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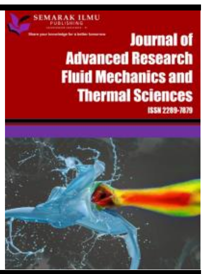

AHP Analysis on the Criteria and Sub-Criteria for the Selection of Fuel Cell Power Generation in Malaysia

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ABSTRACT

Malaysia is currently facing challenges in finding the right mix of energy sources for achieving sustainable energy supply. In term of fuel cell technology development, Malaysia is lacking the economic and infrastructure factors, besides local expertise, public perception, and industrial support. In fact, fuel cell technology at the present time is not being commercialized on a large scale in Malaysia. Due to much research is focused to the transportation sector, research on the other sectors, especially for power generation, is relatively lacking in Malaysia. For a start, this study aims to identify the criteria and sub-criteria for selecting the sources of fuel cell technology for power generation. An AHP analysis based on a group decision was performed and has found the impact on ecosystem (from environmental criterion), payback period, and investment cost (from economic criterion) are the most important sub-criteria for selecting the sources of power generation with fuel cell technology. This suggests that when it comes to renewable energy, the effect on environment will always come first in the mind. However, when it comes to the acquisition of fuel cell technology, no doubt that the economic factors are the main concern. This implies the focus should be on how to make the sources of fuel cell technology economical to justify its adoption. On the other hand, the less important criterion is technical, while the less important sub-criterion of technical is the technological maturity. However, this does not necessarily mean the technological factors are not important, but at the current stage of fuel cell technology development in Malaysia other issues seem to be more profound. For future study, few suggestions were made to improve the model.

Keywords:
AHP; fuel cell; renewable energy; sustainability; technology selection

1. Introduction

The world is currently facing a challenge to sustain energy supply due to fossil fuels depletion, unstable market prices, limited and unsustainable resources in long-term. To make it worst, 86.92% of electricity (power) generation as in 2015 are coming from fossil fuel-based resources [1]. In fact, relying heavily on fewer exporters of non-sustainable resources has elevated the energy crisis in European Union (EU). This was recently evidenced when the Russian gas flowing through Ukraine's pipelines was halted [73]. Meanwhile, in Malaysia, 80% of the total anthropogenic greenhouse gases

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in 2014 was contributed by the power sector alone, due to high dependency on fossil fuels [74]. Despites that, most countries are facing the challenge of finding the right fuel mix to ensure a sustainable and secure energy supply [2].

In the meantime, the world has recorded increasing energy demands from both developed and emerging economies, which has elevated the challenges on energy supply. The solution to this problem comes from renewable energy, which are basically clean, environmentally friendly, and abundant [3]. Based on a report from the United Nations in the trends of consumption and production of energy, household sector is representing up to 25% of energy consumption in the developed economies, and even more for the developing economies. However, the diffusion of new energy technologies in the developing economies has been slow [4].

In power generation industry, fuel shortages such as gas and coal are the real problems facing today. These fuels are now at high prices and suppressing the energy industry and so do with the consumers. In Malaysia, the impact of fossil fuels on the economy and the environment is increasingly difficult to disregard [5]. In term of alternative energy, biomass resources in Malaysia create huge potential for fuel mix generation. Unfortunately, exhaust gas from biomass combustion may contain pollutants to the environment, causing acidification, urban smog and other [6]. Besides biomass, solar photovoltaic (PV) also provides significant source of energy in Malaysia, but a solar plant would require about 10 times more land to achieve the same amount of output from fuel cell [7]. Besides that, heat can reduce solar PV efficiency [76].

Despite of the advantages of fuel cell technology, at the present time it is not being commercialized on a large scale especially for power generation [8]. In addition, fuel cell technology is mainly focused on and limited to the transportation (automotive) sector, such as by Taib *et al.,* [77]. Malaysia is relatively behind in the fuel cell technology development, from the economic and infrastructure perspectives, besides lacking local expertise, public perception, and industrial support [10,11].

Therefore, study on fuel cell technology is important to encourage the adoption process and utilization of fuel cell energy in parallel with the Government of Malaysia's policy to move towards green energy and achieving the target of 4000MW of renewable energy capacity by 2030. Hence, pilot projects, government policy and infrastructural development is central to strengthen the prospect of hydrogen fuel cell implementation in Malaysia [12]. However, a feasibility study comparing the renewable energies has found the implementation cost for fuel cell technology is the highest due to its early stage of adoption [13]. This implies the process of selecting the most appropriate fuel cell technology for power generation is quite challenging. Despite that, the multi-criteria decision making (MCDM) with Analytic Hierarchy Process (AHP) is found to be the popular technique for providing solution to the sustainable energy management problems [62].

Accordingly, a review by Zaidi *et al.,* [38] has found the decision-making process with multi criteria have been applied by numerous studies, covering wide variety of areas, focusing on many criteria and sub-criteria, for the purposes of selecting, allocating, evaluating, or benchmarking different alternatives of technology. However, previous studies within and between countries have found different results of the best renewable energy. In the field of sustainable energy, it was found the decision-making process with multi criteria, especially with AHP, for selecting the sources of power generation technology is still limited. In term of fuel cell technology, the study is quite low especially in Malaysia. Due to this research gap, this study is focusing on the important factors for decision making in selecting the appropriate fuel cell technology for power generation. Specifically, this study aims to achieve the objective – to identify the criteria and sub-criteria for selecting the best source of fuel cell technology for power generation in Malaysia with AHP model.

2. Fuel Cell Technology

Fuel cell technology is quite new in ASEAN renewable energy development. It has the potential to become a future energy system. It is a promising technology for power generation with clean emission [59]. Fuel cell is an electrochemical gadget that converts chemical energy directly into electrical power that can be used in stationary and mobile applications. One great appeal of fuel cell is that they generate electricity with very little pollution. This happen due to the hydrogen and oxygen that are used in generating electricity in combination will form a harmless by-product, namely water. Fuel cell systems can improve the efficiency up to three times the efficiency of traditional combustion technologies corresponding to more than 50% reduction in fuel consumption. Nowadays, to improve efficiencies, flexibility and possibly costs of current biomass power generating systems, a power plant concept combining with fuel technology are being looking forward [14].

In the future, fuel cell could also join electricity as an important energy generation. For instance, European countries through Strategic Energy Technology Plan are investing about £1.4 billion on fuel cell and hydrogen technology as a new target to reduce the dependency on fossil fuel and emissions [15]. State officials in Connecticut approved plans to build what will be the largest fuel cell power plant in the world. Equipped with 21 fuel cells, the 63.3-MW Beacon Falls fuel cell power plant is expected to be completed in 2019 [7]. Currently, the largest fuel cell power plant in Hwasung City, South Korea consists of 21 2.8-MW hydrogen fuel cells with a total of 59MW [16]. In developing country, fuel cell is yet to be applied commercially and it remains under study for some research centres throughout the region [17].

In Malaysia, the government has identified solar, hydrogen energy and fuel cell as priority research areas in the alternative energy family, hence Malaysia has started seriously to invest in R&D in this field of study [12]. According to Akademi Sains Malaysia [18], fuel cell is on the top five lists of emerging technology in green technology that were identified as having potential application towards realizing a progressive Malaysia towards 2050. According to the Malaysia hydrogen roadmap, Malaysia will be a global supplier of hydrogen fuel and provide the hydrogen distribution system and infrastructure for local networks by 2030 [19]. Electricity generation by fuel cell is targeted at 3000 GWh by 2035. Parallel to this, Sarawak Energy Berhad will spearhead a RM5 million feasibility study on hydrogen and fuel cell application in Sarawak, Malaysia [20]. Therefore, it is expected fuel cell-based energy system can be implemented for electricity generation in line with the government target to improve the penetration of renewable energy to 30% of electricity generation in 2050.

Due to various challenges, selection of fuel cell technology from the external source is a strategy that can benefit the acquirer, which means development of fuel cell energy in Malaysia can be done through technology selection [21]. The selection strategy is important since a feasibility study comparing fuel cell with the other renewable energies has found the implementation cost for fuel cell technology is the highest due to its early stage of adoption [13]. This finding is just one example of many possible challenges faced by the industry in Malaysia. Many different issues need to be considered when embarking on a selection of fuel cell. Therefore, understanding the various options available and selecting the most appropriate fuel cell technology is a challenge. One of the popular techniques to assist technology selection is with AHP.

3. Analytic Hierarchy Process

Malaysia is strategically located in the middle of equatorial line with a very conducive climate suitable for various sources of sustainable energy for power generation. Despite that, a previous study has found Malaysia is relied heavily on the non-renewable resources to supply energy to the users, both in the urban and rural areas. Even though Malaysia has diversified its sources of non-renewable resources, due to rapid growth in demand and increasing concern over global climate change, Malaysia must develop a renewable energy for the users [5].

Meanwhile, the user's intention to use renewable energy in Malaysia was found to be related to perceived ease of use, perceived behavioural control, awareness, relative advantage, and cost reduction [22]. Besides that, a previous study has found consumers in Malaysia do have awareness and intention to use energy efficient appliances [23]. This implies that the users do have the intention not just to use energy efficient appliances but also renewable energy as the source of power generation for domestic usage. However, the selection process of the renewable energy needs to be done correctly, i.e., with the AHP technique.

AHP is "a theory of measurement through pairwise comparisons and relies on the judgements of experts to drive priority scale" [27]. This method was developed by Saaty, T.L. from 1971 to 1975 [28]. It is one of popular MCDM methods widely used in various applications, to make a decision that is rational with efficient choices [29,30]. When compared to the other MCDM methods, AHP is faster for doing analysis, with comprehensive logic, widely used and applied for technology evaluation and selection of sustainable energy [31].

In addition, AHP is also adaptable, does not involve complex mathematical model, and using hierarchy structure that is more focused and transparent [32]. Moreover, AHP method is flexible to be integrated with the other MCDM methods [33]. Hence, AHP is always used together with the other methods. Besides that, AHP is also used for allocating, evaluating, and benchmarking of alternatives [34]. As a result, AHP was applied in various areas including resource management, corporate policy and strategy, public policy, energy planning, and logistics and transportation planning [32]. AHP applications were also seen in various disciplines, such as mathematic, business and management, economics, computer science, environment science and technology, and social studies [35].

Correspondingly, the literature on AHP applications for selecting the sources of renewable energy for power generation is relatively low. In fact, the criteria, sub-criteria, and alternatives used are quite varied from one study to another. For instance, Saaty [28] was using national economy, health, safety and environment, and political factors as the examples of criteria for energy selection. Meanwhile, Kabir and Shihan [36] were using cost per unit power, social impact, technical, location, and environment as the criteria for selecting renewable energy. In contrast, Stojanović [37] was using technical, economic, social, and environmental as the selecting criteria. These variations are expected since different industries have applied wide variety of criteria for AHP [33].

Accordingly, AHP for power generation has been studied in Malaysia by Ahmad and Tahar [24] with four sources – hydropower, solar, biomass, and wind. They have found renewable energy to have great potential to develop a sustainable electricity system. However, for a specific study focusing on fuel cell technology for power generation, more studies with AHP are needed in Malaysia. This is crucial since the previous studies have ranked and prioritized the criteria, sub-criteria, and alternatives of renewable energy in a different way. This is because AHP can be biased [58]. For example, there were two AHP studies in Turkey that resulted with different alternatives [25,26]. For that, the results cannot be generalizable towards fuel cell technology. Although the usage of fuel cell is presently perceived as significant energy transformation systems with great promise, unfortunately, Malaysia is facing economic and infrastructural challenges, besides lack of local expertise, public perception, and industrial support for fuel cell [11]. Due to these challenges and since fuel cell can utilize any sources of sustainable energy, a specific AHP study focusing on fuel cell technology should be performed in Malaysia.

4. AHP Model for Fuel Cell Power Generation

According to the summary in Table 1, the environmental, economic, technical, and social are found to be the popular criteria for selecting sustainable power generation technology [38]. In fact, in the context of sustainable development, sustainability has been long categorized into environmental, economic, and social [39]. This set of criteria was also applied in previous studies in Turkey and Bangladesh [25,58]. For the reason, this study has decided to focus on the same criteria consisting of environmental, economic, social, and technical for selecting sustainable energy for fuel cell power generation in Malaysia. Based on the proposed AHP model in the study by Zaidi *et al.,* [38], this study also adopting the "impact on society, pollutant emission, and land use" as the sub-criteria for environmental; "investment cost, operation and maintenance cost, and payback time" as the sub-criteria for economic; "social acceptability, social benefits, and job creation" as the sub-criteria for social; while "efficiency, reliability, and technological maturity" as the sub-criteria for technical.

Table 1
AHP criteria for selecting sustainable energy [38]

Sources	Criteria										
	Environmental	Economic	Technical/ Technological	Social/ Social-Ethics/	Institutional-	Capacity	Cost	Quality	Risk	Security	Job Creation
Stojanović [37]	√	√	√	√							
Algarín *et al.,* [63]	√	√	√	√					√		
Ansari *et al.,* [64]	√	√	√	√							
Budak *et al.,* [65]	√					√	√			√	√
Demirtas [66]	√	√	√	√							
Ertay *et al.,* [67]	√	√	√	√							
Karakaş and Yıldıran [68]	√	√	√	√							
Li-bo and Tao [69]	√	√	√	√							
Sadeghi *et al.,* [70]	√	√	√	√							
Sliogeriene *et al.,* [71]	√	√	√	√	√						
Tasri and Susilawati [72]	√	√	√	√				√			

At this time being, the alternatives level of AHP will not be covered in this study. The AHP model (with criteria and sub-criteria) applied by this study for selecting the suitable sources of fuel cell technology for power generation is shown in Figure 1. The hierarchy in this model (i.e., goal, criteria, sub-criteria, and alternatives) are created based on the research by Saaty [28].

5. Research Methodology

The list of knowledgeable individuals on renewable energy was gathered from relevant government agencies, such as Malaysian Green Technology Corporation, Malaysian Nuclear Agency, and Suruhanjaya Tenaga. These agencies were selected due to their responsibilities or nature of working environment with sustainable or renewable energy including R&D. These agencies also closely related with the policy making on renewable energy in Malaysia. In addition, due to fuel cell technology is still at early stage of development, it is challenging to identify respondents from the industry. Furthermore, it still under study in many developing countries [17].

In total, there are around 80 knowledgeable individuals shortlisted with valid email addresses. All of them hold various positions at the managerial and professional levels. The overall AHP methodology used by this study is according to Saaty [28]. Hence, this study is utilizing a pair-wise comparison matrix with nine scale from the original work of Saaty [28]. Nine scale is used because although “the scaling is not necessary 1 to 9 but for qualitative data such as preference, ranking and subjective opinions, it is suggested to use scale 1 to 9” [40]. The scale ranged from equally preferred (1) to extremely preferred (9) with reciprocal e.g., (1/9) for extremely preferred.

The responses are analysed with AHP tool based on a group decision. Since “AHP is a subjective approach for addressing specific issues” [41], the advantage of AHP is it did not require statistically significant sample size where a large sample size is not mandatory for AHP [42,43]. Therefore, AHP analysis is different from a typical quantitative method with a statistical approach. In other word, there is no restriction required on the minimum sample size for AHP analysis [54]. This analysis is suitable since the list of knowledgeable individuals gathered from various government agencies is small, which is around 80. This study is following the AHP analysis structure in the study by Hummel *et al.,* [55]. The analysis is performed with the AHP software tool version 15.09.2018 developed by Goepel from the Business Performance Management Singapore. The questionnaire was designed based on the proposed AHP model for fuel cell technology as shown in Figure 1 [38]. This study has developed a Google form to collect data from the list of knowledgeable individuals.

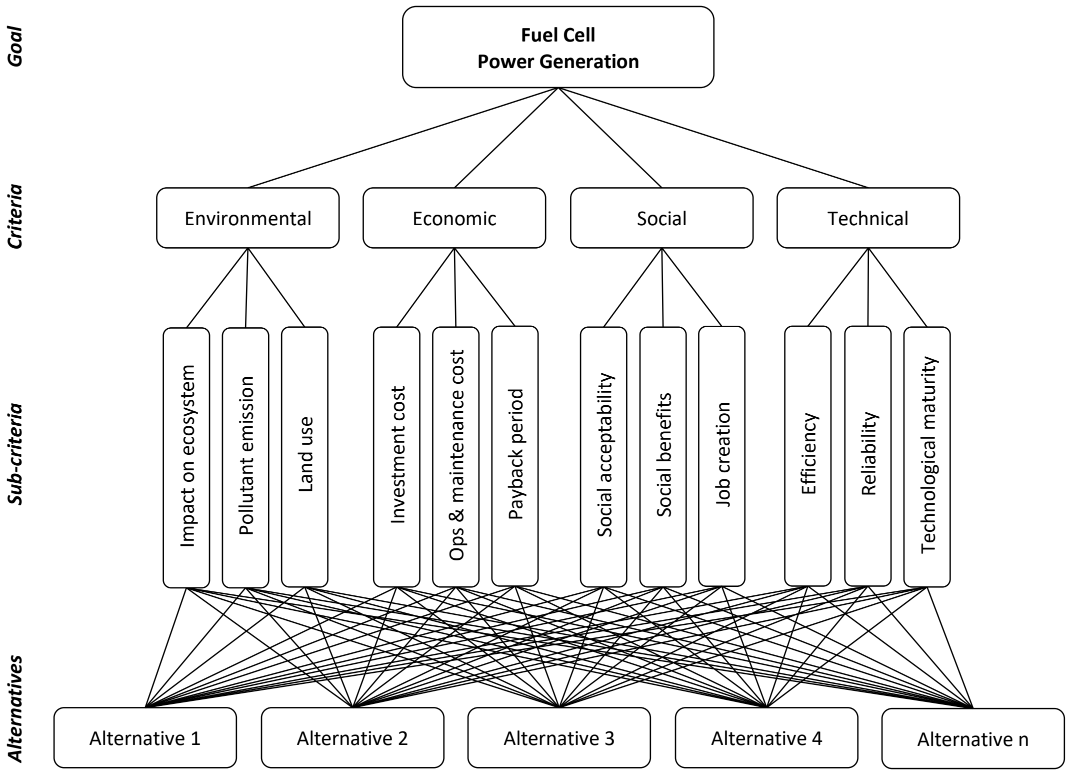

Fig. 1. Proposed AHP model for fuel cell power generation

6. Analysis of Findings

A Google form was sent to the respondents between October and November 2020 and has received five responses. Five responses may sound too small for quantitative survey, but this study is qualitative in nature. AHP is suitable for small sample size to get reliable results [44,56]. Furthermore, “AHP studies are typically conducted with a small sample size and thus fewer responses is the norm" [49]. Because AHP can be conducted with small sample size of knowledgeable individuals, a sample size of 10 or below is sufficient to generate reliable results [47,53]. For instance, previous studies have applied AHP with just 10 responses, six responses, five responses, three responses, two responses, and even with just a single response [41,43-49]. Because respondent size is not a limitation of current study with AHP, five responses received by this study is sufficient for analysis with AHP [50]. As such, the responses are analysed as a group decision of five.

For better interpretation of the results, the following terms are explained. First, Consistency Ratio (CR) – CR is calculated by dividing the Consistency Index for the set of judgments by the Index for the corresponding random matrix. CR that is equal or less than 10% is acceptable [40]. Second, Geometric Consistency Index (GCI) – GCI considers the priority vector to be estimated by the geometric mean method. The GCI threshold for n = 3 is 0.31, and n = 4 is 0.35 [51]. Third, Consensus indicator – it refers to the estimate of the agreement on the outcoming priorities between participants. It can be categorized into very low consensus (below 50%), low consensus (50% to 65%), moderate consensus (65% to 75%), high consensus (75% to 85%), and very high consensus (above 85%).

Based on the summary of analysis in Table 2, the results have found the CR value are all less than 10% for the criteria (4.7%), environmental sub-criteria (1.2%), economic sub-criteria (2.2%), social sub-criteria (6.9%), and technical sub-criteria (9.0%). Meanwhile, all criteria, sub-criteria, and alternatives have met the GCI threshold for n = 3 and n = 4. The group consensus for every level of analysis is between moderate (65% to 75%) and high (75% to 85%). In details, the consensus for criteria (81.4%), environmental (75.1%), economic (75.7%), and social (79.3%) is high, while the consensus for technical (74.6%) is moderate. These results generally mean the analysis has achieved good consistency and consensus among respondents.

Table 2
Analysis on CR, GCI, and consensus

Level	Num.	CR	GCI	Consensus
Criteria	4	4.7%	0.17	81.4%
Environmental Sub-criteria	3	1.2%	0.03	75.1%
Economic Sub-criteria	3	2.2%	0.06	75.7%
Social Sub-criteria	3	6.9%	0.20	79.3%
Technical Sub-criteria	3	9.0%	0.26	74.6%

Table 3 summarized the results of AHP analysis on the criteria and sub-criteria for selection of fuel cell technology. The analysis on criteria has found the economic criterion (0.343) scores higher than the other criteria. At second place is the environmental criterion (0.321), followed by the social (0.211), and technical (0.125). Meanwhile, the analyses on sub-criteria have found the impact on ecosystem (0.1846) as the most important sub-criterion, followed by the payback period (0.1509), and investment cost (0.1108). These sub-criteria representing 44.63% of the total global weights. On the other hand, the less important sub-criteria were found to be the technological maturity (0.0208), reliability (0.0373), and land use (0.0465). In combination, they only contributed for less than 11% of the total global weights.

Table 3
Results and weights of criteria and sub-criteria

Criteria	Weights	Sub-criteria	Local weights	Global weights	Local rank	Global rank
Environmental	0.321	Impact on ecosystem	0.575	0.1846	1	1
		Pollutant emission	0.280	0.0899	2	4
		Land use	0.145	0.0465	3	10
Economic	0.343	Investment cost	0.323	0.1108	2	3
		Operations and maintenance cost	0.237	0.0813	3	5
		Payback period	0.440	0.1509	1	2
Social	0.211	Social acceptability	0.385	0.0812	1	6
		Social benefits	0.298	0.0629	3	9
		Job creation	0.318	0.0671	2	7
Technical	0.125	Efficiency	0.536	0.0670	1	8
		Reliability	0.298	0.0373	2	11
		Technological maturity	0.166	0.0208	3	12

7. Discussion

Study on the selection process of renewable energy for power generation with AHP technique is not new. However, most of the focus are on the common types of renewable energy technology (e.g., solar, wind, hydropower, etc.) and not focusing on the specific fuel cell technology [24-26,58,60]. Therefore, this study is among the few that has applied the AHP analysis on fuel cell technology for power generation. This study has adopted the criteria for the selection from the research by Zaidi *et al.,* [38]. Based on the AHP analysis, this study has found the most important criterion to be economic, followed by the environmental, social, and technical.

As for comparison, an AHP study in Turkey has found environmental as the most important criterion, while in Bangladesh it was the technical [25,58]. Even though both studies in Turkey and Bangladesh are on the fuel cell technology, it shows the results of AHP analysis is contextual dependence. Therefore, in the case of fuel cell technology in Malaysia, the economic criterion was found to be the most critical, while the technical is the less important. This finding is somehow consistent with the literature on sustainability development, which linked sustainability dimensions with the environmental, economic, and social factors, but not with the technical [52]. Since the nature of this study is about renewable or sustainable energy, it is not surprising when the respondents have linked the importance of criteria with sustainability.

In details, economic has become the most critical criterion possibly due to the respondents are more concerned about the costs of acquiring the technology. This is because the cost of renewable energy is relatively higher compared to the non-renewable energy. High cost of renewable energy has been addressed many times in literature. For instance, a previous study in Malaysia has found the implementation cost for fuel cell technology is the highest due to its early stage of adoption [13]. This implies that the economic factors, e.g., investment cost, payback period, and operating and maintenance cost are the major concern on the selection of fuel cell technology for power generation. On the other hand, the respondents have rated technical as the less important criterion.

However, this result does not necessarily mean the technical aspect of fuel cell selection can be ignored. This is because just like any other technology, the selection process of fuel cell technology will still need the technical considerations. When we relate with the economic criterion, it makes sense the technical criterion is relatively less critical because any fuel cell technology can be acquired with sufficient financial support. Therefore, regardless of the technical aspects, the selected fuel cell technology must be justified with the investment cost, payback period, and operating and maintenance cost. In the meantime, the social criterion does have some influence in the selection process of fuel cell technology in Malaysia. In fact, this criterion is even rated higher than the technical criterion. It has 21.1% influences on the selection process. This shows that social effects also important in the selection process of fuel cell technology, particularly relating to the social acceptability, social benefits, and job creation.

Meanwhile, when looking at the 12 sub-criteria for the selection of fuel cell technology for power generation, the impact on ecosystem, payback period, and investment cost are the most important sub-criteria from the environmental and economic criteria. They alone in combination contributed nearly half of the selection decision. Interestingly, the land use, which is the sub-criterion of environmental was ranked 10^{th} of 12. This means although environmental is the second most important criterion after economic, the land use is very less contributing to the ranking. One of the possible reasons could be because fuel cell technology is using less land to generate similar power output of solar plant [7].

Another explanation for this could be due to the by-product of fuel cell technology that is water, which will not be polluting the land and environment. Therefore, the land use appeared not to be a critical sub-criterion in this case. Nevertheless, the most unimportant sub-criterion belongs to technological maturity. With just 2% of total global wights, the influence of this sub-criterion to the decision to select fuel cell technology is very minimal. Interestingly, a previous study on the technology readiness level has found where the “end use is more important than the maturity of fuel cell types” [61].

With these results, the study has managed to determine not only a set of sub-criteria but also able to prioritize them into importance. The analysis also managed to determine the less important sub-criteria, which are the technological maturity and reliability from the technical criterion, and land use from the environmental criterion. Although environmental is the second most important criterion after economic, the result suggests that there could be better indicators for environmental criterion than the land use. This also implies the issues regarding how the land is to be used with fuel cell technology is not as important as the other issues. On the other hand, issues regarding technological maturity and reliability of the sources of fuel cell technology for power generation are the less concerned currently. Therefore, the focus should be on how to make the sources of fuel cell technology economical to justify its usage. This result is consistent with the previous study that has found the implementation cost of fuel cell technology is high at this stage of adoption [13].

8. Limitations and Suggestions

Firstly, this study is focusing on the criteria and sub-criteria for selection the sources of fuel cell technology for power generation. Although alternative is part of AHP analysis, it is not the focus of this study. There are many potential alternatives for fuel cell technology that need to be categorized and shortlisted first, e.g., alkaline, sulfuric, phosphoric, solid polymer, molten carbonate, solid oxide, and proton exchange membrane. Studies also have been done on the microbial fuel cell, and galvanic fuel cell [57,59]. Furthermore, the analysis on alternatives will need enormous numbers of pair-wise comparison matrices with the sub-criterion.

Therefore, for future research agenda, a study emphasizing on the specific set of alternatives for fuel cell technology should be initiated. Secondly, this study was targeting the respondents from the government agencies as they are linked to the policy maker. This study excluded the industry practitioners to avoid mixing different backgrounds of respondents that might affect consensus in the analysis. As such, the results could be different if the responses come from the industry practitioners. Hence, a similar study focusing on the industry practitioners should be initiated in future. In addition, the similarities, and differences in prioritizing the criteria and sub-criteria for the selection of fuel cell technology between the "policy makers" and the industry practitioners should enable us to understand the gaps between them. By narrowing the gaps will ensure a successful implementation of initiatives related to fuel cell technology in the future. Furthermore, "an aggressive and more effective policies and technologies are needed in order to achieve the ambitious scenario with higher renewable energy shares in Malaysia" [75].

9. Conclusions

This study has found the most important criterion for fuel cell technology selection is economic, while the most important sub-criterion is the impact on ecosystem. In contrast, the less important criterion is technical, while the less important sub-criterion is technological maturity. The results show that when it comes to renewable energy, the environmental factor, as suggested by the impact on ecosystem sub-criterion, is always comes first in the mind. This implies that studies on renewable or sustainable energy always associated with the effect on environment. However, the selection of the sources of power generation for fuel cell should be looking at the economic factor. This suggests although renewable energy is no doubt associated to the environment, but in the economic sense, the payback period and investment cost are the main consideration when selecting the sources of fuel cell technology for power generation. On the other hand, the technical criterion with technological maturity was less emphasized by the respondents. This does not necessarily mean that the maturity of fuel cell technology is not important, but it is currently not being emphasized at the present stage of fuel cell development in Malaysia. This study has contributed to the knowledge by prioritizing the criteria and sub-criteria for the selection of fuel cell technology. The information also added value to the policy making process for fuel cell technology in Malaysia.

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