ADOPTION OF SOLAR ENERGY: A STUDY ON ENABLERS AND INHIBITORS

Dr. G. Mahendar
Assistant Professor, MITS School of Business,
MITS, Andhra Pradesh, India
E-mail: mahendarg@mits.ac.in

Abstract

Energy plays a key role in the socio-economic growth of any country. Demand for energy is growing due to rapid industrialization, urbanization and burgeoning population. India being the fifth largest energy consumer in the world facing numerous challenges to bridge the gap between energy demand and supply with its limited fossil fuels. For an emerging economy like India renewable energy, solar energy, proves to be the best substitute as alternate energy sources. The current research focused on various factors influencing customer adoption of solar energy products for business purpose. The main predictor variables include solar energy awareness, cost, environmental concern and functionality of solar energy products. Data were collected from 136 solar energy users and analyzed using exploratory factor analysis and multiple regression using SPSS 20 version. Solar energy awareness, cost and functionality have a signification relationship with the adoption levels where as environmental concern has no impact on the adoption of solar energy. The findings of the study have important implications to both the marketers and the policy makers.

Key words: *Solar energy, Solar energy awareness, Cost, Environmental concern, Functionality*

1. Introduction

Energy is a critical commodity. It functions as a factor of production, as well as a consumer good. Availability of energy determines quality of the life style of individuals and that of the total economy. It is the lifeblood of economic development as it is a crucial input to majority of the goods and services of the modern era. Power sector is one of the key sectors contributing significantly to the growth of country's economy. Power sector needs a more useful role to be played in defining, formulating and implementing the research projects with close involvement of all utilities such that the benefit reaches the ultimate consumer (Naveen Kumar *et.al.* 2012). Solar energy has emerged as an alternative source, but its marketing has not been successful despite the advantages. As the demand for energy in emerging nations is increasing tremendously, it is of immense importance to understand the user's adoption levels of solar energy and the factors influence. Therefore, the current research focused to study the various factors influence the customers' adoption levels of solar energy products.

2. Literature Review and Hypotheses Development

Energy is considered a prime agent in the generation of wealth and a significant factor in economic development. Energy is also essential for improving the quality of life. Limited fossil resources and environmental problems associated with them have emphasized the need for new sustainable

energy supply options that use renewable energies. (Atul Sharma, 2011).

Srinivasan Chinnammai (2014) indicated that growing consumption of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Rising prices of oil, gas and coal and potential shortages in future lead to concerns about the security of energy supply needed to sustain our economic growth. Increased uses of fossil fuels have also caused environmental problems both locally and globally. Against this background, the country urgently needs to develop a sustainable path of energy development. The ultimate solution for the secure supply of energy will be the discovery of methods of harnessing non-conventional energy sources. The extraction and utilization of non-conventional energy will not only help in meeting energy demands but also help in their development. Since non-conventional energy sources provide environment-friendly, non-polluting energy, they help keep the atmosphere and environment clean and safe. Moreover, such energy sources are available locally; therefore, they will reduce the losses due to transmission.

Therefore, alternative sources of energy have become very important and relevant to today's world. These sources such as the sun and wind, can never be exhausted and therefore are called renewable. They cause less emissions and are available locally.

According to Hae-Kyong Bang et.al. (2000) Renewable energy comes from easily replenishable natural resources and technologies that are environmentally sound. Surendra Kumar Yadav and Govind Chandra Mishra (2013) defined Renewable energy is energy that comes from resources which are continually replenished such as sunlight, wind, rain, tides, wave sand geothermal heat.

India, being the first country in the world to have established an exclusive ministry, Ministry of New and Renewable Energy (1992) to meet the growing energy demands of the country. It launched its flagship programme Jawaharlal Lal Nehru National Solar Mission (JNNSM) in 2010 to capitalize the solar potential to cater the energy needs.

It is evident from past research that, most consumers in developed countries resort to solar energy mainly due to its positive impact on the economy and environment.

Dr. Bindiya Kansal, Mr Ajay Kumar Pathania (2015) defined solar energy as the energy available from the sun through sun rays. It is produced through two forms; one is a Solar Thermal Generator and other Solar Photovoltaic (PV) modules.

Velayudhan, S. (2003) states that need for disseminating SPV products in India has a vast geographical spread with most parts having 300 clear sunny days in a year. The daily average solar energy incidence varies from 4 to 7kWh/m2, depending on the location. The country receives solar energy equivalent to over 5000 trillion kWh per year.

2.1 Solar Energy Awareness

Renewable technology awareness is a concept where potential users can collect or have access to necessary information about the basic use, financial prospects and environmental impact of renewable energy (Sidiras & Koukios, 2004).

A higher level of awareness enables the users to make informed decision and it also increases the level of acceptance among new users. Fredric and Martinot (2004) argue that social awareness and lack of

understanding of the choice of the end users are among the important reasons behind the slow growth of renewable energy revolution in many countries.

Higher level of awareness towards renewable energy technologies enables the users making informed decision and increases the level of acceptance among new users. To make information cheap and accessible by mass users, government can undertake extensive marketing plans. Large scale training and community awareness programs can be carried out to facilitate an easy transition. Higher benefit-cost trade-off, higher level of awareness and higher ease of use directly influence intention to use renewable energy (Syed Shah Alam, Mamunur Rashid, S. S., 2012; Mirza, Ahmad, Harijan & Majeed, 2009).

Empirical study in Bangladesh proved that lack of public awareness is the major reason for the adoption of renewable energy technologies (Md. Alam Hossain Mondal *et.al*. 2010).

Solar energy awareness is positively related to the adoption of solar energy products.

H1: There is a significant relationship between solar energy awareness and adoption of solar energy.

2.2 Cost

Cost is the amount of money customer pays to install solar energy products. The most frequently cited reason for non-subscription was the relatively higher monetary cost of purchasing green electricity compared to conventional energy sources, with almost 40%of non-subscribers citing financial reasons (Elizabeth V. Hobman, E. R., 2014).

Low cost of renewable energy is positively related to the purchase intention of renewable energy Syed Shah Alam, Mamunur Rashid, S. S. (2012).

An important obstacle to the adoption of Renewable Energy Technologies is the high costs. Especially initial investment costs are high (Md. Alam Hossain Mondal et.al. 2010; Timilsina *et al.*, 2000).

The literature on solar home systems and other stand-alone systems deals with issues related to financing, repair and maintenance, capacity building, marketing, subsidy arrangements, socio-economic impacts on people and communities, accessibility, affordability and benefits for people, typical barriers and opportunities for the disseminations of the systems, and strategies for implementation (Chaurey and Kandpal 2006, Chaurey and Kandpal 2010, Kumar *et al.* 2009, Miller 2009, Palit 2003, Ulsrud 2004, Urmee *et al.* 2009).

Alzola *et al.* (2009) depicted that the high cost of initial investment is the main barrier for the extensive use of solar photovoltaics.

H2: There is a significant relationship between cost of solar energy and its adoption.

2.3 Environmental Concern

Environmental concern represents a broad concept referring to a wide range of indicators such as beliefs that the environment is under threat, that there are adverse consequences to environmental degradation and general concern for human-caused environmental problems (Schultz, 2001).

Past research has found that environmental concern is positively and significantly correlated with environmentally friendly behaviour (Kinnear *et al.*, 1974; Roberts, 1996; Roberts and Bacon, 1997), and consumers with higher levels of such

concern are more likely to purchase green products (Banerjee and McKeage, 1994; Chan, 1999; Chan and Lau, 2000; Laroche *et al.*, 2001; Straughan and Roberts, 1999). Suchard and Polonsky (1991) stipulated that ecologically conscious consumers will try to protect the environment in various ways, by performing such activities as purchasing green products, engaging in recycling activities and favoring packaging made of recycled materials.

The literature strongly suggests that concern for the environment manifests itself in consumers' purchasing behaviors. Therefore, the current research anticipated a positive relationship between concern for the environment and willingness to pay more for renewable energy (Hae-Kyong Bang et.al. 2000; Bang, H.K., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A., 2000)

Environmental value, among a variety of values, is the most relevant to the SPS install intention, since that environmental value is an enduring prescriptive or proscriptive belief that directly reflects individual's environmental concern (Kee Kuo Chen. 2014).

Environmental Motivations are Not Necessary, or Sufficient. Yet some of these homeowners were adamantly against environmentalism and not motivated by environmental concern. Many customers did not fit with ideas associating PV adoption with environmental concern, and all identified other reasons to adopt (Schelly, C. 2014).

H3: There is a significant relationship between environmental concern and adoption of solar energy.

2.4 Functionality

Functionality refers to the reliability and efficient operating of a system.

Reinders *et al.*, (1999) study found that technically the solar home systems performed well. The users are satisfied about the performance.

Rishi Raj Borah, Debajit Palit, Sadhan Mahapatra (2014) found in their survey that majority of the customers were satisfied with the performance of solar energy products.

Lack of confidence in the long-term performance of the solar systems is limiting widespread adoption (ETSU, 2001; Timilsina *et al.*, 2000).

H4: There is a significant relationship between functionality of solar energy products and the adoption.

3. Conceptual Framework

Based on the extant literature review the below conceptual framework has been framed where solar energy awareness, cost, environmental concern and functionality have positively related to the adoption levels of solar energy products. Conceptual framework can be seen from figure 1.

Insert Figure 1

4. Research Methodology

The paper aims to study the various factors leading to customer adoption of solar energy products who use for business purpose. For the current study data were collected from 136 solar energy customers from Telangana and Andhra Pradesh states. There are 14 items were used to collect primary data from the respondents which have been drawn from the previous literature. The survey was conducted using a structured questionnaire. Responses from

the participants were captured using a five-point Likert rating-scale ranging from 5 (strongly agree) to 1 (strongly disagree). Snow ball sampling technique has been adopted for data collection as this method allows the researcher to get the referrals. Respondents for the study include owners, tenants, builders developers who installed solar energy products. Data were analyzed by utilizing SPSS 20 version. Exploratory factor analysis technique was used for extraction of factors later multiple regression was conducted to the test the framed hypotheses.

5. Data Analysis and Findings

5.1 Factor Analysis Results

Factor analysis is predominantly used in social sciences research as a technique for data reduction. The data for the study comprises responses from 14 items. Before proceeding to exploratory factor analysis some preliminary tests were conducted. Questionnaire reliability was assessed, and the Cronbach's alpha value was 0.796 which was above 0.70 as suggested by George, D. (2003). Sampling adequacy was checked using Kaiser-Meyer-Olkin (KMO) value, which was 0.711 above the threshold value, 0.70 as recommended by Tabachnick, B.G. and Fidell (1989). Bartlett's test value was found to be significant, $p<0.001$ as recommended by Hair, Anderson *et al.* (1995).

From the results, it is concluded that the scale was reliable, and the sample data was adequate to proceed to exploratory factor analysis.

There are 14 linear components included in the data set. Item value with Eigen value more than one was taken as factor. Four factors were extracted finally which explained 72.35 percentage variance. The output of factor analysis is shown in table 1 Further, multiple regression was carried in order to examine the effects of predictors i.e. solar energy awareness, cost, environmental concern and functionally on the dependent variable i.e. adoption of solar energy.

Insert table 1

5.2 Multiple Regression Analysis

5.2.1 Model fit: from the table 2 The multiple regression model was significant i.e. $p < 0.001$.the predictors i.e. solar energy awareness, cost, environmental concern and functionality able to explain 58.9 percent of the total variance in the dependent variable, adoption of solar energy. For an accepted model fit the difference between R^2 and adjusted R^2 should not exceed 0.05. In this case the difference is 0.017 (R^2 – adj $R^{2)} < 0.05$, which suggests a good model fit. Durbin-Watson test was performed to assess auto correlation, the value was found to be 2.027 which was close to 2, suggests that there is no auto correlation problem in the model. Table 2 displays the summary of the regression model, and table 3 provides the ANOVA results.

Insert table 2, 3, 4

5.2.2 Multicollinearity Diagnostics

The multiple regression concept is based on the intercorrelations among the predictors. Therefore, it is suggested to check the data for multicollinearity i.e. high inter correlations of predictor variables. Multicollinearity is calculated using Tolerance and Variance Inflation Factor (VIF). Tolerance value is calculated using $1\text{-}R^2$ formula. Tolerance should be higher

the lower the collinearity. The tolerance value more 0.50 is considered as no multicollinearity problem. Similarly, VIF value less than 3 suggests there is no multicollinearity problem in the data set. From the table 4 it is evident that there is no multicollinearity problem.

Insert table 5

6. Hypothesis Testing and Results

H1: There is a significant relationship between solar energy awareness and adoption of solar energy.

From the results of multiple regression from the table 5, that customer's awareness levels towards solar energy products can predict customer's adoption of solar energy ($t = 6.879$, $p = .000$). $\beta = 0.364$ which indicates that these two variables are positively related. Hence, H1 is accepted.

H2: There is a significant relationship between cost of solar energy and its adoption.

Based on the results from the table 5, it is observed that $t = 2.785$, $p = 0.005$ ($p < 0.05$), cost of solar energy products can predict the adoption of solar energy products. $\beta = 0.147$ suggests that there is positive effect of cost with respect to the adoption of solar energy. Therefore, H2 is accepted.

H3: There is a significant relationship between environmental concern and adoption of solar energy.

Multiple regression analysis results revealed that environmental concern and adoption of solar energy are not related, and environmental concern cannot predict adoption of solar energy products as the value of $\beta = 0.274$ (> 0.05). Hence H3 is not accepted.

H4: There is a significant relationship between functionality of solar energy products and the adoption.

The results of multiple regression analysis, $t = 5.186$, $p = 0.000$ ($p < 0.05$) indicate that functionality of solar energy products can predict the adoption of solar energy products. Furthermore, $\beta = 0.245$, means that functionality of solar energy products is directly proportional to adoption of solar energy products. H4 is accepted.

Limitations and Directions for Future Research

The current study was conducted in only two States i.e. Telangana and Andhra Pradesh with a limited sample size, hence findings of the study cannot be generalized. Hence, future studies can focus with large geographical areas with bigger sample size. The study was confined only to four variables i.e. customer awareness, cost, environmental concern and functionality of solar energy products. There are other variables could focus on different attitudinal and behavioural dimensions. Sample size for the study includes the customers who use solar energy products for business operations/ purposes, future studies could be directed at household customers and rural customers. The study is limited only one type of renewable energy i.e. solar energy, further studies could be taken up on other renewable energy products. A major limitation of the study is that the study is conducted from the customer's perspective, hence the studies could be aimed at other stakeholders in the market such as solar energy dealers, marketers, policy makers, manufactures.

Implications of the Study

Results of the study indicate that customer adoption levels of solar energy are positively influenced by solar energy awareness and functionality where as it is negatively influenced by cost of solar energy products due to high initial investment for setting up solar energy. Manufactures need to focus more to bring down the solar energy equipment cost down by incorporating innovative Research and Development activities. At the same time, the policy makers can encourage the customers for the installation of solar energy by providing some incentives and subsidy facilities. And environmental concern has no impact on purchase of solar energy. Therefore, policy makers need to focus on the behavioural aspects of the customers about environmental concern.

Discussion and Conclusion

The current paper empirically examined the various factors influencing adoption of solar energy products. From the study, it was found that solar energy awareness and functionality of solar products have a positive impact on purchase of solar energy products. Results of the study revealed that cost of solar energy has a major impact on adoption compared to other variables. It is due to high initial cost, cost of solar energy is negatively impacting purchase of solar energy due to high initial cost. Government can take further steps to bring down the cost by manufacturing indigenously and adopting innovative Research and Development activities. Environmental concern levels are very low in majority of the customers which need to be addressed both by the maketers and policy makers by creating awareness and the importance of environmental conservation through aggressive campaigning.

References

1. Alzola J. A. Vechiu I. Camblong H. Santos M. Sall M. Sow G. (2009). Microgrids project, Part 2: design of an electrification kit with high content of renewable energy sources in Senegal. *Renewable Energy*, 34(10), 2151-2159.
2. Atul Sharma (2011). A comprehensive study of solar power in India and World. *Renewable and Sustainable Energy Reviews*, 15, 1767–1776
3. Banerjee, B. and McKeage, K. (1994). How green is my value: Exploring the relationship between environmentalism and materialism. *Advances in Consumer Research*, 21 (1), 147-152.
4. Bang, H.K., Ellinger, A.E., Hadjimarcou, J. and Traichal, P.A. (2000). Consumer concern, knowledge, belief and attitude toward renewable energy: An application of reasoned action theory. *Psychology and Marketing*, *17*(6), 449-468.
5. Chan, K. (1999). Market segmentation of green consumers in Hong Kong. *Journal of International Consumer Marketing*, 12(2), 7-24.
6. Chan, R.Y.K. and Lau, L.B.Y. (2000). Antecedents of green purchases: A survey in China. *Journal of Consumer Marketing*, 17(4), 338-357.
7. Chaurey A, Kandpal T.C. (2006). Solar lanterns for domestic lighting in India: viability of central charging station model. *Energy Policy, 37*(11), 4910–8.
8. Chaurey A, Kandpal TC (2010). A techno-economic comparison of rural electrification based on solar home systems and PV microgrids. *Energy Policy,* 38 (6):3118–29
9. Elizabeth V. Hobman, E. R. (2014). Barriers to green electricity

subscription in Australia: "Love the environment, love renewable energy . . . but why should I pay more?. *Energy Research & Social Science*, 78-88.

10. Fredric, B. and E. Martinot, (2004). *Renewable Energy Policies and Barriers.* Amsterdam: Elsevier Academic Press.

11. George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference 11.0 update.* (4th edn). Boston: Allyn & Bacon

12. Govinda R. Timilsina, Lado Kurdgelashvili, Patrick A. Narbel (2011). A Review of Solar Energy: Markets, Economics and Policies. Policy Research (Working Paper 5845) http://documents.worldbank.org/curated/en/546091468178728029/pdf/WPS5845.pdf

13. Hae-Kyong Bang et.al. (2000). Consumer Concern, Knowledge, Belief, and Attitude toward Renewable Energy: An Application of the Reasoned Action Theory. *Psychology & Marketing*, 17(6), 449–468

14. Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1995). *Multivariate Data Analysis with Readings*, 4th Ed., London: Prentice Hall.

15. Kee Kuo Chen. (2014), Assessing the effects of customer innovativeness, environmental value, and ecological life styles on residential solar power systems install intention. *Energy Policy*, 951–961.

16. Kinnear, T.C., Taylor, J.R. and Ahmed, S.A. (1974). Ecologically concerned consumers: Who are they? *Journal of Marketing*. 38(2), 20-24.

17. Kumar A, Mohanty P, Palit D, Chaurey A. Approach for standardization of off-grid electrification projects (2009). *Renew Sustain Energy Rev*, 13, 1946–56.

18. Laroche, M., Bergeron, J. and Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing*, 18(6), 503-520.

19. Md. Alam Hossain Mondal et.al. (2010). Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh—An innovation system analysis. *Energy Policy*, 38, 4626–4634

20. Miller D. (2009). Selling solar: the diffusion of renewable energy in emerging markets. London: Sterling, VA: Earthscan

21. Mirza, U.K., Ahmad, N., Harijan, K. & Majeed, T. (2009). Identifying and addressing barriers to renewable energy development in Pakistan. *Renewable and Sustainable Energy Reviews*, 13(4), 927-931.

22. Naveen Kumar Sharma, Prashant Kumar Tiwari, Yog Raj Sood (2012). Solar energy in India: Strategies, policies, perspectives and future potential. *Renewable and Sustainable Energy Reviews*,16, 933– 941

23. Roberts, J.A. (1996). Green consumers in the 1990s: Profile and implications for advertising. *Journal of Business Research*, 36 (3), 217-231.

24. Roberts, J.A. and Bacon, R. (1997). Exploring the stable relationship between environmental concern and ecologically conscious consumer behaviour. *Journal of Business Research*, 40(1), 79-89.

25. Schelly, C. (2014). Residential solar electricity adoption: What motivates, and what matters? A case study of early adopters. *Energy Research & Social Science*, 183–191.

26. Schultz PW (2001). The structure of environmental concern: concern for self, other people, and the biosphere. J. Environ. Psychol. 21(4):327-339.

27. Sidiras, D.K. & Koukios, E.G. (2004). Solar systems diffusion in local markets. *Energy Policy* 32(18), 2007-2018.

28. Srinivasan Chinnammai (2014). A Study on Energy Crisis and Social Benefit of Solar Energy. *International Journal of Environmental Science and Development, 5(4).*

29. Straughan, R.D. and Roberts, J.A. (1999). Environmental segmentation

alternatives: A look at green consumer behaviour in the new millennium. *Journal of Consumer Marketing*, 16 (6), 558-575.

30. Suchard, H.T. and Polonsky, M.J. (1991). A theory of environmental buyer behaviour and its validity: The environmental action-behaviour model", *AMA Summer Educators' Conference Proceedings*, 2, 187-201.

31. Surendra Kumar Yadav and Govind Chandra Mishra (2013). Renewable Energy Potential in India. *International Journal of Engineering Research and Technology*, 6 (5), 709-716

32. Syed Shah Alam, Mamunur Rashid, S. S. (2012). Intention to use renewable energy: Mediating role of attitude. *Energy Research Journal*, *3* (2), 37-44.

33. Tabachnick, B.G. and Fidell, L.S. (1989). *Using Multivariate Statistics*, Harper & Row, Cambridge, MA.

34. Tania Urmee, David Harries (2009). Issues related to rural electrification using renewable energy in developing countries of Asia and Pacific, *Renewable Energy*, 34, 354–357

35. Ulsrud K. Winther T. Palit D. Rohracher H. Sandgren J. (2011). The solar transition research on solar mini-grids in India: Learning from local cases of innovative socio-technical systems. *Energy for Sustainable Development,* 15(3), 293-303.

36. Velayudhan, S. (2003). Dissemination of solar photovoltaics: a study on the government programme to promote solar lantern in India. *Energy Policy*, 31, 1509–1518.

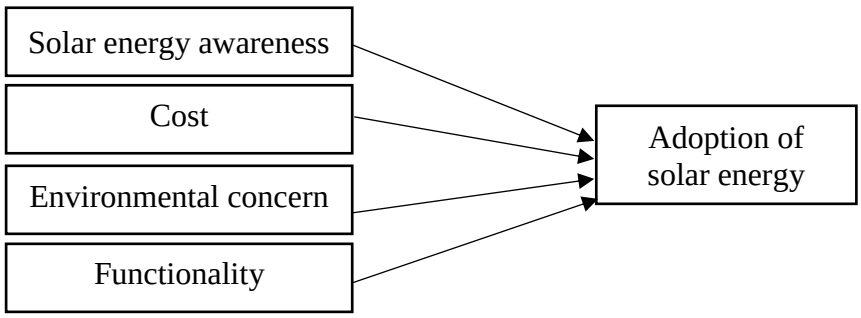

Figure 1: Conceptual framework

Table 1 - Reliability and Factor Loadings

Description of Variables	Factor Loading	Cronbach' Alpha
Solar Energy Awareness		0.931
SEAW1: I am aware of solar energy	0.912	
SEAW2: I am familiar with solar-generated electricity	0.908	
SEAW3: I can recognize the solar energy products (systems) easily	0.914	
SEAW4: I have adequate knowledge about solar energy	0.875	
Cost		0.918
Co1: Renewable energy more costly than conventional fossil fuel systems	0.916	
Co2: Solar energy is an affordable technology	0.895	
Co3: Initial investment costs for solar energy are too high	0.854	
Co4: Cost of maintenance of solar energy is low compared to conventional energy	0.926	
Environmental Concern		0.689
EC1: I am concerned about the environment (air, water and land use) before purchasing any product	0.785	
EC2: I am concerned about pollution before purchase any product.	0.793	
Functionality		0.768
FC1: Solar energy systems are reliable enough to safely provide electricity	0.747	
FC2: Solar energy is robust enough to meet the energy needs	0.754	
FC3: Solar energy systems are efficient to meet the energy needs	0.670	
FC4: Level of performance of solar energy systems is satisfactory	0.816	

Table 2 - Regression Model Summary

Model Summary [b]

Model	R	R Square	Adjusted R square	Std. Error of the Estimate	Durbin-Watson
1	0.767[a]	0.589	0.572	0.978	2.027

Table 3 - ANOVA results

ANOVA [a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	378.062	4	94.515	96.124	0.000[b]
	Residual	124.672	128	0.974		
	Total	502.734	134			

a. Outcome Variable: Adoption of Solar Energy

b. Predictors: Solar Energy Awareness, Cost, Environmental Concern, unctionality.

Table 4 - Multicollinearity Analysis

Multicollinearity Statistics[a]:

		Collinearity statistics	
Model		Tolerance	VIF
1	Solar Energy Awareness	0.632	1.583
	Cost	0.617	1.621
	Environmental Concern	0.944	1.059
	Functionality	0.686	1.457

Note: [a] Dependent Variable: Adoption of Solar Energy