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Assessment of Non-Technical Barriers for Widespread Adoption of Building Integrated Photovoltaic System (BIPV) in Malaysian Urban Residential Sector

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Abstract

Building Integrated Photovoltaic BIPV technology (BIPV) is a mature and proven technology, yet it still encounters many barriers for penetration into public realm especially residential sector. Malaysian residential sector consumed approximately 19% of the total energy usage of the country (R. Saidur et al., 2007). As the process of urbanization is going at a rapid pace in a developing country like Malaysia, this percentage is expected to rise rapidly in the near future. Therefore, it is critical to identify these barriers in the Malaysian urban residential sector, analyse them and draw strategies for the penetration of BIPV into Malaysian urban residential sector. One important aspects in identification of these barriers is to understand the public awareness and perception of this emerging renewable technology in Malaysia. According to Farhar, B.C.,(1996), perceptions are important because what people believe to be real is real in its consequences. She also added that perceptions and preferences are themselves facts that describe the social world in which people operate. Farhar, B.C.,(1996), also pointed out that people perceptions and preferences about energy and the environment are influenced by objectively factual information. Due to great diversity of barriers to finding and implementing solutions to this emerging renewable technology like BIPV, it will be useful to group these barriers in some way which should not seen as rigid, but as a framework for identification and analysis. In gauging this understanding, a Trudgill (1990) framework for analysis will be deployed as a basis to identify areas of concern and investigation concerning public response towards this new emerging renewable energy source. Trudgill (1990) framework for analysis consist of six major groups of barriers – agreement, knowledge, technological, economic, social and political – which will refer to collectively as the 'AKTESP' barriers. Upon identification of the non-technical barriers, this research will subsequently undertake to conduct a field survey in the Malaysian urban areas to assess these barriers. Based on the analysis of the field survey data, it will provide a realistic agenda for forming strategies and recommendations to solution of these barriers.

Keywords: Building integrated Photovoltaic (BIPV), non-technical barriers, Malaysia residential sector, framework analysis and emerging renewable technology.

1. Introduction

Malaysian residential sector consumed approximately 19% of the total energy usage of the country [1]. As the process of urbanization is going at a rapid pace in a developing country like Malaysia, this percentage is expected to rise rapidly in the near future. Building Integrated Photovoltaic (BIPV) technology being a proven renewable energy technology has great potential especially in Malaysia due to its Equatorial climate. BIPV as a renewable energy technology can assist to reduce the ever increasing demand for fossil fuel in electricity power generation in Malaysia.

BIPV technology has been introduced in Malaysia since year 2000. From 2000 to 2006, there are only total of 18.92 kWp BIPV capacity installed in residential properties with an average of 3.15 kWp BIPV installations per year [2]. Most of these installations are scattered around urban residential areas in Kuala Lumpur.

Currently, there is only one initiative by the Government of Malaysia to promote BIPV technology. This BIPV programme is known as the Malaysian Building Integrated Photovoltaic Programme or MBIPV which was endorsed into the 9th Malaysian Plan in 2006. The MBIPV programme will be implemented from 2005 to 2010 with financial support from the Global Environmental Facility (GEF) under the UNDP programme. The main objective of this project is to promote a widespread of BIPV technology among Malaysian residential sector. UNDP-GEF established the BIPV project with the purpose of promoting renewable energy to supplement the current fossil fuel consumption for power generation in Malaysia; it is a platform for the dissemination of BIPV among Malaysian residential sector.

Although with this initiative by the Government of Malaysia to promote BIPV technology, the diffusion of BIPV technology in urban residential sector is still slow and there are many hurdles yet to be overcome especially on public perceptions of this new emerging technology.

As Farhar B.C., (1996) pointed out that, public perceptions are important because what people believe to be real is real in its consequences. She also added that perceptions and preferences are themselves facts that describe the social world in which people operate. She goes on to state that people perceptions and preferences

about energy and the environment are influenced by objectively factual information [3].

A similar research project was carried out by Farhar, B.C., and Buhrmann J., in 1998 on Public Response to Residential Grid-Tied PV Systems in Colorado, USA. The study revealed that the public are generally receptive over the Grid-Tied PV (GPV) technology than conventional energy technologies which uses fossil fuels. However, the significantly higher cost of GPV compared with conventional electricity sources constitutes an important barrier to adoption [4].

With these great diversity of barriers to finding and implementing solutions to this emerging renewable technology like BIPV, it will be useful to group these barriers in a systematic way which should not seen as rigid, but as a framework for identification and analysis. In gauging this understanding, a Trudgill (1990) framework for analysis will be deployed as a basis to identify areas of concern and investigation concerning public response towards this new emerging renewable energy source.

2. Trudgill's Framework for Analysis

Stephen Trudgill (1990) framework for analysis consist of six major groups of barriers – agreement, knowledge, technological, economic, social and political – which will refer to collectively as the 'AKTESP' barriers. Refer to Fig.1. This framework can first used for identification of the non-technical barriers and subsquently forms a basis for analysis and discussion. Each of major groups of barriers need not all exist in an orderly manner as listed below and they might sometimes overlap each other [4]. The six major groups of barriers are categorized as:-

1. AGREEMENT: Situation uncertainty; Situation recognition but problem denial; Problem recognition but problem rejection; Problem acceptance but causal uncertainty; Problem dismissal.
2. KNOWLEDGE: Knowledge inadequacy; Knowledge adequacy but knowledge rejection; Knowledge adequacy but knowlegde inappropriateness; Knowledge adequacy but knowledge uncommunicated.
3. TECHNOLOGY: Technology unavailability; Technology availability but technology complacency; Technology availability but technologically inappropriate.
4. ECONOMIC: Economic insufficiency; Economic denial; Economic inappropriateness; Economic exploitation.
5. SOCIAL: Social value systems; Social resistance; Social leadership; Social allocation; Social morality.
6. POLITICAL: Political cynicism; Political ideology.

In barrier identification, each stage is constantly being question whether it impedes progress towards a solution. Difficulties over agreement of a problem may be a major impediment. If the first hurdle of agreement is crossed, subsequently the next question to ask is whether or not there is adequate evidence or knowledge on the causes of the problem. On the other hand, even if a problem is agreed and the causes and their effects are clearly known, a lack of appropriate technology to solve the problem may then prove to be a major barrier. Likewise, if the technology is available to solve a problem, it may be too costly or it may not be appropriate socially or there is lack of political will [5].

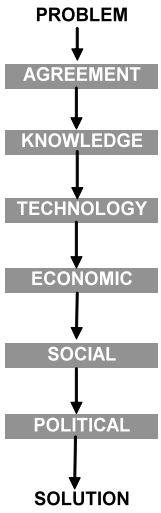

Fig 1. The AKTESP groups of barriers (Source: Trudgill, S.,1990.)

Trudgill's framework has been adopted in various studies like the decision analysis for development of acid rain policy in the UK and barriers to health integration in environmental assessment [6,7].

3. Problem Statement

In spite of the Malaysian Building Integrated Photovoltaic Programme has received good responses and BIPV technology has great potential in a tropical country like Malaysia, this renewable energy technology has yet to penetrate into the local market due to their high cost and the lack of enabling environment for a sustainable BIPV market. Therefore, it is critical to formulate realistic strategies in order to promote rapid diffusion of this renewable energy technology in this country.

4. Research Objectives

This research project embarks on the following objectives:-

i. To investigate the public perceptions of BIPV applications
ii. To identify non-technical barriers to widespread adoption of BIPV applications
iii. To assess the interest in BIPV as a renewable energy technology among Malaysian Urban residential sector.
iv. To identify Malaysian urban residential electricity consumers willingness to pay for BIPV technology.

v. To develope a strategic framework for BIPV penetration into Malaysian Urban residential sector.

5. Research Approach

StephenTrudgill's framework is used to identify the non-technical barriers for the adoption of BIPV. Subsequently, a survey questionnaire is developed and a field survey is conducted in Kuala Lumpur urban residential areas to assess public perceptions on these barriers. Based on the Trudgill's framework for analysis, the field survey data will provide a framework for forming strategies and recommendations to solution of these barriers.

5.1 Sampling

This survey was conducted from April 2008 till June 2008 and it constitutes of 302 respondents from Kuala Lumpur urban residential areas. A purposeful sampling strategy is chosen for this research due to uavailability of a sample frame. Therefore, the sample is undoubtly atypical of Kuala Lumpur urban residential sector. According to the Valuation and Property Services Department of Malaysia in fourth quarter report of 2007, there are 105,905 units of landed residential properties excluding highrise residential dwellings like apartment and condominiums in Kuala Lumpur[8].

5.2 Trudgill's framework for analysis

The non-technical barriers have been identified and divided into the 6 major group of barriers under Trudgill's framework which are categorized as:-

1.AGREEMENT: recognizing that by using renewable energy, it able to help reduce environmental problems;
2.KNOWLEDGE: awareness of BIPV technology; media in promoting BIPV awareness;
3.TECHNOLOGY:availability of BIPV technology; appropriateness of BIPV technology;
4.ECONOMIC:willingness to pay for BIPV technology; anticipated payback period for BIPV;
5.SOCIAL: altruism here refers to desire to save the environment for future generation sake;
6.POLITICAL: government's incentives like tax examption, subsidies, low interest loan for BIPV purchase; effectiveness of current government's programme like MBIPV programme.

6. Findings and Discussion

There are total of 302 respondents involved in this survey.

6.1 Respondent Characteristics

The residential areas of the respondents are divided into urban and sub-urban areas of Kuala Lumpur.

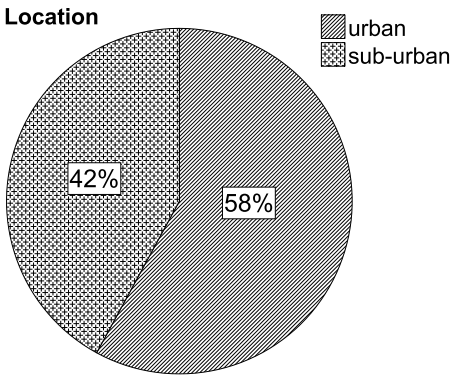

Fig 1. The distribution of respondents in urban and sub-urban residential areas of Kuala Lumpur

Based on Fig. 1, 58% of the total 302 respondents are from urban areas and 42% are from sub-urban residential areas of Kuala Lumpur.

Table 1: The distribution of respondents' age group

	Frequency	Percent
less than 25	105	34.8
25 - 34	123	40.7
35 - 44	38	12.6
45 - 54	23	7.6
55 and above	13	4.3
Total	302	100.0

Based on Table 1, adults aged between 25-34 and aged less than 25 composed most of the sample. Minorities are aged between 45-54 and 55 and above.

Table 2: The distribution of respondents' type of dwellings

	Frequency	Percent
bungalow	31	10.3
semi-Detached	28	9.3
Terrace house	162	53.6
apartment / flat	66	21.9
condominium	15	5.0
Total	302	100.0

Table 2 reveals majority of the respondents are staying in terrace housing type which has the highest potential for BIPV application compare to apartment and condominium type of dwellings.

6.2 Testing Normality of data collected

All the survey data was computed into SPSS statistical software for normality test before analysing them statistically. The results after the normality test was *non-normally distributed*. Therefore, the data for non-normally distributed was subjected to non-parametric test for significant correlation or association like Chi-square (2, $p<.05$) test. Subsequently, the

analysis was conducted based on 6 major group of barriers of the Trudgill's framework for analysis, namely Agreement, Knowledge, Technology, Economic, Social and Political.

6.3 Agreement Barrier

In assessing the agreement barrier among the respondents, it addresses such question as: Do you recognize that using renewable energy able to help reduce the environmental problem?
95% of the respondents agreed that environmental problems can be improved by using renewable energy. Refer to Table 3.

Table 3: Response towards Agreement of Renewable Energy able to help reduce environmental problem

Response categories	Frequency	Percentage (%)
Yes	287	95
No	15	5
Total	302	100

6.4 Knowledge Barrier

Respondents were asked if they have heard any type of solar energy. Forty-nine percent of the respondents revealed that they mostly heard about solar hot water technology and only eleven percent heard about BIPV or photovoltaic system. Therefore, the knowledge about BIPV is relatively low compare to solar hot water system. Refer to Table 4. The barrier to this problem is the lack of promotion of BIPV technology to the public.

Table 4: Response towards Knowledge about type of solar energy

	Type of solar energy	Frequency	Percent (%)
	BIPV/photovoltaic	3	1
	Solar hot water	144	48
	both the above	91	30
	Total	238	79
Missing	System	66	22
Total		302	100

In further cross tabulation, the chi-square analyses reveals a significant association or correlation between respondents levels of education and believes in using renewable energy to reduce environmental problems, $\chi 2 = 5.76$, $p < 0.05$. Refer to Table 5.

Table 5: Chi-square test reveals a significant association between levels of education and believes in using renewable energy to reduce environmental problems.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.761	2	0.050
Likelihood Ratio	4.631	2	0.090
Linear-by-Linear Association	4.672	1	0.031
N of Valid Cases	302		

The cross tabulation reveals that 66.9% of university graduates are more knowledgeable in terms of using renewable energy to reduce environmental problems. Refer to Table 6. This shows that the level of education did significantly influence their knowledge and understanding of using renewable energy to reduce environmental problems. Therefore, in order to overcome this barrier, more educational programme regarding the awareness of renewable energy needs to be channelled and introduced into primary school level and college level.

Table 6: Cross tabulation between Level of Education and Believe in using renewable energy to reduce environmental problems.

			Level of education			
			Primary / Secondary	College / Polytechnic	University	Total
Believe in using renewable energy	Yes	Count	46	49	192	287
		% within Believe in using renewable energy	16.0	17.1	66.9	100
	No	Count	6.0	2.0	7.0	15
		% within Believe in using renewable energy	40.0	13.3	46.7	100
Total		Count	52.0	51.0	199.0	302
		% within Believe in using renewable energy	17.2	16.9	65.9	100

Communication channels used is one of the vital means to determine the rate of awareness and adoption of BIPV. Table 7 shows that, 23.8% of the respondents indicated that they came to know about BIPV technology through TV. Second effective media for promoting BIPV is through internet. Using less effective media for promoting BIPV technology is a barrier and could results in slower rate in dissemination of BIPV technology awareness. Therefore, TV and Internet have the best effective media coverage for the promotion of BIPV technology among urban residential sector.

Table 7: The type media and ways in knowing about BIPV technology

	Frequency	Percent
TV	72	23.8
Radio	7	2.3
Newspaper	40	13.2
Magazine	24	7.9
Friends	46	15.2
Colleague	25	8.3
Neighbour	8	2.6
Relatives/Family	5	1.7
Internet	54	17.9
Total	281	93.0
Missing System	21	7.0
Total	302	100.0

According to Rogers E.M.,(1967), the rate of adoption also can be influenced through "observability". Observability is "the degree to which the results of an innovation are visible to others. The observability may include how visible

adoption is to others, thereby showing that the innovation indeed "works" [9]. Observability may also include the ability to actually see the effects of the innovation and in this case, BIPV demonstration houses in urban residential sector.

Table 8: Have you seen any building with BIPV installation?

		Frequency	Percent
	Yes	101	33.4
	No	199	65.9
	Total	300	99.3
Missing	System	2	0.7
Total		302	100.0

65.9% of the respondents revealed that they have no seen any building with BIPV installation before in urban or sub-urban residential areas around Kuala Lumpur. This shows that the barrier to observability is lack of demonstration houses with BIPV installations.

6.5 Technology Barrier

BIPV technology is a proven technology and it has made its entrance into Malaysian residential market since year 2000 with its first residential installation of 3.08 kWp. From year 2000 till 2006, there are only 6 BIPV residential installations [2]. Most of the initial BIPV installations are for demonstration and mostly are government residential units. In current context, the availability of technology is not an issue and actual issue is whether the BIPV technology is appropriate for today's Malaysian urban residential needs. Although BIPV technology has grid-connection capability for urban applications but the cost of electricity generation using BIPV is still high due to its high investment cost in couple with the low electricity tariff rate in Malaysia. Therefore, the BIPV technology is not a barrier but the real barrier lies in the economic aspect.

6.6 Economic Barrier

One of the economic methods for making financial decision is the payback period. The unit measurement for payback period is the number of years to pay back the investment cost. The payback period is often an economic barrier when the investment cost for a certain technology has long payback periods. Long payback period is always perceived to have higher risks. If the payback period is significantly less than the expected BIPV system life span, this technology is likely to be considered as cost effective [10].

Table 9: The payback period that the respondents willing to consider for investment in BIPV system.

	Years of Payback	Frequency	Percent	Valid Percent
	Below 5	11	3	5
	5 - 6	9	3	4
	10 - 11	69	23	31
	15 - 16	3	1	1
	Above 20	2	1	1
	Total	22	7	10
Missing	System	7	2	0
Total		30	10	
		2	0	

Refer to Table 9, 52% of the respondents are willing to consider BIPV if the payback period is below 5 years and about 42% of respondents willing to consider if the payback period is within 6 to 10 years. This finding revealed that most of the respondents are expecting a breakeven of below 10 years. Therefore, payback period could be a barrier if the investment cost of BIPV system is not kept at lower investment cost in order to have a shorter payback period. The following findings strengthen the public perception on economic barrier with their willingness to pay for 1 kWp of BIPV system. Refer to Table 10.

Table 10: Willingness to pay for 1 kWp of BIPV System

	Willingness to pay for 1 kWp of BIPV (USD)	Frequency	Percent	Valid Percent
	Below 1515	17	5	6
	1515 - 3030	86	28	32
	3030 - 4545	11	4	4
	4545 - 6060	12	4	4
	6060 - 7575	2	1	1
	Above 7575	25	8	10
	Total	84	28	31
Missing	System	3	1	0
Total		30	10	
		2	0	

66% of the respondents are only willing to invest in BIPV if the cost of investment is below USD1515 per kWp. The current cost of investment on BIPV system in Malaysia for 1kWp is approximately USD9090.00. Therefore, a subsidy of 83% is required to overcome the high investment cost barrier for BIPV installation.

6.7 Social Barrier

One important aspect of social barriers is Altruism. Altruism in this context refers to the desire to invest on BIPV systems for respondents' future generation and environment sake. Based on Table 10, 84.1% of respondents are willing to invest in BIPV for future generation's sake. This shows a very strong altruistic sense among the urban residential folks.

Table 10: Willingness to invest in BIPV for Future Generation sake.

	Frequency	Percent (%)
Yes	254	84.1
No	48	15.9
Total	302	100.0

Further findings; show that 83.8% of the respondents are willing to invest in BIPV for the environment sake. Refer to Table 11. Therefore, both results show that there is no social barrier especially in the aspect of altruism.

Table 11: Willingness to invest in BIPV for the environment sake

	Frequency	Percent
Yes	253	83.8
No	49	16.2

Total	302	100.0

6.8 Political Barrier

To assess political barriers, the study analyzes support from the government in terms of providing incentives as well as enforcing the use of renewable energy. Based on Table 12; majority of the respondents rated important and very important to have tax incentives for using BIPV system.

Table 12: Tax incentives for using BIPV system

	Frequency	Percent
not important at	8	2.
not	1	4.
somewhat	5	18.
importan	14	46.
very	8	27.
Tota	30	100.

By examining further, it revealed that 82.5% of the respondents have not heard or come to know about any government incentives for using BIPV system or renewable energy. Refer to Table 13.
Although the government has launched the Malaysian Building Integrated Photovoltaic Programme since 2005 but the promotion has not reach majority of the urban residential population in Kuala Lumpur. Therefore, the communication channels as discussed earlier are vital for rapid widespread of BIPV adoption among urban residential population.

Table 13: Heard of any government incentives for using BIPV system or Renewable energy.

	Frequency	Percent
Ye	5	17.
N	24	82.
Tota	30	100.

7. Conclusion

Based on the conducted survey and assessment of the survey data using Trudgill's framework for analysis or AKTESP barriers as mentioned in previous sections, a set of recommended actions can be proposed to ensure a rapid and successful widespread adoption of BIPV technology into urban residential population in Kuala Lumpur. This study revealed that, awareness is still one of the major barriers that need to be overcome especially among schools and college students so that the information can also be carried to their homes and disseminated into their families' members. The samples also viewed majority of the respondents have not heard of BIPV system in comparison to solar hot water system. Therefore, there is a lack of education about BIPV technology among the urban residential sector. This can be addressed by introducing more BIPV education programme through more effective communication means or channels like TV and internet. This approach has to be long term commitment towards diffusion of BIPV technology for urban residential sector. Another major barrier is the economic barrier. Most of the respondents expressed their view that the high investment cost of BIPV is the problem hindering them from making their purchase. This problem of high investment cost of BIPV also results in long payback period due to the low electricity tariff rate in Malaysia. Therefore, higher subsidy is needed for the purchase of BIPV installation. The research shows that subsidy of 83% is preferred by the majority of the respondents. Based on this study, it shows that majority of the urban residential folks believed adopting BIPV was the right thing to do for future generation and environment sake. This social attitude and altruistic characteristic is an added advantage for rapid diffusion of BIPV technology.
In summary, BIPV has a long gestation period and it requires government long term commitment. Constant review of government incentives like tax exemption or rebate is one of the vital means for promoting BIPV technology. The government of Malaysia need to review their green policies and programmes regularly in order to main a sustainable market environment for rapid adoption of BIPV technology.

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