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Long-Run Dynamics of Energy Consumption and Economic Growth in Malaysia

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Abstract

This study investigates the long-run dynamics between energy consumption and economic growth in Malaysia from 2000 to 2021, emphasizing sectoral drivers, efficiency performance, and future projections to 2030. Using secondary data from the National Energy Balance (NEB), the study analysis correlations between Final Energy Consumption (FEC), Gross Domestic Product (GDP), and population to determine whether Malaysia's economic growth is primarily energy-dependent or efficiency-led. The result shows a strong positive relationship between GDP and FEC ($r^2 = 0.96$), suggesting that economic expansion remains closely linked to energy use. The correlation between Final Energy Consumption and population is also significant ($r^2 = 0.92$). This indicates that both economic and demographic factors drive Malaysia's energy demand, with economic activity has a slightly greater influence. Despite this dependency, energy intensity decreases from 52 to 41 toe per RM million (2015 prices), demonstrating measurable efficiency gains. In addition, most of the Final Energy Consumption came from industrial and transport sectors. According to projections, total FEC could reach 88 Mtoe by 2030 in a baseline scenario. The results underscore the need for targeted energy efficiency initiatives and sector-specific transition strategies that align with Malaysia's National Energy Transition Roadmap (NETR) and its long-term decarbonization goals.

Keywords: Energy Growth, Final Energy Consumption, GDP, Energy Efficiency, Decarbonisation

Introduction

Energy consumption is fundamental to economic development, especially in emerging economies experiencing industrialization and urbanization (Apergis & Payne, 2010; Ozturk, 2010). In Malaysia, energy has historically driven economic transformation, however increasing consumption presents challenges to sustainability, efficiency, and climate

commitments as outlined in the National Energy Transition Roadmap (NETR) and the Twelfth Malaysia Plan (2021–2025) (Economic Planning Unit, 2021).

Between 2000 and 2021, Malaysia experienced significant growth in real GDP and population, accompanied by a rise in Final Energy Consumption (FEC) in major sectors, including industry, transport, and residential (Energy Commission, 2021). Determining the extent to which economic growth relies on energy versus efficiency enhancements is essential for developing sustainable energy policies and attaining carbon neutrality by 2050 (Ministry of Economy, 2023). Numerous studies have examined the energy growth relationship in Malaysia (Ali Bekhet, 2011; Ang, 2007; Tang & Tan, 2013). However, most analyses concentrate on earlier periods and do not include sectoral decomposition or updated projections. This study examines existing gaps by analysing recent trends from 2000 to 2021, assessing the impact of GDP and population on final energy consumption (FEC), evaluating energy efficiency, and projecting potential FEC trajectories through 2030.

The study utilizes a multidimensional approach to analyse the energy-growth dynamics in Malaysia. This study examines the relationships among energy consumption, economic growth, and demographic changes to determine whether output growth or population pressures are the primary drivers of energy demand. This analysis includes an assessment of energy efficiency and per capita energy consumption, providing insight into Malaysia's progress toward sustainable and efficient energy use. Sectoral heterogeneity is significant, warranting focused analysis on the roles of industry and transport, alongside the implications of non-energy use (NEU) in industrial processes that could distort aggregate consumption patterns. Based on these empirical insights, the study formulates projections of final energy consumption (FEC) through 2030, considering various growth and efficiency scenarios aligned with the National Energy Transition Roadmap (NETR). The analytical strands collectively enhance the empirical understanding of the energy–growth nexus in Malaysia, informing strategic policy development, guiding sectoral efficiency improvements, and supporting a coherent transition to a low-carbon and sustainable energy future.

Recent studies also show that energy use is no longer driven by economic growth alone. Factors such as urbanization, technological change, and shifts in lifestyle increasingly influence how countries consume energy, especially in developing and emerging economies (Shahbaz & Lean, 2012). As nations modernize, industries upgrade, and cities expand, energy demand can continue to rise even when efficiency improves. Other research highlights that structural economic changes such as movement toward higher-value industries or service-based activities can alter sectoral energy needs in ways that are not always visible in aggregate statistics (Inglesi-Lotz, 2016). Similarly, evidence from cross-country work shows that demographic pressures and broader developmental patterns can shape long-term energy trajectories independently of GDP (Salahuddin, Gow, & Ozturk, 2015). These insights underline the need to examine Malaysia's energy trends from multiple angles, not only through the lens of economic growth. By using updated post-pandemic data, incorporating sectoral patterns, and providing forward-looking projections, this study helps fill an important gap in the Malaysian literature and offers a clearer understanding of how economic, demographic, and structural forces interact to shape Malaysia's evolving energy pathway.

Experimental Details / Procedures (Methods & Analysis)

Data Source

This study utilized secondary data obtained from the National Energy Balance (NEB) Malaysia 2021, as published by the Energy Commission (Suruhanjaya Tenaga). The dataset spans the years 2000 to 2021 and provides detailed information on Malaysia's Final Energy Consumption (FEC) categorized by economic sector including industry, transport, residential, commercial, and agriculture. The dataset includes annual data on real Gross Domestic Product (GDP) at 2015 constant prices, population figures, and non-energy use (NEU) components. The data provide a solid basis for analysing long-term trends in Malaysia's energy consumption, economic growth, and demographic changes.

Analytical Framework

Descriptive statistics and the correlation analysis method are used to explore the relationship between energy consumption and economic growth. This analysis is supported by examining complementary indicators, such as energy efficiency and per-capita energy use. In order to identify long-term changes in key variables such as final energy consumption, GDP, and population, this study analysed the data using descriptive statistics and visualized the trends. Next, Pearson correlation was applied to determine the strength and direction of the relationships between FEC and both GDP and population. This approach allowed for a direct comparison of whether economic or demographic factors have a more substantial influence on energy demand.

Energy Intensity (the ratio of final energy consumption to real GDP) is calculated to assess energy efficiency performance. The declining intensity over time indicates improvements in energy efficiency, reflecting structural economic transformation and the impact of policy-driven conservation measures. An examination of Per-Capita Energy Consumption (FEC divided by population) similarly allowed us to gauge individual energy use in relation to economic development and population growth. This study also analysed sectoral contributions to total energy demand by estimating the proportional share of each primary sector, such as industry, transport, residential, commercial, and agriculture, in the overall FEC. This sectoral perspective is crucial for pinpointing which economic segments drive energy growth and for understanding the impact of Non-Energy Use (NEU).

Finally, under two alternative growth scenarios, the research developed projections of FEC up to 2030. Based on historical trends: a baseline projection assuming a continuation of current patterns, and an efficiency-enhanced scenario assuming progressive improvements in energy intensity aligned with Malaysia's National Energy Transition Roadmap (NETR).

Results & Discussion

Relationship between Final Energy Consumption (FEC) and Gross Domestic Product (GDP)

Figure 1 illustrates a steady upward trend from 2000 to 2021, which is occasionally interrupted by periods of global economic upheaval, such as the 2008 financial crisis and the 2020 COVID-19 pandemic. Despite these short-term contractions, the long-term co-movement between Malaysia's final energy consumption (FEC) and Gross Domestic Product (GDP) remains remarkably strong.

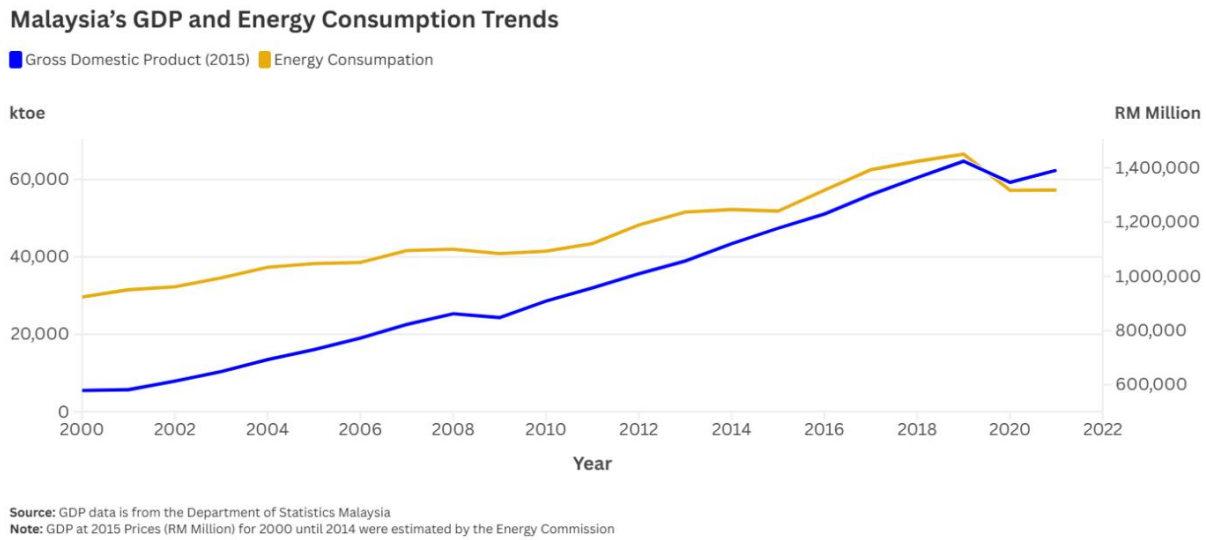

Figure 1. Malaysia's GDP and Energy Consumption Trends (2000 – 2021).

Figure 2 shows the correlation between GDP and Energy Consumption. The study uses the Pearson correlation coefficient (r^2), yielding a r^2 value of 0.9603, indicating a strong relationship. According to the growth hypothesis, economic development drives energy consumption, meaning that when Malaysia's economy grows, energy use also increases. Continued reliance on energy inputs reflects Malaysia's dependence on energy to support GDP growth. This finding aligns with previous studies (Ang, 2007; Tang & Tan, 2013), which also observed a causal relationship between energy use and economic growth in emerging economies.

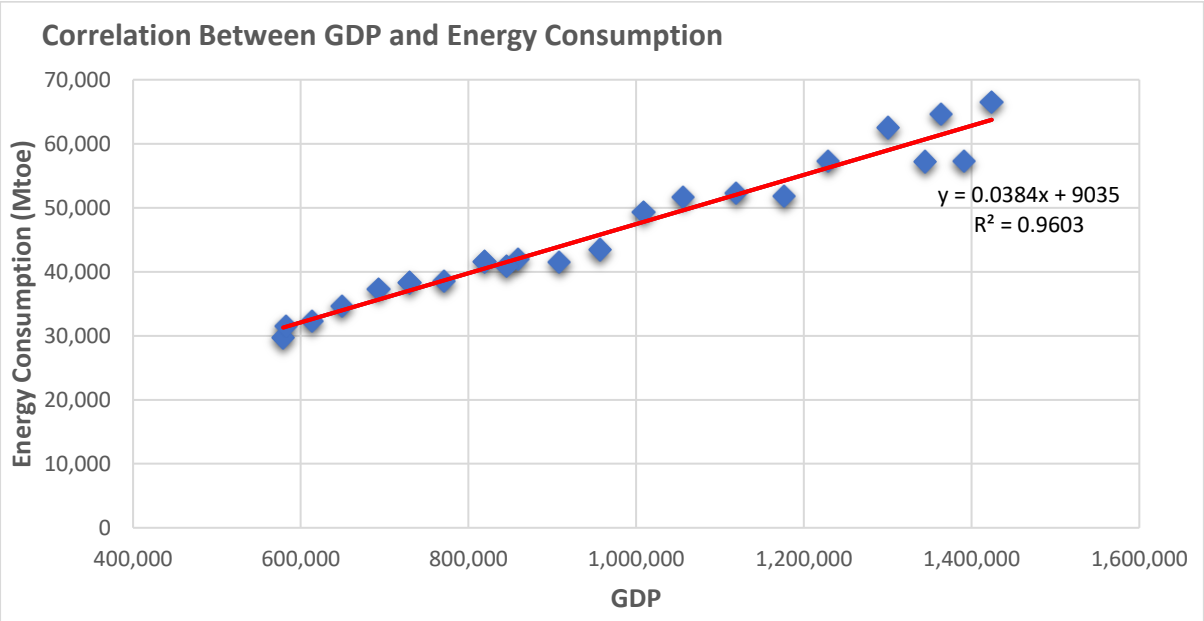

Figure 2. Relationship Between GDP and Energy Consumption.

Relationship between Final Energy Consumption (FEC) and Population

In comparison, the relationship between Malaysia's Final Energy Consumption (FEC) and population growth is strongly positive, but it is slightly lower than the correlation between FEC and GDP. Malaysia's population grew at an average rate of approximately 1.6%

per year, while the FEC increased by roughly 3.1% annually. These indicate that energy consumption increased more rapidly than population growth. Industrial development, urban expansion, and increased transport activity mainly drive this trend.

As shown in Figure 3, the Pearson correlation coefficient between FEC and population is $r^2 = 0.92$. The value of r^2 is indicates a strong relationship. However, when compared to the FEC – GDP correlation, which has an r-squared value of 0.96, it indicates that economic performance has a greater influence on Malaysia's energy use. This result implies that economic output is the primary driver of the nation's rising energy demand, with population growth serving as a supporting factor.

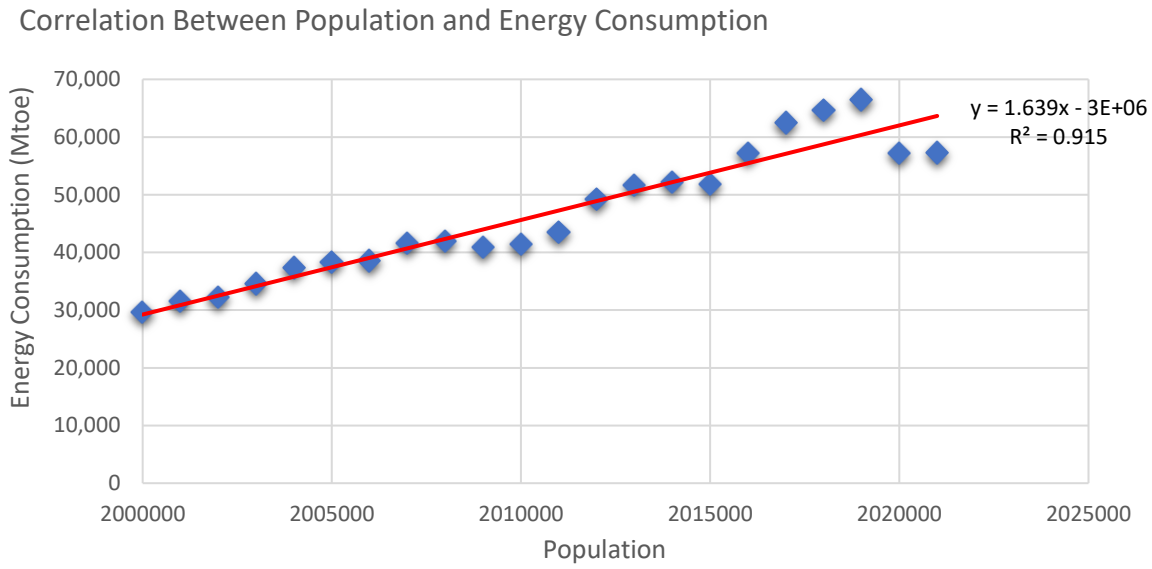

Figure 3. Relationship Between Population and Energy Consumption.

Energy Efficiency and Per-Capita Trends

The analysis of energy intensity shows steady improvement in Malaysia's energy efficiency from 2000 to 2021. As shown in Figure 4, energy intensity decreased consistently from about 52 toe per RM million in 2000 to around 41 toe per RM million in 2021 (based on the 2015 prices). These indicate that the economy is producing more output with less energy. When the country's economy transitioned from energy-intensive sectors, adopted new technologies, and implemented government policies such as the Minimum Energy Performance Standards (MEPS) and the Energy Efficiency and Conservation Act (EECA), it can reduce to approximately 80,000 ktoe (~80 Mtoe) by 2030 with 2% annual improvement in energy intensity. There were some minor changes between 2010 and 2018, likely due to shifts in the economy or business practices. However, this growth in energy use per person is slower than GDP growth, meaning Malaysia's economy is expanding faster than its energy demand. Hence, it is a good sign of sustainable and efficient growth. Overall, the trend continues to show that efficiency is improving over time.

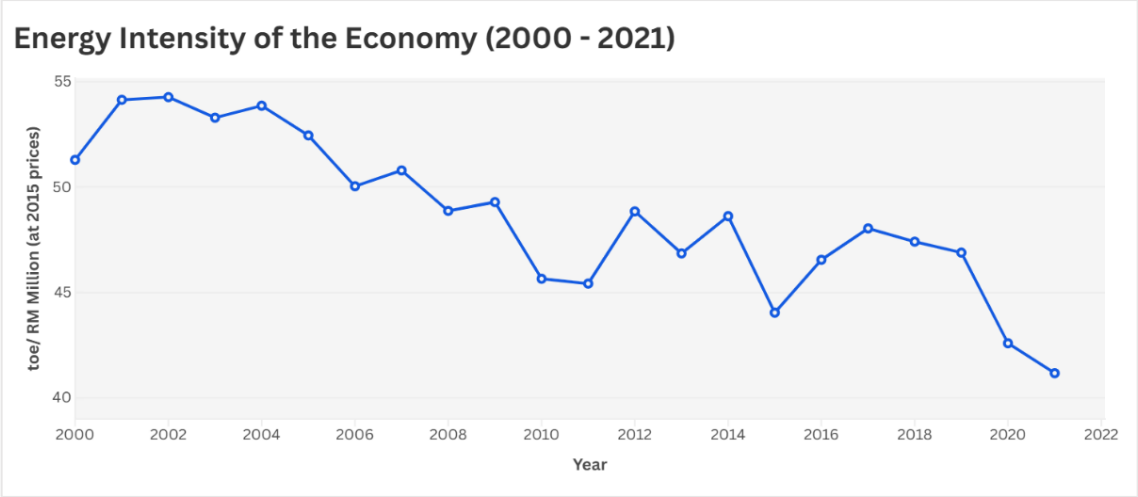

Figure 4. Energy Intensity (toe/GDP).

Figure 5 illustrates the trends in energy intensity per capita (toe/person), which increased from about 1.2 toe per person in 2000 to nearly 2.0 toe per person in 2018. It then levelled off at approximately 1.7 toe per person by 2021. This increasing trend suggests that more people are accessing energy services, living standards are improving, and an increasing number of individuals are relocating to urban areas. These factors are all consistent with Malaysia's socioeconomic development. However, the fact that GDP is increasing more slowly than per capita energy demand indicates that the two are becoming less intertwined. Malaysia's economy is expanding more quickly than its energy requirements. All things considered, these trends indicate that efficiency improvements have decreased energy intensity, even as overall energy consumption continues to rise. This suggests that we are making steady progress towards a more energy-efficient and sustainable economy. Overall, these trends suggest that increases in efficiency have reduced the intensity of energy use, even though overall energy use is still increasing. This means that we are making continuous progress towards an economy that uses less energy and is more environmentally friendly.

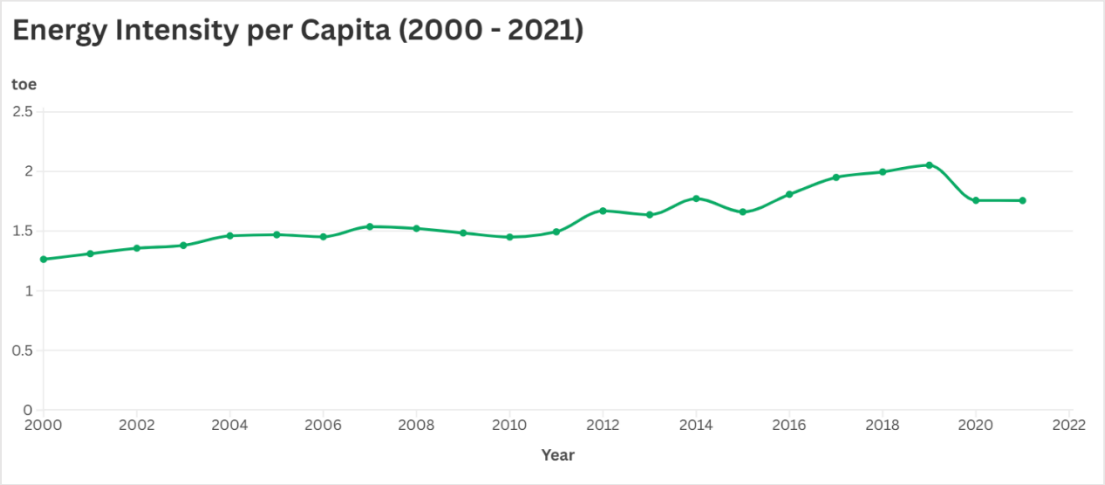

Figure 5. Energy Intensity per Capita (toe/Person).

Sectoral Contributions and Non-Energy Use

Based on the sectoral analysis, there are diverse characteristics of Malaysia's energy demand. According to Figure 6, the sectoral energy use from 2000 to 2021 shows that the

transport and industry sectors dominated the final energy consumption. The industry sector increased from 11,406 in 2000 to 19,157 in 2021 due to the sustained growth of the industrial base. Other than that, the transport sector also increases, indicating that growing car ownership and logistical demands are driving this sector's vital importance. These two sectors together used the most final energy. The contributions from the Residential, Commercial, and Agriculture sectors were still relatively minor. However, the Residential and Commercial segment increased slightly, which could be a sign of the energy needs associated with urbanization. Non-Energy Use (NEU), which primarily includes petrochemical feedstocks, is a significant and growing component of total energy consumption. It is essential for accurate greenhouse gas inventory reporting that NEU be kept always separate from energy combustion. This is because NEU does not burn, which stops energy-related emissions from being overestimated.

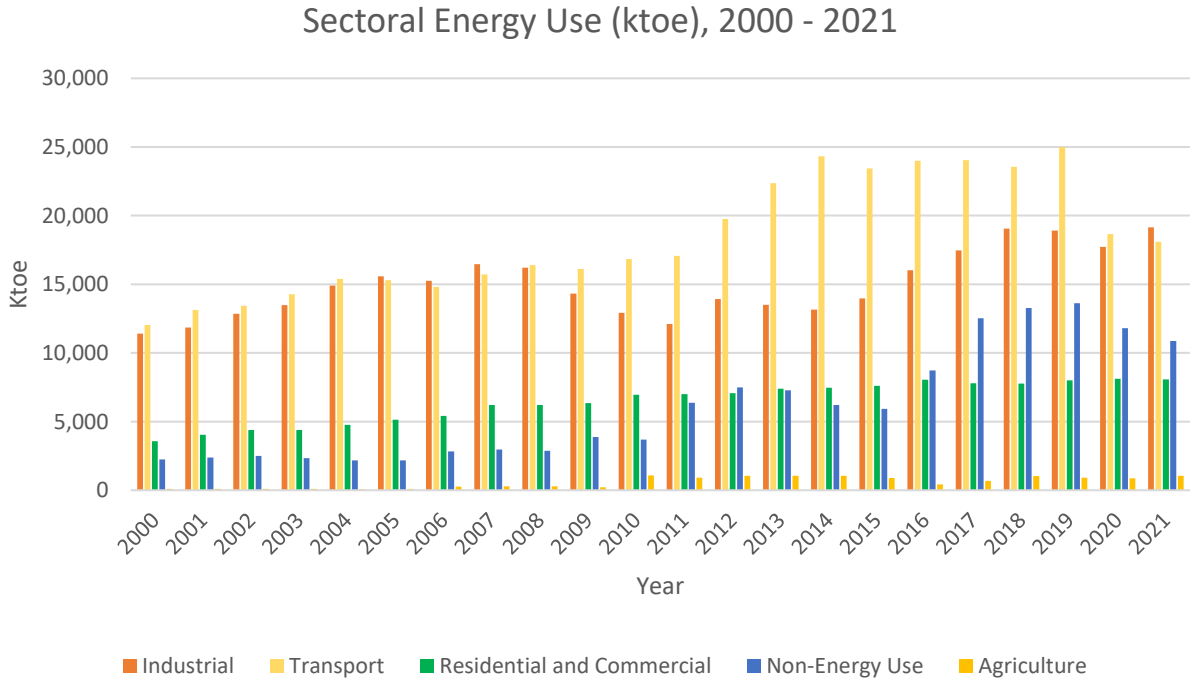

Figure 6. Sectoral Energy Use (ktoe) from 2000 to 2021.

Final Energy Consumption (FEC) Projection to 2030

The projection of Malaysia's final energy consumption (FEC) provides an analytical evaluation of the country's potential energy requirements within the existing macroeconomic and policy contexts. According to historical data, final energy consumption grew steadily from 29,639 ktoe in 2000 to 66,483 ktoe in 2019. This represents an average annual growth rate of 4.9%. The transitory drop in demand in 2020 was due to the COVID-19 pandemic, followed by a strong recovery in 2021. This demonstrates that Malaysia's energy demand is robust enough to deal with challenges in the short run.

Based on previous elasticities and assuming an average GDP growth rate of 4% and a population growth rate of 1% per year, projections suggest that both economic and demographic expansion will continue to drive energy demand. According to the baseline scenario, total FEC will increase from 70,076 ktoe in 2020 to approximately 88,486 ktoe (around 88 Mtoe) by 2030, at a rate of 2.4% per year.

Figure 7 clearly demonstrates that energy consumption has been increasing consistently since 2000 and is expected to continue doing so until 2030. The blue line depicts historical demand, while the orange line indicates what is expected to occur given current economic and policy conditions. The total FEC could be maintained at 88,486 ktoe by 2030, if energy intensity increases by around 2% annually. This aligns with the Twelfth Malaysia Plan (12MP) and the National Energy Transition Roadmap (NETR) goals, which prioritize decoupling energy demand from economic growth through initiatives such as electrifying transport, enhancing energy efficiency, and integrating renewable energy. According to the projection of energy demand, energy use will continue to be influenced by economic growth until more significant policies are introduced and implemented.

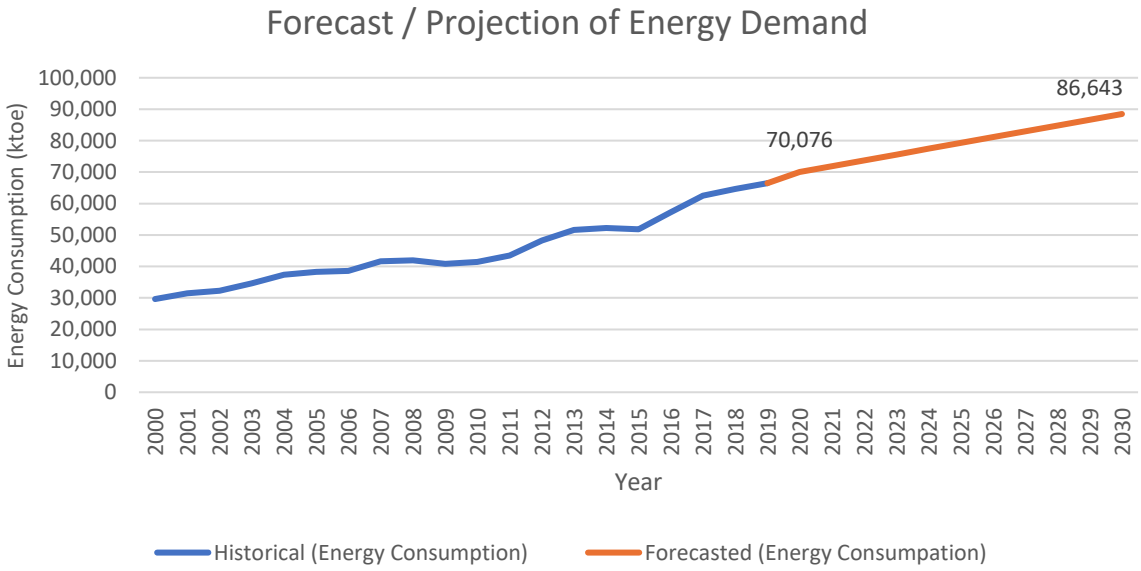

Figure 7. Forecast / Projection of Energy Demand.

Conclusion

In this study, we examined the relationship between economic growth, population, and energy consumption in Malaysia using comprehensive NEB data from 2000 to 2021. The findings show that Malaysia continues to exhibit a strong growth-driven pattern of energy demand, with GDP emerging as the dominant long-term driver. Moreover, sectoral analysis reveals that industry and transport continue to contribute a substantial amount of final energy use, while NEU has become more relevant in recent years. While the pace of efficiency gains has increased over time, it has not been sufficient to offset the upward pressure resulting from economic growth. Based on the forecast to 2030, it appears that energy demand will continue to grow on a baseline trajectory, underlining the importance of accelerating efficiency measures and structural transition under the National Energy Transition Roadmap (NETR). This study confirms the link between Malaysia's economic growth and its energy consumption over the long run, as well as extending prior work that includes GDP, population dynamics, sectoral patterns, and efficiency indicators. Together, these contributions enrich our understanding of the theoretical basis for energy demand drivers and strengthen our empirical basis for supporting Malaysia's ongoing energy transition. The findings emphasize the need for sustained policy efforts to promote low-carbon development, enhance energy productivity, and enhance long-term planning for Malaysia's energy future.

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