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The Economics of Renewable Energy Expansion for Rural Households

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Abstract: Cities' energy consumption increases as they grow. Also, as cities aspire to become "smart," green solar and wind energy will play a critical role in achieving their objectives. Civilization has required continual transition in the world over time, and as a result, infrastructure must be continuously changed to keep up with demands. The current study is unique in that it presents valuable data that will help rural households enhance their understanding of how solar panels as renewable energy may affect household energy costs and empirical findings that will persuade households to replace electricity with solar energy. Thus, the key aim of this study is to analyze the moderating effect of socio-economic factors such as household size, average age, and household income between household energy cost and solar energy usage. A total of 180 households were selected for data collection through convenience sampling using a structured questionnaire. The renewable energy access was measured through binary variables with two values (0,1), and household energy cost was measured by taking the mean value of electricity bills for the last twelve months. Linear regression was applied for hypotheses testing. The study's findings indicate that renewable energy access has a significant negative effect on household energy cost with a -0.712-beta value which depicts that using solar energy has 71.2 percent less energy cost for that household. Similarly, the demographic factors also have a significant moderating effect between renewable energy access and household energy cost, and all these findings are statistically significant. Therefore, based on empirical findings, the current study suggested that the authorities should promote the installation of solar panels on the roofs of future buildings, particularly public buildings and housing societies, to reduce energy costs and address environmental concerns.

Keywords: Solar energy, household energy cost, demographic factors

1. Introduction

Energy is a necessary component of all economic systems. Most current economic activities are based on fossil fuels such as natural gas, coal, and oil, non-renewable fuels. Renewable energy sources likewise solar energy, wind energy, and hydroelectric energy, now account for less than 10% of worldwide energy production. Numerous renewable energy sources have been used for centuries. Most renewable energy sources are less common and/or more expensive than traditionally used fossil fuels. Renewable energy supplies have high pricing because of their basic properties, such as high capital intensity, intermittent availability, and low net energy ratios. Although new technologies will cut costs, renewable energy may not be cost-competitive with market rates for fossil fuels soon unless fossil-fuel externalities are considered [1]. Meanwhile, better utilization of energy is crucial for any country as energy consumption is essential to reduce the expenses of any government. As soon, the size of any city grows, it needs more energy sources to fulfill its demand. In addition, as cities aspire to become "smart," green solar and wind energy will play a critical role in achieving their objectives [2]. Civilization has required continual transition in the world over time, and as a result, infrastructure must be continuously changed to keep up with demands. / Buildings, transportation networks, and industries would be reconfigured to utilize less energy as energy costs rose. A substantial part of the shift to renewable energy will most likely be accomplished by restructuring systems to use less energy rather than adding new energy sources. Because energy conservation is optimum when the marginal cost of energy conservation equals the marginal cost of renewable energy, this would be induced by the higher cost of renewable energy. Solar photovoltaic (SPV) energy is practically infinitely available and has a marginal cost that is the highest energy expense [3]. Moreover, the world energy council gives world residential electricity used per capita as shown in Figure 1.

One of the main concerns is how to deal with the transition to renewable energy by declining the energy cost and the losses of energy while its usage. The current fossil-fuel-dominated energy system will eventually be replaced by a

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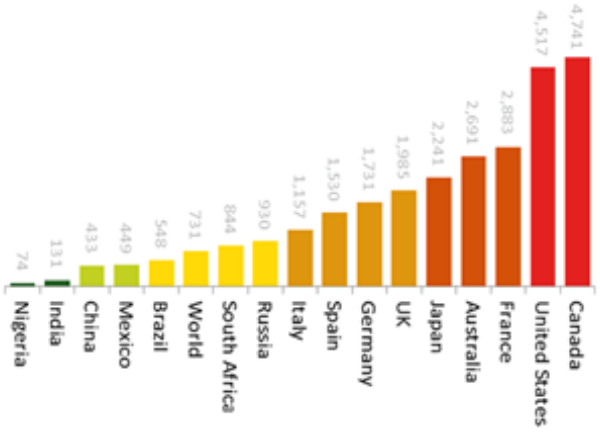

Figure 1. Residential Electricity Use Per Capita (kWh/Year)

combination of conservation and renewable energy sources. When it comes to climate change, it appears that this should be done sooner rather than later. This sort of energy is seen to be the most effective at increasing a country's economic power and investment. Renewable energy is the key to expanding economic growth and opening a new door to the rest of the globe [4]. Figure 2 depicts 2050 Projected Renewable Energy Mix.

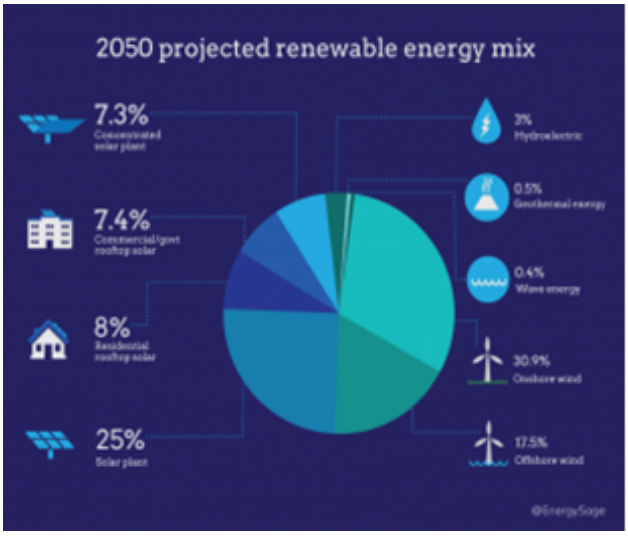

Figure 2. 2050 Projected Renewable Energy Mix

Most of the countries in the world have an abundance of renewable energy resources; key stakeholders were consulted to create a broad scope. The scope perspective emphasizes resource capacity and high levels of economic competence and advantages and technical challenges. In this context, waste energy, wind energy, and solar energy have all been explored [5]. The world is heading towards implementing renewable energy projects by utilizing its existing resources because renewable energy has immense perceptible benefits. In this connection, the world energy council gives the projection about the global primary energy consumption from 2010 to 2050 (as shown in Figure 3).

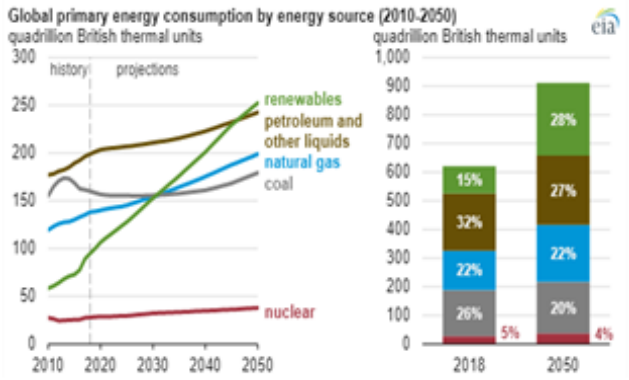

Figure 3. Global Primary Energy Consumption (2010-2050)

Over the last five years, all of this effort has resulted in a 70% to 80% reduction in the cost of solar and wind energy, while the authorities are benefiting from the reduction in the quantity of gas used to generate electricity instead of solar and wind energy. Aside from that, using solar plans to create electricity, does not release any greenhouse gasses into the environment. Moreover, Solar power is an important energy source in the transition to sustainable energy production since the sun produces far more energy than humanity can ever use [6]. Although there are many studies on renewable energy, however, there are minimal studies that focus on the moderating influence of different demographic parameters to evaluate the effect of solar energy utilization on household energy costs. The current study is unique in presenting valid data that will assist households to increase their awareness of how solar panels as renewable energy can affect an individual's household energy cost. Empirical findings will convince consumers to replace conventional electricity with solar energy. As a result of the preceding scenario, the current study investigates the moderating effect of socio-economic variables such as family size, average age, and household income on household energy costs and solar energy utilization [7].

2. Literature Review

The use of power generated by off-grid power plants, such as solar energy, has already been acknowledged as a feasible solution from a technological viewpoint. The next step is to examine its application's economic and social viability. In terms of economic viability, the cost structure of solar energy production must be compared to the cost structures of the significant conventional sources, considering both direct and indirect expenses spent at various stages of production and distribution. Production, transmission, and distribution expenses make up the cost of energy in fossil fuel-based centralized power plants. In contrast, generation costs make up the majority of the cost of energy in decentralized power plants [8]. Likewise, the traditional energy-producing plants, such as coal-based,

enjoy economies of scale to generate a large amount of power and distribute its significant portion of power to industrial use through high-tension lines. However, they face diseconomies of scale when they have to distribute the generated power through low/medium-tension lines to remote and rural areas far from production points. In this connection, the high distribution cost of low-tension lines is mainly linked to high line loss, and these losses increases as the distance increase between the grid point and the end-user. Another case for diseconomies of scale is the low capacity of initialization due to low electricity demand, mainly because of limited industrial activities in those areas [9].

A comparative study was conducted to estimate the per-unit cost of power generation by conventional coal and diesel-based systems, as well as the SPV system, and the results showed, as predicted, that conventional energy production using non-renewable sources produces low-cost power as compared to other production methods just because of the size of production. And this massive production benefited with economies of scale and production efficiency, which is hardly possible with a smaller size and locally installed plants. Similarly, the production cost of another conventional diesel generator energy production is also higher compared to other sources because of higher fuel prices, shorter system life, maintenance, and operating costs. Meanwhile, in this connection, the most expensive cost of the SPV plant is its high capital or installation cost [10]. A Solar Photovoltaic Installation is shown in Figure 4

Figure 4. Solar Photovoltaic Installation

The most severe issue with traditional power supply is its reliance on finite, exhaustible resources, instead of the endless supply of solar power in SPV plants. Even if we consider globally, the existing supply of fossil fuels might last a few more years. The United Nations summit in Reo-de-Janerio in June 1992 addressed establishing worldwide sustainable development, believing that it would be impossible to achieve without substantial changes in the global energy system. This conference affirmed that developing such new energy technologies is a necessary element of any effective strategy for sustainable development [11]. It called for small steps toward introducing energy efficiency and renewable energy technologies. The rapid rise in the price of imported fuel in countries like India, which rely heavily on imported fuel, has driven up the cost of energy generation dramatically over time. On the other hand, Solar Photovoltaic (SPV) is appealing since it is several times more potent than world energy use, has a low cost of production, and is ecologically beneficial. Because of ongoing research and development, the cost of SPV cells is steadily decreasing[12].

According to the UN World Development Energy Assessment report from 2000, SE has an annual capacity of 1575–49837 exajoules [18]. This is several times more energy than was used globally at the start of the twenty-first century [13]. SE, according to some researchers, has even more potential. The International Energy Agency (IEA) stated in 2011 that developing powerful, inexhaustible, and renewable solar energy technologies would have long-term benefits. Consequently, countries' energy stability will increase, as they will be able to rely on endless, indigenous energy that is wholly independent of import sources [14].

The energy sector is soaring all around the world due to its importance in facilitating household as well as business needs. As a result, it is critical to determine and investigate the impact of renewable energy on household energy costs. There is potential in building construction that will allow solar cells to entirely supply the building's energy demands, according to the 2030 Solar Thermal Energy Review study. According to academics, the use of solar cells in the design and construction of buildings is critical. Solar energy will be the dominant source of energy for buildings in the future as shown in Figure 5 [15].

Almost every country has a heritage of putting batteries and PVT (Photovoltaic Thermal) systems on building roofs. As a result, compact PV and PVT systems may be more convenient and practical. For example, in the United States, a collection of 5 kW solar panels costs around $15,000. PV or PVT systems are widely used and economical in a nation where the average wage is around $3000. It is, however, a costly procedure to install such systems in residences in nations where solar panels are imported, and incomes are low. On the other hand, collecting and storing energy generated by massive solar cells is a severe problem. A considerable amount of energy generated by massive solar cells, in most situations, cannot be utilized without storage [16].

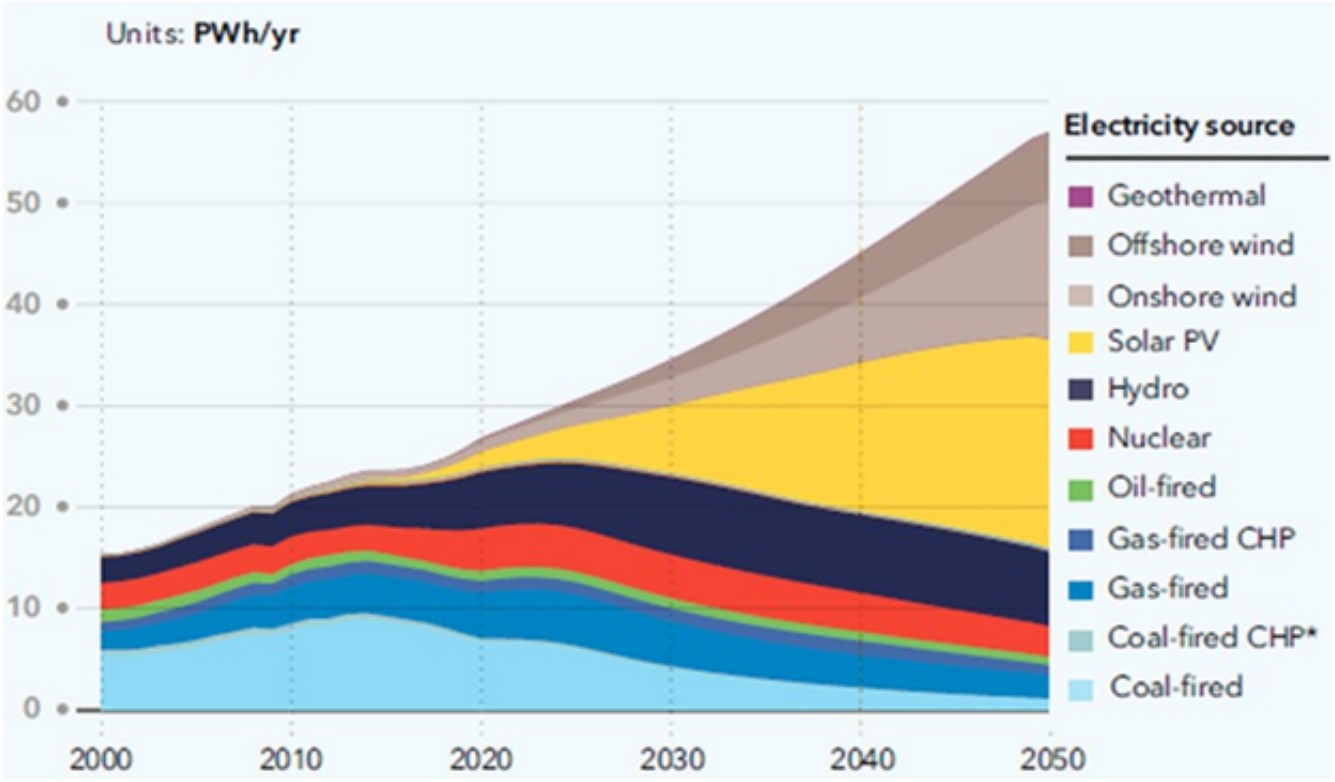

Figure 5. World Electricity generation by source

Several methods for producing clean energy have been described. Solar and wind energy technologies have progressed to the point that they can currently be used to replace fossil-fuel-generated electricity. Because most Asian countries have abundant renewable energy resources, a thorough thematic picture has been formed via interactions with diverse stakeholders. Small and medium-sized solar power facilities, for example, produce most of the solar energy in Pakistan [17]. The emphasis of the scope view is on resource capacity and economical high skill level, as well as advantages and technological challenges. The key strategies that have been used in the context have been wasted energy, wind energy, and solar energy [4].

Unlike the rest of the Asian countries, Pakistan has a high percent ratio of competence in the solar energy industry. Vertical rays worldwide are predicted to be approximately 2120 kWh/m2, and photovoltaic yearly generated energy is roughly 1600 to 1700 kwh/kwp/year. The average solar energy ray was roughly 5.18 kWh/m2/day, with a median of 9.2 hours of sunray. Combining renewable energy sources helps to integrate energy and improve the use of local gas resources, reduce gas emissions, generate economic competition, and improve long-term energy security. Pakistan has significant various seasons in electricity consumption. Because of the summer heat season, electricity consumption increases massively during months from April to October. Mainly this referred to by using an incentive for air-conditioning units that represent the maximum of buildings using electricity [18].

The most crucial societal benefit of decentralized energy sources is that it's easy to make available for remote locations, such as islands, rural localities, and top hills where central electrical grid lines are hard to reach. Therefore, in such conditions, renewable energy power, such as solar PVs, is the best option for power provision in these areas. To be sure, in regions like the one under consideration, demand is currently low, owing to the low purchasing power of the local population [19]. However, as people's living standards improve, demand is likely to rise, and it's easy to see how energy supply is critical to achieving such changes. Also, cheap and sustainable energy must be available for a variety of sustainable development activities, i.e., trade and business during extended hours, studies and human capital formation, irrigation for agriculture, as well as for local small businesses. In this connection, the local supplies would be the only realistic solution to electrification in remote areas, even if it is more expensive financially than grid-connected electricity [20].

Although renewable energy production in-country is still in its infancy, it is likely to play a significant role in the future, with opportunities for both the public and commercial sectors as the country attempts to maximize the use of its current resources and grow power supplies and

feedstock. As a result, the present study will examine the moderating influence of socio-economic parameters such as family size, average age, and household income on household energy costs and solar energy consumption.

3. Hypotheses Development

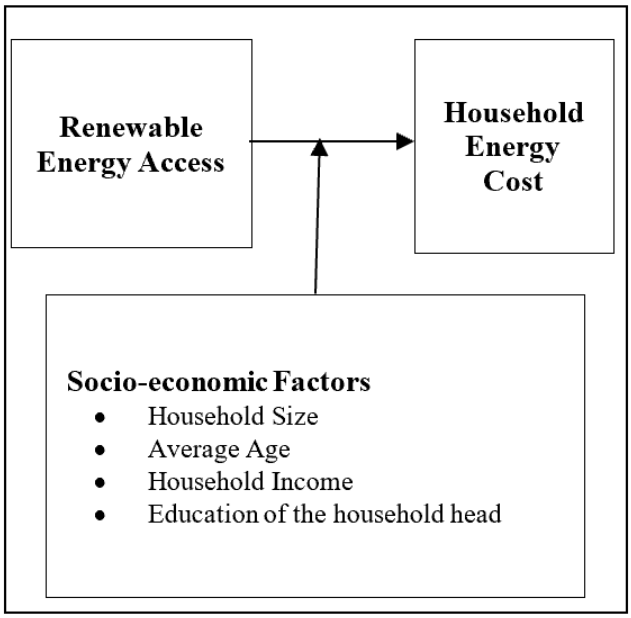

Figure 6. Conceptual Framework

Based on the above literature discussion, the conceptual framework (Figure 6) and following hypotheses are developed.

H1. There is a significant effect of renewable energy access on household energy costs.

H2. There is a significant moderating effect on household size between renewable energy access and household energy cost.

H3. There is a significant moderating effect on the average age of the household between renewable energy access and household energy cost.

H4. There is a significant moderating effect on household income between renewable energy access and household energy cost.

H5. There is a significant moderating effect of education of the household head between renewable energy access and household energy cost.

4. Methodology

The current study is based on a primary source of data collected through convenience sampling from 180 households living in rural areas of Punjab, Pakistan, using a structured questionnaire. Before hypotheses testing, the multicollinearity of the model was analyzed through the person correlation as suggested by Wooldridge [21]. It ensured the basic assumption of the regression that all the independent variables are not directly correlated. Lastly, the multiple regression analysis was applied for hypotheses testing as this method is considered the most appropriate tool to analyze when assessing the one-way effect of independent variables on the dependent variable. Also, regression deals with dependence amongst variables within a model [21], [22]. Several previous related research based on cross-sectional data applied a similar regression method [23], [24]. The multiple linear regression equation is: where,

$$Household\ Energy\ Cost = \beta_i \sum_{i=5}^{n} X_i$$

$$Household\ Energy\ Cost = \beta_0 + \beta_1(Solar\ Energy\ Usage) + \beta_2(Household\ Size^{*}\ Solar\ Energy\ Usage) + \beta_3(Average\ Age\ of\ household^{*}\ Solar\ Energy\ Usage) + \beta_4\ (Total\ Income\ of\ the\ household^{*}\ Solar\ Energy\ Usage) + \beta_5(Education\ of\ the\ household\ head^{*}\ Solar\ Energy\ Usage) + \varepsilon_i$$

A. Household Energy Cost:

The study calculated the cost of energy for that household by averaging the previous 12 months' electrical bills.

B. Usage of Solar Energy:

A summary variable with two values 0 and 1 have been used to measure the usage of solar energy. If any household was using solar energy, the value 1 was assigned and otherwise, the value 0 was assigned to that household.

C. Socio-economic Factors:

The following indicators have been used to measure the socio-economic for that household, 1) household size, 2) average household age, 3) an average household income and 4) Education of the household head.

5. Results and Discussion

The Table I shows demographic data for 180 houses, including average household age, household size, household head's education, and household income. Table 1 indicates the demographics of the households selected for the current study. The findings show that 18.70 percent of the household has less than 25 years of average age, 35.64 percent of the household has 25 to 35 years of average age, 29.31 percent of household lies under 36 to 50 years of age, and lastly around 16.35 percent household has above 50 years of average age.

Moreover, the findings also indicate that around 23.01 percent of the household has less than 4 members, 39.36 percent of the household has between 4 to 7 members, 22.58 percent of the household has 8 to 10 members and 15.05 household with above 10 members. Likewise, the results also depict that 52.55 percent of the household had intermediate education, 30.14 percent had bachelor's

education, 11.63 household heads had master's education, and only 5.68 percent of the head had other or above education. Lastly, the household income has divided into four categories, and results indicate that 23.67 percent of households are earning less than 10,000 PKR, around 47.23 percent of households have 10,000 to 20,000 PKR income, 16.45 percent of households are earning 20,000 to 50,000 PKR and 12.64 percent of household's income is above 50,000 PKR.

TABLE I. Households' Demographic Statistic

Demographic Measurement	Characteristics	Percentage
Average Age of household (Years):	Less than 25 years	18.70%
	25-35 years	35.64%
	36-50 years	29.31%
	Above 50 years	16.35%
Household Size	Less than four members	23.01%
	4 to 7 Members	39.36%
	8-10 members	22.58%
	Above 10 members	15.05%
Education of household Head	Intermediate or less	52.55%
	Bachelor	30.14%
	Masters	11.63%
	Others	5.68%
Household's Income	Less than 10,000	23.67%
	10,000-20,000	47.23%
	20,000-50,000	16.45%
	Above 50,000	12.64%

The Table II shows the correlation analysis used to determine how closely two or more variables are connected. Correlation analysis evaluates the correlation coefficient, which informs how much one variable varies when the other does. One of the regression's basic assumptions is that there will be no multicollinearity among the independent variables. For this purpose, the Pearson correlation was calculated, and the coefficient value of all the variables was less than the threshold value of 0.7 [25]. Thus, the recent finds indicate that all the variables are not highly correlated and are independent.

The present regression model's findings show that solar energy consumption has a considerable negative influence on household energy costs, with a beta value of 0.712. This beta value shows that a 1 percent increase in renewable energy access will 71.2 percent reduce the household energy cost (shown in Table III), and this result is significant at a 1 percent level of significance. Thus, the first hypothesis has been rejected, and the current findings prove a significant effect. Because of the great potential of accessible solar energy, the use of technology for converting it into electricity will allow consumers to minimize the amount of payment for consumed electricity, lowering the cost of products and services. Despite the great benefits of solar energy, its application is still limited and experiencing high installation costs. Meanwhile, the current results are aligned with existing literature [26], [27].

Similarly, renewable energy access, along with different demographic indicators, has significant adverse effects at different significance levels, such as with a -0.530 (-2.827) beta value, household size has a solid moderating influence between solar energy consumption and household energy costs, and this finding is significant at the 1% level of significance. Thus, based on the study's empirical findings, the second hypothesis was also rejected, and the study indicates a significant negative moderating effect of household size between renewable energy access and household energy cost. Because electricity is a typical public product, it has a significant potential for economies of scale in-home usage. People do not use electricity directly but rather indirectly through products such as lighting and cooling systems shared among family members. When a family develops in size, the home may better use shared resources like electricity. Therefore, the per capita electricity consumption can be decreased as the household size increases. The current findings are similar to the existing studies [28], [29].

Furthermore, the average household age has a substantial negative moderating influence between solar energy consumption and household energy costs, with a beta value of -0.482 (3.587), significant at the 1% level of significance. Therefore, the study concludes a negative and significant moderation of the average age of households between renewable energy access and household energy cost, and the third hypothesis of the study is also rejected. Furthermore, there is a substantial variation in electricity usage for various age groups. Likewise, Brounen et al. [30] analyzed the data from 300,000 households from 2008 to 2009 and found that older married couples consume less electricity than middle-aged married couples. It's also clear that seniors use less energy-intensive equipment despite spending more time at home. Families with children under the age of four had higher per capita spending than middle-aged couples, but families aged five to twelve and over twelve had higher per capita consumption among all. Furthermore, the difference in demand between an adult and an older person might be because of the elderly's saving attitude [29].

Likewise, the household income also has a significant negative moderating effect between energy cost and renewable energy access with a 0.479 (2.507) beta value. This result indicates that a 5 percent increase in income with the same level of solar energy usage will 47.9 percent decrease the household energy cost, and the current result is significant statistically at a 1 percent level of significance. Thus, the findings concluded a significant negative moderation of household income between household energy cost and renewable energy access. Thus, the fourth hypothesis of the study was also rejected. The findings indicate that the higher

TABLE II. CORRELATION

	Education of household head	Household Size	Average Age of household	Household Income	Usage of Solar Energy
Education of household head	1.000				
Household Size	-0.165	1.000			
Average Age of household	0.257	0.119	1.000		
Household Income	0.357	0.478	0.689	1.000	
Renewable Energy Access	0.656	-0.614	0.521	0.551	1.000

TABLE III. REGRESSION COEFFICIENTS

Model	β	*t*	Sig.
Constant	21.017	5.752	0.000
Renewable Energy Access	-0.712	-3.08	0.000
Renewable Energy Access*Household size	-0.530	-2.827	0.001
Renewable Energy Access*Average Age of household	-0.482	3.587	0.000
Renewable Energy Access*Household Income	-0.479	2.207	0.031
Renewable Energy Access *Education of household head	-0.613	-3.189	0.000
Std. The error of the Estimate	89.365		
R Square	0.572		

income group has more power to install the solar panels as the installation cost of such panels is still higher. Therefore, the study shows the negative moderating effect of household income, and the results are aligned with existing literature [29].

Finally, the household head's education has a negative moderating effect between household energy cost and solar energy usage, with a beta value of -0.613 (3.189) and a significance level of 1%. Thus, the fifth hypothesis is also rejected. Education is essential for achieving this potential, as it may assist in identifying not just where energy is spent in the home but also the potential savings of various equipment. Furthermore, manufacturers and merchants can ensure that when consumers replace outdated equipment, they consider energy-efficient appliances, which needs an understanding of the importance of both cost and emissions. Therefore, the study found the negative moderating effect of the head of household education on energy cost because education always creates the awareness to utilize their resource with maximum utility [30], [31].

6. Conclusion and Recommendations

Since the beginning, fossil fuels have been used to generate electricity, which is a nonrenewable and limited source of energy, which is the primary cause of the increase in electricity cost and the economy's reliance on it. When solar panels are placed, they provide a considerable quantity of energy for institutions, colleges, schools, households, and businesses. The design of solar panels allows them to continue generating energy even when the environment changes. The researchers hardly focused on analyzing the role of household demographic factors to install the solar panels as well as their effect on household energy costs. As a result, the primary goal of this study was to examine the moderating influence of demographic characteristics such as family size, average age, and household income between household energy cost and solar energy utilization.

For this purpose, the study formulated the five null hypotheses that were further tested through regression analysis based on primary data collected from 180 households residing in rural Punjab, Pakistan. The current study's findings show that solar energy consumption has a substantial negative influence on household energy costs at the 1% level of significance. Thus, the first hypothesis has been rejected, and the empirical results prove the adverse effect. Moreover, the moderating effect of all the used demographic factors also has a significant negative moderating effect between renewable energy access and household energy cost. As a result, all four null hypotheses are rejected, confirming that socioeconomic characteristics moderate the relationship between solar energy utilization and household energy costs.

It is commonly established that energy prices change over time and that this volatility influences fuel supply, electricity consumption, and the cost of electricity generation, distribution, and transmission. Households with their energy production capabilities, on the other hand, do not need to be concerned about price swings since they can better estimate the cost. If a household has its renewable energy resources and is connected to the grid,

the odds of an outage are reduced. The system becomes more versatile when solar power is introduced. Individuals, schools, universities, businesses, and even the government will profit from dealing with solar energy and realizing its worth.

In the current digital era, it is necessary to produce more environmentally friendly energy, which also causes to decline in the footmark of carbon. This is a prevalent and popular concept of installing solar panels on the rooftop, especially for colleges, universities, schools, homes, and other commercial buildings having wide and flat or even pitched roofs. Solar panels can assist in lowering operational expenses, especially with the present increase in power and water tariff prices. The appealing aspect of solar energy is that it is a free energy source that is still available. With the improvement of technology and professional installation knowledge, it is becoming easier to acquire and utilize. All institutions, including universities, schools, business leaders, and families, can acquire access to some of the low-cost (therefore low-cost per watt) systems. The cost per watt decreases as the size of the system grows. That means they can benefit from electricity at a fair price without relying on grid estimations.

Furthermore, the research suggested that the authorities encourage future building development, particularly in public buildings and housing societies, by placing solar panels on their rooftops to minimize energy costs and solve environmental issues. Solar panels will provide power and act as a symbol of a particular culture and community, as well as create a new job sector.

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References

[1] D. Delgado, M. Carvalho, L. M. C. Junior, R. Abrahão, and R. Chacartegui, "Local and regional climate change environmental impacts view project eia-transriego view project photovoltaic solar energy in the economic optimisation of energy supply and conversion," *Renew. Power Gener*, vol. 12, no. 11, pp. 1263–1268, 2018.

[2] J. Li, S. Chen, Y. Wu, Q. Wang, X. Liu, L. Qi, X. Lu, and L. Gao, "How to make better use of intermittent and variable energy? a review of wind and photovoltaic power consumption in china," *Renewable and Sustainable Energy Reviews*, vol. 137, p. 110626, 2021.

[3] A. Olabi, C. Onumaegbu, T. Wilberforce, M. Ramadan, M. A. Abdelkareem, and A. H. Al-Alami, "Critical review of energy storage systems," *Energy*, vol. 214, p. 118987, 2021.

[4] P. K. S. Rathore, S. Rathore, R. P. Singh, and S. Agnihotri, "Solar power utility sector in india: Challenges and opportunities," *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 2703–2713, 2018.

[5] V. Khare, S. Nema, and P. Baredar, "Solar–wind hybrid renewable energy system: A review," *Renewable and Sustainable Energy Reviews*, vol. 58, pp. 23–33, 2016.

[6] M. Y. Raza, M. Wasim, and M. S. Sarwar, "Development of renewable energy technologies in rural areas of pakistan," *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, vol. 42, no. 6, pp. 740–760, 2020.

[7] A. M. Levenda, I. Behrsin, and F. Disano, "Renewable energy for whom? a global systematic review of the environmental justice implications of renewable energy technologies," *Energy Research & Social Science*, vol. 71, p. 101837, 2021.

[8] M. I. Khan, T. Yasmeen, A. Shakoor, N. B. Khan, and R. Muhammad, "2014 oil plunge: Causes and impacts on renewable energy," *Renewable and Sustainable Energy Reviews*, vol. 68, pp. 609–622, 2017.

[9] M. Chesser, J. Hanly, D. Cassells, and N. Apergis, "Household energy consumption: A study of micro renewable energy systems in ireland," *The Economic and Social Review*, vol. 50, no. 2, Summer, pp. 265–280, 2019.

[10] ESRTP, "Solar thermal vision 2030 document," *European Solar Thermal Technology Platform*.

[11] G. N. Senna and E. G. Serra, "Estimating the genuine progress indicator (gpi) for the state of rio de janeiro, brazil, from 2002 to 2016, as a tool for public policy decision making," *Environment, Development and Sustainability*, vol. 23, no. 11, pp. 16 325–16 342, 2021.

[12] P. Charalambous, G. G. Maidment, S. A. Kalogirou, and K. Yiakoumetti, "Photovoltaic thermal (pv/t) collectors: A review," *Applied thermal engineering*, vol. 27, no. 2-3, pp. 275–286, 2007.

[13] B. Dudley *et al.*, "Bp statistical review of world energy," *BP statistical review, London, UK, accessed Aug*, vol. 6, no. 2018, p. 00116, 2018.

[14] M. G. Gulaliyev, E. R. Mustafayev, and G. Y. Mehdiyeva, "Assessment of solar energy potential and its ecological-economic efficiency: Azerbaijan case," *Sustainability*, vol. 12, no. 3, p. 1116, 2020.

[15] W. A. Salah, M. Abuhelwa, and M. J. Bashir, "The key role of sustainable renewable energy technologies in facing shortage of energy supplies in palestine: Current practice and future potential," *Journal of Cleaner Production*, vol. 293, p. 125348, 2021.

[16] W. P. U. Wijeratne, R. J. Yang, E. Too, and R. Wakefield, "Design and development of distributed solar pv systems: Do the current tools work?" *Sustainable cities and society*, vol. 45, pp. 553–578, 2019.

[17] M. A. U. Haq, M. A. Nawaz, F. Akram, and V. K. Natarajan, "Theoretical implications of renewable energy using improved cooking stoves for rural households," *International Journal of Energy Economics and Policy*, vol. 10, no. 5, p. 546, 2020.

[18] K. Mushtaq, F. Abbas, and A. Ghafoor, "Energy use for economic growth: cointegration and causality analysis from the agriculture sector of pakistan," *The Pakistan Development Review*, pp. 1065–1073, 2007.

[19] A. M. Oliveira, R. R. Beswick, and Y. Yan, "A green hydrogen economy for a renewable energy society," *Current Opinion in Chemical Engineering*, vol. 33, p. 100701, 2021.

[20] S. Haji, A. Durazi, and Y. Al-Alawi, "Feed-in tariff structure

development for photovoltaic electricity and the associated benefits for the kingdom of bahrain," *International Journal of Sustainable Energy*, vol. 37, no. 5, pp. 479–497, 2018.

[21] J. M. Wooldridge, *Introductory econometrics: A modern approach*. Cengage learning, 2015.

[22] D. N. Gujarati, *Essentials of econometrics*. SAGE Publications, 2021.

[23] D. Laufer and M. Schäfer, "The implementation of solar home systems as a poverty reduction strategy—a case study in sri lanka," *Energy for sustainable Development*, vol. 15, no. 3, pp. 330–336, 2011.

[24] M. Abrar ul Haq, F. Akram, U. Ashiq, and S. Raza, "The employment paradox to improve women's empowerment in pakistan," *Cogent Social Sciences*, vol. 5, no. 1, p. 1707005, 2019.

[25] J. F. Hair, J. J. Risher, M. Sarstedt, and C. M. Ringle, "When to use and how to report the results of pls-sem," *European business review*, 2019.

[26] T. P. Yendrapati, A. Gautam, S. Bojja, and U. Pal, "Formation of zno@ cus nanorods for efficient photocatalytic hydrogen generation," *Solar Energy*, vol. 196, pp. 540–548, 2020.

[27] A. Belenov, Y. V. Daus, S. Rakitov, I. Yudaev, and V. Kharchenko, "The experience of operation of the solar power plant on the roof of the administrative building in the town of kamyshin, volgograd oblast," *Applied Solar Energy*, vol. 52, no. 2, pp. 105–108, 2016.

[28] Y. V. Daus, "Reducing the costs for consumed electricity through the solar energy utilization," *Int. J. Energy Econ. Policy*, vol. 9, no. 2, pp. 19–23, 2019.

[29] H.-S. Nguyen and M. Ha-Duong, "Family size, increasing block tariff and economies of scale of household electricity consumption in vietnam from 2010 to 2014," *External Economics Review/Tp chí Kinh t i ngoi*, vol. 2017, no. 101, pp. 1–11, 2017.

[30] D. Brounen, N. Kok, and J. M. Quigley, "Residential energy use and conservation: Economics and demographics," *European Economic Review*, vol. 56, no. 5, pp. 931–945, 2012.

[31] A. Alexandru and E. Jitaru, "Education for energy saving in the house," in *Proceedings of the WSEAS International Conference on Energy Planning, Energy Saving, Environmental Education (EPESE'07), Arcachon, France*. Citeseer, 2007, pp. 84–89.

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