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Energy Scenario in Haryana: An Analysis of Energy Sources in Household Activities

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Abstract. Energy is a vital component for an economy and it fuels the engine of growth of an economy. Energy demand for an economy is influenced by several factors like urbanisation, technological advancement and increase in population. In India the Energy security is the biggest challenge along with the over dependence on non-renewable sources of energy and still a large section of the population is not even aware about the ill effects of non-renewable resources and doesn't have incentives to move towards renewable energy sources. Lack of availability, accessibility and affordability along with health issues are major concerns to ensure energy security. The Household sector is the second biggest consumer of energy after industry so energy access is a big issue and 100 percent electrification of a country does not ensure energy accessibility and cannot be the sole solution for the demand supply gap of energy. Against this background this paper focuses on the household energy consumption aspect of energy for cooking, lighting and heating purposes and analyses the sources of energy and awareness towards renewable sources of energy in Haryana. The results of the study reveals that LPG is used as main cooking fuel and prevalent more in urban areas as compared to rural areas. Electricity is used as main fuel for lighting both in urban and rural areas. For heating LPG and electricity are used more in urban areas and in rural areas fuel stacking is prevalent.

Index Terms: Energy source, renewable energy, household, cooking, heating and lighting.

I Introduction

Energy stands as a cornerstone among the indispensable inputs for any economy serving as a vital lifeline across all sectors It is recognized as a linchpin for societal progress and development playing a crucial role in the evolution growth and survival of all living beings either directly or indirectly The pursuit of goals such as poverty eradication improved living standards and heightened economic output necessitates an augmentation in energy resources In contemporary times marked by structural and

technological transformations the dynamics of energy resource utilization and availability have undergone substantial changes Energy has assumed the status of a strategic commodity and any uncertainties regarding its supply pose a potential threat to the seamless functioning of an economy especially those in the developing phase. For an economy like India over time the demand for energy is increasing but the supply lacks behind because of heavy dependence on non-renewable sources of energy. There is a need to mitigate this demand supply gap either by reducing the demand for energy resources or by switching towards renewable sources. As for the developing economy like India, the demand cannot be reduced so renewable sources of energy and energy efficiency measures need to be promoted, considering it a better alternative to mitigate the climatic changes and promoting the sustainable development goals.

Still, a large section of the population is not aware of the ill effects of non-renewable resources and does not have incentives to move towards renewable energy sources (Multiple Indicator Survey in India, Government of India, March, 2023). Lack of availability, accessibility and affordability along with health issues are major concerns to ensure energy security. Over time as the rural urban consumption pattern changes due to income distribution patterns, regional income disparities narrow and rural will catch up to urban counterparts and will further enhance the demand for energy(Crompton & Wu, 2005). Factors influencing households' transition from traditional fuel wood to modern energy carriers encompass urbanization economic development regional specific income levels the availability of local resources alternative fuel options after sales services and behavioral considerations Balachandra 2011 In more developed countries households often focus on a singular fuel option that caters to all their needs However such specialization proves challenging in developing nations due to issues like unstable access affordability constraints and the limited availability of fuels The household sector ranking as the second largest consumer of energy after industry MoSPI 2022 grapples with significant challenges in energy access Achieving 100 percent electrification in a country while a noteworthy goal does not automatically guarantee widespread energy accessibility and falls short of addressing the demand supply gap India for instance heavily relies on coal as a primary energy source and the dependence on commercial energy sources does not necessarily translate to access to clean energy Despite governmental efforts to enhance LPG availability through initiatives like the Pradhan Mantri Ujjwala Yojana PMUY and Pratyaksh Hanstantrit Labh PAHAL schemes approximately 800 000 premature deaths in India are still attributed to household air pollution (Health Effects Institute, 2020). As biomass is abundantly available at no or low monetary cost for a significant number of population especially in rural areas so people in rural areas use biomass along with LPG for similar purposes depending on their cooking preferences (India Energy Outlook, 2021).

The basic activities of household energy consumption are cooking, heating and lighting, so the paper makes an attempt to assess the situation of sources of energy for

household activities in Haryana. Haryana State has limited availability of natural sources of energy. There is very little Hydro Generation potential in the State. Even the coal mines are far away located from the State. There is very limited forest area. Wind velocity prevailing in the State is also not sufficient to exploit the power generation. Although the solar intensity is relatively higher, the land area limitation does not encourage large-scale harnessing of this resource (Economic survey of Haryana, 2020). Against this background paper makes an attempt to explore whether the fuel used for household activities are traditional, transitional or modern and clean fuels. The paper comprises of seven sections-Section 1 includes Introduction and objectives , Section 2 - Review of Literature, Section 3 - Survey Design and Research Methodology, Section 4 Data Analysis, Section 5 - Results and Findings, Section 6 - Conclusion and Policy recommendation and Section 7 includes References.

1.1 Objectives of the Study

- To explore the consumption of energy sources for cooking, heating and lighting purposes.
- Comparatives Analysis of energy sources for cooking, heating and lighting purposes.

To explore the knowledge and preference of renewable energy sources.

II. Review of Literature

(Pohekar et al., 2005) delves into the trends of household cooking energy usage by analyzing data from the National Sample Survey Organization (NSSO) spanning the years 1950 to 2000. The study reveals a notable increase in the use of LPG and electricity as primary fuels, rising from 0.06 percent in 1950 to 10.34 percent in 2000. It suggests a shift among households, particularly those with higher incomes and improved living standards in urban areas, from traditional wood-based fuel to modern sources like LPG and electricity. A comparison between the 50th and 55th rounds of the NSSO indicates a decline in fuel wood consumption for cooking in urban areas and a more substantial decrease in rural regions.

(Ding et al., 2014) investigates the energy structures and the impact of renewable energy on gender relations in rural villages in north-western China. Traditional energy sources like biomass and coal are contrasted with enhanced structures incorporating renewable sources such as solar energy cookers, energy-saving stoves, and biogas digesters. The study suggests that adopting renewable energy could enhance energy efficiency, altering women's labor intensity, living standards, health, and even redistributing some cooking duties compared to traditional biomass-based energy use.

(Malakar, 2018) explores the role of affordability in household decisions to switch to cleaner fuel choices. Based on a sample of households in Andhra Pradesh, the study finds that over 90 percent have TV sets and annual subscriptions, while only

one household has an LPG connection. The cost dynamics of TV ownership, being higher than that of LPG, challenge the notion that cost is the sole factor influencing families' decisions to adopt new fuel technologies. The paper emphasizes that household decision-making is a multidimensional and complex phenomenon, influenced by factors beyond cost, such as social status and the availability of fuel wood.

(Blenkinsopp et al., 2013) conducted a study in the village of Uddhar in the Raigarh district of Maharashtra, India. The research aimed to understand the awareness of different renewable energy technologies and the obstacles hindering their adoption in the community. Electricity emerged as the primary energy source for household lighting due to its ease of use and availability. The findings highlight a common usage of a combination of LPG and firewood or biomass for cooking, with users potentially opting for the cheaper and more familiar firewood or biomass due to the higher cost of LPG. The study emphasizes that while people express interest in sustainable or renewable energy technology, factors such as cost, reliability, and convenience outweigh environmental advantages.

(Balachandra, 2011) reviews the rural energy situation in India, focusing on access to advanced cooking fuels and electricity for lighting across households with varying incomes and regions. The study reveals that the poorest households face the most energy deprivation, relying heavily on biomass for cooking. While urban-rural gaps in lighting access are narrowing, the study underscores persistent challenges in energy access for cooking, indicating variations among states in providing access to rural households. Factors such as poverty, inadequate initiatives, and resource constraints contribute to disparities between top-performing and bottom-performing states.

(Mudombi et al., 2018) aims to understand the obstacles to the uptake of ethanol stove technologies by eliciting consumers' perceptions, adoption patterns, and use in Maputo. Combining quantitative and qualitative approaches, the study finds that approximately 17 percent of households use ethanol stoves, while 71 percent have never used them. Though some users prefer ethanol stoves for their cooking advantages, there is a decline in ethanol use compared to charcoal.

(Dimitra Kotsila et al., 2021) conducted a study in Greece focusing on the residential sector's contribution to energy use. The investigation explores socio-economic parameters, dwelling characteristics, and climate conditions influencing electricity consumption in households. Analyzing data from 1801 dwellings, the study builds statistical models, indicating that the number of occupants, dwelling size, heating type, heating and cooling hours, and weather conditions are significant determinants influencing electricity consumption.

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

III. Survey Design and Research Methodology

Haryana is one of the richest states in India. Here, an attempt has been made to study the energy use pattern in Haryana as it is one of the top states in terms of energy efficiency initiatives (MoP,2019) and 80 percent of its population are LPG subsidy recipients (IRES,2020). To explore the consumption of energy sources for cooking, heating, and lighting activities, a purposive sampling method is used to choose seven districts among 22 districts of Haryana and further, in the selection of villages and cities, the same sampling method is used. These seven districts are Sirsa, Hisar, Fatehabad, Gurugram, Nuh, Rohtak and Rewari. More than 400 samples is chosen and the selection is random and relied upon respondents' willingness to participate from the villages and cities of these districts. Few responses have been dropped due to incomplete and inconsistent information and the study entailed the result of 389 samples to find out the current energy consumption pattern in different activities in the household sector. A questionnaire containing quantitative questions was conducted to find out a comprehensive picture of energy consumption patterns in different activities of the household sector such as cooking, lighting, and heating along with to know the awareness of respondents about renewable energy and government initiatives to provide access to cleaner energy. Stata-15 software is used to interpret the data and to highlight any relationship between different variables along with relevant tables and diagrams.

III. Data Analysis

The study covered 389 respondents out of which 59 percent respondents belonged to rural areas and 41 percent belonged to urban areas. Among the total respondents, 31.11 percent were undergraduate and 28.53 percent were postgraduate.

The economic conditions of respondents are classified based on their annual income and we found that more than 50 percent of the sample earned less than 1 Lakh in a year and only 15.42 percent of respondents were found with income more than 5 Lakh. More than 50 percent of our respondents were housewives who were not the decision maker but the main factor of consuming energy, especially in cooking and heating activities. The socioeconomic status of respondents is expressed in table-1.

The respondents were asked about the primary fuel used for cooking, lighting, and heating and they were given the options of both clean fuel such as LPG, electricity, and unclean sources of energy like Cow Dung, Fuel wood. It was found from the study that the use of clean energy sources was more in the urban area in all three activities, 80 percent of respondents uses LPG as a primary source of cooking, 89 percent of respondents uses electricity as a primary source of lighting and 64 percent of respondent were found to use electricity for heating purpose in the urban area and on the other side 59 percent, 86 percent and 60 percent in the rural area in respective activities with the reason that these were easy to use. It was observed that mixed fuel

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

(fuel stacking) was very common among respondents and it was 36 percent in cooking, 11 percent in lighting, and 30 percent in heating in rural Haryana.

Table-1 Socio-economic status of the sample

Education (In percentage)	Below Matric	Matric	Senior Secondary	Under Graduation	PostGraduation	Above PostGraduation	Total
	9.5	10.54	15.17	31.11	28.53	5.14	100
Family Income	Below 50K	50K-1L	1 Lakh-2L	2 lakh-4 L	4 Lakh-5L	More than 5 L	
	24.16	30.59	15.17	10.54	4.11	15.42	100
Occupation	Govt job	Housewife	Private Job	Selfeployed			
	16.97	51.93	10.54	20.57			100

Lack of access to 24 hours supply of electricity and high price of electricity were the one side reasons not to adopt it as a single source of energy in lighting and heating and free availability of alternative resources played an important role on the other side. Although there is 100 percent coverage of LPG in Haryana still 36 percent in rural and 19 percent of urban respondents use fuel stacking rather than switching on a single source. It was discovered that the consumption of fuel wood for cooking has dropped in urban areas, but it happened significantly in rural areas (Pohekar et al., 2005). A pessimistic attitude towards cylinder refilling and free availability of other sources were found the main reason for mixed fuel uses. It stands with the result that acceptance of clean fuel is observed as a main constraint rather than the accessibility of clean fuel (Rajan and Singh, 2020).

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

Table-2. Energy Consumption in Different Activities of the household sector

Place of Residence (in %)	Energy Source in Cooking			Energy source in Lighting			Energy source in Heating		
	Fuelwood	LPG	Mixed fuel	Electricity	Mixed fuel	Solar energy	Electricity	Fuel wood	Mixed fuel
Rural	4.80	59	36	86	11	4	60	10	30
Urban	0.63	80	19	89	6	4	64	8	28

It was also observed that there was no particular and positive relation between the clean fuel energy consumption in all activities and the family income, size, occupation, and education level of the respondents contrary to many studies which show a positive relation between them (Giri and Aadil, 2018; Gupta, 2018; Yadav et al, 2020)

V. Results and Findings

5.1 Fuel Used for Cooking Requirements

As stated in Figure 1 below when the respondents were asked about the fuel used for cooking, more than 70 percent of households were found using LPG as primary cooking fuel followed by 29 percent of the household found using mixed fuel (cow dung and fuel wood and LPG) and only 3 percent were found using the fuel wood.

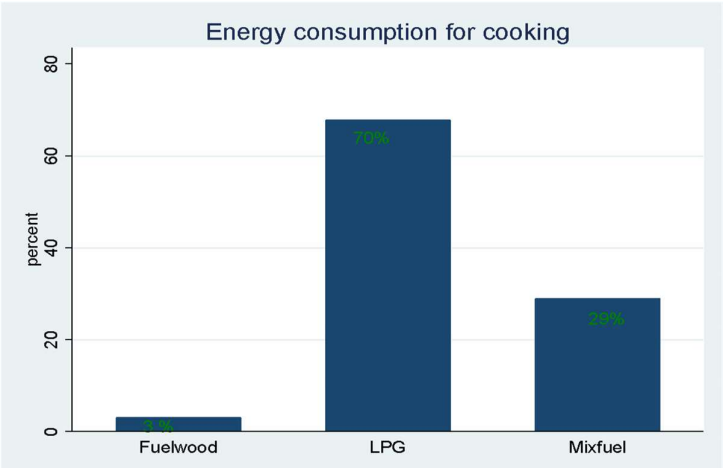

Fig. 1 (a) Energy used for cooking purposes

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

Energy source preferred for cooking if given a choice - When respondents were asked about their preference as to which fuel would be preferred by them for cooking if given a choice more than 57 percent of respondents were preferring LPG followed by 16 percent for mixed fuel and almost 4 percent showed their interest for cow dung and 11 percent wanted to use fuel wood as depicted in fig 2 as their favoured one due to the free availability and access to this fuel.

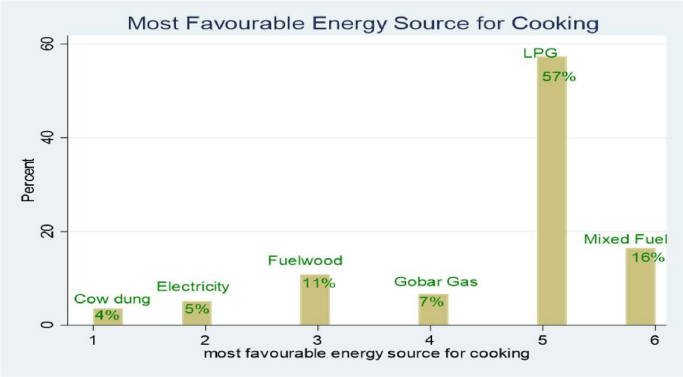

Fig. 2 Energy source preferred for cooking if given a choice.

Reason for Unhappiness about cooking fuel - When respondents were asked about their reason for unhappiness about the use of energy for cooking purposes, 59 percent of respondents reported expensive cooking fuel was the main reason followed by smoky i.e. 20 percent and more than 11 percent complained mixed reason such as expensive, smoky, takes time to burn and unreliable was the main reason for their unhappiness. 59 percent of respondents were not satisfied with the given subsidy and price for LPG uses. This result shows that affordability is the major barrier in household decisions to opt for cleaner fuel choices (Malakar, 2018).

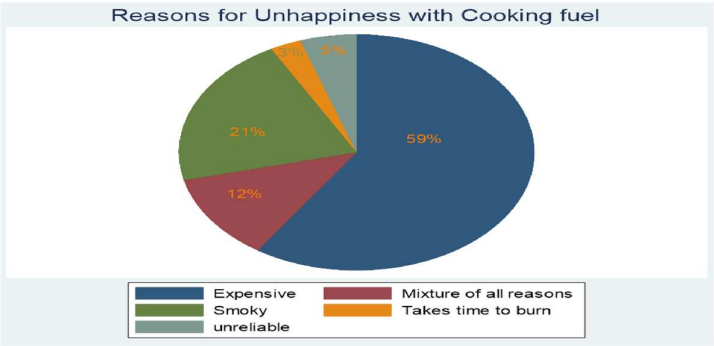

Fig. 3 Reason for Unhappiness about cooking fuel.

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

5.2. Fuel Used for Lighting Requirements

Fig 4 depicts the distribution of energy used for lighting purposes in these districts of Haryana. The survey focused on the usage of electricity, solar energy, and the combination of solar energy and electricity. Liquefied petroleum gas (LPG), fuel-wood, and biogas are some of the other additional energy sources used for lighting. Electricity is one of the most common fuels, with 87 percent of households using it. However, solar energy is not widely used; about 3.86 percent of respondents use it and 9 percent of respondents use mixed fuel. It shows that electricity is the main source of lighting for more than one-fourth of respondents.

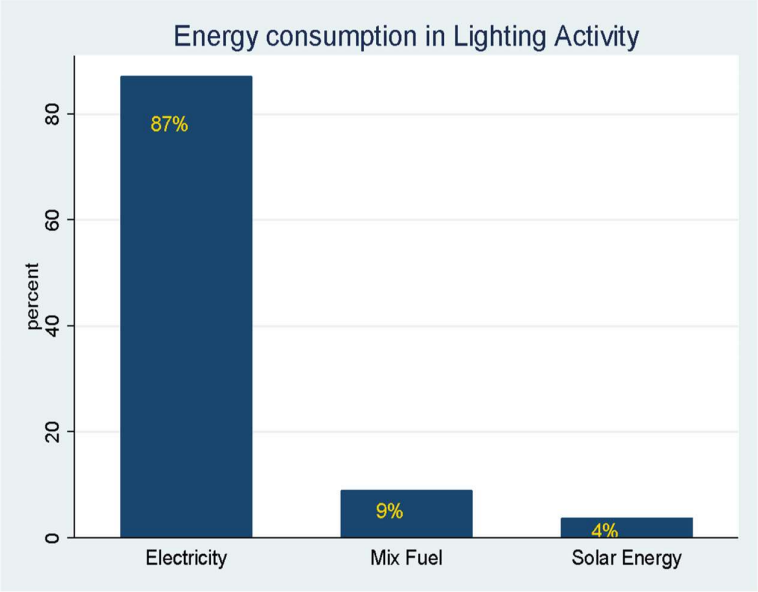

Fig 4 Energy consumption in Lighting.

Most favoured source for lighting - When respondents were asked about which fuel they would prefer for lighting if given a choice, more than 55 percent of respondents chose solar energy, followed by 34.45 percent for electricity. Only 10.54 percent of respondents are preferring fuel stacking rather than a particular fuel. Here, it was found that people were very well aware about the benefits of solar energy and want to replace non-renewable source generated electricity with solar energy especially in the lighting sector.

Reason for unhappiness in lighting - When respondents were asked about the un-happiness among them, 72 percent of respondents explained expensiveness of fuel as a main constraint, 9 percent respondent showed unreliability as a main constraint. Unreliability is a fact for a developing Indian economy. India got 100 percent electri-

fication in 2018 but still there is a lack of consistent supply and lack of access to 24 hours availability especially in rural areas which enforce use of mixed fuel such as kerosene and fire wood still persistent to some extent.

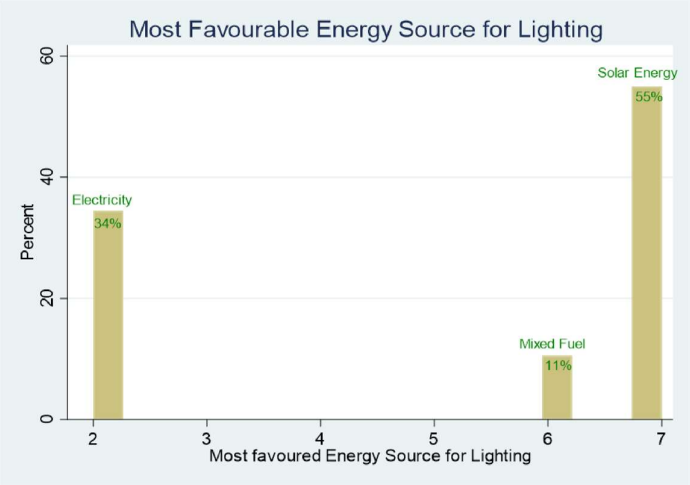

Fig 5 Most favoured source of lighting.

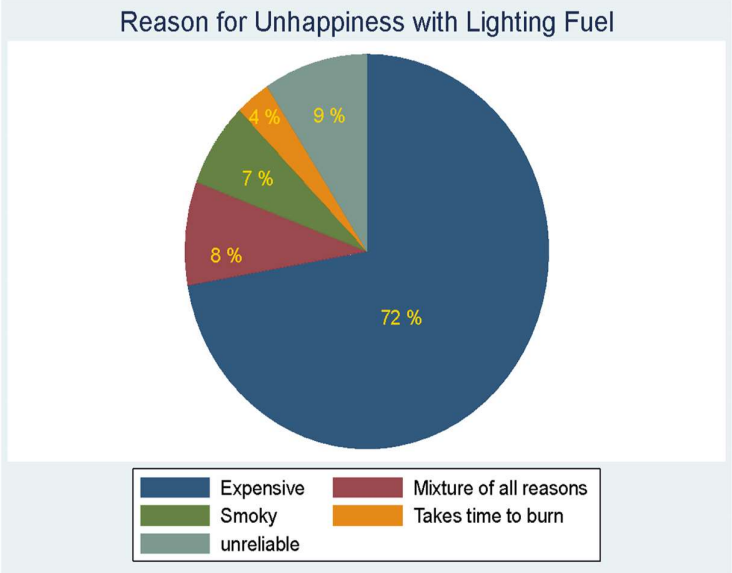

Fig. 6 Reason for unhappiness with lighting Fuel

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

5.3. Fuel Used for Heating Requirements

The various sources of energy used for heating such as Cow Dung, Electricity, Fuel Wood and LPG in districts of Haryana especially in rural areas. The survey indicates that about 61 percent of the respondents were using Electricity as primary fuels for heating while 8.74 percent were using Fuel Wood. Thus, the finding of the survey shows a significant energy transition from fuel wood to electricity for heating. However, it is quite distressing that only 5.14 percent of respondents used LPG which is more environmentally friendly than other sources of energy.

When it comes to usage of mixed fuel the data of the survey shows a large 18.51 percent of respondents come under this combination. The results depict less consumption of cow dung for heating by about 4.11 percent which is a good sign although cow dung is renewable energy but it is not clean energy. It was also observed that respondents want to use solar energy for heating purposes as depicted in figure 7 more than 40 percent respondent belong to this category but in actual only 2 percent of respondents were using solar energy for heating. It depicts that there is a wide gap between the preferences and actual use of solar energy despite the provision of financial help in the form of subsidies by the government.

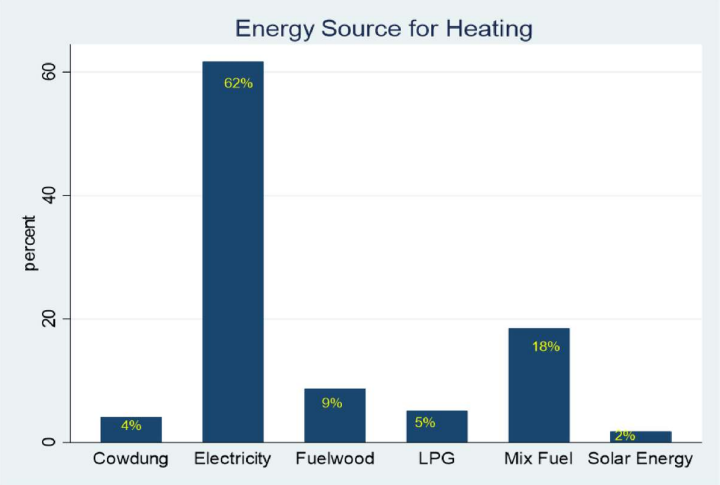

Fig 7 Energy consumption in Heating.

Most favoured source of energy in Heating - When asked which fuel they would prefer if given an option, more than 55 percent chose Solar Energy for heating, followed by more than 25 percent Electricity and approximately 6 percent were preferring both commercial and noncommercial fuel. This fig 8 shows a very low preference of fuel food and LPG for heating.

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

Thus, the overall results revealed that the majority of respondents would like to use solar energy for heating as it was also shown in case of lighting.

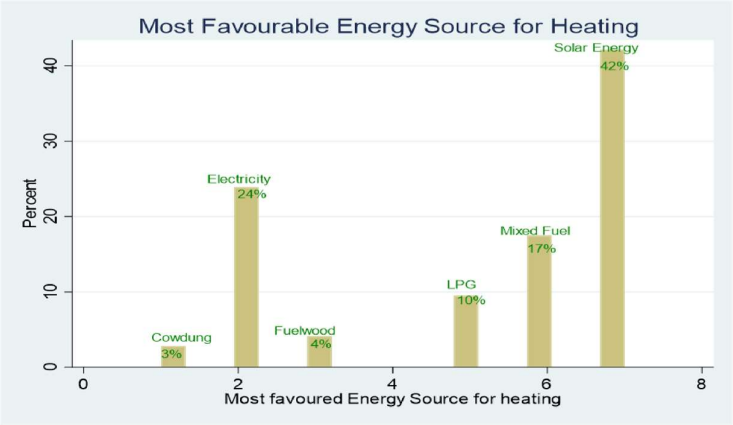

Fig 8 Most favoured source of energy in Heating

Reason for unhappiness with heating fuel - When the respondent were asked what the reason of using either mix fuel or traditional fuel such as cow dung and fuel wood, they stated lack of access for full time access and cost of the fuel were the reasons on one side and easily availability of traditional full without any cost was the reason on other side.

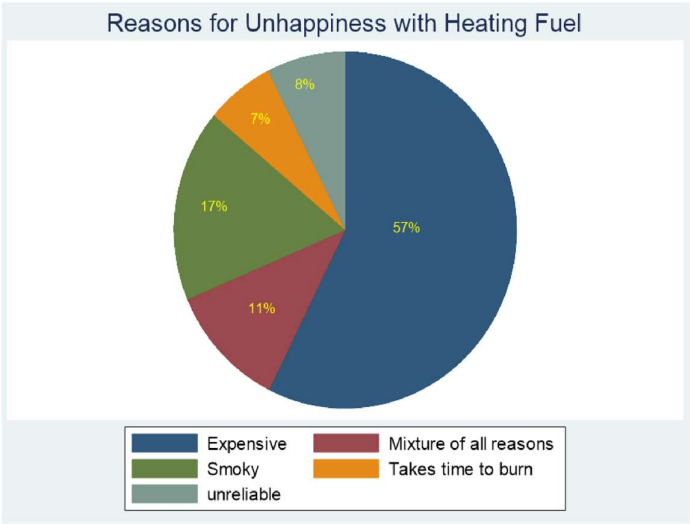

Fig.9 Reason for unhappiness with heating fuel.

International Journal for Research Trends in Social Science & Humanities
Volume 1 Issue 1
Nov-Dec 2023, Nov-Dec 2023, PP 40-55

V. Conclusion

The results of the survey indicate that the LPG is main fuel used for cooking in Haryana and when analysed separately in urban and rural areas the percentage of people using LPG for cooking in rural areas is low as compared to the urban areas. In the case of lighting electricity are the main fuel used both in urban and rural areas and for heating, LPG and electricity are the main fuels but when analyzed for rural and urban areas separately it was found that in rural areas non-commercial fuel-fuel wood and cow dung are the main source of fuel used for heating as compared to LPG and electricity.

When asked about the preferences of people and their reason for unhappiness with the current fuel more than 60 percent told that clean fuels such as LPG and electricity are easy to use but very expensive in comparison to traditional fuels which are available without any cost especially in rural Haryana especially for cooking purpose throughout the year and heating purpose during winters. Both LPG and electricity are non-renewable sources of energy and are used as the primary fuel for cooking, lighting, and heating if they are able to afford the cost. But if unable to afford the cost they need to rely on compulsion on non-commercial sources of energy like fuel wood and cow dung because they are less expensive. Most respondents in rural areas belonged to the low-income group and they had a strong belief in using these traditional sources of energy ignoring their long-term health effects. Most respondents who were more than 50 years of age showed their preference for the food cooked on kacha chulha rather than LPG and liquid fuel-based stoves and have their belief of negative impact on their health if they continuously used these clean sources for cooking. When asked about any initiative taken by the government to promote energy resources 40 percent of respondents replied that LPG cylinders are available but not at affordable cost. It was observed that high-income respondents in rural areas also prefer kacha chulha-cooked food and this is also one reason that the rural population is not completely switching towards LPG sources for cooking. For lighting, heating, and cooling purposes people like to switch on electricity and they are also aware of the benefits of using electricity from renewable sources. When asked about government initiatives 30 percent responded that some solar initiatives like rooftop solar plants and solar LED lighting were initiated on a subsidy basis but there is no certainty about their maintenance and their productivity. When asked about the availability of energy resources in villages and expectations about future maximum, respondents stated that they want clean energy to be promoted but they were not interested in investing in these steps and are fully dependent on the government. The results of the study show that income is not the sole determinant of demand for sources of energy, affordability and accessibility are equally important. Because of the difference in living standards between urban and rural areas and the free availability of fuel wood and cow dung fuel stacking is prevalent in rural areas and a total transition to clean fuels is not possible. So the policy for promoting clean sources of energy should be separately designed for

rural and urban areas keeping in view the complexity of factors shaping the demand for energy sources. As it is clear from the survey conducted LPG is the main cooking fuel and electricity is used for lighting and heating but in rural areas, the still mixed fuels are used. People are aware of renewable energy technology and want to adopt it but a large segment of population lacks the access to renewable energy sources for domestic use. Also, the usage differs among the different income groups because of non-affordability. The people do have the desire to shift to clean sources of energy, they want to shift from non-renewable sources of energy sources to renewable sources but because of high prices of commercial fuels and low income they remain accustomed to non-commercial fuels. So people are totally aware about renewable energy and its benefits Government needs to make it a massive campaign keeping in view the above factors so that nobody will be left behind for an affordable clean and secure source of energy. Household decision environment is multidimensional and complex and it is necessary to deconstruct it to understand the fuel choices. Policy institutions and markets have a limited role in making people upgrade their fuel. Also, policies promoting clean fuel need to strengthen household internal opportunity set such as skills, knowledge, and preferences. A lack of information on social security, prestige, and social status prevents people from adopting LPG (Treiber et al., 2015).

There has been no dearth of Government programs and policies for ensuring energy security and the promotion of cleaner energy. In Haryana for renewable energy, there is Haryana Solar Policy, and Haryana Biomass Policy and for household clean cooking fuel there is Pradhan Mantri Ujjwala Yojana (PMUY). But how far these programs have been successful in achieving the targets of providing energy sources for the basic requirement of cooking, lighting, and heating reducing the penetration of traditional fuel in energy sources will be our further area of research and we would also attempt to analyze the effect of various socio-economic factors, cultural beliefs, lack of awareness about health effect, low income of respondent, high price of clean energy consumption, low certainty about renewable energy initiatives and free availability of traditional energy sources.

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