

Tracing the Path to Sustainability: A Study on Domestic Electricity Consumption, Historical overview of Renewable energy resources, transitioning to sustainable energy sources and its impact on Health

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Abstract: Modern economies are centered on electricity, which is also contributing to an increasing amount of energy services. As a result of increased household incomes, electrification of transport and rising demand for digital connected devices and air conditioning, there will be a rise in the need for energy. Residential electricity consumption in India has tripled over the past few decades with houses having access to uninterrupted power supply. This study is conducted in order to understand the determinants of electricity consumption such as income, family size, stock of electrical appliances, size of dwellings and their influence on consumer's electricity consumption. It also seeks to examine if the consumers are willing to reduce their electricity consumption and are interested in shifting to renewable energy resources considering the costs involved in shifting to more sustainable energies. Due to the nature of power, which is invisible from the moment it was discovered, as well as consumer attitudes and behavior, saving electricity may appear to be a challenging undertaking. However, if the consumer acquires a basic understanding of what electricity is, how it is utilized, and, more significantly, how energy is wasted, the problem might become very simple. This will make consumers more aware of wasteful electricity use and perhaps encourage them to modify their daily consumption of electricity.

Key words: Electricity power consumption, consumer, renewable energy, sustainability, historical, human health.

1 Introduction

A major force in the global energy economy, India's energy consumption has more than doubled since 2000, propelled forward by a growing population and rapid economic growth. The continued process of industrialization and urbanization, imperative to this economic growth creates huge demands of India's energy sector. The country's 80% energy needs are met by three fuels: coal, oil and solid biomass. Coal underpins the expansion of electricity generation and industry, and remains the largest single fuel in the energy mix. In 2019, India achieved near-universal household access to electricity, meaning that over 900 million citizens gained an electrical connection in less than two decades. However, this energy use on a per capita basis is still well under half the global average, and there are widespread differences in use and the quality of electricity service across states and between rural and urban areas. Affordability and reliability of energy supply remaining key concerns for India's consumers.¹

As a driver of economic growth, when electricity was first introduced in India in the late 19th century, India was a British colony. The consumers of electricity then, were apart from public utilities, mostly industries, banks, clubs and very few private residences. That changed in early 1900's with the onset of Industrialization, modern means of transport and way of life.²

The wheel of development powered by fossil fuels in the 19th and early 20th century turned a full circle in the 21st century with the onset of climate change. The buzz word of the current era became sustainable development. Attempts to reverse climate change, drove nations and policy makers to search for technology that would not only meet but also sustain the development goals of the 21st century socio-economic growth. The reset button reintroduced age-old renewable energy sources as the future. For example, Solar energy, wind energy seen as futuristic technology is often forgotten to be also the technology of the past. Harnessing these non-conventional energy sources appropriately, however requires investment in infrastructure that is presently neither cost effective nor cent percent reliable. Nonetheless, they are critical to ensuring energy security of nations for the future and till that time, discourses such as the one in this paper, ought to be undertaken to understand the patterns of energy consumption and what avenues are available for switching to renewables. Impact on health is another key factor.

As therefore understood in present times, access to electricity is essential for economic development and improvement of income-generating activities. Similarly, comprehending domestic power consumption is important to knowing the consumer driven energy requirement of the country and map its future trajectory in terms of accessibility and sustainability.

To put it in lay man's term, household electricity consumption includes electricity used for lighting, for running refrigerators, water heaters, kitchen- appliances, music systems, air-conditioners etc. According to the World Bank (2008), lighting, followed by refrigerators, fans, electric water heaters, and televisions, account for over 30% of total residential electricity use in India. The small amount of power that many modern gadgets use while they are not actively being utilized i.e., standby power accounts for about 4% of total residential electricity use.

According to report by the Council on Energy, Environment and Water, "An average Indian household receives 20.6 hours of power supply from the grid per day" and urban areas have a slightly longer average daily supply (22 hours) than rural areas do (20 hours).

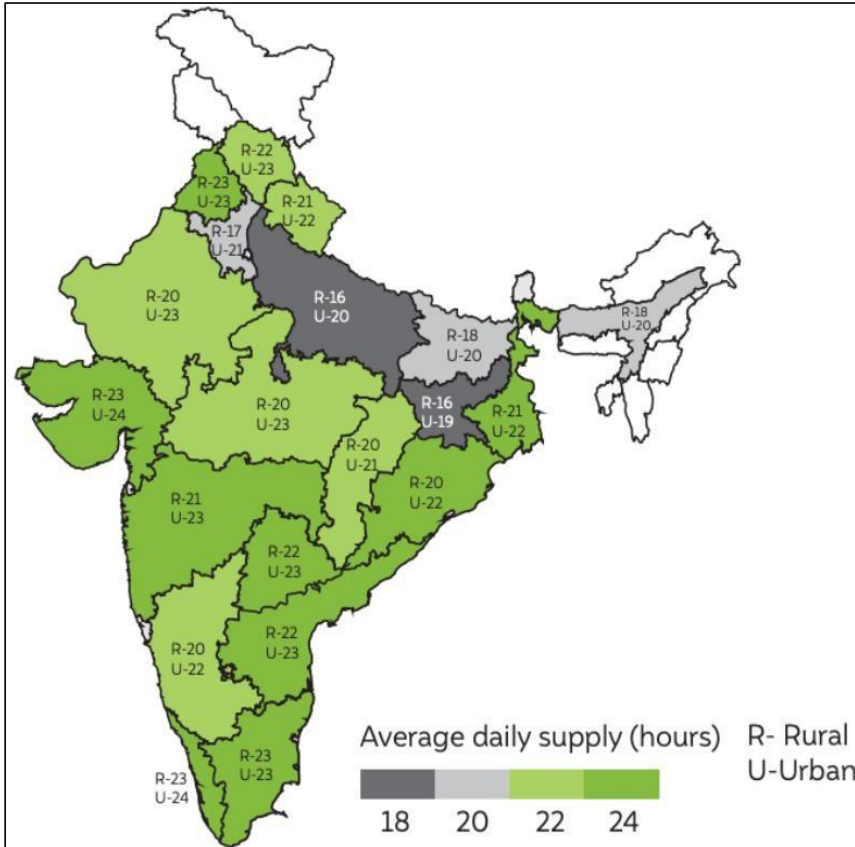
¹ IEA (2021), India Energy Outlook 2021, IEA, Paris <https://www.iea.org/reports/india-energy-outlook-2021>, License: CC BY 4.0

² [2007 IEEE Conference on the History of Electric Power](#)

Map 1 Indian Map Showing the Average Daily Supply (Hours) Of Power in Rural Areas and

Urban Areas

Source: Council on Energy, Environment and Water



Higher levels of urbanization have increased access to electricity for the household sector over time. A household now uses more kitchen appliances and home electronics as a result of having more disposable income. Additionally, as customers' purchasing power has grown, Indian households have adopted new lifestyles, which have led to a rise in their use of electricity. A household's energy consumption is influenced by a variety of factors, including its income, the size of its home, the number of people living there, and the weather. In India, the residential sector accounted for 24% of all electricity consumption in 2016, and by 2050, it is expected to increase by more than eight times, mostly due to equipment and appliances.

2 Materials and Methods

The study focuses on the following objectives:

- To determine the factors that influence consumption of electricity in households
- Understand electricity consumption patterns of households
- To determine whether there is any relation between income and consumption
- Understand if consumers are willing to shift to renewable energy/ technology
- Understand Impact on Health

The research employs quantitative analysis of domestic electricity consumption from the survey in the form of

questionnaire was sent to diverse audience, and information was collected from a total of 162 respondents. So, the study tries to give us the insight of cost of domestic consumption of electricity from sample i.e. size of family/house. Looking at the expenditure incurred monthly people may shift to renewable energy sources. By identifying and addressing cost incurred in installing renewable energy researchers and policymakers can design more effective policies, interventions, and communication strategies that accelerate the transition to sustainable energy sources at the household level. The goal is to provide comprehensive understanding of cost of domestic consumption of electricity, monthly bill and annual income /the respondents are interested to shift to renewables sources.

The methodology includes Collection of domestic electricity consumption data from the sample of household. Calculation of average electricity. Based on size of family/house Data analysis by using a statistical tool i.e., Correlation to measures the extent to which two variables are linearly related. This study was undertaken, completely on the basis of information obtained through primary data. A look at following studies highlights the significance of the present paper.

Tewathia (2014) conducted a study of Delhi residents to learn about the factors that influence their consumption of power. The monthly power consumption is affected by household income, the number and usage of electrical appliances, the size of the home, the number of family members, the length of time spent away from the home, and the educational level throughout the year. The educational level has a negative link because more educated families use less electricity. The survey also showed that the average monthly power usage of houses fluctuates across seasons because the demand for electricity varies according to the temperature.

Wood and New borough (2003) classified the components of a home's electricity usage into three categories. The labels "predictable," "moderately predictable," and "unpredictable" were used to define these components. The former happens while the building is unoccupied or when the tenants are sleeping (small, cyclic loads from appliances such as refrigerators and steady loads from security lighting and always-on gadgets such as TVs and VCRs). The remaining usage is influenced by both occupancy and external factors (such as seasonal/weather fluctuations). The "moderately predictable" consumption is related to the habitual behavioural patterns of the occupants. For example, the majority of people watch TV at regular intervals throughout the day and week, and they turn on and off the lights every weekday morning as they prepare for work. Wiesmann et al. (2011) compare the per capita power use and housing characteristics of Portuguese consumers. They come to the conclusion that income, appliance ownership, and floor area all have a beneficial influence on per capita power usage. Apartment buildings, single-family homes, and/or rural households all consume more electricity than urban, single-family, and/or suburban families. Because residences in colder climates use less power per capita than those in warmer ones, the Per capita consumption is affected by the number of individuals per family, the number of dwellings per structure, and the number of heating degree-days. According to Bedir et al. (2013), household size, style of dwelling, and amount of time spent using electrical equipment (such as dryers and washing machines) all have a substantial impact on how much power is utilized in the Netherlands. Furthermore, Brounen et al. (2012) studied data from 300,000 Dutch houses. The kind of residence influences electricity consumption, with detached and semi-detached homes consuming more per person than row homes or apartments. It has been discovered that households with children, particularly those with teenagers, have a positive impact on per capita power consumption. The number of persons in a family has a negative impact on per capita energy consumption, whereas income has a positive impact.

Sanquist et al. (2012) based their study on data from the Residential Energy Consumption Survey (RECS), which was conducted in the United States in 2005. The usage of an air conditioner, laundry, laptops, the home atmosphere, and televisions all have a significant impact on electricity use. Kavousian et al. (2013) examine the maximum and minimum daily household electricity use of 952 US households. The use of high-consumption appliances and the number of persons influence daily maximum consumption, whereas weather, location, home size, and the number of refrigerators influence daily minimum consumption.

3 Results and Discussion

In general, household income determines its demand for all the goods it consumes. The same holds true for domestic electrical consumption. Considering this, it can be said that as household income rises, so does the number of appliances owned. This indicates a positive relationship between consumer income and the number of appliances. This shows that people earning a higher annual income spend more on their monthly electricity bill than people earning a lower income.

Analyzing the monthly expenditure on electricity bill and annual family income

No of Respondents	Annual Family Income				
Monthly Expenditure on Electricity bill	₹15 lakhs and above	₹8 lakhs - ₹15 lakhs	₹3lakhs – ₹8 lakhs	Below ₹3 lakhs	Grand Total
1500-3500	15	19	11	5	50
3500 and above	8	4	0	0	12
500 -1500	10	19	32	18	79
Below 500	0	0	9	12	21
Grand Total	33	42	52	35	162

Source: Primary Data

The above table shows the annual family income of the respondents and their monthly expenditure on electricity bill. Most respondents (79 of them) spend ₹500 – ₹1500 on their monthly electricity bill. 21 respondents spend below ₹500 on their monthly electricity bill which mostly comprises of people from income group below ₹3 lakhs and ₹3lakhs – ₹8 lakhs. Respondents from the higher income groups of ₹8 lakhs - ₹15 lakhs and ₹15 lakhs and above spend ₹3500 and above on their electricity bill. 50 respondents spend ₹1500 - ₹3500 on their electricity bill monthly and this majorly includes people from the income group ₹8 lakhs - ₹15 lakhs.

Analyzing monthly expenditure on electricity bill and annual family income (in percentage)

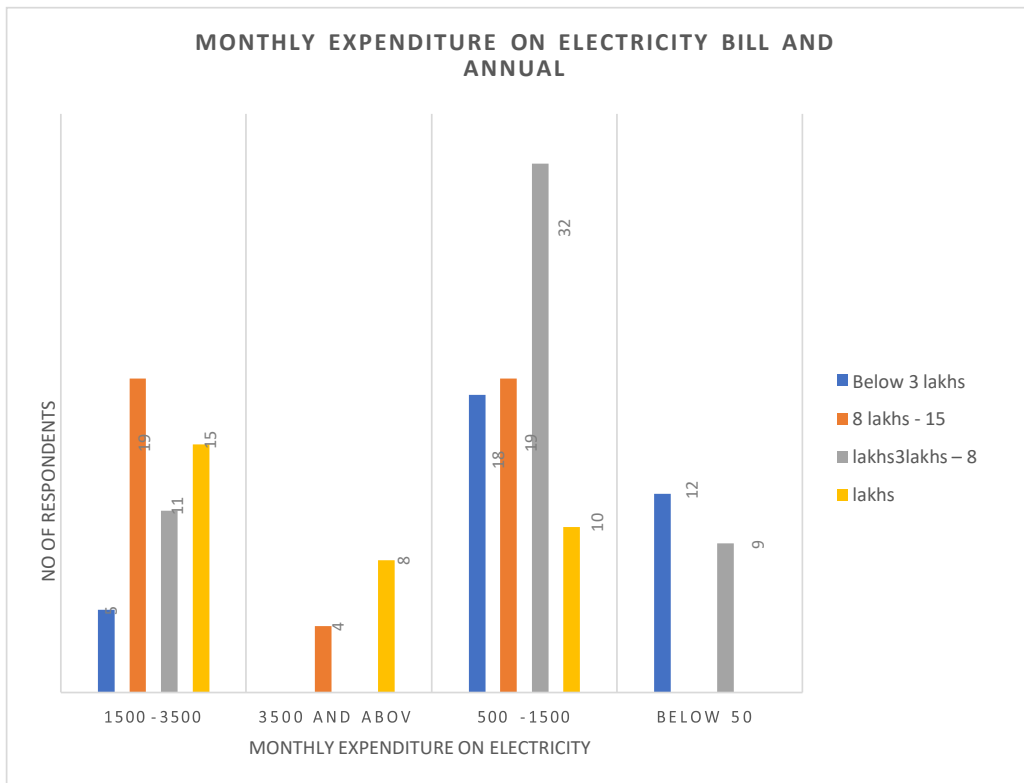
% Respondents	Annual Family Income				
Monthly expenditure on electricity bill	₹15 lakhs and above	₹8 lakhs - ₹15lakhs	₹3lakhs – ₹8lakhs	Below ₹3 lakhs	Grand Total
1500-3500	9.26%	11.73%	6.79%	3.09%	30.86%
3500 and above	4.94%	2.47%	0.00%	0.00%	7.41%

500 -1500	6.17%	11.73%	19.75%	11.11%	48.77%
Below 500	0.00%	0.00%	5.56%	7.41%	12.96%
Grand Total	20.37%	25.93%	32.10%	21.60%	100.00%

Source: Primary Data

The above table shows the annual family income of the respondents and their monthly expenditure on electricity bill in percentage. 48.77% of the respondents spend ₹500 - ₹1500 and 30.86% of them spend ₹1500-3500 on their monthly electricity bill. Only 7.41% of them spent ₹3500 and above which includes respondents from the higher income groups. This shows that the annual family income has an influence on their monthly expenditure bill. Families having a higher annual family income are likely to spend more on their monthly electricity bill than compared to families with a lower annual family income.

Fig 1 Graphical representation of monthly expenditure on electricity bill and annual family income



Source: Primary Data

- 30.67% of the respondents spend ₹1500 - ₹3500 per month on their electricity bill and only 7.98% of the respondents spend 3500 and above on their monthly electricity bill and these 7.98% of the respondents include those who belong to the income group ₹8 lakhs – ₹15 lakhs and ₹15 lakhs and above
- 21 respondents (12.96%) out of 162 spend Below ₹500 on their electricity and these 21 respondents belong to the income group of Below ₹3 lakhs and ₹3 lakhs – ₹5 lakhs.

The number of people in the family, or the size of the family, is the other aspect that affects the household's electricity use. A common misconception is that a family would use more electricity as its size increased.

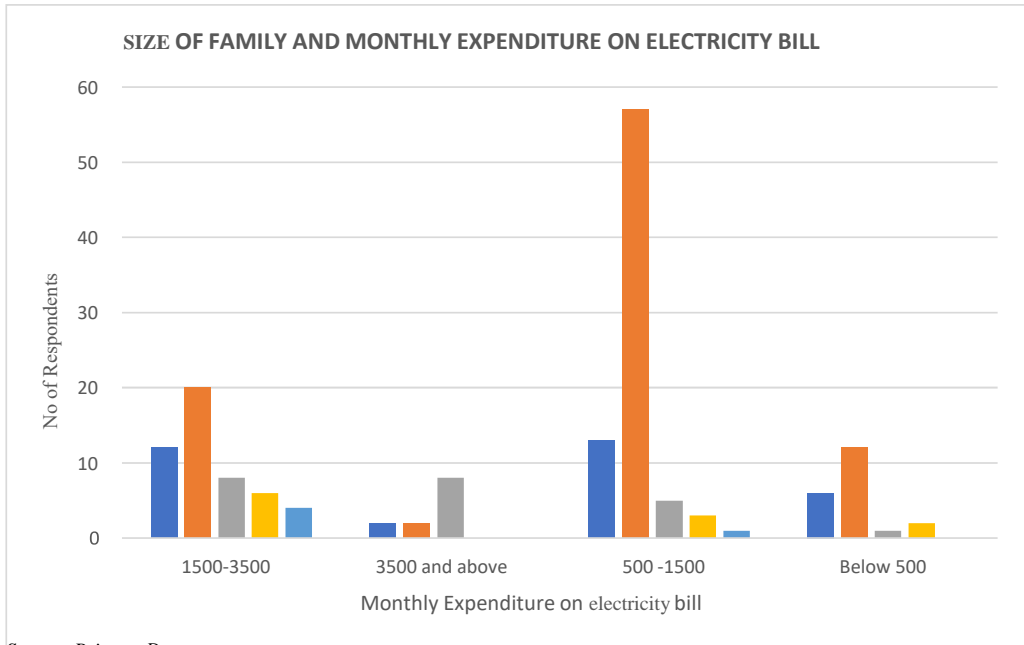
However, it is also evident that both big families (families having more than 4 members) and small families (families have 4 or less than 4 members) who show similar trend in the ownership of electric appliances spend almost same figures on their monthly electricity bill.

Analyzing size of family and monthly expenditure onelectricity bill

Monthly expenditure onelectricity bill					
Size of Family	Below ₹500	₹500 - ₹1500	₹1500 - ₹3500	₹3500 and above	Grand Total
3 members	6	13	12	2	33
4 members	12	57	20	2	91
5 members	1	5	8	8	22
6 members	2	3	6	0	11
7 or 7 +	0	1	4	0	5
Grand Total	21	79	50	12	162

Source: Primary Data

Fig 2 Graphical representations of size of family and monthly expenditure on electricity bill



Source: Primary Data

The above table shows the size of the family and how much money they spend per month on their electricity bill. Respondents having a family size of 3 spent mostly between ₹500 - ₹3500 on their electricity bill and about 57 respondents having a family size of 4 spent ₹500 - ₹1500 on their monthly electricity bill.

Analyzing size of house and monthly expenditure on electricity bill

Size of family or the number of people residing in a household is also a factor affecting electricity consumption in households to some extent. More number of people would imply higher electricity consumption. But income along with the size of family has a much greater influence on household electricity consumption than size of family alone.

Representation of size of house and monthly expenditure on electricity bill

No of Respondents	Monthly Expenditure on electricity bill				Grand Total
	Below 500	500 -1500	1500-3500	3500 and +	
Size of House					
1 BHK	11	11	2	0	24
2 BHK	8	43	21	0	72

3 BHK	1	21	21	9	52
Villa	1	4	6	3	14
Grand Total	21	79	50	12	162

Source: Primary Data

Bigger houses normally use more electricity because of a greater number of electric appliances installed in such houses as compared to smaller houses which have a smaller number of installed electronic appliances. The above table shows that on an average most houses spend ₹1500 - ₹3500 on their monthly electricity bill. The highest expenditure i.e., ₹3500, and above is mostly spent by people residing in 3-bedroom houses and villas. So, it can be said that there exists a positive relationship between the size of the house and electricity consumption.

Analyzing factors given priority while purchasing anelectronic appliance

When asked about the first thing that one would look at before purchasing an electronic device, power saving and price received the highest responses respectively. More consumers now look at energy star-rating on electronic appliances to lower their electricity bill. Price is the next important factor followed by brand. When a consumer looks for power saving guides on electronic appliances before he decides to purchase an electronic appliance, this shows that they not only reduce the money but also the energy at home by choosing energy efficient appliances and electronics.

Representation of factors given prioritywhile purchasing an electronic appliance

Parameters	No of respondents
Brand	39
Latest model	32
Power saving	47
Price	44
Grand Total	162

Source: Primary Data

The above table shows what parameters the respondents prefer/ watch out the most before deciding to invest in a new electronic appliance. The parameters are brand, latest model, power-saving, and price. 47 respondents looked for power saving guides and 44 of them make their decision based on price. Brand was also deciding factor for 39 respondents.

Use of renewable energy / solar panels

Only 7 respondents out of 162 have installed solar panels in their houses. The capacity of these solar panels as mentioned by the respondents ranges between 1Kw to 5Kw. The reasons for non-installation of solar panels in majority of the households could be due to the high cost of installation: they also occupy considerable rooftop space and people with no rooftop space do not consider the idea of installing solar panels. Terraces of residences and other commercial buildings, where the roofs are rarely used, are suitable places for rooftop solar installation. The typical 10 square foot area taken up by a 1 kW rooftop solar installation. However, many consumers object to solar panels being installed on their rooftop because they take up a lot of space. There is also not much information available about solar subsidy.

A solar system costs more than an air conditioner, television, refrigerator, fan, etc. The installation and maintenance costs for a solar system are the two main expenses. Rooftop solar system installation is a long-term investment; thus, due care and vigilance are required before making the decision. When installing a rooftop system

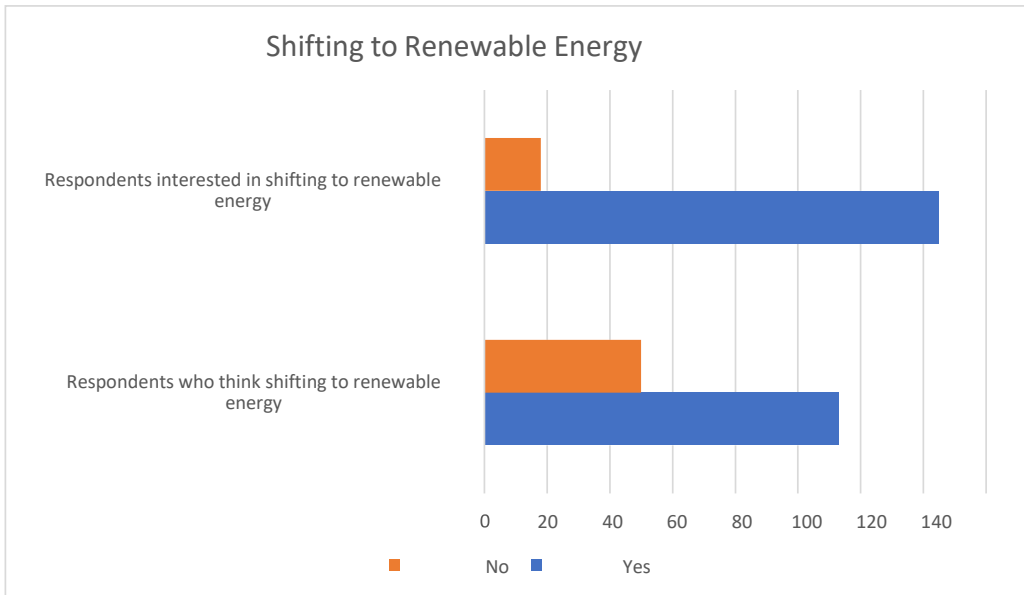
on your home, cost must be considered as well. A typical 1 KW rooftop system costs between Rs. 60,000 and 80,000.

Representation of shifting to renewable energy resources

Response	Yes	No
Respondents who think shifting to renewable energy sources is expensive	113	50
Respondents interested in shifting to renewable energy sources	145	18
CORRELATION	-1	

Source: Primary Data

Fig 3 Graphical representation of shifting to renewable energy resources.



Source: Primary Data

The above table shows that 145 respondents are interested in shifting to renewable energy resources and 135 respondents think that shifting to renewable energy resources is expensive. 18 respondents have stated that they are not interested in shifting to renewable energy options and 50 of them have stated that renewable energy sources are expensive. The negative correlation suggests that although people are interested in shifting to renewable energy sources, considering the benefits involved, the costs involved in installing renewable energy sources have reduced the willingness of the consumers to shift to renewable and more sustainable options.

Energy efficiency measures can support good physical and mental health primarily by creating healthy indoor living environments with healthy air temperatures, humidity levels, noise levels, and improved air quality. Recent evidence shows that chronic thermal discomfort and fuel poverty also have negative mental health impacts (anxiety, stress, and depression). Energy efficiency improvements targeting fuel poverty can therefore improve mental well-being. Energy efficiency's impact on mental health may be enhanced if combined with financial

support mechanisms and strong community engagement. Governments use a range of policies to mitigate fuel poverty, including support payments for fuel costs, social tariffs (subsidies) on energy prices, grant programmes for expenses associated with energy efficiency upgrades, or free retrofit programmes for low-income households. To date, programmes for energy efficiency retrofitting of low-income housing have delivered the greatest benefits, with health improvements representing as much as 75% of the total return on the investment for these interventions.

Fuel poverty is also strongly associated with sub-optimal mental health, in part because of the financial stress of coping with high energy bills and debt. Energy efficiency measures that improve the affordability of energy bills in low-income homes can have a measurable effect on improving mental well-being (e.g. happiness and coping) and preventing mental disorders (e.g. anxiety and borderline depression).³

Conclusion

The country's urban population has been expanding quickly, and the middle class has been expanding. Urban populations have become more "awake" as a result of global warming, the COVID-19 epidemic, and economic constraints and are determined to change the way we consume energy and switch to green energy sources. India is currently one of the top three nations in the world calling for a quicker switch to renewable energy. Government-sponsored or not, the industrial and residential sectors are increasingly adopting this change as well. Depending on the region each grid is located; there is a significant discrepancy in the power supply. In order to address this problem, switching to renewable energy sources has shown to be a positive move. Ecologically, urban India's need for industrial goods and a higher standard of living is causing a continuous deepening of the nation's carbon footprint. India's proactive support of green energy in the fight against climate change gives future generations hope for a healthier and cleaner ecosystem. Many residential buildings and people from all over the world have vowed to accept the change, as awareness of the availability and usefulness of clean energy sources like solar electricity has grown over the past year. Despite the high initial cost of installing a plant, various studies have shown that over the plant's 25-year lifespan, the return on investment is achieved in less than four years.

The installation of solar plants, which was earlier thought of as a luxury, is now increasingly becoming a part of the owner's plan. It took some time, but consumers increasingly see the necessity to making savings plans for their ongoing, recurring electricity costs. Also the impact on health not discounted

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