INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
Vol. 13 No. 2 (2022) 91-99

IJSCET

http://penerbit.uthm.edu.my/ojs/index.php/ijscet
ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Successful Renewable Energy Implementation Model

Mohamed Abdulwahab Abdulwali Alahdal[1], Md.Nizam Abd Rahman[2*], Najmaddin Abo Mosali[3]

[1,2]Faculty of Technology Management and Technopreneurship,
Universiti Teknikal Malaysia Melaka (UTeM)

[3]Faculty of Mechanical and Manufacturing Engineering
Universiti Tun Hussein Onn Malaysia (UTHM)

*Corresponding Author: dr.mohameduae2018@gmail.com

DOI: https://doi.org/10.30880/ijscet.2022.13.02.008
Received 10 April 2022; Accepted 25 April 2022; Available online 9 May 2022

Abstract: This paper presents a case study on developing a relationship of success factors affecting to the sustainable solar energy success project implementation model. The model adopted partial least square (PLS) approach of structural equation modelling (SEM) and developed in SmartPLS software. The model comprised of six exogenous constructs of success factors and one endogenous construct of sustainable solar energy success. The data used to develop the model was derived from 295 valid responses of a questionnaire survey amongst the UAE employees of energy sectors. The survey adopted simple random sampling technique in respondents' selection. The developed model was evaluated at the measurement and structural components of the model it was found that the model has achieved its goodness-of-fit, GoF criteria of 0.518 which indicates that the model has substantial validating power. When conducting hypothesis testing using bootstrapping function on the model, it was found that four of the constructs are significant based on t-value and p-value. The four significant constructs are economy, environment, technology and government support in relation with the sustainable solar energy project. Unfortunately, the other two exogenous constructs that are not significant are organisational and management (OAM) and Technology (TEC). These unsignificant relationships are due to the characteristics of the collected data which is not strong enough to establish significant relationship as what have been hypothesized. The findings are contributions to any parties that involved in the development of sustainable solar energy project.

Keywords: sustainable solar energy success, critical success factors.

1.0 Introduction

Energy contributes enormous impact to the progress and development of every country. It provides basic requirement needed to power homes, transportations, institutions, industries, hospitals, economies and day-to-day human activities. Energy therefore influence the lives and livelihood of the people at all level (Jamil et al., 2016b). Energy sector is one of the greatest sectors in many countries and specifically in UAE. The sector is given more priority because of the role it plays for the economic growth and development of each country and its global competitiveness. However, the major issue of concern is how the energy is generated. Conventionally, the energy is generated using fossil fuels and natural gas. This energy source emits significant CO2 into the atmosphere raising the concern of pollution and global warming thereby bringing to question the sustainability of such energy sources (AlFarra & Abu-Hijleh, 2012b; Alzaabi & Mezher, 2021; Poullikkas et al., 2015). Therefore, it requires innovativeness to drive renewable energy as alternative to the non-sustainable energy sources.

In the UAE, several renewable energy projects have been launched which include the solar renewable energy (Shams 1, Masdar city PV project, Mohammed bin Rashid Al Maktoum Solar Park [MBR Solar Park], Noor Abu Dhabi, Dubai Rooftop Solar Program, and Abu Dhabi Rooftop Solar Program), waste to energy renewable energy (WtE, Bee'ah, Al Warsan 2 WtE Plant, Abu Dhabi WtE Plant, and Al Ain WtE Plant). Of these projects, only Sham 1, Masdar city PV project, Mohammed bin Rashid Al Maktoum Solar Park [MBR Solar Park] Phase 1 and 2, and Dubai Rooftop Solar Program are completed (Salim & Alsyouf, 2020). However, he wind energy which is also an alternative renewable energy source has relatively lower potential due to moderate speed thereby making the solar renewable energy preferable (Alzaabi & Mezher, 2021; Eveloy & Gebreegziabher, 2019; Gherboudj & Ghedira, 2016; Jamil et al., 2016b; Poullikkas et al., 2015; Soonmin, Okoroigwe, Giwa, Balogun, & Yusuf, 2018).

Implementation of renewable solar energy in the UAE has not been evaluated empirically to ascertain their level of effectiveness and success. The previous studies in UAE were mostly limited to the potentials of the renewable energy source sources in providing the energy needs of UAE. For instance Salim and Alsyouf (2020) studied the status and the potential of the solar energy, wind energy and waste to energy renewable energy sources. The study did not evaluate whether the implemented renewable energy projects are effective and successful or otherwise. Similarly, Poullikkas et al. (2015) estimated the optimal power generation expansion methods for renewable energy generation in the UAE. The study was simulated scenario not the actual implemented projects. Alzaabi and Mezher (2021) also look at the renewable energy needs in the UAE but did not evaluate the implemented project to discern their effectiveness and success or otherwise. Other studies on renewable solar energy sources in the UAE were on their potential to provide the much energy need of the UAE populace without looking into the effectiveness and success or otherwise of the already implemented renewable solar energy project to gain insight of the success factors for application in subsequent projects (AlFarra & Abu-Hijleh, 2012b; Jamil et al., 2016b; Mokri et al., 2013b).

There are many factors that the implementation of renewable solar energy effective and successful. Several studies have identified different success factors for renewable energy implementation. Ali, Sopian, Yen, Mat, and Zaharim (2008) have identified management of risk as the core success factor for renewable energy implementation. However, Maqbool, Rashid, Sultana and Sudong (2018) identified communication factors, team factors, organisational factors, technical factors and technical factors as the critical success factors for renewable energy. Madriz-vargas, Bruce and Watt (2015) identified tariff collection, final user education and effective monitoring. While (Benecke, 2008) identified economic factors, political factors, social factors and institutional factors as the success or obstacle factors of renewable energy implementation. Some studies suggested that administrative innovation, process innovation, product innovation, radical innovation, and incremental innovation influence the effectiveness and success of new technologies for renewable energy (Khanna & Nerkar, 2016; De Marchi, 2012; Cainelli, & Grandinetti, 2015; Wagner, 2015; Wadin et al., 2017; Van Der et al., 2015; Cantillo et al., 2016). These success factors for implementation of renewable energy projects can be clustered into 6 groups namely the economic; environment; social; technology; government support; organizational and management (Mokan, et.al., 2019):

1. ***Economic factor*:** It is one of the critical success factors to ensure the success of implementing the renewable energy project. Among the economic factors include investment costs, operation and maintenance costs, R&D costs, production costs and return on investment.
2. ***Environment factor*:** Environment is another factor that drives the success of the renewable energy project. The environmental factors which affect the success of renewable energy projects are carbon dioxide emission, air pollution, land use requirement and impact on the ecosystem.
3. ***Social factor*:** Public interest, social acceptability, job creation, community support, public confidence and private sector involvement are the social factors that contribute to the success of renewable energy projects. These factors contribute changes in the energy industry where the willingness of customers to pay extra for electricity derived from renewable energy sources.
4. ***Technology factor*:** Among the technology factors that affect the success of renewable energy are R&D development, technical, innovative technology, advanced technology, new technology and information technology.
5. ***Government support factor*:** This factor is very crucial in attaining the success of renewable energy project. Government factors that affect the success of the implementation of renewable energy projects are government policies, politics, financial support and Feed-in-Tariff (FiT) programme.
6. ***Organizational and management factors***: These factors affect the success of renewable energy such as leadership, teamwork, top management support, risk management and stakeholder participations.

These success factors were used in the questionnaire development where the respondents were requested to rate each of the factors on the degree of influence on the sustainable solar energy success based on 5-points Likert scale. Data collected from questionnaire survey was based on 350 questionnaire sets that were distributed and only 291 valid responses were used analysis were used in this analysis. The respondents were requested to gauge each of the knowledge management factors using 5-points Likert scale that affect the company performance. The collected data was prepared in

MS Excel worksheet and then saved as *comma delimited* (*CSV*) type. Then, data was uploaded in the SmartPLS software for constructing the model.

2.0 Model description

This paper presents the study on developing a relationship of success factors contributing to the success on the implementation of renewable energy projects. The model development adopted Structural Equation Modelling (SEM) of Partial Least Square (PLS) technique. Fundamentally, there are two techniques for conducting SEM which are Partial Least Squares Structural Equation Modelling (PLS-SEM) and Covariance-Based Structural Equation Modelling (CB-SEM). PLS technique was selected because it is meant for theory prediction and development. While CB-SEM technique is use for theory testing and confirmation (Hair et al., 2017). The development and assessment of the model was carried out using SmartPLS software and the model is as figure 1.

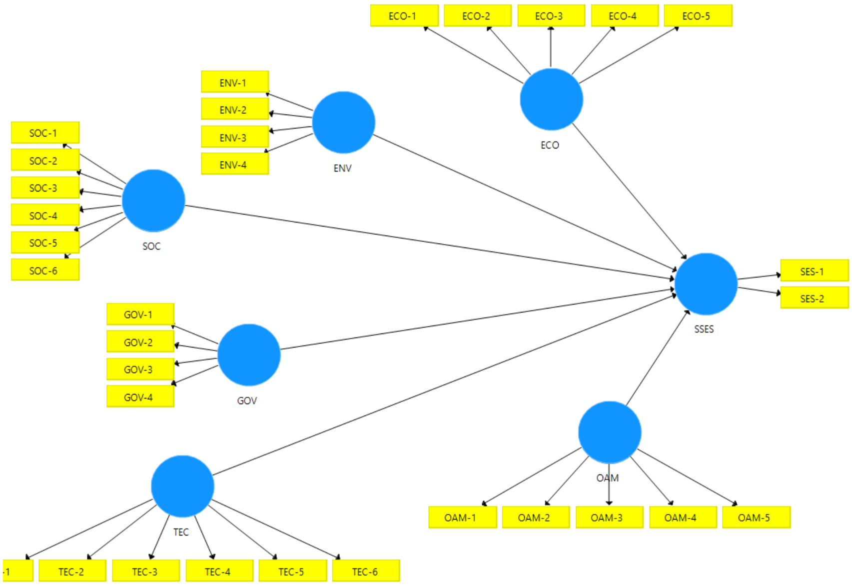

Figure 1 The model

This model comprises of six independent constructs and one dependent construct. The characteristics of the constructs and variables involved in the model are as in table 1

Table 1 Characteristics of model's construct

Constructs	Code	Number of factors
Exogenous Constructs		
1. Economic factor	ECO	5 factors
2. Environment factors	ENV	4 factors
3. Social factors	SOC	6 factors
4. Technology factors	TEC	6 factors
5. Government support	GOV	4 factors
6. Organizational and management factors	OAM	5 factors
Endogenous Construct		
Sustainable Solar Energy Success	SSES	2 factors

Table 1 shows the six exogenous of success factors of sustainable solar energy success which acts as the endogenous. The data used to develop the model was based on 295 valid responses from 350 selected respondents who are employees of UAE energy sectors and this represents 84% of response rate. The respondents were requested to gauge each of the success factors using 5-points Likert scale that affect the sustainable solar energy success project. The collected data was prepared in MS Excel worksheet and then saved as *comma delimited* (*CSV*) type. Then, data was uploaded in the SmartPLS software for constructing the model as figure 1. The shape of the model is categorised as reflective model because path of the indicators is in outward direction from the constructs (Hair *et al.*, 2017). Hence, model evaluation was conducted according to the processes and regulations which comply with reflective model specification. Evaluation of the model is carried out in two phases where the first phase is evaluation at measurement component and the second phase is at structural component of the model is as follow.

3.0 Assessment of Model's Measurement Component

The measurement model component is assessed based on the indicator reliability, convergent validity, and discriminant validity (Rahman, et.al., 2022)

3.1 Indicator reliability

Once the model has been constructed, the processes started by conducting iteration on the model using ***PLS Algorithm*** function to calculate the model criteria's estimates. The assessment of the indicator reliability depends on examining the factor loading values. The modelling evaluation is carried out by consecutive iterations and deletion of item/variable until and also checking for achievement of criteria threshold. At the final iteration/modelling, the model has achieved indicator reliability criteria threshold values as displayed in table 2.

Table 2 Indicator reliability

	Constructs						
Factors	**ECO**	**ENV**	**GOV**	**OAM**	**SOC**	**SSES**	**TEC**
ECO-1	0.808						
ECO-2	0.83						
ECO-5	0.76						
ENV-2		0.858					
ENV-3		0.885					
ENV-4		0.905					
GOV-2			0.901				
GOV-3			0.898				
OAM-2				0.939			
OAM-3				0.924			
SES-1						1	
SOC-4					0.864		
SOC-5					0.884		
SOC-6					0.762		
TEC-5							0.931
TEC-6							0.895

Table 2 indicates that all the left-over indicators/variables in the model are having factor loading equal or more than 0.5 which is above cut off value for the factor loading.

3.2 Convergent validity

The convergent validity is assessed by examining the construct reliability include Cronbach's alpha (α) and Composite Reliability (CR) must be greater than or equal to 0.70, and Average Variance Extracted (AVE) should greater than 0.50. Then for convergent validity of the constructs of the model, the values are as presented in table 3.

Table 3: convergent validity values

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
ECO	0.718	0.842	0.640
ENV	0.859	0.914	0.780
GOV	0.764	0.894	0.809
OAM	0.849	0.930	0.868
SOC	0.790	0.876	0.703
SSES	1.000	1.000	1.000
TEC	0.802	0.909	0.833

Table 3 shows all the values are above the threshold criteria. Where the Cronbach's alpha (α) and Composite Reliability (CR) for all constructs are above 0.70 and the Average Variance Extracted (AVE) values are more than the cut-off value of 0.5. Hence, the evaluation of the indicator reliability and convergent validity values of the measurement model are above the criteria cut-off values.

3.3 Discriminant validity

Discriminant validity can be carried out in two approaches which are cross-loading technique and Fornell-Larcker criterion technique. Cross-loading technique makes comparisons between the AVE square root values with the latent variable correlation value. Thus, this study accepted Fornell–Larcker and cross-loading criterion in inspecting the discriminant validity of the measurement model. Finally, the square root of AVE value of the model reached the adequacy of discriminant validity criterion as in Table 4.

Table 4: Fornell-Lacker criterion

Constructs	ECO	ENV	GOV	OAM	SOC	SSES	TEC
ECO	**0.800**						
ENV	0.018	**0.883**					
GOV	0.496	-0.045	**0.899**				
OAM	-0.194	0.266	-0.248	**0.932**			
SOC	0.417	0.007	0.399	0.076	**0.838**		
SSES	0.477	-0.121	0.408	-0.077	0.436	**1.000**	
TEC	0.702	0.034	0.514	-0.233	0.483	0.436	**0.913**

Table 4 represent the bolded square root of AVE and non-bolded values represent the inter-correlations value between constructs. It is indicated that all off-diagonal elements are lower than square roots of AVE. Hence, confirming that the model had achieved criterion of discriminant validity of the measurement model and the final model is as figure 2.

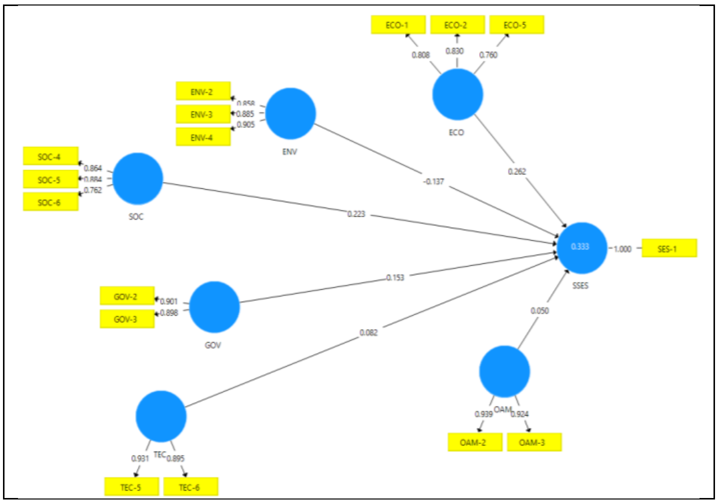

Figure 2 final model

4.0 Structural assessment

The structural component assessment involved path relationship strength, coefficient of determination, predictive relevance of the model, goodness-of-fit (GoF) and hypotheses of the paths

4.1 Strength of path relationship

According to Hair *et al.* (2019), path coefficients is measured with beta (β) value that reflect is the strength of the path or relationship between exogenous and endogenous constructs with values approximately between –1 and +1 (values can be smaller/larger but usually fall in between these bounds). Path coefficients values close to +1 represent strong positive relationships and vice versa for negative values that are usually statistically significant. The closer the estimated coefficients are to 0, the weaker are the relationships. The generated path coefficients or beta values of the model are extracted from the software and tabulated as in table 5

Table 5 Beta values of the paths

Exogenous constructs	Endogenous construct [SSES]	Rank of strength

ECO	0.262	1
ENV	-0.137	4
GOV	0.153	3
OAM	0.05	6
SOC	0.223	2
TEC	0.082	5

Table 5 shows that beta values of four relationships. According to Hair et al. (2017), β value should be above 0.1 regardless its signage either positive or negative. Thus, economy construct (ECO) is having the strongest while organisational and management construct (OAM) is the frailest relationship to the sustainable solar energy success project construct (SSES).

4.2 Coefficient of determination

Coefficient of determination is also known as R^2 which can be viewed as the combined effect of the exogenous variables on endogenous variables of the model. The R2 values ranges from 0 to 1 with value closer to 1 representing complete predictive accuracy. This study adopted the R2 threshold value by Cohen (1988) which R2 value of 0.26 is considered as substantial, R2 value of 0.13 is regarded as moderate, and R2 value of 0.02 is considered as weak. The R2 value for this model is extracted from the final model generation using PLS Algorithm function in SmartPLS software which is equal to 0.720 and considered as substantial effect.

4.3 Predictive relevance of the model

Predictive relevance is by measuring on Q^2 values that quantify the variances between the omitted and the predicated data points (Chin, 1998; Tenenhaus et al., 2005). By applying the blindfolding iteration process, the Q^2 values can be generated as in table 6.

Table 6: Generated predictive relevance (Q^2)

	SSO	SSE	Q^2 (=1-SSE/SSO)
ECO	873	873	
ENV	873	873	
GOV	582	582	
OAM	582	582	
SOC	873	873	
SSES	291	198.592	**0.318**
TEC	582	582	

According to Cohen, (1988) as the rule of thumb, it states that if the Q^2 value is equal and more than 0.02 but less than 0.15 then it indicates that the respective exogenous construct is having small predictive relevance, for Q^2 value is equal or more than 0.15 but less than 0.35, it indicates that the respective exogenous construct is having medium predictive relevance, for Q^2 value is equal and more than 0.35 then it indicates that the respective exogenous construct is having large predictive relevance (Hair *et al.*, 2017). Thus, based on the generated results in table 6, the model has achieved medium predictive relevance. This means that the exogenous constructs has medium predictive relevancy on to the endogenous construct.

4.4 Goodness-of-Fit (GoF)

GoF index is for assessing the global validity of a model. It is the geometric mean of the average communality (AVE) and the average coefficients of determination (R^2) value of the model (Hair, Ringle & Sarstedt, 2011). The GoF value of the model should be in the range between 0 and 1. If the value is equal or more than 0.1 but less than 0.25, the model can be categorised as having small validating power; if the GoF value is equal or more than 0.25 but less than 0.36 then it can be categorised as having medium validating power and for GoF value equal or more than 0.36, the model is considered having high/large validating power (Wetzels *et al.*, 2009; Akter *et al.*, 2011). Hence, GoF index of a model can be calculated manually using the following formula:

Goodness-of-fit, $GoF = \sqrt{\overline{AVE} \times \bar{R}^2}$ (1)

where;

AVE = average communality

R^2 = coefficients of determination

Hence, for this model the average of AVE for the entire construct variable and the R² for all dependent constructs variables as in Table 7.

Table 7: Calculation of GoF

All Constructs	**Values at the final stage of model**	
	AVE	**R^2 value**
ECO	0.64	
ENV	0.78	
GOV	0.809	
OAM	0.868	0.333
SOC	0.703	
SSES	1.000	
TEC	0.833	
Average	**0.805**	

The average of AVE for endogenous variable is 0.805 and the average R² for all dependent variables is 0.333. Thus, the calculated, $GoF = \sqrt{0.805 \times 0.333} = 0.518$. This indicates that the model is having global large/high validating power.

4.5 Hypothesis testing

Hypothesis testing for this model is conducted using bootstrapping function of the SmartPLS software. The bootstrapping method is basically the derivation of the sample from the sample. In this procedure, a large number of 5000 resamples are taken from the original sample with replacement to give bootstrap standard errors, which in turn gives approximate T-values and P-value for significance testing of the structural path (Hauser, Ellsworth, & Gonzalez, 2018; Gamil, Y. and Abdul Rahman, I., 2020). The generated t-values and p-values for the hypothesis testing for this study's model are shown in Table 8.

Table 8: Results of bootstrapping

Hypothesis	T Statistics (**≥1.96**)	P Values (**≤0.05**)	**Remark**
ECO -> SSES	3.659	**0**	Significant
ENV -> SSES	2.991	**0.003**	Significant
GOV -> SSES	2.34	**0.019**	Significant
OAM -> SSES	0.912	0.362	Not significant
SOC -> SSES	4.325	**0**	Significant
TEC -> SSES	0.937	0.349	Not significant

The hypothesis testing results show that four out of six relationships are significant which are having t-value and p-value above the cut-off values. Unfortunately, the other two exogenous constructs which are not significant are organisational and management (OAM) and Technology (TEC). This is due to the characteristics of the collected data which is not strong enough to establish significant relationship as what have been hypothesized.

5.0 Conclusion

This paper has discussed the construction and assessment of PLS-SEM model on the relationship between six domains of factors influencing/affecting the sustainable solar energy success project. The model adopted partial least square (PLS) approach of structural equation modelling (SEM) and developed in SmartPLS software. The model was evaluated at measurement level/component and then at structural level/component. The result of the evaluations found that the model has achieved its goodness-of-fit, GoF criteria of 0.518 which indicates that the model has substantial validating power.

The fit model was checked for hypothesis testing using bootstrapping function of the software and found that four of the constructs are significant based on t-value and p-value. Four of the significant relationships are economy, environment, technology and government support with the sustainable solar energy project. Unfortunately, the other two exogenous constructs that are not significant are organisational and management (OAM) and Technology (TEC). This is due to the characteristics of the collected data which is not strong enough to establish significant relationship as what have been hypothesized. The findings are contributions to any parties that involved in the development of sustainable solar energy project.

Acknowledgment

The authors would like to thank the Universiti Teknikal Melaka Malaysia (UTeM) for giving the opportunity to conduct this research.

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