Predicting Adoption of Solar Power System in Southern Region of Pakistan through Linear Regression Model

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Abstract

In this paper the main aim is to focus on preparing a best linear regression model to predict the attitude of Pakistani consumers toward adoption of solar power system.

This research is carried out on the bases of the Multiple Linear Regression Model. For this research, a survey is conducting in the southern region of Pakistan and then Minitab software is used to run and test of the significance of the Regression model.

This study showed that 6 factors Knowledge about Renewable energy, Environmental Belief, Social Influenced, Hedonic Motivation, Price Value and Perceived Behaviour Control are the significant factors to predict the Attitude of consumers toward use of Solar Power System. Some other factors such as Income, Education, Occupation, Gender, Age, Performance Expectancy and Effort Expectancy are not the significant factors toward adoption of solar power system.

Keywords: Renewable Energy**,** Solar Power System, Consumer Intention, Multiple Linear Regression, Pakistan

1. Introduction

With the enormous usage of energy reserves at large scale, the individuals by and large and researchers specifically should be prepared to confront the threats of global warming and energy crisis. The global warming is increasing due to the combustion of non-renewable energy sources. These non-renewable energy sources including superior rates of carbon incorporate coal (27%), oil (36%) and petroleum gas (23.4%). The consuming of these petroleum derivatives creates around 21.3 billion tons of CO_2 for each year **[1].** CO_2 is one of the ozone depleting substances that enhances radiative restricting and increases to a worldwide temperature alteration. Since these characteristic assets on earth are constrained and can't be recreated over a brief timeframe. Therefore, energy crisis will increase gradually day by day. So as to beat these

interconnected issues it is important to

- ➢ Shift from fossil fuels to renewable energy sources.
- ➢ Fabricate low-carbon energy devices.
- ➢ Harvest unused energy from the atmosphere.

Now on larger scale, dynamic innovative works are occurring to discover alternate energy reserves like wind, solar, wave and nuclear energy. But it is equally important to focus on the consumers view regarding adoption among the available energy resources. This issue becomes more critical especially in this part of the world due to poor economic condition of the people.

As indicated by the Pakistan Economic Survey 2019-20 **[2]**, the installed power generation capacity is now reached at 37,402 MW in 2020. The maximum total demand coming from domestic and business areas remains at nearly 25,000 MW, while the transmission and supply facility is slowed down at around 22,000 MW. This prompts a deficiency of around 3,000 MW while the requirement increases. This extra 3,000 MW required can't be transferred even though the highest requirement of the state is clearly lower than its installed capacity of 37,402 MW. Although Pakistan has scaled down power outages and expanded power production significantly, power outages are yet regular, and the expense of energy has however increased. Recent tariff has added to this expansion in costs. In this manner, it is the need of the day to search for alternatives also.

Pakistan total power generation capacity in 2018-19 is 35,924 megawatts and renewable (wind, solar and bagasse combined) energy capacity is 1999 megawatts, which is 5.56% of total power generation capacity and solar power capacity was 400 megawatts which is 1.11% total power generation capacity **[3].**

The Government of Pakistan has taken several steps to improve solar technology in the country and developed a system for that purpose. In 1981, the National Institute of Silicon Technology (NIST) was established. NIST participates in the research, solar energy's marketing and development, with a particular emphasis on the photovoltaic solar energy **[4].**

In 1985, the Pakistan council for appropriate technology (PCAT) came into being and it focused on the small power conversion systems, solar cookers, biogas plants and small hydroelectric power plants. In 2001, the Pakistani Government joined the Pakistan council for renewable energy technology (PCRET), Pakistan council for appropriate technology (PCAT) and

the national institute of silicon technology (NIST) for conducting research on the promotion of renewable energy in the country **[4].**

PCRET has conducted pilot projects such as small-scale studies, solar biofuel installations, solar dryers, solar cookers, photovoltaic cells, solar water heaters and wind turbines' performing in the regional environment. PCRET also provides training opportunities for the protection and use of this knowledge. In 2003, the Pakistan's Government formed the alternative energy development board (AEDB). The organization's major objective is to play an important role in the renewable energy sector through executing different programs and policies.

The foreign investment and private sector is encouraged by the AEDB through providing a framework for the renewable energy production projects' sustainable and smooth implementation **[5].** Like other emerging countries, Pakistan is as well dealing similar obstacles in the successful implementation of solar systems **[6].** Pakistan's energy crisis is not easy to deal with and it requires a lot of investment in production distribution and acceptance of the people to use alternate energy resources.

Energy is lifeblood of the economy of the world. To perform the tasks related to all walks of life energy plays a vital role. It can be said that no human action is possible without the use of energy as all important sectors of a country needs continuous supply of energy. A nation's development can't progress without energy. So, we can say that energy is a fundamental factor of a nation's economy **[7].** Pakistan is rapidly growing as a developing nation and to run the economy of the country the energy generation is must. To improve its enormous population and business, the nation requires a massive amount of energy to maintain the things flourishing. **[8, 9].** Ironically, the energy supply in the state is not as per the demand and the nation is in a state of emergency. The difference between supply and demand of electricity has been extended in the previous few years and is extremely evident during hot weather which has made almost the complete halt of strength for 10 to 12 hours in city and for 16 to 18 hours in rural regions **[10–13]**. Energy shortage concerns not just the natural life of individuals including impeding the financial progress of the nation. All divisions like transport, agricultural, industry, household and energy production have been affected immensely because of long force shutdowns and created tremendous economic disaster to the state. The present part of sustainable power supply is inadequate in the complete energy mix of Pakistan **[14].** The nation satisfies its energy requirement by using fossil fuels **[15].** Tremendous reliance on non-renewable energy sources not only has a burden on the

country's economy yet in addition has encouraged distinct natural perils like the greenhouse effect, CO_2 emissions, a global heat variation and unstable climate shapes. Moreover, natural resources are being reduced because of overutilization of fossil fuels. As a result, there is a need to invent or explore alternate energy economy. At the present time, sustainable power sources, for example, solar, wind and biomass will be utilized to convey energy which can lessen the fossil import bill on one hand, and decline the climatic challenges on the other hand **[16].** Muhammad Irfan et al. **[17]** have assayed to equate the local renewable energy sources over various components to get a better understanding and to make the best energy decision for Pakistan. They have compared the effectiveness of solar radiation intensity and wind turbines in four main cities of Pakistan. The research showed that the best available renewable energy choice for Pakistan is solar energy because of numerous reasons. For example, cost, operation costs and preservation and life span. While studying the literature it came to our observation that the current energy resources are quite expensive like oil and gas and they are becoming costly day by day and even going beyond the reach of people having low income. This is also worth mentioning that the current energy resources oil, gas and coal are not environment friendly and causing irrecoverable damages to our whole ecological system so the environment friendly resources like solar can be the best alternative which is low in cost, affordable as well as environmental friendly and it can cover the needs of the masses and the future lies in it, so through this study we will develop a model for consumers in decision making of their selection of Solar Power System. Although fellow countrymen and organizations are shifting towards renewable energy system, but we are far away from developing a framework that could motivate people to adopt the solar energy system while keeping in mind social economic factors. The study is aimed to focus to prepare a Regression model that could provide the consumers a way out so that it will help them to adopt the most economical power system which is solar energy.

2. Theoretical framework

Multiple Linear Regression

Multiple Linear Regression is a statistical method that uses various independent variables to predict the result of a response variable. The main objective of multiple linear regression is to develop the linear relationship between the response variable and independent variables.

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \epsilon$$

Where,

Y = Response variable (Predicted variable)

X_i = Independent variable

β_0 = Y-intercept (constant)

β_i = Slope for each independent variable

ϵ = error (Residual)

The detail of each variable is mentioned below:

Response Variable:	
Y	Attitude toward use of solar Technology
Independent Variables:	
X_1	Gender
X_2	Age
X_3	Education
X_4	Occupation
X_5	Household Income
X_6	Marital Status
X_7	Knowledge About Renewable Energy
X_8	Average Monthly Electricity Consumption
X_9	Performance Expectancy (Enhance the performance)
X_{10}	Effort Expectancy (Easy to maintain)
X_{11}	Environmental Belief (Belief about green energy which control the climate)
X_{12}	Social Influence (Influenced of family and friend towards use of Solar Power system)
X_{13}	Facilitating Condition (Available Space and Helping condition)
X_{14}	Hedonic Motivation (Excitement toward use of Solar Power System)
X_{15}	Price Value (Affordable price which reduce the electricity bill)

X_{16}	Perceived Behaviour Control (Its Easy-to-use Technology)

3. Methodology:

In the proposed study, an exploratory investigation has been designed as the knowledge available is quite limited relating to solar power system's adoption and social acceptance within Pakistan. To conduct research, the quantitative research method is used and primary data has been collected. Further, survey method is employed for collecting the primary data from the participants. Therefore, a survey questionnaire with close ended questions was developed and circulated among the targeted population in different regions of Pakistan particularly southern region of Pakistan. The information has gathered from the urban areas. Moreover, the questionnaire's language was kept simple with limited technical terms so that the participants from different educational and family backgrounds can easily comprehend it. Furthermore, deductive approach has been used. In the survey's sample design, two criteria will be deemed significant. Firstly, the participants must be permanent inhabitants of different regions of Pakistan particularly southern region of Pakistan. Secondly, they must be at least 18 years of age or above. Before data collection, the participants was asked some questions regarding the renewable energy (RE) like the information relating to global warming, interest in solar power system, interest in the environmental problems and familiarity with the technologies used in generating renewable energy.

The data analysis will be done through different stages. First cleaned the data through MS Excel then the descriptive statistics calculated for all data with the help of SPSS software. Then to perform Multiple Regression Minitab software used.

Table 1. Descriptive Statistics.

Variables	Classification	N	Percentage
Gender	Male	159	79.5%
	Female	41	20.5%
Age	Under 18	1	0.5%
	18 to 24	50	25.0%
	25 to 34	88	44.0%
	35 to 44	46	23.0%
	45 to 54	10	5.0%
	55 to 64	4	2.0%
	65 and above	1	0.5%
Education Level	Middle School	1	0.5%
	Intermediate	5	2.5%
	Graduation	92	46%
	Post-Graduation	102	51.0%
Occupation	Govt. Servant	32	16.0%
	Private Sector	104	52.0%
	Retired	1	0.5%
	Self Employed	16	8.0%
	Student	39	19.5%
	Unemployed	8	4.0%
Household Income	Below 50,000	30	15.0%
	50,000 to 75,000	43	21.5%
	75,001 to 125,000	60	30.0%
	125,001 to 200,000	33	16.5%
	200,001 to 300,000	15	7.5%
	More than 300,000	19	9.5%
Marital Status	Divorced	3	1.5%
	Married	95	47.5%
	Single	101	50.5%
	Widowed	1	0.5%
Knowledge About Renewable Energy	Maybe	18	9.0%
	No	35	17.5%
	Yes	147	73.5%
Average Monthly Electricity Consumption	0 to 200	23	11.5%
	200 to 300	63	31.5%
	300 to 400	48	24.0%
	400 to 500	30	15.0%
	more than 500	36	18.0%

4. Results

Table 2. Regression Analysis with all 16 independent variables

Predictor	Coefficient	SE Coefficient	T	P
Constant	0.0958	0.563	0.17	0.865
Gender	0.0952	0.1028	0.93	0.356
Age	0.01785	0.05661	0.32	0.753
Education	-0.07752	0.07722	-1	0.317
Occupation	-0.03719	0.03016	-1.23	0.219
household Income	-0.03676	0.0314	-1.17	0.243
Marital Status	-0.03731	0.09495	-0.39	0.695
Knowledge about RE	-0.07508	0.05425	-1.38	0.168
Monthly Energy Consumption	0.02847	0.03336	0.85	0.394
Performance Expectancy	0.10577	0.06518	1.62	0.106
Effort Expectancy	-0.03654	0.0588	-0.62	0.535
Environmental Belief	0.18234	0.06088	3	0.003
Social Influenced	0.19564	0.05822	3.36	0.001
Facilitating Condition	0.05377	0.05656	0.95	0.343
Hedonic Motivation	0.24904	0.05132	4.85	0.000
Price Value	0.22983	0.0633	3.63	0.000
Perceived Behaviour Control	0.13614	0.05527	2.46	0.015

Table 3. Regression Analysis after removing constant and 7 most insignificant factors

variables Gender, Age, Education, Marital Status, Monthly Consumption

of Electricity, Effort Expectancy and Facilitating Condition

Predictor	Coefficient	SE Coefficient	T	P
No constant				
Occupation	-0.02812	0.02514	-1.12	0.265
Household Income	-0.01669	0.02777	-0.6	0.548
Knowledge about RE	-0.07435	0.05085	-1.46	0.145
Performance Expectancy	0.09985	0.06169	1.62	0.107
Environmental Belief	0.18506	0.05806	3.19	0.002
Social Influenced	0.19993	0.05667	3.53	0.001
Hedonic Motivation	0.25712	0.04927	5.22	0.000
Price Value	0.21891	0.06023	3.63	0.000
Perceived Behaviour Control	0.14449	0.0492	2.94	0.004

Table 4. Regression Analysis after removing 2 most insignificant factors

Occupation and Household Income

Predictor	Coefficient	SE Coefficient	T	P
No constant				
Knowledge about RE	-0.08892	0.04915	-1.81	0.072
Performance Expectancy	0.08746	0.05988	1.46	0.146
Environmental Belief	0.18673	0.05673	3.29	0.001
Social Influenced	0.1986	0.05648	3.52	0.001
Hedonic Motivation	0.25506	0.04902	5.2	0.000
Price Value	0.20535	0.0578	3.55	0.000
Perceived Behaviour Control	0.15112	0.04877	3.1	0.002

Table 5. Regression Analysis after removing 1 insignificant factor Performance Expectancy

Predictor	Coefficient	SE Coefficient	T	P
No constant				
Knowledge about RE	- 0.0813	0.04902	-1.66	0.099
Environmental Belief	0.21012	0.05458	3.85	0.000
Social Influenced	0.2276	0.05303	4.29	0.000
Hedonic Motivation	0.26277	0.04887	5.38	0.000
Price Value	0.22393	0.05655	3.96	0.000
Perceived Behaviour Control	0.15557	0.04881	3.19	0.002

S = 0.547020   R-square = 98.27%

Table 6. Analysis of Variance

Source	DF	SS	MS	F	P
Regression	6	3306.65	551	1842	0.000
Residual Error	195	58.35	0.3		
Total	201	3365			

The required Multiple Linear regression equation is

Attitude Toward Use = - 0.0813 Knowledge About RE + 0.210 Environmental Belief + 0.228 Social Influenced + 0.263 Hedonic Motivation + 0.224 Price Value + 0.156 Perceived Behaviour Control

5. Discussion

Table 2 indicate Regression analysis of response variable "Attitude toward Use" and all 16 independent variables. The results show there are 7 insignificant factors Gender (β_1=0.0952, p-value=0.356), Age (β_2=0.01785, p-value=0.753), Education (β_3=-0.07752, p-value=0.317), Marital Status (β_6=-0.03731, p-value=0.695), Monthly Consumption of Electricity (β_8=0.02847, p-value=0.394), Effort Expectancy (β_{10}= -0.03654, p-value=0.535) and Facilitating Condition (β_{13}=0.05377, p-value=0.343), The constant (β_0=0.0958, p-value=0.865) is also insignificant here, so for the best model in next step remove these most insignificant factors along with constant and then re-run regression again. Table 3 also indicate 2 most insignificant factors Occupation (β_4= -0.02812, p-value=0.265) and Household Income (β_5= -0.01669, p-value=0.548) which removed in next step. Table 4 indicate 1 most insignificant factors Occupation (β_9= 0.08746, p-value=0.146).

Table 5 indicate all significant factors Knowledge About RE (β_7= -0.0813, p-value=0.099), Environmental Belief (β_{11}= 0.21012, p-value=0.000), Social Influenced (β_{12}= 0.2276, p-value=0.000), Hedonic Motivation (β_{14}= 0.26277, p-value=0.000), Price Value (β_{15}= 0.22393, p-value=0.000) and Perceived Behaviour Control (β_{14}= 0.15557, p-value=0.002). The value of R-square 98.27% mentioned indicate the percentage of variation explained by regression model. The p-value mentioned in Table 6 indicate overall the regression model is significant here.

6. Conclusion

The present energy crisis and environment change have a great influence on social behaviour and changing lives. The study is conducted in the Pakistan to investigate that there are various factors that have influenced use of Solar Powe System. The most significant factors that influenced the use of Solar Power System in our research are Knowledge About RE, Environmental Belief, Social Influenced, Hedonic Motivation, Price Value and Perceived Behaviour Control. So, for the recommendation of this study is to Government should focus on to allocate fund and awareness work for the improvement of these significant factors so that consumer can adopt the most economical and green energy Solar power System which also resolve the issue of shortage of electricity problems in Pakistan.

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