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Enlightening Malaysia's Energy Policies and Strategies for Modernization and Sustainable Development

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***Abstract*—**Malaysia has achieved remarkable economic growth since 1957, moving toward modernization from a predominantly agriculture base to manufacturing and—now—modern services. The development policies (i.e., New Economic Policy [1970–1990], the National Development Policy [1990–2000], and Vision 2020) have been recognized as the most important drivers of this transformation. The transformation of the economic structure has moved along with rapid gross domestic product (GDP) growth, urbanization growth, and greater demand for energy from mainly fossil fuel resources, which in turn, increase CO_2 emissions. Malaysia faced a great challenge to bring down the CO_2 emissions without compromising economic development. Solid policies and a strategy to reduce dependencies on fossil fuel resources and reduce CO_2 emissions are needed in order to achieve sustainable development. This study provides an overview of the Malaysian economic, energy, and environmental situation, and explores the existing policies and strategies related to energy and the environment. The significance is to grasp a clear picture on what types of policies and strategies Malaysia has in hand. In the future, this examination should be extended by drawing a comparison with other developed countries and highlighting several options for sustainable development.

***Keywords*—**Energy policies, energy efficiency, renewable energy, green building, Malaysia, sustainable development.

I. Introduction

SUSTAINABLE development is an important aspect highlighted in the current era. The Brundtland Commission Report (1987) defined sustainable development as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [1]. This concept first emerged in the 1970s, and it concerns not only economic development, but also social and environmental development. Climate change is one of the consequences of unsustainable development because humans have overexploited the natural resources (fossil fuel sources) to generate electricity, cut down forests, and move vehicles [2], ignoring the impact of such development on the environment and future generations. For instance, the world's carbon dioxide (CO_2) emissions grew from 17.78 billion tons in 1980 to 32.1 billion tons in 2015 [3], and the resulting warming has influenced human health, agriculture, economic activities, biodiversity, and ecosystem functioning. Reference [4] reported that, if no action is taken to reduce such emissions, the concentration of greenhouse gas (GHG) in the atmosphere could double its preindustrial levels by as early as 2035.

Malaysia is a developing country that has significantly transformed itself from a predominantly agriculture-based country to manufacturing and, now, toward modern services and modernization. Its development policy (New Economic Policy [NEP: 1970–1990], the National Development Policy [NDP: 1990–2000], and Vision 2020) was recognized as one of the important drivers of economic transformation, modernization, and urbanization [5]. Today, Malaysia has been acknowledged as one of the urbanized countries in East Asia as well as a high middle-income country [6]. Consequently, in the 11th Malaysia Plan (11MP) and Vision 2020, the government of Malaysia set a target to become a high income nation by 2020 and to achieve a GDP growth of 6% annually over the subsequent 5 years. With the rapid economic development, modernization, and the need to meet the target, Malaysia requires more and more energy to support its industrial development, as well as enhance the productivity of capital, labor, and other factors to production [7] and support urbanization growth. Both GDP and energy consumption are expected to grow by 4.6% and 4.3%, respectively, between 2004 and 2030. Unfortunately, Malaysia struggles with an overdependence on non-renewable energies (fossil fuels and coal) to generate electricity and other production activities (end-user consumption). As a result, the growth of energy consumption has in turn increased the CO_2 emissions.

In 2009, recognizing the importance of sustainability, Malaysia established a voluntary target of reducing the GHG intensity of its GDP by up to 40% compared to 2005 levels by 2020 [8]. Under the 10th Malaysia Plan (2011–2015), energy intensity had decreased by 33% by the end of 2013, and it is still below the targeted reduction. The crucial challenge faced by Malaysia today is supporting economic development by keeping its GDP up and bringing CO_2 emissions down (CO_2 accounted for three quarters of GHG emissions), which is also known as green growth. Solid policies and strategy to reduce the dependencies on fossil fuel resources, the energy intensity, and CO_2 emissions are needed to achieve sustainable development, specifically in urban areas. In view of these considerations, the aim of this study is to retrospectively

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analyze the Malaysian economic, energy, and environmental scenario, to highlight the past and current energy and environmental policies adopted to achieve sustainable development in the Malaysian economy, and finally, to review the past and current strategies to control CO_2 emissions stimulated by Malaysia's modernization. This study also focuses on CO_2 emissions, utilizing it as a proxy for GHG emissions, because it is the main source of GHG and accounted for three quarters of GHG emissions [9]. By highlighting the economic, energy, environmental scenario, and policies, we can grasp a clear picture of Malaysia's experiences to date.

The structure of this study is organized as follows. Section II examines the Malaysian economic, energy, and environmental (3Es) scenario. Section III reviews the energy and environmental policies. Section IV illuminates the challenges faced by Malaysia in terms of sustainability and explores the possible energy strategies toward sustainability development. The final section provides the conclusion and recommendations.

II. The Malaysian Economic, Energy, and Environmental Scenario

Malaysia has achieved remarkable economic growth since 1957. It has moved steadily toward modernization, successfully transforming its economy from a predominantly agriculture-based economy in the 1970s to a manufacturing-based economy in the mid-1980s and modern services in the 1990s [10]. Reference [6] declared Malaysia's achievements from the ranks of a low-income economy in the 1970s to a high middle-income economy in 1992 and maintained this status to date. This economic transition and modernization are the outcome of an intensive planned, action, execution, and review of nation's policies to achieve its target (see Table I). Within the period of the aforesaid policies (1971–2015), Malaysia's GDP grew 6.03% (see Fig. 1), and it was targeted to grow within this range for the next five years. The manufacturing and service sector was anticipated to contribute more than 75% of the GDP [10].

Thus, Malaysia's industrial development and expansion are closely related to the transformation of its urban areas [5], especially in Klang Velley, Penang, and Johore Bahru. The urban population increased from 34.3% of the total population in 1971 to 73.3% of the total population in 2015, accounting for 2.4% growth for the 1971–2015 period. If this trend continues, more than 80% of the Malaysian population will be urban in 2020 (see Fig. 1). Such growth resulted in Malaysia becoming among the more urbanized countries and economies in the region in demographic terms [6] and clearly demonstrated that people increasingly prefer to live in urban areas for better quality of life because most infrastructures are built in urban areas to cater to the needs of industries, shelter, recreation, and other services [11], thereby contributing to higher CO_2 emissions. In addition, domestic investment on fixed assets (K) and foreign direct investment (FDI) are essential factors driving the economic development [12]. In 2013, the Department of Statistic Malaysia [13] reported that domestic investment posted a positive momentum in all types of assets (i.e., structure, ICT and machinery, transport). The asset for structural purposes accounted for 48.2% of total investments, ICT equipment and other machinery equipment accounted for 25.2%, and transport equipment accounted for 14.1%. These investments are expected to increase in order to provide a good and efficient infrastructure, like the implementation of large-scale projects (e.g., the Klang Valley Mass Rapid Transit [KVMRT] Line 1 from Sungai Buloh to Kajang, Electrified Double-Track Railway Ipoh-Padang Besar, Light Rail Transit [LRT] extension from Kelana Jaya and Sri Petaling to Putra Heights, KLIA2 Terminal, Central Spine Road from Kuala Lipis to Bentong, as well as the Regasification Terminal [RGT-1] in Melaka), which in turn improves national competitiveness and productivity and makes Malaysia the preferred logistics gateway to Asia [10]. Fig. 2 shows the 6.6% domestic investment for the 1971–2015 period.

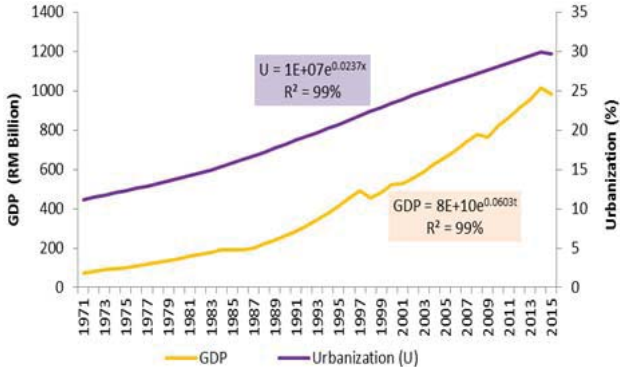

Fig. 1 The time trend of GDP and urbanization for the (1971-2015) period [67]

TABLE I
The Flow of Major Economic Policies [10]

Policy	Period	Target
Economic and Social Development Plan Policy	1966-1970	The policy target is to improve living conditions in rural areas.
New Economic Policy	1971-1990	Contained the 2nd -5th Malaysia Plan. It was focused on poverty eradication irrespective of ethnicity and eliminating identification of ethnicity by economic function.
National Development Policy	1991-2000	Contained the 6th – 7th Malaysia Plan. It was focused on ensuring the balanced development of major sectors of the economy and regions, as well as reducing socio-economic inequalities across communities
National Vision Policy	2001-2020	Contained the 9th -11th Malaysia Plan. It was aimed to sustainable development and to be high income country in 2020.

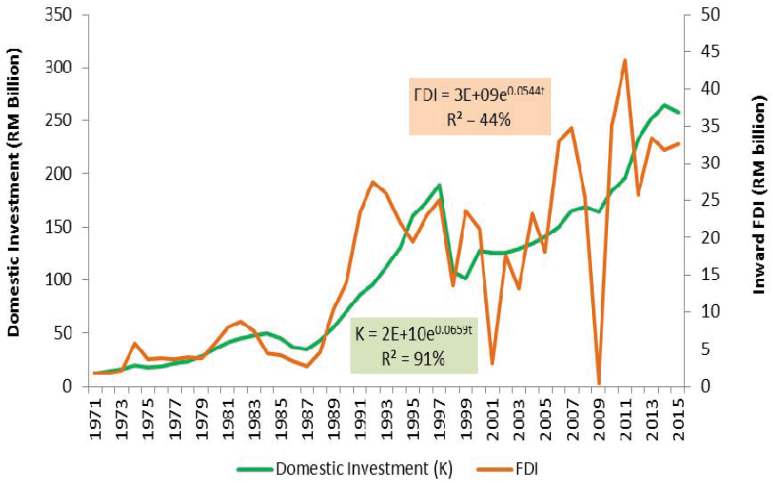

Fig. 2 Domestic Investment and FDI (inward) for the (1971-2015). Period [67]

Instead of domestic investment, FDI has served as an important source of investment. Likewise, it was one of the channels for technology transfer and the way to access foreign markets. History has demonstrated that Malaysia has transformed itself from agriculture and raw material production with a high unemployment rate, low level of education for the labor force, and scarcity of capital and technology in the early 1970s to become the current largest semiconductor components exporters in the world [14]. Reference [15] also reported that the FDI (net inflow) recorded US$10.11 billion (RM35.3 billion) in 2014, with manufacturing generating the highest income (44.1%), followed by service (38.7%), and mining and quarrying (14.7%). However, Fig. 2 shows the FDI inflow grew by 5.4% during the 1971–2015 period. In the days ahead, FDI will continuously serve as an important instrument to support GDP growth, and the efforts to increase FDI will focus on attracting investments in higher value-added and knowledge-intensive employment activities [16].

Energy is an indispensable factor for economic development [17] and an important element to support urbanization and industrialization [18]. It is no longer viewed as a luxury, as it is used to become a necessity in our everyday activities, such as vehicle utilization, production, and commercial activities, as well as residential anthropogenic activities. Fig. 3 indicates that the transportation sector is the highest energy user, followed by the industrial and residential sectors. The energy consumption growth in each of these sectors is 7%, 6%, and 7%, respectively, for the 1978–2015 period. As energy consumption is expected to grow proportionally with economic development, Malaysia has to prepare solid strategies to ensure a sustainable and affordable energy supply in the future [12].

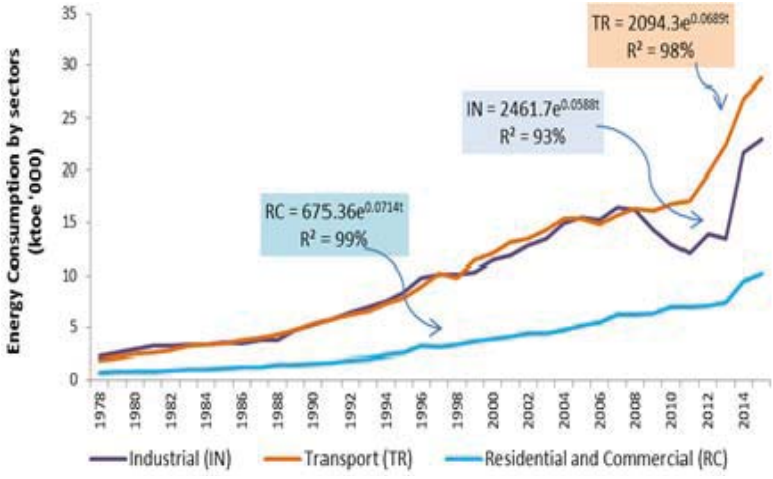

Fig. 3 Energy consumption by sectors for the (1978-2015) period [68]

Due to the trend of Malaysian economic activities and high dependence on fossil fuel and coal resources, CO_2 emissions increased [19], [20]. Fig. 4 shows that CO_2 emissions increased by 7.14% between 1971 and 2015. If no control

options are exercised, these emissions will reach 285.73 million tons in 2020, where the electricity generation sector is the major source of CO_2 emissions (43.45%), followed by the transportation sector (30.25%), industrial sector (26.26%), and the residential sector (0.03%) [21]. Furthermore, Malaysia is required to meet an environmental target, which is a 40% reduction in terms of the GHG intensity of GDP by 2020, compared to the 2005 level, as well as the 11th Malaysia Plan target, which is 5% to 6% GDP growth per annum. The current upward trend of macroeconomic indicators, energy consumption, and CO_2 emissions has forced the Malaysia government to develop appropriate strategies for sustainable development.

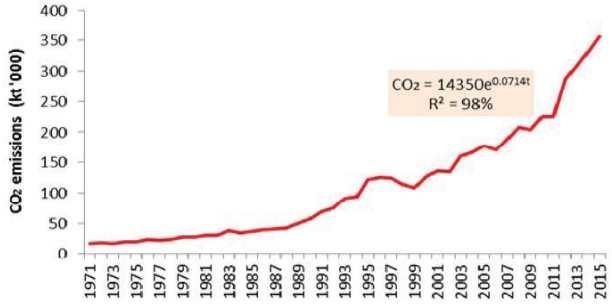

Fig. 4 Time trend of CO_2 emissions in Malaysia for the (1971-2015) period [67]

Yet the adoption of energy efficient (EE) and renewable energy (RE) strategies have created a negative relationship between energy consumption and CO_2 emissions [22], [23]. To date, the EE strategy has successfully reduced Malaysia's energy consumption by 306.9 gigawatt hour (GWh) and avoided 208,705 tons (tCO_2) of CO_2 through the Sustainability Achieved via EE (SAVE) program between 2011 and 2013. Meanwhile, the retrofitting of four government buildings also successfully reduced energy consumption by at least 19% per month (EPU, 2015). Reference [24] projected that the Malaysia CO_2 will drop to 358 million tons ($MtCO_2$) by 2035, and half of the reduction in CO_2 emissions will come from energy-efficient improvements in the end-user sector via the demand side. Furthermore, the RE strategy proved its potential to avoid CO_2 emissions through the adoption of solar, wind, geothermal, hydro, and some form of biomass for electricity generation (see Table II).

TABLE II
RE AND CO_2 EMISSION AVOIDANCE [69]

Year	RE sources	CO_2 Avoidance (tonnes')
2012	124403.8	124403.8
2013	375502.6	375502.6
2014	737780.3	737780.3
2015	1136597.37	1136597.37
2016	1186708.84	1186708.84

III. Energy and Environmental Policies

In Malaysia, the threat of increased global warming resulting from the use of fossil fuels pushed policymakers to formulate and adopt policies for sustainable development. EE and RE have been identified as the vital instruments to be highlighted when formulating energy and environmental policies due to its ability to mitigate CO_2 emissions. Since 1979, diverse energy and environmental policies have been introduced to tackle this particular issue. The National Energy Policy (NEP), National Depletion Policy (NDP), Four Fuel Diversification Policy (4FDP), and Five Fuel Diversification Policy (5FDP), all aim to guarantee the security of energy supply. Although the National Environment Policy (NPE), National Policy on Climate Change (CCNP), and National Green Energy Policy (NGTP) focused on EE as a tool of sustainable development, the National Renewable Policy (NRE) aims to achieve the previously unfulfilled target and then come out with a bigger agenda for sustainable development. Thus, this section reviews the existing energy and environmental policies chronologically, as summarized in Table III.

TABLE III
THE FLOW OF MAJOR ECONOMIC POLICIES [12], [18], [20], [26], [28], [48]

Year	Policy	Target	Strategy
1979	NEP	To ensure efficient, secure, and environmental sustainable supply of energy.	Security and energy supply
1980	NDP	To prolog the lifespan of oil and gas resources.	
1981	4FDP	To prevent overdependence on oil resource.	
2001	5FDP	To include RE as energy supply mix.	
2002	NPE	To enhance quality of life through environmentally sound and sustainable development.	Sustainable Development
2009	CCNP	To reduce the negative impact of climate change.	
2009	NGTP	To promote low carbon technology.	
2010	NRE	To enhance utilization of RE.	

A. Security Energy Policies

In 1979, the NEP was introduced to ensure the efficient, secure, and environmentally sustainable supplies of energy, including electricity [25]. This policy was formulated based on three primary objectives: (a) to ensure the provision of adequate, secure, and cost-effective energy supply by developing indigenous energy resources using the least cost option and to diversify supply sources; (b) to promote the efficient utilization of energy and to discourage wasteful and non-productive patterns of energy consumption; and, (c) to ensure that environmental protection is not neglected in the pursuit of the supply and utilization objectives [17], [26].

In 1980, the NDP was introduced to safeguard the exploitation of crude oil reserves due to its uncontrollable and over production. To do so, the government controls the production of crude oil and subsequently included natural gas reserves in 1996. The production of crude oil is limited to an average 630,000 barrels per day (bpd) while the consumption of gas in Peninsular Malaysia is limited to approximately 32,000 million standard cubic feet per day [26]. With the implementation of this policy, Malaysia can prolong the lifespan of the national oil and gas reserves for future security and the stability of oil supply [12].

In 1981, after the occurrence of two world oil crises and quantum leaps in prices in the years 1973 and 1979, the 4FDP was implemented. During that time, the Malaysian energy sector was highly dependent on a single source of energy [17]. The 4FDP was formulated to prevent overdependence on oil as the main energy resource and to ensure the reliability and security of the energy supply by focusing on four primary energy resources: oil, gas, hydropower, and coal [27].

Unfortunately, the 4FDP was highly dependent on fossil fuel resources (oil, gas, and coal), which were not secure and are exposed to depletion. The combustion of these sources contributes significantly to GHG emissions. In 2001, the government under the 8th Malaysia Plan (2001 to 2005) changed the 4FDP to the 5FDP with the addition of RE (biomass, solar, and mini-hydroelectric stations to generate electricity) as the fifth source of fuel in order to ensure the sustainability of energy resources and reduce the GHG emission [26]. Under this plan, the Small Renewable Energy Power (SREP) program was launched to encourage private sectors to invest in small power generation projects utilizing biomass, biogas, mini-hydroelectric, solar, and wind energy [28]. This policy targeted RE to generate 5% of all electricity produced by 2005, which was equal to between 500 and 600 megawatts (MW) of installed capacity.

As a consequence of the 4FDP and 5FDP strategies, Malaysia drastically tipped its fuel mix balance in energy consumption from a 55% dependence on oil in 1980, reduced to 40% in 1995 and 30% in 2014. For the 1980–2014 period, coal and natural gas dominated the energy mix, where each contributed 40% to 55% from 2000 to 2014. In addition, the RE utilized 5% of the electricity generated [29] and reduced the environmental degradation problem that emerged due to the emission of CO_2 oxides of nitrogen (NO_x), and oxides of sulfur (SO_x) as a result of energy generation from fossil fuel resources [26]. Thus, the increase in the utilization of RE can minimize the negative impacts of energy generation, transmission, conversion, and consumption on the environment. The result of the implementation of fuel diversification policies (i.e., 4FDP and 5FDP) for the 1980–2014 period is shown in Fig. 5.

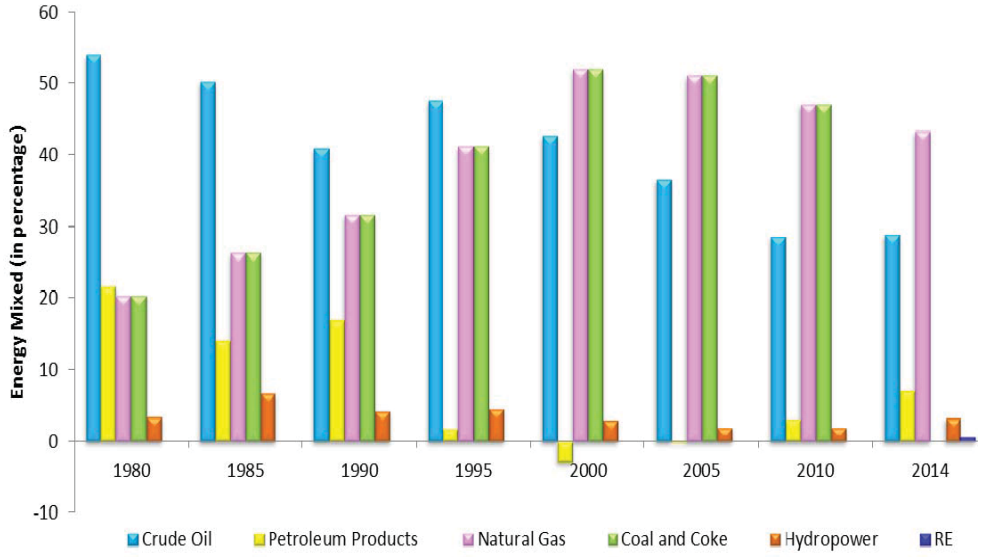

Fig. 5 The Trend of energy mix for 1980-2014 period [68]

B. Sustainable Development Policies

The previously mentioned policies are generally concerned depleting fossil fuels and energy security issues [25]. However, these policies did not further emphasize sustainable development and EE issues. In 2002, the Minister of Science, Technology, and the Environment highlighted the sustainable development issues with the integration of economic development, social development, and environmental protection, which led to the development of the NEP with the aim of continuing Malaysia's economic, social, and cultural progress, as well as the enhancement of the quality of life through environmentally sound and sustainable development. Several strategies under the NEP have been formulated, including efforts to exploit Malaysia's natural resources in a sustainable way along with economic development, promote energy conservation, use energy-efficient technology and process, and encourage the use of cleaner fossil fuels and alternatives to fossil fuels. These strategies will provide guidance to all federal and state agencies, the industrial sector, local communities, and other stakeholders in ensuring that the environment is clean, safe, healthy, and productive [30].

As a result of the strong dependency on conventional energy sources (i.e., fossil fuels), Malaysia's status is even more vulnerable to climate change and global economic fluctuations. Moreover, neither historical nor current national policies have directly addressed the climate change issue through sustainable development [31]. Thus, the Malaysian government has seriously aimed to overcome the climate change issue by putting a voluntary target of reducing the GHG emission intensity of its GDP by up to 40% by 2020

compared to 2005 levels [8]. In 2009, the Climate Change National Policy (CCNP) was formed to provide a framework to mobilize and guide all key stakeholders in addressing the challenges of climate change in an effective and holistic manner and guide the nation toward sustainability. The CCNP drafted five principles with 10 strategic thrusts (policy goals) and 43 key actions that focus on climate change mitigation, adaption, and capacity building [32]. Unfortunately, the CCNP does not provide a detailed description or timelines for the achievement of these key actions.

For that reason and in light of the urbanization growth issue (the World Bank expects the urban population to increase to 82% by 2020), the National Green Technology Policy (NGTP) was developed in 2009 with a mission to promote green technology and ensure sustainable development while conserving the natural environment and resources. The term *green technology* (GT) is the development and application of products, equipment, and systems used to conserve the natural environment and resources, which minimizes and reduces the negative impact of human activities. These GT elements accelerate the national economy and promote sustainable development or green growth (i.e., balance the energy, environment, economics, and social achievement). NGTP's objectives are to enhance economic development with minimum energy consumption, facilitate the growth of the GT industry and enhance its contribution to the national economy, increase national capability and capacity for innovation in GT development and enhance Malaysia's competitiveness in the global arena, ensure sustainable development, and enhance public education and awareness on GT, as well as encourage its widespread use. In order to achieve the identified objectives, five strategic thrusts were identified: establish a GT council for high-level coordination amongst key stakeholders, provide a conducive environment for GT development, intensify human capital development by providing training and education programs, as well as by introducing financial packages and incentives to students embarking on GT-related subjects, intensify GT research and innovation towards commercialization, and promote public awareness of GT to achieve the policy's target [33].

In 2010, the NRE was formulated after enduring eight years of market failure to promote RE. The vision of this policy is to enhance the utilization of indigenous RE resources, to contribute to national electricity supply security and sustainable socio-economic development [34]. The NRE's objectives are to increase RE contribution in the national power generation mix and facilitate the growth of the RE industry, ensure the generation of RE at reasonable costs, conserve the environment for future generations, and enhance awareness of RE's role and importance. To meet these objectives, five strategic thrusts have been identified, which are to introduce an appropriate regulatory framework, provide conductive environments for RE business, intensify human capital development, enhance RE research and development, and design and implement an RE advocacy program [35]. Thus, the anticipation of NRE will bring about a positive impact by 2020 by achieving the environmental and economical target, as previously discussed.

IV. Reduction of Energy Consumption and Co_2 Emission Challenges

The major challenge that needs to be addressed is how to reduce the gap between Malaysia's economic development and CO_2 emissions—specifically, how to reduce CO_2 emissions and maintain sustainability in a rapid urbanization and modernization scenario. Urbanization and modernization have contributed to higher energy consumption and CO_2 emissions because urban areas are merely hubs for production and other economic activities to meet other areas' demands. Furthermore, most rural residents have changed their lifestyles in certain ways and improved their living standards during the urbanization process. In pace with the improvement of living conditions and income levels, urban residents' consumption levels also continue to increase, while their consumption patterns have gradually shifted from survival mode to development mode and even enjoyment mode, which may directly or indirectly increase urban energy use [36]. Many previous studies [37]-[40] have demonstrated the positive relationship between urbanization and CO_2 emissions, with residential household, transportation, and building material industries being the major CO_2 emitters in urban areas [41], [42].

According to [43], urbanization generally affects CO_2 emissions in three ways: through residential and industrial energy consumption; through energy used by the construction sector for the purpose of building better infrastructure, transportation, and residential dwellings; and through the conversion of grasslands and woodlands to allow for urban development. Furthermore, increased use of residential home appliances (e.g., air conditioning, water heater) has consumed high electricity power and indirectly affects the level of CO_2 emissions. All these factors highlight that urbanization is the main GHG contributor, accounting for 50% of all GHG specifically in Malaysia (see Fig. 6). Thus, the strategic options to reduce energy consumption and CO_2 emissions will focus on construction, transportation, plantation, and residential sectors in the urban area. The detailed strategies are presented next.

Fig. 6 Contributors of GHG emissions [11]

A. Green Building Strategy

CO_2 emissions caused by building (including residential, office, and commercial building) energy consumption are an important issue to highlight due to the increasing amount of GHG emissions. Such building accounts for approximately 40% of global energy consumption [44] and 25% of GHG emissions [45], with a large portion being used for cooling, ventilation, lighting, appliance, etc. In addition, the outdated facilities and buildings, as well as inefficient construction schedules, also has a great potential to accelerate the increasing rate of energy consumption. Instead of continuing such problems, the building sector has very promising opportunities for saving energy and CO_2 emissions through building envelope, EE, and fuel switching measures [46].

Due to the green building's great potential, the government introduced it by combining EE and RE features. Examples included well-insulated walls and roofs, exterior window shadings, EE lighting according to occupancy and daylight availability (it following MS1525:2007 Code of Practice Use of Energy Efficiency & Renewable Energy for Non-residential Buildings), EE office equipment, a comprehensive energy management system, implementation of a series of best practice solutions for mechanical and electrical systems, and a three-kWp grid connected photovoltaic (PV) system installed on the roof [47]. Surveys have shown that new buildings that apply EE and RE features are consuming approximately 200–250 kWh/m^2 of energy, which could be reduced to about 135kWh/m^2 (KeTTHA, 2014). KeTHHA's Low Energy Office (LEO) building and the Malaysia Green Technology Corporation's (MGTC) Zero Energy Office (ZEO) are two examples of building with EE design [48].

District cooling (DC) is another EE and RE feature for controlling energy usage and reducing adverse effects on the environment. The function of a DC system is to distribute cooling from one or more sources to multiple buildings. Such a system produces chilled water at a central plant and then pipes that energy out to buildings in the area for air cooling use. To date, DC systems have been installed in many government and private developments, such as the Kuala Lumpur City Centre (KLCC), Putrajaya government offices, Cyberjaya, Kuala Lumpur International Airport (KLIA), Kuala Lumpur Central, and New Johore Administrative Centre Nusajaya [49].

In addition to commercial buildings, residential buildings also have a great potential to improve EE because they have historically contributed 75% of building energy consumption [9]. Thus, the installation of a PV system for every single residential building is a practical strategy for producing electricity and reducing CO_2 emissions. SURIA 1000, under the Malaysia Building Integrated Photovoltaic (MBIPV) Project, is one government initiative encouraging the installation of PV systems. The program targets at least 1,000 kWp of building-integrated photovoltaic (BIPV) installations at residential and commercial buildings. As of 2007, Japan produces most of the world's solar BIPV products and has seen residential solar BIPV systems growing at 50,000 systems per year [50]. This amount can be increasing in other Asian countries, which have the highest potential to receive solar radiation compared to other temperate countries, as sunshine duration in such countries is high throughout the year [51].

B. Green Mobility and Infrastructure Strategy

Due to the flexibility and comfortability of private motor vehicles, the number of such vehicles is growing in urban areas. The Federal Territory of Kuala Lumpur has an estimated average of two cars for each resident [52]. Moreover, the usage of public transport in Malaysia has been reported to be 16%, which is the lowest among the Asian peers [53]. Conversely, it creates negative side effects for the environment due to congestion and traffic fatalities because the Malaysian transportation sector is still relying on fossil fuel resources. One car trip emits approximately 0.26kg of CO_2 [11]; thus, the use of electric vehicles (EV) may reduce the tailpipe emissions from the vehicles [53]. Green Technology Malaysia (GTM) has encouraged the use of EV and established a target to achieve at least a 10% market share for EVs and the deployment of 2,000 electric buses by 2020 to reduce dependency on fossil fuels resources. From 2010 to 2013, 13,699 units of EV and hybrid vehicles were registered in Malaysia (GTM); this amount is expected to increase given the Malaysian initiative to import 100 units EV from American car makers [54].

The other options to support green mobility are by encouraging the use of public transportation, walking, and cycling. This strategy has played a key role in most city planning in Portugal to combat the negative environmental impact and to promote quality of life and citizen well-being [55]. China is one of the countries that has successfully developed the largest public bicycle traffic in the world, with a convenient connection to existing transit modes [56]. The Malaysian government also initiated the adoption of green mobility by improving public transportation through the Government Transportation Program (GTP) and the 10th Malaysia Plan [20]. Recently, the Malaysian government integrated land use and transportation planning in urban areas, expanding and improving the public transportation infrastructure, such as LRT, buses, and mass rapid transit (MRT) [57]. Instead of focusing on vehicles, Malaysia also needs a compact urban layout [58] for residence areas and industrial parks to reduce daily commute time and lower the cost of congestion. Public services, including medical care, traffic, and education facilities, also require a rational layout to increase the EE of urban life and reduce the cost of urban residential energy [36]. For Malaysia, this strategy was effectively stated in its Low Carbon Cities Framework and Plan [11].

C. Green Vegetation Strategy

The lack of vegetation and the presence of the dark surface lead to the development of an urban heat island (UHI), a phenomenon whereby cities become significantly warmer than their surrounding areas [11]. Green vegetation in the form of tree planting is another approach to fight CO_2 emissions and

cool the urban environment [59]. Trees absorb the CO_2 and transfer it to their roots during the photosynthesis process [60]. One tree can absorb approximately 1,000 kg of CO_2 [11]. Thus, planting trees in recreation and residential areas can significantly increase CO_2 sequestration, reduce the need for electricity for air conditioning [61], and ultimately improve the urban environment, making communities better places to live. This strategy was implemented in Canberra, where 400,000 planted trees are estimated to have a combined energy reduction, pollution mitigation, and carbon sequestration worth US$20–$67 million (30,200 tons of CO_2 sequestration) between 2008 and 2012 [62], [63]. In Singapore, green vegetation deployment was able to reduce the near-surface air nighttime temperature, when UHI intensity is high, by more than 1°C [64].

D.Green Purchasing Strategy

The residential sector is one of the most electricity-consuming sectors in an economy [65]; thus, the use of EE appliances is a significant strategy for reducing electricity consumption [25] and supporting low carbon cities [58]. According to [36], a healthier urban consumption is created by guiding rational consumption, spending wisely and saving diligently, resisting extravagance and waste, and reasonably controlling the excess capacity consumption. Thus, the EE label provides information on energy savings, and this element guides consumers to choose which appliances can benefit them in terms of reducing energy bills, electricity consumption, and GHG emissions, ultimately improving quality of life. This strategy has successfully been applied in developed countries (Europe, the United States, Japan, etc.). However, in Malaysia it was first introduced in 2006, and for the time being, the EE label was applied to certain electrical appliances, such as refrigerators, air conditioning, lighting, and ceiling and stand fans. This label is issued by the Energy Commission to manufacturers of electrical appliances that comply with the standards and requirements of energy performance testing for the star rating established by the Energy Commission [66]. The more stars on the upper part of the EE label indicates the greater the EE of the product (1-star label is the least efficient and 5-stars is the most efficient, as shown in Fig. 7).

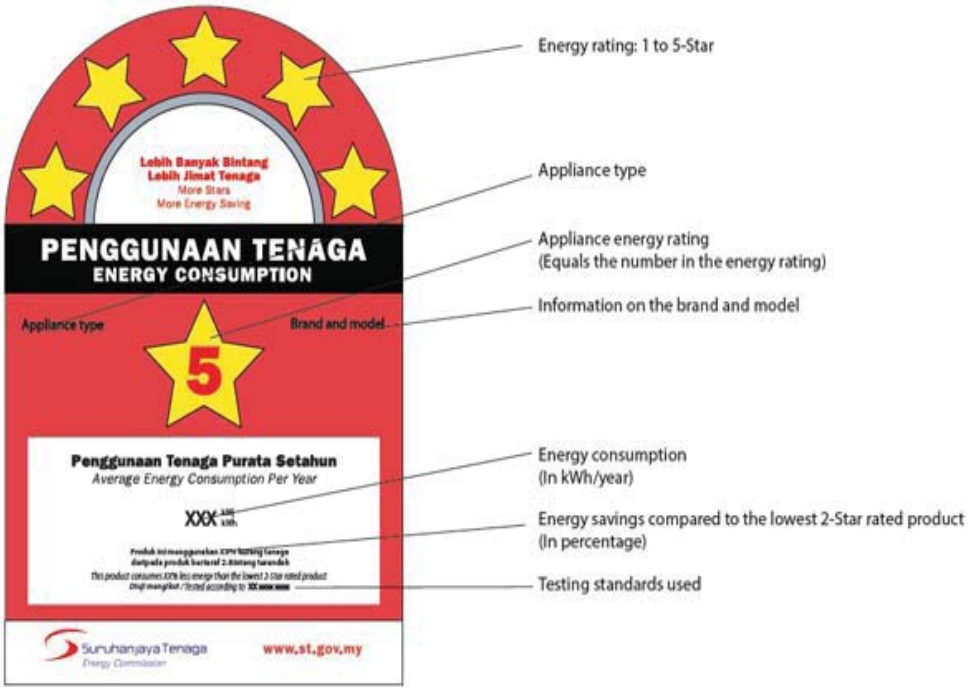

Fig. 7 EE label [66]

V.Conclusion and Recommendations

In Malaysia, sustainable development is an important aspect to highlight in the current era. The sustainable development of a country ensures the ability to balance the current needs for development without compromising the environmental degradation factor that prevents future generations from addressing their own needs. This paper has offered an overview of Malaysia's economy, energy, and environmental scenario, as well as highlighted the role of Malaysia's development and energy policies that have shifted the country toward modernization. The Malaysian economy has experienced a transition from a predominantly agriculturally based economy to manufacturing based in the 1980s and, from the 1990s onwards, modern services. This rapid industrialization was complemented with urbanization growth, and today, Malaysia has been acknowledged as an urbanized and high middle-income country. If this trend continues, more than 80% of the Malaysian population will be urban in 2020.

Such urbanization and modernization has contributed to higher energy consumption and CO_2 emissions because urban areas are merely economic activity hubs, with the residential household, transportation, and building material industries being the major CO_2 emitters. The situation becomes more complicated because the environmental quality was badly infected by the economic and social activities. Several energy and environmental policies have been implemented in order to reduce the gap between Malaysia's economic and CO_2 emissions level, such as NEP, NDP, 4FDP, 5FDP, NEP, CCNP, NGTP, and NRE. However, only NGTP comprehensively measures the economic, energy, environment, and social factor through GT. Furthermore, it has a great potential to reduce the gap between Malaysian economic development and CO_2 emissions.

Several EE and RE elements were absorbed in formulating strategic options to reduce the gap between Malaysia's economic development and its CO_2 emissions, including green building, green mobility and infrastructures, green vegetation, and green purchasing strategy. This study only focused on past and current policies and strategies implemented in Malaysia in order to create a clear picture of the types of policies and strategies in place in Malaysia. Future studies should extend the findings of the current project by comparing Malaysia's situation with other developed countries and highlight several options to achieve everlasting sustainable development.

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