Malaysia's renewable energy policies and programs with green aspects Saad Mekhilef a,n , Meghdad Barimani a , Azadeh Safari b , Zainal Salam c a Power Electronics and Renewable Energy Research Laboratory (PEARL), Department of Electrical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia b Department of Electronic Engineering, Macquarie University, 2109 Sydney, NSW, Australia c Center of Electrical Energy Systems, Faculty of Electrical Engineering, Universiti Teknologi Malaysia, 8130 Johor Bahru, Malaysia article info Article history: Received 2 December 2011 Received in revised form 11 June 2014 Accepted 9 July 2014 Keywords: Renewable energy Energy policy Malaysia Green prospect abstract Malaysia, as a developing country and a member of the Association of Southeast Asian Nations (ASEAN), is looking into inexhaustible and repeatable alternative energy sources such as solar, wind, mini-hydro and biomass. The estimated GDP at 2010 is $15,385 per capita and the economic and industrial growth of the country implies that energy demand is growing very fast. In addition, the growing prices of fossil fuels, and greenhouse gas (GHG) emissions, make inevitable renewable energy solutions for the country. Geographically, Malaysia is located in a region of tropical and humid climate which provides easy access to a variety of renewable energy sources. The government of Malaysia has initiated renewable energy policies to encourage industries and individuals to employ renewable-energy-powered systems in power applications. This paper first gives a brief overview of the current status of renewable energy in Malaysia. Then it provides the energy policies, specifically the renewable energy policies in Malaysia, in Section 2. The renewable energy programs are reviewed in Section 3. The building energy efficiency program with green aspect is provided in Section 4. Lastly, the conclusion and forecasts of this paper are given in Section 5. & 2014 Elsevier Ltd. All rights reserved. Contents 1. Introduction . . . . . 498 2. Energy policies in Malaysia. . . . . 498 2.1. Renewable energy policy. . . . . 498 2.1.1. Five-Fuel Diversification Policy under the 8th and 9th Malaysia Plans. . . . . 498 2.1.2. The National Biofuel Policy . . . . . 498 2.1.3. The National Renewable Energy Policy and Action Plan . . . . . 499 3. Renewable energy programs. . . . . 500 3.1. The Small Renewable Energy Power (SREP) Program . . . . . 500 3.2. The UNDP-GEF Biomass Power Generation and Demonstration (BioGen) project . . . . . 500 3.2.1. FELDA Besout POME Biogas Project . . . . . 500 3.2.2. Bandar Baru Serting Biomass Project . . . . . 501 3.3. The Malaysian Building Integrated Photovoltaic (MBIPV) Project . . . . . 501 3.4. The Economic Transformation Program (ETP) . . . . . 501 3.5. The

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1. Introduction

Malaysia's rapid population growth and economic development have increased the energy demand [1]. From 2005 to 2008, the final energy consumption growth rate was 5.6%. It is expected that the total energy consumption will increase to 98.7 Mtoe by 2030, which is three times the 2002 level [2–4]. Currently Malaysia is mostly dependent on fossil fuels such as coal, oil and natural gas to generate electricity. Predictions state that around 82% of electricity will be generated by fossil fuels in 2015. Crude oil reserves have been 2.9 billion barrels/day and the estimate of total crude oil production on 1st January 2010 was 553,960 BPD [5]. Hence, the oil reserves will be finished within 15 years at the current rate of usage. Statistics released by [5] show that the proportion of electricity generated by gas will be reduced from 62.9% in 2005 to 51.6% in 2030; however, fossil fuel dependency for electricity generation is still high. Malaysia's total coal consumption increased from 88,000 t/annum in 1980 to 15.219 million tonnes/annum in 2009 and its share is predicted to grow from 27% in 2005 to 37% in 2030 [6–8]. A four-fuel diversification strategy was introduced in 1981 as an extension of the 1979 National Energy Policy to guarantee the security of energy supply and a balance between different types of fuels. The Malaysian Government has initiated several efforts to move to alternative types of energy, specifically renewable energy, to reduce Malaysia's over-dependence on fossil fuels and manage the growing demand for energy. Subsequently, the Five-fuel diversification strategy was set up in 2001 to provide 5% of electricity generation via renewable energy by 2005. The program will be followed until 2020. To reinforce the policy, fiscal incentives such as investment tax allowances have been considered in parallel with different programs to improve the renewable energy status. In the 8th Malaysia plan (2001–2005), the aim was to share 5% of the total energy supply mix from RE sources to cope with the upward trend of energy demand in the market. Thorough investigations are being undertaken to find new methods to evaluate the availability of RE and promote the utilisation of renewable resources to achieve sustainability of energy supply in the long term.

Although several fiscal incentives have been launched by the Malaysian government, the development of RE is still rather slow. According to the 10th Malaysia plan, renewable energy has to increase from o1% (41.5 MW) in 2009 to 5.5% (985 MW) of total electricity generation by 2010 [9,10]. The cumulative renewable energy installation capacity in Malaysia is estimated to be 11.5 GW in 2050, 34% of the power mix [11]. The following are the renewable energy sources in Malaysia: – Solar: The average daily solar radiation in Malaysia is between 4.21 kW h/m2 and 5.56 kW h/m2 [12]. The BIPV project has been announced to increase the grid-connected PV system installations up to 850 MW by 2030 (and more than 8000 MW by 2050) [11]. – Biomass: Currently, biomass is the most viable among the RE resources in Malaysia [13]. Malaysia has 4000 ha of palm trees and is the world's second-largest producer of palm oil. Palm oil production increased by 17.4% between 2005 and 2009 to reach 17.6 million tonnes. The potential for biomass from Empty fruit bunches (EFB) is estimated to be 1340 MW by 2030 [11]. – Biogas: The major sources of biogas are Palm Oil Mill Effluent (POME) and livestock manure. In July 2009, a total capacity of 4.45 MW was under construction and the potential biogas constructions will produce 410 MW by 2028 [14,15]. – Municipal solid waste (MSW): The total annual solid-waste production of Malaysia was been 7 million tonnes in 2010, and the GDP growth rate of the country was 5.5% by 2011 which means a remarkable increase in solid-wastes production. Malaysia generated 5.5 MW of electricity from MSW in August 2009 and it is expected that, with the policies adopted by the government, the total installations will rise to 360 MW by 2022 [15]. – Small and mini-hydro: The total hydroelectric capacity of Malaysia is around 18,500 MW which is about 20% of the total energy provided by Tenaga Nasional Berhad (TNB) [16,17]. The total mini-hydro installations in Malaysia were 30.3 MW by July 2009 and the expected potential by 2020 is 490 MW [18]. – Fuel cells: After solar, fuel cells are considered the cleanest RE sources with the least environmental issues. The Ministry of Science, Technology and Innovation (MOSTI) of Malaysia funded RM34 million (US$ 9.7 million) of research and development (R&D) of fuel-cell technology between 1996 and 2007 [19,20]. In addition, a total RM7 million (US$2 million) was invested in hydrogen production and storage technologies between 2002 and 2007. – Wind energy: Although Malaysia's wind energy potential is not as high as Europe's [21], wind energy is a promising way of generating electricity using on-shore and off-shore power systems. There are two wind-turbine units already installed in Pulau Perhentian, Terengganu and Pulau Layang-layang in Sabah with a total capacity of 250 kW [22]. – Geothermal power: The Tawau geothermal program is planned to install a total capacity of 67 MW of geothermal power systems. Furthermore, RM1.5 million has been allocated in the 10th Malaysia Plan for research on geothermal power generation in Sabah [23]. 2. Energy policies in Malaysia Energy policy is defined as "The manner in which a given entity (often governmental) has decided to address issues of energy development including energy production, distribution and consumption" [24]. The main goals for setting up RE policies are to persuade societies and individuals to adopt RE as an alternative source of energy. Energy policies try to encourage RE in the country's energy mix by facilitating technological barriers, addressing market failures and decreasing associated costs. Energy policies in Malaysia are supervised by the Economic Planning Unit (EPU) and the Implementation and Coordination Unit (ICU). These policies are controlled directly by the country's prime minister. Various policies have been undertaken by the Malaysian government to ensure

sustainable energy in the future. The energy policies adopted by Malaysia and the main goals of each policy since 1974 are presented in Table 1. Table 1 indicates that the National Energy Policy was adopted in 1979 when the world was experiencing an oil crisis [19]. The main objectives of this policy have been production, utilisation and environmental issues. Generally in energy policies, the supply objectives target the full exploitation of RE sources. Utilisation objectives target energy conservation and efficiency promotion as well as providing solutions to eliminate wasteful and non-productive energy applications. The environmental objectives try to lessen the environmental issues when taking advantage of energy sources. A year after introducing the National Energy policy, a new policy called the National Depletion Policy was launched. The purpose of the new policy was to conserve the main energy resources (mainly oil and gas) of the country. Subsequently, in 1981, the Four Fuel Diversification Policy was announced. The policy emphasises the importance of utilising and diversifying the usage of the four main resources (oil, gas, coal and hydro). 498 S. Mekhilef et al. / Renewable and Sustainable Energy Reviews 40 (2014) 497–504 2.1. Renewable energy policy 2.1.1. Five-Fuel Diversification Policy under the 8th and 9th Malaysia Plans In 2001, greater efforts were made for utilising RE resources. In the 8th Malaysia plan, a new energy policy called the "Five-Fuel Diversification Policy" was announced. It was the first time in the country that RE was targeted to be the major contributor to generation of electricity. It was urged due to the significant depletion of oil and gas in that era. Hence, government added RE as a significant source of energy after oil, gas, coal and hydro [25]. The Five-Fuel Diversification Policy aimed to generate and feed 500 MW of electricity to the national grid; however, at the end of the plan in 2005, only 12 MW was delivered to the grid under the Small Renewable Energy Power Program (SREPP) [26]. The development pace of RE in Malaysia is rather slow and is still in the infant stage. Although the fifth energy policy was announced a decade ago, the RE contribution is 1% of the total energy mix [19]. Thereafter, the government decided to continue the Five-Fuel Diversification Policy in the 9th Malaysia plan between 2006 and 2010 [27]. During the 9th Malaysia Plan, 300 MW was generated and fed to the Tenaga Nasional Berhad (TNB) grid in Peninsular Malaysia plus 50 MW to the Sabah Electricity Sendirian Berhad (SESB) grid in Sabah [28]. The expectation was to generate 5% of total electricity from RE by 2005; however, by the end of the 9th Malaysia Plan, only 41.5 MW was successfully connected to the grid [29]. 2.1.2. The National Biofuel Policy In spite of the successful development of the first biofuel production in ASEAN-6, its sustainability has been more and more Table 1 Energy policies in Malaysia. Policy name and year Description of energy policy Petroleum Development Act 1974 Vested the exclusive right to explore, develop and produce petroleum in Malaysia to PETRONAS National Petroleum Policy 1975 To regulate downstream oil and gas industry via the Petroleum Act National Energy Policy 1979 Based on three objectives: Supply, Utilisation and Environmental National Depletion Policy 1980 To prolong lifespan of Malaysia's oil reserves for the future Four-Fuel Diversification Strategy 1981 To balance utilization of oil, gas, hydro and coal Renewable energy Policies Description of Renewable energy Policy Five-Fuel Diversification Strategy 2001 RE included as fifth fuel in energy supply mix National Biofuel Policy 2006 Promote the demand for palm oil National Renewable Energy Policy and Action Plan 2010 Enhance the utilisation of indigenous renewable energy resources Other related Policies Authorised organiser Science &

Technology Policy, 1986 MOSTI Environmental Policy, 2002 NRE Bio-Fuel Policy, 2005 KPPK Green Technology Policy, 2009 KeTTHA Climate Change Policy, 2009 NRE Nomenclatures ACEM Association of Consulting Engineers Malaysia ASEAN Association of Southeast Asian Nations BioGen biomass-based power generation and cogeneration BIPV building integrated photovoltaic DanIDA Danish International Development Assistance EE energy efficiency EFB empty fruit bunches EPU Economic Planning Unit ETP Economic Transformation Program FiT Feed-in Tariff GBI green building index GDP gross domestic product GEF Global Environmental Facility GHG greenhouse gases emission ICU Implementation and Coordination Unit KeTTHA Ministry of Energy, Green Technology and Water KPPK National Union of Teaching Malaysia LEO Low Energy Office MBIPV Malaysian Building Integrated Photovoltaic MIEEIP Malaysian Industrial Energy Efficiency Improvement Project MOSTI Ministry of Science, Technology and Innovation MSW municipal solid waste NKEA National Key Economic Area NRE natural resources and environment PAM Pertubuhan Arkitek Malaysia POME palm oil mill effluent PPP purchasing power parity PTM Malaysia Energy Centre PV photovoltaic RE renewable energy RM Ringgit Malaysia SCORE Special Committee on Renewable Energy SEDA Sustainable Energy Development Authority of Malaysia SESB Sabah Electricity Sendirian Berhad SREPP Small Renewable Energy Power Program TNB Tenaga Nasional Berhad UNDP United Nations Development Program US United States of America ZEO Zero Energy Office Subscripts $ dollar BPD barrels per day CO2 carbon dioxide GW gigawatt RM/kW h Malaysian Ringgit per kilowatt hour m2 square metre Mtoe million tonnes of oil equivalent MW megawatt S. Mekhilef et al. / Renewable and Sustainable Energy Reviews 40 (2014) 497–504 499 questioned. There was increasing criticism of the destruction of valuable ecosystems like rainforests as well as increased CO2 emissions from the conversion of peat forest into palm-oil plantations. As a result, interest in the potential of so-called advanced and second-generation biofuels has been raised [30]. The new fuels could offer a great potential to improve economic conditions and support rural development. Hence, a National biofuel policy was launched on 21st March 2006. The primary goals of this policy were reducing the country's dependency on fossil fuels, promoting the demand for palm oil to generate electricity and subsidising the installation costs [31]. 2.1.3. The National Renewable Energy Policy and Action Plan As part of the 10th Malaysia Plan in 2010, the National Renewable Energy Policy and Action Plan was launched. This policy has been launched to provide a secure and sustainable national electricity supply for socio-economic development [12]. The main goals were: – Increasing the contribution of RE to the electricity power generation mix. – Helping growth of the RE industry. – Making RE available at reasonable cost. – Maintaining the environment for future generations. – Increasing awareness of the public on the importance of RE. To increase the public awareness, a "Feed-in Tariff" was introduced in the 10th Malaysia plan. According to the 10th Malaysia plan, a total electricity generation of 985 MW should be achieved during 2010 to 2015, which is almost 23 times the 41.5 MW of previously installed capacity [10]. Fig. 1 shows the total RE capacity in 2009 and the expected capacity in 2015. 3. Renewable energy programs To support renewable energy policies in Malaysia, several fiscal and financial programs have been launched by the government. Table 2 presents the main RE programs approved by the Malaysian government. The following sections will present these programs. The other two topics, ETP and FiT, will be discussed as related programs that

were effective in the growth of RE in Malaysia. 3.1. The Small Renewable Energy Power (SREP) Program Along with the 5th Fuel Policy, SREP Program was introduced with the 8th Malaysia plan on 11th May 2001. It was to encourage RE project developers and facilitate the wider use of RE for generating electricity in Malaysia. Successful sub-programs of SREP Program include Jana Landfill biogas generation project at Puchong (shown in Fig. 2), and TSB Bio-energy project at Sabah [2]. In the Jana Landfill biogas generation project two 1000 kW engines were installed on the Puchong Snitary Landfill, and the generated power was fed to the public grid. This project won the ASEAN renewable energy awards in 2005. Through SREP Program, independent small RE power plants could sell generated electricity to the grid. This program covered almost all renewable energy sources such as solar, wind, biomass, mini-hydro, biogas and MSW. The special Committee on Renewable Energy (SCORE) supervised by the Ministry of Energy, Water and Communications (currently the Ministry of Energy, Green Technology and Water) is responsible for the co-ordination and implementation of this program. The committee has set up a series of guidelines which explain licences to supply electricity generated from RE to the grid. These guidelines also indicate that the small electricity power plant should be at a distance of at least 10 km from the nearest interconnection point. The preference of this Fig. 1. RE capacity in 2009 and the expected capacity in 2015. Table 2 Renewable energy programs. Program Launched in Goals Small Renewable Energy Power Program (SREP) 2001 Permission to small RE power producers (o10MW) to sell electricity to utility UNDP-GEF Biomass Power Generation & Demonstration (BioGen) project 2002 Promote utilisation of biomass (EFB) & biogas (POME) grid-connected project in order to reduce the GHG emission Malaysian Building Integrated Photovoltaic (MBIPV) Project (UNDP-GEF) 2005 To reduce cost of technology of solar PV and increase total capacity Fig. 2. Jana Landfill biogas generation project at Puchong. Source: http://www.jdgroup.com.my/index.php. 500 S. Mekhilef et al. / Renewable and Sustainable Energy Reviews 40 (2014) 497–504 program was for co-generation plants. The maximum capacity of each small power plant to supply to the grid should be 10 MW. Table 3 shows the status of SREPP in March 2010 [32]. 3.2. The UNDP-GEF Biomass Power Generation and Demonstration (BioGen) project Following the SREP Program, a new project was initiated to develop a high-efficiency RE cogeneration plant for the palm-oil industry in 2002. The United Nations Development Program (UNDP) and the Global Environment Facility (GEF) were initiated to support the UNDP/GEF Biomass Power Generation and Demonstration (BioGen) Project. The project has been supported technologically and financially by government. The project aimed to reduce emissions (GHG and Methane from biomass decay), and specifically to use waste residues from palm oil (Empty Fruit Bunches) to generate electricity, and sell to the public grid [33]. Launching this project was in the line with reducing barriers to generate biomass electricity and promote growth of power generation. Two small-scale demonstration project activities under BioGen project are: FELDA Besout POME Biogas Project, and Bandar Baru Serting Biomass Project. 3.2.1. FELDA Besout POME Biogas Project The FELDA Besout POME (Palm Oil mill) biogas project involved the construction and operation of a closed anaerobic pond and a biogas flaring and combustion plant located in Jengka. This project has two phases. Phase one aimed to capture and utilize the methane gas released from anaerobic ponds s in an enclosed type flare. The excess biogass

was used at the second phase to generate electricity. The electricity generated at phase two was used instead of the generated electricity by fossil fuels on-site. The efficiency of the operations in The FELDA Besout POME biogas project was around 16%, which made it a standalone lowefficiency project. Hence, it can be considered neither as a renewable energy plant nor rural electrification program. 3.2.2. Bandar Baru Serting Biomass Project The Bandar Baru Serting Biomass Project was a small-scale demonstration project activity developed by MHES Asia Sdn Bhd in the Serting Industrial Estates. It was towards the Government 5th fuel policy renewable energy to encourage developing biomass and biogas facilities to generate electricity using palm oil wastes (collected from nearby plantations), and deliver 10.5 MW to the national grid. This project set sustainable developments including increased local employment opportunities, increases diversity and security of electricity supply, and reduce fossil fuel consumption. According to the reports, this project became a standalone low efficiency tragedy. There are various reasons for project failure most importantly is approving the standalone project while the funding was originally allocated to demonstrate a cogeneration project. Hence, the project was left abandoned after a last drawdown of a government guaranteed loan. 3.3. The Malaysian Building Integrated Photovoltaic (MBIPV) Project In 2004, GEF together with UNDP approved support for the development of the Malaysia Building Integrated Photovoltaic (MBIPV) project [34]. The project was launched for the period of 5 years between 2005 and 2010. It was initiated to encourage the industry sector and householders to employ PV systems for producing electricity and reducing GHG emission. The MBIPV has contributed to the overall energy efficiency in buildings without sacrificing aesthetics by considering the guidelines known as MS1525 published in the year 2001. MS1525 was later revised and updated in 2006. It represents an attempt to achieve efficient use of energy in non-residential buildings [35]. The SURIA1000 project was introduced under the MBIPV program. The target was the residential and commercial sectors. The aim of the project was to provide a direct chance to protect the environment and participate in RE initiatives. The funds for the program were granted by the Malaysia government (Suruhanjaya Tenaga), PV manufacturers and householders. Under the MBIPV project, applicants can contribute to the program based on a bidding process which is open to the public each six months. "SURIA for Developer" is the main part of the National Malaysian Building Integrated Photovoltaic (MBIPV) program. SURIA 1000 is exclusively for property developers to promote the widespread use of solar photovoltaic systems on buildings [36]. Based on cost and benefits analysis photovoltaic systems are not an economical option at this time. Including solar photovoltaic in electricity bill can be considered in about 6–7 years when this technology becomes cost-effective. Although photovoltaic is a wide spread renewable energy technology, new technology and experiments should be incorporated to make them more efficient. 3.4. The Economic Transformation Program (ETP) The Economic Transformation Program was announced in October 2010. It was introduced to lift the country's economy in 12 main National Key Economic Areas (NKEA) [37] and make Malaysia a high-income nation by 2020. The NKEAs are the core of ETP. They have higher priority to receive government support including funding and ministerial attention. Energy has been recognized by ETP as one of the main NKEAs and electricity as Table 3 Status of SREPP in March 2010 [32]. No Category Mini hydro Biomass Biogas Remark No. of projects Capacity (MW) No. of projects Capacity (MW) No. of projects Capacity (MW) 1 Licensed

Projects 6 17.8 9 79 3 4.95 Total licensed projects is 18 with capacity of 101.75 MW Projects already in operation 3 8 5 45 2 3.7 10 Projects with 56.7 MW capacity is already operational Projects under construction 2 7.3 1 5 1 1.25 4 Projects with 13.55 MW capacity are under construction and expected to be operational before 2010 2 Approved Projects(yet to be licensed) 7 43.5 12 125 6 15.9 Total projects is 25 with capacity of 184.4 MW Projects under construction 0 0 1 10 3 2.9 4 projects with 12.95 MW capacity are under construction and expected to be operational in year 2011–2012 Total 13 61.3 21 204 9 20.85 Total approved projects is 43 with capacity of 276.15 MW S. Mekhilef et al. / Renewable and Sustainable Energy Reviews 40 (2014) 497–504 501 one of the most important energy categories in Malaysia's economic growth. In line with the ETP, there is a great need to boost PV panel production between 2010 and 2020. PV panel production in Malaysia has been about 3% of the world's total production in 2009 [38]. Under ETP, Malaysia is going to be at the forefront in the manufacturing of PV technology by 2020, instead of a mere assembler. In addition to energy, palm-oil production has a significant role in the national economy. 3.5. The Feed-in Tariff (FiT) The Feed-in Tariff (FiT) conception was first hosted by the United States (US) [39]. It was first established in Malaysia in 2011. The program is monitored by the Sustainable Energy Development Authority of Malaysia (SEDA) [40] under the Ministry of Energy, Green Technology and Water. Based on the program schedules, 1% of the electricity tariff from the consumer will be used to support development of RE. The aim is to run the RE industry economically and enhance the public awareness [41]. Proposed FiT rates are presented in Table 4. According to Table, 1% of the electricity tariff from the consumer will be used to support development of RE and will not have an effect on low-income consumers (consumption less than 200 kW h per month). 4. Building an energy efficiency program with green prospects The green building idea was introduced to save energy and increase the efficiency of building resources including water, energy and materials. The program was initiated to lessen the long-term harmful impacts of toxic substances on humans. The building efficiency program tries to propose a better use of resources in the design, operation, construction, maintenance and destruction of buildings [42]. 4.1. The Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP) In 1999, the Malaysian Government, the United Nations Development Program (UNDP) and the Global Environmental Facility (GEF) announced a collaborative project called MIEEIP. In the 7th Malaysia Plan (1996–2000), energy efficiency (EE) was introduced nationwide for the first time. It was founded on the Malaysia Energy Centre (PTM); however, some barriers forced the government to initiate MIEEIP to further improve energy efficiency in the industrial sector. The major barriers have been as follows: – Inadequate energy rules (such as EE standards and labelling). – Limited consciousness of EE techniques and their economic effects. – Industry tendency to invest in production improvements rather than efficiency. A number of measures were adopted to improve the EE including a plan to gradually eliminate incandescent light bulbs by 2014. This program intends to decrease carbon-dioxide emissions by 732,000 t and also reduce the energy consumption by 1074 GW each year. An EE building has been modelled and constructed as a "Low-Energy Office" in Putrajaya. Another example of EE building modelling is the "Zero-Energy Office" in Bandar Baru Bangi. The low-energy office and zero-energy office buildings are discussed subsequently. 4.1.1. Low-Energy Office (LEO) building Fig. 3 shows the low-energy office building in Putrajaya. The construction of the

building was completed in 2004. The architecture and design was provided by Danish International Development Assistance (DanIDA) with the participation of local consultants [43]. Currently, the Ministry of Energy (currently Ministry of Energy, Green Technology and Water) occupies the building. The energy consumption of the building is only 50% of that of a normal office building by saving energy for the lighting, heating and cooling purposes of the building. Table 4 Proposed Malaysian FiT rates (starting at 2011) [15]. RE technologies/ resources FiT duration (Years) Range of FiT rates (RM/kW h) Min–Max Annual degression (%) Displaced electricity cost (RM/kW h) Biomass (palm oil, agrobased) 16 0.24–0.35 0.5 0.2214 Biogas (palm oil, agrobased, farming) 16 0.28–0.35 0.5 0.2214 Mini-hydro 21 0.23–0.24 0 0.2214 Solar PV 21 1.25–1.75 8 0.3504 Solid waste and sewage 21 0.30–0.46 1.8 0.2214 Wind 21 0.23–0.35 1.5 0.2214 Ocean, geothermal 21 0.28–0.46 1 0.2214 Fig. 3. LEO building in Putrajaya. Fig. 4. PTM-ZEO building in Bandar Baru Bangi. 502 S. Mekhilef et al. / Renewable and Sustainable Energy Reviews 40 (2014) 497–504 4.1.2. Zero-Energy Office (ZEO) building As a result of the LEO project, a ZEO building was designed and constructed in Bandar Baru Bangi and is used as a Pusat Tenaga Malaysia (PTM) office. This building is totally dependent on the energy produced by in-site RE installations [43]. It is the first self-sustainable building in Southeast Asia. Fig. 4 shows the PTMZEO building in Bandar Baru Bangi. 4.2. The green building index (GBI) The PAM (Pertubuhan Arkitek Malaysia/Malaysian Institute of Architects) and ACEM (the Association of Consulting Engineers Malaysia) introduced the Green Building Index (GBI) as a new rating system in April 2009. The new rating system takes into account the indoor environment quality, sustainable site planning and management, materials and resources, energy efficiency, water efficiency and innovation. Moreover, environmental issues and criteria are planned to be promoted to enhance the awareness of designers, architects, planners, engineers and the public [44]. Residential buildings are evaluated based on sustainable site planning and management, while commercial buildings would be assessed based on energy efficiency and indoor environmental quality. Although GBI labelling is voluntary, applicants must first be assessed by a certifier appointed by GSB (Green building index Sdn Bhd) to be GBI-certified. Initially, a provisional award is issued. When the building has been completed, the full award is given. The building needs to be checked and verified every three years to keep the award. 5. Conclusion In line with the energy diversification in Malaysia's plans and projects, renewable energy has been recognised as a promising alternative to conventional energy resources. Malaysia has accepted the need to reduce greenhouse-gas (GHG) emissions by ratifying the 1972 Montreal and Kyoto protocols. The Government of Malaysia has announced various programs and policies to increase the awareness of the public about the significance of using renewable energy resources. Another major concern for initialising RE projects is the contribution to CO2 emission reduction and becoming a green developing country. In this regard national and international energy policies obviously show a great effort in energy scenarios; however, Malaysia still has a lot of potential in order to fully utilise RE resources. Hence more collaboration between public and government needs to be performed to ensure a remarkable achievement. Malaysia has initiated various programs to encourage individuals and communities to apply RE sources for household and industrial applications and invest in RE resources. These programs can significantly promote energy efficiency applications and conserve forests and natural resources from pollution.

Furthermore, these programs are aimed at reducing GHG emissions, decreasing the global-warming incidence and helping to improve solid-waste management. However, the country is undertaking vast developments in socio-economic status as a developing country, so that GHG emissions will tend to increase in the near future.