Study of Energy Consumption in Residential and Commercial Sector of Hubli City

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Abstract

Energy is fundamental for economic progress of nation. Energy input is vital in every sector of an economy for survival and growth. The consumption in residential and commercial sector is going to rise further in the near future, as we see increase in population. Homes and business represent a significant portion of global energy demand, especially when electricity usage is considered. Globally this demand will grow substantially in the residential and commercial sector. The energy use in residential and commercial sector is an important area for campaigns to conserve energy. For a developing country like India, characterized by severe energy shortages, the need for energy conservation is of top most priority. The energy efficiency improvements in these sectors go a long way in their sustainable development. The share of different energy carriers used in both the sectors such as electricity, diesel and LPG is studied. The energy efficiency level is computed in both the sector in terms of Specific Energy Consumption (SEC). The factors influencing the energy efficiency and energy consumption in these sectors is studied. The factors are analyzed using multiple regression models. The regression analysis is carried out using SPSS (Statistical Package for Social Science software version 20). Barriers and drivers for the efficient use of energy in both the sectors are also identified and ranked using their average scores.

Keywords: Energy, Energy system, Sustainable Energy and Development

I. INTRODUCTION

Energy has become an important need in our life. Our primary needs of energy - for heat and light to sustain life on earth are obtained from the sun. Here we concern ourselves about the acquired needs of man for energy. The structure and size of the energy system are driven by the demand for energy services. The structure and level of demand for energy services, together with the performance of end-use technologies, largely determine the magnitude of final energy demand. The amount of final energy per unit of economic output (usually in terms of gross domestic product, or GDP), known as the final energy intensity, is often used to measure the effectiveness of energy use and the consumption patterns of different economies.

Energy prices influence consumer choices and behavior and can affect economic development and growth. High energy prices can lead to skyrocketing import bills, with adverse consequences for business, employment, and social welfare. Energy exporters benefit from high energy prices. High energy prices also stimulate exploration and development of additional resources, foster innovation, and encourage efficiency improvements. While some impacts of energy prices are fairly steady, others are more transient. The price hikes of the 1970s, affected economic growth in all energy importing countries. Thus it appears that economies are more sensitive to price changes than to price levels. But even price changes appear not to cause the turbulence of the past. The recent near-tripling in world oil market prices has, at least in OECD countries, not yet had any impact on economic development. [8]

Efficient energy use, sometimes simply called energy efficiency, is the goal to reduce the amount of energy required to provide products and services. For example, insulating a home allows a building to use less heating and cooling energy to achieve and maintain a comfortable temperature. Installing fluorescent lights reduces the amount of energy required to attain the same level of illumination compared with using traditional incandescent light bulbs. Compact fluorescent lights use one-third the energy of incandescent lights and may last 6 to 10 times longer. Improvements in energy efficiency are generally achieved by adopting a more efficient technology or production processes or by application of commonly accepted methods to reduce energy losses. There are many motivations to improve energy efficiency. Reducing energy use reduces energy costs and may result in a

financial cost saving to consumers if the energy savings offset any additional costs of implementing an energy efficient technology. [6]

Though various sectors contribute to the prevailing "energy dilemma", residential and commercial sectors deserves utmost attention due to intensive use of energy in most of the developing countries. Though there is significant potential for improving efficiency in all sectors, the greatest opportunity for saving are in energy-intensive residential and commercial sectors which comprises different types of buildings, households, shops, hotels and restaurants, etc. The energy intensive cluster chosen for the study is different localities of residential and commercial sector buildings within the corporation limits of Hubli city, Karnataka. In this study, the objectives are framed with reference to energy intensive residential and commercial sectors of Hubli city. The residential sector includes different varieties of buildings which use different types of energy consuming appliances such as television sets, computers, refrigerators, etc. the commercial sector facilities include stores, hotels, office buildings, shopping malls, etc. in these facilities energy used is mainly for lighting, cooling and energy using appliances, etc.

II. LITERATURE SURVEY

The year 2012 saw a slowdown in the growth of energy consumption globally, partly as a result of the economic slowdown but also because individuals and businesses have responded to high prices by becoming more efficient in their use of energy. At the same time, the review shows that the supply of energy is coming from an increasing diversity of sources as the world's energy market continues to adapt, innovate and evolve. Brazil, China, the EU, India, Japan, Russia and the US all saw below-average growth in energy consumption. Indeed, consumption growth of all forms of fossil energy was below average. [9]

The Indian economy has experienced unprecedented economic growth over the last decade. Today, India is the ninth largest economy in the world, driven by a real GDP growth of 8.7% in the last 5 years (7.5% over the last 10 years). In 2010 itself, the real GDP growth of India was the 5th highest in the world. This high order of sustained economic growth is placing enormous demand on its energy resources. The demand and supply imbalance in energy is pervasive across all sources requiring serious efforts by Government of India to augment energy supplies as India faces possible severe energy supply constraints. [7]

Karnataka has always been on the forefront in power generation. Asia's 1st major hydro electric generating station was set up in Karnataka in 1902; Ranks 2nd in installed hydro capacity at 3,599.8 MW Karnataka has a total installed capacity of 11,546 MW i.e. 6.64% of the total power generated in the country (2010-11).The proposed and the ongoing projects in Karnataka together contribute 18,183 MW. In terms of total installed capacity of power plants Karnataka stands 5th and in terms of State initiated power plants, Karnataka stands 3rd in the country. Largest Ownership share: State - 57%, Private sector - 32%, Central-11%. Instead of state taking initiatives increasing the power generation there is a lot of scope for the private investments in the state. The state has a total 95 power generation stations with installed capacity of 6,005 MW. The state is also home for major Independent Power Producers (IPPs) with total installed capacity of 3,609 MW. [10]

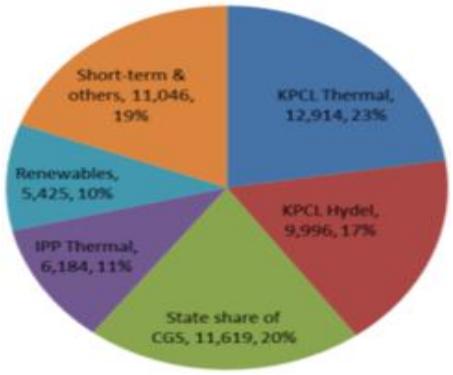

Fig. 1: Source-wise purchases by utilities (in Million units) in Karnataka

III. OBJECTIVES, SCOPES AND METHODOLOGY

A. Objectives:

The overall objective of the study is to analyze the energy consumption in the residential and commercial sectors by probing causes, consequences and constraints for energy efficiency so as to ultimately help the energy efficiency improvement initiatives in these sectors. In this backdrop the project has the following specific objectives for residential and commercial sectors of Hubli city.

1) To study the energy consumption pattern in residential and commercial sectors of Hubli city. Here the energy consumption pattern is studied based on different energy carriers used in both sectors.
2) To estimate the specific energy consumption (SEC) in terms of energy consumed per sq. ft. of area.

3) To estimate the environmental impact in terms of CO_2 emission for different energy consuming devices in both sectors and to identify the range of energy saving options.
4) To categories and analyze the factors influence energy efficiency and also the factors influencing energy consumption in residential and commercial sector.
5) To identify the barriers and drivers for the efficient use of energy and prioritize them.

B. Methodology of the Study:

The primary data required for the study is gathered through canvassing a structured questionnaire administered personally. Separate questionnaire were developed for residential and commercial sectors. The questionnaire covered different aspects of household and commercial building energy consumption, energy consuming appliances and the attitude and behaviour of individual towards energy etc. nevertheless, the questionnaire for both the sectors had common sections covering following aspects:

A survey was conducted in various households and various facilities in different locations of Hubli city. Socio-economic and energy data was collected from randomly selected samples. A sample of 100 households and 100 commercial buildings like shopping malls, textile shops, hotels, showrooms, jeweller shops, etc., are chosen for pilot study. The questions specific to energy in the survey were on primary use of energy for lighting, cooling and cooking, etc.

1) *Energy Consumption Pattern:*

The quantum of various energy inputs in different forms enabled the computation of total energy consumed in both sectors that is residential and commercial sector. The relative share of various energy carriers in total energy inputs reveals the prevailing "energy consumption pattern" in both sectors. Here the energy data is collected for 100 buildings each in both the sectors. All these computations fulfill the first objective of the study.

2) *Specific Energy Consumption:*

In order to meet the second objective of the study, one of the widely accepted energy efficiency indicator viz., Specific Energy Consumption (SEC) is adopted. The area of building is computed from the collected information of the survey. The average energy efficiency for both the sector is worked out in terms of SEC (kWh/sq. ft. of area).

3) *Environmental Impact In Terms Of Co_2 Emission;*

The residential and commercial sector includes the wide variety of buildings used by business, organizations and government agencies, including office buildings, hotels and multi-storey apartments, shopping malls etc. the bulk of greenhouse gas emission caused by these buildings is from energy use for heating, cooling and lighting, with additional use for domestic hot water, refrigerator, electronic equipment and other operations. Based on the quantum of energy use, type of energy carrier, the environmental impact in terms of CO_2 is calculated for different energy carriers in both sectors. Further, the varieties of energy saving options are discussed in both commercial and residential sectors.

4) *Factors Influencing The Energy Efficiency And Energy Consumption In Residential And Commercial Sectors:*

As a first step towards this, groups of factors formed which are likely to influence energy efficiency in residential sector and groups of factors which influence energy efficiency formed, based on the literature available and discussion with experts. Each factor comprises different variables. Factor score in each group is obtained by summing up the values of variables in the respective groups which are derived on an interval scale. Further, assuming a linear relationship between energy efficiency level and the considered factors, multiple regression models are developed.

5) *Barriers and Drivers for the Efficient Use of Energy:*

Finally, with an intension to probe the hurdles in improving current energy efficiency levels, a broad analysis is attempted covering what prevents in achieving higher efficiency (barriers) and what motivates in achieving energy efficiency (drivers). Depending on the average score, these barriers are ranked. Regarding drivers, six potential motivators for energy efficiency improvement are identified and are ranked.

IV. RESULTS AND DISCUSSION

A. Energy Consumption Pattern In Residential Sector And Commercial Sector:

The energy consumption pattern is studied for the different households from the energy data which were collected for different residential buildings. The energy data was collected for 100 households at different locations in Hubli city. Generally in residential sector buildings electricity and LPG are the primary energy carriers. Without these energy carriers life of the urban people would be unimaginable. LPG is the primary energy carrier for cooking purpose in the urban households.

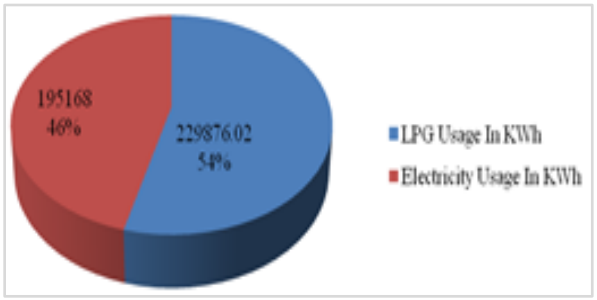

Fig. 2: Energy consumption pattern by the type of energy carrier used in residential sector.

From Figure 2 it can be seen that, the annual LPG consumption is more compared to the annual electricity usage. About 54% of energy is shared by the LPG and 46% is shared by electricity in all residential buildings. The share of LPG is more in residential sector because most of the energy used in this sector is for cooking purpose. The electricity is required for equipments like television, refrigerator, washing machine, mixer, lighting, etc. which can be considered as secondary need, but LPG is the prime requirement in every urban household for cooking purpose. In some households, the LPG is used for gas geysers to provide hot water for bath.

Similarly, the energy consumption pattern is studied for the different commercial sector buildings from the energy data is collected for different commercial sector buildings. Here the energy data is collected for 100 commercial sector buildings like textile shops, showrooms, hotels, etc. from these energy data different energy consuming devices were considered and for these devices estimated daily usage was also noted down. Generally in commercial sector buildings electricity, diesel and LPG are the primary energy carriers. In commercial buildings electricity is primarily used for lighting. It is also used for different like computers, fans, air conditioners (AC), printers, refrigerators, television (TV), etc. LPG is primary energy carrier for cooking purpose in hotels and restaurants. The diesel is used in different commercial sector building for generators.

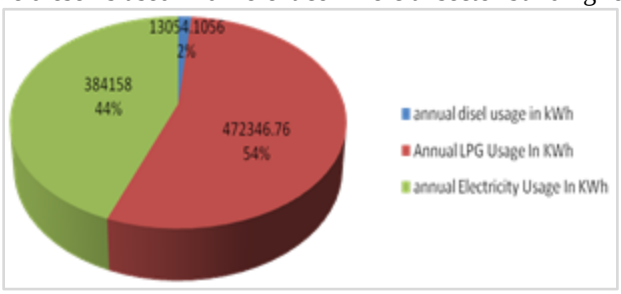

Fig. 3: Energy consumption pattern by the type of energy carrier used in commercial sector

From figure 3 it can be seen that, the annual LPG consumption is more in commercial sector buildings compared to the annual electricity usage and annual diesel usage. On an account, 54% energy is supplied by LPG, 44% by electricity and 2% is by diesel in all commercial sector buildings. In all these the main attraction for customer is because of the way lighting is provided and the comfort.

B. Specific Energy Consumption (SEC):

For international comparison of energy efficiencies, the two hybrid energy efficiency indicators viz. physical-thermodynamic indicators and economic- thermodynamic are recommended. The physical thermodynamic indicators, popularly called SEC (specific energy consumption) are more useful in giving actual insights into difference in energy efficiency at disaggregated level. In this backdrop, we are reporting indicator of energy efficiency viz., SEC.

1) *SEC in Residential Sector:*

Apart from the energy related data in the survey, total are of residential buildings (in terms of sq. ft.), number of people residing or family size in residential buildings are also collected. Then, then the SEC is calculated as total annual energy consumed per sq. ft. of area.

In residential sector, the energy used per sq. ft. of floor space area is represented in terms of SEC, specific energy consumption = 257.9981 kWh per sq. ft. of floor space area. For each sq. ft. 2.41091 kWh of total energy is consumed in residential sector.

2) *SEC in Commercial Sector:*

From the energy data which were collected, total floor space area of commercial buildings is noted down in terms of Sq. ft. the number of employees working in the commercial building is also noted down while collecting the energy data. The specific energy consumption is calculated for energy consumed per sq. ft. of area. Then, specific energy consumption is calculated for energy consumed per employee in commercial buildings.

The SEC for total annual energy consumption per sq. ft. is calculated as follows,

– SEC = total annual energy consumption (kWh) / total floor space area (sq. ft.)

- SEC = 869558.8656 (kWh) / 229400 sq. ft.
- SEC = 3.790579 kWh per sq. ft.

In commercial sector, the energy used per sq. ft. of floor space area is represented in terms of SEC, specific energy consumption = 3.790579 kWh/sq. ft. of floor space area. For each sq. ft. 3.790579 kWh of total energy is consumed in commercial sector. Also, the specific energy consumption for total energy consumed per employee is calculated as follows,

SEC = Total energy consumption (kWh) / No. of employees working

SWC = 869558.8656 (kWh) / 663

SEC = 1311.55183 kWh per employee.

In this sector energy used by an individual is represented as, specific energy consumption = 1311.55183 kWh / employee. Each individual consumes about 1311.55183 kWh of energy annually. Although this value is less compared to developed countries, it is much more compared to previous year values in India and it is increasing much rapidly.

C. Environmental Impact in Residential and Commercial Sector:

The residential sector includes the wide variety of buildings and wide range of energy consuming devices. The bulk of greenhouse gas emissions caused by these buildings is from energy use for heating, cooling, and lighting, with additional use for domestic hot water, refrigeration, electronic equipment, and other operations. In residential sector, the CO2emission is caused by other energy carrier is LPG. The electricity causes about 93% of total annual CO2emission in residential sector where as LPG has a share of 7% (figure 4). Although LPG has a large share in total annual energy consumption (54%) compared to electricity (46%), the annual CO_2 emission of LPG is less (7%) compared to electricity (93%). To calculate CO_2 emission by LPG, emission factor for LPG is 2.9 kg CO_2/kg LPG.

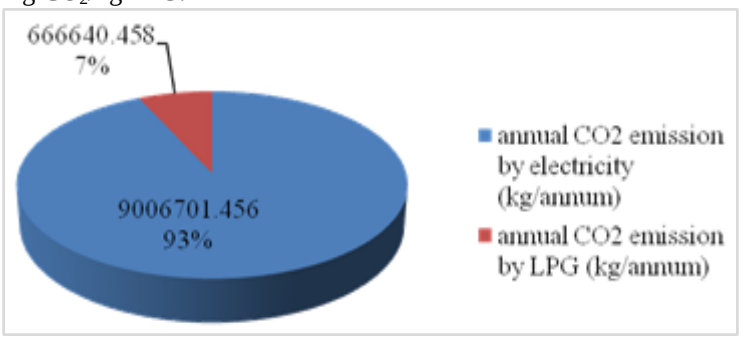

Fig. 4: Annual CO_2 emissions by the type of energy carrier in Residential sector

The economical sector includes wide variety of buildings used by businesses, organizations, and government agencies, including office buildings, hotels and multistory apartments, shopping malls, etc. the bulk of greenhouse gas emissions caused by these buildings is from energy use for heating, cooling and lighting, with additional use for refrigeration, electronic equipment and other operations.

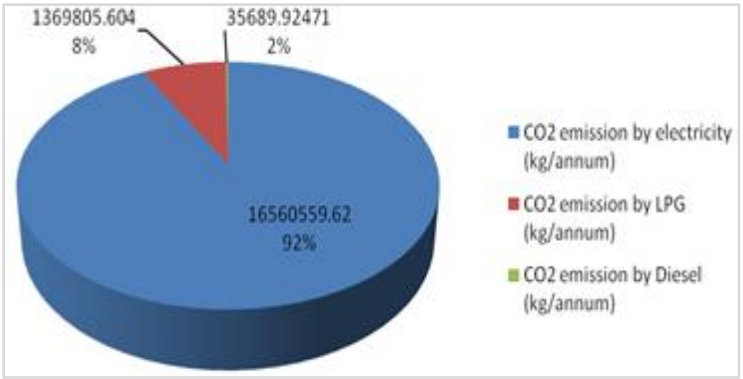

Fig. 5: Annual CO_2 emissions by the type of energy carrier in commercial sector

D. Factors Influencing Energy Efficiency and Energy Consumption:

In the course of achieving better energy efficiency, it is essential to explore what factors influence energy efficiency (SEC) and total energy consumption (TEC), so that focused attention can be paid towards them. Factor analysis is used for data reduction and to identify a small number of factors that explain most of the variance that is observed in a much larger number of manifest variables.

1) *Analysis Of Factors In Residential And Commercial Sector:*

Total of nineteen variables are selected from the questionnaire in order to find the main factors which influence the SEC. After completing the empirical study, a reliability test is run on the obtained data using SPSS software. The test conducted for the data in this study produced a Cronbach's alpha value of 0.745 in residential sector and alpha value 0.680 in commercial sector with a sample size 100, a Cronbach's alpha value of 0.745 and 0.680 is considered satisfactory. The solution is then rotated for ease of interpretation using varimax rotation. The entry analysis has been carried out using SPSS (statistical package for social science) software version 20. Only those components with Eigen values greater than one are considered. The values of extraction communalities which indicate the amount of variance in each variable that is accounted for by the components were found to be satisfactory as they arrange from 0.5 to 0.9. The extracted five components explained about 72.82% of the variability in the original nineteen variables in residential sector, whereas, the extracted five components explained about 72.27% of the variability in the original nineteen variables in the commercial sector.

The scree plot, shown in figure 6 helps in determining the optimal number of components. It is a plot of the total variance associated with each factor. Typically, the plot shows a distinct break between the steep slope of the large factor and the gradual trailing off of the rest of the factors. Generally, the components are extracted on the steep slope. The components on the shallow steep contribute to the little to the solution. The last big drop occurred between the 5^{th} and 6^{th} components. Hence, the first five components are retained.

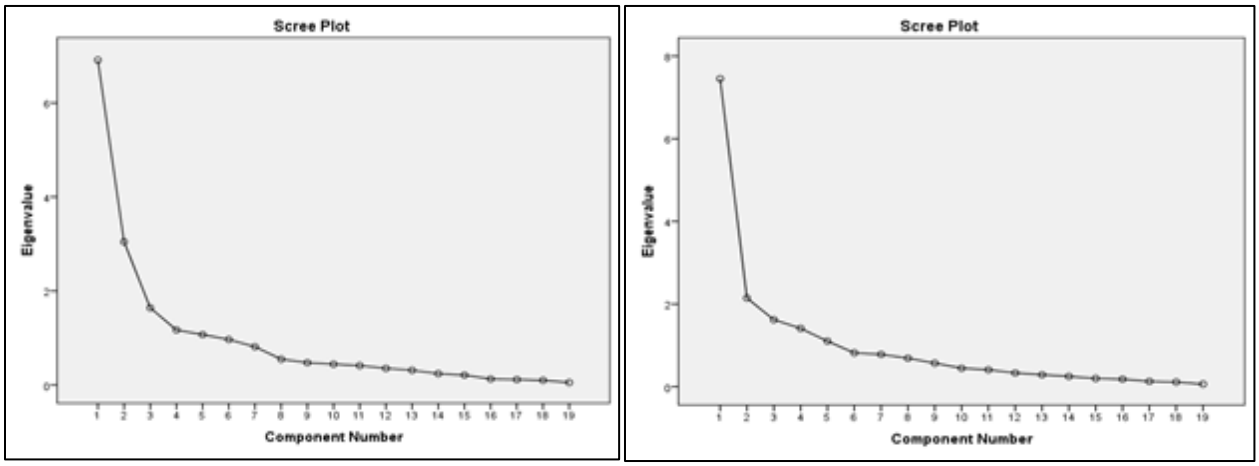

Fig. 6: Scree plots for the Variables in residential and commercial sector

As observed under each of the derived components, all variables with correlation coefficients greater than 0.5 (as obtained by the rotated component matrix) are considered significant. Keeping these variables in mind the factors are appropriately named in this table. Subsequently, these factors have been ranked based upon the average factor scores. In residential sector, based on the rankings obtained, it is observed that 'Government policy factor' is the most important factor and the 'Economic factor' is the least important one in influencing household's adoption of energy efficiency. The people in this group think that implementation of regulation and risk coverage, are important for energy efficiency. The second most important factor is 'Subsidy. The people think that the subsidy by the government should be provided. In commercial sector, it may be observed that the 'Government policy factor' is the most important factor and the 'Technology factor' is the least important one in influencing commercial sector's adoption of energy efficiency. In this, the people think that Govt. must implement the regulations and risk coverage, which is the most important for energy efficiency. The second most important factor is Govt. subsidy.

The factor scores obtained in principal component analysis are used in multiple regressions, with the SEC (kWh/sq. ft.) in the households as the dependent variable. The equations were fitted using the forward selection procedure of the SPSS software version 20. An important part of statistical procedure that builds models from data is establishing how well the model actually fits. A commonly used measure of the goodness of the fit is R^2. If all the observations fall on the regression line, R^2 is 1. If there is no linear relationship between dependent and independent variables, R^2 is 0. For good results, the adjusted R^2 should be more than 0.6 and significance F change should be less than 0.10 (10%). In the current study, for residential sector, the adjusted R^2 of 0.129 and significance F change 0.042 and for commercial sector, the adjusted R^2 of 0.119 and significance F change 0.061 was obtained. Though it does not has a reasonable good explanatory power with adjusted R^2 being 0.129 and 0.119, but the significance F change is less than 0.10 i.e., less than 10%. Hence the model is significant.

The standardized beta coefficients for all the factors are obtained by the co-linearity statistics table. It is found that Personal factor (0.999), Economic factor (0.494) and Govt. subsidy factor (0.358) in residential sector and attitudinal factor (0.434), Govt. subsidy factor (0.862) and Govt. policy factor (0.751) are less significant. Their value should be less than 0.10 for significant result. Therefore, these factors are eliminated and again regression analysis is carried out for remaining factors. By using beta coefficients the regression equation is formed. Higher the beta coefficient, larger is the extent that factor influences the energy efficiency (dependent variable).

The resulting regression equation for residential sector obtained is,

- $Y = b_0+b_1 F_1+b_2 F_2+b_3 F_3+b_4 F_4+\ldots+ b_n F_n$

- $SEC = 2.58 + 0.211 * F_2 – 0.217 * F_4$

Where Y is the energy efficiency (SEC) in the households and F_1 to F_5 are the factor scores. The ranking of factors based upon the beta values is shown in the table 1. From this table it is clear that in every household the 'Govt. policy factor' is the most important criterion for energy efficiency. Regulations and Risk coverage are important variables of Govt. policy factor. Interestingly, 'Govt. policy factor' is placed at second in this regression analysis. The people think least about the govt. policy, contrary to the result obtained in the factor analysis. Technology factor is the most significant factor.

Table -1:
Ranking of Factors based on Beta values for SEC (Residential sector)

Factor	*Beta value*	*Ranking*
Technology Factor	*-0.217*	*I*
Govt. Policy Factor	*0.211*	*II*

The resulting regression equation for commercial sector obtained is,

- $Y = 4.584 - 0.101 * F2 + 0.165 * F4$

The ranking of factors based upon the beta values is shown in table 2. From this table it is clear that in every commercial building the Technology factor is important criterion for total energy consumption. This factor is directly proportional to the energy efficiency. The second most important factor is Personal factor.

Table -2:
Ranking of Factors based on Beta values for SEC (Commercial sector)

Factor	*Beta value*	*Ranking*
Technology Factor	*0.165*	*I*
Personal Factor	*-0.101*	*II*

E. Barriers and Drivers to Energy Efficiency:

1) *Barriers to Energy Efficiency:*

A barrier is defined as a mechanism that inhibits as decision or behavior that appears to be energy-efficient as well as economically efficient. The key barriers considered in this study are Awareness &Information barrier (AIB) [2], Behavioral & Lifestyle barrier (BLM), Economic & Financial barrier (EFB), Market Related barrier (MRB) [3] and Technical Related barrier (TRB). These barriers are studied briefly and among these which barrier has more impact on energy efficiency is also identified in both residential and commercial sector. [1]

Table -3:
Ranking of Barriers in Residential sector

Sl. No.	*Types of barriers*	*Average score*	*Rank*
1	*Awareness & Information barrier (AIB)*	*2.774*	*II*
2	*Behavioral & Lifestyle barrier (BLB)*	*2.37*	*V*
3	*Economic & Financial barrier (EFB)*	*2.692*	*III*
4	*Market Related barrier (MRB)*	*3.258*	*I*
5	*Technical Related barriers*	*2.654*	*IV*

Table 3 shows that Market related barrier is the main barrier in residential sector which causes the lack of improvement in energy efficiency. The second barrier is 'awareness and information barrier. This is due to lack of awareness among the people of the potential gains from improved efficiency. The lack of awareness and information regarding issues pertaining to energy efficiency like "energy conservation", "energy tax", "energy labels", "energy efficient and environmentally sound technologies" and "Energy Conservation Act", etc. third barrier is the 'economic and financial barrier' which causes the lack of improvement in energy efficiency.

Table -4:
Ranking of Barriers in Commercial sector

Sl. No.	*Types of barriers*	*Average score*	*Rank*
1	*Awareness & Information barrier (AIB)*	*2.542*	*IV*
2	*Behavioral & Lifestyle barrier (BLB)*	*2.292*	*V*
3	*Economic & Financial barrier (EFB)*	*2.668*	*II*
4	*Market Related barrier (MRB)*	*3.092*	*I*
5	*Technical Related barriers*	*2.58*	*III*

The above table shows that the 'market related barrier' is the main obstacle for energy efficiency in commercial sector. The second barrier is 'economic and financial barrier'. The energy sourcing and price, fiscal measures provided for energy related investments like tax concessions, subsidy and depreciation benefits would also influence the resistance level for energy efficiency improvements.

2) *Drivers to Energy Efficiency:*

While barriers represent the obstacles in energy efficiency improvement initiatives the drivers stand for the factors that promote it. The idea is to stimulate the drivers and overcome the barriers through various means including policy interventions to enhance energy efficiency. [4] Six potential drivers are recognized based on the limited literature available and discussion with the experts. The drivers considered in the study include are Financial benefits, high level of awareness, decrease in cost of energy efficient technology, increase in energy prices, technology appeal, non-energy benefits. [5]

From the table 5 it is clear that 'high level of awareness' is the most important for the adoption of energy efficiency in residential sector. The second important driver is 'financial benefits', followed by technology. Along with the advertisement campaigns, the competition should lead to a decrease in the cost of the technology. Such reduction in the prices can safely be assumed to lead to an increase in the sales of the technology.

Table -5:
Ranking of Drivers in Residential sector

Sl. No.	*Types of drivers*	*Average score*	*Rank*
1	*Financial benefits*	*1.81*	*II*
2	*High level of awareness*	*1.77*	*I*
3	*Decrease in cost energy efficient technology*	*3.02*	*IV*
4	*Increase in energy prices*	*3.63*	*VI*
5	*Technology appeal*	*2.78*	*III*
6	*Non-energy benefits*	*3.13*	*V*

The drivers for efficient use of energy in commercial sector are studied using the energy data collected during the survey. The table 6 shows the average score for each driver and their ranking.

Table -6:
Ranking of Drivers in Commercial sector

Sl. No.	*Types of drivers*	*Average score*	*Rank*
1	*Financial benefits*	*2.28*	*II*
2	*High level of awareness*	*1.65*	*I*
3	*Decrease in cost energy efficient technology*	*2.62*	*IV*
4	*Increase in energy prices*	*3.28*	*VI*
5	*Technology appeal*	*2.52*	*III*
6	*Non-energy benefits*	*2.93*	*V*

From the above table it is clear that 'high level of awareness' is the most important for the adoption of energy efficiency in residential sector. The second important driver is 'financial benefits', followed by technology appeal.

V. CONCLUSION

Though residential and commercial sectors are vital component of Indian economy, it appears that the energy related aspects of them have not much attracted the attention, at least at the micro level. This project analyzed energy use in the residential and commercial sectors of Hubli city involving study of energy consumption pattern, energy efficiency level and environmental impact due to energy use. Apart from this, it also probed causes, consequences and constraints for energy efficiency, eventually to help energy improvement initiatives in these sectors.

Based on the study, it may be concluded that there is a significant scope for energy improvement in both the sectors. The following conclusions are drawn from the present study.

1) Electricity is the major energy carrier in both the sectors.
2) Energy efficient equipments should be adopted to reduce the environmental impact.
3) High level of awareness should be created about energy efficient technologies.
4) Also, financial benefits are to be supported to improve energy efficiency.

The present study comprises analysis of energy consumption in residential sector and commercial sector of Hubli city. The work presented in this study can be expanded and enhanced by undertaking the following tasks.

- Further study can be extended for metropolitan cities.
- In the present study residential sector comprises middle income group households. Further, the study can be extended for all income groups.

The present study focuses only on CO_2 emission from both sectors. Other GHGs which also affect the environment can be studied further.

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