



ELSEVIER

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Renewable energy technology acceptance in Peninsular Malaysia

Roozbeh Karadooni^{a,*}, Sumiani Binti Yusoff^b, Fatimah Binti Kari^c^a Institute of Graduate Studies, University of Malaya, 50603 Kuala Lumpur, Malaysia^b Department of Civil Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia^c Department of Economics, Faculty of Economics and Administration, University of Malaya, 50603 Kuala Lumpur, Malaysia

HIGHLIGHTS

- Public acceptance is an essential element in the diffusion of renewable energy.
- Perceived ease of use and perceived usefulness affect intention to use renewables.
- It is important to reduce the cost of renewable energy, particularly for end users.
- Renewable energy policies should address issues of public perception and awareness.

ARTICLE INFO

Article history:

Received 4 July 2015

Received in revised form

5 October 2015

Accepted 8 October 2015

Available online 24 October 2015

Keywords:

Renewable energy barrier

Renewable energy technology

Perceived ease of use

Perceived usefulness

ABSTRACT

Despite various policies, renewable energy resources have not been developed in Malaysia. This study investigates the factors that influence renewable energy technology acceptance in Peninsular Malaysia and attempts to show the impact of cost and knowledge on the perceived ease of use and perceived usefulness of renewable energy technology. The results show that cost of renewable energy has an indirect effect on attitudes towards using renewable energy through the associated impact on the perceived ease of use and perceived usefulness. The results also indicate that public knowledge in Peninsular Malaysia does not affect perceived ease of use, although the positive impact of knowledge on perceived usefulness is supported. Furthermore, our results show that the current business environment in Peninsular Malaysia does not support the adoption of renewable energy technology, and thus, renewable energy technology is not commercially viable in Peninsular Malaysia. Additionally, the population of Peninsular Malaysia associates the use of renewable energy with a high level of effort and therefore has a negative attitude towards the use of renewable energy technology. There is, therefore, a definite need to pay more attention to the role of public perception and awareness in the successes and failures of renewable energy policy.

© 2015 Elsevier Ltd. All rights reserved.

1. Introduction

Research has indicated that the threat from global warming and climate change has increased and requires more attention (Saboori et al., 2012). The Intergovernmental Panel on Climate Change (IPCC) stated that total anthropogenic greenhouse gas (GHG) emissions continued to increase between 1970 and 2010, with larger absolute decadal increases towards the end of this period. Despite a growing number of climate change mitigation policies, annual GHG emissions grew, on average, by 1.0 Gt carbon dioxide equivalents (GtCO₂eq) (2.2%) per year from 2000 to 2010, compared with 0.4 GtCO₂eq (1.3%) per year from 1970 to 2000

(IPCC, 2014). The IPCC also reported a possible increase in global temperatures from 1.1 °C to 6.4 °C and a rise in sea levels from 16.5 cm to 53.8 cm by 2100 (IPCC, 2007).

As a country in Southeast Asia, the climate in Malaysia shows the same trends as those encountered globally (Bindoff et al., 2007; Trenberth, 2009). According to MOSTE (2000), the country's temperature has increased by 0.18 °C per decade for over 40 years. The UTM (2007) also reported a sea level rise of approximately 1.25 mm at a southern coastal site in Peninsular Malaysia since 1986. The rate of increase in carbon emissions in Malaysia is also one of the highest in the world: Malaysia ranks as the third highest worldwide, with an average annual growth of 4.7% from 1970 to 2008 (Klugman, 2011). The “business as usual” scenario (i.e., the continuation of the current trend) projects that, without additional mitigation measures, 285.73 million tonnes of CO₂ will be released in Malaysia in 2020, which is a 68.86% increase compared with the amount of CO₂ emitted in the year 2000 (Safaii

* Corresponding author.

E-mail addresses: r_karadooni@yahoo.com (R. Karadooni), sumiani@um.edu.my (S.B. Yusoff), fatimah_kari@um.edu.my (F.B. Kari).

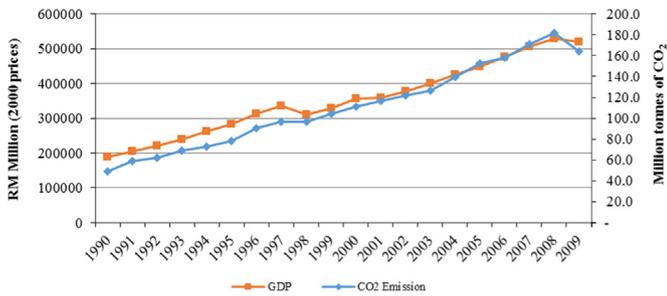


Fig. 1. CO₂ emissions and GDP trends in Malaysia. Source: NEB (2010).

et al., 2011). The trends in total CO₂ emissions and gross domestic product (GDP) in Malaysia are presented in Fig. 1. This figure shows that the increase in total domestic output is correlated with an increase in carbon emissions.

In addition, Malaysia, like other countries around the world, strongly depends on non-renewable energy sources, which has increased economic policy makers concern over the reserves of these resources and their global price fluctuations.

It is important to note that the total energy demand in Malaysia grew at an average annual growth rate of 6.6%, from about 5114 ktoe (kilotonnes of oil equivalents) in 1980 to 41,476 ktoe in 2010. Fig. 2 illustrates the annual growth rate of the total energy demand in Malaysia for 1980–2010.

It is worthwhile to acknowledge the important role that energy has had in the attainment of Malaysia's development targets. An early benchmark was the establishment in 1974 of the Petroliaam Nasional Berhad (PETRONAS) as the national oil company. The formation of PETRONAS was the first policy that really impacted the industry (Oh et al., 2010). In 1979, the National Energy Policy was launched, and this policy identified priorities and objectives for energy issues and aimed to minimize any negative environmental impacts in the energy supply chain (Othman et al., 2009). One year later in 1980, the National Depletion Policy (NDP) was introduced to guard against the over exploitation and depletion of oil and gas resources (EPU, 1981). During the Fourth Malaysian Plan (1981–1985), a four fuel diversification policy was designed to assist in fuel diversification and alleviate the country's dependence on oil; with this policy, increased emphasis was placed on oil, gas, coal, and hydro (NEDO, 2004). The 1990s began with the announcement of Vision 2020, which contemplates that Malaysia will be a developed and industrialized nation by 2020. The government emphasized that "every member of Malaysian society should have access to high-quality, secure electrical power and other convenient forms of energy supplied in a sustainable manner by the year 2020" (Poh and Kong, 2002). The new century and the second decade of Vision 2020 started with the introduction of the Third Outline Perspective Plan (OPP3), which focused on building a resilient and competitive nation. Within this framework and to provide adequate and sustainable energy and reduce the emissions of greenhouse gases, in 2001, the government of

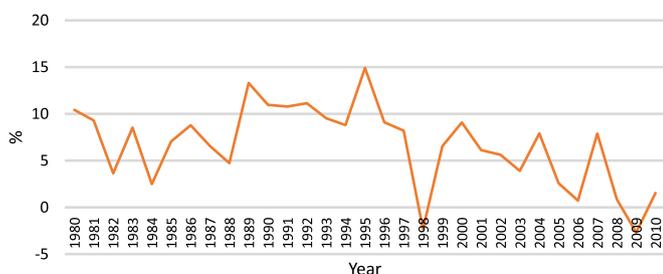


Fig. 2. Annual growth rate of the total energy demand in Malaysia (1980–2010). Source: Malaysia Energy information HUB (2015), <http://meih.st.gov.my/statistics>.

Table 1

Total realizable potential for renewable energy; share of ASEAN countries. Source: Ölz and Beerepoot (2010).

Country	Renewable energy potential per capita
Malaysia	4.73
Vietnam	2.18
Thailand	1.85
Indonesia	1.57
Singapore	0.73

Malaysia broadened the country's four fuel energy policy, which focused on oil, gas, coal, and hydro resources, by adding renewable energy as the fifth fuel.

Among the members of the Association of Southeast Asian Nations (ASEAN), Malaysia is a country that is gifted with abundant renewable energy potential (see Table 1), which is defined as energy "that comes from resources which are continually replenished by nature such as sunlight, wind, rain, geothermal heat, biomass, waves and tides" (Chang et al., 2003). Renewable energy technologies include technologies that use—or enable the use of—one or more renewable energy sources. It is important to note that there is significant realizable potential for renewable resources in Malaysia (Chua et al., 2011). The main indigenous renewable energy sources include (1) palm oil biomass wastes, (2) hydropower, (3) solar power, (4) solid waste and landfill gas, and (5) wind energy. Among these resources, hydropower is suitable for both small- (mini-hydro) and large-scale applications. Solar photovoltaic (PV) power is suitable for use in small-scale applications and at the household level. Biomass developments have been established and proven cost-effective, particularly at large scales and in industrial applications (Haris and Ding, 2009). Table 2 summarizes the estimated renewable energy potential in Malaysia.

It should also be noted that Malaysia has the highest renewable electricity potential compared to its share of the ASEAN population (Ölz and Beerepoot, 2010).

The Fifth Fuel Policy was launched during the 8th Malaysian Plan (2001–2005), and the government set itself a target of obtaining 5% of its energy from renewable sources by 2005. However, this policy ended up reaching only 0.3% of the target by the year 2005 (Muhammad-Sukki et al., 2011). The same target of 5% renewable energy was again set in the 9th Malaysia Plan (2006–2010).

Under the 8th and 9th Malaysian plans, the Malaysian government took several steps to explore and promote the use of renewable energy as an alternative fuel source (see Table 3). In this regard, more than 800 million USD were invested in new renewable energy production (Ölz and Beerepoot, 2010). Nonetheless, the renewable energy goals under the 8th and 9th Malaysian plans were not achieved, and so far, only 8.3% of the target has been reached (Maulud and Saidi, 2012).

Even though the target for Peninsular Malaysia is 300 MW, and that for Sabah and Sarawak is 50 MW, only 56.7 MW of energy in Malaysia is produced from renewable energy sources (Hashim and

Table 2

Renewable energy potential in Malaysia. Source: Oh et al. (2010).

Renewable energy	Potential (MW)
Hydropower	22,000
Mini-hydro	500
Biomass–biogas	1300
Municipal solid waste	400
Solar PV	6500

Table 3

Major renewable energy projects implemented under the 8th and 9th Malaysian plans. Sources: Chua and Oh (2010), Hashim and Ho (2011), Lau et al. (2009), Rahim and Liwan (2012) and Sovacool and Drupady (2011).

Project	Description
Small Renewable Energy Programme (SREP)	Launched during 2001, the SREP attempted to install 500 MW of power capacity from 2001 to 2005, but only 12 MW of capacity by the end of 2005 and 61.7 MW by the end of 2010 were achieved.
Bio Gen project	Launched during 2002, the Bio Gen project aims to decrease the growth rate of greenhouse gas (GHG) emissions from fossil fuel by utilizing excess oil palm biomass residues.
Malaysian Energy Commission	Formed in 2001, this group took over the role of the Department of Electricity and Gas, which was dissolved on the same date. The Malaysian Energy Commission strives to be an effective and competent regulator of the energy sector.
Malaysia Building Integrated Photovoltaic Technology Application (MBIPV) organization	Launched in 2005, this organization aims to catalyze BIPV technology acceptance among the public, policy makers, financiers, and building industry.
National Bio-fuel Policy	Launched in 2006, this policy aims to reduce the country's fuel import bill and achieve resilience in light of rapidly depleting fossil fuels and the escalating price of petroleum.

Ho, 2011). This means that after 10 years of implementing renewable energy policies, the share of renewable energy in Malaysia's total generated electricity is still less than 1% (EPU, 2010).

This situation poses a question regarding the types of barriers that are associated with the failure of renewable energy policy in Malaysia. It is therefore important to identify the factors that influence Malaysian residents' acceptance of renewable energy. Addressing this issue is essential because learning from experience is fundamental for promoting the development of renewable energy. Renewable energy development remains a concern of the Malaysian government. For example, in the 10th Malaysian Plan (2011–2015), the government aimed to achieve a renewable energy target of 985 MW by 2015, or 5.5% of Malaysia's total electricity generation mix. Concurrently, the National Renewable Energy Policy was also launched in 2010, and it set a target of 11% of the total energy from renewable sources (2080 MW) by 2020.

In this study, we apply a theoretical framework to understand the barriers to renewable energy acceptance in Peninsular Malaysia. In doing so, our objective is to identify and assess factors that influence the acceptance of renewable energy technology in Peninsular Malaysia. The conceptual foundations of renewable energy technology acceptance in Malaysia have not been fully developed so far, and there is no consensus regarding the key elements that capture the concept of green technology acceptance, particularly in relation to renewable energy. Therefore, this study will make a substantial contribution to the growing body of literature on renewable energy usage and will validate a comprehensive model of the elements that impede the acceptance of renewable energy technology.

2. Conceptual framework

The adoption of renewable energy from conventional energy sources is a socially oriented process in which individuals' perceptions play a pivotal role (Alam et al., 2014). Trudgill (1990) explained that people's knowledge of the environment can be one of the principal barriers responsible for the environmental policy implementation gap. It is important to note that use of technology is largely influenced by multidimensional forces that have societal, regulatory, and economic dimensions (Bush, 2006; Garcia et al., 2008; Leucht et al., 2010; Stephenson and Loannou, 2010).

User acceptance of technology has been recognized as an important field of study for over two decades (Chuttur, 2009). The technology acceptance model (TAM) was developed by Davis (1989) to determine the factors that cause failures of systems and technology. In his model, Davis (1989) proposed that users' motivations can be explained by the following three factors: perceived ease of use (PEOU), perceived usefulness (PU), and attitude toward the use of the technology (Davis, 1989).

The original TAM has been extended in many studies, mainly through examinations of the effects of external variables on internal beliefs, attitudes, and behavioral intentions. Additionally, studies have put forward a comprehensive framework of energy technology acceptance based on technology acceptance studies, and these aimed to explain the intention to act in the use of new sustainable energy technologies (e.g., Midden and Huijts, 2009). For example, studies have looked at the acceptance of carbon capture and storage technologies (Molin et al., 2007). Additionally, preferences for alternatively fueled cars (biodiesel vehicles, hybrid vehicles, and hydrogen vehicles) have been studied. Huijts et al. (2012) put forward a comprehensive framework for energy technology acceptance based on a review of psychological theories. Toft et al. (2014) analyzed the acceptance of electricity from renewable sources used to gain independence from imported fossil fuels. Gupta et al. (2012) reviewed socio-psychological determinants of the public acceptance of sustainable technologies, and Finucane et al. (2000) also investigated how people judge the risks and benefits of specific hazards and pointed out that there is an inverse relationship between perceived risk and perceived benefits.

These studies have shown that the TAM can be used as a comprehensive framework for energy technology acceptance based on technology acceptance studies. Owing to its holistic approach and its wide use in green energy technology research, the TAM allows researchers to understand the barriers facing renewable energy development; this framework is therefore used in this study.

3. Research design

An integrated model of renewable energy acceptance in the Malaysian context is developed based on the Davis (1989) TAM and technology acceptance framework (Huijts et al., 2012) (Fig. 3). This model is comprised of two external variables (cost and knowledge) and the residents' PEOU, PU, and attitude toward using the technology. In the TAM, PU together with PEOU are indicated as fundamental and distinct constructs that influence an individual's decision to use technology (or systems) (Davis, 1989). According to Moore and Benbasat (1991), PEOU is "the degree to which an innovation is perceived as being difficult to use." Davis (1989) defined PU as the user's belief that the technology improved performance.

The conceptual framework of the present research includes six main hypotheses to be tested. Hypotheses (H₁, H₂) and (H₃, H₄) reflect the influence of the two external variables, cost and knowledge, respectively, on the PEOU and the PU. Hypotheses H₅ and H₆ identify the effect of the PEOU and the PU on attitudes toward using technology, respectively. These hypotheses are

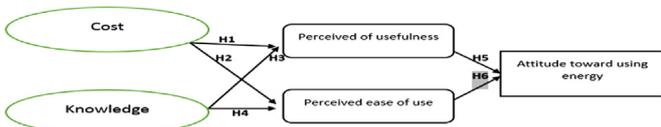


Fig. 3. Research model.

summarized as follows.

- H₁: cost (cost of using renewable energy) will positively affect the PU.
- H₂: cost (cost of using renewable energy) will positively affect the PEOU.
- H₃: knowledge will positively affect the PU.
- H₄: knowledge will positively affect the PEOU.
- H₅: PEOU will positively influence attitudes toward using technology.
- H₆: PU will positively influence PEOU.

The major objective of this study is to determine the factors influencing renewable energy acceptance in Peninsular Malaysia. We conducted an empirical survey to accomplish the objectives of the study. Here, we will briefly address some methodological issues related to the sampling and procedures (Section 3.1), the measures (Section 3.2), and the data analysis (Section 3.3).

3.1. Sampling and procedures

This research involved a nationally representative quota sample of Peninsular Malaysian citizens aged 20 years and over with higher education qualifications; 21.75% of the total population in this area (4,893,086) was interviewed face-to-face.

As the current study is quantitative, probability sampling and a stratified technique were employed to collect data. The samples for this study were collected from four regions (the north, south, east coast, and central regions) in Peninsular Malaysia, and the stratification technique is an appropriate method in this case.

Initially, a questionnaire was pretested to 50 academic professionals to establish the face validity of the items and to detect any problems with the questionnaire's contents, wording, and other design features.

Using the questionnaire, the data for this study were gathered using the face-to-face interview method. The probability stratified sampling method was used in this study owing to the cost and convenience of obtaining adequate respondents.

In order to conduct the survey, researchers and students from local cities were first identified and asked to collect data from 32 sample points selected randomly from a cluster sample. Second, to obtain a nationally representative quota sample, a total sample size of 784 was used (according to the Cochran formula). Third, the sampled elements were allocated across the four regions of Peninsular Malaysia (north, central, east coast, and south), thus allowing an adequate proportion of the total elements sampled for each region to be selected (north region: 23%; central region: 28%; south region: 27%; east coast region: 22%).

3.2. Measures

The scales used in this study were nominal and ordinal (i.e., the Likert scale). In order to determine demographic characteristics, nominal scales were used and ordinal scales (five-point Likert scales) were applied to investigate respondents' opinions towards the acceptance of renewable energy technology. Cox (1980) suggested that scale points between five and nine should be used depending on the specific situation. In this study, the five-point

scale was applied because it is employed in many studies of technology acceptance (Davis, 1989; Moon and Kim, 2001).

Table A1 in the Appendix presents the relationships among the research questions, hypotheses, variables, and the scales used in this study.

3.3. Data analysis

The analysis of the data was conducted in four stages. Descriptive analyses for all samples were performed with SPSS (Statistical Package for the Social Sciences). The SPSS software was used to screen the collected data prior to performing structural equation modeling. To test the hypotheses of this study, we applied structural equation modeling (SEM) by using AMOS 19.0 (Analysis of Moment Structures). The SEM method is a multivariate statistical technique that is often used to confirm causal relationships among latent variables. The SEM was conducted by using the two-stage approach recommended by Anderson and Gerbing (1988). The model fit was determined through goodness-of-fit indices, and the significance of paths was determined through the use of coefficient parameter estimates.

4. Results

4.1. Demographic profile of the respondents and public perceptions about climate change

As mentioned above, the data were collected from residents of Peninsular Malaysia. Table 4 reports the personal and demographic characteristics of the respondents. Approximately 56% of the respondents were male. Most of the respondents (75%) were between 20 and 40 years of age.

Table 4 Respondents' characteristics.

Demographic Profile	Number of respondents (N=784)	Valid percentage (%)
Gender		
Male	443	56.5
Female	341	43.5
Age		
21–30	399	51
31–40	174	22
41–50	109	14
51–60	77	10
61 above	25	3
Ethnic groups		
Malaysian	533	68%
Chinese	188	24%
Indian	63	8%
Monthly income		
RM1000 and below	141	18
RM1001–RM2000	220	28
RM2001–RM3000	148	19
RM3001–RM4000	110	14
RM4001–RM5000	78	10
RM5001 and above	87	11
Marital status		
Single	384	49
Married	337	43
Divorced/widow	63	8

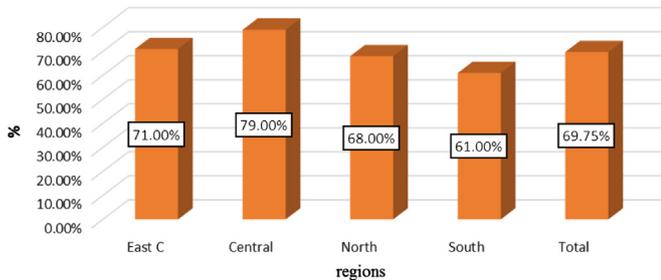


Fig. 4. Level of concern regarding climate change in Malaysia.

4.1.1. Public concern about climate change

To address the question of renewable energy acceptance, it is necessary to have a clear picture of how concerned the public is about climate change. Similar to the study by Capstick et al. (2015), respondents in this study were asked how concerned they were about climate change. This research found that the majority of Malaysians (69.75%) are concerned about climate change. This figure suggests that the level of concern regarding climate change in Malaysia is high, with only 12% of the public stating that they were not at all concerned about climate change. On a regional scale, data showed that public concern regarding climate change in the central regions was significantly higher than the average for Peninsular Malaysia (79%), while in the east coast (71%) and the north (68%), this figure was close to the average for Peninsular Malaysia (Fig. 4). In contrast, the data showed that only 61% of survey respondents were concerned about global warming in the south region, which is a considerably smaller proportion than both the average proportion and the values for other regions.

4.1.2. Responses to “when you think of global warming/climate change, what first comes to mind”?

The results of this study show that the term “climate change” evokes different free associations among the Malaysian public. The majority of associations with the term “climate change” fell into the “weather” (87%) and “rain” (79%) categories, while the smallest category was “greenhouse gases (GHGs)” (see Fig. 5).

4.1.3. Measures to increase public awareness of environmentally friendly practices

In the questionnaire used in this study, respondents were also asked to give their views on measures that could be taken by the government to increase public awareness of environmentally friendly practices and green technology products (see Table 5).

The results demonstrate that the public recommended three measures in particular. These measures included introducing environmental and technology curriculum at all levels of school (mean=4.26), improving environmental campaigns and the portrayal of green technology in mass media and social media (mean=4.24), and introducing a one-stop center/agency to disseminate information on green technology (mean=4.09).

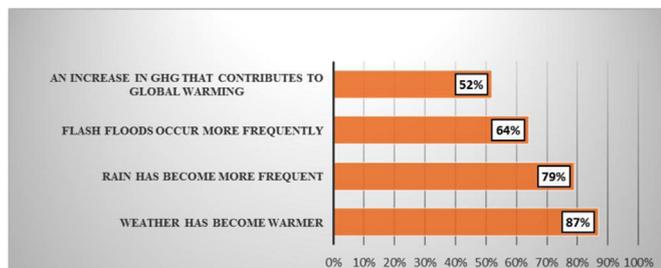


Fig. 5. Climate change associations.

Table 5

Measures to increase public awareness of environmentally friendly practices.

Statements	Mean
Modules on green technology should be introduced at all school levels	4.26
Campaigns on the environment and the use of green technology should be increased via mass media and social media	4.24
The introduction of a one-stop center/agency to disseminate information on green technology is appropriate	4.09

4.2. Normality

A critically important assumption in the conduct of SEM analyses in general, and in the use of AMOS in particular, is that the data are multivariate and normally distributed. This means that the SEM variables have to be normally distributed (Tabachnick and Fidell, 2001). Thus, before data analysis, it is important to check that this criterion has been met. For checking for any abnormality, one method is to evaluate the skewness and kurtosis values. If the observed distribution is exactly normal, these values should not be significant. Kline (1998) reported that values of the kurtosis index greater than 10.0 suggest a problem. Additionally, absolute values of skewness and kurtosis should not be greater than 3 and 10, respectively. By applying AMOS 19.0, the values of both skewness and kurtosis were calculated. Results showed that the skewness and kurtosis values conformed to the above-mentioned criteria. Therefore, the assessment showed that there was no severe deviation from normality. As mentioned by Tabachnick and Fidell (2001), if these variables do not deviate from normality, it is not necessary to make any adjustments such as transformation of the data.

4.3. Fit indices and model estimates

In SEM, the hypothesized model can be presented in the form of a path diagram. As shown in Fig. 6, the SEM diagram in this study consisted of five constructs including cost, knowledge, PEOU, PU, and attitude toward using technology (AT), which are presented in ovals. The single-headed arrows in the diagram indicate that one variable (construct) is dependent on another (causal paths or relationships). Measurement error has been represented and enclosed in small circles.

One particularly important issue in SEM is to determine how well the sample data fit the theoretical model. In other words, to what extent is the theoretical model supported by the obtained sample data? Global omnibus tests of the fit of the model are available as well as the fit of individual parameters in the model.

To determine whether the model fits the data, there are a series of goodness-of-fit indices that can be used with SEM. To provide the best general picture of the model fit, Hair et al. (2003) and Holmes-Smith et al. (2006) suggested the use of at least three fit indices. This research adopts those measures most commonly used in TAM research, in which four fit indices are reflected. As outlined in Table 6, these four indices include the goodness-of-fit index (GFI), the root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the normalized chi-square (χ^2/df). The GFI measure indicates the relative amount of variance and covariance together, as set out in the model by Byrne (2012). The RMSEA measure assists in correcting the tendency of the chi-square index to reject specified models, while the CFI compares the covariance matrix predicted by the model to the observed covariance matrix; the normalized chi-square (χ^2/df) evaluates the appropriateness of the model (Hair et al., 1995).

All fit indices suggest that the covariance structure constructed in the substantive model fits the data acceptably (according to the Hair et al. (2003) acceptable fit thresholds, which are given in

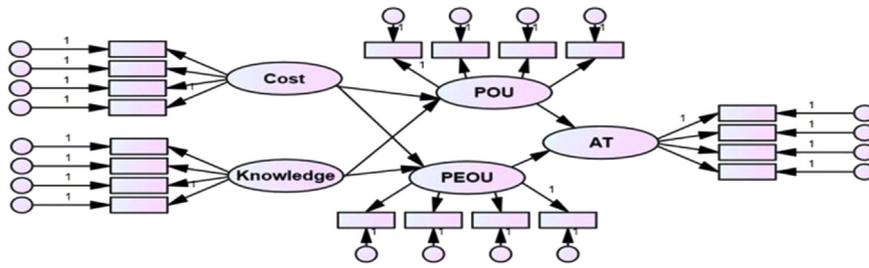


Fig. 6. Path diagram.

Table 6
Fit indices for the substantive model.

Name of Index	Level of acceptance	Index value	Comment
GFI	GFI \geq 0.90	0.904	The required level was achieved
RMSEA	RMSEA \leq 0.08	0.0646	The required level was achieved
CFI	CFI \geq 0.9	0.902	The required level was achieved
χ^2/df	$\chi^2/df \leq$ 0.5	3.451	The required level was achieved

Table 6 for each fit index).

4.4. Results of hypotheses testing

After conducting the first step (measurement model), a structural model was tested as the second stage of the analysis. In this study, the objective of the structural model was to test the hypotheses in order to address the research questions discussed above.

As presented in Table 7, these hypotheses are represented in six paths (H_1 , H_2 , H_3 , H_4 , H_5 , and H_6) to determine the relationships between the constructs in the adopted model. In the proposed theoretical model, there are two categories for constructs, namely, external constructs (cost, knowledge) and endogenous constructs (PU, PEOU, and attitude toward using the technology).

In testing the hypothesized model, the results presented in Table 7 indicate that the hypotheses H_1 , H_2 , H_3 , H_5 , and H_6 were statistically significant and in the hypothesized direction. Thus, these hypotheses were supported. The hypothesis H_4 was rejected because it was not statistically significant. The indices for goodness-of-fit demonstrate that this model fits the data adequately.

From the results, it can be seen that PU has a statistically significant, positive (0.006), and direct impact on attitudes toward using renewable energy. The results of this study also demonstrate that the PEOU has a statistically significant, positive (0.001), and

Table 7
Results for testing with the hypothesized model.

Construct	Path	Construct	P-value	Result	Result for hypothesis
Perceived usefulness	←	Cost (H_1)	0.001	Significant	Supported
Perceived ease of use	←	Cost (H_2)	0.001	Significant	Supported
Perceived usefulness	←	Knowledge (H_3)	0.012	Significant	Supported
Perceived ease of use	←	Knowledge (H_4)	0.629	Insignificant	Not supported
Attitude	←	Perceived usefulness (H_5)	0.006	Significant	Supported
Attitude	←	Perceived ease of use (H_6)	0.001	Significant	Supported

direct impact on attitudes toward using renewable energy. In terms of cost and knowledge, results show that cost has a statistically significant and direct impact on both PU and PEOU (0.001), and via these factors, it influences users' attitudes towards using renewable energy. However, knowledge concerning renewable energy has been found to be an important factor affecting attitudes towards using renewable energy through its indirect impact on PU. The results for this factor indicate that the hypothesis claiming that knowledge positively affects PEOU should be rejected, and only the positive impact of knowledge on PU is supported. This means that our findings support the path from knowledge to PU, but reject the path from knowledge to PEOU.

5. Discussion

This study finds that the majority of Malaysians are concerned about climate change. Similarly, Corner et al. (2011) reported that 71% of the UK population were either fairly or very concerned about climate change. It seems that the level of concern regarding global warming in Peninsular Malaysia is approximately equal to that in the population of the UK. The results of this study showed that the term "climate change" evoked different free associations among the Malaysian public. Following this strategy, respondents in this study were asked their opinion regarding climate change associations and, as shown in Fig. 5, results showed that the term climate change elicits significantly more associations with weather than with GHGs. Interestingly, Leiserowitz et al. (2014) also reported that, for the American public, climate change also evokes significantly more associations with weather.

This is the first study to investigate the effects of PU and PEOU on attitudes toward using renewable energy technology in the Malaysian context. The results of this study indicate that both these factors are important in determining the acceptance and use of renewable energy in Malaysia. This finding is supported by Liang and Yi-Hsuan (2009), who claimed that PU has been proven to be the most significant element in explaining why people adopt a technology and because of that, this concept "has remained relatively unchanged since the inception of the research stream." Venkatesh et al. (2003) also mentioned that PU is a powerful element for "intention to use" in technology adoption. Similarly, Han (2003) pointed out that in determining usage behavior, the importance of PU should be stressed. The PU has been consistently shown to be a powerful predictor for "intention to use" in technology adoptions and related literature (Venkatesh et al., 2003).

Modeling results suggest that the cost of renewable energy has an indirect effect on attitudes towards using renewable energy through associated impacts on PU and PEOU. A possible explanation for this might be that Malaysia is among the nations with the highest fossil fuels subsidies. Subsidies for fossil fuels have resulted in market failure and made it difficult for renewable energy technologies to compete economically. The cost of producing and using renewable energy is therefore relatively expensive. Fig. 7 provides more details concerning fuel subsidies in Malaysia

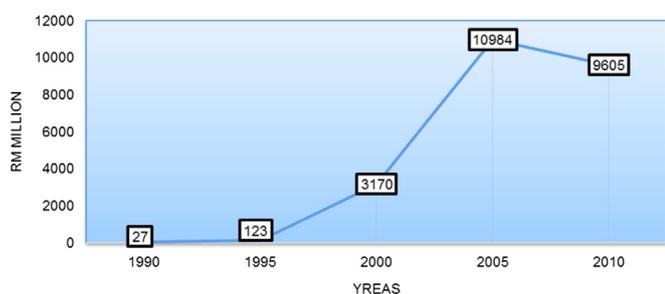


Fig. 7. The fuel subsidy trend in Malaysia. Source: Hamid and Rashid (2011).

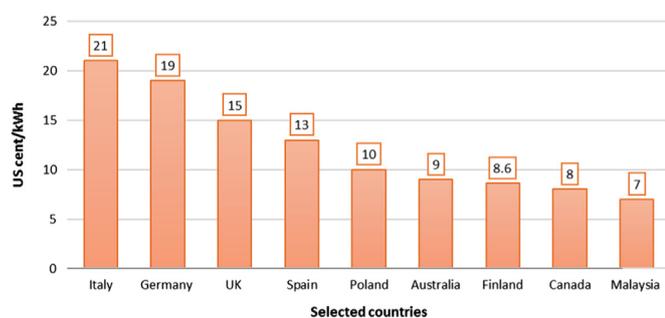


Fig. 8. Average electricity prices in US cents/kWh for selected countries. Source: Nus consulting group (2014) and Tenaga Nasional Berhad (TNB) (2015).

between 1990 and 2010. Note that in 2007, energy subsidies in Malaysia were the second largest in the ASEAN region (after Indonesia) and exceeded 8 billion USD.

Another possible explanation is that in Malaysia the electricity price was low and did not account for the external costs. Because of inadequate tariffs, renewable energy producers could not sell their power to the market at a profitable price. Fig. 8 shows the electricity prices for selected countries.

This finding is in line with the findings of Seng et al. (2008), who reported that in Malaysia, owners of PV systems were not able to make any financial return on their investment, and as a result, the current size of the PV market was very small. It should be noted that Ölz and Beerepoot (2010) suggested the removal of distortionary subsidies for fossil fuel consumption and production. These subsidies often disproportionately benefit more affluent segments of society, and their removal will help level the playing field so that renewable energy technologies can compete with other energy technologies. In this regard, it is critical to take into account the external benefits and costs of all energy technologies. Overall, in terms of cost barriers, the economic ethos of Malaysia does not support renewable energy, especially in terms of providing a balance between costs and benefits.

Knowledge concerning renewable energy has been found to be an important factor affecting attitudes towards using renewable energy only through its indirect impact on PU. The results for this factor indicate that the hypothesis that claims that knowledge positively affects PEOU should be rejected, and only the positive impact of knowledge on PU is supported. This result implies that knowledge regarding renewable energy does not coincide with the perception that using renewable energy would be effortless. Therefore, people feel that the use of renewable energy would involve a high level of effort, and this has a negative effect on their attitude toward using renewable energy technology. A possible explanation for these results may be a lack of knowledge and skill among the professionals and technicians in the renewable energy sector. Ölz and Beerepoot (2010) have emphasized that limited capacity in renewable energy technology manufacturing and servicing, and a lack of skilled technicians for the installation and maintenance of technologies impede the introduction of

renewable energy technologies in Malaysia.

There are, however, other possible explanations. This result may also be explained by the fact that little effort has been put into shaping public opinion to support renewable energy policy in Malaysia. In this study, when respondents were asked to give their views on the measures that could be taken by the government to increase public awareness of environmentally friendly practices and renewable energy products, three recommendations stood out. These three reasons indicated why public knowledge in Peninsular Malaysia does not support PEOU for renewable energy, i.e., the lack of appropriate programs in the educational system, the absence of the role of mass media, and the absence of a government policy implemented through one agency.

Lack of knowledge is also likely to be related to inadequate research and development (R&D). After announcing the Five Fuel Policy and setting the 5% target for renewable energy, government budget appropriations for environmental R&D should have increased, but the opposite occurred. According to the Malaysian Science and Technology Information Center, in 2002, the total R&D expenditure in Malaysia was 0.69% of the GDP, while in 2006 this value declined to 0.64% of the GDP. In the energy sector, government R&D programs and R&D pursued by utility companies play a vital role in generating knowledge. Thus, the lack of funding for new knowledge creation in renewable energy technologies may have allowed detrimental “business-as-usual” scenarios to persist.

6. Conclusion and policy implications

The Malaysian government has begun to focus on renewable energy to address the climate change challenge and meet energy needs in a sustainable way. Renewable energy was first announced in the country's energy mix through the Fifth Fuel Policy under the 8th Malaysian Plan. Over the past 14 years, the government of Malaysia has applied many different policies to promote the implementation of renewable energy as an alternative energy. Despite the continuous efforts to develop renewable energy, renewable energy is not yet utilized to its maximum potential in Malaysia, and the implementation of renewable energy policy has received a sluggish response.

By proposing a technology acceptance framework, this study set out to understand the public's acceptance of renewable energy technologies in Peninsular Malaysia, as public acceptance of renewable energy technology is an essential element for diffusion and development of renewable energy. To this end, a structure equation model was employed to analyze data collected by surveying residents' intentions to use renewable energy in four regions of Peninsular Malaysia. This represents the first study reporting the applicability of technology acceptance models in Malaysia, as most previously published studies have focused on data from western countries (e.g., Sweden, the UK).

This study has shown that PU is an important factor in influencing the intention to use renewable energy. The second major finding was that PEOU is also an important factor affecting the intention to use renewable energy. These findings enhance our understanding of the barriers to developing renewable energy in Malaysia.

The results of this survey may motivate policy makers to pay more attention to the role of public perception and awareness in the successes and failures of renewable energy policy. This study has raised our understanding about important role of public knowledge in renewable energy acceptance in Peninsular Malaysia.

There is, therefore, a definite need for increasing the awareness of the public about the costs and benefits of renewable/sustainable energy technologies through suitable programs and campaigns.

Table A1

Relationships among research questions, hypotheses, variables, and the scale development for this study.

Objectives	Construct	Hypothesis	Scale	Relevant questions
1 Classify respondents'demographic profile			Nominal	Income Age Gender
2 Determine respondents'attitude toward using renewable energy	Attitude toward using renewable energy		Likert 5 point	Q8-I intend to use renewable energy technology as often as necessary. Q9-I intend to continue using renewable energy in the future. Q10-Assuming I have access to renewable energy technology, I intend to use it. Q11-I find the quality of renewable energy products is not as good as ordinary products. Q12-I will strongly recommend that others use renewable energy technology.
3 Investigate opinions on renewable energy acceptance	Perceived usefulness (PU)	PU → AT	Likert 5 point	Q13-Renewable energy technology improves the quality of daily life for the public at home. Q14-Renewable energy technology makes it easier to protect the environment. Q15-Continuous use of renewable energy technology enables me to reduce my electricity costs. Q16-Renewable energy products enable me to protect the health of society. Q17-Using renewable energy technology enhances the effectiveness of using energy.
4 Investigate opinions on renewable energy acceptance	Perceived ease of use (PEOU)	PEOU → AT PEOU → PU	Likert 5 point	Q18-Learning to operate renewable energy is easy for me. Q19-I find it easy to make renewable energy technology do what I want it do. Q20-I find renewable energy technology flexible to interact with. Q21-It is easy for me to become skillful at using renewable energy technology. Q22-Overall, I find renewable energy technology easy to use.
5 Investigate the influence of external variables on TAM's core hypothesis	Cost	Cost → PEOU Cost → PU	Likert 5 point	Q23-I find that renewable energy products are more expensive. Q24-I find the purchase of renewable energy products a good investment for future generations. Q25-I find that renewable energy products are more expensive compared with other product brands. Q26-I think that renewable energy products should be cheaper price to encourage their purchase.
6 Investigate the influence of external variables on TAM's core hypothesis	Knowledge (Kn)	Kn → PEOU Kn → PU	Likert 5 Point	Q27-I think that the weather has become warmer in Malaysia. Q28-I think that the level of consciousness and knowledge amongst Malaysians regarding environmental care should be increased. Q29-Excessive burning of fossil fuel is the main reason for climate change. Q30-The excessive use of natural resources (such as water and air) is the reason for climate change. Q31-Green technology minimizes degradation to the environment.

Another important practical implication is that education and material dissemination related to renewable energy should be introduced at all school levels and information from resource studies about various renewable technologies should be made available through government programs and initiatives. Considering the fact that in the energy sector, government R&D programs play a vital role in the development of renewable energy technology (Jacobsson and Johnson, 2000), a key government priority should be to increase budget appropriations for environmental R&D. Moreover, efforts are needed to contribute to local knowledge, which is knowledge that is “practical, collective and strongly rooted in a particular place” (Geertz, 2000), and to stimulate the policymaking process from problem definition and policy formulation to policy implementation and policy evaluation.

The results of the SEM analysis confirm the expectancy that the intention to use renewable energy is influenced by the cost of renewable energy technology. Cost affects users’ motivation for using renewable energy by its indirect impact on PU and PEOU. It is therefore important that the cost of renewable energy products be reduced, especially for end users. These findings suggest several courses of action for controlling market risk and reducing the cost of renewable energy technology, which should be done by the government. Management to remove distortionary subsidies for fossil fuel consumption and production should be a key focus of governmental energy policy. As fundamental fiscal policy, a green tax should be implemented that levies taxes on activities and products that have a negative impact on the environment and curtails subsidies that favor unsustainable development. As the result of this study shows that knowledge only affects PU, further studies are needed to validate the impact of knowledge on PU and PEOU.

Appendix A

See Table A1

References

- Alam, S.S., Hashim, N.H.N., Rashid, M., Omar, N.A., Ahsan, N., Ismail, M.D., 2014. Small-scale households renewable energy usage intention: theoretical development and empirical settings. *Renew. Energy* 68, 255–263.
- Anderson, J.C., Gerbing, D.W., 1988. Structural equation modeling in practice: a review and recommended two-step approach. *Psychol. Bull.* 103, 411–423.
- Bindoff, N.L., et al., 2007. Observations: oceanic climate change and sea level. In: Solomon, S., et al. (Eds.), *Climate Change 2007: The Physical Science Basis*. Cambridge University Press, pp. 385–432.
- Bush, S.R., 2006. Acceptance and suitability of renewable energy technologies in Lao PDR. The Netherlands Environmental Policy Group, Wageningen University, The Netherlands.
- Byrne, B.M., 2012. *A primer of LISREL: Basic Applications and Programming for Confirmatory Factor Analytical Models*. Springer Science & Business Media, Berlin, Germany.
- Capstick, S.B., Demski, C.C., Sposato, R.G., Pidgeon, N.F., Spence, A., Corner, A., 2015. Public perceptions of climate change in Britain following the winter 2013/2014 flooding. Understanding Risk Research Group Working Paper 15-01, Cardiff University, Cardiff, UK.
- Chang, J., Leung, D.Y., Wu, C.Z., Yuan, Z.H., 2003. A review on the energy production, consumption, and prospect of renewable energy in China. *Renew. Sustain. Energy Rev.* 7 (5), 453–468.
- Chua, S.C., Oh, T.H., 2010. Review on Malaysia’s national energy developments: key policies, agencies, programmes and international involvements. *Renew. Sustain. Energy Rev.* 14 (9), 2916–2925.
- Chua, S.C., Oh, T.H., Goh, W.W., 2011. Feed-in tariff outlook in Malaysia. *Renew. Sustain. Energy Rev.* 15, 705–712.
- Chuttur, M., 2009. Overview of the technology acceptance model: origins, developments and future directions. *Work. Papers Inf. Syst.* 9 (37), 9–37.
- Corner, A., Venables, D., Spence, A., Poortinga, W., Demski, C., Pidgeon, N., 2011. Nuclear power, climate change and energy security: exploring British public attitudes. *Energy Policy* 39 (9), 4823–4833.
- Cox, E.P., 1980. The optimal number of response alternatives for a scale: a review. *J. Mark. Res.* 17, 407–422.
- Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* 13 (3), 319–339.
- EPU (Economic Planning Unit Malaysia), 1981. Third Malaysia Plan 1981–1985. Available at: (<http://www.epu.gov.my/web/guest/fourth-malaysia-plan-1981-1985>).
- EPU (Economic Planning Unit Malaysia), 2010. 10th Malaysian Plan. Putrajaya, Malaysia. Available at: (http://www.epu.gov.my/epu-theme/RMKE10/rmke10_bm.html).
- Finucane, M.L., Alhakami, A., Slovic, P., Johnson, S.M., 2000. The affect heuristic in judgments of risks and benefits. *J. Behav. Decis. Mak.* 13 (1), 1–17.
- Garcia, C.O., Perez-Lugo, M., Baiges, I., 2008. Study on Community Perception and Attitude About the Location of a Pilot Windfarm Project in Vieques, ITEAS, Puerto Rico.
- Geertz, C., 2000. *Local Knowledge: Further Essays in Interpretive Anthropology*. vol. 5110. Basic Books, USA.
- Gupta, N., Fischer, A.R.H., Frewer, L.J., 2012. Socio-psychological determinants of public acceptance of technologies: a review. *Public Understand. Sci.* 21 (7), 782–795.
- Haris, I. A. Hadri, Ding, J., 2009. The Final Report on the Renewable Energy Policy and Action Plan. Ministry of Energy, Green Technology and Water Malaysia.
- Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1995. *Multivariate Data Analysis* (3rd ed.). Macmillan Publishing Company, New York.
- Hair, J.F., Bush, R.B., Ortinau, D.J., 2003. *Marketing Research within a Changing Information Environment*. McGraw-Hill, New York, NY.
- Hamid, K.A., Rashid, Z.A., 2011. Economic Impacts of Subsidy Rationalization Malaysia. Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies, ERIA Research Project Report. vol. 17, 2011, pp. 207–252.
- Han, S., 2003. Individual Adoption of Information Systems in Organizations: A Literature Review of Technology Acceptance Model. TUCS Technical Report. TUCS, India, p. 540.
- Hashim, H., Ho, W.S., 2011. Renewable energy policies and initiatives for a sustainable energy future in Malaysia. *Renew. Sustain. Energy Rev.* 15 (9), 4780–4787.
- Holmes-Smith, P., Coote, L., Cunningham, E., 2006. *Structural Equation Modelling: From the Fundamentals to Advanced Topics*. SREAMS, Melbourne.
- Huijts, N., Molin, E., Steg, L., 2012. Psychological factors influencing sustainable energy technology acceptance: a review-based comprehensive framework. *Renew. Sustain. Energy Rev.* 16 (1), 525–531.
- IPCC (Intergovernmental Panel on Climate Change), 2007. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change – Climate Change 2007: Mitigation of Climate Change, IPCC Secretariat, Geneva.
- IPCC (Intergovernmental Panel on Climate Change), 2014. Summary for policy-makers. In: Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E. S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom; New York, NY, USA, pp. 1–32.
- Jacobsson, S., Johnson, A., 2000. The diffusion of renewable energy technology: an analytical framework and key issues for research. *Energy Policy* 28 (9), 625–640.
- Kline, R.B., 1998. *Principles and Practice of Structure Equation Modelling*, 1st ed. The Guildford Press, New York.
- Klugman, J., 2011. *Sustainability and Equity: A Better Future for All*. Human Development Report. UNDP, New York, USA.
- Lau, L.C., Tan, K.T., Lee, K.T., Mohamed, A.R., 2009. A comparative study on the energy policies in Japan and Malaysia in fulfilling their nations’ obligations towards the Kyoto Protocol. *Energy Policy* 37, 4771–4778.
- Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., Rosenthal, S., Marlon, J., 2014. *Climate Change in the American Mind: Americans’ Global Warming Beliefs and Attitudes in November 2013*. Yale Project on Climate Change Communication. Yale University and George Mason University, New Haven, CT.
- Leucht, M., Kölbl, T., Laborgne, P., Khomenko, N., 2010. The role of societal acceptance in renewable energy innovations breakthrough in the case of deep geothermal technology. In: *Proceedings of the World Geothermal Congress, Bali, Indonesia*.
- Liang, T.P., Yi-Hsuan, Y., 2009. Situational effects on the usage intention of mobile games. In: Weinhart, Christof, Luckner, Stefan, Stößer, Jochen (Eds.), *Designing E-Business Systems. Markets, Services, and Networks*. Springer, Berlin Heidelberg, pp. 51–59.
- Malaysia Energy Information Hub, 2015. (<http://meih.st.gov.my/statistics>). (accessed 18.09.15).
- Maulud, A.L., Saidi, H., 2012. The Malaysian fifth fuel policy: re-strategising the Malaysian renewable energy initiatives. *Energy Policy* 48, 88–92.
- Midden, C.J.H., Huijts, N.M.A., 2009. The role of trust in the affective evaluation of novel risks: The case of CO₂ storage. *Risk Anal.* 29, 743–751.
- Molin, E., Aouden, F., van Wee, B., 2007. Car drivers’ stated choices for hydrogen cars: evidence from a small-scale experiment. In: *86th Annual Meeting on Transportation Research Board*.
- Moon, J.W., Kim, Y.G., 2001. Extending the TAM for a World-Wide-Web context. *Inf. Manag.* 38 (4), 217–230.
- Moore, G.C., Benbasat, I., 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. *Inf. Syst. Res.* 2

- (3), 192–222.
- MOSTE (Ministry of Science, Technology and Environment), 2000. Malaysia Initial National Communication, pp. 131.
- Muhammad-Sukki, F., Ramirez-Iniguez, R., Abu-Bakar, S.H., McMeeekin, S.G., Stewart, B.G., 2011. An evaluation of the installation of solar photovoltaic in residential houses in Malaysia: Past, present, and future. *Energy Policy* 39, 7975–7987.
- NEB (National Energy Balance), 2010. National Energy Balance. Ministry of Energy, Water and Green Technology, Putrajaya, Malaysia.
- NEDO (New Energy and Industrial Technology Development Organization), 2004. Infrastructure Improvement Project for Rationalization of International Energy Use. Survey Project on Best Practices of Energy Conservation for Building in Southeast Asian Countries. Available at: (<http://www.eccj.or.jp/cooperation/2-1-2/2004/14.pdf>).
- Nus consulting group, 2014. Available at: (<http://www.statista.com/statistics/263492/electricity-prices-in-selected-countries>).
- Oh, T.H., Pang, S.Y., Chua, S.C., 2010. Energy policy and alternative energy in Malaysia: issues and challenges for sustainable growth. *Renew. Sustain. Energy Rev.* 14 (4), 1241–1252.
- Ölz, S., Beerepoot, M., 2010. Deploying renewables in Southeast Asia: Trends and potentials. OECD Publishing, U.K..
- Othman, M.R., Zakaria, R., Fernando, W.J.N., 2009. Strategic planning on carbon capture from coal fired plants in Malaysia and Indonesia: a review. *Energy Policy* 37 (5), 1718–1735.
- Poh, K.M., Kong, H.W., 2002. Renewable energy in Malaysia: a policy analysis. *Energy Sustain. Dev.* 6 (3), 31–39.
- Rahim, K.A., Liwan, A., 2012. Oil and gas trends and implications in Malaysia. *Energy Policy* 50, 262–271.
- Saboori, B., Sulaiman, J., Mohd, S., 2012. Economic growth and CO₂ emissions in Malaysia: a cointegration analysis of the environmental Kuznets curve. *Energy Policy* 51, 184–191.
- Safaai, N.S.M., Noor, Z.Z., Hashim, H., Ujang, Z., Talib, J., 2011. Projection of CO₂ emissions in Malaysia. *Environ. Prog. Sustain. Energy* 30 (4), 658–665.
- Seng, L.Y., Lalchand, G., Lin, G.M.S., 2008. Economical, environmental and technical analysis of building integrated photovoltaic systems in Malaysia. *Energy Policy* 36, 2130–2142.
- Sovacool, B.K., Drupady, I.M., 2011. Examining the Small Renewable Energy Power (SREP) Program in Malaysia. *Energy Policy* 39 (11), 7244–7256.
- Stephenson, J., Loannou, M., 2010. Social Acceptance of Renewable Electricity Developments in New Zealand. Centre for the Study of Agriculture, Food and Environment, University of Otago. Energy Efficiency and Conservation Authority.
- Tabachnick, B.G., Fidell, L.S., 2001. *Using Multivariate Statistics* Boston, 4th ed. Allyn and Bacon, USA.
- Tenaga Nasional Berhad (TNB), 2015. Available at: (<http://www.tnb.com.my/tnb/re-sidential/pricing-and-tariff/tariff-rates.html>).
- Toft, M.B., Schuitema, G., Thøgersen, J., 2014. Responsible technology acceptance: model development and application to consumer acceptance of Smart Grid technology. *Appl. Energy* 134, 392–400.
- Trenberth, K.E., 2009. An imperative for adapting to climate change: Tracking Earth's global energy. *Curr. Opin. Environ. Sustain.* 1, 19–27. <http://dx.doi.org/10.1016/j.cosust.2009.06.001>.
- Trudgill, S., 1990. *Barriers to a Better Environment: What Stops us from Solving Environmental Problems?*. Belhaven Press, London.
- UTM (Universiti Teknologi Malaysia), 2007. National Coastal Vulnerability Index Study – Phase 1. Drainage and Irrigation Department (DID). Ministry of Natural Resources and Environment Malaysia, Malaysia.
- Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User acceptance of information technology: Toward a unified view. *MIS Q.* 27, 425–478.