EXECUTIVE SUMMARY

Introduction

Nepal has huge potential of electricity and renewable energy. The clean energy resources from Nepal can be used in cooking sector. The traditional fuel and imported Liquefied petroleum gas (LPG) are dominant for cooking in residential as well as commercial sectors of Nepal. The preliminary objective of this assignment is to investigate the status of clean cooking technology used in two major cities of Nepal i.e. Butwal and Pokhara.

This study has been conducted for residential and commercial sectors in Pokhara Metropolitan city and Butwal Sub-Metropolitan city of Nepal. In residential sector, households were considered as sample units whereas commercial entities were considered as sample units for commercial sector. The primary data was collected in the form of interviews through structured questionnaires. The questionnaires were designed in order to inform about socioeconomic information, existing cooking status, willing of switching possibilities, cost of fuel and technologies, obstacles and indoor pollution.

The data collected was analyzed and energy model was designed to investigate the future possibilities of switching of cooking mechanism by cleaner version of technologies. The cost and emission for different cooking fuel resources and technologies have been calculated. The study further aimed to forecast the different energy demand scenarios for different cooking technologies with business as usual (BAU) and switching of cooking technologies for the upcoming 15 years in 5-year step.

Cooking technology in Nepal

Energy consumption in Nepal is still dominated by traditional fuel for cooking i.e. many people living in Nepal are using fuelwood, agricultural residue and dung cake as their primary source of fuel. According to annual household survey 2017, 52.4% of household are still using fuelwood as primary source of fuel where, 65.8% of households in rural area and 54.1% household in urban area are using fuelwood as primary source of fuel. While in Province 1 and Madesh Province, the share of traditional energy for cooking was determined to be 82.91% and 91.28% respectively (WECS, 2021) which shows that clean cooking technology is still challenging in many sector of Nepal. In commercial sector of Province 1 and Madesh province, the proportion of fuelwood being used are 58.78% and 1.23% respectively. According to census 2011, the share of fuelwood in Pokhara and Butwal was 21.53% and 21.57% while, the share of LPG was 71.63% and 73.63% respectively. In Nepal, 82.90% of households are using single cook stove and 16.40% are using two type cookstove while remaining are using three and more type cook stove (Worldbank, 2019).

Clean cooking

In context of Nepal, clean cooking technology is considered as induction stove, biogas, improved cookstove etc. and tire 3 and above cooking appliances are considered as clean cooking appliances. The commonly used clean cooking stoves in Nepal are LPG stove, biogas and electric stoves. To minimize the use of traditional cookstove in Nepal, government has been promoting improved cooking solutions. On the other hand, Alternative Energy Promotion

Center (AEPC) has prioritized the use of cook stove that emits much lower Carbon dioxide (CO_2).

The Government of Nepal has developed different policies and targets to penetrate electricity as primary cooking technology. According to the Second National Determined Contribution (NDC) and Sustainable Development Goal (SDG) 25% of households by 2030 use electricity as the primary source for cooking purpose and ensure access to affordable, reliable, sustainable and modern energy for all sector including cooking.

Survey design and sample determination

Butwal is a sub metropolitan city located in Lumbini province. The number of family size in Butwal is 51,099 which corresponds to sample size of 412 for residential sector. The population size of the commercial sector was considered from "National Economic Census" published by Center Bureau of Statistics (CBS) in 2018. The size of the commercial entities in Butwal is 1,512 in which the observed sample size was 325. While Pokhara is metropolitan city located in Gandaki province. The number of family size for residential sector was 143,137, in which the sample size was determined to be 439. The size of commercial entities in Pokhara was 5,403 and the observed sample size was 322. The sample was taken from each ward of the Butwal sub-metropolitan as well as Pokhara metropolitan city.

Before the survey, questionnaires were prepared and one-day training was conducted for enumerators to familiarize them with the data collection procedures. While undertaking the survey, continuous monitoring of the collected data was done and feedbacks and guidelines by the core team regarding the collected data was incorporated.

Cooking in Butwal sub-metropolitan city

Residential sector

In residential sector of Butwal, 95.15% of the households use LPG stove while rice cooker is used by 40.78%, biomass cookstove by 10.68%, electric stove by 6.40% and biogas stove by 1.21%. On the basis of fuel, 95.15% of household use LPG, 40.78% use electricity, 10.68% use fuelwood 1.21% use biogas, 0.97% use agricultural residue and 0.49% use dung cake as the source of fuel for cooking. Regarding stove stacking, 52.67% of household use single type stove, 43.2% use two type stoves while the remaining percentage of household use more than three type stoves. Also, 52.18% of households use single type fuel, 46.36% use two type fuels and remaining percentage of household use three and more type fuel. Although there is fuel stacking in household sector of Butwal, 92.96% of household use LPG as their primary cooking technology. The total final energy consumption in Butwal Sub Metropolitan city is determined to be 554.25 TJ and the specific energy consumption is 2.84 GJ/capita.

During the survey, 51.95% of respondents were female while 48.06% were male. Among them, most of the male and female agreed that the current technology consumes less time for cooking and is cheapest fuel while most of the both male and female disagreed on having health problems and indoor pollution using the current technology of cooking as 92.96% of households are using LPG as the primary source of fuel. The willingness of switching towards clean technology was also observed during the survey in which 44.67% of respondents were

currently not in favor of shifting while 51.46% of respondents were willing to shift their technology into electric cooking and rest into LPG and improved cook stoves. Most of the respondents who were not willing to shift towards new technology believe that the current technology is the best technology so for those, awareness on the advantages of newer technologies should be delivered. The major barrier on shifting towards electric cooking technology is fuse rating as for using electrical cookstove, fuse rating should be higher but in case of residential sector, 46.84% of household are still using 6 A fuse.

On the basis of the survey, the fuelwood consumed is estimated to be 5.55 kg/person/month while the LPG consumed is determined to be 2.95 kg/person/month and the electricity consumed is 6.97 kWh/person/month. Also, the specific cost of fuelwood, LPG and electricity is estimated to be NRs. 83.27 per person per month, NRs. 331.84 per person per month and NRs. 61.30 per person per month respectively. The emission due to the use of fuelwood and LPG consumption is estimated to be 25,783.58 tonnes of CO_2 equivalent.

Commercial sector

In commercial sector of Butwal, 97.85% of commercial entities are using LPG for cooking while 13.85% of commercial entities use rice cooker also, oven, furnace, induction and biomass stove are used by 13.54%, 4.00%, 2.46% and 2.15% of commercial entities respectively. In regard to cooking fuels, 97.85% of commercial entities use LPG while electricity, fuelwood and briquette is used by 25.54%, 2.15% and 3.69% of commercial entities respectively. Stove stacking is lower in case of commercial sector than in residential sector. Among the commercial entities 72.31% uses single stove, 20.92% entities uses two type stove and the remaining percentage of entities use three or more type stove. On the other hand, 72.31% use one type fuel while 25.85% use two type fuel and the remaining percentage of commercial entities use more than two type fuel for cooking. As more percentage of commercial entities use LPG for cooking, it is the primary source of fuel in 97.55% of commercial entities use LPG as the primary source of fuel. The total final energy consumption is determined to be 81.83 TJ and the useful energy is estimated to be 40.42 TJ.

During the survey, user's perception towards current technology was also observed in which most of the respondents agreed that the current technology consumes less time for cooking and is cheaper and disagreed on production of indoor pollution and health problems caused by the current technology. Also, 44.01% of respondents are not interested towards shifting to newer technology while 55.69% of respondents are willing to shift their technology towards electricity. Most of the respondents who were not willing to shift towards new technology believe that food tests better in current technology and is the best technology. The major barrier on shifting towards electric cooking technology is fuse rating as for using electrical cookstove. Fuse rating should be higher but in case of commercial sector, 19.28% of commercial entities are still using 6 A fuse.

On the basis of the survey, the fuelwood consumed is estimated to be 13.93 kg/person/month while the LPG consumed is determined to be 89.33 kg/person/month and the electricity consumed is 81.45 kWh/person/month. Also, the specific cost of fuelwood, LPG and electricity is estimated to be NRs. 209.01 per person per month, NRs. 10,065.88 per person per month

and NRs. 1,185.85 per person per month respectively. The emission is due to fuelwood and LPG consumption and the total emission is estimated to be 2,884.65 tonnes of CO_2 equivalent.

Cooking in Pokhara metropolitan city

Residential sector

In case of residential sector of Pokhara, 94.06% of the households use LPG stove while rice cooker is used by 67.58%, biomass cookstove by 14.84%, electric stove by 10.73% and biogas stove by 5.25%. On the basis of fuel, 94.06% of household use LPG, 72.60% use electricity, 14.84% use fuelwood, 5.25% use biogas, 1.83% use agricultural residue and 0.46% use dung cake as the source of fuel for cooking. 26.04% of household use single type stove, 57.52% use two type stoves which is higher than residential sector of pokhara and the remaining percentage of household use more than two type stoves. Also, 23.52% of households use single type fuel, 67.12% use two type fuels and remaining percentage of household use three and more type fuel. Although there is fuel stacking in household sector, 84.25% of household use LPG as their primary cooking technology. The total final energy consumption in Pokhara metropolitan city is determined to be 1,585.98 TJ and the specific energy consumption is 3.05 GJ/capita.

During the survey, 58.29% of respondents were female while 41.73% were male. Among them, most of the male and female agreed that the current technology consumes less time for cooking and is cheapest fuel while most of the both male and female disagreed on having health problems and indoor pollution using the current technology of cooking. The willingness of switching towards clean technology was also observed during the survey in which 37.78% of respondents were not in favor of shifting while 59.04% of respondents were willing to shift their technology into electric cooking. Most of the respondents who were not willing to shift towards new technology believe that the current technology is the best technology so for those, awareness on the advantages of newer technologies should be delivered. The major barrier on shifting towards electric cooking technology is fuse rating as for using electrical cookstove, fuse rating should be higher but in case of residential sector, 28.08% of household are still using 6 A fuse.

On the basis of the survey, the fuelwood consumed is estimated to be 4.78 kg/person/month while the LPG consumed is determined to be 3.22 kg/person/month and the electricity consumed is 10.96 kWh/person/month. Also, the specific cost of fuelwood, LPG and electricity is estimated to be NRs. 71.76 per person per month, NRs. 363.33 per person per month and NRs. 96.40 per person per month respectively. The emission is due to fuelwood and LPG consumption and the total emission is estimated to be 86,064.36 tonnes of CO_2 equivalent.

Commercial sector

In commercial sector of Pokhara, 99.33% of commercial entities are using LPG for cooking while 53.44% of commercial entities use rice cooker also, oven, induction, biomass and biogas stove are used by 29.49%, 6.43%, 3.10%, and 0.22% of commercial entities respectively. In regard to cooking fuels, 99.33% of commercial entities use LPG while electricity, fuelwood and biogas is used by 66.30%, 3.10% and 0.22% of commercial entities respectively. 32.37% of commercial entities use single stove, 55.88% of commercial entities use two type stoves and

the remaining percentage of commercial entities use three or more type stoves. On the other hand, 32.37% use one type fuel while 66.30% use two type fuel and the remaining percentage of commercial entities use more than two type fuel for cooking. As more percentage of commercial entities use LPG for cooking, it is the primary source of fuel i.e. 98.45% of commercial entities use LPG as the primary source of fuel. The total final energy consumption is determined to be 520.71 TJ and the useful energy is estimated to be 48.27 TJ.

During the survey, user's perception towards current technology was also observed in which most of the respondents agreed that the current technology consumes less time for cooking and is cheaper and disagreed on production of indoor pollution and health problems caused by the current technology. Also, 65.01% of respondents are interested towards shifting to newer technology and 34.99% of respondents are seem to have no interest on shifting towards newer technology among them also all of respondents are willing to shift their technology towards electricity. Most of the respondents who were not willing to shift towards new technology believe that there is no any option available in market and have lack of information regarding new technology. The major barrier on shifting towards electric cooking technology is High cost of electricity for cooking as per NEA tariff. Around, 1.77% of commercial entities are still using 6 A fuse.

On the basis of the survey, the fuelwood consumed is estimated to be 10.32 kg/person/month while the LPG consumed is determined to be 164.28 kg/person/month and the electricity consumed is 136.41 kWh/person/month. Also, the specific cost of fuelwood, LPG and electricity is estimated to be NRs. 154.78 per person per month, NRs. 18,510.17 per person per month and NRs. 2,074.20 per person per month respectively. The emission is due to fuelwood and LPG consumption and the total emission is estimated to be 17,600.14 tonnes of CO_2 equivalent.

Energy demand forecasting

For forecasting, business as usual (BAU) and shifting scenario has been developed. In BAU the trend of cooking fuel is assumed to be same for the upcoming year while the shifting scenario id developed on the basis of SDG and NDCs goal.

In residential sector of Butwal, the demand is expected to be 664.77 TJ, 813.81 TJ and 996.26 TJ for year 2026, 2031 and 2036 respectively. In commercial sector of Butwal, demand of energy expected to increase to 100.20 TJ, 122.66 TJ and 150.15 TJ for year 2026, 2031 and 2036 respectively for BAU scenario. For shifting scenario, the penetration of electricity in useful energy demand is assumed to be 60% which would fulfil the NDCs goal. In shifting scenario, the final energy demand in residential sector is expected to be 576.75 TJ, 626.17 TJ and 620.25 TJ for 2026, 2030 and 2036 respectively while the final energy demand in commercial sector is expected to be 91.75 TJ, 102.60 TJ and 113.71 TJ respectively.

In Pokhara metropolitan city also the BAU and shifting scenario is developed. The energy demand in residential sector for BAU scenario is expected to be 1846.19 TJ, 2149.11 TJ and 2501.73 TJ for 2026, 2031 and 2036 respectively and for shifting scenario, the demand is expected to be 1654.67 TJ, 1703.64 TJ and 1723.90 TJ for 2026, 2031 and 2036 respectively. the demand in commercial sector for BAU scenario is expected to increase to 606.31 TJ, 705.99

TJ and 822.06 TJ for 2026, 2031 and 2036 respectively and for shifting scenario, the demand is expected to be 554.17 TJ, 587.88 TJ and 617.95 TJ respectively. Thus, using the clean technology i.e. electricity for cooking may decrease the total consumption of energy as the efficiency it is greater than other sources of energy.

Comparative analysis and Conclusion

On the basis of this study, it was found that Pokhara being more advanced city uses more type of stove than Butwal. Both the cities consume LPG the most as it is easily accessible but are showing their interest to shift towards electricity. The percentage of residential sector using electricity for cooking is more in Pokhara than in Butwal as the in residential sector of Butwal only 10.6% are using electricity while in residential sector of Pokhara 15.48% are using electricity. This percentage should be increased as there are many benefits using electricity as fuel for cooking. Also, most of the household sectors of both cities are willing to change their cooking technology into electricity after certain years.

In commercial sector also, the use of more than one technology is more in Pokhara than in Butwal but here also, more commercial entities are found to be using LPG as primary fuel as the respondents assumes that it takes less time for cooking than other technologies. Here also, it was found that most of the commercial entities of both cities are having interest to switch their cooking technologies into electricity after certain period. So, for this the main barrier is fuse rating as most of the households and some commercial entities are still using 6A fuse, therefore, the connection line should be upgraded to at least 16 A and the transmission and distribution line should also be upgraded. Along with this, the financial incentives such as reduction in value added tax (VAT) and custom duty should be provided so that the consumers get motivated to use clean source of energy for cooking.

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AEPC	Alternative Energy Promotion Center
BEST	Biomass Energy Strategy
BAU	Business As Usual
CBS	Central Bureau of Statistic
CCS4ALL	Clean Cooking Solution for All
CO	Carbon Monoxide
DoI	Department of Industry
EIA	Environment Impact Assessment
FY	Fiscal Year
GoN	Government of Nepal
GWh	Gigawatt hour
ICS	Improved Cook Stove
ktoe	kilo tonnes of oil equivalent
LPG	Liquefied Petroleum Gas
MAED	Model for Analysis of Energy Demand
MECS	Modern Energy Cooking Services
MTF	Multi-tier Framework
MW	Mega Watt
NEA	Nepal Electricity Authority
NPC	National Planning Commission
NSIC	National Standard Industrial Classification
PM	Particulate Matter
RFP	Request for Proposal
RETs	Renewable Energy Technologies
TCS	Traditional Cook Stove
TOR	Terms of Reference
UNEP	United Nations Environment Program
WECS	Water and Energy Commission Secretariat
WHO	World Health Organization

CHAPTER ONE : INTRODUCTION

1.1 Background

The Water and Energy Commission Secretariat (WECS) under Government of Nepal has been engaged in conducting field surveys to collect energy resources and consumption data and information from primary sources of different energy consuming sector. The data and information related to current status of the energy resources and technology helps in the formation of the sustainable plans and policy, and create a scientific basis for the academic researcher. With the backdrop of ambitious campaign of Clean Cooking Solution for all (CCS4ALL) initiated in 2013, the Government of Nepal (GoN) had endorsed Investment Prospectus and Biomass Energy Strategy (BEST) 2017. BEST has the aim of attaining CCS4ALL in two stages i.e. by improved solutions of cooking by 2022 (no traditional way of cooking with open fire burning) and modern solutions of cooking with at least tier-3 level by 2030.

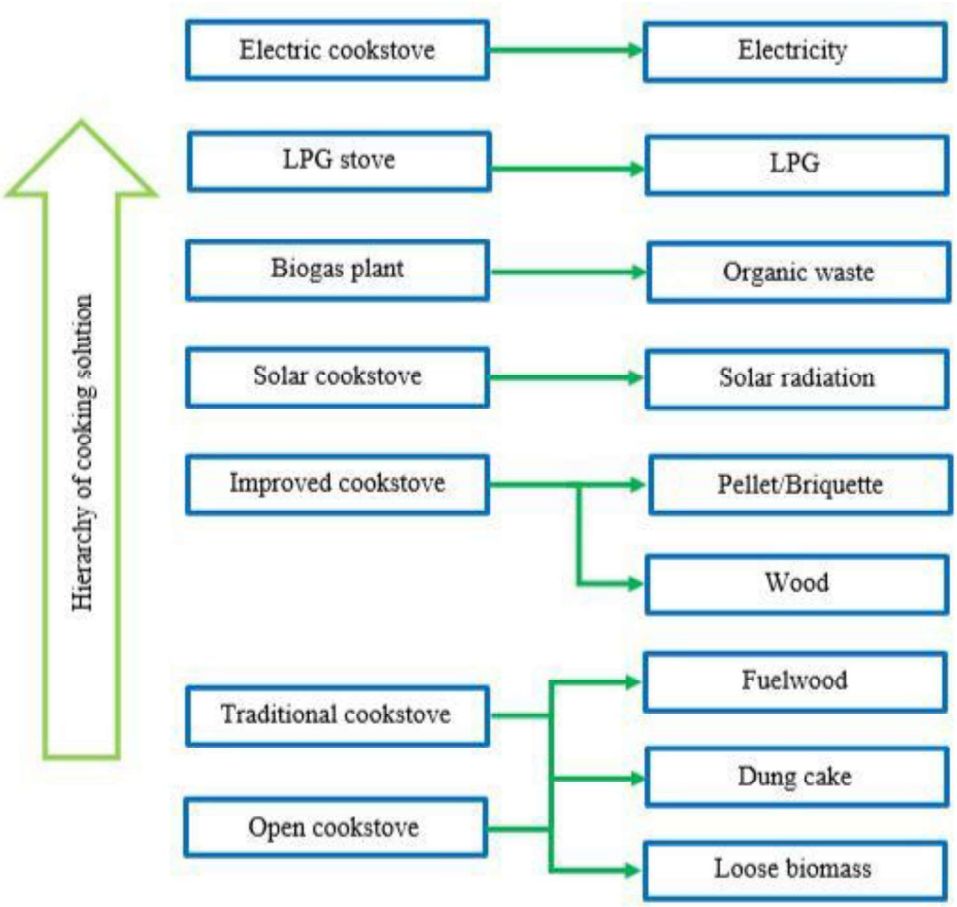


Figure 1.1: Hierarchy of cooking devices

Clean energy is critically important for economic, social and sustainable growth. Despite several efforts by the government and non-governmental organization the consumption of traditional energy is still high. According to the Economic Survey 2020/21, in the fiscal year 2020/21 (till Falgun), 68.63% of the total energy consumed is due to the use of traditional fuels.

If this trend continues the energy consumption due to traditional fuel will still be high in 2030. The energy consumption from traditional fuelwood especially solid fuel is very high in case of the residential and commercial sector for cooking purpose. To increase the use of clean cooking technology, reliable planning and execution by various parties involved is required. In places with sufficient supply of electricity, electric cook stoves should by promoted by various subsidy mechanism. Similarly, in rural location, biogas technologies and other improved cook stoves should be promoted.

Another impact of the use of high traditional fuel especially fuelwood from forest is deforestation. According to United Nations Environment Program (UNEP), if deforestation continues at the current rate, Nepal's forest will disappear in coming 50 years. In this regard, WECS has launched an assignment entitled **"Status of clean energy cooking technologies used in two major cities of Nepal"**.

1.2 Objectives

The main objective of the assignment is to find out the status of clean cooking technology used in two major cities of Nepal. The study shall be conducted in the Pokhara and Butwal cities of Nepal. The specific objectives are:

- To find out the status of use of different cooking technologies in commercial and household sector
- To find out the future possibilities of switching of cooking technologies by cleaner version of technologies
- To calculate and compare the cost and emission for different cooking fuel resources and technologies
- To find out the barriers and constraints in switching to cleaner form of technologies.
- To analyze and forecast the different energy demand scenarios for different cooking technologies with business as usual (BAU) and with switching of cooking technologies for the upcoming 15 years in 5-year step

1.3 Scope of work

The assignment will be carried out systematically using appropriate methods and methodology in Pokhara and Butwal cities. The scope of work in order to fulfill the consulting assignment as indicated in Request for Proposal (RFP) include

- Preparation of detailed questionnaire for residential and commercial sector in consultation with WECs
- Determination of sample size at 95% level of confidence, 5% margin error and at 5% non-response rate for different economic sector
- Conduction of energy survey to collect basic socioeconomic information and information related to cooking technologies and fuels of Pokhara and Butwal cities
- Assessment of future possibilities and willingness of switching to clean cooking technologies
- Gap analysis to identify the barriers and constraints in switching to cleaner form of technologies

- Identification of the cost and emission parameters of different cooking technologies and cooking fuel resources
- To calculate the energy demand for various scenarios for different cooking technologies with BAU and switching of technologies for upcoming 15 years in 5 years step
- Conduction of consultation workshop between client, consultant and stake holders before energy survey and after each output

1.4 Limitations

During the survey, some problems and constraints have been faced. The survey has to be done with certain limitations. Some of the major limitations during the study are listed below:

- The study has been conducted in each wards of both the cities, hence the sample size in each ward is small and hence could not be sub categorized.
- Electrical equipment used for mixing and grinding of different spices has not been considered as the cooking technology.
- All the information regarding the calorific value and efficiency has been from various peer reviewed journal. The consultant has not performed any experiments.
- Lack of recent secondary data as well as historical data has made difficulty on validating the results obtained from the study.

CHAPTER TWO : COOKING TECHNOLOGY IN NEPAL

2.1 Cooking status

According to "The State of Access to Modern Energy Cooking Services" Published by World Bank in 2020, out of the 5.3 billion samples from the lower and lower middle income countries, around 4 billion lack the ability to cook efficiently, cleanly and affordably. Out of the 4 billion without access to clean and efficient cooking technology, 1.25 billion are considered in transition while the rest faces significant barrier. In case of South Asian countries with lower and lower middle income, 54% of the household does not have access to the clean cooking while the 37% are in transition (Tier 2 and 3) and only 27% has the access to clean cooking.

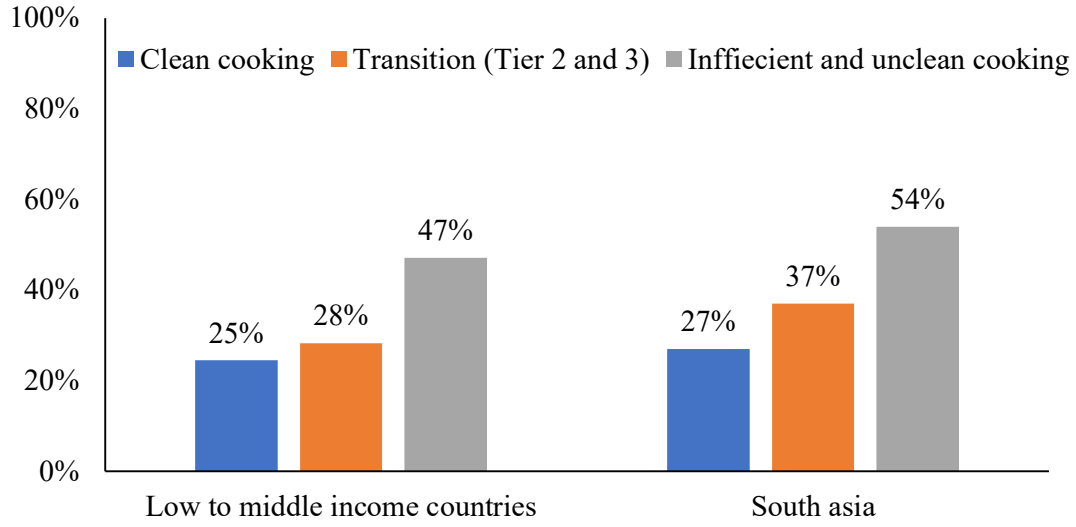


Figure 2.1: Access to clean energy

(World Bank, 2020)

2.2 Energy situation of Nepal

In context of Nepal, energy consumption is still dominated by the by the traditional source of energy which include fuelwoods, agricultural residue, animal waste and loose biomass. The share of the traditional source of energy (fuelwood, dung cake and agricultural residue) in the fiscal year 2020/21 (till march) was 68.63%, while that of the commercial energy (coal and grid electricity) and renewable energy was 28.18% and 3.17% respectively. The figure in the FY 2019/20 was 66.53% traditional source, 31.02% commercial sources and 2.43% renewable sources. It is evident that there is depreciation in the growth rate of traditional sources, but the decline is not at sharp. The total energy consumption during the FY 2019/20 was 14,464 ktoe and has reached 9,597 ktoe by mid-March of FY 2020/21 (Ministry of Finance, 2020/21)

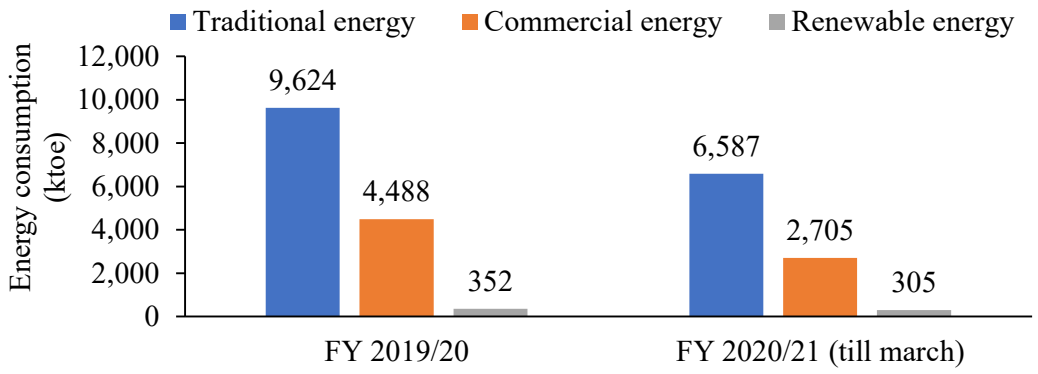


Figure 2.2: Status of energy consumption

(Ministry of Finance, 2020/21)

Glancing at the trend in the use of the traditional, commercial and renewable energy over the last decade that is from FY 2010/11 to 2019/20 the consumption has increased at a rate of 7.92%, 11% and 16.72% respectively. Although there is significant increase in consumption of renewable energy and commercial energy but still the dominant source used in Nepal is still traditional energy. Hence in order to achieve sustainable development goals in energy, some drastic actions are required and is possible only by the proper energy planning.

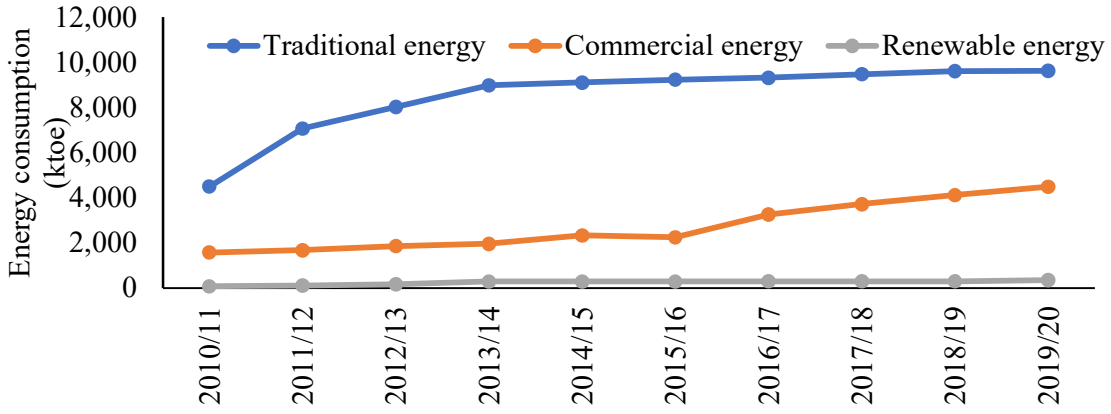


Figure 2.3: Trend of various energy

(Ministry of Finance, 2020/21)

2.3 Policy and strategy overview

Nepal has aimed to achieve the sustainable development goals set by the United Nations and reach the level of medium income countries by 2030 A.D. Among the sustainable development goals, the seventh goal is aimed to ensure the accessibility of affordable, reliable, sustainable and modern energy for all. To achieve these goals, it is necessary to establish policy, legal and institutional framework that ensures the availability of affordable and reliable energy

Second Nationally Determined Contribution

Goal: Formulation of Long-term low GHG emission development strategy by 2021 to achieve net-zero GHG emission by 2050.

Residential cooking and biogas

- By 2025, install 500,000 improved cookstoves, rural area will be focused
- By 2025, install an additional 200,000 households' biogas plants and 500 large scale biogas plants
- By 2030, ensure 25% of households use electricity as primary source for cooking purpose

The combined target of residential cooking and biogas can reduce emission about 11% in 2025 while 23 % in 2030.

Sustainable Development Goals

Goal: Ensure access to affordable, reliable, sustainable, and modern energy for all

Target:

- By 2030, ensure universal access to affordable, reliable and modern energy services
- By 2030, increase substantially the share of renewable energy in the global mix
- By 2030, double the global rate of improvement in the energy efficiency
- By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology and promote investment in energy infrastructure and clean energy technology.
- By 2030, expand infrastructure and update technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries and small island developing states.

Goal: Ensure sustainable consumption and production pattern

Target:

- Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking lead, taking account the development and capabilities of developing countries.
- By 2030, achieve the sustainable management and efficient use of natural resources
- By 2020, achieve the environmentally sound management of chemical and all wastes
- By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuses.
- Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production

2.4 Cooking fuels in Nepal

According to annual household survey 2017, 52.4% of the household across Nepal still are dependent on fuelwood as primary cooking fuel and 33.1% of the household are dependent on LPG. In case of rural area, the use of fuel wood is more significant as 65.8 % of the households use fuelwood. Similarly, in urban area the LPG dominates the household with 54.1% of the household using it as primary fuel. Although LPG use in urban is high, but LPG being an imported fuel always has supply risk and macroeconomic concern. The detail of cooking fuel is presented in Figure 2.4.

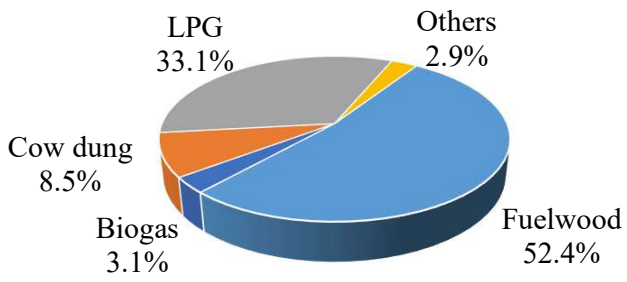
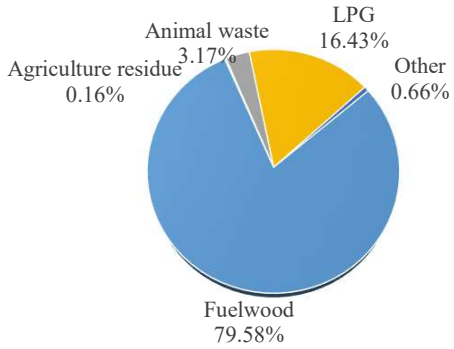


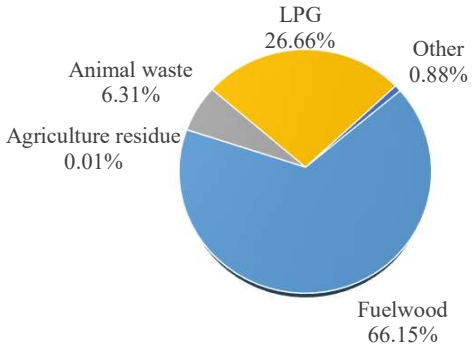
Figure 2.4: Primary source of fuel in various household

(CBS, 2017)

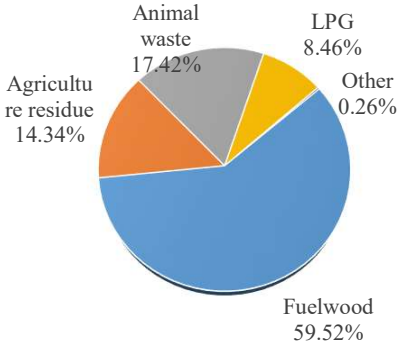
According to the report "Energy Consumption and supply situation in federal system of Nepal (Province 1 and Madesh Pradesh)" published by WECS in 2020/21, the share of traditional energy for cooking i.e. fuelwood, agricultural residue and animal waste in residential sector of Province 1 and Madesh Pradesh is 82.91% and 91.28% respectively. The proportion of LPG in residential sector of Province 1 and Madesh Pradesh is 16.43% and 8.5% respectively. In urban areas of Province 1 and Madesh Pradesh the share of LPG in energy consumption is 26.65% and 10.72% respectively. The detail of the energy consumption for cooking in Province 1 and Madesh Pradesh in residential sector is presented in Figure 2.6.



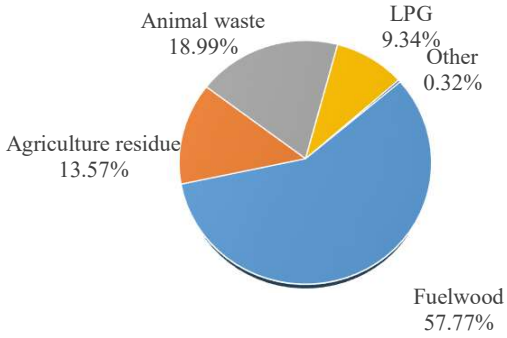
a. Province 1 (Overall)



b. Province 1 (Urban)



a. Madesh Province (Overall)



b. Madesh province (Urban)

Figure 2.5: Energy consumption for cooking in residential sector of Province 1 and Madesh Province

(WECS, 2021)

The energy consumption in commercial sector in province 1 is dominated by the fuelwood followed by LPG. The proportion of fuelwood and LPG in total energy consumption in commercial sector of province 1 is 58.75% and 40.82% respectively. Similarly, in Madesh province the energy consumption in commercial sector is dominated by LPG at 94% and fuelwood at 1.23%. The energy consumption in cooking in commercial sector of Province 1 and Madesh Province is shown in Figure 2.6.

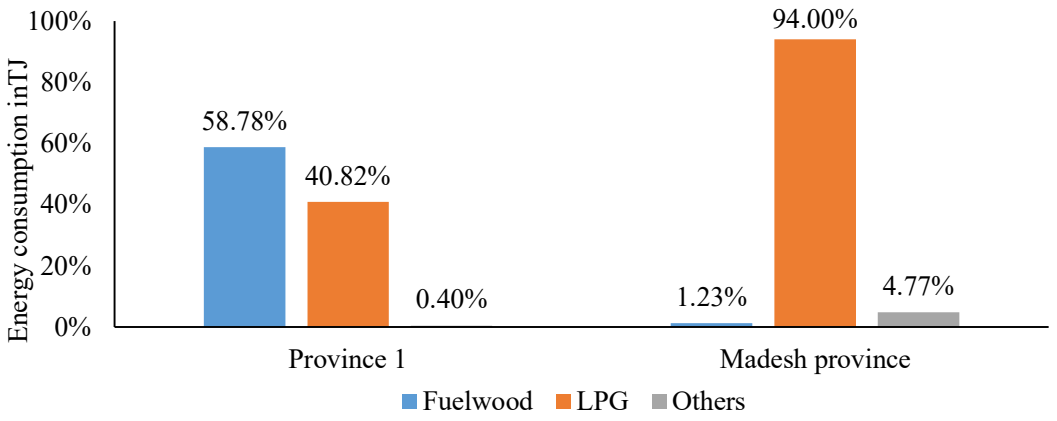


Figure 2.6:Energy consumption for cooking in commercial sector of Province 1 and Madesh Province

(WECS, 2021)

Based on the population census of 2011, In case of Pokhara and Butwal city, the primary source of cooking energy is LPG followed by fuelwood. The share of LPG in Pokhara and Butwal cities are 71.63% and 73.63% respectively while that of fuelwood is 21.53% and 21.57% respectively.

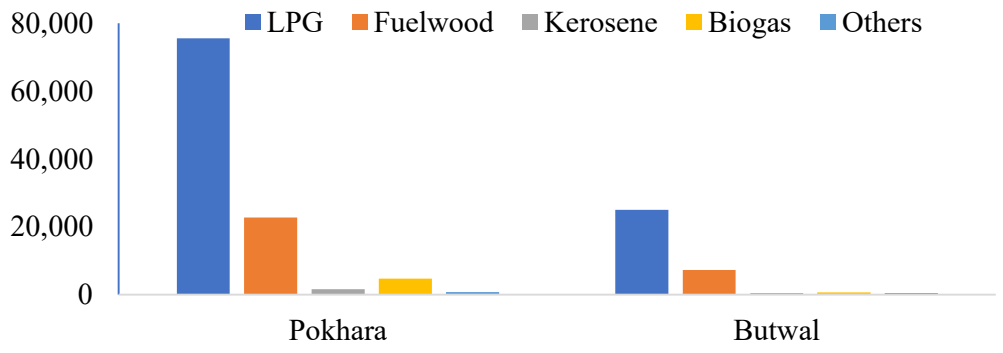


Figure 2.7: Cooking fuels in Butwal and Pokhara cities

(CBS, 2011)

2.5 Cook stoves in Nepal

According to the Multi Tier Framework 2019 published by World Bank Group, based on 6000 samples data collected throughout the country distributed proportionally based on physiographical region, traditional cook stoves leads the way with use in 47.6% of household

followed by the use of LPG stove and open fire stove at 26.3% and 15.1% respectively. Proportion of various cook stoves used in the households of Nepal is presented in Figure 2.8.

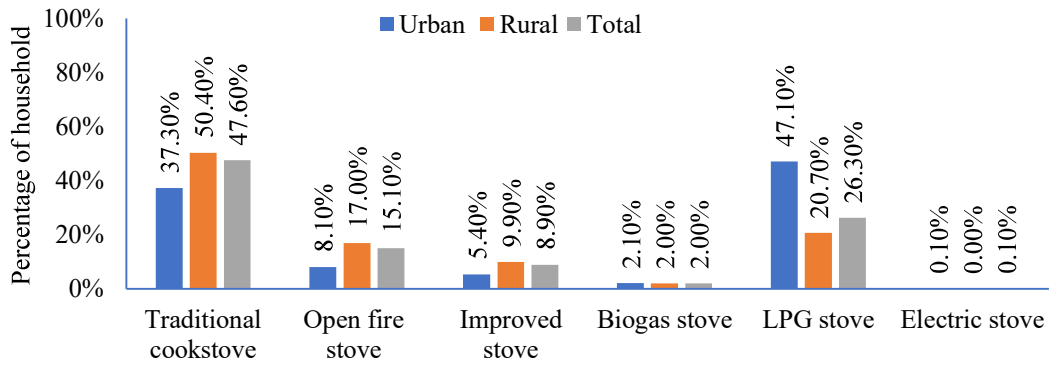


Figure 2.8: Cook stoves used in Nepal

(Worldbank, 2019)

The process of using more than one type of cook stoves is called stove staking. Most of the households in Nepal use only one type of stoves for cooking while few households use two and more type of cooking solution. According to the Multi Tier Framework 2019, 82.9% of the household use single cook stoveswhile 16.4% and 0.7% of the households use two and three types of cook stovesrespectively. Similarly, 7.2% of the household use the combination of traditional cook stovesand LPG followed by 2.7% household using open fire and LPG. The details of the stove stacking is shown in Figure 2.9.

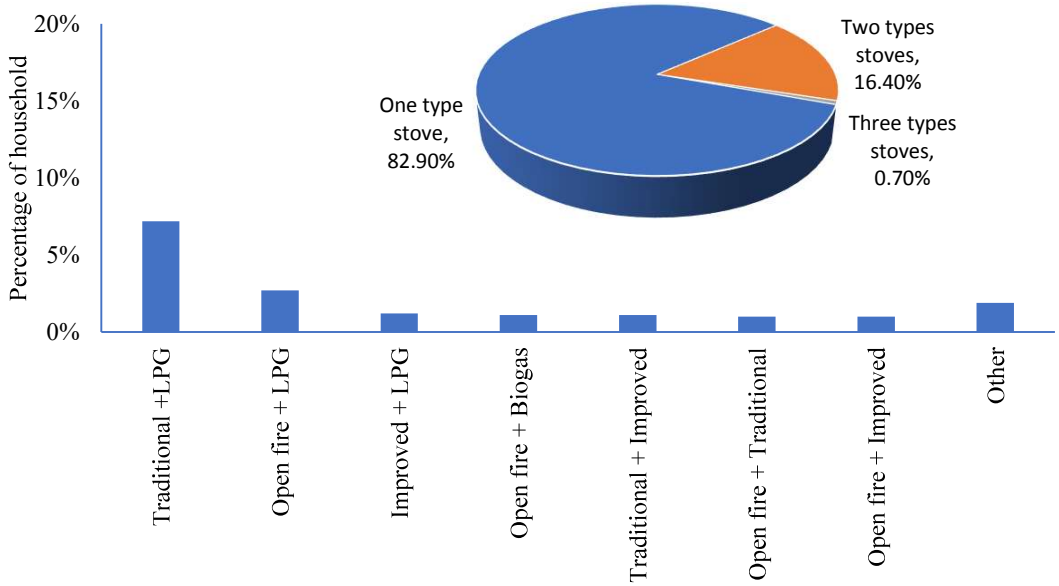


Figure 2.9: Stove stacking, combination of stove

(Worldbank, 2019)

2.6 Clean cooking technology

Any type of cook stove is considered "clean" if its emissions meet WHO Guidelines. Currently available options that are clean at point-of-use include electricity, gas, ethanol, solar, and the highest performing biomass stoves. The Guidelines discourage household use of kerosene and unprocessed coal in the home, due to significant health risks from these fuels. Various technologies like improved cook stove, biogas, induction stove etc is considered as clean cooking solutions in Nepal. The efficiency of various tiers of cook stoves are presented in Table 2.1.

Table 2.1: Tiers of cook stoves

Parameter	Units	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4
High power thermal efficiency	%	<0.15	≥ 0.15	≥0.25	≥0.35	≥ 0.45
Low power specific consumption	MJ/min/L	>0.05	≤0.05	≤0.039	≤0.028	≤0.017
High power CO	g/MJ_d	>16	≤16	≤11	≤9	≤8
Low power CO	g/min/L	>0.2	≥0.2	≥0.13	≥0.1	≥0.09
High power PM	Mg/MJ_d	>979	≤979	≤386	≤168	≤41
Low power PM	g/min	>8	≥8	≥4	≥2	≥1
Indoor emission CO	g/min	>0.97	≤0.97	≤0.62	≤0.49	≤0.42
Indoor emissions PM	mg/min	>40	≤40	≤17	≤8	≤2
Safety	Johnsons	<45	≥45	≥75	≥88	≥95

(RETS, 2014)

Cooking without clean stoves and fuel releases toxic pollutants into the environment and endangers the health and well-being of billions across the globe. Open fires and inefficient stoves create indoor pollutant which can cause health hazards especially to women and girls in the case of Nepal. The use of inefficient stove in cooking emits carbon monoxide and carbon which contributes to climate change.

2.7 Clean cooking appliance

Tier 3 and above cooking appliances in Nepal are considered as clean cooking appliances. The efficient cooking stoves with biomass as fuel along with LPG, biogas and electric stoves are commonly used clean cooking stoves in Nepal. The features of various cooking appliances are presented in Table 2.2

Table 2.2: Clean cook stoves

Technology	Fuel	Features
Improved cook stoves(metallic,	Wood, Pellets, Briquettes	• Insulation of combustion chamber (enclosed combustion chamber)

Technology	Fuel	Features
rocket, Mud) without exhaust		• High internal chimney • Fuel is resting on ground or shelf • Effective insulation material (in case of rocket stove)
Metallic improved cook stoves with exhaust	Wood	• Has exhaust system • Enclosed combustion chamber Pot placed above fire • Fuel rests on ground • Serves dual purpose of cooking and space heating
Biogas Stove	Organic waste	• Converts organic wastes and dung into combustible methane gas called biogas, • Slurry from the digester can be used as fertilizer
LPG	LPG gas (mixture of propane & butane)	• For distribution to the end-user, LPG is bottled in individual gas cylinders of various sizes • Easy to transport
Electric stove	Electricity	• Electric stoves can be either an induction type stove or an electric coil stove • Converts electric energy into thermal energy
Solar cook stoves	Solar radiation	• There are several types of solar cookers: panel cookers with a clamshell shape, box cookers that fully enclose the pot, parabolic cookers that resemble a satellite dish, and vacuum tube cookers that work like greenhouses.

2.8 Electricity for clean cooking

According to the MECS 2021 (funded by UK Aid), energy infrastructure (in particular) and human development are key enabling factors in the viability of a scale up of electric cooking and that the countries most in need of a transition away from biomass cooking are often lacking in these areas. However, several notable exceptions have strong potential for scale up of electric cooking, as well as a pressing need to transition away from traditional fuel and as such present strong opportunities for impact by private, public and third sector actors alike. The various actions that can be taken to increase the penetration of electricity for cooking is presented below

- A national grid supported transition to electric cooking needs to be coupled with decarbonisation of electricity grids
- Efforts to improve access, reliability and strength of national grid, mini-grid and off-grid electrical infrastructure must accelerate and integrate electric cooking where possible

- Electrification needs to be coupled with accurate, up-to-date datasets on tier of access, cooking fuels and costs.
- More globally complete data is needed around other cooking fuels (e.g. cooking fuel prices for charcoal, LPG and kerosene) to provide comparison with electric cooking.
- Contextual understanding – food preferences, cooking practices, fuel/device stacking – is an essential component around which further work is needed to most effectively accelerate the scale up electric cooking
- Expansion of data gathering around electric cooking for rise and others would improve opportunities

CHAPTER THREE : SURVEY DESIGN AND SAMPLE DETERMINATION

3.1 Project location

The project shall be conducted within the borders of Pokhara Metropolitan City and Butwal Sub-Metropolitan City. Similarly, as the cooking is generally conducted in the residential sector and commercial sector (food and accommodation sub category) hence only these two sectors are considered for this study. According to the preliminary result of census 2021, the population of Pokhara Metropolitan city and Butwal Sub- Metropolitan city was 518,452 and 195,054 respectively. Similarly, the number of households in the Pokhara Metropolitan city and Butwal Sub- Metropolitan City was 143,137 and 51,099 respectively. Also, the number of food and accommodation service of commercial sector in Pokhara Metropolitan City and Butwal Sub- Metropolitan City according to National Standard for Industrial classification NSIC 2018 was 5,403 and 1,512 respectively.

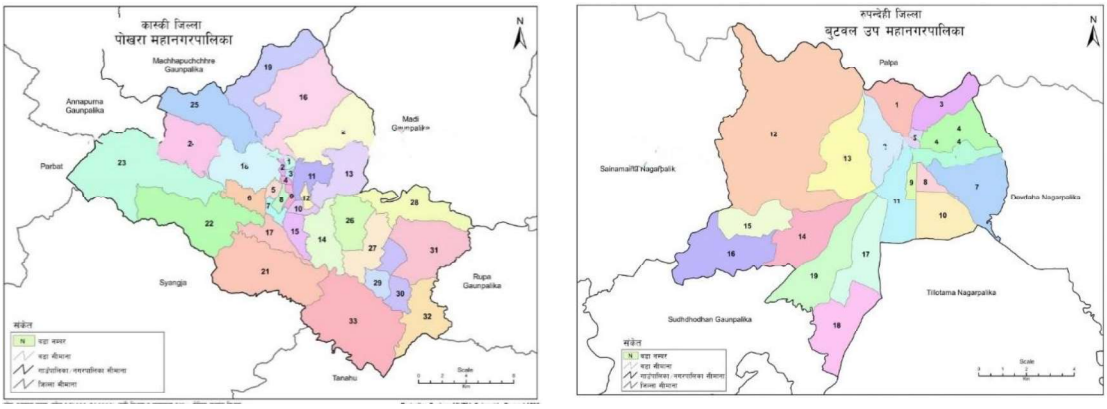


Figure 3.1: Map of Pokhara Metropolitan City and Butwal Sub- Metropolitan City

(CBS, 2011)

3.2 Questionnaire design

The questionnaire that details out the consumption and supply of various fuels and technologies for cooking along with users' behaviors and challenges for shifting to clean cooking has been developed. The questionnaires developed is attached in Annex 2. Separate questionnaires were developed for the survey in residential and commercial sector.

Figure 3.2: Questionnaire design

3.3 Sampling method

This study adopts a combination of quantitative and qualitative research methods. Data has been collected mainly from primary sources while some information have also been gathered from the secondary sources (available reports/documents) of National and International report on energy sectors.

The estimation of sample size has been determined with 95% level of confidence, 5% margin error and at 5% non-response rate. In case of the residential sector the sample shall be further categorized based on the roof type while in case of commercial sector the sample shall be further categorized as hotel/ restaurant, hostel/ institutional canteen/ party palace/ banquet etc.

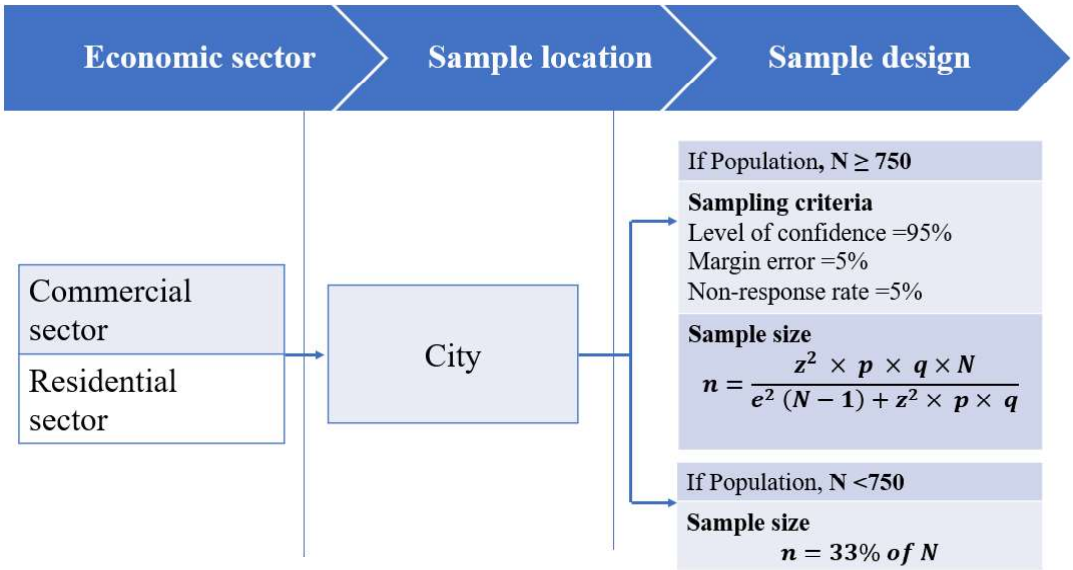


Figure 3.3: Sampling design

The detail of sampling is shown in Figure 3.3. The symbol represented denotes

- z^2 = Z square for specific confidence level (95%) = 3.841.
- p = probability of success = 0.5
- q= 1-p = probability of unsuccessful= 0.5
- e = margin of error
- N = Population size
- n = required sample size

For 5% non-response rate the total sample size in each sector = $1.05 \times n$

3.3.1 Residential sector

In residential sector, household is considered as sample unit whereas city is taken as the location for sampling. Sampling has been distributed proportionally on the basis of roof types on the basis of CBS classification. The population size i.e. number of household for both cities and is considered from preliminary report of census 2021. The detail of the sampling for residential sector in Pokhara and Butwal city is mentioned Table 3.1.

Table 3.1: Sample size for residential sector

Parameters		Pokhara	Butwal
Population (Family size)		143,137	51,099
Sample size	GI Sheet/Tin	70	116
	RCC	359	291
	Others	9	5
	Grand Total	438	412

3.3.2 Commercial sector

In commercial sector, city is taken as the sample location. The population size of the commercial sector is considered from "National Economic CBS" published by CBS in 2018. The commercial sub sector is sub categorized based on National Standard Industrial Classification (NSIC). As food and accommodation sub-sector covers the institution with cooking in commercial sector. So, population size for food and accommodation sub category is only considered for sample calculation. The detail of the sample size is shown in Table 3.2.

Table 3.2: Sample size for commercial sector

Parameters		Pokhara	Butwal
Population size		5,403	1,512
Sample size	Hostel & barrack	15	20
	Hotels & restaurant	405	290
	Institutional canteen	18	10
	Party palace & banquet	9	5
	Homestay	4	-
	Total	451	325

3.4 Data collection and assurance

The questionnaire prepared for residential and commercial sectors were used to conduct the survey. The primary data collection was done by the interviews with the head of household in residential sector and authorized representative in the commercial sectors. The secondary data regarding the population size, growth rate etc. was collected from different ministries, governmental institution and associations.

Before the survey the one day training was conducted including the pre-test for enumerators to familiarize them with the contents in questionnaire along with the data collection procedures. The data collection process was continuously monitors to ensure optimum quality. The quality assurance of data collected was done by utilizing appropriates measures as mentioned below

- Development of questionnaires by the experts and the incorporating suggestions from client and stakeholders
- Enumerators training regarding the content of the questionnaire and survey methods
- Continuous monitoring of the data collected
- Monitoring of the data collection by WECS officials during the survey phase
- Continuous feedbacks and guidelines by the core team regarding the data collected

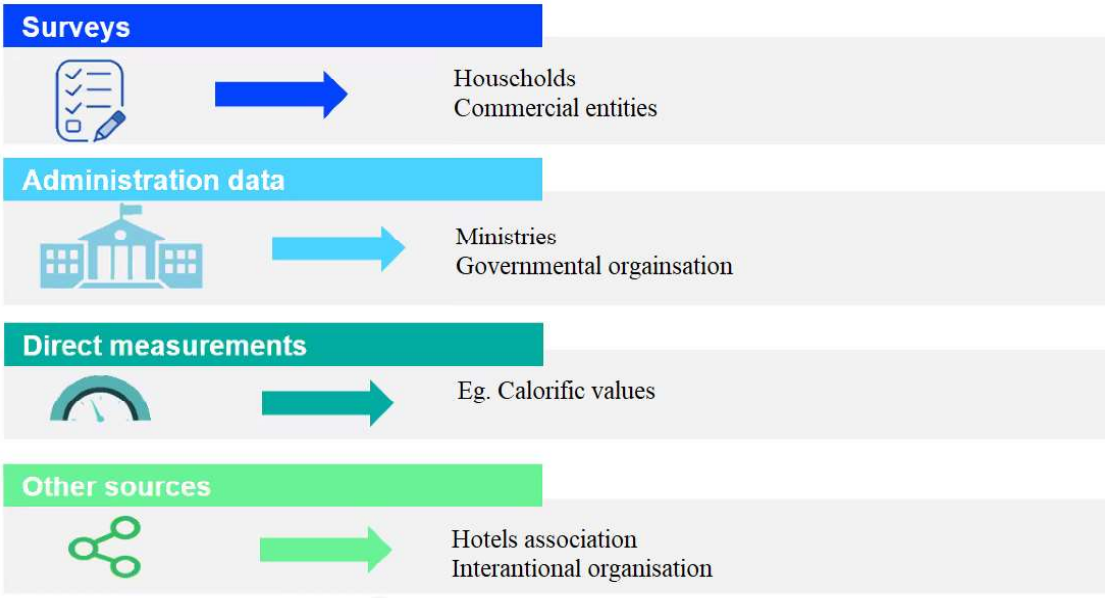


Figure 3.4: Data collection

CHAPTER FOUR : COOKING IN BUTWAL SUB METROPOLITAN CITY

4.1 Cooking in residential sector

Cooking technologies and fuels used in the residential sector differ according to various socio economic, environmental and cultural parameters. Additionally, the availability of the technologies, supply of fuels, environmental and health concern also play a major role in the cooking technologies and fuel selection.

4.1.1 Status of cooking technologies

According to the survey conducted at residential sector of Butwal Sub-Metropolitan city, it was found that almost all household have LPG stove for cooking i.e. 95.15% household are using LPG stove. It is efficient and effective as well as easily accessible mode of cooking. Similarly, people are also interested on electric cooking technologies especially, ricecooker with 40.78% of household currently using it. Although the use of LPG and electric technology is increasing, 10.68% of household are still using biomass for cooking. With the trend of cooking shifting towards induction stove/coil heater 6.40% of households have currently using this technology. Also, biogas is used in 1.21% households of Butwal. The detail of cooking technologies in residential sector of Butwal is shown in Figure 4.1.

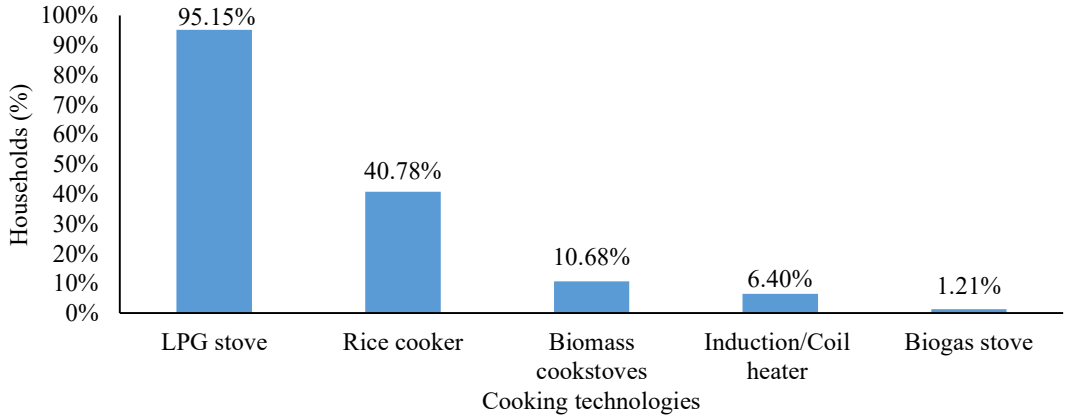


Figure 4.1: Cooking technologies in Butwal Sub Metropolitan city

The information regarding the use of cooking fuels can assist the policy makers and stakeholders to determine the energy demand. In most of the cooking technologies, there is specific fuel requirement, but this is not the case in biomass cook stoves where different fuels can be used. The status of cooking fuels in Butwal is shown in Figure 4.2. The most used fuel in residential sector of Butwal is LPG i.e. 95.15% of households are using LPG for cooking. The use of electricity in the field of cooking is increasing and 40.78% of households are using it. As biomass cookstove is still being used, 10.68% of households are using fuelwood, 0.49% are using dung cake and 0.97% of households are using agricultural residue for cooking. The other fuels being used in residential sector of Butwal is biogas with1.21% of households using it.

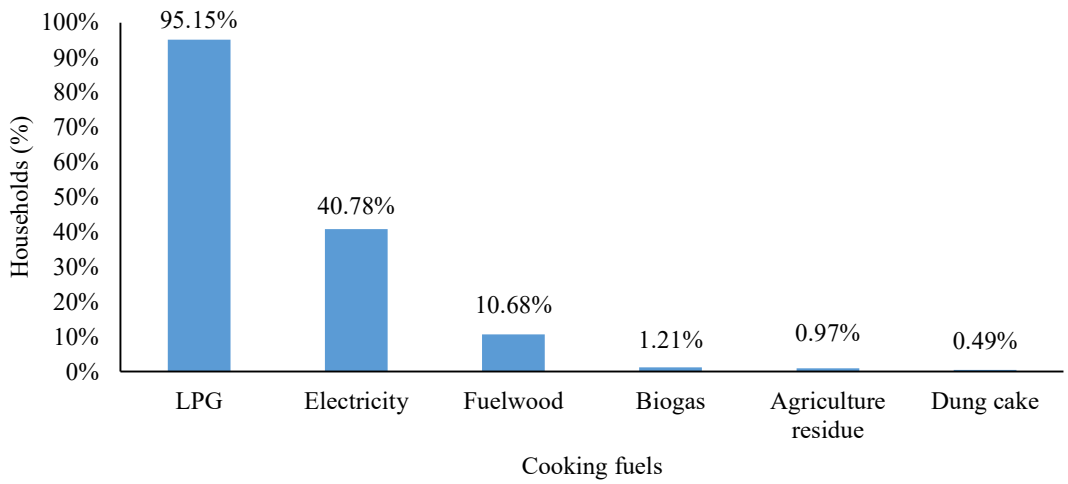


Figure 4.2: Cooking fuels in Butwal Sub Metropolitan city

The use of multiple (more than one) stove/fuel is called stove/fuel stacking. In case Butwal Sub Metropolitan city, 52.67% of the household use only one stove i.e. LPG and biomass at 49.27% and 3.40% respectively. While 43.20% of household use two technologies, the rest use more than two stoves. Similarly, 52.18% of the household use only one fuel, while 46.36% use two fuels and the remaining use more than two fuels. Although stacking reflects energy mix, in household sector of Butwal, stacking extra stove/fuel are found to be used on occasional basis.

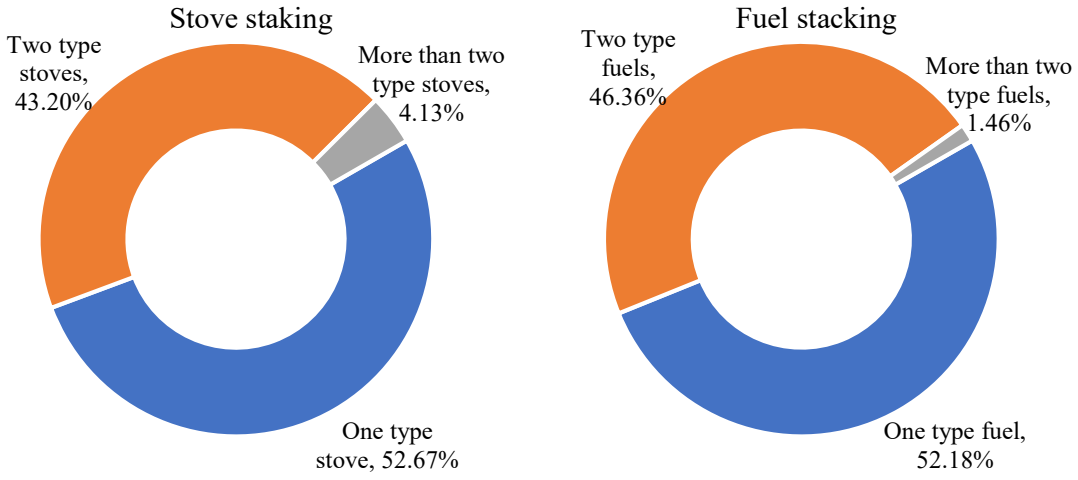


Figure 4.3: Stacking

As 47.33% of the household are using more than one technologies, households are using different combination of technologies which varies from household to household. In most of the cases with two or more technologies, rice cooker is the predominant second technology, 40.05% of the household use rice cooker with LPG. The detail of the combination of these household is presented in Figure 4.4.

36.17% LPG + Rice cooker	3.39% LPG + Biomass stove	3.64% LPG + Rice cooker + Induction/coil heater	0.24% LPG + Biomass stove + Rice cooker
0.73% Biomass stove + Rice cooker	1.94% Biomass stove + LPG		
0.24% Biogas + LPG	0.73% Biogas + Biomass stove	0.24% Biogas + LPG + Biomass stove	

Figure 4.4: Combination of stoves

(Primary + Secondary + Tertiary)*

Although most of the households are using LPG, many use other fuels along with it. The combination of fuels varies from household to household. In most of the cases with two or more technologies, LPG with electricity and fuelwood with LPG predominates other combination, 39.56% of the household use LPG and electricity while 5.34% of the household uses LPG with fuelwood. The detail of the combination of these household is presented in Figure 4.4.

39.56% LPG + Electricity	3.39% LPG + Fuelwood	0.24% LPG + Fuelwood + Electricity	0.24% LPG + Electricity + Agri. Residue
0.24% Biogas + Fuelwood + Dung cake	0.24% Biogas + fuelwood	0.24% Biogas + LPG	0.24% Biogas + LPG + fuelwood
0.24% Fuelwood + Agri. residue	0.49% Fuelwood + Electricity + Agri. residue	0.24% Fuelwood + Dung cake	0.24% Fuelwood + Electricity

Figure 4.5: Combination of fuels

(Primary + Secondary + Tertiary)*

The percentage of household using more than one cooking technology is 47.33% but they are found to be using one of the technology the most often. This can be called as primary cooking technology. As LPG is efficient and can be use easily, 92.96% of households use LPG as primary cooking technology. The other technologies use in primary cooking are biomass, biogas and electricity. The primary cooking technologies based on the response of the

households is presented in Figure 4.6. Although LPG stove is a cooking technology that is ranked above tier 3 by Renewable Energy Testing Station (RETS), as it consumes an imported fuel, its supply can be disturbed.

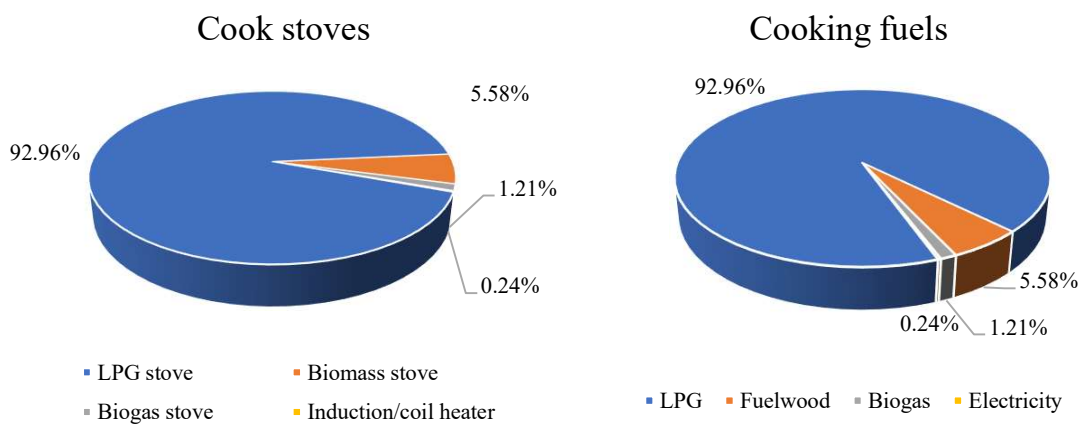


Figure 4.6: Primary cooking technologies

4.1.2 Status of kitchen

The status of kitchen in the households along with the type of cooking solutions is one of the important factors that affects the respiratory system of the users especially women in case of Nepal. Improper ventilation in the kitchen can cause various respiratory problems along with causing safety hazards like fire. During the study, type of kitchen in different households was accessed. The type of kitchen in households of Butwal sub-metropolitan city is presented in Figure 4.7

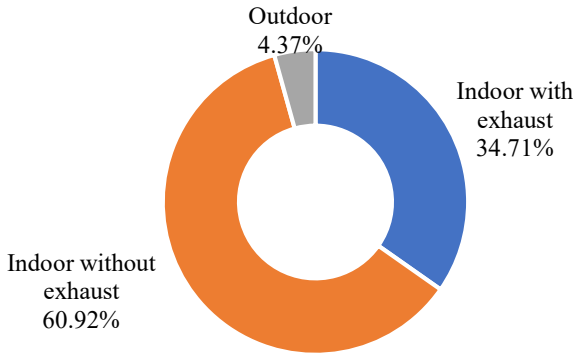


Figure 4.7: Type of residential kitchen

The high proportion of the Indoor kitchen without exhaust signifies the lack of awareness regarding the use of cooking technology and health hazards caused by it. In addition to the health hazards, the kitchen without exhaust can also cause fire hazard in case of gas leakage or smoke filling in the kitchen.

4.1.3 Energy consumption for cooking

The combustion of different cooking fuel converts the fuel into heat energy which is used for cooking. The incomplete combustion along with the losses incurred during heat transfer to the surrounding are the major cause of efficiency drop in fire based cooking technologies. In case of electricity, the copper loss is incurred due to heating of coil which is used for cooking. Here, the efficiency of cook stove is based on heat transfer only. The total energy consumption for cooking in Butwal is shown in Table 4.1.

Table 4.1: Energy consumption in Butwal

S.N.	Fuel type	Final Energy (TJ)	Average efficiency (%)	Useful energy (TJ)
1	Fuelwood	184.50	15	27.68
2	LPG	310.20	48	148.90
3	Biogas	0.803	37	0.30
4	Electricity	58.74	92	54.04
Total		554.25	41.66	230.92
Population		195,054		
Specific energy consumption		2.84 GJ/capita		1.18 GJ/capita

Hence, the total energy consumption in residential sector of Butwal is 554.25 TJ and the specific energy consumption i.e. energy consumption per capita is 2.84 GJ/capita. The energy equivalent of cooking fuel used for cooking is called final energy while the amount of energy that is actually used for cooking is called useful energy. So, the useful energy consumed is 230.92TJ. The comparison of final energy with useful energy is shown in Figure 4.8.

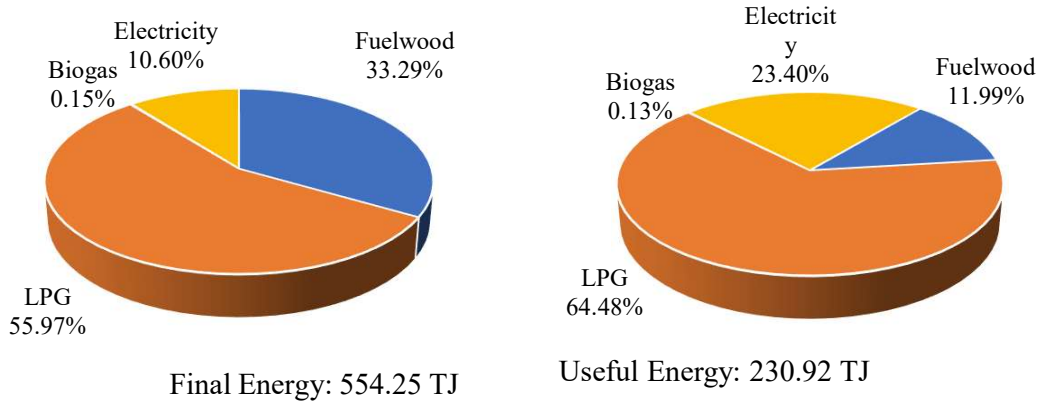


Figure 4.8: Final energy (left) and useful energy (right)

The perception of users toward current technologies also plays an important role in shifting to cleaner technologies. This study also aims to determine the impact of current fuels on indoor pollution, health hazards, cooking time and cost of fuels. On the basis of the study, 94.9% of respondents has disagreed on having health problems and 84.22% of respondents disagreed on having indoor pollution due to current technology as most of the household use LPG as their primary fuel. While 91.26% of respondents agreed that the current technology consumes less

time for cooking and 60.68% of respondents agreed that the current technology uses cheapest fuel. But in actual, the perceptions of the respondents may not be correct as the highest consumption of fuel is LPG and it is one of the imported fuels and the price may not be affordable for all the consumers. On the other hand, Government of Nepal is trying to subsidize electricity for cooking and reduce the consumption of LPG.

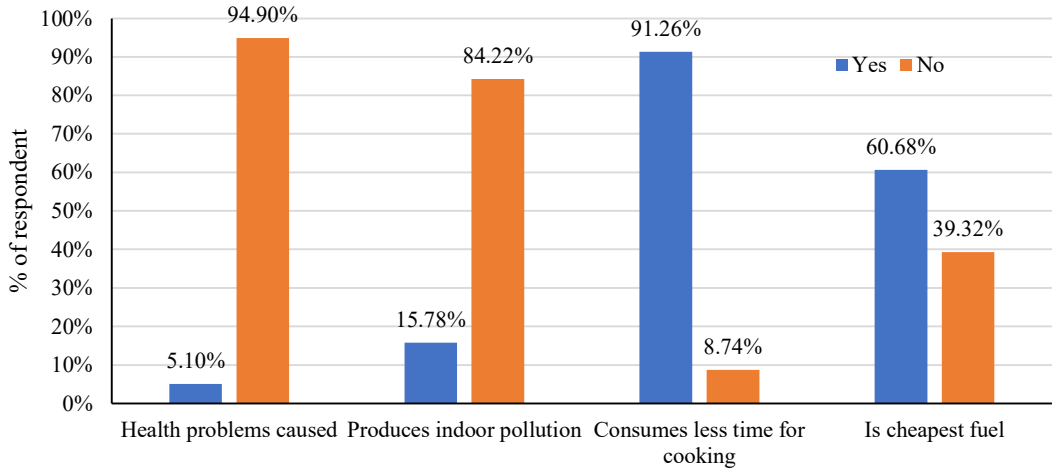


Figure 4.9: Users perception toward current technology

Among the respondent from the household, 51.94% of the representative were female while 48.06% of the respondent were male. The perceptions of both male and female respondents are almost similar as shown in Figure 4.10. As 57.94% of female and 63.64% of male consider that the current technology is the cheapest, this shows that the respondents may not have adequate knowledge about the advantages of using electric energy for cooking. So, proper awareness should be provided for those respondents.

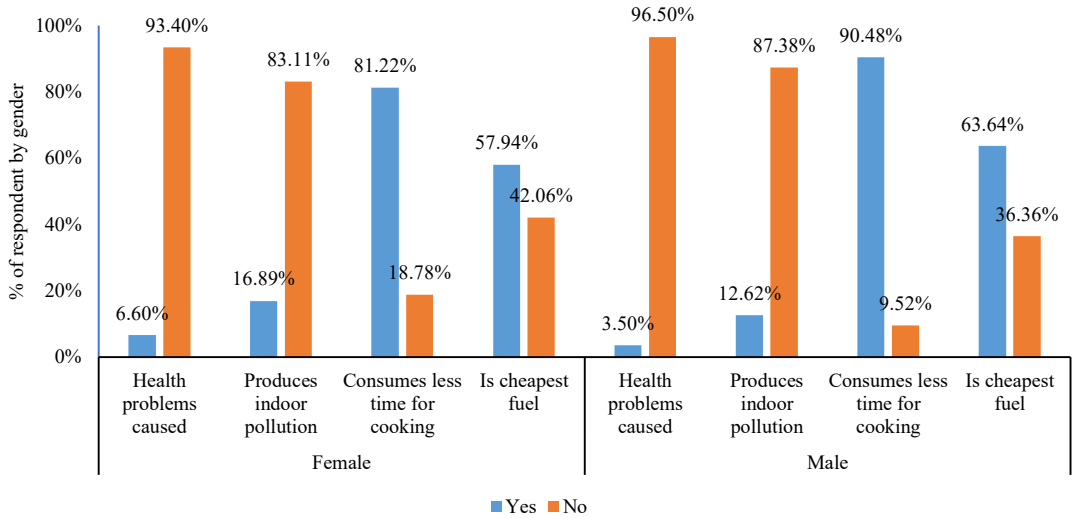


Figure 4.10: Users perceptions towards current technology on the basis of gender

4.1.4 Willing to switch clean technology

The study queries the interest of the households toward switching to other technologies. In this regard, 44.66% of the respondents were not in favor of switching. Out of remaining 55.34%, 51.46% were interested in switching to Induction stove, 3.64% into LPG and 0.24% into ICS as shown in Figure 4.11. The main reason for not having interest on shifting towards other technology may be lack of awareness about the advantages of the newer technology and also they may not be familiar with the emerging technologies.

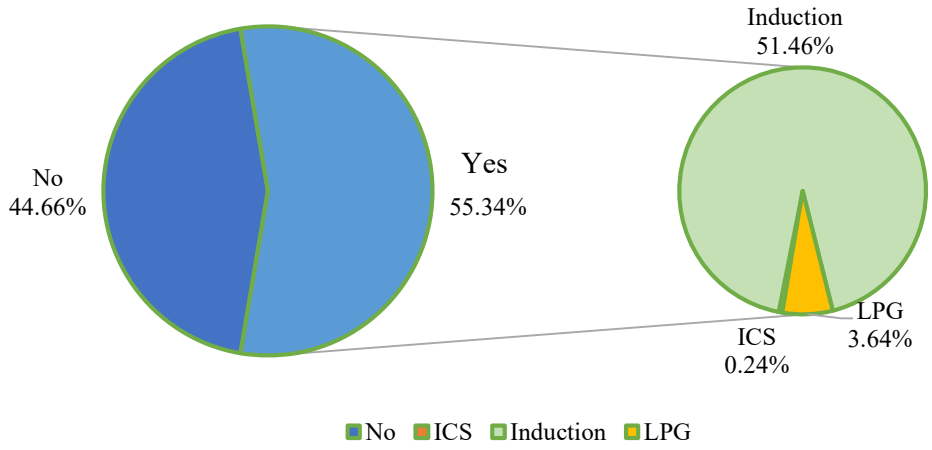


Figure 4.11: Users' willingness towards technology shifting

The current fuels used in households also plays a vital part in switching to newer technology. In general terms, the households currently relying on the fuelwood or biogas may shift to either ICS, LPG or induction stove, but those using LPG might be interested in shifting to induction stove only. The interest of user and their current fuel is shown in Figure 4.12

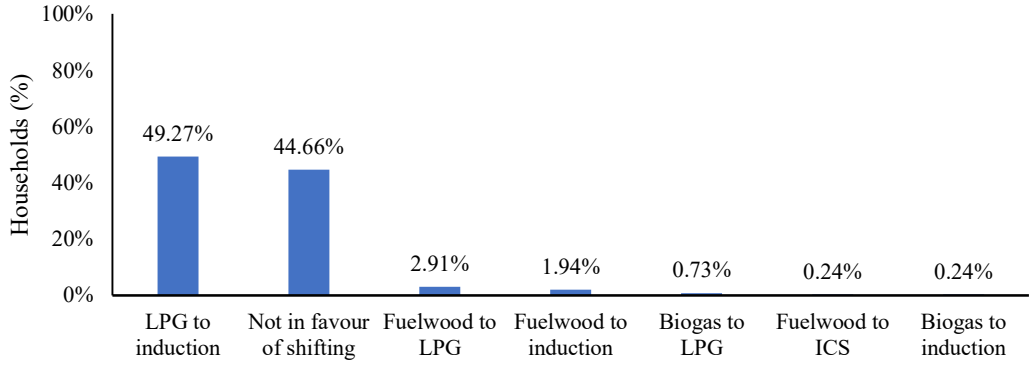


Figure 4.12: Shifting interest of household

The major reasons for the interest toward shifting is due to the various technical, socio cultural and economic reasons. These parameters were further categorized and presented to the respondents. The categorizations are:

- Better technology available in market
- Currently using inefficient stoves

- Fuel cost of newer technology is cheaper
- Current cooking technologies causes health problem
- High indoor pollution in current technology
- Newer technology takes less time to cook
- Uses locally produced fuels

The response of the users when asked to rank their perception is shown in Figure 4.13.

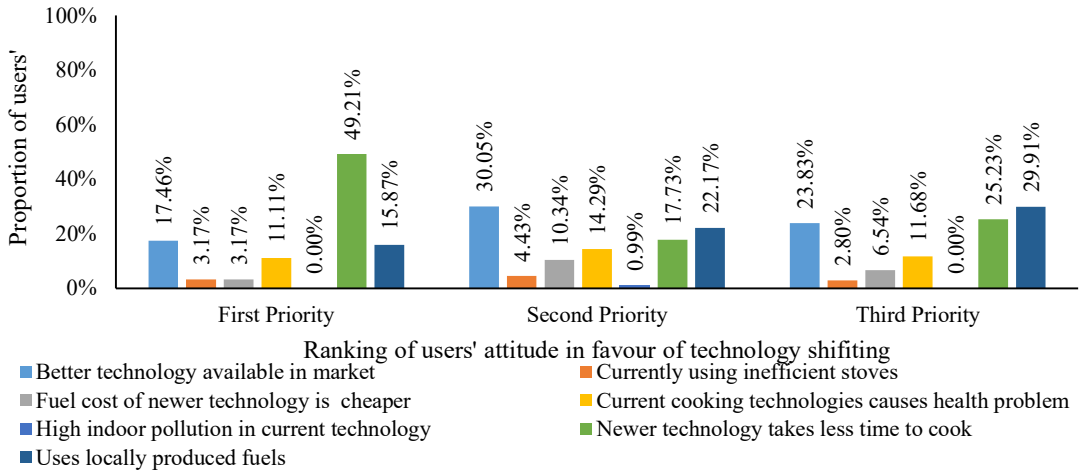


Figure 4.13: Reasons for shifting of cooking technology

In regards to shifting, their plan for the next fifteen years in five years' interval was queried during the survey. As mentioned above, although 44.66% were not in favor of shifting currently, but in the upcoming years all of them were planning to use either LPG or electricity or both as cooking fuels. The trend of shifting in five years interval is shown in Figure 4.14. This shows that the percentage of population using only electricity for cooking in upcoming years would increase gradually and estimated to be 54.37% in 2036 while population using only LPG would gradually decrease till year 2036. In contrast, the population of using both LPG and electricity might increase till 2026 and after that year, it could get decreased.

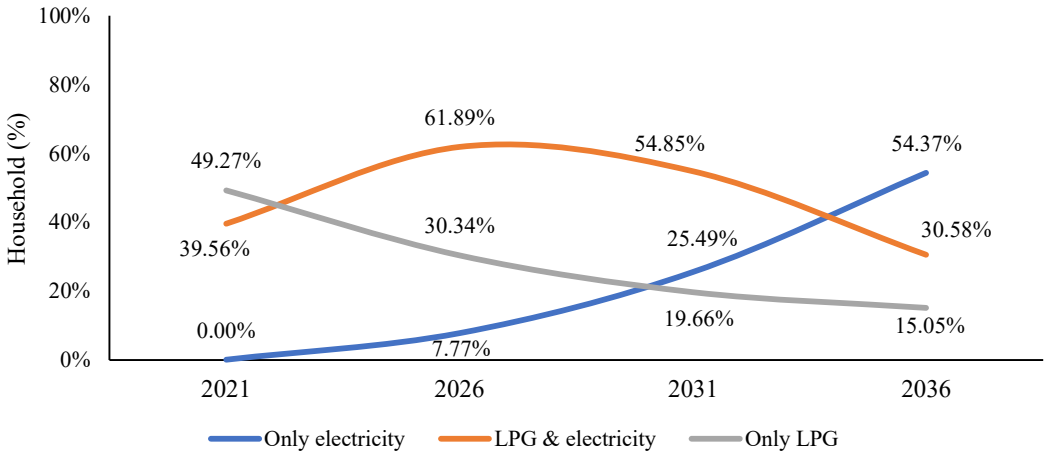


Figure 4.14: Shifting trend as per users' response

4.1.5 Barriers identification

The proportion of the households (44.65%) who were not interested in shifting to other technologies were asked the reasons behind their response. Most of the respondent believed that their current technology is the best technology available in the market hence they are not in favour of shifting. Other major reasons include food tastes better in current technology, newer technologies are expensive, no other option available in market, lack of information regarding other technologies, fuel cost for other technologies is high, sociocultural values etc. The response of the household is presented in Figure 4.15.

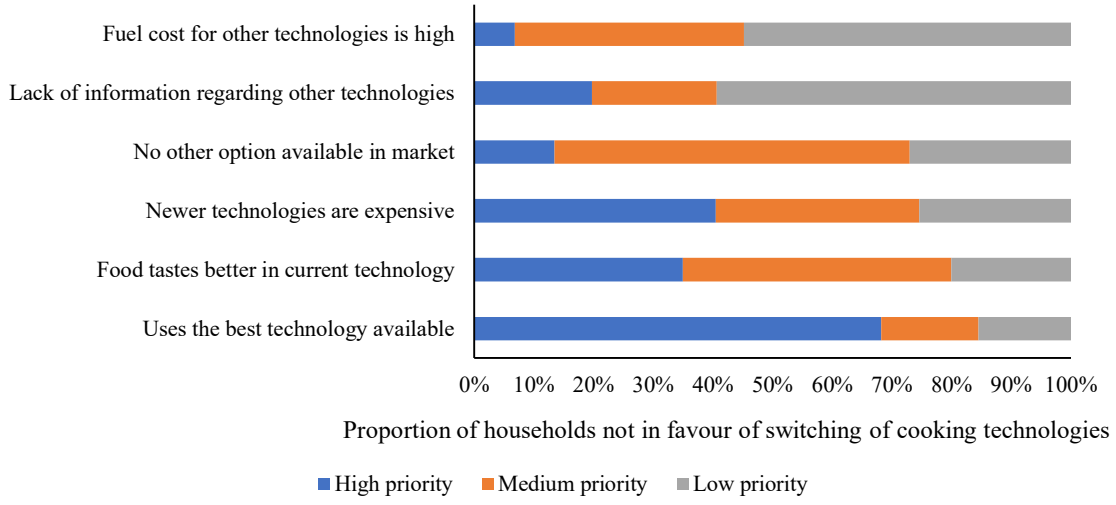


Figure 4.15: Barriers for shifting

Electricity is the only fuel that is produced within the country and does not produce any harmful environmental impact. With the government's current policy of shifting 25% of the primary cooking fuels to electricity, this study aims to identify the barriers for shifting to electricity as a fuel for cooking. The major barriers for shifting to electricity for cooking were

- Electric cook stoves and accessories are expensive
- High cost of electricity for cooking as per NEA tariff
- Unstable electricity and frequent power cut off
- Utensils for induction stove are not available
- Shifting to 16A and above electric meters is lengthy process
- Electric technologies are still in testing phase

In this regard, the respondents were asked to prioritize the barriers for shifting and 38.35% of the respondent said that the major barrier was unstable electricity and frequent power cut off. Similarly, 33.74% respondent said that the barrier was high cost of electricity for cooking as per NEA tariff and 13.59% said that they do not trust the technology and more modification to the technology was required. The detail of the responses regarding the barrier is presented in Table 4.2.

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Table 4.2: Barriers for promotion of electric cooking

Barriers	Major	Medium	Minor	Manageable
Electric cook stoves and accessories are expensive	8.98%	9.71%	51.46%	14.07%
High cost of electricity for cooking as per NEA tariff	33.74%	45.87%	9.71%	3.33%
Unstable electricity and frequent power cut off	38.35%	31.55%	17.96%	5.56%
Utensils for induction stove are not available	1.46%	5.83%	8.74%	47.41%
Shifting to 16A and above electric meters is lengthy process	3.88%	3.40%	5.83%	16.67%
Electric technologies are still in testing phase	13.59%	3.64%	6.31%	12.96%

For the promotion of electric cooking, distribution and transmission networks should be modified as problems occur in many of these due to simultaneous using of electric cooking. A bare minimum use of electric cooking especially induction and infrared stoves is the installation of 16A or above fuse rating provided by Nepal Electricity Authority (NEA). But in case of Butwal Sub Metropolitan City, 46.84% of the households still has 6A fuse which is insufficient for proper operation of induction stove. The fuse rating in the households of Butwal Sub Metropolitan city is shown in Figure 4.16.

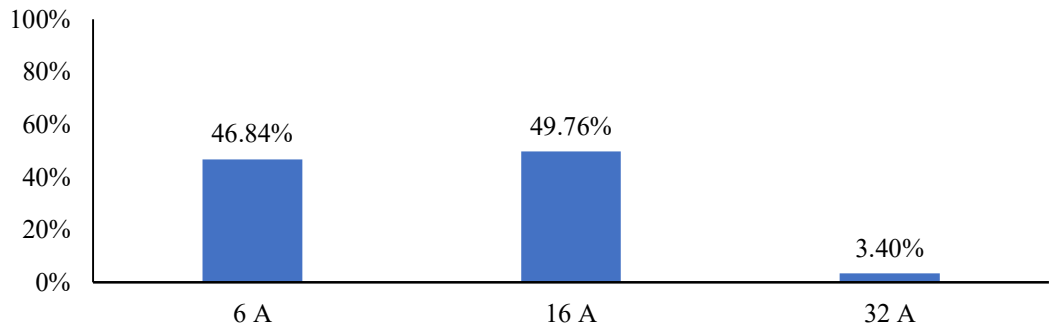


Figure 4.16: Fuse rating in Butwal based on survey

4.1.6 Cost and emission

There are two components of cost involved with the cooking technology, technology cost and fuel cost. The details of the cost of different technology is presented in Table 4.3.

Table 4.3: Cost of cooking solution

S.N.	Fuel	Specific energy consumed		Specific cost of fuel	
		Unit	Quantity	Unit	Quantity
1.	Fuelwood	kg/person/month	5.55	NRs./person/month	83.27
2.	LPG	kg/person/month	2.95	NRs./person/month	331.84
3.	Electricity	kWh/person/month	6.97	NRs./person/month	61.30

In addition to the cost of fuel, the technology like LPG requires continuous maintenance. The cost of operation and maintenance based on the study is presented in Table 4.4.

Table 4.4: Cost of operation and maintenance of LPG stoves

S.N.	Technology	Units	Cost involved with stove		
			Initial (NRs.)	O&M (NRs.)	Lifetime (Years)
1	LPG	Avg.	5,230	995	4.7
		Max.	9,500	3000	15
		Min.	1,000	100	1

Glancing at the emission from different fuels, CO_2 emission per kg of fuelwoods in case of Nepal is around 1.88kg CO_2 equivalent (Pokharel and Rijal,2020). Similarly, the CO_2 equivalent emission from 1 cylinder of LPG is around 21.31kg CO_2 equivalent. The biogas technology and electric technology are carbon neutral. In case of residential sector of Butwal Sub Metropolitan City, the total consumption of fuel wood and LPG is around 12,993 tonnes and 485,480 tonnes respectively. As the use of agricultural residue and dung cake is negligible, the emission from those are neglected. Considering these parameters, the total CO_2-eq emission from cooking is around 25,783.58 tonnes. The detail of emission is shown in Table 4.5.

Table 4.5: Emission from cooking fuels

S.N.	Fuel	Total annual consumption	Total CO_2 equivalent emission (tonnes CO_2-eq)
1.	Fuelwood	12,993 tonnes	15,440.06
2.	LPG	485,450 cylinders	10,343.52
Total			25,783.58

4.2 Cooking in commercial sector

Cooking in the commercial sector uses more convenient and efficient energy than in the residential sector as the per capita energy consumption is more. So, almost all commercial sectors use LPG gas for cooking. However, some of them also uses electrical energy as well as traditional fuel for cooking. The main source of energy is therefore considered to be fossil fuel while the use of electrical energy is gradually increasing as it is a reliable and cheap source of energy. NEA therefore is upgrading the distribution system by improving the capacity of transformers and feeders.

4.2.1 Status of existing cooking technologies

According to the survey conducted during this study in the commercial sector of Butwal, it has been found that 97.85% of commercial entities use LPG for cooking which indicates that the city is practicing clean fuel which releases less pollutants than traditional fuel. While the use of electricity is also increasing these days, 13.85% of the commercial sector use rice cookers, 13.54% use electric ovens and 2.46% use induction. Although, the commercial entities using LPG is more and the use of electricity is increasing, there are also some commercial entities that are using biomass stove for cooking i.e. 2.15% of commercial entities are using it and 4.0% of commercial entities use furnaces in which briquette or fuelwood is used as fuel. The cooking technologies that have been used in the commercial sector of Butwal are shown in Figure 4.17.

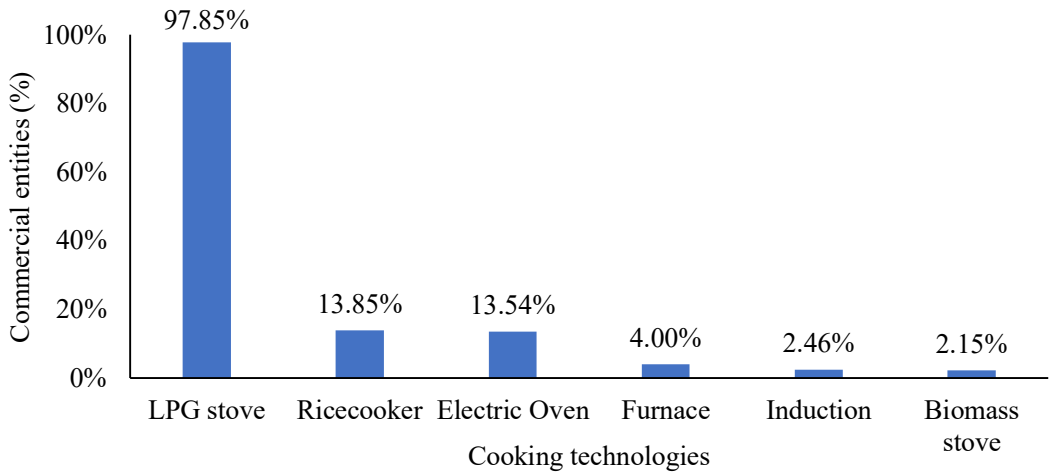


Figure 4.17: Cooking technologies of commercial sector in Butwal

In regards to cooking fuel, most of the commercial sector are using LPG i.e. 97.85% of total commercial entities in Butwal use LPG as their cooking fuel while 25.54% of commercial entities use electricity for cooking purposes. This shows that the commercial sector is likely to use electricity for cooking purposes. But the main disadvantage of using electrical equipment for cooking is that it consumes more time than LPG. The other fuels such as fuelwood, briquette are also being used in this sector. The commercial entities using fuelwood is 2.15% and briquette is 3.69% as shown in Figure 4.18.

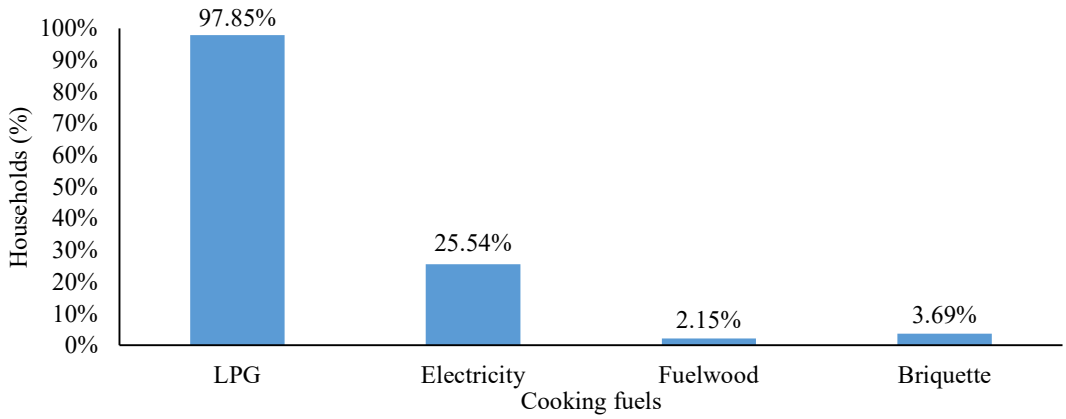


Figure 4.18: Cooking fuel in commercial sector of Butwal

Most of the commercial sectors in Butwal use only one technology stove, whereas there are some commercial sectors that use two or more different types of stoves at the same time which is called stove stacking. In Butwal, 72.31% of the commercial entities use single stove i.e. LPG stove (71.08%), biomass cookstove (0.92%) and electric oven (0.31%). While, 20.92% of commercial entities use two different types of stoves and only 6.77% use more than two types of stoves. Based on fuels, 72.31% of the commercial entities uses one fuel i.e. LPG (71.08%, fuelwood (0.92%) and electricity (0.31%). Similarly, 25.85% of commercial entities are using two different types of fuels for cooking purposes and 1.85% uses three or more fuels. The stacking of cooking technology is shown in Figure 4.19.

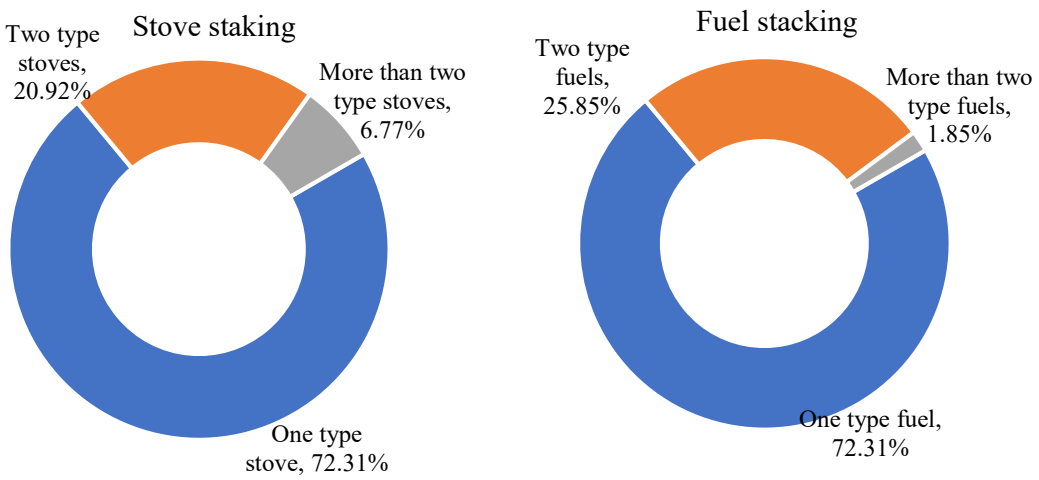


Figure 4.19: Stacking of cooking technology

The various combinations of technologies being used in the commercial sector of Butwal is shown in Table 4.6. Here, 8.92% of the commercial entities use LPG with a ricecooker while 8.62% use LPG with an electric oven. Other combinations used are marginal and used in specific commercial entities. The detail of the cook stoves used in various commercial entities is shown in Table 4.6.

Table 4.6: Combination of stoves in commercial sector of Butwal

Primary Technology	**Secondary Technology**	**Tertiary Technology**	**Share (%)**
Biomass cook stoves	Rice cooker		0.31
Biomass cook stoves	Furnace		0.62
Biomass cook stoves	LPG	Rice cooker	0.31
LPG	Rice cooker		8.92
LPG	Electric oven		8.62
LPG	Induction		0.62
LPG	Furnace		1.85
LPG	Rice cooker	Electric oven	0.31
LPG	Electric oven	Coffee machine	0.31
LPG	Rice cooker	Electric oven	3.08
LPG	Rice cooker	Induction	0.62
LPG	Induction	Electric oven	0.62
LPG	Furnace	Coffee machine	0.31
LPG	Furnace	Rice cooker	0.31
LPG	Furnace	Electric oven	0.31
LPG	Furnace	Induction	0.31
LPG	Furnace	Induction & electric oven	0.31

As there is fuel stacking, use of more than one fuel with different combinations is detected. In the commercial sector, almost all are using LPG as their main source of fuel and the other sources of fuel such as fuelwood, electricity and briquette are combined with LPG as the secondary source of fuel. Table 4.6 illustrates the details of combination of fuel in the

commercial sector of Butwal. The commercial entities that use LPG and electricity is 23.08% while 1.53% of commercial entities use LPG, electricity and briquette, 1.84% of commercial entities use LPG and briquette and the remaining all combination is 0.31%.

Table 4.7: Combination of fuel in commercial sector of Butwal

Primary Fuel	Secondary Fuel	Tertiary Fuel	Share (%)
LPG	Electricity		23.08
LPG	Electricity	Briquette	1.53
LPG	Briquette		1.84
Fuelwood	LPG	Electricity	0.31
Fuelwood	Briquette		0.31
Fuelwood	Electricity		0.31

Looking at the primary technology for cooking, LPG stove as well as LPG as fuel has the highest share of 97.55%. The detail of the primary cooking technologies by stove and fuels is shown in Figure 4.20. The commercial entities using fuelwood as the primary fuel is 2.15% while 0.31% of commercial entities use electricity as the primary fuel. The reason behind large percentage of commercial entities depending on LPG as primary cooking technology is it's easy accessibility and cooking in LPG is faster and convenient than other technologies.

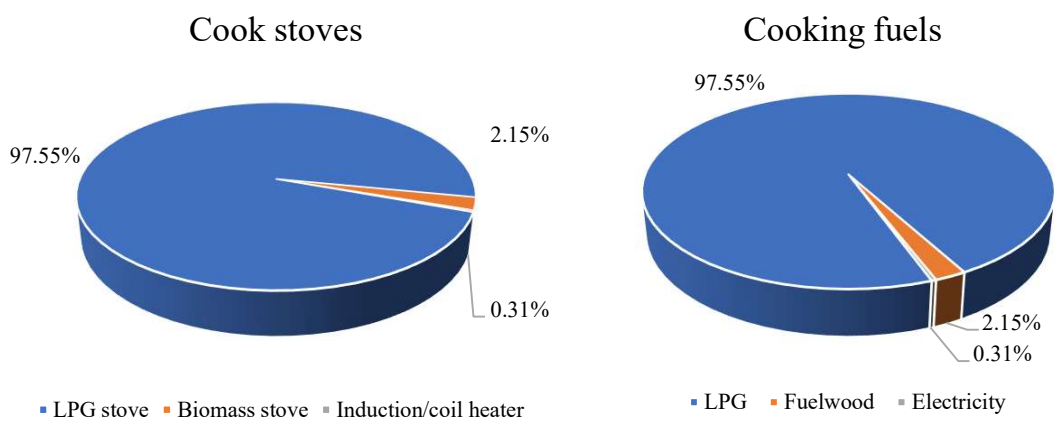


Figure 4.20: Primary Cooking Technologies

4.2.2 Status of kitchen

Although in households, indoor cooking without any exhaust is extremely common, in the commercial sector indoor cooking with exhaust is most practiced. In the commercial sector of Butwal Sub-Metropolitan city, 64.67% of kitchen status practices indoor cooking with exhaust while 28.44% of kitchens are indoor without exhaust. The remaining 6.89% kitchens are outdoor type. This indicates that cooking in the commercial sector of Butwal is being progressive. As the percentage of the cooking system having exhaust is more, indoor pollution and health hazards created while cooking is low.

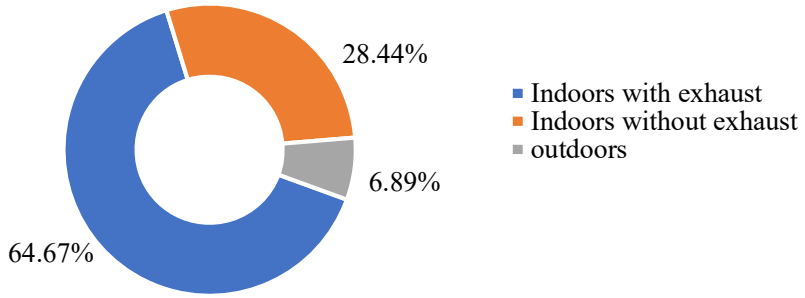


Figure 4.21: Type of kitchen

4.2.3 Energy consumption for cooking

The energy equivalent of cooking fuel used for cooking is called final energy while the amount of energy that is actually used for cooking is called useful energy. As in most of the commercial sectors, LPG is the primary fuel, the final energy consumption of LPG is determined to be higher. Table 4.8 shows the energy consumption in the commercial sector of Butwal. The total energy consumption is 81.83 TJ in which the share of LPG, fuelwood, and electricity are 72.94 TJ, 3.59 TJ and 5.32 TJ respectively and the specific energy consumption is 54.14 GJ/capita. Similarly, the total useful energy in the commercial sector of Butwal is 40.42 TJ with the specific useful energy of 29.95 GJ/entities.

Table 4.8: Energy consumption in commercial sector of Butwal

SN	Fuel type	Final energy (TJ)	Average efficiency (%)	Useful energy (TJ)
1	Electricity	5.30	92	4.87
2	Fuelwood	3.59	15	0.54
3	LPG	72.94	48	35.01
Total		81.83	49.93%	40.42
Total population		1512		
Specific energy consumption		54.14 GJ/entities		26.75 GJ/ entities

As the efficiency of electricity is higher than other fuels, the percentage of useful energy consumption by electricity is increased while useful energy consumption of fuelwood and LPG is decreased as shown in Figure 4.22. In final energy consumption, the share of LPG, fuelwood, and electricity is 89.11%, 4.39% and 6.50% respectively while in useful energy the share of LPG, fuelwood and electricity is 86.61%, 1.33% and 12.05% respectively.

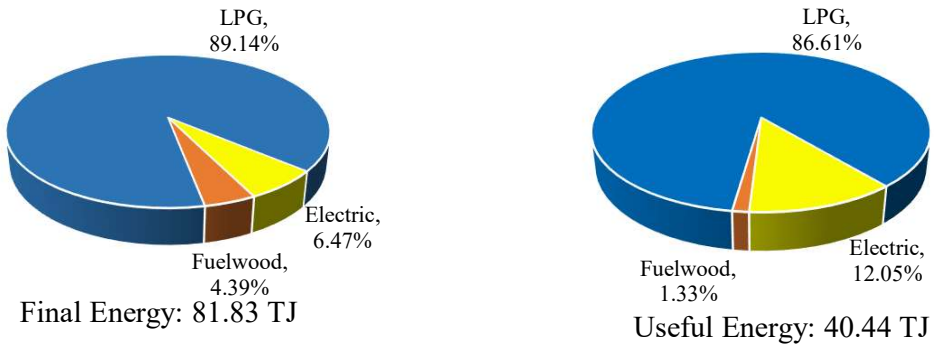


Figure 4.22: Final energy and useful energy consumed in commercial sector of Butwal

The user's perception towards the current technology is represented in Figure 4.23. As most of the commercial sectors are using LPG fuel for cooking purpose, they are not facing health problems during cooking since it does not produce indoor pollution. The consumption of time for cooking is also considered to be less by most of the commercial sector as compared to traditional cooking system. In contrast, 63.11% of respondents assume that the current technology is cheapest but in actual, most of the commercial entities are using LPG as their primary source of cooking which is one of the imported fuel and so, the price may get changed according to the international market value i.e. it may not be affordable in future. So, replacement of LPG by other renewable energy such as electricity could be a good solution.

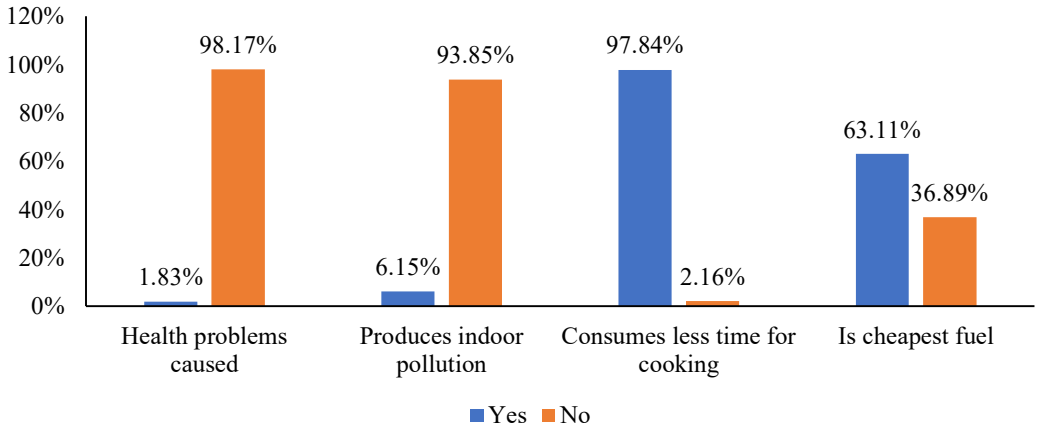


Figure 4.23: Users perception towards current technology

4.2.4 Willing to switch to clean technologies

During the survey, the interest towards switching to other technologies was also viewed in which only 55.69% of total respondents seem to be in favor of switching while the remaining are not in favor of switching due to various reasons. Among the ones that favor switching, a majority are interested in switching their technology into an electric system is included in Figure 4.24.

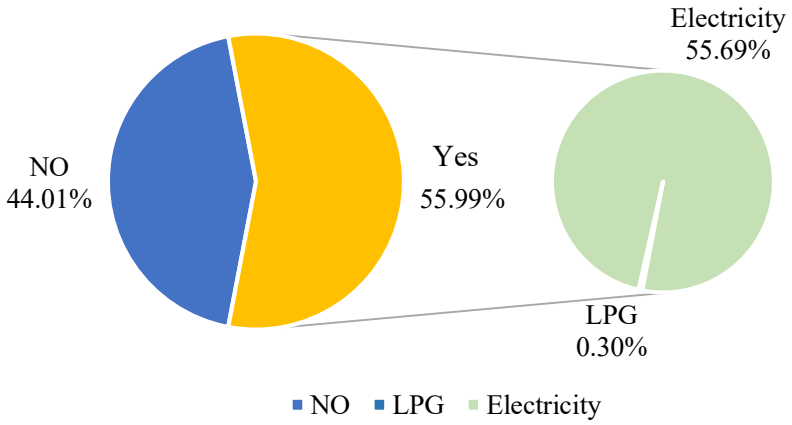


Figure 4.24: Interest towards shifting

The shifting interest of the users' is also affected by the current technologies that are being used. The detail of the shifting and current technologies used is presented in Figure 4.25. Among the respondents having interest to switch, 55.69% are willing to switch their cooking technology to electricity i.e. induction cookstove while 0.30% are willing to switch their technology from fuelwood to LPG. This shifting interest has been studied on the basis of the respondent's point of view during the survey. The reason of having no interest in shifting towards newer technology by 44.01% of respondents may be that they are unknown about the advantages of new technologies. So, proper guidelines should be provided as per requirement to those respondents.

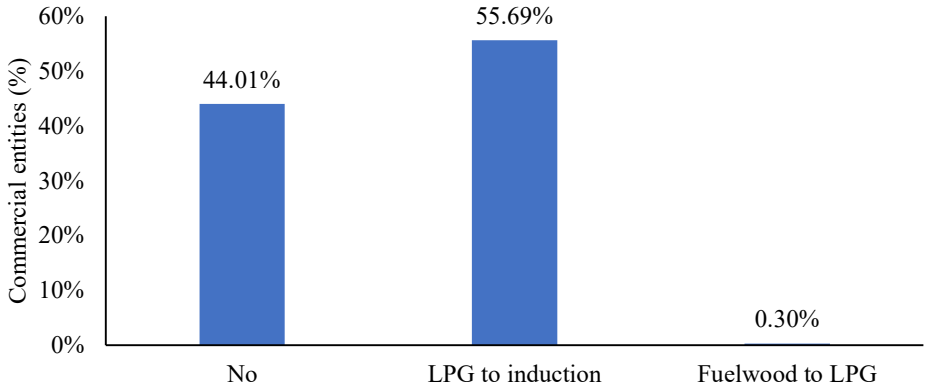


Figure 4.25: Shifting interest of commercial sector

Although 44.01% respondents are not interested on switching their cooking technology, in the long term, they might also shift to various technologies. The long term plan of the consumers is shown in Figure 4.26. This shows that in the future, the consumers of only electricity are expected to grow while the consumers of only LPG are expected to decrease. On the other hand, the consumers of LPG and electricity are expected to increase at a certain point and after that, it might decrease.

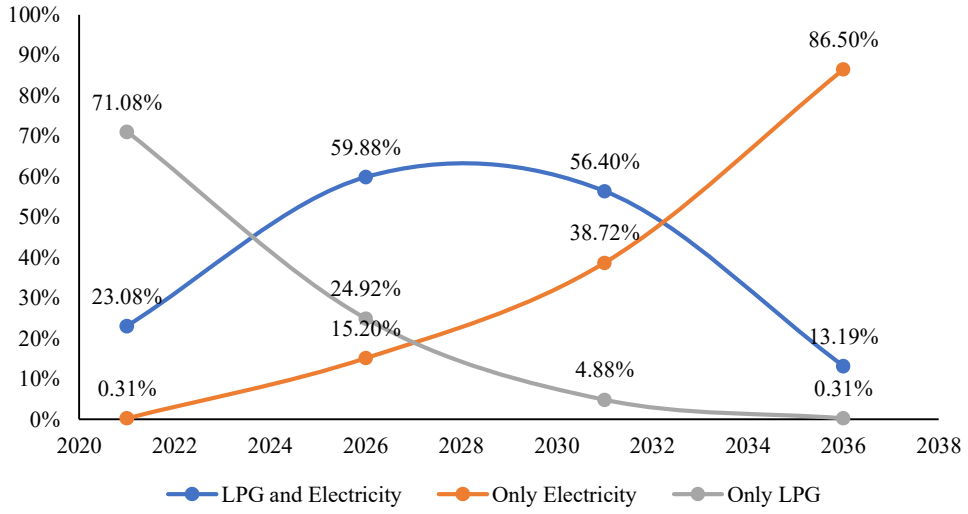


Figure 4.26: Shifting to clean technology

Figure 4.27 illustrates the major reasons for sifting towards other technologies. This shows that the major reason for most of the commercial sectors who want to switch their cooking technology is availability of newer technology that takes less time to cook and better technology available in the market.

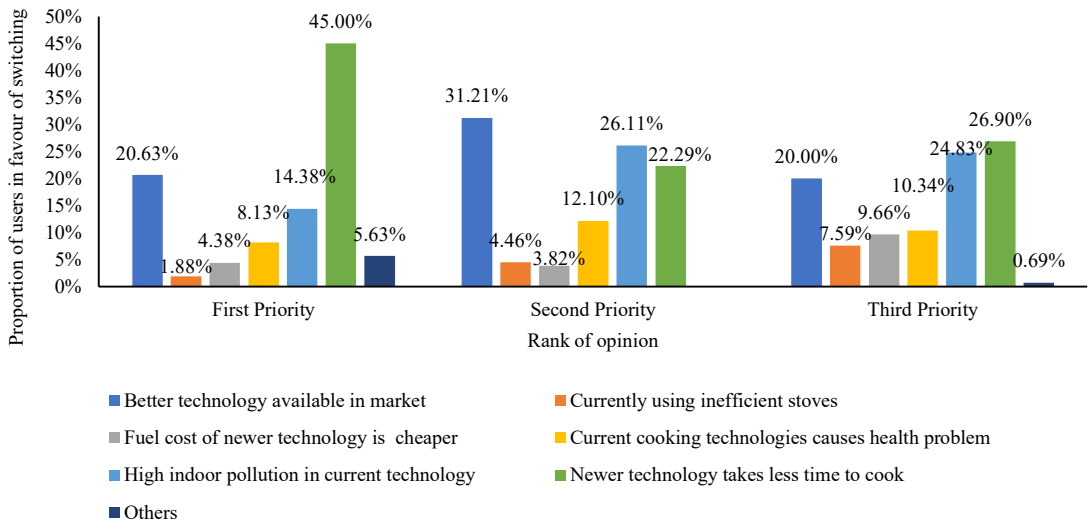


Figure 4.27: Reasons for shifting towards other technologies

4.2.5 Barriers identification

Although there are benefits of switching towards the newer technologies, there are some barriers that do not let many commercial entities to switch their technology. Most of the respondents believe that they are using the best technology currently which shows that they may not be aware of the other better technologies available in the market. The respondents also assume that food tastes better in current technology and having fear that the taste might change after switching their cooking technology. Some of the perception of users towards not shifting is shown in Figure 4.28.

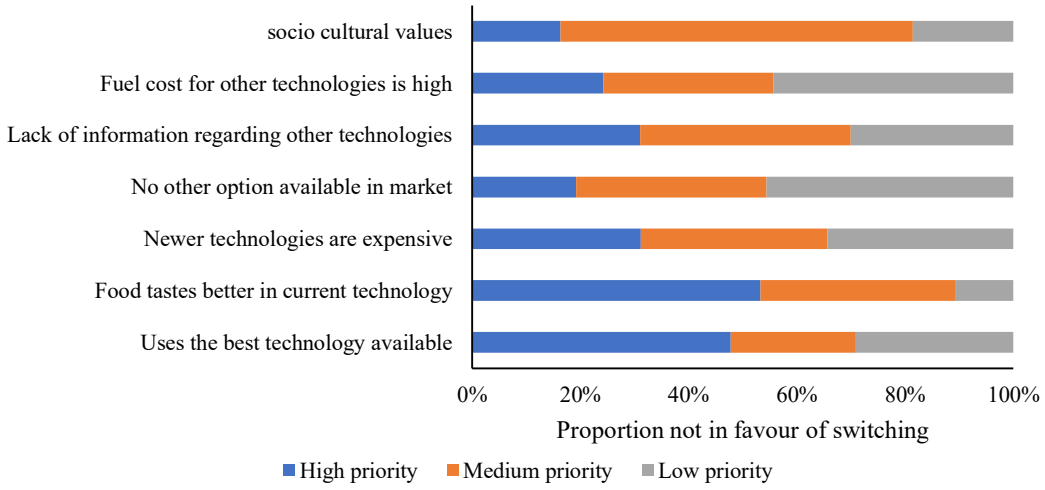


Figure 4.28: Reasons for not shifting to other technologies

Electricity is the only fuel that is produced within the county and does not produce any harmful environmental impact while cooking. With the government's current policy on shifting 25% of the primary cooking fuels to electricity, this study aims to identify the barriers for shifting to electricity as a fuel for cooking. The major barriers for shifting to electricity for cooking were,

- Electric cook stoves and accessories are expensive
- High cost of electricity for cooking as per NEA tariff
- Unstable electricity and frequent power cut off
- Utensils for induction stove are not available
- Shifting to 16A and above electric meters is lengthy process
- Electric technologies are still in testing phase

The detail of the responses regarding the barrier is presented in Table 4.9.

Table 4.9: Barriers for promotion of electric cooking

Barriers	Major	Medium	Minor	Manageable
Electric cook stoves and accessories are expensive	14.67%	13.47%	26.35%	21.86%
High cost of electricity for cooking as per NEA tariff	27.84%	35.33%	14.37%	10.48%
Unstable electricity and frequent power cut off	27.25%	32.04%	25.45%	7.19%
Utensils for induction stove are not available	5.39%	5.99%	15.57%	25.75%
Shifting to 16A and above electric meters is lengthy process	5.09%	3.29%	5.99%	21.56%
Electric technologies are still in testing phase	19.76%	9.88%	12.28%	13.17%

Although most of the commercial sectors are in favor of switching towards electric technology in future, 19.28% of the commercial sector are using 6A fuse and 45.48% are using 16A fuse which is insufficient for proper operation of newer electric technologies. Also, the use of electric technology will increase in future. So the main barrier for switching towards electric technology is fuse rating. For overcoming this barrier, proper change in distribution line and transformer should be done.

During the survey, all the wards have been visited and data from small commercial organizations such as tea shops and hotels were also collected which are being operated in residential buildings. This is the reason for the majority of the commercial sectors seems to be using 6 A fuse. And only 4.52% of commercial entities in Butwal are using 3-phase supply.

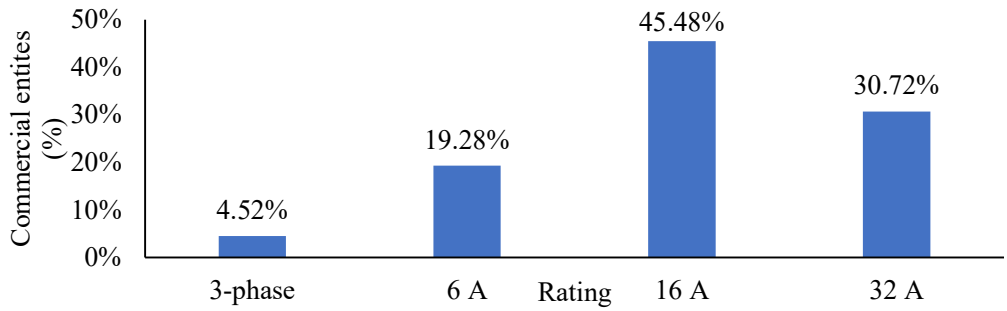


Figure 4.29: Fuse rating in commercial sector of Butwal

4.2.6 Cost and emission

Total cost of the cooking stove depends on technology cost and fuel cost. Technology cost again depends on initial cost, operation and maintenance cost and lifetime. Fuel cost varies within the time and place as well while the initial cost of any technology varies along with different equipment or brand. Table 4.10 represents the cost of different fuels used in the commercial sector of Butwal.

Table 4.10: Cost of cooking solution

S.N.	Fuel	Specific energy consumed		Specific cost of fuel	
		Unit	Quantity	Unit	Quantity
1.	Fuelwood	kg/person/month	13.93	NRs./person/month	209.01
2.	LPG	kg/person/month	89.33	NRs./person/month	10,065.88
3.	Electricity	kWh/person/month	81.45	NRs./person/month	1185.85

In addition to the cost of fuel, the technology like LPG requires continuous maintenance. The cost of operation and maintenance based on the study is presented in Table 4.4.

Table 4.11: Cost of cooking solution

S.N.	Technology	Units	Cost involved with stove		
			Initial (NRs.)	O&M (NRs.)	Lifetime (Years)
1.	LPG	Avg.	20855	3855	4.3
		Max.	230000	30000	20
		Min.	1000	100	1

In case of Nepal, the CO_2 emission per kg of fuelwood is around 1.88 kg of CO_2 equivalent and emission from 1 cylinder of LPG is around 21.31 kg of CO_2 equivalent. Commercial sector of Butwal consumes 239.50 tonnes of fuelwood and 114,147 cylinders of LPG form which the total CO_2 emission is around 2,809.39 tonnes. Table 4.12 illustrates the total CO_2 equivalent emission from fuelwood and LPG.

Table 4.12: Emission from cooking fuels

SN	Fuel	Total annual consumption	Total CO_2 equivalent emission (tonnes CO_2-eq)
1	Fuelwood	239.50 tonnes	452.18
2	LPG	114,147 cylinders	2,432.47
Total			2,884.65

CHAPTER FIVE : COOKING IN POKHARA METROPOLITAN CITY

5.1 Cooking in residential sector

Cooking technologies and fuels used in the residential sector differs according to various socio economic, environmental and cultural parameters. Additionally, the availability of the technologies, supply of fuels, environmental and health concern also plays a major role in the cooking technologies and fuel selection. As Pokhara Metropolitan city is one of the advanced city of Nepal, the cooking technology in this city is also getting innovative in compare to Butwal. In residential sector also, it has been found that the people are influenced by the new technologies available also the technologies that are shown in social media has changed their cooking standard.

5.1.1 Status of cooking technologies

According to the survey conducted in the residential sector of Pokhara, 94.06% of the household use LPG stove. As LPG stove is convenient and easily accessible cooking technology the percentage of households using LPG is higher. Besides, the use of ricecooker and induction/coil heater is also increasing, i.e. 67.58% and 10.73% of households are using ricecooker and induction/coil heater for cooking. Despite, the use of electrical appliances for cooking technology is increasing, 14.84% of households are still using biomass cookstove. In residential sector of Pokhara, biogas stove is also being used by 5.25% of households. The details of the cooking status is shown in Figure 5.1.

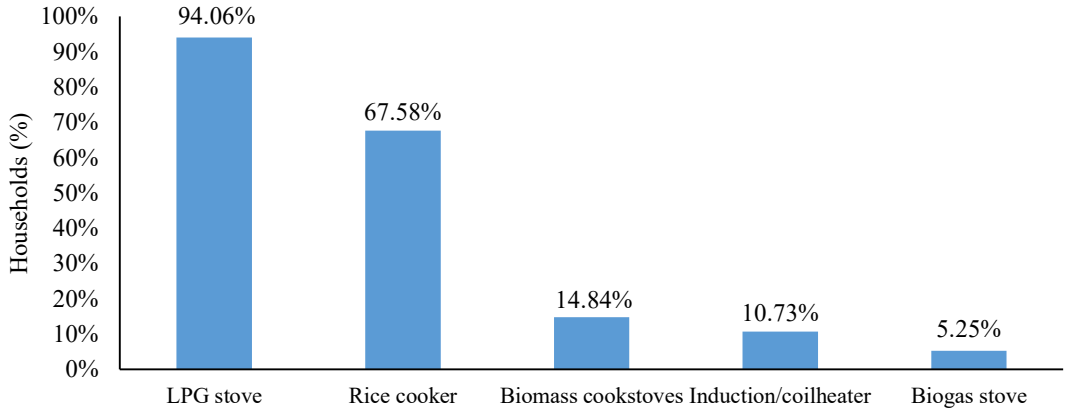


Figure 5.1: Cooking technologies in Pokhara Metropolitan City

Similarly, the fuels used in different cooking technologies may vary based on household status. In order to understand the cooking requirements, the information regarding the use of cooking fuels can help the policy makers and stakeholders to determine the energy demand. In most of the cooking technologies, there is specific fuel requirement, but this is not the case in biomass cook stoves where different fuels can be used. Here, LPG and electricity is used by most of the households and from survey it was found that 94.06% and 72.60% of households are using LPG and electricity respectively for cooking. The other cooking fuels used in Pokhara is presented in Figure 5.2.

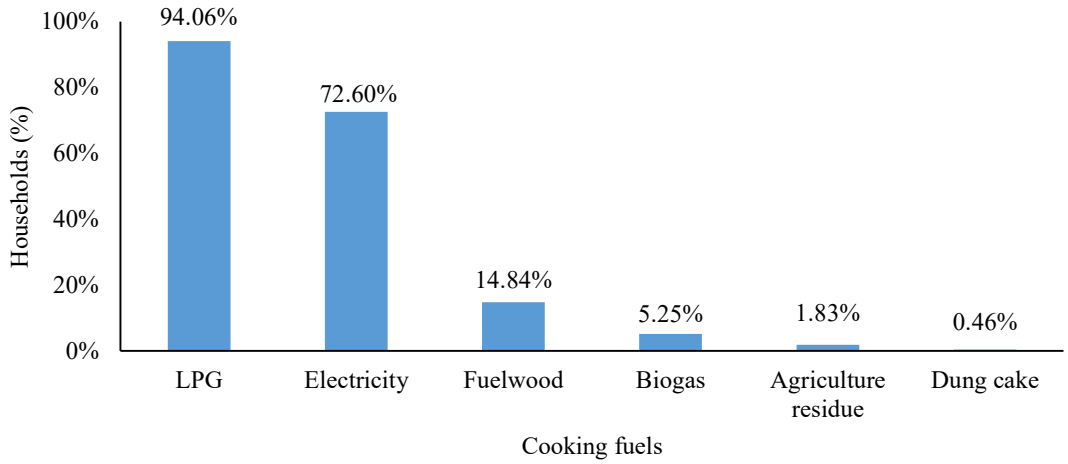


Figure 5.2: Cooking fuels in Pokhara Metropolitan City

In case of Pokhara Metropolitan City, 26.04% of the household use only one stove i.e. LPG (21.92%) and biomass cook stoves (4.12%). While 57.52% of household use two type of stoves and the rest use more than two stoves. On the basis of fuels used, 23.52% of the household use single fuel i.e. LPG (21.92%) and fuelwood (1.60%) while 67.12% use two type fuels while the rest use more than two fuels. The use of more than one fuels signifies energy mix in the household, but in case of Nepal, extra stove/fuel are found to be used on occasional basis.

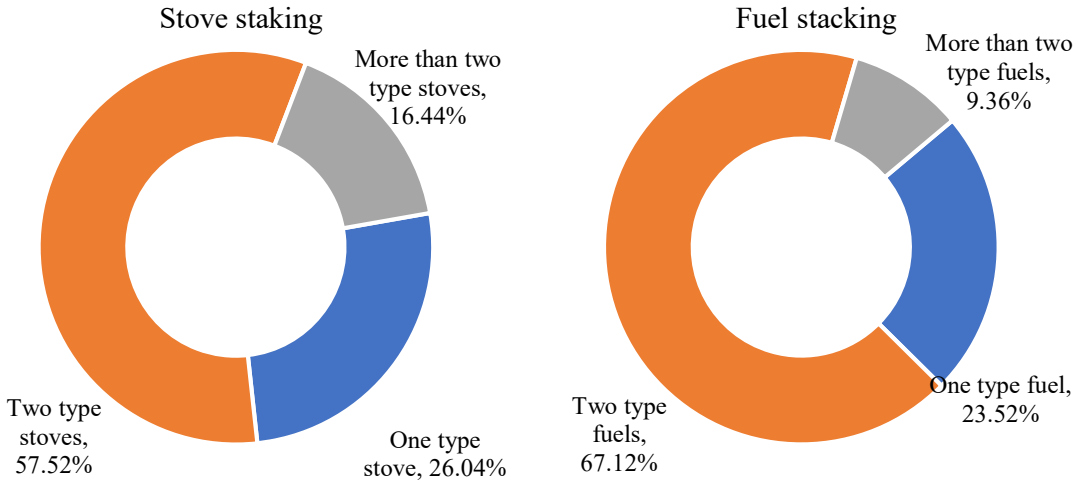


Figure 5.3: Stove stacking

There are 74.96% of the household using more than one technology. The combination of technology varies from household to household. In most of the cases with two or more technologies, rice cooker is the predominated second technologies i.e. 50.91% of the household use rice cooker with LPG. The detail of the combination of stoves is presented in Figure 5.4.

50.91% LPG + Rice cooker	1.37% LPG + Biomass stove	7.76% LPG + Rice cooker + Hot plate	2.28% LPG stove + Hot plate	1.14% Biogas stove + LPG + Rice cooker
0.91% Biogas + LPG	0.46% Biogas + LPG + Biomass stove	0.23% Biogas + Biomass stove	0.91% Biogas + Biomass stove + Rice cooker	1.60% Biogas stove + Biomass stove + LPG + Rice cooker
4.11% Biomass stove + LPG + Rice cooker	0.68% Biomass stove + Rice cooker	0.46% Biomass stove + LPG + Hot plate + rice cooker	0.91% Biomass stove +LPG	0.23% Induction/coil heater + LPG

Figure 5.4: Combination of stoves

In most of the cases with two or more fuels, LPG with electricity predominates other combination with 60.96% of the household. Whereas, the combination of other fuels is lower as compare to combination of LPG and electricity. The detail of the combination of these household is presented in Figure 5.5.

60.96% LPG + Electricity	1.37% LPG + Fuelwood	3.88% LPG + Fuelwood + Electricity	0.68% Biogas + fuelwood + Electricity	0.46% Biogas + LPG + fuelwood
1.14% Biogas + LPG + Electricity	0.23% Biogas + Fuelwood	0.91% Biogas + LPG	1.37% Biogas + Fuelwood + LPG + Electricity	0.23% Biogas + Fuelwood + Agri. residue + LPG + Electricity
0.23% Biogas + Fuelwood + Agri. residue + + Electricity	2.74% Fuelwood + Electricity	0.46% Fuelwood + Electricity + Agri. Residue	0.23% Fuelwood + Agri. Residue + LPG	0.68% Fuelwood + Agri. Residue + LPG + Electricity
0.68% Fuelwood + LPG	0.23% Electricity + LPG			

Figure 5.5: Combination of fuels

Although, there is use of more than one cooking technologies in different households, there is one primary technology that is used for cooking. The primary cooking technologies based on the response of the households is presented in Figure 5.6. The percentage of households using LPG as primary cooking technology 84.25% followed by biomass, 10.27% of households. Beside, biogas is also being used as the primary cooking technology by 5.25% and the

remaining 0.23% of household use induction/coil heater (electricity) as the primary source of cooking. The main reason behind depending more percentage of households on LPG as primary cooking technology might be it is easily available and also most of the people find it easy to use. While the use of electricity as primary cooking technology seems to be increased within few years as most of the respondents are found to be interested on electrical cooking system. And although LPG stove is a cooking technology that is ranked above tier 3 by Renewable Energy Testing Station (RETS), it consumes an imported fuel and hence supply could get disturbed.

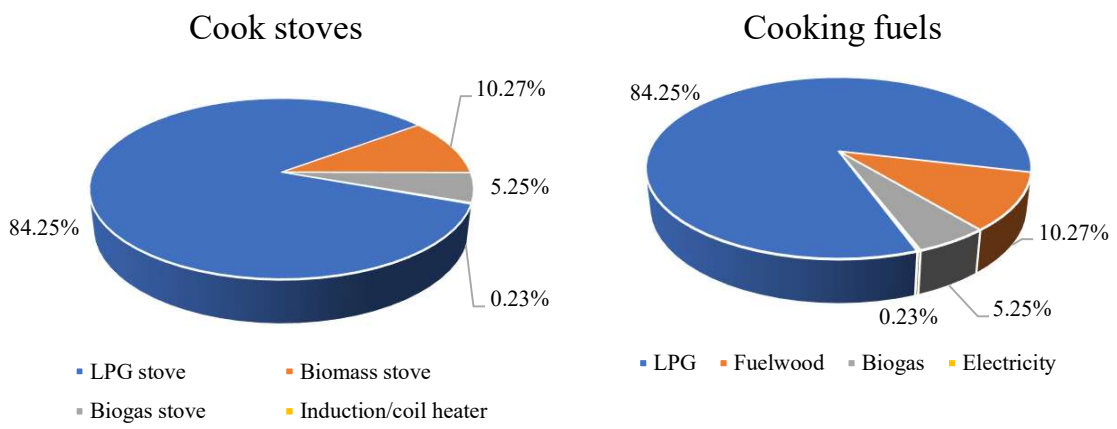


Figure 5.6: Primary cooking technologies

5.1.2 Status of kitchen

The status of kitchen in the households along with the type of cooking solutions is one of the important factors that effects the respiratory of the users especially women's in case of Nepal. Improper ventilation in the kitchen can cause various respiratory problems along with causing safety issue in case of fire hazard. During the study, type of kitchen in different households was accessed which shows that 75.80% of households are practicing indoor cooking with exhaust while 23.06% of household practices indoor cooking without exhaust and remaining practices outdoor cooking. The type of kitchen in households of Pokhara Metropolitan City is presented in Figure 5.7.

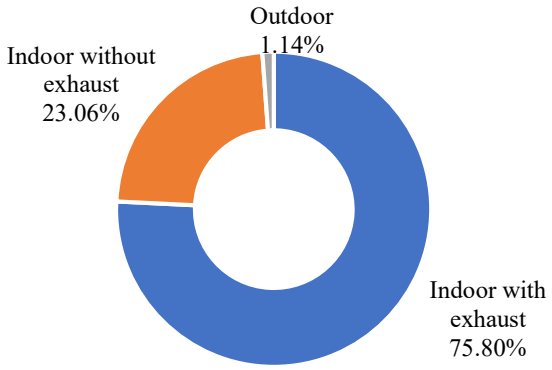


Figure 5.7: Type of kitchen

The proportion of the indoor kitchen without exhaust signifies lack of awareness regarding the use of cooking technology and health hazards caused by it. In addition to the health hazards, the kitchen without exhaust can also cause fire hazard in case of gas leakage or smoke filling in the kitchen.

5.1.3 Energy consumption for cooking

The combustion of different cooking fuels converts the fuel into heat energy which is used for cooking. In case of electricity, the copper losses incurred due to heating of coil is used for cooking. The total energy consumption for cooking in Pokhara is shown in Table 5.1.

Table 5.1: Energy consumption in Pokhara Metropolitan City

S.N.	Fuel type	Final Energy (TJ)	Average efficiency (%)	Useful energy (TJ)
1	Fuelwood	422.65	15	63.39
2	LPG	902.76	48	433.32
3	Biogas	15.056	37	5.572
4	Electricity	245.50	92	225.86
Total		1,585.98	47.15	728.14
Population of BSMC		518,452		
Specific energy consumption		3.05 GJ/capita		1.41 GJ/capita

Hence, the total energy consumption in Pokhara is 1,585.98 TJ and the specific energy consumption i.e. energy consumption per capita is 3.05 GJ/capita. The energy equivalent of cooking fuel used for cooking is called final energy while the amount of energy that is actually used for cooking is called useful energy. As the efficiency of fuelwood is very lower compare to electricity and LPG so, although final energy consumption of fuelwood is higher, the useful energy consumption is lower. The total useful energy consumption by residential sector of Pokhara is 728.14 TJ. The Figure 5.8 compares the final energy with the useful energy.

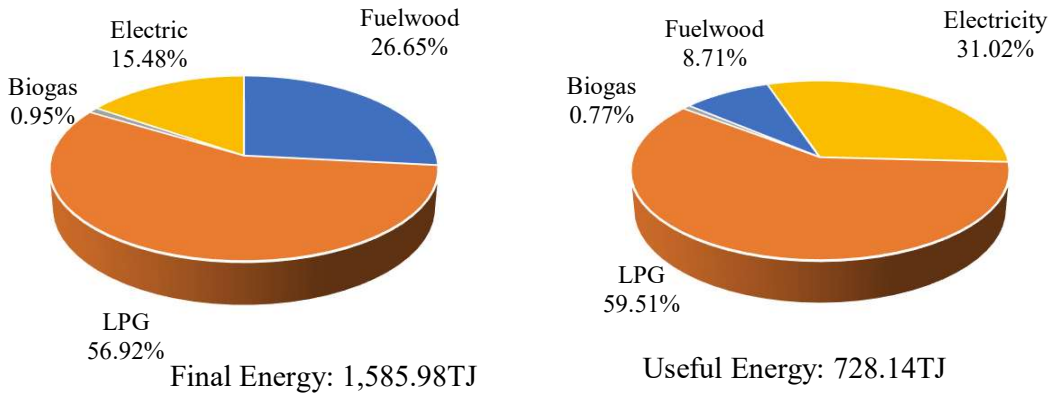


Figure 5.8: Final energy and useful energy

The perception of users toward current technologies also plays an important role towards shifting to cleaner technology. The study aims to determine the impact of current fuels on indoor pollution, health hazards, cooking time and cost of fuels. The response of the users is

presented in Figure 5.9. According to which 94.98% and 90.87% of total respondents disagreed on having health problems and indoor pollution due to current technology while 79.91% and 60.27% of respondents agreed that the current technology consumes less time for cooking and is the cheapest fuel respectively. In residential sector of Pokhara also, most of the household use LPG as their primary source of fuel for cooking but also most of the users assume that the current technology they are using is cheapest but in actual, cooking using LPG is expensive than electricity. So, proper guidelines and motivations should be provided for cooking using electricity.

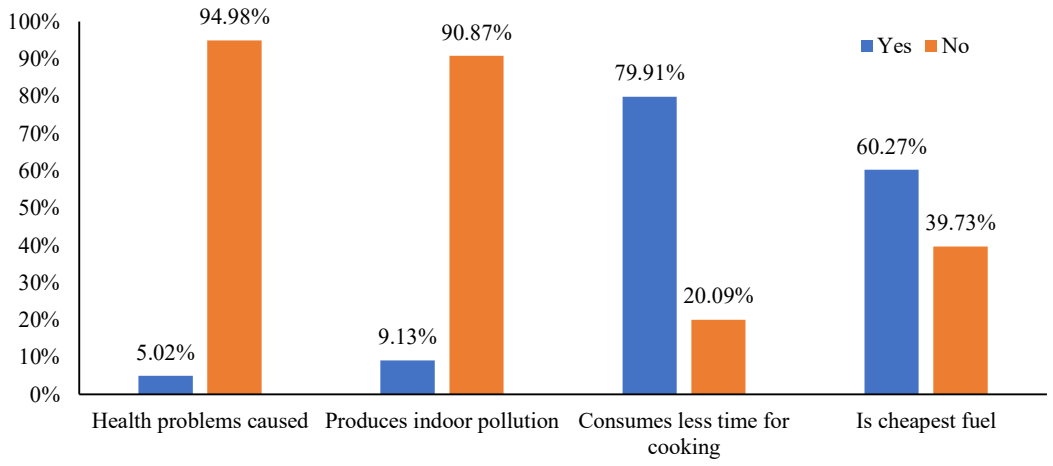


Figure 5.9: Users perception toward current technology

During the study 58.29% of the respondent were female and 51.73% of respondent were male and both male and female are having similar opinion towards the current technology. The perception on the basis of gender is shown in Figure 5.10.

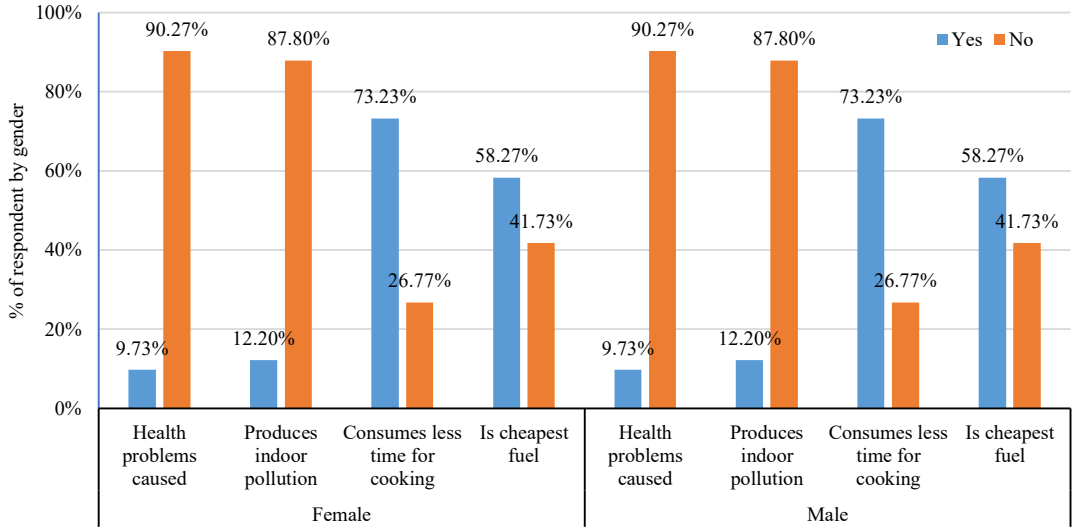


Figure 5.10: Perception towards current technology on the basis of gender

5.1.4 Willing to switch to clean technology

The study also queries the interest of the household towards switching to other technologies. In this regard, 37.78% of the respondents were not in favor of switching and out of remaining 62.39% households, 59.04% were interested in switching to induction stove, 2.50% into LPG, 0.45% into biogas and 0.23% into ICS as shown in Figure 5.11. The main reason behind not having interest on shifting towards new technology might be they are unknown about the advantages of new technologies proper awareness should be provided.

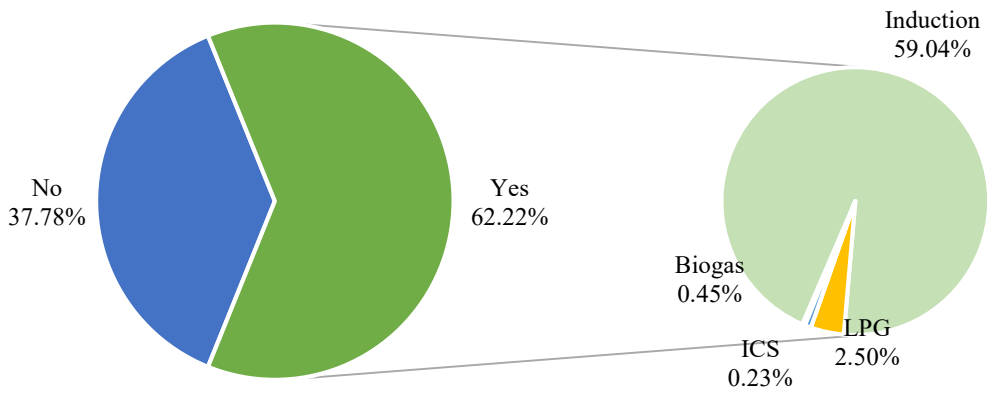


Figure 5.11: Interest toward shifting

The current fuels used in households also plays an important part in switching to newer technology. In general terms, the households currently relying on the fuelwood or biogas may shift to either ICS, LPG or induction stove, but those using LPG might be interested in shifting to induction stove only. As most of the households are using LPG, the percentage of respondents willing to shift from LPG to induction stove is also higher and was found to be 54.91%. While the interest of other users and their current fuel is shown in Figure 5.12

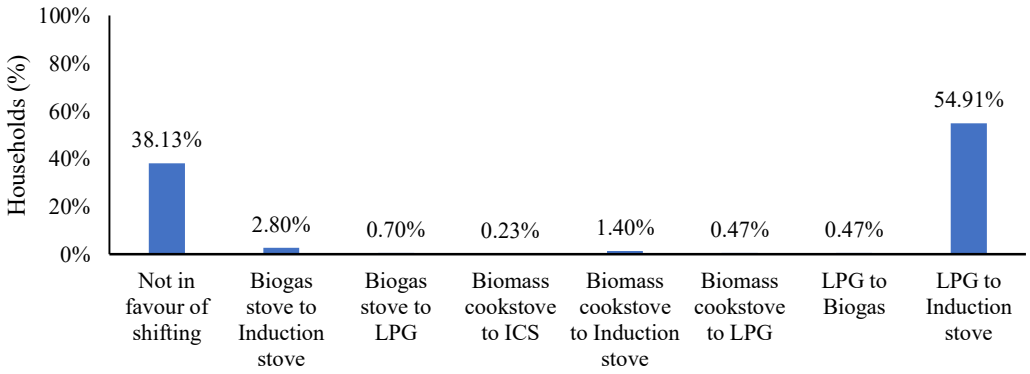


Figure 5.12: Shifting interest of household

The major reasons for the interest toward shifting is due to the various technical, socio cultural and economic reasons. These parameters were further categorized and presented to the respondent. The categorizations are:

- Better technology available in market
- Currently using inefficient stoves,
- Fuel cost of newer technology is cheaper
- Current cooking technologies causes health problem,
- High indoor pollution in current technology
- Newer technology takes less time to cook
- Uses locally produced fuels

During the survey, the respondents were asked to rank their perception on the basis of priority, according to which 49.21% of respondents ranked on the newer technology takes less time to cook as first priority. The other views of respondents is shown in Figure 5.13.

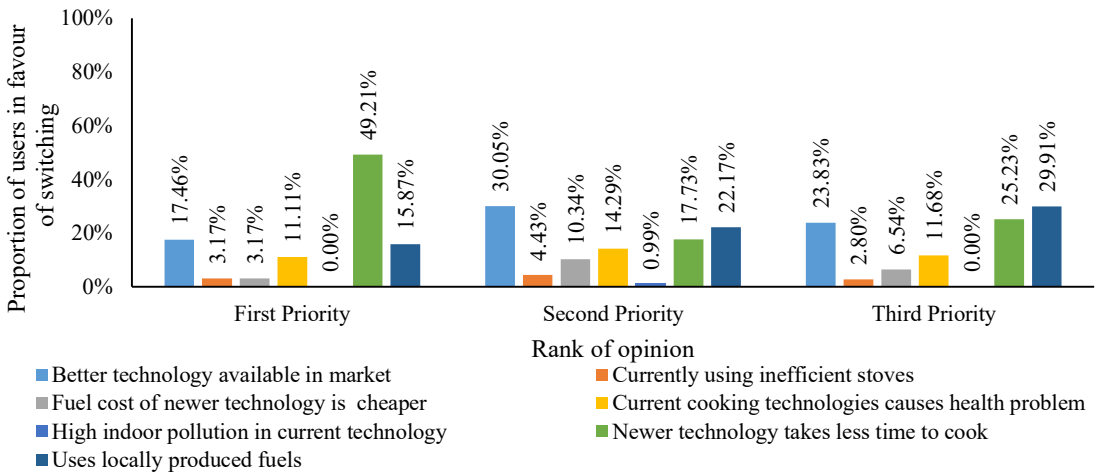


Figure 5.13: Reasons for shifting

In regards to shifting, their plan for the next fifteen years in five years' interval was queried during the survey. As mentioned above, although 38.13% were not in favor of shifting currently, in the upcoming years all of them were planning to use either LPG or electricity or both as cooking fuels. The trend of shifting in five years interval is shown in Figure 5.14.

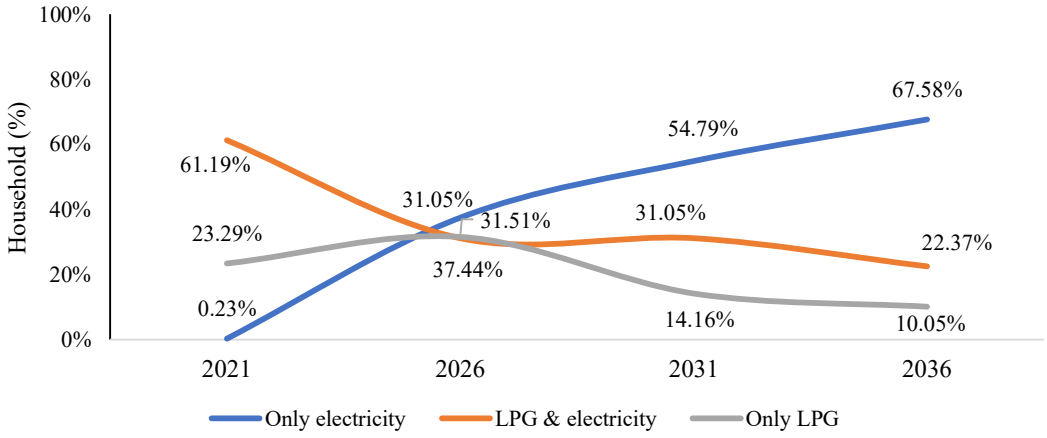


Figure 5.14: shifting trend as per users' response

5.1.5 Barriers identification

The major perception of the users towards not shifting were that, they are using the best technology available, food tastes better in current technology, newer technologies are expensive, no other option available in market, lack of information regarding other technologies, fuel cost for other technologies is high, sociocultural values etc. The 38.13% of the households that were not interested in shifting to other technologies were asked the reasons behind their response. And it was found that most of the respondents assumes that they are using the best technology available, this could be because they are not aware of having better technology. The response of the household is presented in Figure 5.15.

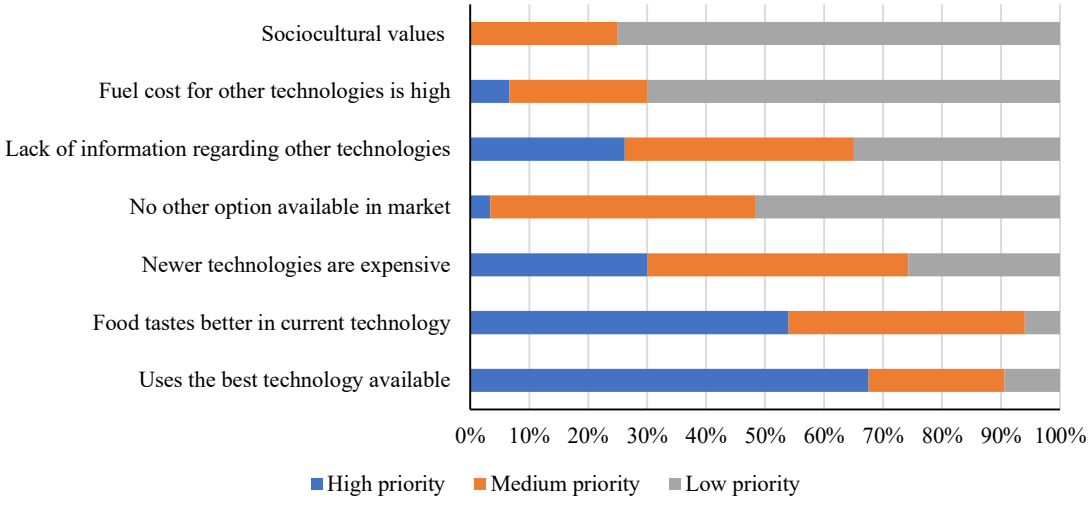


Figure 5.15: Barriers for shifting

Electricity is the only fuels that is produced within the county and does not produce any harmful environmental impact. With the government current policy of shifting 25% of the primary cooking fuels to electricity. The study aims to identify the barriers for shifting to electricity as a fuel for cooking. The major barriers for shifting to electricity for cooking were

- Electric cook stoves and accessories are expensive
- High cost of electricity for cooking as per NEA tariff
- Unstable electricity and frequent power cut off
- Utensils for induction stove are not available
- Shifting to 16A and above electric meters is lengthy process
- Electric technologies are still in testing phase

In this regard, the respondents were asked to prioritize the barriers for shifting from high to low. 60.73% of the respondent said the major barrier was high cost of electricity for cooking as per NEA tariff. Similarly, 18.26% respondent said that the barrier was high cost of stove and accessories and 15.98% said that the electricity supply is not stable. The detail of the responses regarding the barrier is presented in Table 5.2.

Table 5.2: Barriers for promotion of electric cooking

Barriers	Major	Medium	Minor	Manageable
Electric cook stoves and accessories are expensive	18.26%	18.72%	39.27%	22.57%
High cost of electricity for cooking as per NEA tariff	60.73%	14.61%	14.16%	9.47%
Unstable electricity and frequent power cut off	15.98%	47.03%	19.41%	10.44%
Utensils for induction stove are not available	1.60%	11.87%	13.93%	11.65%
Shifting to 16A and above electric meters is lengthy process	0.23%	4.57%	4.79%	32.77%
Electric technologies are still in testing phase	2.97%	2.74%	7.76%	12.14%

For the promotion of electric cooking, distribution and transmission networks should be modified. Although problems occur in many of these due to simultaneous using of electric cooking. A bare minimum for the use of electric cooking especially induction and infrared stoves is the installation of 16A or above fuse rating provided by Nepal Electricity Authority (NEA). But in case of Pokhara Metropolitan City, 28.8% of the households still has 6A fuse which is insufficient for proper operation of induction stove. The fuse rating in the households of Pokhara Metropolitan City is shown in Figure 5.16.

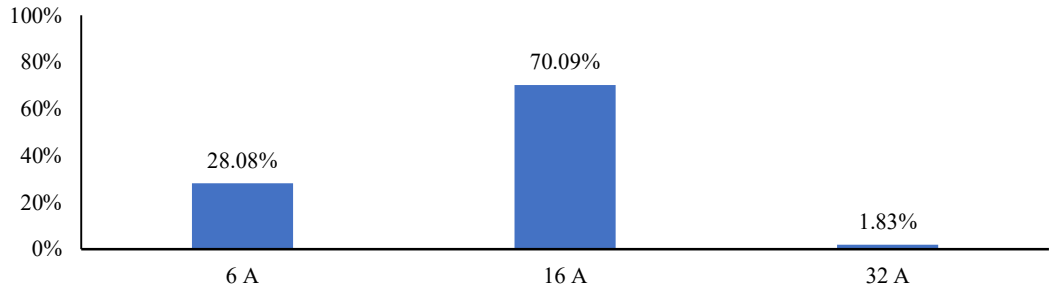


Figure 5.16: Fuse rating in Pokhara Metropolitan City

5.1.6 Cost and emission

There are two components of cost involved with the cooking technology, technology cost and fuel cost. The detail of the cost of different technology is presented in Table 5.4.

Table 5.3: Cost of cooking solution

S.N.	Fuel	Specific energy consumed		Specific cost of fuel	
		Unit	Quantity	Unit	Quantity
1.	Fuelwood	kg/person/month	4.78	NRs./person/month	71.76
2.	LPG	kg/person/month	3.22	NRs./person/month	363.33
3.	Electricity	kWh/person/month	10.96	NRs./person/month	96.40

In addition to the cost of fuel, the technology like LPG requires continuous maintenance. The cost of operation and maintenance based on the study is presented in Table 5.4.

Table 5.4: Cost of cooking solution

S.N.	Technology	Units	Cost involved with stove		
			Initial (NRs.)	O&M (NRs.)	Lifetime (Years)
1.	LPG	Avg.	5,245	6,90	4.7
		Max.	11,000	2,800	18
		Min.	1600	100	1

Glancing at the emission from different fuels, CO_2 emission per kg of fuelwoods in case of Nepal is around 1.88kg CO_2 equivalent (Pokharel and Rijal,2020). Similarly, the CO_2 equivalent emission from 1 cylinder of LPG is around 21.31kg CO_2 equivalent (source). The biogas technology and electric technology are carbon neutral. In case of Pokhara Metropolitan City, the total consumption of fuel wood and LPG is around 29,764 tonnes and 1,412,793 cylinders respectively. As the use of agricultural residue and dung cake is negligible, the emission from those are neglected. Considering these parameters, the total CO_2-eq emission from cooking is around 86,064.36 tonnes. The detail of emission is shown in Table 5.5.

Table 5.5: Emission from cooking fuels

S.N.	Fuel	Total annual consumption	Total CO_2 equivalent emission (tonnes CO_2-eq)
1.	Fuelwood	29,764 tonnes	55,957.73
2.	LPG	1,412,793 cylinders	30,106.63
Total			86,064.36

5.2 Cooking in commercial sector

Cooking in commercial sector uses more convenient and efficient energy than in residential sector as the per capita energy consumption is more. So, almost all commercial sector uses LPG gas for cooking. However, some of them were also using electrical energy as well as traditional fuel for cooking. The main source of energy is therefore considered to be fossil fuel while the use of electrical energy is gradually increasing as it is reliable and cheap source of energy. NEA therefore is upgrading the distribution system by improving the capacity of transformers and feeders.

5.2.1 Status of existing cooking technologies

According to the survey conducted in commercial sector of Pokhara metropolitan city, proportion of commercial entities using LPG stove is 99.33% which indicates that the city is practicing clean fuel which releases less pollutants than traditional fuel. While the use of electricity is also increasing these days, 53.44% of commercial sector use rice cooker, 29.49% use electric oven and 6.43% use Induction for cooking. The other cooking technologies being used in commercial sector of Pokhara are Biomass, Biogas, etc. The details of cooking technologies of commercial sector in Pokhara is shown in Figure 5.17.

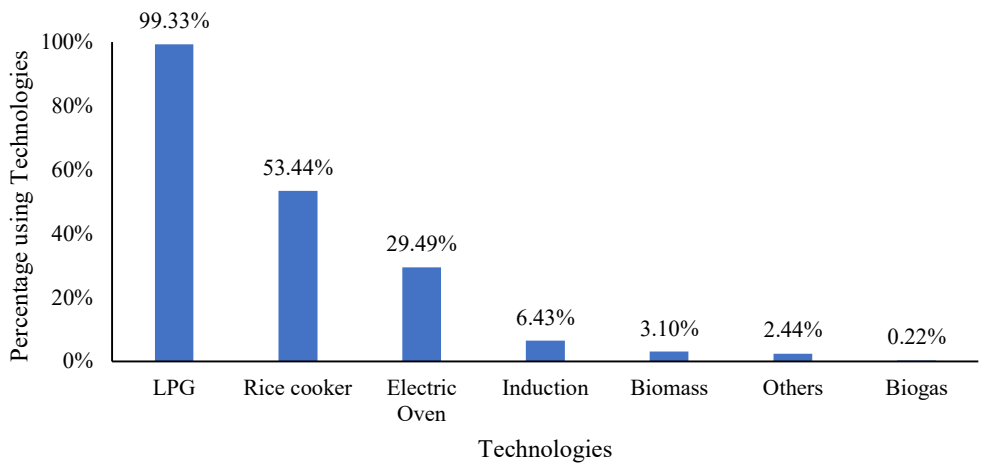


Figure 5.17: Cooking technologies of commercial sector in Pokhara

In regards to cooking fuel, most of the commercial sector are using LPG as the primary source of fuel. 99.33% of total commercial sector in Pokhara uses LPG as their main source of cooking fuel while 66.30% also uses electricity for cooking purpose. The other fuels such as fuelwood, briquette is also being used in this sector as shown in Figure 5.18.

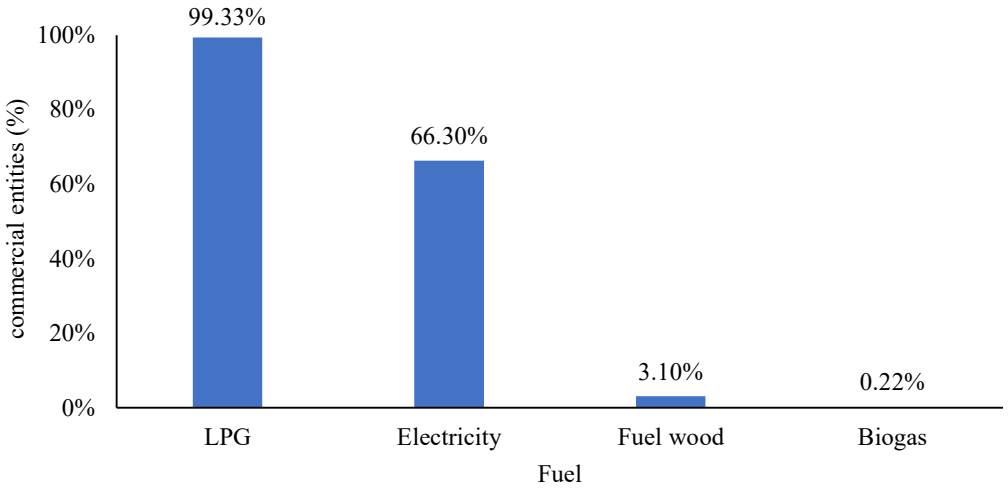


Figure 5.18: Cooking fuel in commercial sector of Pokhara

In Pokhara, 32.37% of the commercial entities uses one stove i.e. LPG stove (32.15%), biomass cook stove (0.22%), 55.88% of commercial sector uses two different technologies stove and 22.84% uses more than two technologies stove. Based on fuels, 32.37% of the commercial entities uses one fuel i.e. LPG (32.15%) and fuelwood (0.22%). Similarly, 66.30% of commercial sectors are using two different fuels for cooking purpose and 1.33% uses three or more fuels.

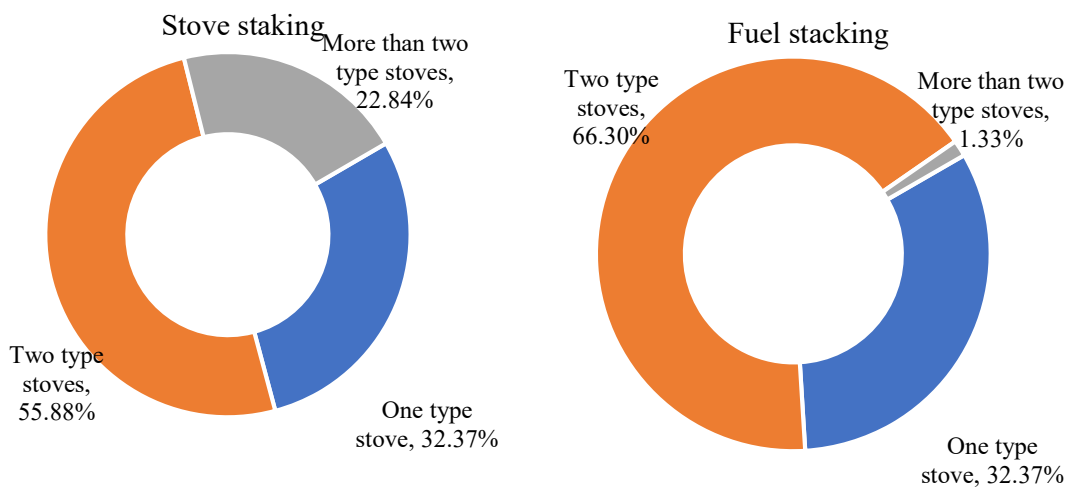


Figure 5.19: Stacking of cooking technology

The various combination of technologies being used in commercial sector of Pokhara is shown in Table 5.6. Based on stoves, LPG stove with rice cooker has the highest share at 31.26% followed by LPG, rice cooker and electric oven at 15.74% and LPG stove and rice cooker at 11.31%. Other combinations used are marginal and used in specific commercial entities

Table 5.6: Combination of stoves in commercial sector of Pokhara

Primary Technology	**Secondary Technology**	**Tertiary Technology**	**Share (%)**
LPG stove	Induction stove		0.67%
LPG stove	Electric oven		11.31%
LPG stove	Rice cooker		31.26%
Biogas stove	LPG stove		0.22%
Biomass cook stoves	LPG stove		1.11%
Biomass cook stoves	Rice cooker		0.22%
LPG	Biomass cook stoves	Rice cooker	1.33%
LPG	Induction stove	Rice cooker	4.21%
LPG	Electric oven	Rice cooker	15.74%
LPG	Induction stove	Electric oven	1.33%
LPG	Biomass cook stoves	Induction stove & Rice cooker	0.22%

As there is fuel stacking, use of more than one fuel with different combination is detected. In commercial sector, almost all are using LPG as their main source of fuel and the other sources of fuel such as fuelwood, electricity etc are combined with LPG as the secondary source of fuel. Figure 5.6 illustrates the detail of combination of fuel in commercial sector of Pokhara.

Table 5.7: Combination of fuel in commercial sector of Pokhara

Primary Fuel	**Secondary Fuel**	**Tertiary Fuel**	**Percentage**
Fuelwood	Electricity		0.22
Biogas	Electricity		0.22
Fuelwood	LPG		1.33

Primary Fuel	Secondary Fuel	Tertiary Fuel	Percentage
LPG	Electricity		64.52
LPG	Fuelwood	Electricity	1.33

Looking at the primary technology for cooking, LPG stove as well as LPG as fuel has the highest share at 98.45%.the detail of the primary cooking technologies by stove and fuels is shown in Figure 5.20.

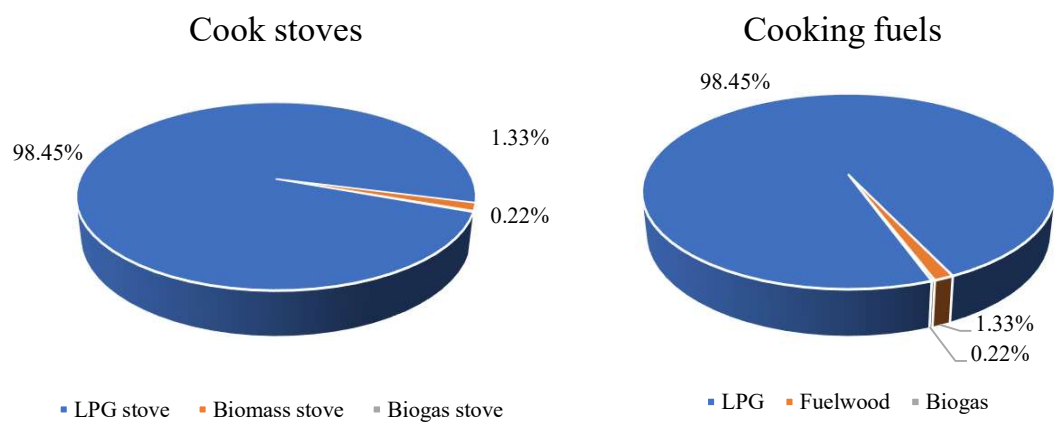


Figure 5.20: Primary cooking Technologies

5.2.2 Status of kitchen

Although in households, indoor cooking without any exhaust is extremely common, in commercial sector indoor cooking with exhaust is most practiced. In Pokhara metropolitan city commercial sector, 85.08% of kitchen status practices indoor cooking with exhaust while 14.48% of kitchen are indoor without exhaust. The remaining 0.45% kitchen are outdoor type. This indicates that cooking technologies of commercial sector of Pokhara are having awareness on their heath issue.

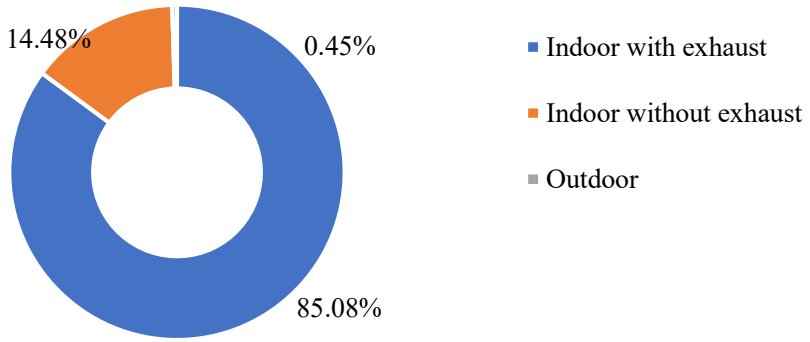


Figure 5.21: Type of kitchen

5.2.3 Energy consumption for cooking in Commercial sector

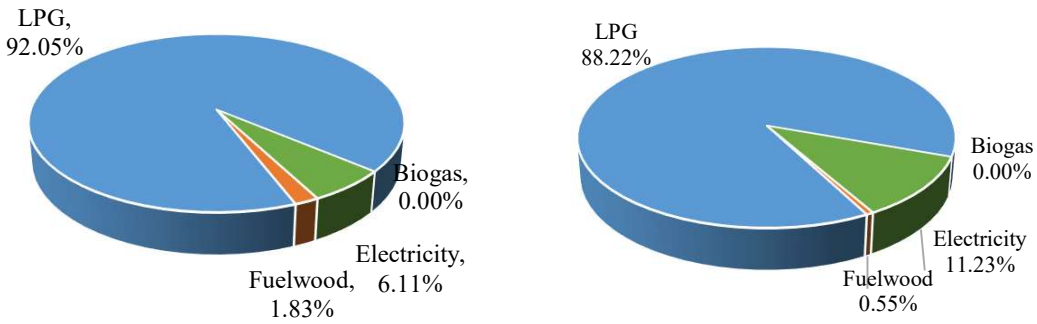
As in most of the commercial sector LPG is the primary fuel so the final energy consumption of LPG is determined to be higher. Table 5.8 shows the Energy consumption in commercial sector of Pokhara. The total energy consumption is 520.71 TJ in which LPG, Fuelwood,

Electricity consumption is 479.30 TJ, 9.55 TJ and 31.84 TJ respectively and the specific energy consumption is 94.37 GJ/commercial entities.

Table 5.8: Energy consumption in commercial sector of Pokhara

S.N.	Fuel type	Final Energy (TJ)	Average efficiency (%)	Useful energy (TJ)
1	Fuelwood	9.5	15	1.43
2	LPG	479.30	48	230.06
3	Biogas	0.017	37	0.01
4	Electricity	31.84	92	29.29
Total		520.71	50.6	260.79
Population		195,054		
Specific energy consumption		96.37 GJ/capita		48.27 GJ/capita

Hence the total energy consumption in Pokhara is 520.71 TJ and the specific energy consumption i.e. energy consumption per capita is 96.37 GJ/capita. The energy equivalent of cooking fuel used for cooking is called final energy while the amount of energy that is actually used for cooking is called useful energy. The figure below compares the final energy with the useful energy.



Final Energy: 520.71 TJ

Useful Energy: 260.79 TJ

Figure 5.22: Final energy and Useful energy consumed in commercial sector of Pokhara

Figure 5.23 represents the user's perception towards the current technology. As most of the commercial sector are using LPG fuel for cooking purpose, they are not facing the health problems during cooking since it does not produce more indoor pollution. The consumption of time for cooking is also considered to be less by most of the commercial sector as compare to traditional cooking system.

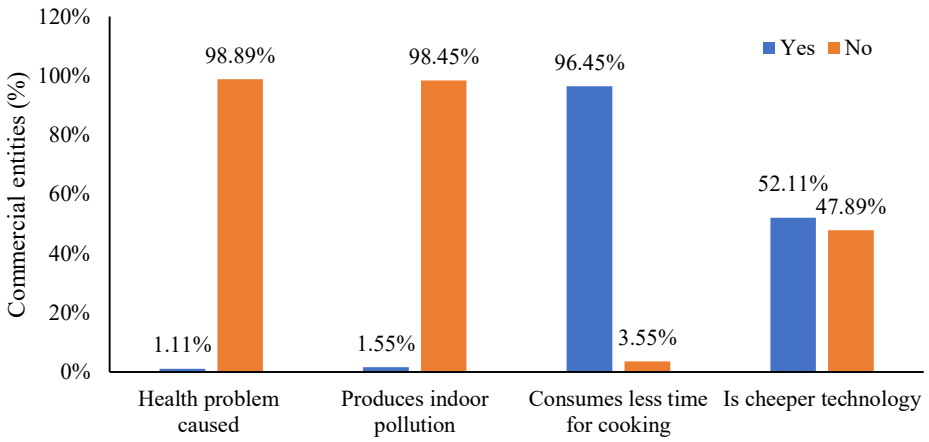


Figure 5.23: Users perception towards current technology

5.2.4 Willing to switching clean technologies

During the survey, the interest towards switching to another technologies is also viewed in which only 65.01% of total population were seem to be in favor of switching while the remaining percentage were not in favor of switching due to various reasons. Among them most of the people were interested to switch into electricity as shown in Figure 5.24.

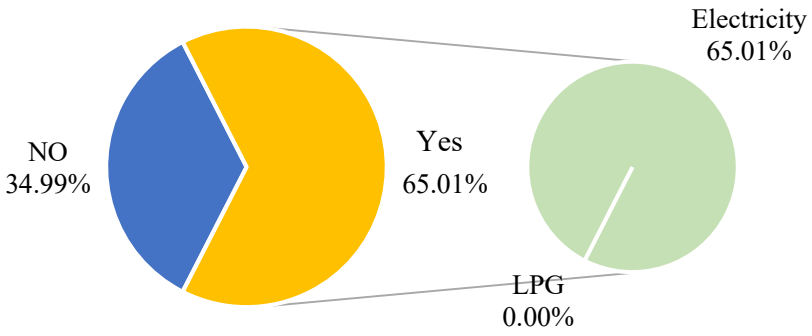


Figure 5.24: Interest towards shifting

The shifting interest of the users' is also affected by the current technologies that is being used. The detail of the shifting and current technologies used is presented in Figure 4.25.

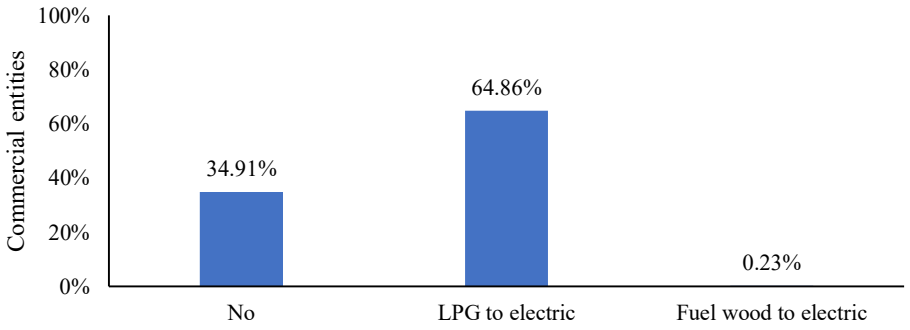


Figure 5.25: Shifting interest of commercial sector

Figure 5.26 illustrates the major reasons for sifting towards other technology. This shows that the major reason for most of the commercial sectors who wants to switch their cooking technology is availability of newer technology that takes less time to cook and better technology available in the market.

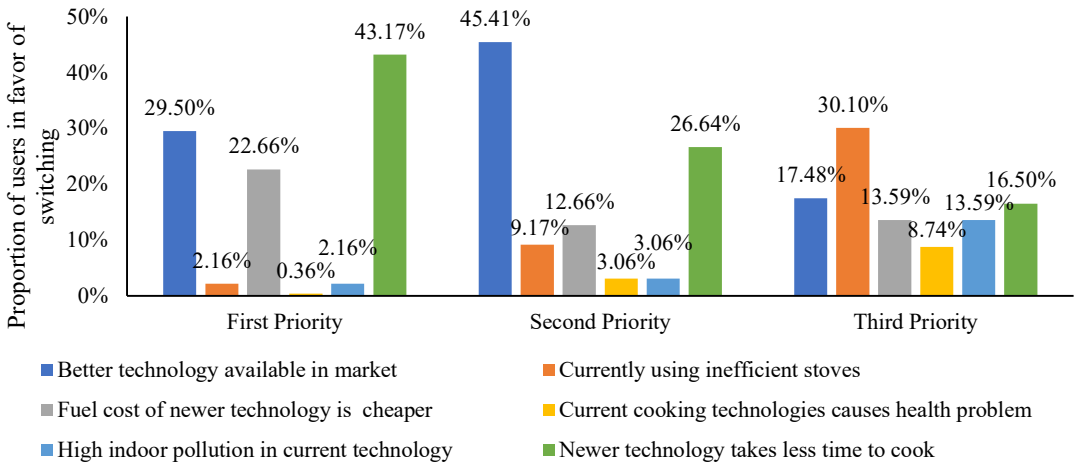


Figure 5.26: Reasons for shifting towards other technologies

In long term, the users shall also shift to various technology. The long term plan based on users response is shown in Figure 5.27.

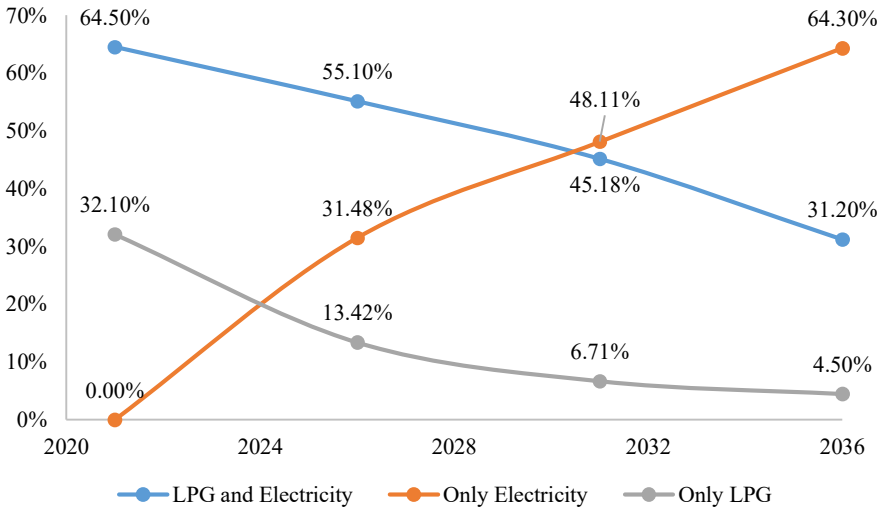


Figure 5.27: Shifting to clean technology

5.2.5 Barriers identification

Although there are benefits on switching towards the newer technologies there are some barriers that do not let many commercial sectors to switch their technology. Some of the perception of users towards not shifting is shown in Figure 5.28.

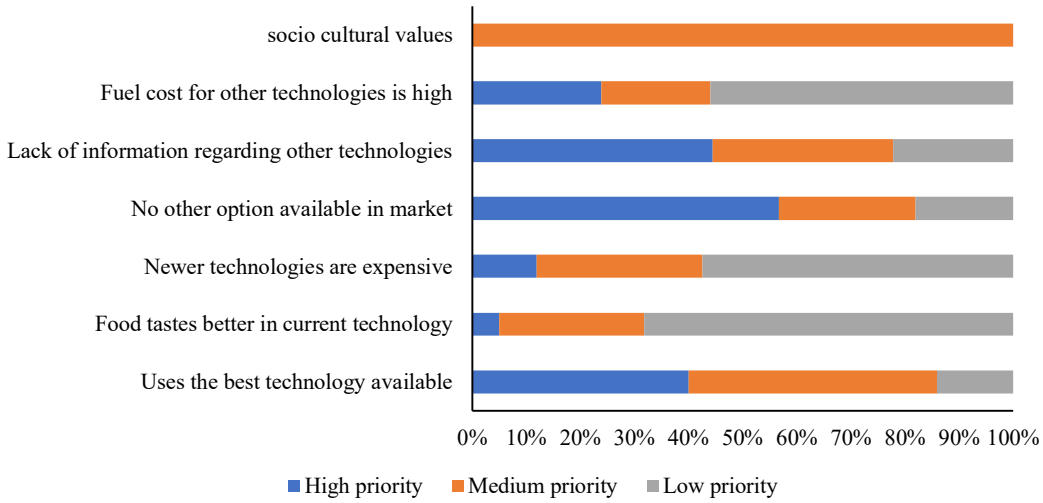


Figure 5.28: Reasons for not shifting to other technologies

Electricity is the only fuels that is produced within the county and does not produce any harmful environmental impact. With the government current policy of shifting 25% of the primary cooking fuels to electricity. The study aims to identify the barriers for shifting to electricity as a fuel for cooking. The major barriers for shifting to electricity for cooking were

- Electric cook stoves and accessories are expensive
- High cost of electricity for cooking as per NEA tariff
- Unstable electricity and frequent power cut off
- Utensils for induction stove are not available
- Shifting to 16A and above electric meters is lengthy process
- Electric technologies are still in testing phase

The detail of the responses regarding the barrier is presented in Table 5.9.

Table 5.9: Barriers for promotion of electric cooking

Barriers	Major	Medium	Minor	Manageable
Electric cook stoves and accessories are expensive	6.59%	12.05%	15.23%	13.86%
High cost of electricity for cooking as per NEA tariff	60.23%	25.23%	23.18%	18.18%
Unstable electricity and frequent power cut off	20.23%	46.82%	20.91%	16.59%
Utensils for induction stove are not available	9.55%	11.14%	12.05%	17.05%
Shifting to 16A and above electric meters is lengthy process	0.91%	1.59%	15.00%	25.00%
Electric technologies are still in testing phase	2.50%	3.18%	13.64%	9.32%

As in future, most of the commercial sector are in favor of switching towards electric technology but 1.77% of commercial sector were using 6A fuse and 29.05% were using 16A fuse which is insufficient for proper operation of newer electric technologies. Also, the use of electric technology will increase in future. So the main barrier for switching towards electric technology is fuse rating. The main reason of having 6A fuse in commercial sector is when doing the survey, the small commercial organizations such as hotels and tea shops were also visited and most of them were established in the residential building. However, 17.52% of commercial entities are having three phase supply.

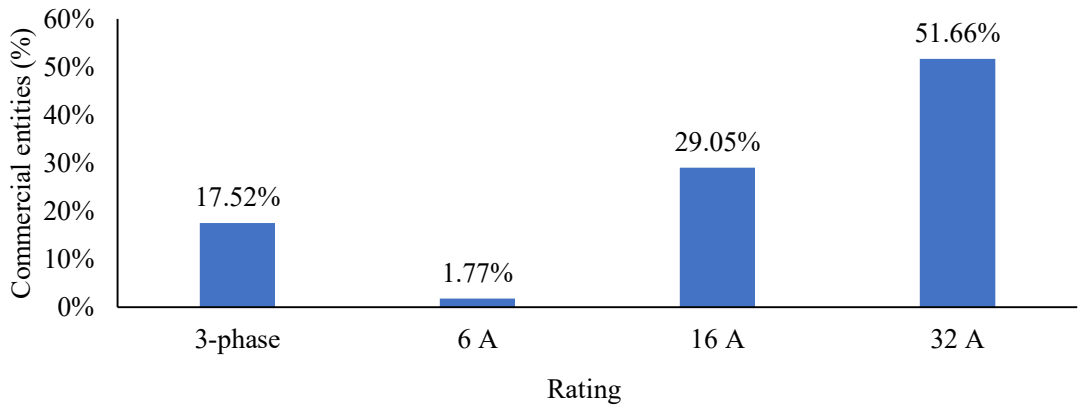


Figure 5.29: Fuse rating in commercial sector of Pokhara

5.2.6 Cost and emission

There are two components of cost involved with the cooking technology, technology cost and fuel cost. The detail of the cost of different technology is presented in Table 5.10.

Table 5.10: Cost of cooking solution

S.N.	Fuel	Specific energy consumed		Specific cost of fuel	
		Unit	Quantity	Unit	Quantity
1.	Fuelwood	kg/person/month	10.32	NRs./person/month	154.78
2.	LPG	kg/person/month	164.28	NRs./person/month	18510.17
3.	Electricity	kWh/person/month	136.41	NRs./person/month	2074.20

In addition to the cost of fuel, the technology like LPG requires continuous maintenance. The cost of operation and maintenance based on the study is presented in Table 5.11.

Table 5.11: Cost of cooking solution

S.N.	Technology	Units	Cost involved with stove		
			Initial (NRs.)	O&M (NRs.)	Lifetime (Years)
1.	LPG	Avg.	5230	995	4.7
		Max.	9500	3000	15
		Min.	1000	100	1

In case of Nepal, the CO_2 emission per kg of fuelwood is around 1.88kg of CO_2 equivalent and emission from 1 cylinder of LPG is around 21.31kg of CO_2 equivalent. Commercial sector of Pokhara consumes 856 tonnes of fuelwood and 750,075 cylinders of LPG form which the total

CO_2 emission is around 17,633.83 tonnes of CO_2 equivalent. Table 5.12 illustrates the total CO_2 equivalent emission from fuelwood and LPG.

Table 5.12: Emission from cooking fuels

SN	Fuel	Total annual consumption	Total CO_2 equivalent emission (tonnes CO_2-eq)
1	Fuelwood	856 tonnes	1,616.13
2	LPG	750,071 cylinders	15,984.01
Total			17,600.14

CHAPTER SIX : ENERGY DEMAND FORECASTING

To forecast the energy demand of cooking sectors of Pokhara and Butwal two scenarios has been considered namely business as usual and shifting scenario. To determine the energy demand, various assumptions were developed. In order to determine the energy consumption of different fuels, energy intensity i.e. specific energy consumption was used. The methodology adopted for the calculation of energy demand for cooking is shown in

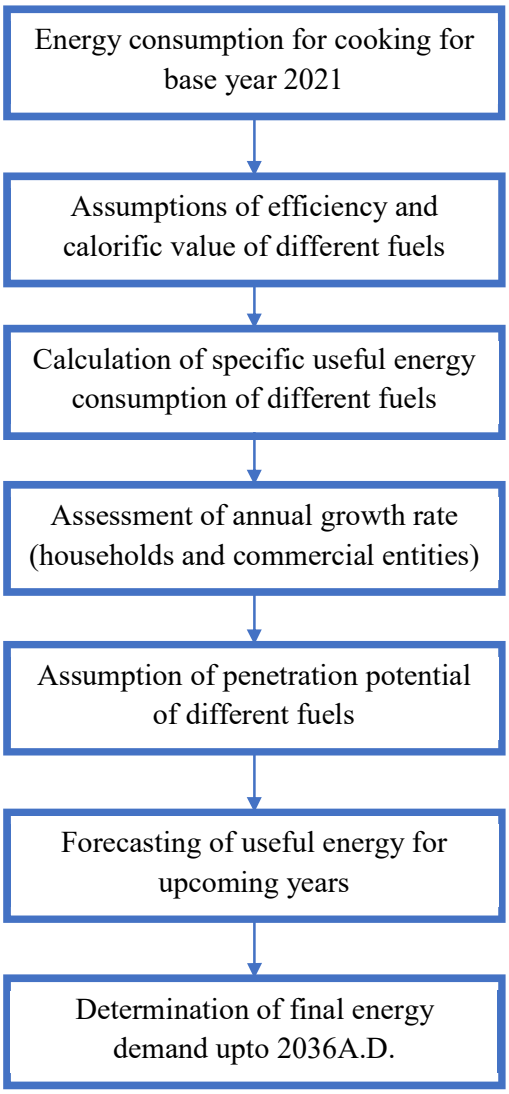


Figure 6.1: Methodology for energy demand forecasting

The annual growth of households is considered according to the preliminary report of census 2021. As the major basis of energy calculation is cooking, the growth rate for food and accommodation in commercial sector is considered same as that of residential sector. The annual growth rate is shown in Table 6.1.

Table 6.1: Annual growth rate

S.N.	Sector	City	Annual growth rate (2021-2036)
1.	Residential	Lekhnath Pokhara Metropolitan City	3.09%
		Butwal Sub-Metropolitan City	4.13%
2.	Commercial	Lekhnath Pokhara Metropolitan City	3.09%
		Butwal Sub-Metropolitan City	4.13%

6.1 Butwal Sub Metropolitan City

6.1.1 Business as usual

In this scenario, the trend of cooking fuels is assumed to be same for the upcoming years. i.e. penetration of fuels is same. Also, the total energy demand for cooking in expected to grow from 624.89 TJ in 2021 A.D to 1146.41 TJ in 2036 A.D. The average annual growth rate for energy demand for cooking is expected to grow at 4.13%. The penetration of different fuels in final energy and useful energy is shown in Table 6.2.

Table 6.2: Fuel penetration in residential sector of Butwal

S.N.	Fuel	Penetration of fuels in % (2021-2036)	
		Final energy	Useful energy
Residential sector			
1.	LPG	57.12%	67.50%
2.	Biogas	0.15%	0.13%
3.	Electricity	8.75%	19.82%
4.	Biomass	33.98%	12.55%
Commercial sector			
1.	LPG	89.11%	86.56%
2.	Biogas	0.00%	0.00%
3.	Electricity	6.50%	12.11%
4.	Biomass	4.39%	1.33%

Based on this energy consumption for cooking in residential sector is forecasted to become 996.26 TJ in 2036 A.D from 543.03 TJ in 2021 A.D. The share of different fuels used for cooking in final energy demand for residential sector is shown in Table 6.3.

Table 6.3: Final energy demand in residential sector of Butwal

S.N.	Fuel	Final energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	310.20	379.74	464.88	569.10
2.	Biogas	0.80	0.98	1.20	1.47
3.	Electricity	47.53	58.19	71.23	87.20
4.	Biomass	184.50	225.86	276.50	338.49
5.	Total	543.03	664.77	813.81	996.26

Similarly, in case of commercial sector, the energy demand for cooking is forecasted to become 150.15 TJ in 2036 A.D. from 81.85 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for commercial sector is shown in Table 6.4.

Table 6.4: Energy demand in commercial sector of Butwal

S.N.	Fuel	Energy demand (TJ)			
		2021	2025	2031	2036
1.	LPG	72.94	89.29	109.30	133.80
2.	Biogas	0.00	0.00	0.00	0.00
3.	Electricity	5.32	6.52	7.98	9.76
4.	Biomass	3.59	4.40	5.38	6.59
5.	Total	81.85	100.20	122.66	150.15

The overall share of different fuels used for cooking in Butwal Sub-Metropolitan City is assumed to stay constant throughout the forecasted period. The overall final energy demand for cooking in Butwal Sub-Metropolitan City is expected to become 1166.97 TJ in 2036 A.D. from 636.10 TJ in 2021 A.D. The trend of change of final energy from is shown in Figure 6.2.

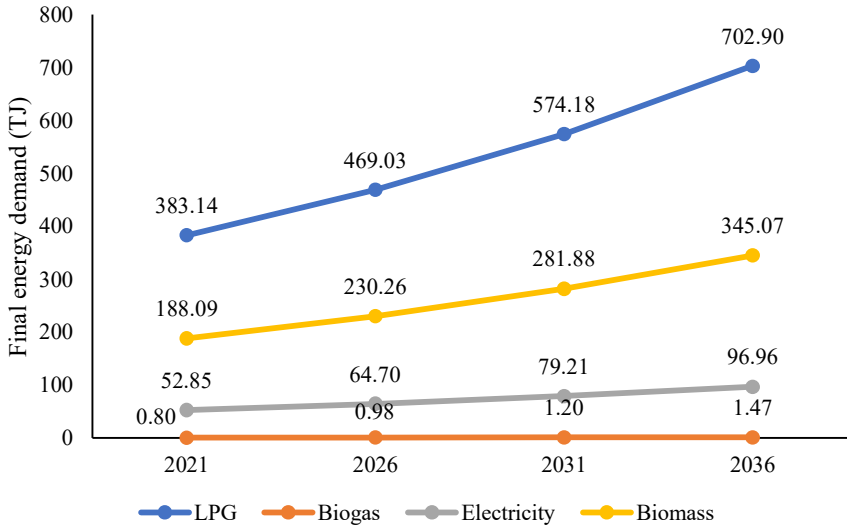


Figure 6.2: Final energy demand projection of Butwal Sub-Metropolitan City

Useful energy is the energy that is actually used for cooking. It considers the efficiency and losses associated with the technology. Hence it can be used as a better tool for estimation of energy requirement in future. The overall useful energy in case of Butwal Sub-Metropolitan City is expected to become 478.90 TJ. The trend of useful energy in Butwal Sub-Metropolitan City is shown in Figure 6.3.

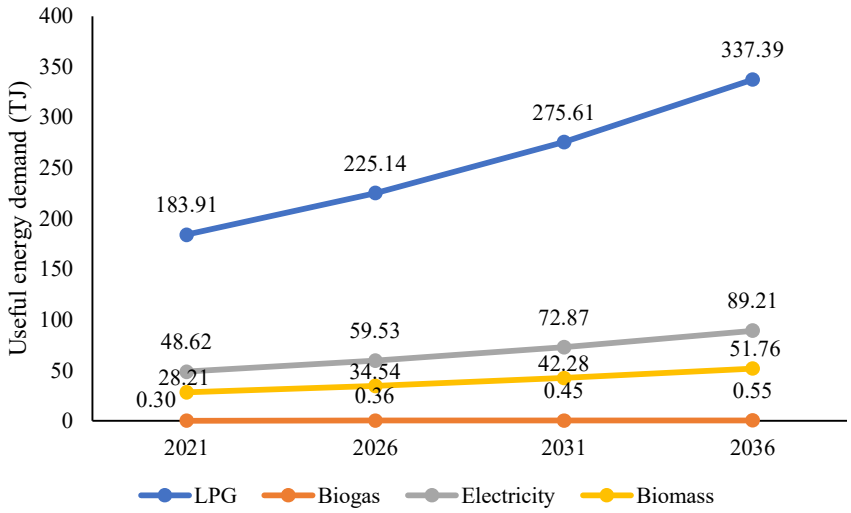


Figure 6.3: Useful energy demand projection of Butwal Sub-Metropolitan City

6.1.2 Shifting scenario

The total energy demand for cooking in expected to grow from 630 GJ to 740TJ. The average annual growth rate for energy demand for cooking is expected to grow at 4.13 %. The shifting scenario has been developed by changing the penetration of different fuels in the useful energy demand. The various assumptions made for the forecasting of energy demand in this scenario are:

- Penetration of electricity in useful energy demand becomes 60%
- Share of biomass in useful energy demand decreases to 1%
- Share of biogas in useful energy demand increases to 0.2%
- Share of LPG in useful energy demand decreases to 38.8%

Based on above mentioned assumption the penetration of different fuels in final energy and useful energy is shown in Table 6.2.

Table 6.5: Fuel penetration in residential sector of Butwal

S.N.	Fuel	Penetration of fuels (%)							
		Final energy demand				Useful energy demand			
		2021	2026	2031	2036	2021	2026	2031	2036
Residential sector									
1.	LPG	57.12%	55.75%	54.77%	52.74%	67.50%	57.15%	49.80%	38.80%
2.	Biogas	0.15%	0.20%	0.25%	0.35%	0.13%	0.15%	0.17%	0.20%
3.	Electricity	8.75%	17.38%	25.54%	42.55%	19.82%	34.15%	44.51%	60.00%
4.	Biomass	33.98%	26.68%	19.44%	4.35%	12.55%	8.55%	5.52%	1.00%
Commercial sector									
1.	LPG	89.11%	78.70%	66.92%	52.74%	86.56%	70.00%	54.38%	38.80%
2.	Biogas	0.00%	0.10%	0.21%	0.35%	0.00%	0.07%	0.13%	0.20%
3.	Electricity	6.50%	16.85%	28.50%	42.55%	12.11%	28.72%	44.38%	60.00%
4.	Biomass	4.39%	4.35%	4.37%	4.35%	1.33%	1.21%	1.11%	1.00%

Based on this energy consumption for cooking in residential sector is forecasted to become 620.25 TJ in 2036 A.D from 543.03 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for residential sector is shown in Table 6.3.

Table 6.6: Final energy demand in residential sector of Butwal

S.N.	Fuel	Final energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	310.20	321.51	342.97	327.14
2.	Biogas	0.80	1.13	1.55	2.19
3.	Electricity	47.53	100.25	159.93	263.94
4.	Biomass	184.50	153.86	121.73	26.98
5.	Total	543.03	576.75	626.17	620.25

Although the final energy demand of LPG increases initially, the share of LPG decreases continuously, this is due to the increase in number of households. Similarly, the final energy demand decrease in 2036. This is because the penetration of electricity finally overtakes LPG. And as the efficiency of electricity as fuel is higher, the overall energy demand decreases.Similarly, in case of commercial sector, the energy demand for cooking is forecasted to become 113.71 TJ in 2036 A.D. from 81.85 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for commercial sector is shown in Table 6.4.

Table 6.7: Energy demand in commercial sector of Butwal

S.N.	Fuel	Final Energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	72.94	72.21	68.67	59.97
2.	Biogas	0.00	0.09	0.21	0.40
3.	Electricity	5.32	15.46	29.24	48.39
4.	Biomass	3.59	3.99	4.49	4.95
5.	Total	81.85	91.75	102.60	113.71

The overall final energy demand for cooking in Butwal Sub-Metropolitan City is expected to become 733.96 TJ in 2036 A.D. from 624.89 TJ in 2021 A.D. The trend of change of final energy is shown in Figure 6.2.

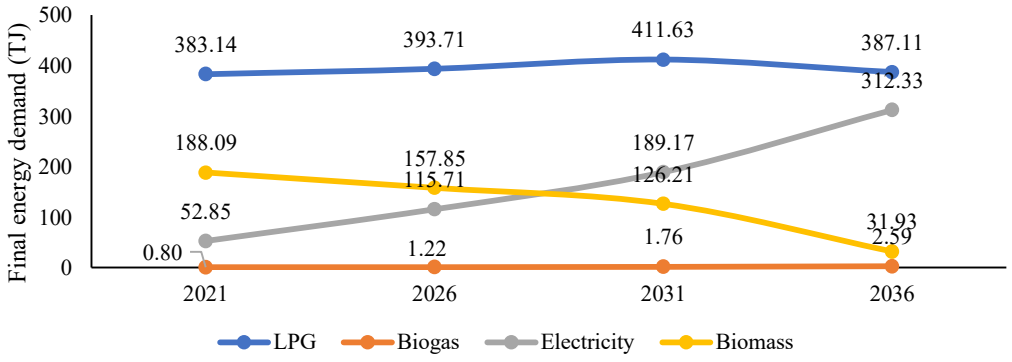


Figure 6.4: Final energy demand projection of Butwal Sub-Metropolitan City

Useful energy is the energy that is actually used for cooking. It considers the efficiency and losses associated with the technology. Hence it can be used as a better tool for estimation of energy requirement in future. The overall useful energy in case of Butwal Sub-Metropolitan City is expected to become 478.90 TJ in 2036. The trend of useful energy in Butwal Sub-Metropolitan City is shown in Figure 6.3.

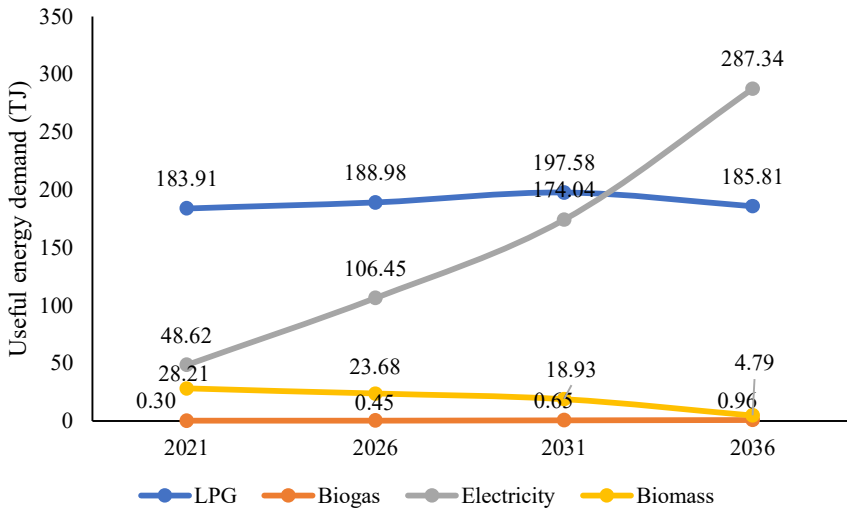


Figure 6.5: Useful energy demand projection of Butwal Sub-Metropolitan City

6.2 Pokhara Metropolitan City

6.2.1 Business as usual

In this scenario, the trend of cooking fuels is assumed to be same for the upcoming years. i.e. penetration of fuels is same. Also, the total energy demand for cooking in expected to grow from 636.10 TJ in 2021 A.D to 1166.97 TJ in 2036 A.D. The average annual growth rate for energy demand for cooking is expected to grow at 3.09 %. The penetration of different fuels in final energy and useful energy is shown in Table 6.8.

Table 6.8: Fuel penetration in residential sector of Pokhara

S.N.	Fuel	Penetration of fuels in % (2021-2036)	
		Final energy	Useful energy
Residential sector			
1.	LPG	56.92%	59.51%
2.	Biogas	0.95%	0.77%
3.	Electricity	15.48%	31.02%
4.	Biomass	26.65%	8.71%
Commercial sector			
1.	LPG	92.05%	88.22%
2.	Biogas	0.0033%	0.0025%
3.	Electricity	6.11%	11.23%
4.	Biomass	1.83%	0.55%

Based on this energy consumption for cooking in residential sector is forecasted to become 2,501.73 TJ in 2036 A.D from 1585.97 TJ in 2021 A.D. The share of different fuels used for cooking in final energy demand for residential sector is shown in Table 6.3.

Table 6.9: Final energy demand in residential sector of Pokhara

S.N.	Fuel	Final energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	902.76	1050.88	1223.31	1424.03
2.	Biogas	15.06	17.53	20.40	23.75
3.	Electricity	245.50	285.78	332.67	387.26
4.	Biomass	422.65	492.00	572.72	666.70
5.	Total	1585.97	1846.19	2149.11	2501.73

Similarly, in case of commercial sector, the energy demand for cooking is forecasted to become 822.06 TJ in 2036 A.D. from 520.71 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for commercial sector is shown in Table 6.4.

Table 6.10: Final Energy demand in commercial sector of Pokhara

S.N.	Fuel	Final Energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	479.30	558.09	649.85	756.68
2.	Biogas	0.02	0.02	0.02	0.03
3.	Electricity	31.84	37.08	43.17	50.27
4.	Biomass	9.55	11.12	12.95	15.08
5.	Total	520.71	606.31	705.99	822.06

The overall share of different fuels used for cooking in Pokhara Metropolitan City is assumed to stay constant throughout the forecasted period. The overall final energy demand for cooking in Pokhara Metropolitan City is expected to become 3323.79 TJ in 2036 A.D. from 2106.67 TJ in 2021 A.D. The trend of change of final energy from is shown in Figure 6.2.

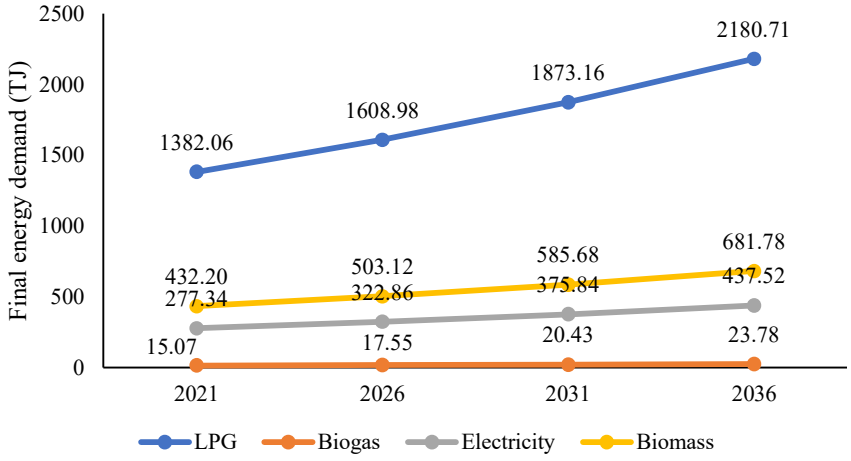


Figure 6.6: Final energy demand projection of Pokhara Metropolitan City

Useful energy is the energy that is actually used for cooking. It considers the efficiency and losses associated with the technology. Hence it can be used as a better tool for estimation of energy requirement in future. The overall useful energy in case of Pokhara Metropolitan City is expected to become 848.00TJ. The trend of useful energy in Pokhara Metropolitan City is shown in Figure 6.3.

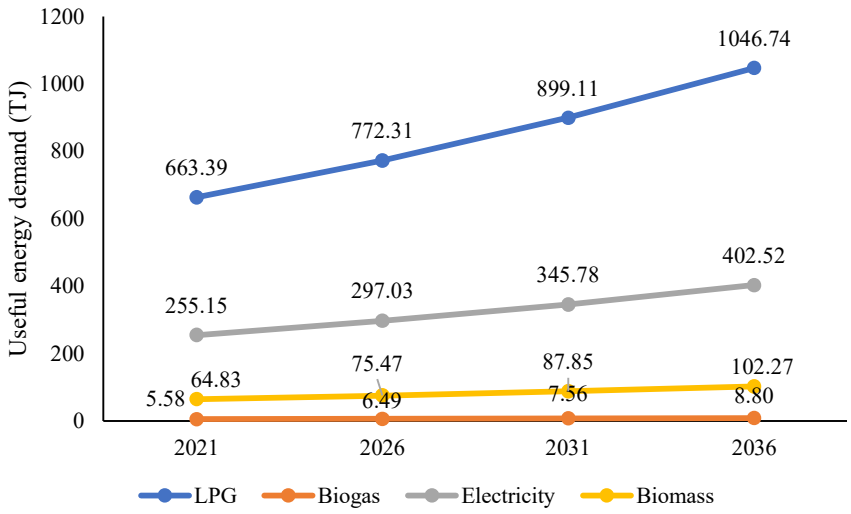


Figure 6.7: Useful energy demand projection of Pokhara Metropolitan City

6.2.2 Shifting scenario

The total energy demand for cooking in expected to grow from 630 GJ to 740TJ. The average annual growth rate for energy demand for cooking is expected to grow at 4.13 %. The shifting scenario has been developed by changing the penetration of different fuels in the useful energy demand. The various assumptions made for the forecasting of energy demand in this scenario are:

- Penetration of electricity in useful energy demand becomes 60%
- Share of biomass in useful energy demand decreases to 1% in residential and 0.2% in commercial sector
- Share of biogas in useful energy demand increases to 0.2% in residential and 1% in commercial sector
- Share of LPG in useful energy demand decreases to 38.8%

Based on above mentioned assumption the penetration of different fuels in final energy and

Table 6.11: Fuel penetration of Pokhara

S.N.	Fuel	Penetration of fuels (%)							
		Final energy demand				Useful energy demand			
		2021	2026	2031	2036	2021	2026	2031	2036
Residential sector									
1.	LPG	56.92%	56.11%	55.12%	53.86%	59.51%	52.58%	45.68%	38.80%
2.	Biogas	0.95%	1.18%	1.44%	1.80%	0.77%	0.85%	0.92%	1.00%

S.N.	Fuel	Penetration of fuels (%)							
		Final energy demand				Useful energy demand			
		2021	2026	2031	2036	2021	2026	2031	2036
3.	Electricity	15.48%	22.66%	31.70%	43.45%	31.02%	40.70%	50.36%	60.00%
4.	Biomass	26.65%	20.05%	11.74%	0.89%	8.71%	5.87%	3.04%	0.20%
Commercial sector									
1.	LPG	92.05%	81.20%	68.86%	53.86%	88.22%	71.14%	54.95%	38.80%
2.	Biogas	0.003%	0.49%	1.09%	1.80%	0.002%	0.33%	0.67%	1.00%
3.	Electricity	6.11%	16.74%	28.81%	43.45%	11.23%	28.10%	44.07%	60.00%
4.	Biomass	1.83%	1.57%	1.24%	0.89%	0.55%	0.43%	0.31%	0.20%

Based on this energy consumption for cooking in residential sector is forecasted to become 1723.9 TJ in 2036 A.D from 1585.97 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for residential sector is shown in Table 6.3.

Table 6.12: Final energy demand in residential sector of Pokhara

S.N.	Fuel	Final energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	902.76	928.51	939.02	928.46
2.	Biogas	15.06	19.47	24.53	31.04
3.	Electricity	245.50	374.98	540.11	749.09
4.	Biomass	422.65	331.71	199.97	15.31
5.	Total	1585.97	1654.67	1703.64	1723.90

Although the final energy demand of LPG increases initially, the share of LPG decreases continuously, this is due to the increase in number of households. Similarly, the final energy demand decreases in 2036. This is because the penetration of electricity finally overtakes LPG. And as the efficiency of electricity as fuel is higher, the overall energy demand decreases.

Similarly, in case of commercial sector, the energy demand for cooking is forecasted to become 617.95 TJ in 2036 A.D. from 520.71 TJ in 2021 A.D. The share of different fuels used for cooking in energy demand for commercial sector is shown in Table 6.4.

Table 6.13: Energy demand in commercial sector of Pokhara

S.N.	Fuel	Final Energy demand (TJ)			
		2021	2026	2031	2036
1.	LPG	479.30	450.00	404.79	332.81
2.	Biogas	0.02	2.71	6.40	11.13
3.	Electricity	31.84	92.75	169.38	268.52
4.	Biomass	9.55	8.71	7.31	5.49
5.	Total	520.71	554.17	587.88	617.95

The overall final energy demand for cooking in Pokhara Metropolitan City is expected to become 2341.85 TJ in 2036 A.D. from 2106.68 TJ in 2021 A.D. The trend of change of final energy is shown in Figure 6.2.

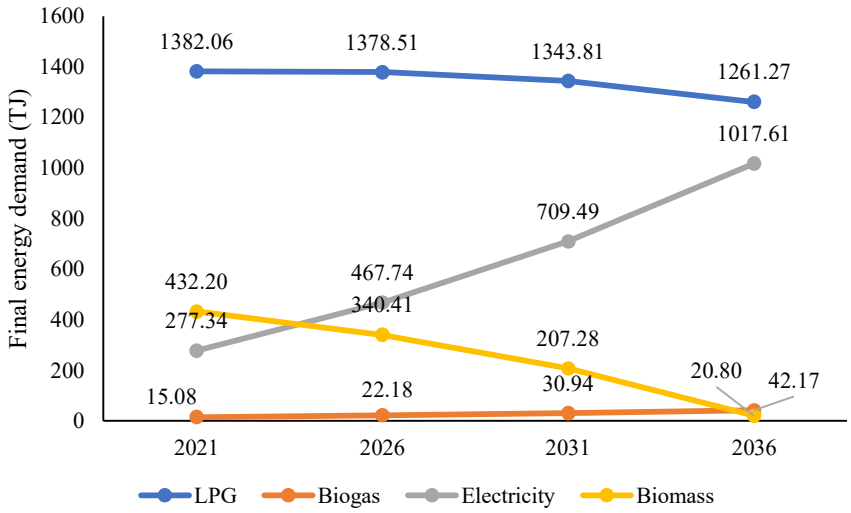


Figure 6.8: Final energy demand projection of Pokhara Metropolitan City

Useful energy is the energy that is actually used for cooking. It considers the efficiency and losses associated with the technology. Hence it can be used as a better tool for estimation of energy requirement in future. The overall useful energy in case of Pokhara Metropolitan City is expected to become 1560.33 TJ in 2036. The trend of useful energy in Pokhara Metropolitan City is shown in Figure 6.3.

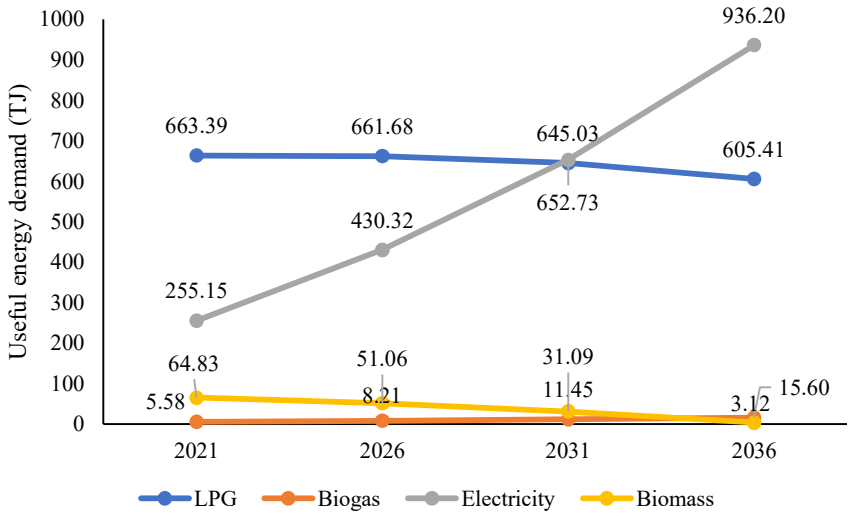


Figure 6.9: Useful energy demand projection of Pokhara Metropolitan City

CHAPTER SEVEN : COMPARATIVE ANALYSIS

7.1 Residential Sector

The stove shaking in Butwal and Pokhara for residential sector is shown in Figure 7.1. In Butwal sub-metropolitan city, 52.67% of households are using only one type of stove while in Pokhara 26.03% of households are using one type stove. Also, 43.20% of households of Butwal and 57.53% of households of Pokhara are using two type stoves i.e. 14.33% of more households in Pokhara are using two type stoves than in Butwal. The remaining percentage of households are using three and more type stoves. This concludes that there is more energy mix in case of Pokhara.

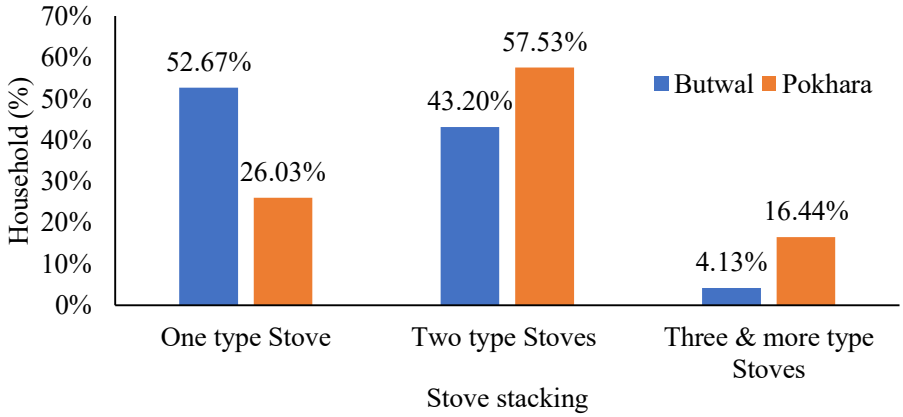


Figure 7.1: Stove stacking for residential sector

Figure 7.2 highlights the fuel stacking in Butwal and Pokhara. As shown in this figure, majority of households in Pokhara are using two and more type fuels for cooking. In Butwal 52.18% of households are using one type fuel while only 23.29% of households in Pokhara are using one type fuel and 46.36% and 67.12% of households in Butwal and Pokhara respectively are using two type fuels. The remaining 1.46% of households of Butwal and 9.59% of households of Pokhara are using three and more type fuels. This data shows that 8.13% more households in Pokhara are using three and more type fuels.

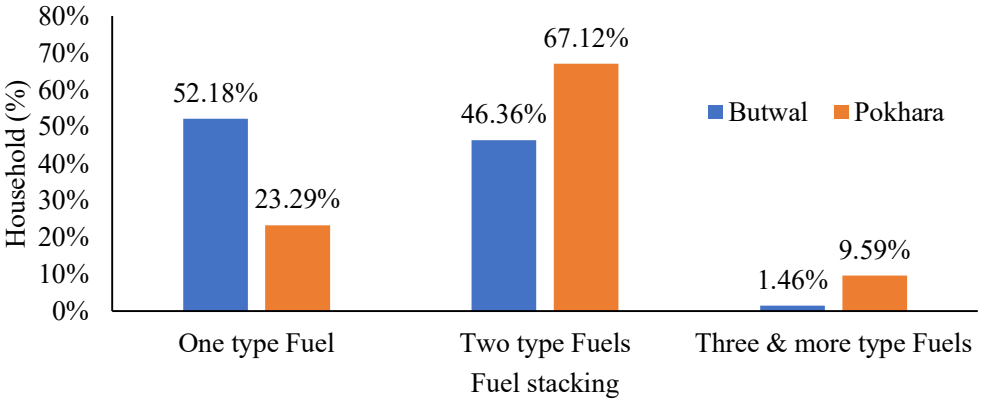


Figure 7.2: Fuel stacking for residential sector

The total energy consumption in residential sector of Butwal and Pokhara is 543.03 TJ and 1585.97 TJ respectively. the main energy consumed for cooking in these cities are LPG, fuelwood, electricity and biogas. The consumption of energy is shown in Figure 7.3. In both cities, the consumption of LPG is higher i.e. 55.97% and 56.92% in Butwal and Pokhara respectively. In addition, the consumption of fuelwood in Butwal and Pokhara is 33.29% and 26.65% respectively and the consumption of electricity is 10.60% and 15.48% in Butwal and Pokhara. the remaining percentage is consumption of biogas. This shows that the consumption of LPG and electricity in Pokhara is higher than Butwal and the consumption of fuelwood is lower than Butwal.

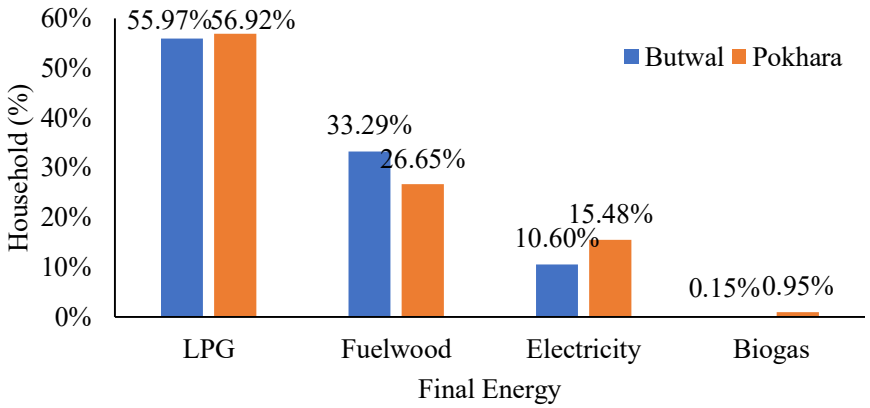


Figure 7.3: Percentage wise energy consumption in residential sector of Butwal and Pokhara

Figure 7.4 represents the shifting interest of residential sector of Butwal and Pokhara. This shows that in Butwal only 44.66% of households are interested to shift cooking technology while the remaining population are not interested in shifting their cooking technology while in Pokhara, 6.88% of more house than of Butwal are interested in shifting their cooking technology and only 37.78% of households are not interested in shifting technology. The cause of not having interest towards shifting to new cooking technology is the lack of knowledge and information about the advantages of new cooking technology which should be provided to them.

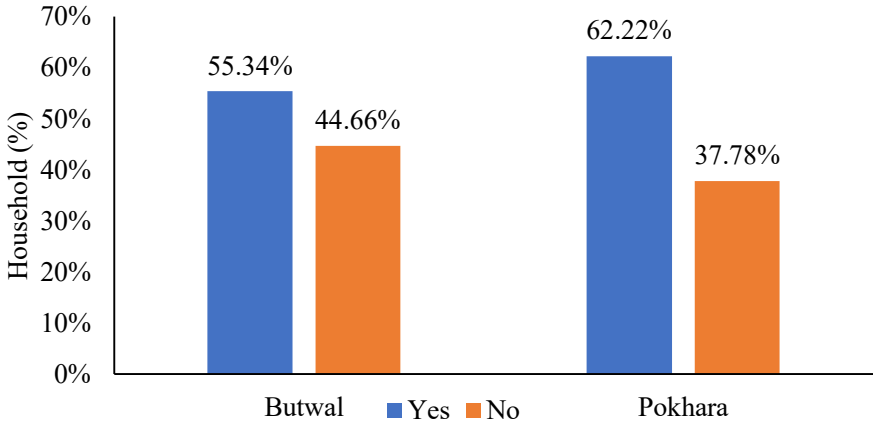


Figure 7.4: Shifting interest of residential sector

As 55.34% and 62.22% of households in Butwal and Pokhara respectively have interest towards shifting cooking technology, among them 51.46% of households of Butwal are showing interest to shift towards electricity and remaining have interest to shift towards LPG and ICS. In case of Pokhara, 59.04% of households have interest towards shifting their technology into electricity and the remaining have interest to shift towards LPG, ICS and biogas. This shifting interest is shown in Figure 7.5.

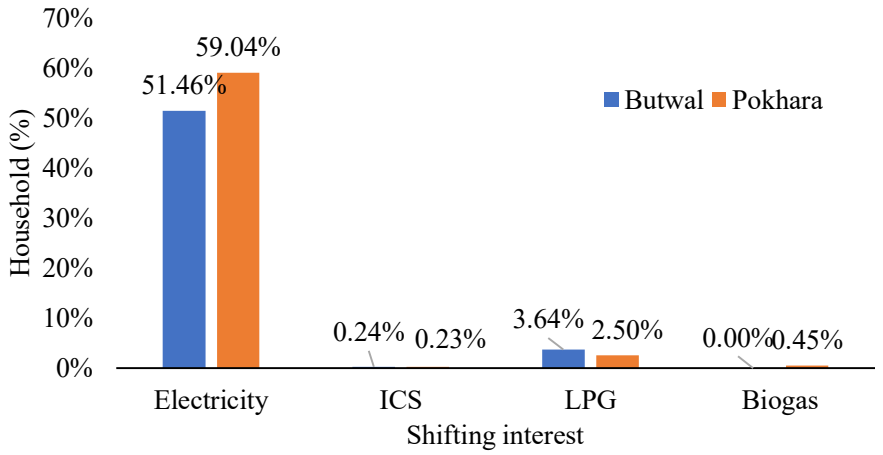


Figure 7.5: Shifting interest of residential sector according to fuel type

As population of Pokhara is more than Butwal, energy consumption by Pokhara is also higher than Butwal which is illustrated in Figure 7.6. The total energy consumption by Pokhara and Butwal in base year is 1585.97 TJ and 543.03 TJ respectively. This energy demand is expected to increase to 2501.73 TJ in Pokhara and 996.26 TJ in Butwal in 2036 but after using clean cooking technology, the demand is expected to decrease to 1723.9 TJ in Pokhara and 620.25 TJ in Butwal in 2036. This result shows that if clean cooking technology is used, the total energy demand is expected to decrease.

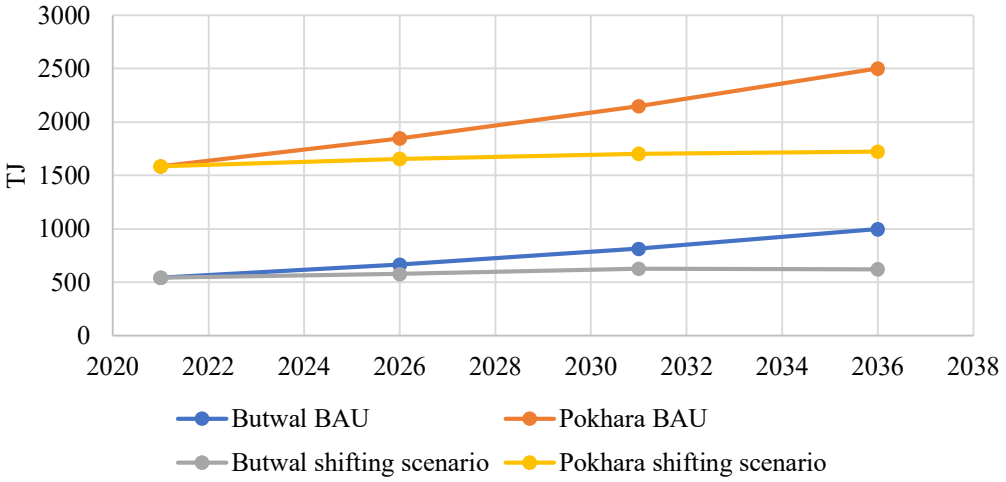


Figure 7.6: Energy consumption before and after shifting towards clean cooking technology

7.2 Commercial Sector

Figure 7.7 shows the stove shaking in Butwal and Pokhara for commercial sector. In Butwal sub-metropolitan city, 64.62% of commercial entities are using only one type of stove while 39.02% of commercial entities of Pokhara are using one type stove. On the other hand, 24.62% of commercial entities of Butwal are using two type stoves and 42.35% of commercial entities of Pokhara are using two type stoves. The remaining percentage of households are using three and more type of stoves.

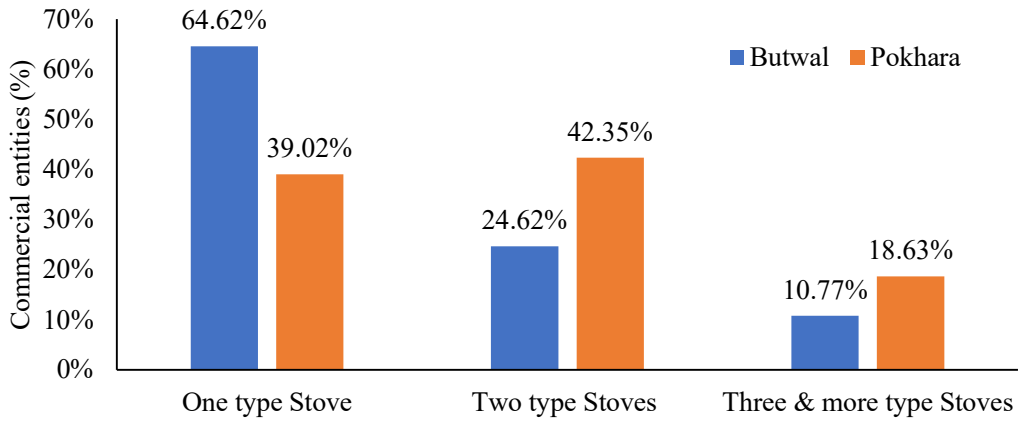


Figure 7.7: Stove stacking in commercial sector

Figure 7.8 represents the fuel stacking in Butwal and Pokhara for commercial sector. More percentage of commercial entities in Pokhara are using two and more type fuels for cooking. In Butwal, 64.62% of commercial entities are using one type fuel while 60.09% of commercial entities in Pokhara are using one type fuel and 33.23% and 39.02% of commercial entities in Butwal and Pokhara respectively are using two type fuels. The remaining 2.15% of commercial entities of Butwal and 0.89% of commercial entities of Pokhara are using three and more type fuels.

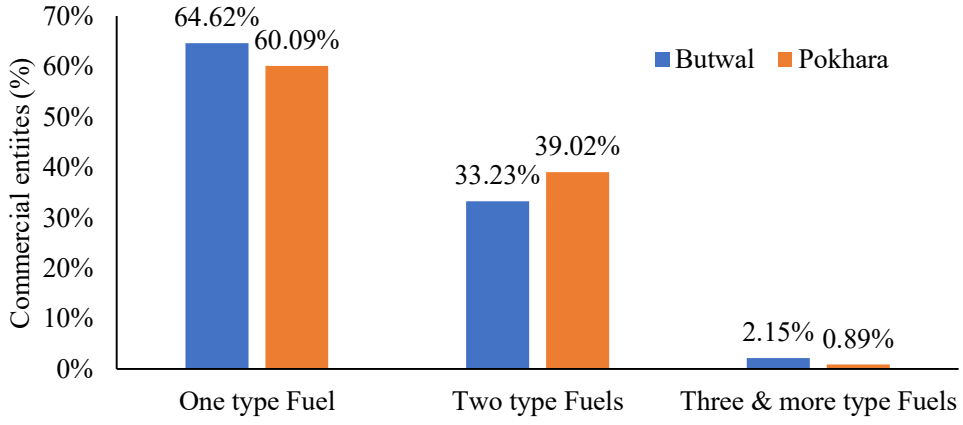


Figure 7.8: Fuel stacking in commercial sector

The consumption of energy in commercial sector of Butwal and Pokhara is determined to be 81.85 TJ and 520.71 TJ respectively. The consumption of LPG is more in both Butwal and

Pokhara as included in Figure 7.9. In commercial sector according to user's view, the consumption of LPG is more as LPG is easy to use as well as it takes less time to cook food than using electricity. So, the consumption of electricity is less and the use of fuelwood is also low as it is used for specific purposes only. In Butwal, 89.11% of total energy is consumption of LPG while in Pokhara, 92.05% of total energy is consumption of LPG. The electricity consumption in Butwal and Pokhara is 6.50% and 6.11% of total consumption respectively. the remaining percentage is consumption of fuelwood.

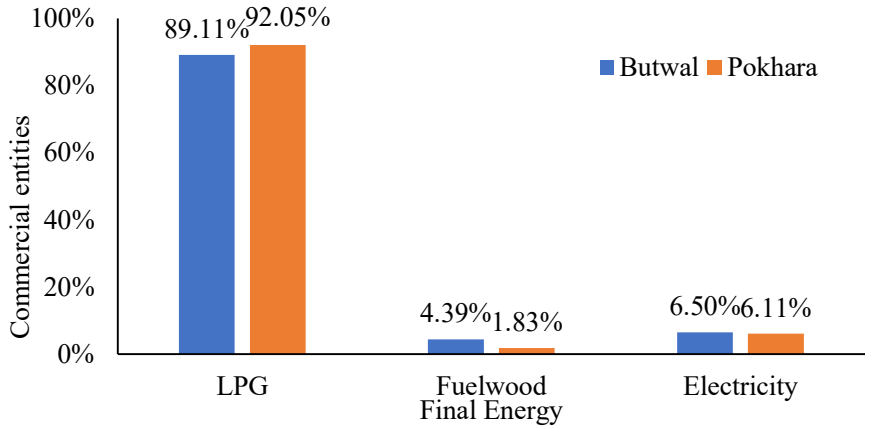


Figure 7.9: Percentage wise energy consumption in commercial sector of Butwal and Pokhara

Figure 7.10 represents the shifting interest of commercial sector of Butwal and Pokhara. This shows that in Butwal 55.99% of commercial entities are interested to shift their cooking technology while the remaining are not interested in shifting cooking technology and in Pokhara, 9.02% more commercial entities are interested in shifting their cooking technology and only 34.99% of commercial entities are not interested in shifting their technology. The cause of not having interest towards shifting to new cooking technology is the lack of knowledge and information about the advantages of new cooking technology which should be provided to them.

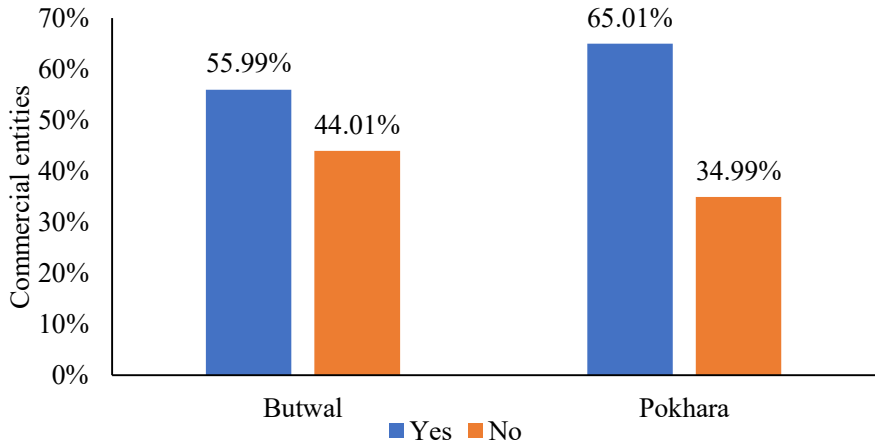


Figure 7.10: Shifting interest of commercial sector

Among the percentage of commercial entities having interest towards shifting, almost all have interest on shifting towards electricity. The shifting interest of the commercial entities is shown in Figure 7.11.

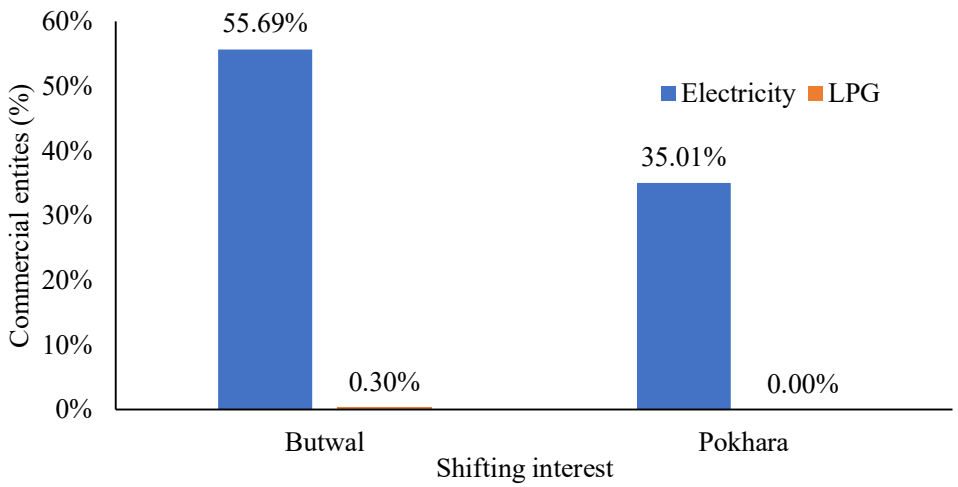


Figure 7.11: Shifting interest of commercial entities according to fuel type

Figure 7.12 illustrates the energy demand before and after using clean cooking technology for commercial sector. The total energy consumption by commercial entities of Pokhara and Butwal in base year is 520.71 TJ and 81.85 TJ respectively. This energy demand is expected to increase to 822.06 TJ in Pokhara and 150.15 TJ in Butwal in 2036 but after using clean cooking technology, the demand is expected to decrease to 617.95 TJ in Pokhara and 113.71 TJ in Butwal in 2036. This shows that if clean cooking technology is used, the total energy demand is expected to decrease.

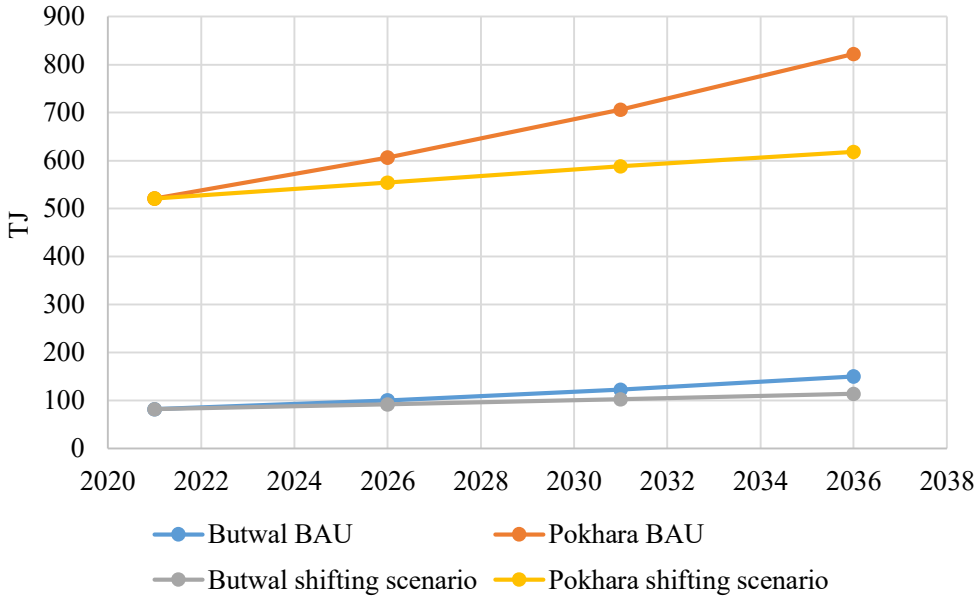


Figure 7.12: Energy demand before and after using clean cooking for commercial sector

CHAPTER EIGHT : CONCLUSION

Residential sector of Butwal

- In Butwal, 52.67% of the household uses one type of stove with 49.27% using only LPG and 3.40% using only biomass stove. Similarly, 43.20% uses two type of stove with LPG and rice cooker leading the share at 36.17% and 4.13% uses three or more stoves.
- As a primary technology, LPG stove is used in 92.96% of households followed by biomass at 5.58%, biogas stove at 1.21%. Similarly, induction stove/ coil heater is used as primary fuel in 0.24% of household.
- In terms of energy use the overall final energy consumption and useful energy consumption is 554.25 TJ and 230.92 TJ. The share of LPG in final energy demand is 55.97% followed by fuelwood at 33.29%, electricity at 10.60% and Biogas at 0.15% respectively.
- The current status of emission is 25,783.58 tonnes $CO_{2\text{-eq}}$ with the share of emission due to fuelwood at 15,440.06 tonnes $CO_{2\text{-eq}}$ and LPG at 10,343.52 tonnes $CO_{2\text{-eq}}$,
- In residential sector of Butwal, 44.66% of the households are not interested in shifting, 51.34% are interested in shifting toward induction stove, among them also 3.64% are interested to shift towards LPG stoves and 0.24% towards improved cook stoves.
- Regarding the shifting trend 54.37% of the household are interested in shifting toward electricity as major fuel, followed by LPG and electricity at 30.58% and LPG as main fuel at 15.05% respectively in 2036 A.D.
- The major barriers for shifting is perception of their current technology as the best technology available along with the high cost of newer technology. Regarding the electric cooking technologies, the major barrier is unstable electricity followed by high tariff charges.
- The overall energy demand in Butwal in 2026 A.D., 2031 A.D. and 2036 A.D. is expected to become 664.77 TJ, 813.81 TJ, 996.26 TJ in BAU scenario and 576.75 TJ, 626.17 TJ and 620.25 TJ in shifting scenario.

Commercial sector of Butwal

- In Butwal, 72.31% of the commercial entities uses one type of stove with 71.08% of them using only LPG and 0.92 % using biomass and remaining electric oven. Similarly, 20.92% use two type of stove with LPG and rice cooker leading the share at 8.92% and 6.77% uses three or more stoves.
- As a primary technology, LPG stove is used in 97.55% of commercial entities followed by biomass at 2.15%. Similarly, electricity is used as primary fuel in 0.31% of commercial entities.
- In terms of energy use the overall final energy consumption and useful energy consumption is 81.83 TJ and 40.42 TJ. The share of LPG in final energy demand is 89.14% followed by fuelwood at 6.47%, electricity at 4.39% respectively.
- The current status of emission is around 2,884.65 tonnes $CO_{2\text{-eq}}$ with the share of emission due to fuelwood at 452.18 tonnes $CO_{2\text{-eq}}$ and LPG at 2,432.47 tonnes $CO_{2\text{-eq}}$,

- In commercial sector of Butwal, 44.01% of the commercial entities are not interested in shifting, 55.69% are interested in shifting toward induction stove, 0.30% towards LPG stoves.
- Regarding the shifting trend, 86.50% of the commercial entity are interested in shifting toward electricity as major fuel, followed by LPG and electricity at 13.19% and LPG as main fuel at 0.31% respectively in 2036 A.D.
- The major barriers for shifting is they perceive their current technology as the best technology available along with the high cost of newer technology. Regarding the electric cooking technologies, the major barrier is high tariff charges followed by unstable electricity supply.
- The overall energy demand in Butwal in 2026 A.D., 2031 A.D. and 2036 A.D. is expected to become 100.20 TJ, 122.66 TJ and 150.15 TJ in BAU scenario and 91.75 TJ, 102.6 TJ and 113.71 TJ in shifting scenario.

Residential sector of Pokhara

- In Pokhara, 26.04% of the household uses one type of stove with 21.92% using only LPG and 4.12% using only biomass stove. Similarly, 57.52% uses two type of stove with LPG and rice cooker leading the share at 50.91% and 16.44% uses three or more stoves.
- As a primary technology, LPG stove is used in 84.25% of households followed by biomass at 10.27%, biogas stove at 5.25%. Similarly, electricity is used as primary fuel in 0.23% of household.
- In terms of energy use the overall final energy consumption and useful energy consumption is 1,585.98 TJ and 728.14 TJ. The share of LPG in final energy demand is 56.92% followed by fuelwood at 26.65%, electricity at 15.48% and Biogas at 0.95% respectively.
- The current status of emission is 86,064.36 tonnes $CO_{2\text{-eq}}$ with the share of emission due to fuelwood at 55,957.73 tonnes $CO_{2\text{-eq}}$ and LPG at 30,106.63 tonnes $CO_{2\text{-eq}}$,
- In residential sector of Pokhara, 37.78% of the households are not interested in shifting, 59.04% are interested in shifting toward induction stove, 2.50% towards LPG stoves, 0.45% towards biogas and 0.23% towards improved cook stoves.
- Regarding the shifting trend, 67.58% of the household are interested in shifting toward electricity as major fuel, followed by LPG and electricity at 22.37% and LPG as main fuel at 10.05% respectively in 2036 A.D.
- The major barriers for shifting is they perceive their current technology as the best technology available along with the high cost of newer technology. Regarding the electric cooking technologies, the major barrier high tariff charges followed by high cost of stove and accessories.
- The overall energy demand in Pokhara in 2026 A.D., 2031 A.D. and 2036 A.D. is expected to become 1846.19 TJ, 2149.11 TJ, 2501.73 TJ in BAU scenario and 1654.67 TJ, 1703.64 TJ and 1723.9 TJ in shifting scenario.

Commercial sector of Pokhara

- In Pokhara, 32.37% of the commercial entity uses one type of stove with 32.15% using only LPG. Similarly, 55.88% uses two type of stove with LPG and rice cooker leading the share at 31.56% and 18.63% uses three or more stoves.
- As a primary technology, LPG stove is used in 98.45% of commercial entities followed by biomass stove at 1.33%, biogas stove at 0.22%.
- In terms of energy use the overall final energy consumption and useful energy consumption is 520.71 TJ and 260.79 TJ. The share of LPG in final energy demand is 92.05% followed by fuelwood at 1.83%, electricity at 6.11% respectively.
- The current status of emission is around 17,600.14 tonnes $CO_{2\text{-eq}}$ with the share of emission due to fuelwood at 1,616.13 tonnes $CO_{2\text{-eq}}$ and LPG at 15,984 tonnes $CO_{2\text{-eq}}$,
- In commercial sector of Pokhara, 34.99% of the commercial entities are not interested in shifting, 65.01% are interested in shifting toward induction stove, 0.001% towards LPG stoves.
- Regarding the shifting trend, 64.3% of the commercial entity are interested in shifting toward electricity as major fuel, followed by LPG and electricity at 31.2% and LPG as main fuel at 4.5% respectively in 2036 A.D.
- The major barriers for shifting is they perceive their current technology as the best technology available along with the high cost of newer technology. Regarding the electric cooking technologies, the major barrier is high tariff charges followed by unstable electricity supply.
- The overall energy demand in Pokhara in 2026 A.D., 2031 A.D. and 2036 A.D. is expected to become 606.31 TJ, 705.99 TJ, 822.06 TJ in BAU scenario and 554.17 TJ, 587.88 TJ and 617.95 TJ in shifting scenario.

CHAPTER NINE : RECOMMENDATION

On the basis of this study, following recommendations are provided:

- Electricity for cooking in household sector of Butwal and Pokhara is 10.6% and 15.48% respectively, and in commercial sector of Butwal and Pokhara, 6.5% and 6.11% only. The perception of people towards the cost of electricity is high. The specific cost of fuel per person per month for electricity is less than LPG. So, proper mass awareness should be provided for cost saving using electricity as cooking technology.
- In residential sector of Butwal and Pokhara, 46.86% and 28.08% of household respectively are using 6A fuse and in commercial sector of Butwal and Pokhara, 19.28% and 1.77% of commercial entities respectively are using 6A fuse so electricity connection line should be upgraded to at least 16 A. Along with this, transformer and distribution system should be upgraded so that there won't be any problem within it and interruption in power supply may not create any issue.
- About 34% and 61% of respondent of household sector in Butwal and Pokhara respectively and 28% and 60% of respondent of commercial entities in Butwal and Pokhara respectively think that cooking using electricity is expensive than LPG or any other fossil fuel, so to increase this percentage, electricity tariff should be made affordable so that the household sectors can afford electricity for not only lighting but also cooking.
- The socio cultural values of traditional cooking system such as fuelwood has made some of the ethnic group to make difficulty in transferring their cooking system. So for those group of people, proper awareness should be provided so that they could know the benefits of the changing cooking habits and also be familiar with the newer technologies.
- Local government policy and regulatory procedures should be formulated for using clean cooking technology. Therefore, subsidy for clean cooking should be provided to those who are in need of it. Also, financial incentives like reduction in custom duty and exemption in value added tax (VAT) should be provided for clean cooking technology.
- During the survey, about 38% and 16% of respondent of household sector in Butwal and Pokhara respectively and 27% and 20% of respondent of commercial entities in Butwal and Pokhara respectively are providing their view as unstable electricity and frequent power cut off as the major barrier for promotion of electric cooking so the reliability of electricity should be increased so that people could get motived to use electricity as their primary source of cooking.
- Since, in future most of the respondents are willing to replace their cooking technology to electric system i.e. induction stoves so the maintenance of those stoves may create a problem. To reduce this problem, proper training for the repairs of induction stove can help. Therefore, government of Nepal should organize such training program.

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