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Review

Energy consumption trends and their linkages with renewable energy policies in East and Southeast Asian countries: Challenges and opportunities

Siva Raman Sharvini [a], Zainura Zainon Noor [a, b, *], Chun Shiong Chong [c], Lindsay C. Stringer [d], Rafiu Olasunkanmi Yusuf [e]

[a] School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[b] Centre for Environmental Sustainability and Water Security, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[c] Department of Biosciences, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia
[d] Sustainability Research Institute, University of Leeds, Leeds LS2 9JT, United Kingdom
[e] Department of Chemical Engineering, University of Ilorin, Ilorin 240003, Nigeria

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ABSTRACT

Global warming is one of today's most critical environmental issues, caused largely by emission of greenhouse gases such as carbon dioxide from burning of fossil fuels. Emissions of carbon dioxide vary throughout countries in Asia. It is increasingly recognised that countries must act to promote the greater use of renewable energy resources as part of actions seeking to mitigate climate change. This paper presents a review of the energy demand scenario in China, Japan, Malaysia and Indonesia and the growth of non-fossil energy in these countries. Energy scenarios within these countries are investigated to identify the opportunities and challenges that exist in developing renewable energy. Energy production among the four countries was analysed. In 2014, China made the highest use of renewables for primary energy production, while Malaysia used them the least. However, fossil energy still constitutes the primary energy source in each country where coal dominates in China (77%) and Indonesia (70%), oil in Japan (28%) and natural gas in Malaysia (61%). In addition, renewable energy policies have been introduced and established based on the energy needs and development status of renewables in each country. This study analyses and compares strengths, weaknesses, opportunities and threats analysis of these countries based on their renewable energy policies. It identifies the challenges for renewable energy development and highlights the necessity of enhanced multilevel governance processes and increased cooperation between the four countries to strengthen their renewable energy sectors and better compete in the global energy market.
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1. Introduction

Energy is essential in meeting many basic human needs, as well as being fundamental in supporting the industrial, transportation, and agricultural activities that shape the world's economic growth [1]. The economic development of a nation is dependent on a continuous supply of energy that caters to all the necessary demands. The conservation of energy and government policies established to support energy security play a major role in sustaining the economic development of a nation. In light of climate change, nations are increasingly recognising that they cannot continue with business as usual (BaU) in terms of their energy portfolio. Countries are therefore developing policies and strategies that utilize a mixture of renewable and non-renewable energy sources.

The main purpose of this paper is to assess on the energy scenario in East Asian (China and Japan) countries and Southeast Asian (Malaysia and Indonesia) countries, identifying the challenges and

* Corresponding author. School of Chemical and Energy Engineering, Universiti Teknologi Malaysia, Johor Bahru 81310, Malaysia.
E-mail address: zainurazn@utm.my (Z.Z. Noor).
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opportunities they face. All four countries share similar types of energy in their energy mix (coal, oil, biomass, hydroelectric and natural gas). Japan is the most developed country with the highest gross domestic product (GDP) per capita in East Asia while China is still a developing country but with high potential for its economy to overtake those of western in 2018 [2]. Both Malaysia and Indonesia are developing countries, rich in abundant of natural resources. Also, Malaysia and Indonesia are top producers of palm oil in which palm oil residues can be converted to energy. Generally, all four countries are rapidly expanding markets for renewable energy.

2. Methods

This paper draws on literature and policy review and individually discusses the energy demand, energy consumption and greenhouse gas emissions for all four countries. These aspects act as the key considerations in the development of renewable energy policies in each of the countries. A comparative analysis on the renewable energy policies in all four countries is undertaken by applying the Strength, Weakness, Opportunity and Threat (SWOT) matrix as an analysis framework. The SWOT framework comprises internal (strengths and weaknesses) and external assessments (opportunities and threats). Strengths explain the available resources to enhance the performance of the policies while weaknesses portray the flaws which may decrease the efficiency of the policies. Opportunities refer to the external changes that lead to development of the policies whereas threats deal with outside factors that may cause issues in executing the policies. SWOT analyses are commonly used in energy management to analyse energy scenario in a system or single region [3]. The paper concludes by suggesting ways to improve the renewable energy capacity in all four countries.

3. Results and discussion

3.1. Outlook for energy usage and greenhouse gas (GHG) emissions in East Asian and Southeast Asian countries

3.1.1. Energy consumption in East Asian and Southeast Asian countries

East Asian and Southeast Asian countries vary in the amount of energy they consume due to differences in climate, dependency on fossil fuels, and use of renewable resources, their energy mix, population and economic growth trajectory.

China, as a developing country in East Asia, has replaced the United States (US) as the largest energy user globally, consuming about 20.3% of world's energy supply in 2012 [4]. Fig. 1 below illustrates the distribution of energy sources that constitute the primary energy sources of energy production in China. The major contribution comes from coal (1622.2 Mtoe, 77%) and the lowest from renewable energy (53.5 Mtoe, 3%). Thus, the country's dependency on fossil energy is relatively high. The 'other renewables' referred to in Fig. 1 are solar, wind and wave energy. China's increasing energy consumption along with continued growth needs to address air quality and climate change, resulting in the establishment of the country's "*13th Five-Year Plan*," which was launched in 2016. It focuses on the reduction of primary pollution and energy consumption, responsibility for which falls to relevant regional government divisions [4,5]. The implementation of upcoming energy saving policies and achievement of related targets are based on identification of the major factors that result in energy consumption.

In contrast, in 2010, Japan, one of the other developed countries in East Asia, generated its electricity supply from nuclear sources (27%), hydropower (7%) and non-hydro renewable energy (3%). Opportunities for the utilization of renewable energy are being enlarged in Japan. The country constitutes the world's third largest economy after the US and China and is a leading industrialized country. In addition, Japan is the fourth largest natural gas consumer and the world's third largest electricity and oil consumer. The country's continuous consumption of local non-renewable resources has led to their depletion, resulting in increased fossil fuels imports to meet demand. Japan is the largest importer of liquefied natural gas, the second largest importer of coal and the third largest importer of oil globally [6]. Fig. 1 shows the types of energy sources that contributed to primary energy production in Japan in 2014 [7]. In 2011, the strong earthquake that hit the northern coastal area of Japan resulted in the shutdown of many nuclear plants [8,9] causing Japan to rely more on oil (7 Mtoe, 28%) for energy production with biomass and other renewables contributing 3 Mtoe (12%) and 2.6 Mtoe (10%). Thus, the energy consumption pattern of Japan is almost the same as that of China.

In contrast, Malaysia, one of the developing Southeast Asian countries has been experiencing high rates of economic development, leading to increased energy consumption since the mid-1980s. Meeting this energy demand is now seen as a basic need [10]. Energy mixes tend to relate to economic growth and consumption demand. In the early 1980s, oil was the major source of energy. However, the government introduced a four-fuel diversification policy [11] in 1981 to reduce oil consumption and simultaneously balance the utilization of other non-renewable energy sources, with a view to ensuring future energy security and stability. Since then, as oil prices increase, focus has diverted to the consumption of natural gas. Also, the share of coal continued to increase from 2000 to 2010 as a substitute to oil [12,13]. In 2014, the Malaysian economy achieved a record 6% growth (up from 4.7% in 2013). The Malaysian government believes that reduced energy consumption will help to deliver improved energy security and more sustainable development without causing economic growth to falter. This can be clearly seen in Fig. 1 which shows the contribution of energy sources for energy production [7].

Indonesia, another major developing country in the region is the fourth most populated nation on the planet [14]. The impact of non-fossil energy on energy production in the country is still lower than in China and Japan, but higher than in Malaysia. This is clearly shown in Fig. 1 [7]. In 2014, the highest percentage contribution was made by coal (289.3 Mtoe, 70%) with the least coming from both biodiesel (2.7 Mtoe, 1%) and other renewables (2.3 Mtoe, 1%). In summary, across the four countries of focus, different mixtures of energy sources are used. While climate change concerns are increasing in importance as a policy consideration, countries fear that their economic growth may be retarded if they shift towards greater use of renewable energy sources.

3.1.2. Energy demand in East and Southeast Asian countries

Energy demand in the study region varies according to countries' needs. Recently, the demand for energy has increased tremendously, especially in highly populated countries such as India and China, where demand is expected to further increase due to the increasing population and economic growth. This raises concerns regarding future energy sustainability. Countries with scarce fossil fuels resources in East Asia depend on imported sources, which results in potential geopolitical and price-fluctuation risks. To achieve energy security and ensure access to an adequate energy supply to support social welfare and economic activity, countries that highly depend on imported energy sources are encouraged to employ risk diversification. The term risk-diversification commonly refers to diversifying the supply of fossil fuels in such a way so as to enlarge the number of suppliers from other countries. Also, instead of just depending entirely on

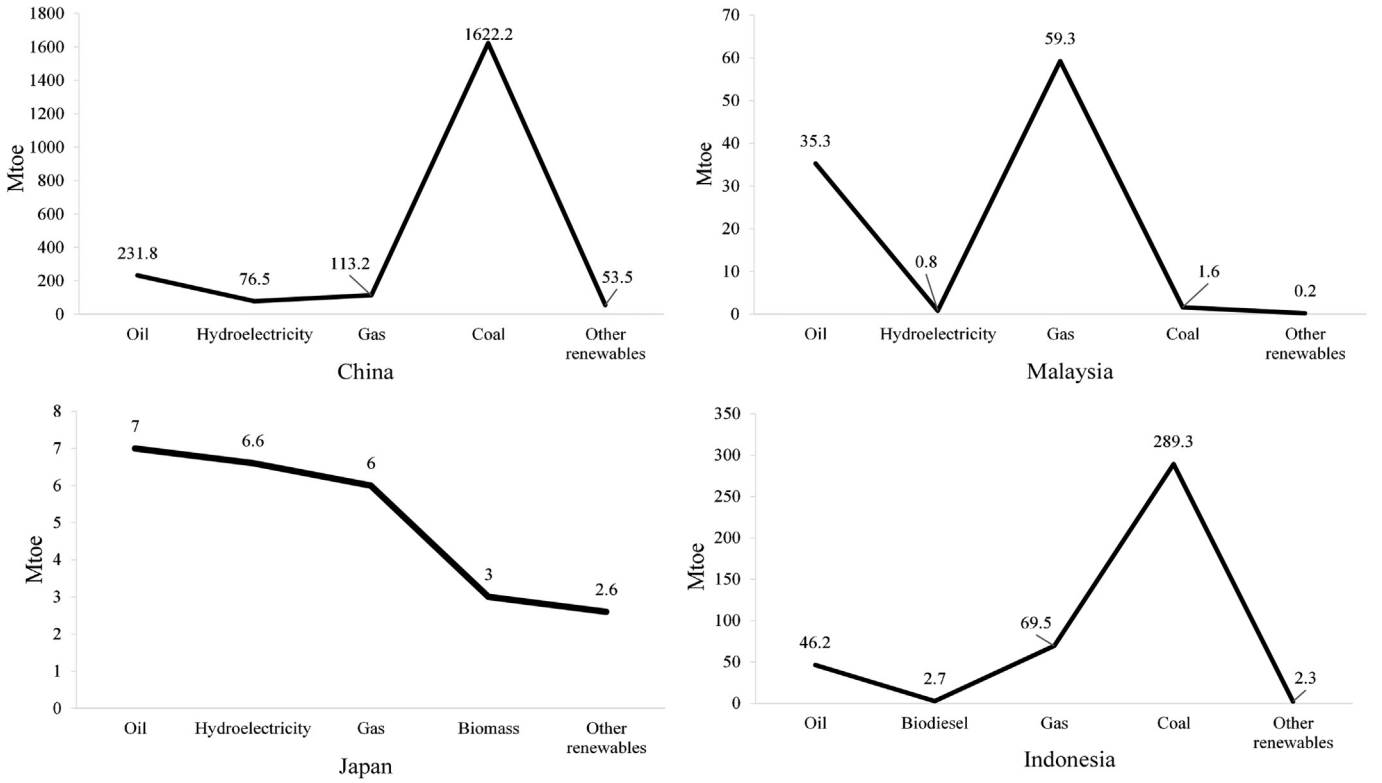

Fig. 1. Primary energy production in China, Japan, Malaysia and Indonesia in 2014.

imported sources of fossil energy, countries can boost their energy self-sufficiency by producing their own renewable energy. This can reduce dependency on imported sources that are limited and scarce in quantity, and which may deplete soon [15].

From 1965 to 1970, world energy demand was driven by the European Union and Japan. This then shifted to Taiwan, South Korea and the Association of Southeast Asian countries between 1980 and 1990. Later, the world energy demand shifted to China then India after 1990 [16]. East Asian countries such as China and Japan started to face energy security issues. Japan produces an insignificant amount of fossil fuels unlike China, which produces fossil fuels simultaneously but still sources energy from outside because the country's demand exceeds its production [15]. This implies that China's economic development is proportional to its energy imports and demand. That energy demand can be greatly reduced with good energy efficiency efforts is undeniable. Nevertheless, the environmental and sustainability costs associated with such development remain unclear.

Southeast Asia is made up of countries with huge variations in the patterns of and measures for their energy reserves and usage [17]. Since the 1990s, energy demand in this area has more than doubled. Moreover, demand is projected to exceed 80% of the usage between 2015 and 2035, increasing at the same level as current demand in Japan. Subsidies for fossil-fuel in Southeast Asia amounted to US$51 billion in 2012. However, this misleads energy markets especially in Malaysia and Indonesia.

The Sustainable Development Goals (SDGs) were outlined in the United Nation's *2030 Agenda for Sustainable Development* [18], which provide a guide for a number of professional disciplines such as policy, engineering, development and research to help deliver a sustainable future. One of the 17 goals involves ensuring access for all to sustainable, affordable, modern and reliable energy [19]. However, about 130 million people in Southeast Asia still do not have access to electricity supplies. Malaysia has an adequate supply of electricity; however, in Indonesia the level of access is below 75%. Thus, to meet energy demand, energy policies in Indonesia and elsewhere have to be orientated towards the concept of diversifying the energy supply to sustain and maintain development and economic growth [20].

3.1.3. Energy related to GHG emissions

Another driver of investments in renewables is related to climate change. Currently, one of the most important issues facing the planet is global warming. From 1970 to 2010, about 78% of the increase in total GHG emissions was due to CO_2 emissions from fossil fuel combustion and industrial processes [21]. Environmental issues such as reduced agricultural productivity and biodiversity loss, reduced productivity of labour force, changing rainfall patterns, melting ice and snow and rising sea level are indications of climate variation and change. Environmentalists and policy makers are therefore beginning to invest more efforts in tackling climate change [22]. Emissions of CO_2 in the Asia Pacific region over the period 2000–2016 are shown in Fig. 2 [23].

In 2016, the global emissions of CO_2 increased by only 0.1% when compared to energy consumption. Also, average emission growth during the period 2014–2016 was the lowest compared to any three-year period since 1981–1983. From 2015 to 2016, India recorded the biggest increment while other significant increments were observed in Indonesia which emitted about 38.9 Mt (7.6%), while Malaysia emitted about 16.3 Mt (6.3%) [23]. To reduce the amount of CO_2 emissions, Indonesia as the third top producer of CO_2 and first largest developing nation decided to endorse the Kyoto Protocol [24,25]. Indonesia declared that it would attempt to decrease the emission of CO_2 by 26% based on its own efforts and by up to 41% with international support to shift away from the BaU by 2020. The unconditional reduction target is 29% of the BaU

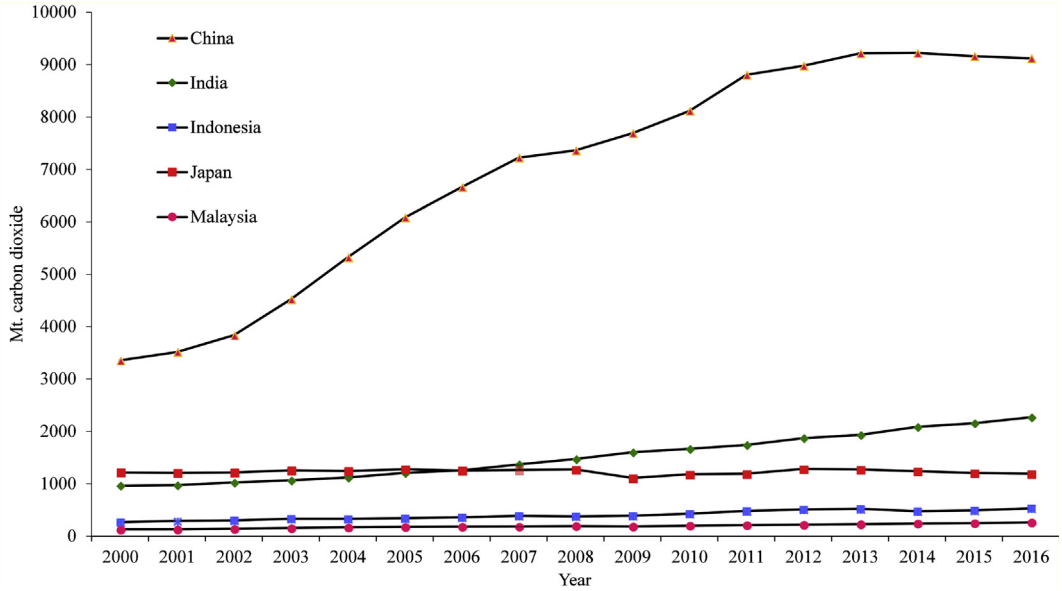

Fig. 2. Carbon dioxide emissions in Asia Pacific (2000–2016).

scenario, based on an assessment of the country's most recent emission level [26]. As for Malaysia, it is highly dependent on fossil fuels (oil, coal and natural gas) as these are major contributors to its electricity supply. Malaysia's contribution to global warming and climate variation is mainly due to the unlimited exploitation of these non-renewable resources. However, in 2001, the Malaysian government realized the need to encourage use of renewable energy as a better alternative and a cleaner solution [12].

Some countries have already reduced their emissions of CO_2 to some extent. The largest decrease has been made by the US, while other significant reductions have been made by China [−41.4 Mt (−0.7%)] and Japan [−15.4 Mt (−1.5%)]. Moreover, the Chinese government has made some additional efforts and plans to reduce its carbon emissions further with the ultimate aim of achieving a CO_2 reduction of 60–65% per unit of GDP compared to the 2005 level by 2030 [27]. As for, Japan, its economy is mostly dominated by high-value-added industries such as services and electronics, which calls for energy efficiency in manufacturing and related sectors.

In response to the rising anxiety in the 1990s about the effects of GHG emissions on global warming, the Japanese government became more involved in the energy market and presented its renewable portfolio standard scheme in 2003 [28] in which it stipulated that electricity retailers should supply a certain amount of electricity produced from renewable resources to grid consumers [29]. This practise would definitely reduce the emission of CO_2 which is a key factor of global warming. However, the country remains heavily dependent on energy imports.

3.2. Renewable energy policy in East & Southeast Asian countries

In East and Southeast Asian countries, renewable energy policies have focused on making step-by-step improvements to encourage the utilization of renewable energy. Fig. 3 depicts the intersection of the main factors in Sections 3.1 and 3.2 along with their connection towards the formation of renewable energy policies indicated in number (Tables 1–4) in all four countries. The intersection of all three components (energy demand, energy consumption and policy) contributes to the amount of CO_2 emitted in each country in 2016. Few unnumbered statements in Fig. 3 demonstrate the issues discussed in Sections 3.1 and 3.2, where no related policies exist.

3.2.1. China

China is a global leader in the low emissions energy sector and in domestic investment in renewable energy. According to Bloomberg New Energy Finance, China has invested about US$103 billion in this energy sector, two and half times the amount budgeted by the US [30]. Table 1 shows the renewable energy policies that have been initiated in China in recent years. Renewable energy policies have been established in China to enhance the importance of non-fossil energy in industrial sectors related to energy and achieve sustainable development.

3.2.2. Japan

Japan is highly dependent on the imports of non-fossil resources for a large part of their energy supply. Japan has enjoyed a constant supply of energy by executing policies to diversify supply and to promote energy conservations since oil crisis of the 1970s [32]. Table 2 shows the renewable energy policies that have been implemented in Japan in more recent times. The policies initially were based on the *Basic Energy Plan* that was established in 2002, which has been reviewed and revised three times since then, resulting in the formation of the *First*, *Second* and *Third Basic Energy Plans* in 2003, 2006 and 2010, respectively. Plans that followed the *Basic Energy Plan* have mostly focused on the implications of energy policies on energy security and concerted efforts have been made to preserve renewable resources to ensure a constant supply of energy. In 2014, the *Strategic Energy Plan* was established after the Fukushima nuclear disaster.

3.2.3. Malaysia

Malaysia's energy policies focus on environmental conservation, sustainability, effective resource consumption and the provision of high quality services to all stakeholders [12]. Table 3 shows the renewable energy policies that have been established in Malaysia since 1979. Both renewable and non-renewable energy were given equal importance in 1979 in order to establish a constant supply and security, and hence ensure a wide network of supply within and outside the country. From 1981, the government has reviewed

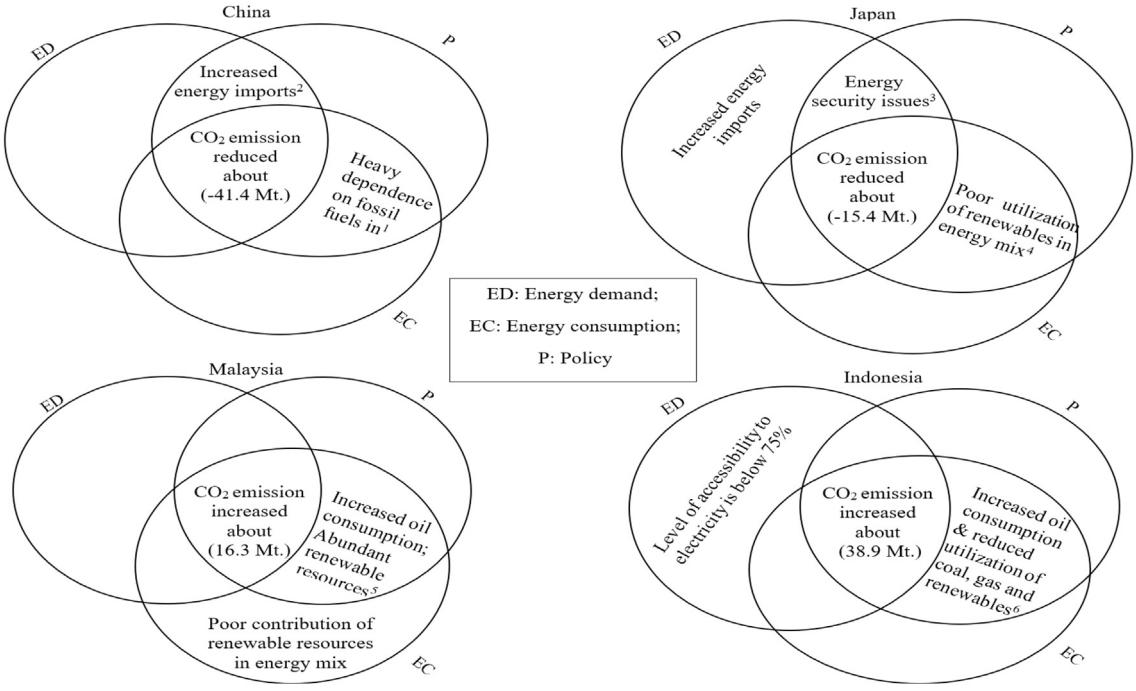

Fig. 3. Factors contributing to the formation of renewable energy policies in China, Japan, Malaysia and Indonesia [superscripts (1–6) refer to the indicator number in corresponding tables].

Table 1
Renewable energy policies in China [31].

Indicator	Policy	Year	Description
	Renewable Energy Law of the People's Republic of China	2006	• States the general conditions for renewable energy and the importance of this energy source to the People's Republic of China
1	Medium and Long Term Development Plan for Renewable Energy	September 2007	• The National Development and Reform Commission issued this policy for renewable energy • To increase the amount of non-fossil energy in total energy consumption
	US China MOU* on Biomass Development *Memorandum of Understanding	December 2007	• To enhance usage of and advance research on biomass • To focus on conversion of biomass into bio-based products and develop an appropriate technique for evaluating biomass in both countries
	Renewable Energy Law Amendments	2009	• To amend the Renewable Energy Law of 2006 • To ensure power grid companies to purchase all the renewable electricity generated
1	The 12th Five-Year Plan for Renewable Energy	August 2012	• To achieve total utilization of non-fossil energy of 478 Mtce[a], which represents 9.5% of the total energy usage, by end of 2015
2	China Energy Technology Innovation Action Plan 2016–2030	April 2016	• To reduce dependency on imports for renewable energy projects
1	China 13th Renewable Energy Development Five Year Plan (2016–2020)	December 2016	• To lead renewable energy technology innovation • To increase the utilization of non-fossil energy in overall primary energy usage from 15% in (2020) to 30% in (2030) • To support ocean power and offshore wind development • To resolve non-fossil energy limitation issues
	China 13th Energy Technology Innovation Five Year Plan (2016–2020)	December 2016	• To enhance the country's effectiveness in the energy field

[a] Mt of coal equivalent.

and amended its energy policies from time to time in order to prevent over-exploitation of coal, natural gas and oil while encouraging energy saving rather than energy wastage. From 1999, the growth of non-fossil energy has been given priority and it was introduced as the fifth fuel of the energy mix with the aim of these resources contributing about 5% of the electricity generated in the nation by 2005. Many renewable energy programmes were encouraged and the importance of using renewable energy for power generation in small industries was emphasized.

Despite the good intentions, renewable energy only contributed to the generation of about 1% of the nation's electricity in 2005. Based on the *9th Malaysian Plan* (2006–2010), dependency on oil/diesel as the source of electricity generation had fallen by less than 1% while emerging major contributors were natural gas, coal and hydropower. Around this time, the sustainable development of the nation was given priority, in line with the aim of reduced dependency on non-renewable resources. From 2009 to 2020, the main focus of the energy policies established by the government has been to find a way to foster the growth of non-fossil energy sources such as biomass derived from oil palm and other feedstocks. The government has offered attractive incentives such as the creation of an enabling environment and an effective pricing policy that it is hoped will result in the generation of sustainable and renewable energy in Malaysia [42].

Table 2
Renewable energy policies in Japan.

Indicator	Policy	Year	Description	Reference
3	Basic Energy Plan	June 2002	• Contains the basic principles of Japan's energy policy in relation to: - Energy security - Safety - Environmental sustainability - Enhancing economic efficiency	[33]
	First Basic Energy Plan	October 2003	• To develop efforts to ensure a constant supply of oil • To promote nuclear energy generation	[34]
3	New National Energy Strategy (Second Plan)	May 2006	• Emphasizes Japan's energy security	[34]
3	New Basic Energy Plan (Third Plan)	June 2010	• Goals to be achieved by 2030 - Improving overall energy security - Assuring the safety of energy resources - Reinforcing policy to deal with global warming - Attaining economic development, with energy as the driving force - Assuring the efficiency of energy markets - Reconstructing the energy sector	[35]
4	Strategic Energy Plan	April 2014	• Developed since the disaster at TEPCO's Fukushima nuclear reactor and the Great East Japan Earthquake • Promotion of disseminated renewable energy resources (solar power, biomass, renewable heat and small/medium hydropower) • Restructuring of the FiT[a] system • Diversified development of non-fossil energy sources • Instituting Fukushima as a centre of the non-fossil energy industry	[36]

[a] Feed-in-Tariff.

Table 3
Renewable energy policies in Malaysia.

Indicator	Policy	Year	Description	Reference
	National Energy Policy	1979	• Supply (to ensure the supply of cost-effective, secure and sufficient energy) • Utilization (to encourage effective usage of energy) • Environmental (efficient energy consumption to reduce the negative impacts of energy)	[37]
	National Depletion Policy	1980	• Protection against dependency on natural gas and crude oil and over-exploitation	[37]
5	Four-Fuel Diversification Policy	1981	• To ensure future stability and security of oil supply by performing balanced consumption of gas, oil, hydro and coal	[37]
5	Five-Fuel Diversification Policy	1999	• To achieve a 5% contribution of renewable energy to the country's electricity usage by 2005	[37]
	Energy Commission Act	2001	• To conserve non-renewable energy sources	[37]
5	8th Malaysian Plan	(2001–2005)	• To generate 5% of electricity from renewables by 2005	[37]
5	National Biofuel Policy	2005	• To brand the utilization of biofuels via incentives • Promote the demand for palm oil as a source of renewable energy	[37]
	9th Malaysian Plan	(2006–2010)	• To focus on energy efficiency with sustainable development	[37,38]
5	National Green Technology Policy	2009	• To promote efficient utilization of biomass and seek to achieve energy independence • To utilize technology for national economic development	[39]
	New Energy Policy	2010	• To improve energy security	[37]
5	Renewable Energy Act	2011	• To implement a feed-in-tariff for the generation of renewable energy • To utilize biogas from effluent waste for the generation of power for the national electricity grid	[40]
	Biomass Sustainable Production Initiative	(2010–2013)	• A collaborative programme between Malaysia and the European Union to harness local biomass resources for high-value utilization by assisting small and medium-sized enterprises in Malaysia • To venture into the gaps in the Malaysian biomass industry and develop sub-programmes to fill these gaps	[39]
	National Biomass Strategy 2020	2011	• To focus on biomass derived from oil palm	[39,41]

3.2.4. Indonesia

The population of Indonesia reached about 266.79 million in 2018 [43] and at an annual growth rate of 5.0% [44] is projected to reach 265 and 306 million in 2020 and 2050, respectively [45]. Also, the consumption of domestic energy has been forecast to triple during the period 2010–2030. Traditional energy production from fossil fuels has failed to keep pace with development and growth. To ensure continuous energy supplies, the government introduced policies to secure energy for the future [45]. Table 4 lists the renewable energy policies available in Indonesia. They place great emphasis on the reduced consumption of non-renewable energy resources, especially oil, and on the increased consumption of renewable resources such as biomass, solar, wind, hydropower and geothermal. Utilization of coal, natural gas and geothermal is being increased in conjunction with reducing the consumption of oil. Thus, energy policies in Indonesia still depend on the consumption of coal and natural gas even though these are depleting and scarce resources.

3.3. Renewable energy development scenario: opportunities and challenges

3.3.1. China

Recently, China launched a major initiative on the utilization and exploitation of non-fossil resources. A number of renewable energy policies have been established in China that give support to

Table 4
Renewable energy policies in Indonesia [46].

Indicator	Policy	Year	Description
6	Green Energy Policy (Ministerial Decree No. 2/2004)	2004	• Discover Indonesia's strength to make the best use of non-fossil energy potential • Create public consciousness on energy efficiency measures
6	Blueprint of National Energy Management	(2005–2025)	• To achieve a target of about 15% of the electricity demand sourced from renewable energy by 2025
6	Presidential Regulation on National Energy Policy (No. 5/2006)	2006	Objectives to be achieved by 2025: • Reduce the consumption of oil to < 20% • Increase the usage of renewables • Enhance energy infrastructure
6	National Energy Policy	2014	• A revised version of *National Energy Policy* 2006 • Aims to: - Rebalance the energy blend towards natural energy supplies - Increase consumption and exploitation of non-fossil energy and coal - Reduce oil consumption - Enhance gas consumption and production • Option of last resort was to consider nuclear energy
	Renewable Energy Purchase Policy	2017	• Regulates electricity purchases from different non-fossil technologies by the nationwide utility • Applies to biomass, solar, hydropower, geothermal, biogas and wind energy

the growth of non-fossil energy use in the economic, industrial and government sectors. The implementation of the policies is generally encouraged via economic means such as financial subsidies, taxation incentives and favourable pricing policies. The most conservative economic encouragement practice is the financial subsidy [47]. There are three main forms of subsidy: investment, user and product subsidies. A direct subsidy to renewable energy programme investors and developers is known as an investment subsidy. The most conventional form of subsidy in China is the user subsidy while the product subsidy is hardly utilized [48].

Currently, the most common method of encouraging the adoption of policy initiatives globally is through the execution of a favourable taxation policy. Unfortunately, this approach is rarely applied in the development of renewable energy in China. Only a few regions take this approach, including a 50% reduction in value added tax (VAT) for the generation of wind energy power, a reduction in VAT tax from 6 to 3% for small hydropower generation companies and exemption from taxation for non-fossil energy power generation parts and equipment imported into China [48]. In addition, local authorities have exempted tax on renewable energy production enterprises. Another form of economic encouragement is the implementation of favourable pricing policies. This is mainly applied to the network power produced with non-fossil energy in order to ensure that there is a favourable electricity price and network access.

Recently, the *State Technical Problem Tackling Plan* was executed by the Chinese government, a plan with high-technology of research and development [49]. By applying this plan, the government is likely to support the utilization of wind energy, photovoltaic power, and solar energy power generation equipment and their parts. Additionally, the government has been giving priority to technical research and development of non-fossil energy sources such as biomass, geothermal, solar, wind and wave power [48].

While some efforts are being focused on improving the development of renewables, a number of challenges are hindering their development. One of the problems is the weakness of innovation and technology in this domain in the country. There is a deficiency in the ability of domestic enterprises to conduct independent R&D and a lack of innovative skills because most non-fossil energy sources are imported from abroad. Also, renewable generation capacity is being wasted due to failures in connections to the electricity grid as well as problems in connecting renewable power to the grid in the first place. This is due to a deficiency in the quality of renewable electricity and a lack of expansion or network building to link the grid to renewable power plants. Another challenge is the low operating efficiency of renewable electricity, which reduces its ability to meet the entire electricity demand. Lastly, the regulations and policies being put in place do not fit with the current status of renewable energy in China. Chinese government departments that are involved in various aspects of the strategies, programmes, policies and management of renewables have proliferated, resulting in the lack of any clear overall plans and insufficient overall coordination [50].

3.3.2. Japan

The establishment of renewable energy policies in Japan has brought about a certain amount of opportunities as well challenges to overcome. The nuclear accident at the Fukushima nuclear plant resulted in the creation of new opportunities for the use of clean and renewable energy. The construction of a few solar plants in Japan is one outcome. In addition, companies that are not even photovoltaic manufacturers have also started to focus on the usage of clean technologies such as renewable energy. Communities and local/municipal governments have also been making plans to deploy non-fossil energy by developing new ways to change the renewable markets from the bottom up. For instance, the installation of 216 solar panels on March 31, 2012 in a small Sanno village with only 42 citizens transformed it into the first settlement in the country to generate its own electricity with the aid of solar energy [51]. Furthermore, plans have been put in place by the central government to give the renewable energy market another opportunity to thrive by de-regulating the non-fossil energy sector. For instance, to overcome issues such as location limitations in a few restricted areas of national parks in 2012, the central government proposed geothermal energy development in such areas. This issue is mainly due to conflict between various laws or regulations [3] and illustrates the competing demands from different sectors that are put on some locations.

Despite the opportunities, there have been a few threats to the renewable energy development in Japan. The Fukushima disaster resulted in the shutdown of the nuclear energy power plant. This created issues like increased electricity prices, as well as the import of fossil fuels, resulting in a trade imbalance and lower energy self-sufficiency. Consequently, Japan resuscitated the nuclear power plant in Ohi town [52] with the introduction of many safety parameters. This supported the growth of non-fossil energy in Japan. Japan, which is dominant in the global energy market, has been

further threatened by competitive countries such as China in the solar module market because the solar panels manufactured in China are half the price of those produced in Japan. Chinese photovoltaic modules are being developed and improved continuously, which has led Japan to encounter huge international competition both globally and domestically [3]. These are the main threats being encountered by Japan in its mission to hasten the growth of renewable energy usage in the country.

3.3.3. Malaysia

The establishment of renewable energy policies in Malaysia has seen many efforts made by the government to develop and promote the use of renewable resources, while also continuing subsidize the price of petroleum products regardless of the global increase in their prices. At the same time, small scale renewable energy programmes are being promoted. Since 2001, the government has offered pioneer status and an investment tax allowance in order to develop the renewable energy sector and has made provisions for subsequent years. The two agencies involved in the implementation of these incentives are the Energy Commission and Malaysia Industrial Development Authority [53]. Due to the increased incentives provided by the government, significant progress was made in renewable energy generation by 2008. To promote renewable energy installations, subsidies targeting non-renewables should have been transferred to renewable energy resources [42].

The policies in Malaysia with respect to renewable energy are not all-inclusive and consistent. Potential investors and the government have differing interests. The government places an emphasis on providing subsidies in order to support its fuel diversity policy, whereas potential investors are keener on giving priority to achieving a satisfactory profit. Thus, the pricing differential between the government and potential investors has resulted in lower investment in renewable energy power projects by developers. The long-term disagreement between fuel suppliers and renewable energy project developers will negatively affect dependency on certain types of fuel [42].

Furthermore, lack of awareness of the advantages of renewable resources and lack of advanced technology for renewable energy generation hinder the development of non-fossil energy [53]. Another factor that is further constraining efforts to promote renewable energy usage of is the high cost of energy generation which includes the final energy costs and investment cost compared to conventional energy. Financial security is also a major issue for renewable energy developers as the Renewable Energy Power Purchase Agreement does not provide a sufficient cash flow for bankers, which leads to reduced confidence among bankers when considering investment [42]. Thus, the Malaysian government needs to make concerted efforts to ensure that sustainable and effective funding mechanisms are put in place to facilitate the growth of renewable energy projects which would then support the sustainable development of the country.

3.3.4. Indonesia

One of the factors that has a major influence on non-fossil energy support in Indonesia relates to multi-level governance. Lack of awareness of national intentions among subnational authorities, together with poor consultation in the process of policy creation among decision-makers both vertically and horizontally leads to misunderstandings about local circumstances among national policy makers [54]. These factors represent key obstacles for the development of renewable energy. When multi-level governance exists, promoting renewable energy becomes much more complicated depending on the specific energy source. Vertical differentiation in line with the decision-making process needs to be added to the horizontal fragmentation of responsibilities concerning energy regulations [55] in order to understand the barriers and potential for renewable energy support in Indonesia. Local authorities and cities are responsible for energy issues such as the provision of licences and permits, project implementation, and renewable energy development and planning due to the process of rapid decentralization (1999–2004) [14]. However, without the support of local governments, specific renewable energy projects cannot be implemented especially when it involves public land acquisition.

3.4. The SWOT analysis of renewable energy policies

China, Japan, Malaysia and Indonesia have attempted to develop their renewable energy capacity through various policies as previously reviewed. Nevertheless, renewable energy still contributes to a fairly small portion of primary energy production in the four countries. The SWOT analysis comparing the strengths, weaknesses, opportunities and threats of promoting renewable energy consumption in all four countries is summarised in Table 5. Implications of the findings from the SWOT analysis are further discussed to identify how the barriers which hinder the development of renewable energy in all four countries can be overcome.

3.4.1. Implications of the SWOT analysis

This study has identified that China, Japan, Malaysia and Indonesia are blessed with abundant of renewable energy resources. All these countries have made good progress in terms of establishing rigid energy policies, yet they lack utilization of renewables within their energy mixes. One of the issues to be taken into consideration is that of multi-level governance, an important factor in highly populated countries like China and Indonesia. Authorities at higher governance levels need to play a bigger role in ensuring efficiency of the management system and need to avoid miscommunications in order to drive forward implementation of renewable energy policies in their country. At the same time, dependence on energy imports should be reduced especially in China, Japan and Malaysia. China and Malaysia have abundant of natural resources to be utilized as a source of energy generation. Also, Japan has to increase its self-sufficiency rate to reduce energy imports. As such, none of the four study countries have utilized or explored the full potential of their renewable energy resources. Lastly, joint development in the form of partnership and multilateral cooperation may result in positive outcomes for the development of renewable energy among these countries, enabling e.g. improved knowledge sharing around technology development. For instance, cooperation between China and Japan can create new opportunities by linking Japan's advanced renewable energy technologies and China's ability to conquer the solar module market. This relationship may develop Japan's ability to expand market share in China while developing the renewable energy technology in China through technology transfer from Japan. Such joint development opportunities can be created between Malaysia and Indonesia which share similar abundant of natural resources including vast areas of palm oil plantations. Joint research to further improve the utilization of palm oil residues, which can contribute to the energy mix [58].

4. Conclusions

In this paper, the East Asian countries of China and Japan and the, Southeast Asian countries of Malaysia and Indonesia were investigated with respect to their energy consumption, energy demand and GHG emissions. Based on the *Statistical Review of World Energy*, Malaysia contributed 6.3% of global CO_2 emissions and Indonesia about 7.6%, whereas China and Japan had reduced

Table 5
Summary of the SWOT analysis of renewable energy policies.

Countries	Internal		External	
	Strengths	Weaknesses	Opportunities	Threats
China	• Highlights the importance of renewable energy • Emphasizes advanced research in biomass, wind and ocean energy	• High dependency on energy imports	• Provides financial subsidies and incentives • Reductions in value added tax and tax exemption for non-fossil energy generation • High-technology of research and development to support utilization of renewables	• Weakness of innovation and technology in renewables • Failures in connecting renewable energy to the electricity grid • Proliferation of departments in the Chinese government
Japan	• Emphasizes energy security and sustainability • Strengthen the FiT system • Diversify the resources to reduce imports	• The introduced FiT scheme succeeded only for the solar system but not for other renewables [56] • Low self-sufficiency rate (6.0% in 2014) [57]	• New opportunities for the use of clean and renewable energy • Geothermal and solar energy development	• Increased electricity prices and importation of fossil fuels • Trade imbalance • Threatened by competitive countries such as China in the solar module market
Malaysia	• Balanced consumption of resources • Emphasizes development of biomass resources that are available in abundance • Promoting renewable energy projects with FiT scheme	• No contribution of biomass observed in the energy mix in 2014 (Fig. 3)	• Promoting small scale renewable energy programmes • Pioneer status and an investment tax allowance • Increased incentives provided by the government	• Subsidies given to conventional fuel sources • Lack of advanced technology • High cost of energy generation • Financial security issue for renewable energy developers
Indonesia	• Emphasizes energy efficiency • Focusses on the development of renewables	• Over exploitation of coal	• Political factors having a positive influence	• Poor consultation among decision-makers • Complications in promoting renewable energy through multi-level governance

their emissions by −0.7 and −1.5% in 2016 compared to 2015. The renewable energy policies of each country were also outlined in relation to their respective energy needs and the requirement to develop renewables as emerging contributors to the energy mix. It was found that, in 2014, non-renewable sources still dominated the energy mix across all four countries, with renewable energy making the smallest contribution to supplies, in descending order, in China, Japan, Indonesia and Malaysia. Efforts are nevertheless being made by the government and other authorities in all four countries to provide subsidies and tax incentives to encourage the development of renewable energy. Nevertheless, all four face their own challenges in achieving this goal and in making progress towards 17 SDGs. It is clear from the SWOT analysis that governments, but also related authorities at lower governance levels, play an important role in ensuring the sustainability of their respective country. Improved multilevel communication and coordination is needed to help better address the slow growth of renewable energy.

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