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VALIDATING OF SOLAR ENERGY ACCEPTANCE MEASUREMENTS AMONG MALAYSIAN HOUSEHOLDS

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Abstract: *The aim of this study is to validate the solar energy acceptance measurements (SEAM) within the context of Malaysian households. The validity and reliability assessments of the scale were performed on 422 household chosen randomly from the urban area in Klang Valley, Malaysia. Confirmatory factor analysis (CFA) was carried out to determine the factor structures of the Malaysian household adaptation of the measurements. The CFA result indicated an acceptable fit (χ^2 = 1551.61 (df = 771), p-value = 0.001, CFI = 0.924, RMSEA = 0.050, NFI = 0.860). Hence, SEAM provides an equally valid measure or acceptable model fits and suggests the feasiblity of applying the measurement with relatively good construct validity and internal consistency for structured model. The study both expands and adds support to the existing body of green behaviour measurement literature.*

Keywords: Confirmatory factor analysis (CFA), solar energy, measurements, validity.

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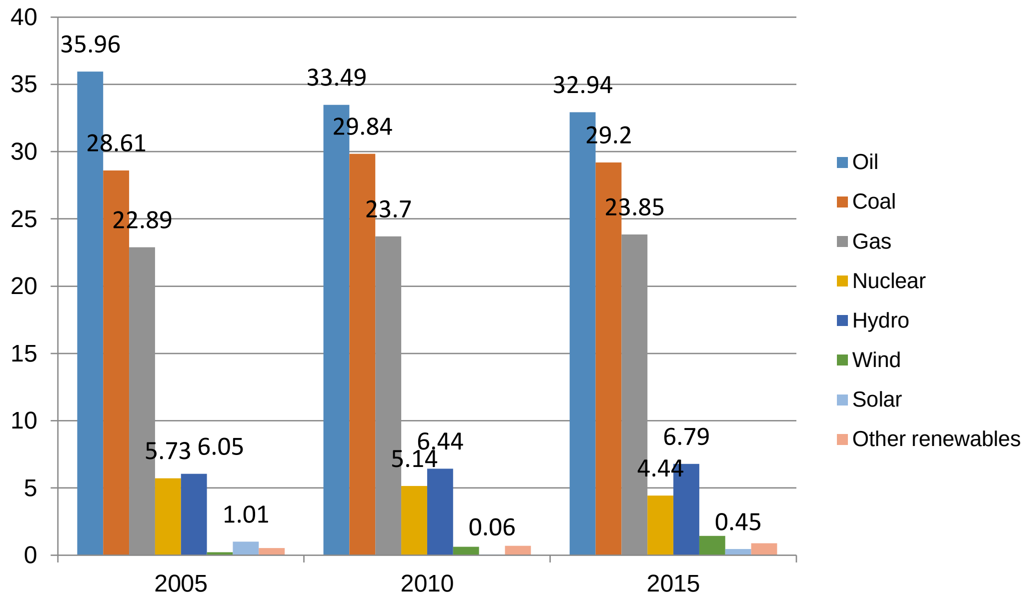
1. Introduction

Promoting an affordable, stable and environmentally sensitive energy are the pricipal objectives of energy leaders and practitioners in the energy system management. World Energy Report (2016) said, sufficient and secure energy is the main enabler for welfare and economic development of the society. As energy-related activities have significant environmental impacts, it is indispendable to provide an energy system which covers the need of economies and preserves the environment. The current situation shows how the need for the energy sector to diversify the technologies and resources of energy. It may create many opoortunities, but the enlarged complexity also leads to increased challenges. With existing level of volatility, relying on data basis for strategic decision making by relevant stakeholders, such as government, international organizations and companies, is becoming even more important than in the past. In the past 15 years have seen unprecedented change in the consumption of energy resources. Unexpected high growth in the renewables market, in terms of investment, new capacity and high growth in developing countries have changed the landscape for the energy sector. Most countries have achieved more diversified energy mix with a growth in community ownerships and an evolution of micro grids.

Figure 1: Comparative primary energy consumption, 2005, 2010 and 2015 (World Energy Resource, 2016)



Global installed capacity for solar-powered electricity has seen an exponential growth, reaching around 227 GW (Gigawatts) at the end of 2015, producing 1 percent of all electricity used globally. Despite some notable progress, the rate of improvements towards cleaner energy is far slower than required to meet emissions targets. Public acceptance remains a challenge, regardless of the energy source, with an increased 'not in my back yard' attitude to the development of energy sources (World Energy Report, 2016). Malaysia in 2016, was introduce Net Energy Metering (NEM) scheme that carried out to complement the Feed-in Tariff (FiT) mechanism. NEM and FiT programs aims to encourage the deployment of Renewable Energy (RE) as meted out in Malaysia Eleventh Plan (RMK-11). FiT scheme was implemented for 5 years which starting from 2011 until 2016 (SEDA, 2018). These two schemes, are executed by Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC), regulated by the Energy Commission (EC), with the Sustainable Energy Development Authority (SEDA) as the implementing agency. Under FiT scheme, the commercial and residential electricity customers can generate electricity from renewable energy and sell all generated energy to the Tenaga Nasional Berhad (TNB), the sole electricity utility in Malaysia. However, the FIT scheme have been replaced by NEM scheme due to the high cost involved to fund FiT scheme and expiration of date. Therefore, in 2016 the government introduced NEM. The NEM also is an approved 5-year-programme implemented since November 2016 and will span up to the year of 2020.

Table 1: Quota Allocation under NEM scheme

Category of	**Peninsular Malaysia**					**Sabah & WP Labuan**				
consumers	**2016**	**2017**	**2018**	**2019**	**2020**	**2016**	**2017**	**2018**	**2019**	**2020**
Domestic/ residential	20	20	20	20	20	4	4	4	4	4
Commercial	35	35	35	35	35	4	4	4	4	4
Industrial	35	35	35	35	35	2	2	2	2	2
Sum (MW)	90	90	90	90	90	10	10	10	10	10
Total (MW)	**450 + 50 = 500**									

Note: MW = Megawatts
Source: Annual report SEDA, 2018

Table 1 shows the proposed quota allocation from 2016 to 2020. Throughout 5 years programme, Malaysian government have allocated total capacity of 500 MW for consumer that have registed under NEM scheme. Each year, 90 MW capacity will be released for Peninsular Malaysia and 10 MW for Sabah. This will bring total capacity of 100MW each year for consumer to produce clean energy from solar photovoltaic (PV) system. The annual allocation of 100 MW is classified into three categories of consumers, which is domestic, commercial, and industrial. Table 2 shows take up rate for NEM quota from 2016 until 2018. The total NEM quota capacity until 2018 was 27.80 MW. This leaves a balance of 472.20 MW of NEM quota which will be available until end of 2020. The Net Energy Metering (NEM) as at end of 2018 continued its lacklustre performance.

Table 2: Take up rate 2016 until 2020

Category of consumers	**Quota allocated**		
	2016	**2017**	**2018**
Domestic/ residential	0.60	1.54	0.23
Commercial	1.96	5.65	1.18
Industrial	2.72	11.05	2.87
Sum (MW)	5.28	18.24	4.28
Total Sum (MW)	27.80 (5.56%)		
Quota Balance (MW)	**500 – 27.80 = 472.20**		

Note: MW = Megawatts
Source: Annual report SEDA, 2018

Several studies have been conducted by researcher in Malaysia regarding NEM scheme from different perspective. Mansur, Baharudin, & Ali (2018a) and Mansur, Baharudin, & Ali (2018b) have conducted a research to evaluate the application of solar PV under NEM scheme of residential house from the economic perspective. In fact, NEM scheme have been analysed from financial aspect by Razali, Abdullah, Hassan, & Hussin (2019) in their study on comparison of new and previous NEM scheme in Malaysia. Their aim was to investigate the potential financial return of the new NEM 2019 in term of net present cost (NPC) and electricity cost savings. With this regard, there are no research have been done to analyse acceptance of NEM scheme from perspective of household behaviour. Therefore, there is a need to explore the acceptance of solar PV under NEM scheme from the consumer behaviour perspective.

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Theories and models of human behavior emanate from all disciplines of the social sciences. Indeed, in many ways disciplinary boundaries simply serve to delineate the types and contexts of human behavior in which researchers are interested and how behavior is defined. Having said this, several models have been used over the past decades to gain a better understanding of the factors of engaging in green behaviour. Interestingly, recent studies have discussed and provide evidence on the validity and reliability issue related to consumers' green behaviour in different settings (Pimdee, 2017; Jin & Kang, 2011; Chin et al., 2018). Creswell (2014) stated that differences in cultural backgrounds are becoming progressive noticeable. The present study reveals that the instruments predominantly employed in international comparative research to measure consumers' green behaviour are prevalently based on those of consumers from western cultures (Sun et al., 2020; Ko & Jin, 2017; Schueftan & Gonzalez, 2013). Extant literature shows that comparative research is necessary to examine if the generally accepted instruments for green behaviour are truely universal. Emperical studies have also indicated that the reliabilities of green behaviour instruments differ across countries. The current research aimed to determine the validity and reliability of of the green behaviour which specifically refer to solar energy acceptance instruments within the context of household in Malaysia. Therefore, the study research questions stated as:

1. Does the eight-factor correlate structure of the solar energy acceptance instrument optimally fit data in the Malaysian context?
2. Is the green behaviour instrument reliable and valid for measuring consumers' solar energy acceptance in Malaysian context?

2. Research Methodology

A total of 600 questionnaires were distributed to households in Klang Valley which comprises of Putrajaya, Kuala Lumpur, and Selangor. In each case, the head of household or spouse was asked to fill out the survey instrument. About 467 questionnaires were returned, representing a response rate of 77.8 percent. Due to missing information and inaduquate responses, a total of 422 usable questionnaires were obtained. Respondents were 177 males and 242 females with 52.1 percent are in range of 26 to 44 years old. In terms of ethnic distribution, the proportion of Malay, Chinese, Indian and other ethnicity are count as 75.8 percent, 12.3 percent, 10.2 percent, and 0.5 percent respectively. 63.7 percent of respondents are married.

This study adapted the measures used to operationalize the contructs included in the investigated model from relevant previous studies, making minor wording changes to tailor these measures to the context of solar energy acceptance. The measures of attitudes was adapted from Ajzen (1991) and (Li, 2011)The subjective norm and perceived behavioral control were revised from Ajzen (1991) and Soyez (2012). Perceived benefit, perceived compatibility with habits and routines, perceived initial cost items were adapted from Claudy (2011), Karahanna et al. (2006), Tornatzky and Klien (1982) respectively, while items for measuring perceived complexity and perceived performance were adapted from Moore and Benbasat (1991) and Kleijnen et al. (2009). All items were measured using a five-point Likert scale ranging from 1 as strongly disagree to 5, strongly agree. With the establishment of content validity, the questionnaire was refined through pilot study. The pilot study focuses on instrument clarity, question wording and validity. During the pilot study, 30 households were taken as subjects and invited to comment on the questions and wordings. The comments of these households then provided a basis for revisions to the construct measures. Several items were removed from the instrument based on the feedback.

The models are emperically tested using structural equation model (SEM) approach with AMOS 26.0 software. Following the two-stage model process, the measurement model was estimated using confirmatory factor analysis (CFA) to test reliability and validity of measurment model. There are several fitness indexes that reflect how fit is the model to the data getting from the survey. However, there is no agreement among researchers which fitness indexes to use. Hair et al. (2010) and Holmes-Smith (2006) recommend the use at least one fitness index from each category of model fit. There is three model fit categories namely absolute fit, incremental fit, and parsimonious fit. Table 3 shown the index categories.

Table 3: index category and level of acceptance for index

Index category	Name of index	Level of acceptance	Comments
Absolute fit	Chisq	P>0.05	Sensitive to sample size > 200
	RMSEA	< 0.08	Range 0.05 to 0.1 is accepted
	GFI	**> 0.90**	GFI = 0.95 is good fit.
Incremental index	AGFI	**> 0.90**	AGFI = 0.95 is good fit.
	CFI	**> 0.90**	CFI = 0.95 is good fit.
	TLI	**> 0.90**	TLI = 0.95 is good fit.
	NFI	**> 0.90**	NFI = 0.95 is good fit.
Parsimonious index	Chisq/ df	Chi square/ df < 5.0	The value should be less than 5.0

3. Results

Table 4 above summarized the results on internal relibility and convergent validity for constructs. Internal consistency reliability to test unidimensionality was assessed by Cronbach's alpha. Most of the result of alpha value are ranged from 0.74 to 0.93, which were above accepted treshold 0.70 suggested by Nunally and Bernstein (1994). However, there are two contructs, perceive compatibilty with habits and routines, and attitudes that shown a moderate level of internal reliability, which stated as 0.54 and 0.66 respectively. Then, convergent validity was test based on factor loading, composite reliabilities, and variances extracted. Convergent validity is the degree to which multiple attemts to measure the same concept in agreement. The result of convergent validity is shown in Table 4.

Table 4: Loading of all measurement items using CFA

Variables	Loadings	CR	AVE
Attitudes (α = 0.66)			
I believe reducing the use of non-renewable energy such as oil and coal has a positive effect in addressing climate change.	0.40	0.79	0.50
I believe the solar system has many benefits for me.	0.76		
I believe solar system have a good impact to the environment.	0.79		
I believe the use of solar systems at home is very worthwhile and beneficial.	0.74		
Subjective norm (α = 0.85)			
The important person in my life thought I should install a solar system.	0.76	0.85	0.65
My family think that I should install solar at home.	0.87		
My friend think that I should install solar at home.	0.80		
Perceived behaviour control (α = 0.84)			
I will install the solar system even though my friend advised me not to use it.	0.78	0.83	0.56
I can make a difference by installing a solar system.	0.78		
Using the solar system completely under my control.	0.67		
Perceived benefit (α = 0.83)			
Installing solar would reduce your monthly energy bill significantly.	0.75	0.81	0.57
By installing solar you would help to improve your local environment.	0.81		
Installing solar would make you self-sufficient.	0.70		
Perceived compatibility with habits and routines (α = 0.54)			
The use of solar systems is in line with my habits.	0.85	0.78	0.50
To use of solar PV would not require significant changes in your existing daily routines.	0.51		
Using solar would be compatible with most aspects of your daily life.	0.78		
To install a solar energy system, it only takes a small change in the structure of the house.	0.58		
Perceive initial cost (α = 0.74)			

You would find it a financial strain to install solar at home.	0.92	0.84	0.64
The initial cost of installing solar system would be too high to you.	0.91		
I do not have money to install a solar system at home.	0.50		
Perceived complexity (α = 0.82)			
It is difficult to understand how solar energy systems are operating.	0.67	0.87	0.58
It is difficult to use a solar energy system at home.	0.79		
It is difficult to install a solar energy system on the roof of your house.	0.88		
Installing a solar energy system requires a lot of knowledge about it.	0.67		
The procedure for installing a solar system at home is complicated and complex.	0.76		
Perceived performance (α = 0.83)			
When thinking about installing a solar system, you are worried about how the product is performing.	0.79	0.83	0.63
When thinking about installing a solar system, you will worry about how much maintenance is needed.	0.89		
When considering the installation of a solar system, you feel that it will not provide the level of benefits that you would expect.	0.68		
Intention (α = 0.93)			
I will educate myself related to solar system in the future.	0.80	0.93	0.70
I intend to buy solar PV	0.97		
I will install solar PV in the future.	0.78		
I will suggest other people to buy solar system.	0.77		

Notes: α is Cronbach's Alpha; CR: Composite Reliability = (square of the summation of the factor loadings)/{(square of thesummation of the factor loadings)+(summation of error variances)}; AVE: Average Variance Extracted = (summation of the square of the factor loadings)/ {(summation of the square of the factor loadings)+(summation of error variances)}

The factor loading for all items exceed the recommended level of 0.6. Composite reliability values, which depict the degree to which the contruct indicators indicate the latent contruct, range from 0.78 to 0.93. The composite reliability of all latent constructs exceeded recommended level of 0.7 (Fornell & Larcker, 1981). The average variance extracted, which reflect the overall amount of variance in the indicators accounted for the latent contruct, were in the range between 0.50 and 0.70. The average variances extracted of all latent constructs exceeded recommended level of 0.5 (Hair et al., 1998). Moreover, discriminant validity is the degree to which the measures of different concepts are distinct. Discriminant validity can be examined by comparing the squared correlations between constructs and variance extracted for a construct (Fornell & Larcker, 1981). The analysis results showed that the square correlations for each construct is less than the average variance extracted by the indicators measuring that construct, as shown in Table 5, indicating the measure has adequately discriminant validity. In summary, the measurement model demonstrated adequate reliability, convergent validity, and discriminant validity.

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The following measured indices was assessed the overall model fit. The observed value of chi-square normalized by degree of freedom for measurement model was 2.01 (X^2 = 1551.610, df = 771) which is smaller than 3 recommended by Bagozzi and Yi (1988). Other fit indexes also show good fit for the measurement model. The adjusted goodness-of-fit index (AGFI) is 0.82, which exceeds the recommended cut-off level of 0.8. The non-normed fit index (NNFI) is 0.90 and comparative fit index (CFI) is 0.92, greater than the 0.9 recommended (Bagozzi & Yi, 1988). The root means square error of approximation (RMSEA) is 0.050, indicates close fit which is lower than the recommended cut-off level of 0.08 recommended by Browne and Cudeck (1993). The combination of these results suggests that the demonstrated measurement model fits the data well.

Table 5: Discriminant validity

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1. **Intention**	**0.70**								
2. **Attitudes**	0.44	**0.50**							
3. **Subjective norm**	0.57	0.49	**0.65**						
4. **Perceived behaviour control**	0.61	0.41	0.60	**0.56**					
5. **Perceived benefit**	0.51	0.47	0.46	0.41	**0.57**				
6. **Perceived compatibility with habits and routines**	0.61	0.43	0.53	0.54	0.55	**0.50**			
7. **Perceived initial cost**	0.25	0.20	0.18	0.14	0.32	0.19	**0.63**		
8. **Perceived complexity**	0.21	0.10	0.14	0.16	0.19	0.07	0.43	**0.58**	
9. **Perceived performance**	0.30	0.21	0.17	0.13	0.20	0.14	0.47	0.44	**0.63**

Notes: Italic numbers on the diagonal show the AVE. Off-diagonal elements are the correlation among the contructs.

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4. Discussion and Conclusion

This paper is about questionnaire validation only. The CFA analysis confirmed the suitability of the questionnaire for measuring solar energy acceptance. This outcome coincides with the findings of Soyez et al. (2012); Claudy (2011); Pimdee (2017) and Sun et al. (2020) that indicated the measurement model fit the data when examined for households in Germany, Australia, Russia, China, Canada and United States of America. The results offer further evidence that the generally accepted green behaviour instruments are truly universal. Hence, the Malaysian version of the green behaviour questionnaire may be employed to measure households' solar energy acceptance in Malaysia. The reliabilities of green behaviour for the Malaysian sample were largely acceptable as well. For construct validation of psychology and behaviour questionnaires, researchers often make use of confirmatory factor analysis (CFA), especially when the tests are supposed to be multidimensional. For this, a covariance matrix is calculated over the scores of a number of subjects and CFA is then applied to test whether a presumed factor structure or pattern is not contradicted by this matrix. CFA is executed by means of structural equation modeling (SEM), a very sophisticated statistical procedure for testing complex theoretical models on data. CFA is only used for the measurement part of the models.

This research found that the solar energy acceptance measurements comprise an eight-factor structure: attitudes, subjective norm, perceived behaviour control, perceived benefit, perceived compatibility with habits and routines, perceived complexity, and perceived performance. The analyses confirm that all measurements suggested can be a worthwhile scale for measuring solar energy acceptance within Malaysian context. The reliabilities of the measurements for the Malaysian sample are also generally acceptable. Both the differences and similarities found between the current and previous studies are indicative of dramatic cultural diversity.

This paper contributes to the literature by testing the robustness of the instrument development within the context of green behaviour. This finding significantly benefits the knowledge on the nature of green behaviour across Malaysian households in regard to the solar energy acceptance measures. Analysis revealed that the eight-factor correlated model for solar energy acceptance result in acceptable model fit for Malaysian context.

This study suggests the importance of validating the structure of households' green acceptance by confirming it through CFA. This recommendation is attributed to the progressively noticeable differences in cultural backgrounds. In addition, the hypothesis about a reliable and a valid green behavior instrument for households in Malaysia must be tested in the future. Other factors, such as socioeconomics issues or financial factors in details, should likewise be investigated further. The next finding of the current research will contribute to the government of Malaysia with current data that would aid the ministry in making better policy decisions and applying the best policy with greater certainty the implementation of solar energy in refer to household's context in Malaysia.

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