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Research paper

Knowledge, awareness and understanding of the practice and support policies on renewable energy: Exploring the perspectives of in-service teachers and polytechnics lecturers

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ABSTRACT

Energy plays a significant and essential role in developing a nation's economy and social growth. However, the decreasing use of oil, gas and coal as energy sources has persuaded the government to develop sources of renewable energy (RE). Although many studies had examine the public perceptions of renewable energy, little information was obtained from teachers and polytechnic lecturers on their awareness, conceptions and knowledge of government's policies on renewable energy, even though they play major roles in disseminating knowledge and awareness of RE to the public. To unpack the contribution of research into renewable energy, this study aims to examine the knowledge and awareness of government policy implementation and support for RE based on the responses from in-service science teachers and polytechnic lecturers. A survey of the feedback from 117 science teachers and 90 polytechnic lecturers currently in service was undertaken. Findings revealed that both groups have good and positive awareness, sufficient knowledge of RE and an in-depth understanding of government policies on supporting and implementing RE. Finally, differences linked to gender and teaching experience while teaching RE within their educational institutions were not significant.

1. Introduction

Energy plays a significant and essential role in developing a nation's economy and social growth (Zakaria et al., 2019). Thus, governments around the world are decreasingly reliant on the remaining fossil fuel sources of energy and are concentrating on the deployment of low-carbon energy sources to reduce carbon emissions into the environment, specifically renewable energy sources (Devine-Wright, 2011a,b). The mass change-over to the use of renewable energy is motivated by two main factors: concerns over energy security and the scarcity and increasingly expensive supplies of fossil fuels (Devine-Wright, 2011a,b). By definition, renewable energy is a naturally replaceable and sustainable energy source which can be reused over and over again (Celikler, 2013). It is also able to decrease and possibly solve the global warming issue (Ahmad et al., 2014). A few examples of natural renewable energy resources are solar, wind, biomass, geothermal, wave and falling-water energy (Daugherty and Carter, 2010). In discussing the advantages and benefits of renewable energy, Morgil et al. (2006) postulated that renewable energy is sustainable, cleaner, safer, non-poisonous and non-polluting to the environment. In Malaysia, previous researchers on renewable energy (Ahmad et al., 2011; Hosseini and Abdul Wahid, 2014) claimed that Malaysia is blessed with an abundance of various sources of natural energy, such as hydro, wind, solar, geothermal and tidal wave, which are, sadly, under-utilised. Hence, because of the depletion of energy from fossil fuels, in 2010 the Malaysian government introduced the National Renewable Energy Policy (NREP) which aims to improve the use of RE resources. The NREP policy listed five major elements: (a) raising the contribution of RE, (b) preparing suitable facilities for RE industry development, (c) studying the cost of various renewable energy sources (RES), (d) protecting the environment for the future and (e) increasing awareness of the importance of RES (Hosseini and Abdul Wahid, 2014).

In order to provide awareness and knowledge related to renewable energy, the role of education institutions is considered crucial even though it faces challenges as listed by Açıkgöz (2011): (a) limited studies related to public opinions about renewable energy and (b) renewable energy not being treated as a separate discipline until it was acknowledged as a new area

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rather than as a topic within technical and engineering studies. In this sense, it is believed that renewable energy should be taught as early as the primary school level to provide initial knowledge, awareness and values to all primary students (Kandpal and Grarg, 1998) as an introduction to studies within higher institutions of learning including technical colleges and universities. Several researchers (Celikler, 2013; Kandar and Rahman, 2005; Guven and Sulun, 2017; Shamsudin et al., 2014; UNCED, 1992; Kandpal and Broman, 2014) have pointed to the significant role of education in understanding renewable energy and providing and nurturing knowledge, creating values and enhancing public and community awareness.

In providing understanding and educating students and society about RE, the role of educators was seen as essential and unique in creating awareness, promoting, clarifying the occurred phenomena and building positive attitudes among community members concerning the development of renewable energy (Ocetkiewicz et al., 2017). In addition, teachers and educators are able to influence the process of changing the behaviour of students, the public and communities to develop increasingly optimistic attitudes and values about the use of renewable energy in their daily lives (Ocetkiewicz et al., 2017). Thus, the role of educators, teachers and academic institutions, such as schools, colleges and universities, in creating community awareness and providing a greater understanding of the knowledge, skills and values concerning renewable energy is highly acknowledged. In addition, they are regarded as the key agent in creating public awareness and overcoming obstacles related to renewable energy implementation and policy (Kandar and Rahman, 2005).

Admittedly, there is plentiful research investigating public attitudes, opinions and acceptance of renewable energy usage within various sectors, mostly involving university students (Scherhaufer et al., 2017; Tabi and Wustenhagen, 2017; Karasmanaki and Tsantopoulos, 2019; Karetepe et al., 2012; Ahamad and Ariffin, 2018; Fah et al., 2012; Shamsudin et al., 2014; Kardooni et al., 2018; Celikler and Aksan, 2016; Alawin et al., 2016). However, a limited number of previous studies have examined the awareness, knowledge and attitudes to renewable energy of teachers (Liarakou et al., 2009; Zyadin et al., 2014) and preservice teachers (Guven and Sulun, 2017; Halderm et al., 2014). However, studies on senior citizen's perceptions of renewable energy are rare (Zakaria et al., 2019). Thus, the issue of providing educators with knowledge and improving their role becomes increasingly critical and of the utmost importance in increasing public understanding and awareness of renewable energy.

These issues make it essential to investigate the knowledge and perceptions of teachers and polytechnic lecturers, especially since they were believed to be partially involved with the implementation of renewable energy within the context of schools and technical higher education, including the public universities and polytechnics. Thus, they have a major and significant role in influencing, creating awareness and instilling values about renewable energy to students and the public.

Hence, this study aims to explore the issue through the perspective of teachers and technical college educators by eliciting their views on their knowledge, awareness and support for the implementation of renewable energy locally. In this paper, we examine explicitly the views on RE of in-service science teachers and polytechnic lecturers based on the following research areas: (1) to explore the knowledge of RE perceived by in-service science teachers and polytechnic educators, (2) to examine in-service science teachers' and polytechnic educators' awareness towards RE, (3) to investigate in-service science teachers' and polytechnic educators' understanding of government policies on the support and implementation of RE and (4) to examine the significant demographic differences of in-service science teachers and polytechnic lecturers towards their awareness, knowledge and understanding of government policies for provided support for the implementation of RE. Thus, this study provides an essential understanding of, and information on, the implementation of RE as seen by two groups of who are responsible for educating students and the public about the concept of renewable energy and the resources involved (Açıkgöz, 2011).

Specifically, the objectives of renewable energy from the educational perspective are to: (a) create awareness among the public and students, (b) identify renewable and non-renewable sources of energy, (c) enhance motivation for creating strategies to overcome challenges and, lastly, (d) provide values and positive attitudes on renewable energy (Kandpal and Broman, 2014). Based on the abovementioned statements, the in-service teachers and polytechnic lecturers in this study are individuals that play a crucial long-term role in disseminating knowledge and creating awareness of renewable energy to prospective students. These educators are also expected to have in-depth knowledge, first-hand exposure and awareness related to renewable energy which will determine students' positive attitudes, knowledge and awareness about the use of renewable energy. Indeed, UNCED (1992) identifies them as influential individuals with the capability to create awareness related to the usage of renewable energy. Thus, educators are seen as the most influential figures and life-changing role models who can influence future manpower to adopt positive attitudes towards the concept and awareness of renewable energy. As it is so important for the public at large to have a deeper global awareness of renewable energy, the educators are expected to have prior knowledge of new information about the technology. Therefore, their knowledge, awareness and understanding of government policies which support and implement renewable energy are considered essential in determining public understanding of renewable energy. The findings of this study should pave the way for more studies to be conducted of the public perceptions and critical awareness of their environments and government policies and how they can support the public's knowledge and confidence in the use of renewable energy.

2. Literature review

2.1. Recent development on RE

In Malaysia, renewable energy is much improved based on the support provided by the government. Thus, various policies have been introduced to support the strategies for the implementation of RE for future generations. These policies include: (i) the Malaysian National Renewable Energy Policy, (ii) the Renewable Energy Act 2011, and (iii) the Sustainable Energy Development Authority Act 2011 (Vaka et al., 2020).

In Malaysia, renewable energy development has been emphasised and mentioned within Malaysia Plans. Fig. 1 below lists the targets set by the Malaysian Government for RE development. Based on Fig. 1, the Government of Malaysia has targeted RE development which started in the 2011 (20 for biogas, 110 for biomass, 20 for solid waste, 60 for small hydro, 9 for solar PV, total: 219). In 2020, the government expected an increase (240 for biogas, 800 for biomass, 360 for solid wastes, 490 for small hydro, 190 for solar PV) which totalled to 2080. In 2030, the government has determined the target amounts of 410 for biogas, 1340 for biomass, 390 solid waste, 490 for small hydro, and 1,370 for solar PV with a total of 4000 projects (Tenaga Nasional Berhad, 2015) (see Fig. 2).

According to Energy Commission of Malaysia (2019a,b), Malaysia is considered as a country which is rich with natural resources which has the capacity in creating and generating RE

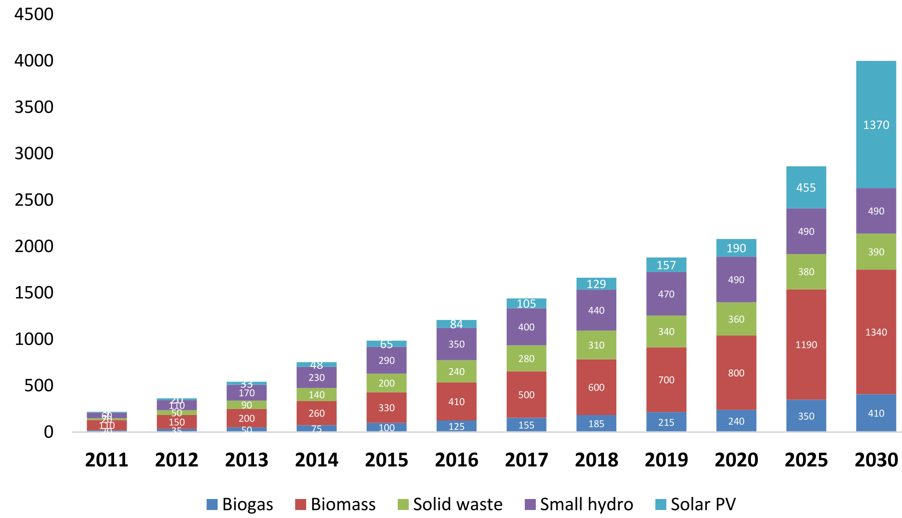

Fig. 1. Renewable energy capacity target.

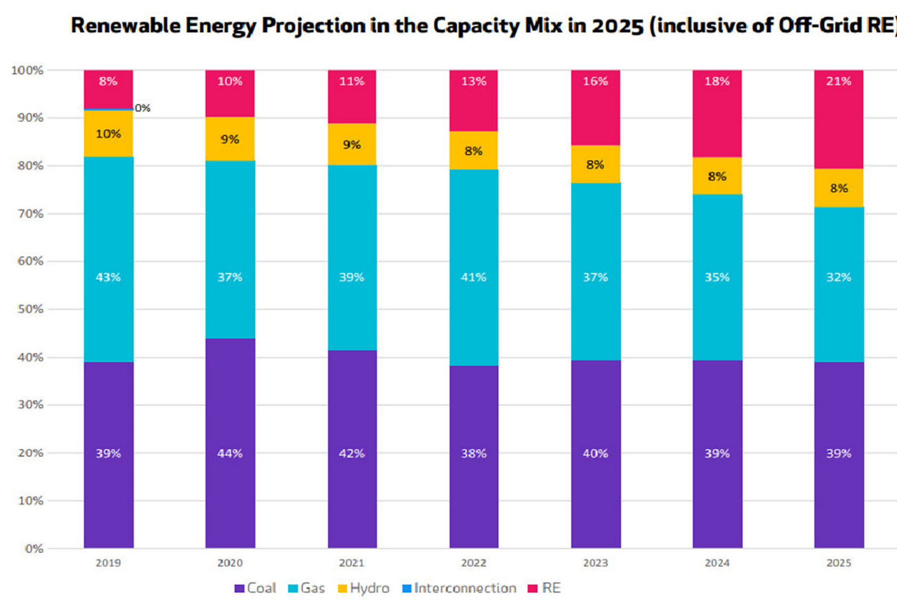

Fig. 2. RE projection in the capacity mix in 2025.
Source: Energy Malaysia, 2019.

in Malaysia. At the moment, Malaysia has about 2 per cent which provide the government in targeting an increase of 20 per cent by the year 2025. By the year 2020, RE resources derived from 44 per cent from coal, 37 per cent from gas, 9 per cent from hydro and 11 per cent are from other RE. Thus, the government predicts by the year 2025, RE resources are 39 per cent from coal, 32 per cent from gas, 8 per cent from hydro and an increase of 21 per cent from other RE sources. In Fig. 3, there is an increase of energy usage from natural gas, coal, biodiesel and electricity together with the employment of petroleum (Energy Commission of Malaysia, 2019a,b).

In 2020, the Sustainable Energy Development Authority (SEDA) Malaysia, which is an agency under the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), continues to facilitate, promote, and develop a cohesive way forward for the growth of sustainable energy (SE) in the form of renewable energy (RE) and energy efficiency in Malaysia. Until November 2019, a total of cumulative Net Energy Metering (NEM) Programme quota of 108 MW had been approved by SEDA. Ultimately, it portrays a growth of 7.8 times increment compared with the previous three years, which only stood at a 13.86 MW take-up rate. This success is contributed to the newly improved NEM 2.0 Programme (SEDA, 2020).

Initially, the Government of Malaysia has estimated 57 per cent of energy generation are from coal, 35 per cent from gas, and 4 per cent each from other RE sources and hydroelectric energy. Later in the year 2020, the government estimated 57 per cent source of RE related to coal, 34 per cent from gas, and 4 per cent each from other RE sources and hydro. Only 1 per cent was estimated by the government to be solar energy. The Government of Malaysia has predicted that by 2026, almost 56 per cent of RE is estimated to be from coal with another 32 per cent from gas. Another 5 per cent is from hydroelectric, 4 per cent from other sources of RE, and another 3 per cent from the interconnection between other sources of RE. In 2020, the government predicted only 1 per cent of solar energy to contribute towards the whole RE sources in Malaysia. By 2025, the government predicted that the solar resource will contribute 1 per cent of RE source (SEDA, 2020).

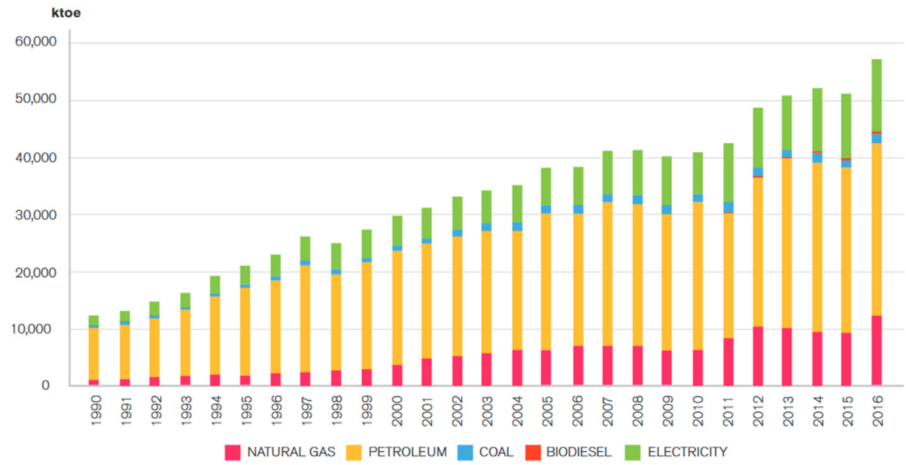

Fig. 3. Energy consumption by fuel until 2018.
Source: Energy Malaysia, 2019.

In addition, the Government of Malaysia also has introduced the Net Energy Metering Scheme which was started in November 2016 with 500 MW quota until 2020 to encourage Malaysians to uptake the RE initiative. The NEM Scheme is executed by the Ministry of Energy and Natural Resources (KeTSA) and regulated by the Energy Commission (EC), with the Sustainable Energy Development Authority (SEDA) Malaysia as the Implementing Agency (IA). The 500 MW quota under NEM 2.0 has been fully subscribed by 31 December 2020. The concept of NEM is that the energy produced from solar PV installation will be consumed first, and any excess will be exported to TNB at prevailing displaced cost. In Fig. 4, the cumulative NEM quota approved from 2016 to 2019 showed an increase from 2016 to 2019. In 2016, 0.01 MW was approved, followed by 2.33 MW in 2017. In 2018, the amount increased to 11.53 MW and lastly in 2019, a total of 94.14 MW was approved. Based on that amount, 7.67 MW was allocated for domestic purposes and 0.13 MW for agricultural purposes, followed by 25.18 MW for commercial purposes and 75.01 MW for industrial purposes (SEDA, 2020).

In terms of Fit-In-Tariff (FiT), it has been successful in supporting the RE implementation in Malaysia over the past eight years. In November 2019, there is a total of 10,269 FiT applications with a total installed RE capacity of 614.93 MW in Malaysia. In 29 December 2020, the ministry launched NEM 3.0 to provide more opportunities for electricity consumers to install solar PV systems on the roofs of their premises to save on their electricity bill. NEM 3.0 will be in effect from 2021 to 2023 and the total quota allocation is up to 500 MW (SEDA, 2020; Tenaga Nasional Berhad, 2015).

Another source for energy generation is biogas. Based on findings by previous researchers (Wan Abdullah et al., 2019; Gopinathan et al., 2018) in Table 1, the production of biogas is mostly contributed by palm oil mill effluent (POME). The wastes of organic materials such as POME and livestock are processed to produce biogas, which is also another source of electricity (Izzah et al., 2019; Siddique and Wahid, 2018). The large POME contribution to the development of biogas is because of huge numbers of palm oil estates and plantations in Malaysia and thus, this RE has a potential market in Malaysia (Wan Abdullah et al., 2019). Another source of biogas in Malaysia is from food waste and sewage, which are known as municipal solid waste (MSW) (Loh, 2017). Statistically, almost 40 per cent of the MSW in Malaysia are derived from food waste, and the government is also targeting another 40 per cent of waste from landfill until 2020 (Wan Abdullah et al., 2019). Later, biogas will be transformed into other sources of energy such as heat, and bio methane (Wan Abdullah et al., 2019).

Recently, Malaysian government also took the initiatives of introducing the EV charging station for electric cars energy consumptions. The total numbers of charging EV public stations in Malaysia are 330 stations with public charging EV stations are about 227 locations in Malaysia. Based on the data by the Energy Commission of Malaysia, there are 172, 859 charging sessions with 935 electricity that being charged. Based on CO^2 that being avoided, a total of 1,190,17 of C02 being avoided per 3 kilogrammes with estimated electric ranged are about 6,321,27 per 3 kilometres (Energy Commission of Malaysia, 2017).

In addition, there are initiatives to provide knowledge on RE education to school students in Malaysia. Through the competition organised by the Energy Commission of Malaysia, secondary schools' students were encouraged to participate in the Energy Efficiency Challenge to inculcate a culture that practice energy efficient among secondary schools' students which officially launched in 2014. Through the challenge, the school's community which includes students, teachers and their principals worked as a team to reduce the energy consumption and adopting the energy efficiency practices for six months (Energy Commission of Malaysia, 2020).

2.2. Challenges within Malaysia RE

Although RE is perceived as an important source of energy to replace fossil fuels in the future, there are some challenges, issues and barriers to its deployment in Malaysia with previous studies pointing out the difficulty in providing funding and incentives (Vaka et al., 2020; Alam et al., 2016; Mustapa et al., 2010), the lack of awareness among key decision makers (Oh et al., 2010), the higher cost of maintaining RE resources (Fernando and Yahya, 2015; Alam et al., 2016; Solangi et al., 2015), the limited local expertise in maintaining RE projects (Fernando and Yahya, 2015), the lack of information related to RE benefits (Mustapa et al., 2010) and the lack of awareness among residents (Teoh et al., 2020), unfavourable energy sector policies and a lack of social acceptance (Alam et al., 2016).

Fernando and Yahya (2015) studied the challenges related to RE implementation. They divided the challenges into two categories: the internal and the external barriers. Internally, seven barriers were listed as reasons for the slow implementation of RE. First, RE projects are considered to be unprofitable in the short term with a lack of incentives being provided and unclear RE policies. Second, there are few records of successful firms.

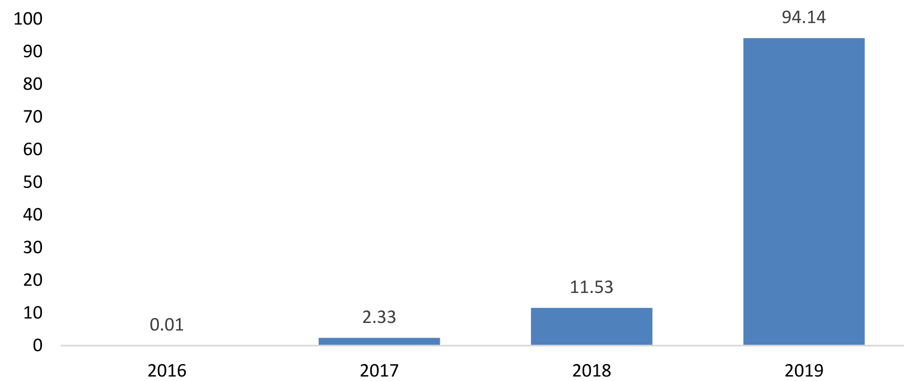

Fig. 4. NEM quota approval amount by government.

Table 1
Potential biogas sources.
Source: Gopinathan et al. (2018) cited with permission.

	Cattle Livestock	POME	Land Fill	
Region	Potential energy generation (MWh)	Potential energy generation (MWh)	Potential energy generation (MWh)	Total potential energy generation (MWh)
South	646	887,602	994	889,242
North	413	545,441	1,081	546,523
East	474	822,830	669	823,973
Centre	118	119,610	1,517	121,299
Total	1650	2,375,484	4262	2381,038

Third, the high cost of maintenance for RE projects, the high financial risks and an inability to maximise profits. Fourth, there is a lack of knowledge among employees and local staff about the maintenance of RE projects. Fifth, the high cost and low profitability of building RE infrastructure, e.g. the lack of sufficient green infrastructure to support the installation of RE electricity generation. Sixth, the lack of available technology and, seventh, the issue of bureaucracy which requires central endorsement for any RE implementation.

Externally, there are three major challenges related to RE implementation: First, limited research and design activities to support RE investment. Second, the supplier involvement issue in which the, mostly foreign, suppliers are reluctant to share knowledge with local firms when technical problems occur. Third, the lack of social pressure from consumers and non-government organisations (NGOs) to install RE projects (Fernando and Yahya, 2015).

In Malaysia, solar energy has emerged as an essential source of renewable energy to generate electricity, heating and for water desalination (Vaka et al., 2020) due to high levels of solar radiation (Florez and Ghazali, 2020) with 4,500kWh/m^2 throughout the year (Teoh et al., 2020). Despite initiatives to use solar in Malaysian industries, come challenges have arisen which slowed its progress [1] the issue of lack of awareness of the financial returns among the Malaysian public and business community, [2] the difficulty of obtaining and processing loans and the high interest rates arising from an apparent lack of awareness among Malaysian bankers (SEDA, 2020), [3] the high cost of installation and maintenance of solar PV systems prevent residents from installing PV systems (Florez and Ghazali, 2020; Teoh et al., 2020). There is also a lack of knowledge and awareness among Malaysian residents related to both the advantages of installing solar panels and their value as a long-term investment (Teoh et al., 2020). Another barrier for solar systems is the lack of suppliers to install and maintain them due to the high cost of importing the solar components (Florez and Ghazali, 2020). In addition, Malaysian residents seem unaware of the financial incentives provided by the government and the FiT (Florez and Ghazali, 2020). By definition, FiT is being implemented under the RE's policy and action plan to catalyse generation of RE which have maximum of 30MW in size which introduced by the Energy Commission of Malaysia. Through FiT's mechanism, it allows electricity produced from RE resources to be sold to generate utilities at a fixed price (Energy Commission of Malaysia, 2020).

As for biogas, the financial issue remains a significant barrier since the investment cost in equipping the infrastructure of a biogas plant together with electricity generation facilities is considered to be high and costly compared to the current practice of waste treatment (Kumaran et al., 2016). In addition, the lack of participation from Malaysian local banks to finance the loan applications for RE projects has resulted from a lack of awareness and knowledge among local investors and bankers (Olz and Beerepoot, 2010). Another challenge related to the biogas industry is the unavailability of local technology and accessibility to grid connection for biogas power plants. Most of the biogas technologies and equipment are imported from Germany (Chin et al., 2013). The last barrier is the lack of skilled local manpower to control and preserve an anaerobic digestion plant (Kumaran et al., 2016).

2.3. Renewable energy in education

In creating public perceptions, awareness and knowledge of the concept of renewable energy, the role of teachers was considered to be an effective and pertinent catalyst (Zyadin et al., 2014) since the role of teachers is seen as essential for disseminating knowledge and teaching students about the concept, values and benefits of renewable energy for society and the environment (Zyadin et al., 2014; Halderm et al., 2014). Thus, teachers and educators play a significant role in providing knowledge of environmental education efforts and in developing society's literacy related to environmental issues for future generations (WCED, 1987). Indeed, previous studies have pointed out and analysed teachers' conceptualisations, knowledge and awareness of environmental issues related to the employment of renewable energy as a means of decreasing carbon emissions (Liarakou et al., 2009;

Halderm et al., 2014). Despite the importance of teachers and educators in disseminating knowledge of renewable energy, it has been found that they have little knowledge of the concept of renewable energy as a means of promoting environmental education (Knapp, 2000).

In recent years, there have been voluminous studies from the secondary and primary levels of education in examining teachers and educators' knowledge related to renewable energy concepts, especially in Jordanian, Greek and Turkish schools. However, related studies in Malaysian schools or higher learning institutions are still lacking. Although in recent years a growing number of studies have analysed secondary school students' knowledge, perceptions and attitudes related to bioenergy and renewable energy concepts, to date, there have not been many studies of educators' and teachers' awareness and knowledge of renewable energy technologies although Liarakou et al. (2009) conducted a study on Greek teachers' attitudes and knowledge regarding the concept of renewable energy resources. Based on this research, it was found that teachers have ample knowledge of energy resources related to renewable concepts, especially for wind and solar energy technologies. In 2014, Zyadin et al. studied Jordanian school teachers' knowledge of renewable energy technologies and found that they have little information and knowledge of the concept of renewable energy. However, there was a focus on the concept of bioenergy sources. In Turkey, Celikler (2013) also conducted a study with a sample of pre-service teachers within their third year which revealed that they have higher awareness and knowledge of renewable energy compared to their counterparts in their first and second years. The reason why seniors have greater knowledge of the concept of renewable energy is that they were asked to enrol on a course on renewable energy technologies during their senior year. Later, in 2014, Halderm et al. conducted a similar study which investigated teachers' knowledge and perceptions related to the employment of bioenergy in Indian schools. The study found that Indian school teachers had a fair knowledge regarding bioenergy and had positive perceptions of bioenergy usage and were keen to receive more information and knowledge on bioenergy. Recently, Guven and Sulun (2017) also explored the awareness and knowledge of 196 pre-service teachers in a public university in Turkey on the concept of renewable energy. The study found that pre-service teachers within the elementary science department have a much higher awareness of the concept of renewable energy compared to their colleagues from the social sciences and early childhood education programmes. Nevertheless, their awareness related to the concept of renewable energy was found not to be significantly different. In addition, the study also indicated that there is a correlation between pre-service teachers' knowledge and their level of awareness of renewable energy.

Additionally, in discussing the importance of renewable energy to society, technical and vocational education plays a significant role in renewable energy technologies. Citing various definitions, technical vocational education and training (TVET) is legitimately defined as training to become a skilful and knowledgeable individual with good employability and career or job prospects (Tripney and Hombrados, 2013). In the context of UNESCO (2004), technical, vocational education and training is defined as aspects of the educational process involving, in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes and knowledge relating to occupations in various sectors of economic life. It incorporates: technical education, vocational education, vocational training, on-the-job training and apprenticeship training (or any combination thereof). In linking renewable energy with technical and vocational education, Kacan (2015) claims that it is important to create awareness among those in technical and vocational roles related to renewable energy, especially the use of renewable energy in industrial contexts, based on the issues highlighted by Jennings (2009) that most engineers are unaware of, and had received little training on, the concept of renewable energy technologies and sustainability principles. Aligned with the above statement, a study in Jordan with students in faculties of engineering by Alawin et al. (2016) also revealed both a lack of awareness and shallow knowledge and information related to renewable energy technologies. This is in line with a research gap concerning the challenges related to the awareness and understanding of renewable energy in technical and vocational institutions. Thus, it is wise to provide some exposure to courses that prepare engineers and technical and vocational experts to produce sustainable energy generation systems. Therefore, based on the above premise, one of objectives of this study is to ensure that educators at technical and vocational institutions have some knowledge and awareness related to renewable energy technologies. This underlines the work of Kacan (2015) who claims that there is still a lack of studies related to the knowledge and awareness of renewable energy concepts and technologies in vocational and technical institutions in developing and developed countries. To date, in Malaysia, there is a dearth of studies that explore renewable energy awareness and knowledge in schools and technical and vocational institutions.

There are abundant studies that measure the awareness of students (Altuntaş and Turan, 2018; Alawin et al., 2016; Assali et al., 2019; Karasmanaki and Tsantopoulos, 2019; Ahamad and Ariffin, 2018), pre-service teachers (Guven and Sulun, 2017; Celikler, 2013) and in-service teachers (Kacan, 2015; Halderm et al., 2014; Liarakou et al., 2009; Zyadin et al., 2014). Nevertheless, there are only limited studies that examined the public's awareness and understanding of policy on renewable energy support and implementation, especially within context of Malaysia. In this sense, Zakaria et al. (2019) made an attempt to investigate the perceptions of the public towards government initiatives and efforts in creating awareness, transferring of knowledge and the importance of renewable energy for better sustainability of energy supplies in the future. From these studies, there are some notable facts concerning public perceptions of renewable energy: (a) the public has wide knowledge and is well-versed in the concept and awareness of renewable energy, especially on the usage of natural energy such as solar and water RE. However, wind energy, biomass and geothermal sources of energy were listed as the non-familiar sources of energy among the public. Also, the public was seen as being ready to implement and use renewable energy within their everyday life routines to help create a sustainable nation. (b) Most of the public have little knowledge of the government's efforts, policies and initiatives on renewable energy, except for government officers and private sector workers who had been highly exposed to the renewable energy projects.

In measuring public perceptions of renewable energy, there are significant reasons to examine their demographics which are strongly related to their perceptions (Karasmanaki and Tsantopoulos, 2019), particularly with participant's gender and teaching experience. In terms of gender, admittedly, there are various findings which are conflicting whether there is a relationship or significant difference between participants' gender and their perceptions on renewable energy. There are studies that found the gender of participants to be unrelated to their perceptions on renewable energy (Pataria et al., 2017; Celikler, 2013; Karytsas, 2014; Assali et al., 2019). For instance, Celikler (2013) concluded that there was no statistically significant meaningful difference in terms of pre-service teachers in Turkey related to their awareness of RE. In addition, Assali et al. (2019) who conducted a study with Palestinian youths also revealed that there is no significant difference among Palestinian students in terms of their knowledge based on their gender, educational level and their parental level of education. However, other previous studies pointed to significant differences related to gender such as studies by Karetepe et al. (2012), Zyadin et al. (2014) and Altuntaş and Turan (2018). From these studies, there are notable statistically significant differences between male and female students related to their opinions on the use of geothermal energy. Based on the findings, it was concluded that in Turkey female students have much greater awareness on renewable energy compared to male students. The same findings also appeared within Zyadin et al. (2014) with Jordanian teachers on their knowledge, awareness, perceptions and attitudes towards renewable energy. From their study, it was summarised that male teachers have more knowledge on renewable energy compared to female teachers who held stronger positive attitudes on renewable energy. In fact, female teachers were indicated to have a tendency to be strongly inclined towards saving energy. In a study conducted by Altuntaş and Turan (2018), it was revealed that there are significant differences on students' demographics towards the information and awareness of renewable energy sources.

Based on their knowledge and awareness of renewable energy, the findings from various previous studies described pre-service teachers' knowledge and awareness; for instance, Guven and Sulun (2017) proved that the awareness and knowledge of the concept of renewable energy by 196 pre-service teachers in a public university in Turkey were higher than those of their colleagues from the social sciences and early childhood education programmes. Similar findings were reported by Liarakou et al. (2009) in a study of Greek schools in which teachers demonstrated high levels of knowledge of energy resources related to renewable concepts, especially for wind and solar energy technologies. Nevertheless, a few studies produced contradictory results on teachers' knowledge and awareness of RE. For example, Halderm et al. (2014) reported that Indian school teachers had a fair knowledge regarding bioenergy and positive perceptions of bioenergy usage. The same finding was revealed by Alawin et al. (2016) who revealed a lack of awareness and also shallow knowledge and information related to renewable energy technologies among Jordanian students in faculties of engineering. Similarly, Zyadin et al. (2014) pointed to Jordanian teachers' lack of information and knowledge of the concept of renewable energy and the technologies involved.

Based on the literature search and review, most of the studies outlined above reported on pre-service teachers' and students' perceptions, awareness and knowledge related to renewable energy. However, their knowledge of government policy relevant to RE invites further innovative studies to be investigated. First, not many studies have been conducted on the knowledge, awareness and understanding of government policy related to the support and implementation of renewable energy. Second, most of the existing studies revolve around the measurement of significant differences based on teachers and lecturers' years of teaching experience while other previous studies focused on differentiating students' years of study. Third, there are limited numbers of studies that investigate the awareness, knowledge and understanding of government policy on supporting and implementing renewable energy with technical and vocational educators involved in teaching polytechnic/technical-based students about renewable energy. These three points are elements that differentiate this study from previous similar research involving in-service science teachers and polytechnic lecturers' knowledge, awareness, and understanding of government policy to support and implement renewable energy. The significant reason as to why these in-service science teachers and polytechnic lecturers were chosen as the sample for this study is because they are the essential individuals that facilitate the public and future students' understanding of renewable energy and who heighten their awareness of the issue.

2.4. Theoretical background

As its theoretical underpinning, this study uses the Theory Acceptance Model (TAM) introduced by Davis in 1986 as in Fig. 5. The TAM theory is influential and most commonly applicable when researchers are examining individual or user acceptance behaviours (Lee et al., 2003; Ma and Liu, 2004). According to the theory, individual beliefs have a strong influence on attitudes, intentions and generated behaviour. Although TAM was introduced to explain the use of technology in organisations, it was generally accepted and examined in various disciplines including renewable energy (Malik and Ayop, 2020).

According to Davis (1989), in examining individual acceptance, two major variables are used as cognitive beliefs that determine the acceptance: Perceived Usefulness (PU) and Perceived Ease of Use (PEU) (Davis et al., 1989). First, PU was conceptualised as an initial phase in which any user or individual trusts a technology and then later comes to believe that using the technology will enhance their performance. Second, PEU was defined as the current and future usage of the technology (Ma and Liu, 2004). Based on Fig. 5, both variables, the PEU and PU, are influenced by a variable which is later perceived and evaluated based on its usefulness. Next, PEU and PU influence an individual's attitude to using the technology. Further, the perceived attitudes towards the technology usage will become associated with an individual's intention to use the technology. According to Davis et al. (1989), how individuals perceived the usage and benefits of technology will influence their intention of using the technology and *vice versa*. Lastly, an individual's intention will impact on their actual usage of technology. Accordingly, Hamed (2018) perceived that TAM is a causal model that illustrates how an individual perceived the usefulness of the adopted technology which later affected their belief through the two elements of attitude and intention, and which later influenced their acceptance of the technology.

3. Methodology

3.1. Participants

In this study, specific sampling was chosen to provide feedback on the participants' awareness, knowledge and understanding of the policy implementation and support received related to RE. The educators that were selected are those who are teaching subjects related to RE. Thus, the in-service science teachers who participated are secondary in-service science teachers at the upper secondary level. As for polytechnic educators, those who are selected are lecturers involved in RE-related teaching and projects. Thus, the use of purposive sampling was chosen since not all teachers and polytechnic lecturers are involved in teaching, research and projects concerning RE. However, the use of purposive sampling prevents the findings being generalised to the whole population of Malaysia (Malik and Ayop, 2020).

Before proceeding with the questionnaire distribution, the department of education in Johore and Malacca states and two polytechnics were visited to obtain permission. After permission was granted, 300 questionnaires were distributed to in-service science teachers and polytechnic educators in nine secondary schools and two polytechnics in the two states of which 207 questionnaires [69%] were returned.

In terms of their level of income, both teachers and lecturers received a standard payment based on their public service grades which are mostly grades 44 and 41. Their payments are standardised based on their public service grade in Malaysia. The participating in-service science teachers and polytechnic lecturers have studied the concept of RE within their undergraduate courses but did not receive specific training on RE.

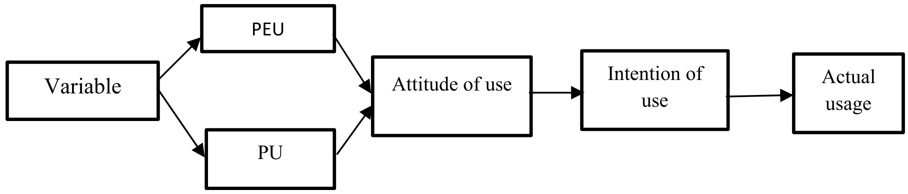

Fig. 5. Technology Acceptance Model (TAM).

3.2. Instrumentation

This study is an effort to provide a broader research into educators' perceptions of RE related to their awareness, knowledge and understanding of the government's policies on RE support and implementation. A closed questionnaire with 27 items comprising four constructs related to the knowledge, awareness, implementation and support for renewable energy concepts was used. Attached with the 27 items on renewable energy were three items investigating demographic factors such as participants' gender, areas of study and role as serving or pre-service teachers or polytechnic educators. All respondents were asked to give their reactions to the 27 items using a five-point Likert scale: 1 – strongly disagree to 5 – strongly agree. In measuring the knowledge construct, eight items were used to examine respondents' knowledge of the renewable energy concept while four items were constructed to represent the awareness constructs on renewable energy. A total of eight items were used to measure the awareness of the implementation of renewable energy in Malaysia followed by seven items to examine the supporting elements on renewable energy in Malaysian contexts, whether at schools, higher learning institutions or through government efforts. The types of renewable energy mentioned in this study were solar, wind, water and thermal energies, which are being emphasised within Malaysia's renewable energy policy.

The questionnaire items related to the RE knowledge construct incorporated **two** themes: the basic information on RE and the benefits of RE within the Malaysian context. The reason for including these items was to obtain information about polytechnic lecturers and teachers' basic knowledge of RE and the benefits of having RE in Malaysia since educators who are well-trained in their own major expertise had only taken RE as one of the subjects studied. In the awareness construct, two themes were used to develop the RE awareness items: information about RE and the potential of RE in the Malaysian context. For the section investigating policy implementation, there were three major themes: research on RE, RE learning and information on RE. The last section in the questionnaire comprised items on support for RE. In this section, items were developed based on major themes such as financial support, incentives for RE, and research support in order to obtain educators' knowledge related to government support for, and implementation of, RE-related research and incentives and RE practice in learning institutions. Some of the items are adopted from previous research into renewable energy such as Alawin et al. (2016), Karetepe et al. (2012), Celikler (2013) and Guven and Sulun (2017) all of whom measured the knowledge and awareness of their samples from various educational systems.

All items were in the Malay language which shows that the respondents were within primary, secondary and technical institutions within the Malaysian educational system. All items had undergone a rigorous translation process that involved the forward and backward process of translation (Sperber et al., 1994) by two translators. A Malay language expert and several teachers were approached in order to ensure the precision of the Malay language items including the sentence structure, meaning and the measurement of grammatical elements. Items were also translated into the English language using a backward approach with the help of language experts. Before proceeding with the pilot study, items were checked by a small sample of assigned teachers to determine the precision of the meaning, sentence structure and the relevance of the items to the Malaysian educational system.

Before proceeding with the actual data collection, all items were piloted to ten selected in-service science teachers and another 15 selected public-polytechnic-based lecturers. All 25 in-service science teachers and polytechnic educators were eliminated from the actual sample for data collection. The vital reasons for conducting a pilot study are to obtain the construct validity and reliability of all the items (Celikler and Aksan, 2016). Secondly, through a pilot study, some reliable processes were implemented such as the inversion process for negative impression items and detecting the lost values. The reliability value was measured at 0.846 based on the *Cronbach*'s alpha value for the pilot study data from 25 in-service science teachers and polytechnic lecturers.

3.3. Data analysis

All data are presented as a descriptive analysis which comprised means, standard deviations and percentages. In determining the level of knowledge, awareness, support and implementation, all mean scores for each item that represented the constructs were totalled and were later divided by the number of items within each construct to obtain the mean scores for each construct. In measuring the differences within the four constructs of knowledge, awareness, implementation and support, an inferential t-test was applied to the gender of the respondents. In addition, the One-way Analysis of Variance (ANOVA) test was used to analyse the four constructs based on the respondents' area of study and role i.e. whether as in-service teachers or polytechnic lecturers. Both the t-test and ANOVA are inferential tests that examine the significant differences based on a sample's demographic variables.

4. Findings

4.1. Participants' demographics

The intention of this study is to obtain the perceptions of science teachers and polytechnic lecturers who regularly teach the concept of renewable energy within their educational institutions. In measuring these perceptions, we asked about the following essential elements that relate to renewable energy: knowledge, awareness of the concepts of renewable energy and also government policies that support the implementation of renewable energy systems. The distribution of the demographics of the participants is shown in Table 2 below. It shows that most of the serving teacher respondents are female (Male = 19; 16.2%; Female = 98; 83.8%) while most of the polytechnic educators are male (Male = 65; 72.2%; Female = 25; 27.8%). As for length of teaching experience, a majority of in-service science teachers had more than 10 years' experience (N = 67;

Table 2
Demographics of in-service science teachers and polytechnic lecturers.

Demographic variables	In-service science teachers		Polytechnic lecturers	
	N	%	*N*	%
Gender				
Male	19	16.2	65	72.2
Female	98	83.8	25	27.8
Teaching experience				
Less than 1 year	2	1.7	–	–
1–3 years	11	9.4	–	–
4–6 years	7	6.0	–	–
7–10 years	30	25.6	41	45.6
More than 10 years	67	57.3	49	54.4
Subjects taught				
Science	117	100	–	–
Technical	–	–	90	100
Attended a course on renewable energy				
Yes	31	26.5	31	34.4
No	86	73.5	59	65.6

57.3%) followed by 7 to 10 years of experience ($N = 30$; 25.6%) and from 1 to 3 years ($N = 11$; 9.4%). 7 teachers had 4 to 6 years of teaching experience ($N = 7$: 6.0%) with two teachers in their first year of teaching (1.7%). A total of 41 polytechnic lecturers had between 7 to 10 years teaching experience (45.6%) and 49 educators had more than 10 years' teaching experience (54.8%). The demographic section also asked whether they had attended any courses related to renewable energy. A total of 31 (26.5%) in-service science teachers replied that they had attended the relevant courses on renewable energy while 86 (73.5%) said that they had never attended any course on renewable energy. The same distribution also applied to the polytechnic lecturers with 31 (34.4%) mentioning that they had attended a course on renewable energy and another 59 (65.6%) replying that they had never attended a course on renewable energy.

4.2. Items' psychometrics

The psychometric analysis employed two major tests: the correlational matrix and the exploratory factor analysis. Initially, all the 27 items that measure the RE knowledge, awareness, support and implementation were assessed through the correlational matrix test, as presented in Table 3. On the basis of the statistical findings, the correlational values were between 0.017 and 0.651, which indicates relationships between the 27 items of the four main RE constructs. At the same time, the highest value was 0.651 (below 0.9), which indicates the least influence of multicollinearity based on the four constructs studied because the correlation values exceed 0.25 and are below 0.95. Results from the correlational matrix (Table 3) imply good internal values of the items based on the four related constructs. Hence, all items in the renewable energy constructs have internal consistency and also strong validity.

Subsequently, the exploratory factor analysis (EFA) with varimax rotation procedure was executed to determine an item's validity. The EFA analysis results demonstrate that the RE items consistency values were higher than 0.30 (the cut off value) [41]. As for the Kaiser–Meyer–Olkin result, the data indicate high values (KMO = 0.788; Approx. X^2 = 2.550E3; df = 351; Sig = 0.00) and the total variance explained for all 26 items was at 64.005%. As a further measurement and check on the items' internal consistency, all renewable energy items were tested separately.

In Table 4, all constructs related to RE items were checked separately and presented. As for the knowledge construct, the total variance explained was at 59.082% with factor loadings between 0.471 and 0.864. The KMO values indicate a good result (KMO = 0.650; Approx. X^2 = 211.766; df = 351; Sig = 0.00) with an Eigenvalue of 1.211. In addition, the awareness construct indicates much higher total variance of 65.663% with KMO results (KMO = 0.662; Approx. X^2 = 178.824; df = 351; Sig = 0.00) with an Eigenvalue of 5.354. As for the government support items, the total variance explained was noted at 64.153% with factor loadings between 0.412 and 0.969. The KMO results (KMO = 0.848; Approx. X^2 = 755.028; df = 351; Sig = 0.00) indicate a good value with an Eigenvalue of 2.229. Lastly, items for RE implementation were between 0.358 and 0.826. The total variance explained was noted with much lower values at 52.310% and an Eigenvalue of 1.394. As for the KMO result, the values were at 0.817 and supported with other related values (Approx. X^2 = 423.960; df = 351; Sig = 0.00).

4.3. Measurement model

In obtaining the structural validity of all items related to RE knowledge, support, implementation and awareness, a measurement model using confirmatory factor analysis was developed. The measurement model was constructed using AMOS software. To ensure the internal consistency, the fit statistics indices were referred through the $\chi 2$/df Chi-square, the RMSEA (Root Mean Square Error of Approximation), the NFI (Normed Fit Index) and CFI (Comparative Fit Index) values. In the first analysis, the chi-square value was X^2/df = 4.680 with a p-value of 0.000 which was significant. However, the fit index values were considered low with NFI = 0.487 and CFI = 0.541. The RMSEA value was determined as 0.130. In an effort to improve the RMSEA and fit statistics, a modification of the indices was performed with the measurement model through the confirmatory factor analysis. After implementation of the modified indices, the chi-square value was X^2/df = 3.606 with a p-value of 0.000 which was significant. Further, the fit index values were also improved with NFI = 0.767 and CFI = 0.847. The RMSEA value was determined as 0.019. However, through the CFA measurement model, four items (B2, B4, C4 and C5) were deleted based on their low loading. Fig. 6 presents the measurement model based on the confirmatory factor analysis. Therefore, only 23 items were presented in representing the awareness, knowledge, and government policy for supporting and implementing renewable energy.

4.4. Information about renewable energy

Table 5 depicts the feedback provided by the in-service science teachers and polytechnic lecturers related to their sources of information about renewable energy. A total of 20 (22.2%) polytechnic lecturers chose the combination of reading newspapers and journals as their source of information related to renewable

Table 3
Correlational matrix.

Renewable energy constructs	Mean	2	3	4
1. Knowledge	4.04	0.388**	0.234**	0.268**
2. Awareness	4.30	1.00	0.017**	0.178**
3. Support	3.74		1.00	0.651**
4. Implementation	3.84			1.00

$N = 207$; Significance level at $p < 0.05^{*}$; $p < 0.01^{**}$.

Table 4
Subscales of RE attributes: eigenvalues, percentage of variance explained, factor loading range, and measures of sampling adequacy.

RE attributes	Eigenvalues	% variance explained	Loadings range	MSA/χ^2 Values
Knowledge	1.211	59.082	0.471 - 0.864	0.650/211.76
Awareness	5.354	65.663	0.523 - 0.930	0.662/178.82
Policy's support	2.229	64.153	0.412- 0.969	0.848/755.02
Policy's implementation	1.394	52.310	0.358 - 0.826	0.817/423.96

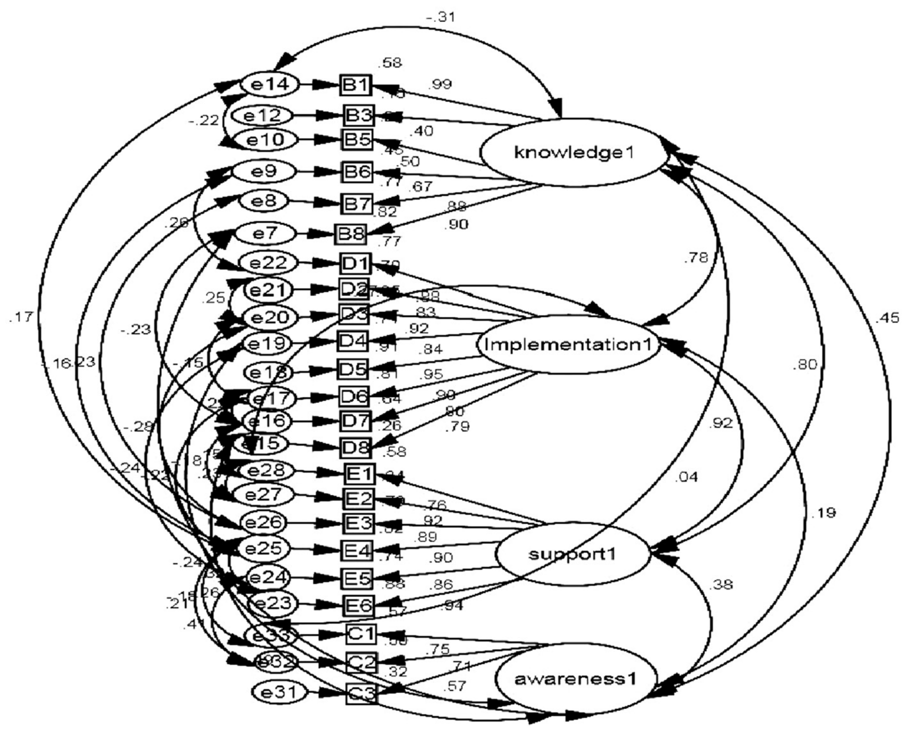

Fig. 6. Measurement model of renewable energy.

energy. However, only 3 in-service teachers mentioned that they obtained the information from reading newspapers and journals. In terms of obtaining information from books and other sources of reading, there are only 7 in-service teachers (5.9%) in favour of books and other sources of reading materials. A total of 26 (22.2%) in-service science teachers and 24 (28.7%) polytechnic lecturers mentioned that the internet and electronic media were their sources of information for understanding renewable energy. Thirdly, 25 (21.4%) in-service science teachers identified their school textbooks as playing a major role as a source of information on renewable energy while 16 polytechnic lecturers (17.7%) disclosed that they obtained information on renewable energy from relevant textbooks. In terms of other sources of reading materials, 23 in-service teachers (19.6%) chose these reading materials compared to 30 (33.3%) of polytechnic lecturers. Through their feedback, 33 in-service science teachers (28.2%) mentioned that they obtained their information on renewable energy from a combination of various sources such as textbooks, the internet and electronic media.

Table 5
Sources of information regarding renewable energy.

Sources of information	Teachers	Polytechnic lecturers
	N	*N*
Readings such as newspaper, journals	3	20
Books and other sources of reading	7	–
Internet and electronic media	26	24
Formal textbooks	25	16
Other sources of reading materials	23	30
Combinations of all abovementioned sources	33	–

4.5. Knowledge about renewable energy

As teachers and lecturers with major roles in teaching and learning about renewable energy with primary, secondary and post-secondary students, their knowledge of the concepts of renewable energy is considered vital. Therefore, we investigated their knowledge through eight items related to renewable energy.

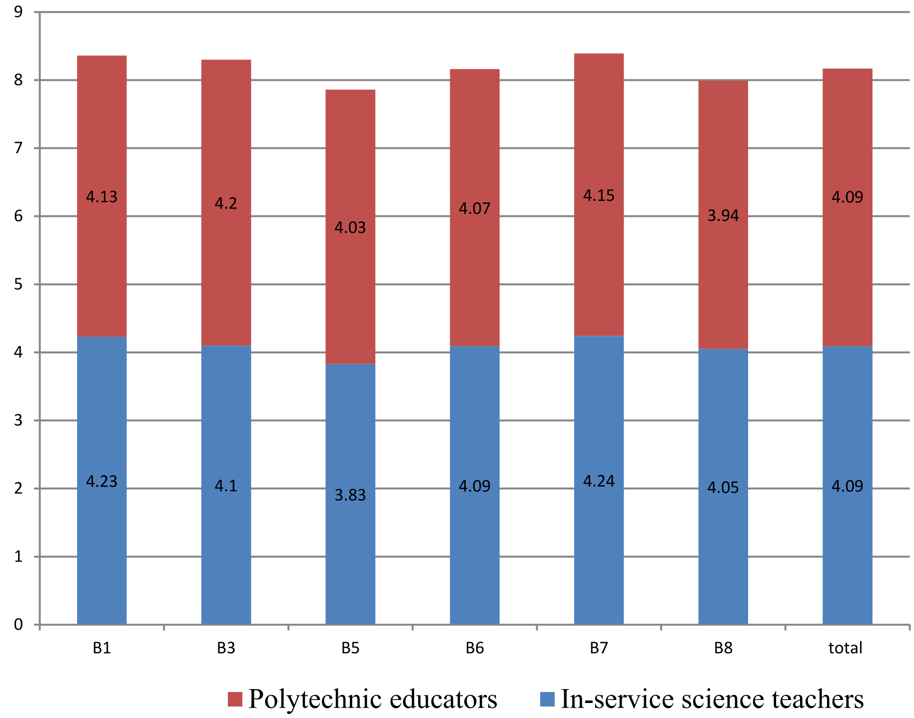

Fig. 7. Teachers and educators' knowledge regarding renewable energy.

Descriptive statistics related to teachers' and polytechnic lecturers' knowledge of renewable energy are presented in Table 6 using mean scores and standard deviations.

The in-service science teachers and polytechnic lecturers' responses are tabulated as mean scores and standard deviations. Table 6 and Fig. 7 show that in-service science teachers highly agreed that renewable energy provided the environment and the nation with cleaner sources of energy compared to previous sources ($\overline{X} = 4.24$; SD $= 0.66$) and that reading was their best source of information ($\overline{X} = 4.23$; SD $= 0.56$). At the same time, in-service science teachers also believed that RE sources will be long-lasting compared to the previous sources of energy ($\overline{X} = 4.05$; SD $= 0.61$). Teachers also responded that the initiative to change to renewable energy consumption is due to our lacking other sources of energy ($\overline{X} = 4.10$; SD $= 0.81$). In addition, teachers also responded that besides wind, water has much potential as an energy source ($\overline{X} = 4.09$; SD $= 0.49$). However, in-service science teachers were not sure about the potential capacity of wind energy as a source of energy in Malaysia ($\overline{X} = 3.83$; SD $= 0.73$).

Comparatively, polytechnic lecturers have different perceptions related to knowledge on renewable energy. They somewhat disagreed that renewable energy will provide long-lasting energy sources ($\overline{X} = 3.98$; SD $= 0.64$). In studying the potential of wind energy in Malaysia, polytechnic lecturers seem to agree with in-service science teachers' perceptions of its potential ($\overline{X} = 4.03$; SD $= 0.64$). In terms of the highest level of agreement, polytechnic lecturers favoured the government's renewable energy initiative for the crucial reason that current sources of energy are diminishing and require replacement ($\overline{X} = 4.20$; SD $= 0.58$). They also believed that renewable energy sources originate from natural sources even though some science teachers are not that sure of the origin of RE ($\overline{X} = 4.16$; SD $= 0.56$). Based on total mean scores, it can be assumed that polytechnic lecturers have similar levels of knowledge on RE to those of in-service science teachers.

4.6. Awareness of renewable energy

In this section, in-service science teachers' and polytechnic lecturers' levels of awareness are examined through their feedback on three items within the questionnaire about RE. Their replies are presented in Table 7.

Based on Table 7 and Fig. 8, polytechnic lecturers had a higher level of awareness of all items concerning RE compared to the in-service science teachers. Polytechnic lecturers, were aware that it is the right time to maximise the use of RE in replacing the remaining energy from such fuels as petrol ($\overline{X} = 4.58$; SD $= 0.63$) and it is the right situation to search for new sources of energy ($\overline{X} = 4.56$; SD $= 0.61$). Simultaneously, polytechnic lecturers were also aware that solar energy [SE] has much potential as a new source of energy due to the Malaysian climate which is hot and sunny year-round ($\overline{X} = 4.46$; SD $= 0.58$). As for teachers, they were aware that solar energy has a high potential as a new energy source in replacing the current sources of energy from petrol, gas and coal resources ($\overline{X} = 4.33$; SD $= 0.60$) and that it is the right action to maximise the use of RE in our industrial context ($\overline{X} = 4.29$; SD $= 0.64$). Comparatively, polytechnic lecturers have a higher level of awareness compared to in-service science teachers based on the typical total mean scores of all items in the awareness of RE section.

4.7. Understanding government policies for the support and implementation of RE

In this study, the government's support and implementation policy related to renewable energy is also being investigated to indicate whether RE has been part of policy concerning future energy usage. In this study, in-service science teachers and polytechnic lecturers were asked to provide feedback on the government's support for, and planned use of, renewable energy through the eight items in sections D and E of the questionnaire. The findings are presented in Fig. 9.

Table 6
Mean scores and standard deviations of in-service science teachers and polytechnic educators related to their knowledge of RE.

Constructs	In-service science teachers		Polytechnic educators	
	$\bar{X}$	SD	$\bar{X}$	SD
Understand RE through reading	4.23	0.56	4.13	0.62
Initiative due to our lacking energy	4.10	0.81	4.20	0.58
WE [Wind Energy] is a potential energy source in Malaysia	3.83	0.73	4.03	0.64
Water has much potential as an energy source	4.09	0.49	4.07	0.45
Cleaner energies	4.24	0.66	4.15	0.53
Long-lasting energies	4.05	0.61	3.94	0.64
Total mean scores	4.09		4.09	

Table 7
Mean scores and standard deviations of in-service science teachers' and polytechnic educators' levels of awareness of renewable energy.

Constructs	In-service scienceteachers		Polytechniclecturers	
	$\bar{x}$	SD	$\bar{x}$	SD
Maximising RE usage	4.29	0.64	4.58	0.63
Search for new energy sources	4.28	0.57	4.56	0.61
SE has potential as a new energy source	4.33	0.60	4.46	0.58
Total mean scores	4.30		4.53	

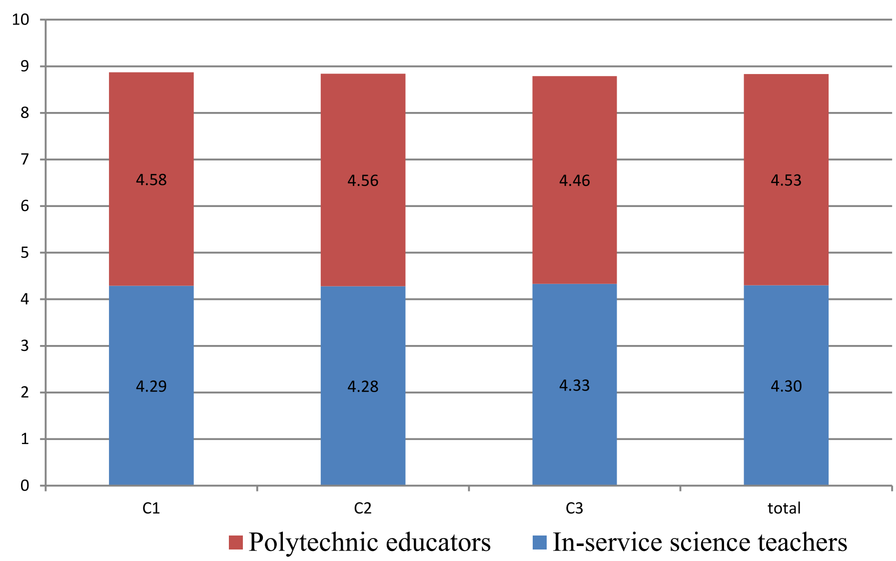

Fig. 8. Teachers and educators' awareness regarding renewable energy.

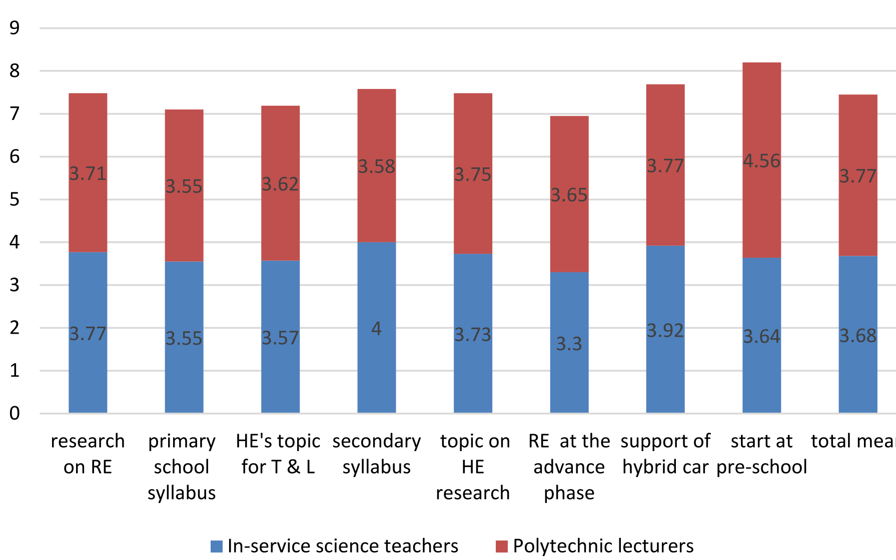

Fig. 9. Teachers' and lecturers' perceptions of the policy implementation of RE.

In Fig. 9, feedback from in-service science teachers and polytechnic lecturers is tabulated and analysed regarding their evaluations of the implementation of policy related to RE. Based on their evaluation of the implementation of RE policy in educational institutions, respondents had very similar perceptions on some items such as 'substantial topic for HE research' ($\bar{X}$ teachers = 3.75; $\bar{X}$ lecturers = 3.75); 'inculcate renewable energy as a topic in the primary school syllabus' ($\bar{X}$ teachers M = 3.55; $\bar{X}$ lecturers = 3.55) and 'had implemented the renewable energy research' ($\bar{X}$ teachers = 3.77; $\bar{X}$ lecturers = 3.71). However, teachers strongly agreed on some items compared to the educators' points of view, especially the item 'renewable energy should be inculcated in the secondary school syllabus' ($\bar{X}$ teachers = 4.00; $\bar{X}$ lecturers = 3.58) and 'people are encouraged to use hybrid cars to decrease the carbon impact within our environment' ($\bar{X}$ teachers = 3.92; $\bar{X}$ lecturers = 3.77). However, polytechnic lecturers favoured some other items compared to in-service science teachers, for example 'renewable energy should begin at pre-school level' ($\bar{X}$ lecturers = 4.56; $\bar{X}$ teachers = 3.64); 'renewable energy research is actually at an advanced phase' ($\bar{X}$ lecturers = 3.65; $\bar{X}$ teachers = 3.30) and 'renewable energy should be introduced as a topic for higher education teaching and learning' ($\bar{X}$ lecturers = 3.62; $\bar{X}$ teachers = 3.57). Overall, the polytechnic lecturers had a much higher perception of RE implementation compared to in-service science teachers.

Furthermore, the government's support for renewable energy was also investigated through the perceptions of in-service science teachers and polytechnic lecturers. Their feedback is presented in Table 8, below, which illustrates that polytechnic lecturers had a much higher level of agreement with the support and initiative provided by the government on the development of research related to renewable energy. Through the overall mean scores, lecturers have a higher level of agreement ($\bar{X}$ = 3.95) compared to in-service science teachers ($\bar{X}$ = 3.66), and the higher level of agreement applied to all six items with 'credits to institutions that are using renewable energy' ($\bar{X}$ lecturers = 4.01; $\bar{X}$ teachers = 3.87) as the most favourable item. At the same time, educators also showed their positive feedback on the item 'support to schools' ($\bar{X}$ = 4.03) compared to teachers who had a low mean score ($\bar{X}$ = 3.57) together with the item 'more grants on renewable energy' ($\bar{X}$ lecturers = 3.86; $\bar{X}$ teachers = 3.46); 'campaigns related to renewable energy' ($\bar{X}$ lecturers M = 3.86; $\bar{X}$ teachers = 3.66) and 'acknowledgement should be awarded related to renewable energy implementation' ($\bar{X}$ lecturers = 3.97; $\bar{X}$ teachers = 3.75).

4.8. Significant differences

In order to investigate whether there are significant or meaningful differences based on in-service science teachers' and polytechnic lecturers' demographics, the inferential differentiation tests – the *t*-test and analysis of variance (ANOVA) – are used. Before proceeding with the inferential differentiation tests, all data were tested at the 0.05 significance level with a 95% confidence level. Firstly, the significant difference based on respondents' gender was inspected and the results presented in Table 10. The *t*-test reveals that there are no statistically significant differences in terms of in-service science teachers' gender on the aspects of policy implementation [$t_{(115)} = 0.118$; $p = 0.906$] and support for renewable energy [$t_{(115)} = 0.397$; $p = 0.692$]. However, two elements related to renewable energy were noted to have a statistically significant difference based on in-service science teachers' gender which were 'knowledge of renewable energy' [$t_{(115)} = 4.510$; $p = 0.000$] and 'awareness about renewable energy' [$t_{(115)} = 4.201$; $p = 0.000$]. As for polytechnic lecturers, all three elements related to renewable energy: policy implementation [$t_{(88)} = 0.010$; $p = 0.992$]; knowledge of renewable energy [$t_{(88)} = 0.305$; $p = 0.761$] and supporting policy for renewable energy [$t_{(88)} = 0.423$; $p = 0.674$] showed no statistically significant differences in terms of gender. On the other hand, the element of 'awareness' did have a statistically significant difference according to gender [$t_{(88)} = 3.902$; $p = 0.000$]. Based on the *t*-test results which indicated significant difference in Table 9, data showed that male in-service science teachers have a much higher level of knowledge ($\bar{X}$ = 4.256) and awareness ($\bar{X}$ = 4.547) on renewable energy with a higher level of mean scores compared to their female counterparts despite the lower sample size. As for polytechnic lecturers, the element of awareness of RE indicates that male polytechnic lecturers ($\bar{X}$ = 4.443) have a much higher level of awareness compared to their female counterparts ($\bar{X}$ = 4.192). Therefore, male in-service science teachers and polytechnic lecturers have much higher levels of knowledge and awareness of RE compared to female in-service science teachers and polytechnic lecturers.

Furthermore, in-service science teachers' and polytechnic lecturers' teaching experience were also inferentially inspected using the ANOVA tests (Table 10). The findings from Table 11 show that the ANOVA test results for in-service science teachers indicate that teaching experience has no statistically significant difference in terms of their perceptions of the four elements of renewable energy, with 'knowledge' ($F_{(4,116)} = 1.627$; $p = 0.172$), 'awareness' ($F_{(4,116)} = 0.846$; $p = 0.499$), 'policy for implementation' ($F_{(4,116)} = 0.281$; $p = 0.890$) and finally the 'policy of supporting renewable energy initiatives' ($F_{(4,116)} = 0.444$; $p = 0.777$). However, the ANOVA results for polytechnic lecturers' teaching experience disclose only one variable that presents a statistically significant difference, which is the 'knowledge of renewable energy' ($F_{(1,89)} = 10.618$; $p = 0.002$) whilst the three other elements – 'awareness' ($F_{(1,89)} = 0.170$; $p = 0.681$), 'policy implementation' ($F_{(1,89)} = 1.749$; $p = 0.189$) and 'policy of supporting renewable energy initiatives' ($F_{(1,89)} = 3.625$; $p = 0.060$) show no statistically significant differences. Further, in measuring significant differences, the ANOVA test was applied to determine any significant difference based on polytechnic lecturers' teaching experience. The results show a statistically significant difference between polytechnic educators with more than 10 years' experience and those with 7 to 10 years of teaching experience with a mean difference (MD = .322; Sig = 0.01). Therefore, it was concluded that there are no, or small, **s**ignificant differences in terms of renewable energy knowledge, awareness and government policy for supporting and implementing renewable energy based on in-service teachers and polytechnic lecturers' years of experience, which showed that the seniority of renewable energy educators and teachers did not provide significant differences related to renewable energy knowledge, awareness and government policy on the support and implementation for renewable energy ($F_{(1,89)} = 3.625$; $p = 0.060$).

5. Discussion

This study is considered very significant in determining Malaysian educators' and public perceptions of renewable energy related to four major elements: their knowledge, their awareness, and the government's policy for the support and implementation of renewable energy. Data was collected using a questionnaire with two major groups: in-service science teachers and polytechnic lecturers, who were highly involved in teaching and researching renewable energy in public schools and polytechnics, respectively. All the feedback from in-service science teachers and polytechnic lecturers was analysed and tabulated using the mean scores and standard deviations. Additionally, the parametric t-test and ANOVA were employed to measure their significant

Table 8
Mean scores and standard deviations of teachers and lecturers' perceptions of government's support for RE.

Constructs	In-service science teachers		Polytechnic lecturers	
	$\overline{X}$	SD	$\overline{X}$	SD
Financial support for RE	3.70	0.64	3.97	0.63
More support to schools	3.57	0.57	4.03	0.61
Acknowledgement to institutions employing RE	3.87	0.60	4.01	0.58
More campaign about RE	3.66	0.58	3.86	0.60
More grants on RE	3.46	0.61	3.86	0.62
Acknowledgement of RE implementation	3.75	0.57	3.97	0.73
Total mean scores	3.67		3.95	

Table 9
t-test results according to in-service science teachers' and polytechnic lecturers' gender.

Variables	In-service science teachers					Polytechnic lecturers				
	Mean		*df*	*t*	*p*	*Mean*		*df*	*t*	*p*
	Male ($n = 19$)	Female ($n = 98$)				Male ($n = 65$)	Female ($n = 25$)			
Knowledge	4.25 (0.29)	3.88 (0.33)	115	4.51	0.00*	4.10 (0.30)	4.08 (0.34)	88	0.30	0.76
Awareness	4.54 (0.43)	4.10 (0.41)	115	4.20	0.00*	4.44 (0.33)	4.19 (0.38)	88	3.90	0.00*
Implementation	3.66 (0.71)	3.69 (0.39)	115	0.11	0.90	3.77 (0.48)	3.78 (0.43)	88	0.01	0.99
Support	3.63 (0.53)	3.68 (0.48)	115	0.39	0.69	3.94 (0.42)	3.98 (0.44)	88	0.42	0.67

Significance level $p < 0.05$*.

Table 10
Results from ANOVA analysis of teaching experience.

Variables	In-service science teachers					Polytechnic lecturers				
	SS	*df*	*MS*	*F*	*p*	*SS*	*df*	*MS*	*F*	*p*
Knowledge of RE										
Between groups	0.802	4	0.20	1.62	0.17	0.94	1	0.94	10.6	0.00*
Within groups	13.80	112	0.12			7.83	88	0.08		
Total:	14.60	116				8.77	89			
Awareness of RE										
Between groups	0.677	4	0.16	0.84	0.49	0.02	1	0.02	0.17	0.68
Within groups	22.39	112	0.20			11.5	88	0.13		
Total:	23.07	116				11.6	89			
Implementation of RE										
Between groups	0.244	4	0.06	0.28	0.89	0.38	1	0.38	1.74	0.18
Within groups	24.30	112	0.21			19.3	88	0.22		
Total:	24.55	116				19.7	89			
Support for RE										
Between groups	0.431	4	0.10	0.44	0.77	0.65	1	0.65	3.62	0.06
Within groups	27.17	112	0.24			15.8	88	0.18		
Total:	27.60	116				16.5	89			

Significance level $p < 0.05$*.

differences on the knowledge, awareness and implementation of RE as well as the government's support for its use.

As expected, in-service science teachers had identified that they acquired knowledge and developed awareness of renewable energy mainly from textbooks, the internet and electronic media. In comparison, polytechnic lecturers have a wider range of sources of knowledge and awareness on renewable energy including academic and non-academic journals, science and engineering magazines and other niche technology reading materials. Based on the findings, textbooks and the internet have served as the major sources of reading references used widely by the teachers and lecturers to let them feel a sense of real awareness in understanding renewable energy. Interestingly, the findings of this study could be related to those of Zakaria et al. (2019) which showed that the electronic media, such as social media and the internet, were the most significant preferred sources of information among the public. On the role of the school subjects and campaign related to educational programmes, the public also recognised the use of this source as an ongoing search which lets them create a "knowledge base" on renewable energy.

In terms of knowledge and awareness related to renewable energy, both groups responded that they have wide knowledge about renewable energy when they pointed out its advantages and benefits such as providing a much cleaner environment and a long-lasting supply of renewable energy as replacement for current energy sources. In terms of knowledge, polytechnic lecturers had a higher level of knowledge on renewable energy compared to in-service teachers. As polytechnic lecturers, they must have relevant exposure and understanding having engrossed themselves with the concepts and projects related to renewable energy. For the element of awareness of renewable energy, the polytechnic lecturers had slightly higher awareness of renewable energy compared to in-service teachers although their mean differences are considered to be broadly equivalent. Overall, the findings are in line with the opinions that both groups of educators whether teaching at higher learning or in schools are the most crucial individuals to ensure the effectiveness of renewable energy awareness and knowledge (Liarakou et al., 2009; Guven and Sulun, 2017). As such, similar opinions were being raised by other researchers on the significant role of educators in supporting the use of renewable energy (Shamsudin et al., 2014; Alawin et al., 2016; Halderm et al., 2014). In other words, the findings support the supposition that educators are the main individuals in supporting and disseminating knowledge and awareness of renewable energy to students and the community; therefore, they should acquire or obtain in-depth knowledge and awareness of renewable energy to encourage students, the public and their community to have a clear understanding of renewable energy.

Surprisingly, both groups of educators were unsure of the possibility of using wind energy in the context of Malaysia even though both groups remarked that they were optimistic about the employment of solar energy in replacing the current energy sources. This finding was not surprising based on a previous study conducted by Zakaria et al. (2019) which also pointed out the public's low level of knowledge about the deployment of renewable energy sources, including wind energy, biomass and geothermal. In this sense, it was suggested that more information and knowledge related to wind energy as a form of renewable energy together with natural RE sources such as solar and water is required. Lastly, to provide more knowledge, more information can be provided to students about the use of wind energy within the students' courses and the syllabus for future students.

In terms of government policy in supporting and implementing RE, both groups gave a positive feedback on the RE implementation in schools and higher learning institutions when they acknowledge the efforts to maximise RE implementation. In addition, they also agreed that renewable energy should be taught as early as the pre-school level of education to provide much earlier exposure to the concept of renewable energy. In this sense, both groups acknowledged the government's efforts on the development of, and research into, renewable energy such as introducing renewable energy as a topic to be studied in primary, secondary and higher education institutions and providing more research and government grants to enhance the employment of, and research into, renewable energy in Malaysia. This finding does not correspond to those of Zakaria et al. (2019) which disclosed a lack of information obtained by the public on the government's initiatives and policies related to renewable energy in Malaysia, except for those who worked as government officials or in the private sector and were involved in renewable energy projects. In this sense, they strongly suggested to the government should provide more information and knowledge through various channels such as social media, to inform the public on the latest renewable energy research, projects and achievements so that the public could better understand the government's policies and initiatives on renewable energy.

Using the difference tests, there are significant differences based on gender within the knowledge and awareness of renewable energy among in-service science teachers, but for lecturers, significance differences were detected in the element of RE awareness. Thus, male in-service science teachers and polytechnic lecturers have much higher levels of knowledge and awareness on renewable energy. There were significant differences in educators' perceptions in terms of their teaching experience, and also in terms of knowledge about renewable energy. Overall measurement of significant differences based on years of experience, suggested that seniority as a renewable energy lecturer and teacher did not lead to significant differences in knowledge and awareness of government support for implementation. The relationship element between participants' demographics with knowledge and awareness of renewable energy has been discussed in-depth by previous researchers (Karasmanaki and Tsantopoulos, 2019; Pataria et al., 2017; Celikler, 2013). Male teachers were perceived as having higher levels of awareness and knowledge of renewable energy compared to female in-service science teachers. This is reflected in the higher mean scores in knowledge and awareness of renewable energy of the male teachers. In terms of government policy on initiatives and efforts to support and implement renewable energy, female teachers have more knowledge compared to male in-service science teachers. The findings also indicate a similar situation among polytechnic lecturers where the male lecturers were more knowledgeable and this is revealed by the higher mean scores for awareness. As for the elements of knowledge of government policy on RE support and implementation, the mean score between genders indicated that both male and female lecturers were at the same level. Based on the results of gender in the study, it can be summarised that there are significant differences among the lecturers and teachers on their renewable energy awareness. This finding is similar to previous findings for RE knowledge and awareness based on respondents' gender (Karetepe et al., 2012; Zyadin et al., 2014; Altuntaş and Turan, 2018). The second demographic element examined was the participants' teaching experience. Interestingly, there are non-statistically significant differences in all four elements for in-service teachers which means that there is no significant difference in terms of knowledge, awareness and understanding of government policy concerning RE support and implementation (Assali et al., 2019; Celikler, 2013; Pataria et al., 2017). However, for polytechnic lecturers, a significant difference was indicated related to knowledge of renewable energy. The findings show that there are differences in terms of the RE knowledge of polytechnic lecturers with more than 10 years' experience and those with 7 to 10 years of teaching experience. It seems that polytechnic lecturers' teaching experience has a much greater influence on their knowledge related to renewable energy which indicated that the more experience they obtain, the greater their knowledge on renewable energy compared to less experienced lecturers.

6. Conclusion and policy implications

To conclude, this present survey study points to the key importance of teaching, researching and disseminating knowledge and awareness on renewable energy by in-service science teachers and polytechnic lecturers. Previous studies emphasised the major role of teachers and lecturers in developing awareness and disseminating knowledge related to renewable energy. As individuals who are vitally important in creating public knowledge and awareness, it is important that they have in-depth knowledge, first-hand exposure and awareness related to renewable energy in order to inculcate positive attitudes towards the use, knowledge and awareness of renewable energy among in their technical students, the public and community. Thus, this study presents the following important conclusions:

- Both teachers and lecturers have wide knowledge and awareness of renewable energy. However, the polytechnic lecturers were seen as having higher levels of knowledge and awareness compared to in-service science teachers.
- Lecturers were recognised as having more understanding of government policies in supporting and implementing renewable energy compared to in-service teachers. This may be because the polytechnic lecturers are educators who are closely involved with research, innovation and projects related to renewable energy. Unlike them, the in-service science teachers only teach a single topic on renewable energy in the science syllabus at their respective schools.
- Male teachers were seen as having a higher level of knowledge and awareness compared to their female colleagues. The same situation also happened to male lecturers who have much higher levels of knowledge and awareness compared to their female colleagues. By contrast, female teachers and lecturers were seen as having better understanding of government policy related to support and implementation compared to male teachers and lecturers.

Taking the above into account, more efforts should be made by the government to build greater confidence within society on the use of wind energy which is currently lower than the public's confidence in solar energy. Therefore, a few suggestions and implications are advanced:

- More campaigns, grants and research should be conducted to provide educators and the public with the capability and potential to utilise wind energy since Malaysia is located on a peninsula with a lengthy coast line which provides many possibilities and significant potential for utilising wind energy. For instance, MESTECC'S research grant has highly emphasised on research related to RE, The MIGHT — UNITEN Smart Grid Training Programme. In addition, the Ministry of Science, Technology and Innovation has offered a few research grants such as Applied Innovation Fund, Technology Development Fund 1 and 2, and Bridging Fund
- The government needs to convey more information and awareness and knowledge of the progress of renewable energy projects through non-formal communication media, such as social media. This should improve the public understanding of government initiatives and efforts in moving towards a renewable-energy-based industry for a sustainable future (Zakaria et al., 2019).
- As for the educators and teacher training, it is believed that the topic of renewable energy and sustainable energy should be introduced to all pre-service teachers within their syllabus at teacher training colleges or faculties of education at public universities. Thus, the pre-service teachers will have initial knowledge and awareness of renewable energy to create positive attitudes and higher levels of knowledge on renewable energy with students (Celikler, 2013).
- Pre-service teachers and polytechnic lecturers should obtain more knowledge and awareness of renewable energy and sustainable energy starting from their pre-service training at academic institutions, such as technical colleges, schools and universities (Açıkgöz, 2011). As emphasised by previous researchers (Kandar and Rahman, 2009; (UNCED, 1992), education and training are the most suitable agents for securing positive attitudes, awareness on RE. In addition, the Tenaga Nasional Berhad also has introduced the TNB Integrated Learning Solution offered by the Sultan Ahmad Shah Training Institute which conduct programmes on RE (Energy Commission of Malaysia, 2019a,b).
- Lastly, it is important to inculcate positive skills and values among the public related to sustainable development and renewable energy education.

Specifically, in order to create more specialist individuals who are involved with RE, a few strategies and approaches can be used by polytechnics and schools to expose students to involvement in the RE industry as engineers and technicians. Listed below are suggestions and recommendations to polytechnics and schools to create more involvement in the RE industry.

Polytechnics

- More courses offered by higher education in Malaysia on sustainability and renewable energy (SRE) as a specialist SRE diploma or degree qualification. Previously, renewable energy was offered as a subject within any engineering courses within the mechanical and electrical engineering courses. Notably, a few countries have offered undergraduate programmes in SRE such as Renewable Energy Engineering (Bachelor degree) at Oregon Institute of Technology, US; Mechanical and Engineering (BSc) at Reykjavik University, Iceland, Environmental Engineering — renewable energy sources, at Krakow University, Poland and Mechanical Engineering with major in energy conversion at the University of Miskolc, Hungary (International Labour Office, 2011).
- Lund et al. (2017) investigated whether SRE can be offered within an undergraduate or postgraduate diploma or Master's degree by taught course or coursework. If so, after graduating, students will be working in the sustainable and renewable energy industry. This initiative seems capable of solving problems noted in previous research which mentioned the challenges related to lack of expertise within a local RE industry that can handle RE projects and installation. As a result, the high dependency on expertise from other countries will be minimised due to Malaysia's own expertise in being able to handle RE projects.
- Creating more specialist programmes and postgraduate diplomas in sustainability and renewable engineering is another option to add more engineers and technicians (expertise) that can major in SRE. Therefore, more expertise and technicians that can handle the technical elements and installation of SRE will be created. For instance, a generalist undergraduate course in SRE is an interesting programme which could provide more expertise in SRE.
- Beside technical expertise, the higher education institutions in Malaysia should be targeted to produce graduates who are willing to work in SRE industries by preparing them with SRE subjects within their degree or diploma programmes.
- More apprenticeship programmes should be offered by Malaysian polytechnics with a diploma or certificate to produce skilled workers who can work as specialist technicians and operators for the operations and maintenance phases, especially dealing with SRE equipment in the wind, hydropower and bioenergy sectors.

Schools

- More in-depth content within the SRE syllabus for secondary schools, especially for the lower secondary students. In fact, within the primary schools, it is better to introduce SRE within the science subject syllabus to introduce and expose students to the importance of SRE.
- In the year 2020, the MOE decided to include SRE within Malaysian science subjects. Therefore, students will receive increasing exposure to the concept of RE through SRE projects and competitions involving SRE and green technology. It also exposes students to the concept of SRE by visiting existing SRE projects. For example, Energy Commission of Malaysia has organised programmes for school students such as Energy Efficiency Challenge for secondary schools in Malaysia.
- In terms of extra-curricular activity, schools can start to introduce a 'Green technology' or 'SRE club' which can expose students to SRE.
- The Ministry of Education with the Energy Commission of Malaysia should start to initiate campaigns and initial projects on SRE for all students. Through both initiatives, it will expose students to the benefits and also the infrastructure of SRE or green technology implementation.
- Ilias et al. (2020) have proposed more practical demonstrations of renewable energy generation and hands-on experiments related to renewable energy for students to supplement textbook-based activities.

As for future research, more study should be conducted from various perspectives among educators and students on their perceptions related to the use of RE as a possible environmentally friendly and long-lasting solution for future energy needs. Secondly, future research should employ qualitative interviews in order to obtain respondents' more in-depth perceptions of the sufficiency of RE as a potential source of energy for the future. Qualitative interviews could generate clearer perceptions and standpoints and also evoke emotional feelings, thereby generating a richer set of data. Thirdly, it is suggested that future studies include perceptions and insights from the top management and policy makers in order to explore their planning, efforts and vision for the employment of RE in Malaysia. Ultimately, the findings of this study should give a clear understanding of the perceptions of Malaysian educators from primary, secondary and technical education related to RE implementation at Malaysian educational institutions which has not been much explored and studied hitherto. From the findings, even though in-service science teachers and polytechnic educators have wide knowledge and awareness of RE, most of them are unsure about the use of wind energy which should be another possible option in replacing our current energy sources. Nevertheless, this study provides fundamental references for the RE literature which specifically focuses on the Malaysian context.

CRediT authorship contribution statement

Nor Aisyah Che Derasid: Analysis and/or interpretation of data, Writing - original draft, Writing - review & editing. **Lokman Mohd Tahir:** Conception and design of study, Acquisition of data, Writing - original draft, Writing - review & editing. **Aede Hatib Musta'amal:** Conception and design of study, Writing - original draft, Writing - review & editing. **Zainudin Abu Bakar:** Analysis and/or interpretation of data, Writing - original draft, Writing - review & editing. **Nazaruddin Mohtaram:** Acquisition of data, Writing - original draft, Writing - review & editing. **Norzanah Rosmin:** Acquisition of data, Writing - original draft, Writing - review & editing. **Mohd Fadzli Ali:** Analysis and/or interpretation of data, Writing - original draft, Writing - review & editing.

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