X100MW)	TNB Tuanku Jaafar PD2 (CCGT) (708 MW) TNB Janamanjung (Coal) (2,070 MW)

Note: CCGT = Combined Cycle Gas Turbine; OCGT = Open Cycle Gas Turbine.
BESS = Battery Energy Storage System

3.12. Malaysia's commitment on sustainable energy pathway will continue with new RE and CCGT Plants coming into the system post-2030. (**Table 2**)

3.13. In addressing system stability concerns due to the influx of RE, five units of Battery Energy Storage System (BESS) with a capacity of 100MW had been planned for installation annually into the system from 2030 – 2034. Following this, a pilot project for grid-connected BESS will be carried out by Grid System Operator before BESS could be fully introduced into grid system starting in 2030.

Table 2: Generation Development Plan (2031-2039)

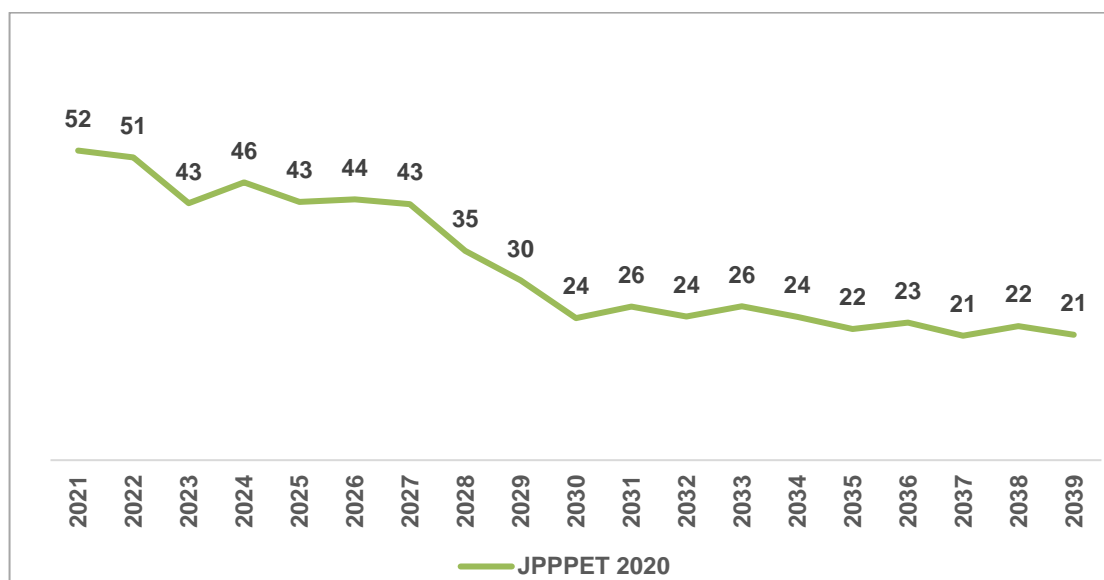
Year	Generation Capacity (31% RE Capacity Mix for Malaysia)	Retiring Plants
2031	CCGT (1x700 MW) Coal (2x700 MW) BESS (100 MW) RE (215 MW)	Tanjung Bin Power (Coal) (2,100 MW)
2032	CCGT (1x700 MW) BESS (100 MW) RE (224 MW)	
2033	CCGT (2x700 MW) BESS (100 MW) RE (232 MW)	Jimah Energy Venture (Coal) (1,400 MW)
2034	Coal (1x700 MW) BESS (100 MW) RE (242 MW)	
2035	RE (278 MW)	

Year	Generation Capacity (31% RE Capacity Mix for Malaysia)	Retiring Plants
2036	CCGT (1x700 MW) RE (80 MW)	
2037	CCGT (1x700 MW) Coal (1x700 MW) OCGT (1x100 MW) RE (77 MW)	TNB Prai (CCGT) (1,071 MW) TNB CBPS (CCGT) (375 MW)
2038	CCGT (1x700 MW) RE (76 MW)	Pengerang Power (Co-Gen) (600 MW)
2039	CCGT (1x700 MW)	

Note: CCGT = Combined cycle gas turbine; OCGT = Open cycle gas turbine;
BESS = Battery Energy Storage System; Co-Gen = Cogeneration Plant

3.14. Taking into account the existing, committed, new and retiring capacities, the reserve margin is projected to reach below 25% in 2030. It will then closely follow the minimum reserve margin requirement and settle at 21% by 2039 (Figure 6).

Figure 6: Reserve Margin Projection (%) (2021-2039)



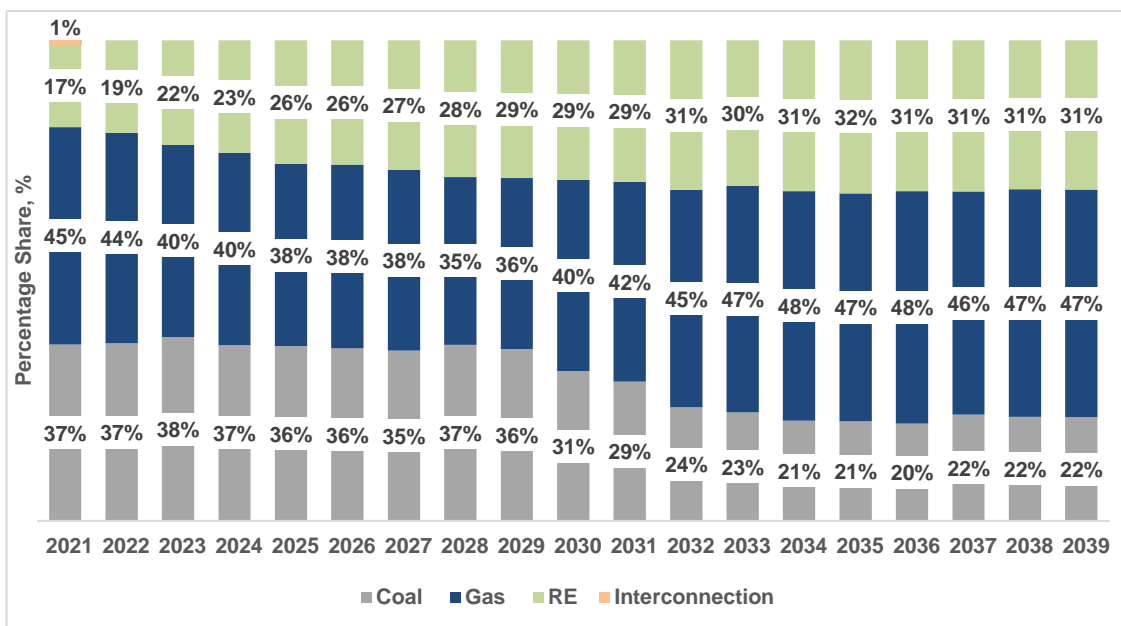
3.15. For the same period, the projected capacity mix for Peninsular Malaysia is shown in Figure 7. Lao PDR-Thailand-Malaysia (LTM) interconnection which currently stands at 300 MW is projected to contribute minimally at 1%. This arrangement was established between the Lao PDR, Thailand and Malaysia

governments in support of ASEAN ambition to leverage on the power grid interconnections to enhance power system stability.

3.16. The RE capacity is projected to increase from 17% to 31%, in tandem with the reduction in thermal (gas and coal) capacity share from the total of 82% to 69% by the end of the horizon.

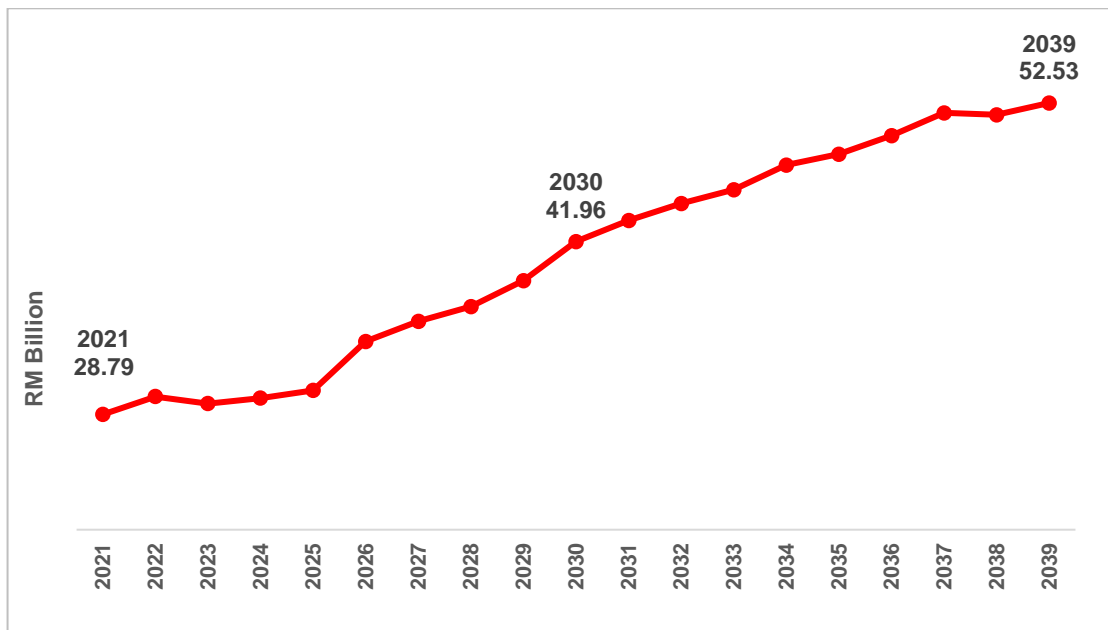
3.17. Coal share is projected to reduce from 37% in 2021 to only 22% in 2039, a net reduction of 4,244MW. The retirement of coal power plants with a total capacity of 7,044 MW is projected to be replaced by only 2,800 MW of new coal capacity.

Figure 7: Capacity Mix by Fuel (%) (2021-2039)



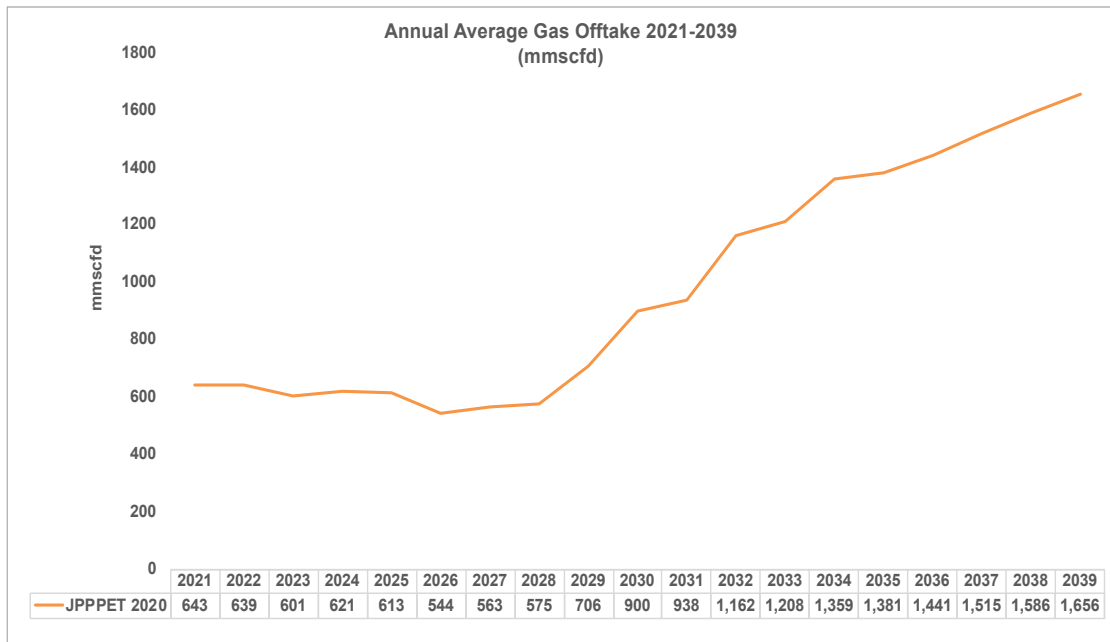
3.18. Following the projected demand growth and the additional supply capacity, the annual system cost for the Generation Development Plan (2021-2030) is estimated to increase from RM 28.79 billion in 2021 to RM 41.96 billion in 2030. Annual system cost is projected to increase further beyond 2030 to RM 52.53 billion by 2039. **(Figure 8)**.

Figure 8: Annual System Cost (RM billion) (2021 – 2039)



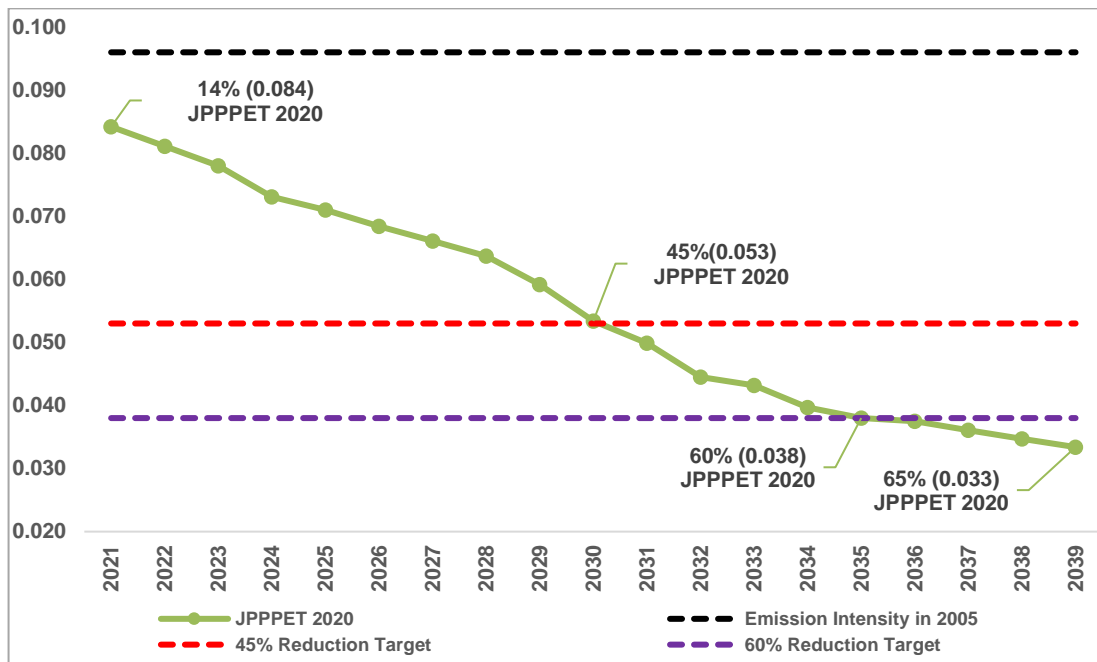
- 3.19. However, this total system cost does not include the costs associated with solar integration to the grid system, which is caused by the limitations of solar in terms of energy availability and dispatchability. Determination of “true costs of solar integration” will ensure a fair comparison and better decisions by all stakeholders. Therefore, the Energy Commission together with Single Buyer and GSO will be undertaking a study to formulate the true cost of solar integration into the national grid system.
- 3.20. Between 2021 to 2030, the gas offtake is expected to be lower due to the rapid increase in RE share while maintaining existing coal capacity in the system, averaging to 650 mmscfd annually. The forecasted gas offtake was made with consideration of the COVID-19 impact and the medium economic demand growth. However, it is important to note that there is a possibility for the gas volume requirement to increase if economic demand growth is rapid post COVID-19. From 2031 onwards, the gas offtake is projected to increase as coal capacity projected decreases. The annual average gas offtake is projected to go beyond 1,000 mmscfd starting in 2032. This projection is done based on the least cost option and is not a committed annual volume. The annual gas offtake is declared to Petronas Energy and Gas Trading (PEGT) according to the Gas Framework Agreement (GFA). **Figure 9** shows the projected annual average gas offtake as approved by the 2020 JPPPET.

Figure 9: Annual Average Gas Offtake (mmscfd) (2021 – 2039)



- 3.21. In terms of carbon emission intensity per GDP, the Peninsular Malaysia power sector is projected to have a downward intensity trend, with a reduction from 0.084 kgCO₂/RM in 2021 to 0.053 kgCO₂/RM in 2030 (**Figure 10**). It is then expected to reduce further post 2030 and reaches 0.033 kgCO₂/RM by 2039.
- 3.22. In comparison with 2005 level, the Peninsular Malaysia power sector is set to reduce its emission intensity (of GDP) by 45% in 2030, which is in line with Malaysia’s commitment in COP21. Power sector commitment in providing sustainable energy pathway expected to continue in the future with a downward trajectory of emission intensity to 65% in 2039.

Figure 10: Carbon Emission Intensity Projection (kgCO₂/RM) (2021-2039) for Peninsular Malaysia Power Sector



4. Conclusion

- 4.1. The Energy Trilemma has been an ongoing challenge for the electricity supply industry, which is continuously evolving, and requires judicious decision making and trade-offs to balance environmental sustainability, energy security and energy equity. The planning of power generation has considered this trilemma through the implementation and adoption of the Government's policies and planning criteria. The COVID-19 pandemic has also provided an additional challenge to the planning for the electricity supply industry as it had impacted the overall demand growth.
- 4.2. Based on the Generation Development Plan 2020, the net demand is projected to grow by 0.6% p.a. for 2021 – 2030 and 1.8% p.a. for 2031 - 2039. By 2030, 6,077MW of new capacity is required to meet demand growth, replacing retiring plants and ensuring system reliability, with the reserve margin projected to reach below 25% by 2039. The new capacity requirement is projected to increase post 2030 to 9,924MW with additional 500MW of BESS for 2031-2039 period, while reserve margin is expected to reduce further to 21% by 2039.

- 4.3. In support to Malaysia's commitment towards sustainable energy pathway, supply capacity mix in Peninsular Malaysia will see an increase in RE share from 17% to 31%, whilst the thermal capacity share will reduce from 82% to 69% by the end of the horizon. As a result, carbon emission intensity per GDP for the Peninsular Malaysia power sector is projected to be on the downward trend with a 45% reduction by 2030 compared to 2005 level, in line with Malaysia's commitment in COP21, and a further 65% reduction by 2039.
- 4.4. In the interest of achieving the 30% solar penetration target by 2039, the Government has taken into consideration the Energy Trilemma and its impact on the consumers. Therefore, the Government has tasked GSO to conduct a study to assess the solar penetration limits and possible impacts on the grid stability due to excessive supply of solar energy, in terms of infrastructure and associated costs.
- 4.5. The Government will then analyse the findings from the study in the interest of cushioning the associated costs that may be borne by consumers and decide further in accordance with recommendations made. These measures are pertinent in ensuring the continuity of supply and stability of the grid for overall system security. In the bigger picture, these initiatives will assist the Government in balancing the people's green aspirations and the cost to the *Rakyat*.
- 4.6. Recognising that the grid connection plan is equally important to the Generation Development Plan, the Government is always assessing the strength of national power network. Mitigation plans and network reinforcement works are actively being done to ensure the power system remains strong and resilience.
- 4.7. While addressing the energy sustainability and security pillars, the other key priority is in ensuring that the *Rakyat* has access to affordable energy. The focus is to ensure that a reasonable tariff is charged to the consumers. Therefore, in order to strike the right balance in the Energy Trilemma, the annual system cost is estimated to be in the range of RM 28.79 billion in 2021 to RM 41.96 billion in 2030, and RM 52.53 billion by 2039. These figures are based on the optimal generation expansion plan along with the least cost dispatch simulation.

4.8. The Generation Development Plan as presented above is reviewed annually to take into account the latest economic, electricity demand, emerging technologies and development status of the planned projects.