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Thesis No. M-126-MSESPM-2017-2021

Sustainable Energy Planning of Residential Sector: A Case Study of Bhanu Municipality, Tanahun, Nepal

by

Dibya Adhikari

A THESIS
SUBMITTED TO THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN
ENERGY SYSTEM PLANNING AND MANAGEMENT ENGINEERING

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING
LALITPUR, NEPAL

MARCH, 2021

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DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

APPROVAL PAGE

The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis entitled "**Sustainable Energy Planning of Residential Sector: A Case Study of Bhanu Municipality, Tanahun, Nepal**" submitted by Dibya Adhikari, in partial fulfilment of the requirements for the degree of Master of Science in Energy System Planning and Management.

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ABSTRACT

Energy is the key indicator of development. Nepal has set target to graduate to developed country by 2022- and middle-income country by 2030 and to achieve sustainable goal by 2030. In order to achieve all these targets energy plays a key role. This research is mainly based on primary data, 152 households sample survey and supported by secondary data. Energy and emission projection was done in LEAP software based on energy demand driving factors, population growth rate and GDP Growth rate. The analysis was made through different scenarios in LEAP, they are; Business as Usual Scenario (BAU), Low Carbon Emission (LOW) Scenario, Efficient Cooking Scenario (EFC) and Efficient Lighting Scenario (EFL). Analysis shows that the total annual energy consumption of Bhanu Municipality is 635.67TJ in the base year 2020 with per capita energy consumption 12.69 GJ/annum. The main fuel for cooking in the residential sector is firewood, with share of 80% supplied from private, government and community forests that covers 38% of the municipality area. Lighting was done through grid electricity, almost 99% of the households had access to grid. The BAU scenario shows that the household energy demand per capita will be 19.07GJ in 2050 and energy per household will be 104.56 GJ in 2050. In EFC, EFL and LOW per capita energy demand will reach to 15.31 GJ, 19.79 GJ and 4.52 GJ respectively. GHG emissions for all the scenario were analysed in the study. The GHG emission of base year was 2985.60 metric tonnes of CO_2 equivalent. The per capita GHGs emission in 2050 will be 109.08 Kg and it will be 34.28 Kg in EFC scenario and it will be reduced to zero in LOW scenario. LOW scenario shows the decrease of GHGs through the policy intervention in which electrification was done in all end use demands.

ACKNOWLEDGEMENT

Firstly, I would like to express my regards to my supervisor, Associate Prof. Dr. Shree Raj Shakya, and Supervisor, Associate Prof. Dr. Nawraj Bhattarai who have guided me all over my thesis with their patience and knowledge. They did not object me for answering my query about research or writing at any time. They constantly let this thesis to be my own work, but guided me in the right direction whenever they thought I needed it.

I would like to show my sincere gratitude and thanks to Prof. Dr. Amrit Man Nakarmi whose valuable instruction and guidance helped me to broaden my boundary of knowledge and helped a lot to conduct this research. Besides, I would like to thanks to all faculty of Mechanical and Aerospace Engineering, for their judicious comments and motivation, and also for the difficult questions which incanted me to broaden my research from different aspects.

I would also like to express my sincere gratitude to Ms. Anita Prajapati and Mr. Utsav Shree Rajbhandari, senior YP Gaire for their valuable support during data analysis in LEAP software. Also**,** thanks to Mr. Raj Kumar KC and Mr. Sagun Poudel for sharing ideas about this research, and helping throughout the thesis. I am very thankful to Mayor of Bhanu Municipality, uncle Keshav Koirala and all the respondents of survey for their incredible help and support during my field work.

Last but not the least, I must express my intense regards to my family members, all friends (073 MSESPM batch) and all members of the department of mechanical and aerospace engineering for their continuous support and inspiration throughout my years of study and during the process of researching and writing the thesis.

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ABBREVIATIONS

AR-5	Fifth Assessment Report
AEPC	Alternative Energy Promotion Center
BAU	Business As Usual
CBS	Central Bureau of Statistic
CFL	Compact Fluorescent lamp
CO_2	Carbon Dioxide
EFC	Efficient Cooking
EFL	Efficient Lighting
EJ	Exa Joule
FY	Fiscal Year
GDP	Gross Domestic Product
GHG	Green House Gas
GJ	Giga Joule
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
kg	Kilogram
kW	kilo Watt
kWh	kilo Watt hour
LDC	Least Developed Country
LEAP	Low Emission Analysis Platform
LED	Light Emitting Diode
LPG	Liquid Petroleum Gas
MAED	Model for Analysis of Energy Demand
MW	Mega-Watt
NEA	Nepal Electricity Authority
PV	Photo Voltaic
SDG	Sustainable Development Goal
SEAP	Sustainable Energy Access Planning
TV	Television
TJ	Tera Joule

Toe	Tonnes of oil equivalent
UN	United Nation
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
VDC	Village Development Committee
WECS	Water and Energy Commission Secretariat

CHAPTER ONE: INTRODUCTION

1.1 Background

Energy by definition is the capacity to do work. Energy plays a vital role for sustainable development of country. Energy is inseparable component of the modern society and it is also one of the major constituents of the socio-economic development. Reliable and efficient energy service provider in a country depicts the good status of country. Nepal had faced increasing gap between supply and demand of energy in the recent years(IBN;GoN, 2011). Till date, the presence of petroleum, gas, or coal reserves has not found in our country, and the accessibility to remote communities is very hard because of its land topography in the Himalayas. As a result, majority of Nepalese people have historically met their demands of energy with human labour, biomass, imported kerosene etc. The huge hydropower potential in our country has been anticipated through the various studies. The power from the available water resources can be harnessed to produce about 43000MW. However, the theoretical potential is estimated to be around 83,000 MW(Surendra et al., 2011). Despite of having huge hydropotential, Nepal has not been able to fully utilize its water resource for hydroelectricity generation in a large scale. The process of hydro electricity generation and development had started in 1911 from the establishment of Pharping Hydropower Project(Shrestha, 2017). Although the period of electricity generation has crossed a century, the electrification or energy generation rate have not picked up as much as it required. The maximum population in Nepal has still no supply of reliable and quality source of energy. As per the data, in FY 2019/20, only 86% of population has the access to grid electricity. Out of total the domestic consumer category with 3.93 million consumers remained the largest category with 93.26% share of the entire electricity consumers. Nepal Electricity Authority (NEA) is working in generation, transmission and distribution of electricity to their consumers and has set target and working to obtain “Electricity for All” up to year 2023. Out of the total available energy(7741 GWh)in NEA’s system, NEA’s generation, Imports from India and IPPs contributed 39.02% ,22.33% and 38.64% respectively(NEA, 2020). Hydroelectricity, Micro-Hydro, Solar, Biomass, Wind, Thermal, petroleum products are the sources of electricity generation in Nepal. The total energy consumption during the fiscal year 2018/19 is 14014.13(‘000toe). Among them the traditional energy source constitutes 68.5% of total energy consumption, commercial constitutes 29.4% of total energy consumption and renewable constitutes 2.1% of total energy consumption. About eighteen percent of the total population have an access to electric supply from the renewable energy sources(MoF, 2020). The per capita energy consumption is one of the key measures of the development, which is found to be significantly higher in developed countries and lower in least developed countries. The energy consumption per capita value of Nepal is 245 kWh. Our Country is one of the forty eighth least developed country in the world and aims to graduate towards developed country by 2022.

1.2 Nepal's Demography

Nepal is situated in between two big countries India and China in the southern part of Asia. Nepal has diverse topography ranging from high Himalayas to low Terai plain lands. The administrative division of Nepal includes 77 number of districts, 7 number of Provinces, and 753 number of local government units(rural municipalities and municipalities) with distinct power sharing mechanism among the governments(Acharya, 2018). Nepal is following the Federal Republican System of Governance. The area of our country is 147,181 square kilometres with the population of 29.7 million. About 78.6% of population resides in rural areas where as only 21.4% are urban residents. The population of Nepal is projected to grow to 30.4 million by 2021AD and 33.6 million by 2031AD with the population growth rate of 2.1 percent per year (Kathry, 2012). Here is provincial data by households and populations of census 2011 where Bagmati Province has maximum number of households and populations.

Table 1-1 Distribution of Households and Populations by Province, census 2011

Province	Households	Populations
Province 1	992,445	4,534,943
Province 2	932,308	5,404,145
Bagmati	1,270,797	5,529,452
Gandaki	578,219	2,403,757
Lumbini	885,203	4,499,272
Karnali	298,359	1,570,418
Sudur Paschim	469,971	2,552,517

(Source: CBS,2020)

1.3 Status of Energy Consumption

The energy consuming sectors of Nepal has been defined according to the economic sector of the country which are Residential, Industrial, Transport, Commercial, Agricultural sectors. Others sectors are also included in the above category which are counted in energy accounting but these sectors do not add economic boon to the country. Street lights, lighting in temples, church, mosques fall under the others category. In FY 2018/19, the annual average consumption of electricity in domestic, industrial, commercial and other sectors has been 42.61%, 38.24%, 7.42 % and 11.73 %, respectively with the total yearly electricity consumption of 4,063GWh. (MoF, 2020)

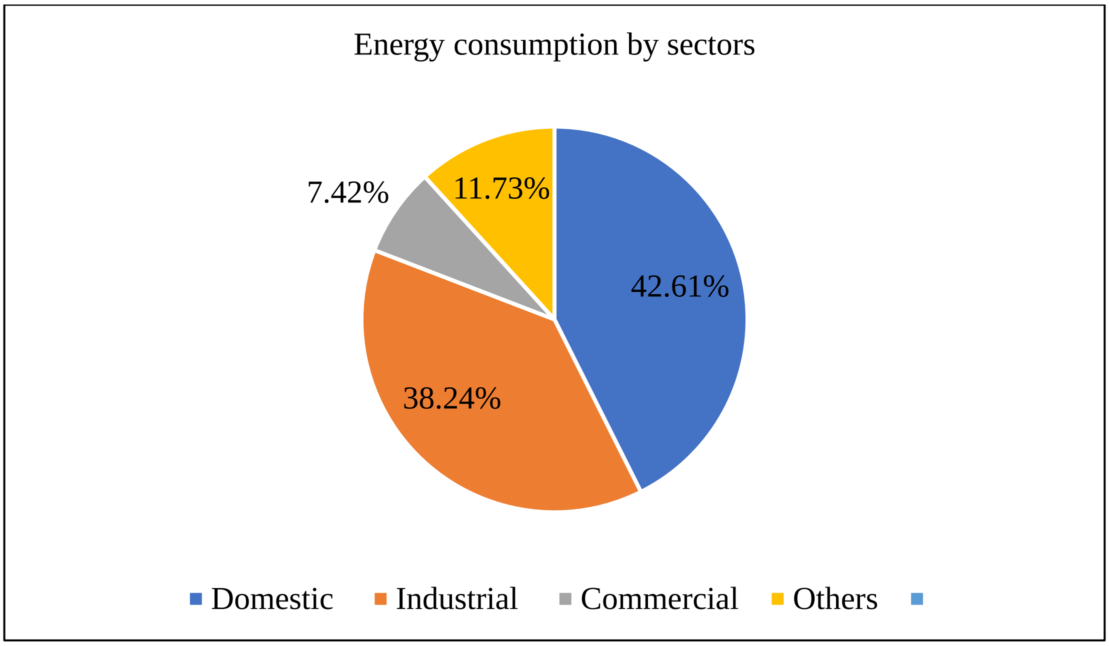

Figure 1-1 Energy Consumption by sectors

(Source: MoF, 2020)

1.4 Research Gap

Nepal has set the target of graduation to Least Developed Country (LDC) by 2022 and Middle-Income Country by 2030. The indicators for graduation are Gross National Income (GNI) per capita, Economic Vulnerability Index (EVI), Human Assets Index (HAI). Nepal is about to achieve the minimum targets of HAI and EVI but the difference between graduation threshold and Nepal's position is increasing in case of

Gross National Income. Energy consumption per capita is a directly proportional to the GNI per capita. So, the energy consumption of the country is essential to increase in a managed way to get the targeted economic growth rate.(Gaire & Shakya, 2015)

Nepal being the member of UN has set aim to accomplish the sustainable development goal targets by 2030. Nepal also included long term perspective with a 25-year vision in the fifth-year plan in order to promote the sustainable development. Sustainable Goal 7 defines the energy sector targets. National level plan does not suit perfectly to every local level due to variance in socio economic factors. Hence, in order to achieve national targets suitable plans should be made remaining within the constraints of each local level.

In developing countries, residential sector is accountable for majority of energy consumption, the value being 87% of total energy consumption for Nepal (NPC, 2013). Hence, in order to mitigate the GHGs emission, and promote the use of efficient technologies and efficient fuel switching for sustainable development and to achieve different targets set by government and UN, focus on residential sector energy planning is essential.

1.5 Problem Statement

In Nepal, research, energy plan and analysis has been done only in the national level not in the local level. National level plan may not be suitable to the local level. Nepal is following the Federal Republican System of Governance. Each local level has authority to plan and implement small scale energy plan. Residential sector is the highest consumer of energy in our country. Bhanu Municipality has higher prospective of development in the tourism and agriculture sector. Energy being the basic need, if we can analyse the scenario of energy consumption and plan sustainable energy for the people living in municipality area, we can manage energy demand from the consumer side, can implement plans and policies to achieve the future energy demand, can improve the quality of life of municipal resident, can control the migration rate that will be beneficial in the development of municipality and also will be a boon for the Nation development. 70.6% of households in Bhanu Municipality use firewood for cooking, which is the main source of GHGs emissions. Increased greenhouse gases (GHGs) emission has contributed to global warming, resulting in increased global temperature and corresponding vulnerabilities. CO2 mitigation has become increasingly an important environmental issue for developing countries. Thus, this study aims to analyse the energy situation of Bhanu Municipality, Tanahun District of Nepal with aim to provide basic information for planning and management of energy and its issues, also to address the question of what would be the true impact of energy efficiency improvements on the energy demand and on reduction of GHG emissions through implementation of energy-efficient technologies.

1.6 Research Objective

Main Objective:

- To study the energy and environment effects of implementing Sustainable Energy Access Planning Framework for sustainable energy development of residential sector of Bhanu Municipality.

Specific Objective:

- To find current energy consumption pattern of residential sector and projection of energy consumption to the year 2050.
- To develop low carbon development scenarios for GHGs emission reduction.
- To find implications of energy efficiency improvement scenario.

1.7 Assumptions and limitations

The major assumptions and limitations of the study are listed below:

1. The national data and the district data are used due to unavailability of the municipal data.
2. Scenarios are based on different targets set by municipality, government and UN.
3. Energy consumption projection is carried done by correlating the annual energy consumption with different economic and demographic parameters.
4. The model is purely based on currently available resources and technologies, penetration of new technologies and resources are not taken into account.
5. GHGs emissions data are used based on IPCC Assessment: fifth (AR-5, 2013) database in LEAP.

CHAPTER TWO: LITERATURE REVIEW

2.1 Global Energy Scenario

Human beings unlike other living species, always have the universal desire of improving quality of life. In order to increase the quality-of-life improvements in different sectors is essential, be it on infrastructure or life style. The driving factor for this transition is the amount and efficiency of energy consumption. With increasing human needs the demand of energy is also increasing rapidly. Gradual reduction in use of the traditional sources of energy and increasing demand of commercial sources of energy and need of renewable sources of energy shows shifting of energy demand for efficient and sustainable sources of energy. The major fuels are oil, coal, natural gas, hydro, nuclear and renewables. The primary energy consumption of the world in 2019 is 193.03 EJ, where oil holds the largest share of energy mix (33.1%). The data's shows that the rapid growth of natural gas and renewables in the recent years as compared to other fuels. The world's per capita primary energy consumption is 75.5 GJ/capita. The carbon emission in 2019 is 34169.0 million tonnes of CO2. Carbon emissions from use of energy just grew by 0.5% from the previous year (2.1%) (BP, 2020). The carbon emission in 2019 is less than half of 10-year average growth (1.1%) per annum due to the short terms' outcome of the covid_19 pandemic(Chapman & Tsuji, 2020).

2.2 Country Status

Nepal is a low-income country, majority of GDP (50.61%) came from service sector. Agriculture is the second most contributor to GDP (24.26%) and industry follows the agriculture with 13.3%. Restructuring of new Nepal and rapid urbanization has contributed to grow in the population of urban to 62.2%. Urbanization has increased the energy demand. Government programs and policies are based on focusing the sustainable development. Though, inadequate amount of budget is on energy sector but the ratio of budget on energy sector is increasing. IPPs and public shares on investment in hydropower sector has been increasing. Hence, the generation of hydroelectricity has increased, and its consumption is also increased. The 86% of population has access to grid electricity. The share of renewable energy has also been increasing. (MoF, 2020)

2.2.1 Energy Resources of Nepal

2.2.1.1 Biomass based Energy Resources

Bioenergy means the energy extracted from organic biomass of recent origin found in various sources i.e., agriculture, forestry and other sectors which includes wood fuels, agrofuels and others. The supply of biomass energy sources is abundance in Nepal. Traditionally biomass resources have the boundary and limited within solid biomass fuels derived from animals and plants. The biomass could be extracted from forests, grasslands, agricultural lands, shrubs and also from the residue of animal in the form of excreta. Recently, the agriculture, livestock, industry and human settlement sectors are included in the traditional energy resources.

In the broader sense, the production of biomass is not directly responsible for energy production, but the biomass policy could influence in the development and use of modern bioenergy applications from the appropriate management of biomass wastes from various sectors like industry and municipality, also for the reduction in greenhouse gases (GHGs) emission. Human settlement sector can also play a vital role in this consideration. Instead of wasting the different wastes came from industry and municipality, they can be utilized in electricity generation, heat production and other various forms of energy.

Biomass is the vital sources of energy especially in the rural area of Nepal. In general, firewood and charcoal are mainly from woody biomass and animal dung and agricultural crops residue are the mainly from non-woody biomass-based resources. Firewood has the highest share among the total energy consumption. The use of charcoal has remained insignificant for the domestic energy. No any forests are solely managed for that purpose. The woody forests resources are also used to make ply, bed, rack etc. (WECS, 2008) The firewood share the 90.8% of total traditional resources, followed by cow dung 4.7% and agricultural residue 4.5%, comprising total traditional resources of 9601 thousand ToE in the fiscal year 2018/19 (MoF, 2020)

2.2.1.2 Animal Residues

Animal excreta, especially cow dung is used traditionally, where both of the woody and non- woody biomass supply sources have been scarce or where their supply does not meet the demand of the community. *Gobar (*cow dung) are used either in a dried cake form or mixed with the leftover herbaceous biomass. It is one of the important forms of traditional sources of energy, in those area which are away from the forests, mostly in the terai are Nepal.

According to Water and Energy Commission Secretariat (WECS) data the total production of animal residue is about 14.9 million tons, which is sufficient to meet about forty percentage of the total national energy requirement. However, availability of the dung is just around 80% of the total production in the country. Animal waste is the second most sources of indigenous energy. Though the energy content is low due to high moisture content, it is used by poor people for fulfilling their needs. Biogas plant has been very popular forms of energy resources of the country, which uses animal residue as a primary feeder for the energy generation through anaerobic digestion mechanism. More than 2,00,000 plants have been installed as biogas digester plants in our country till date (WECS, 2010).

2.2.1.3 Hydropower Potential

Nepal's theoretical hydropower potential has been estimated at about 83,000 MW and its technically and economically feasible potential of about 45,000 MW and 42,000MW respectively. Though the hydropower potential is 83,000MW but the technical and economic potential is 42,000MW. All of the theoretical potential cannot be extracted as there comes the various technical and economic constraints. (Source: WECS, 2013)

2.2.1.4 Renewable Energy Resources

The traditional sources of residential energy are not sustainable and environment friendly, which also have serious and negative impact on the livelihood of the people and on their health condition. So, the replacement of those traditional sources of energy by modern and sustainable energy resources is of utmost importance. Solar energy, water power, wind energy, biomass, hot springs etc. are abundantly found as a source of renewable energy in Nepal.

These sources of energy are sustainable, environment friendly, non- depletable and uninterruptable in nature, which could be reliable on accommodating the huge demand of energy for the country. Also, renewable sources of energy have very few adverse impacts on GHG emission, climate, physical and topographical environment.(Subedi, 2016)

Various forms of renewable energy technologies like Pico/micro-hydropower, biogas, liquid bio-fuel, gasifier, briquettes, solar thermal, improved cooking stove (ICS), wind power plants, briquette, solar photovoltaic (PV)can be used for local power supply. Out of them ICS, micro hydro, biogas stove, solar PV, solar are becoming more popular. But other many renewable energy technologies such as wind, geothermal, solar cooker, solar dryer and briquettes etc. are in research stage, which still needs more commercialization.

2.2.1.5 Solar Energy Resources

Solar radiation is abundant all over the country with the total sunshine days of about 300 days. The average solar radiation ranges from 3.6 to 6.2 kWh/Sq.m/day across the country. The commercial potential of utilization of solar power with grid connection is 2100 Megawatt. With National average sunshine hours of 6.8/day and solar insolation intensity of about 4.7 kWh/m2/day, there is a large potential for the solar thermal devices such as Solar Cookers, Water Heaters, Solar Dryers etc. (WECS, 2010).

2.2.1.6 Wind Energy

The study undertaken by (Dangrid 1992) shows that 200 Mega Watt of wind power could be produced in the 12-kilometer long Kagbeni to Chusang corridor of Mustang alone. It is projected that 500 GWh of electricity could be generated from wind annually. The potential of wind power is of 3000 Megawatts for commercial production as per the report of Solar & Wind Energy Resource Assessment (SWERA) project prepared by AEPC in 2008 (WECS, 2013)

2.2.2 Status of Energy Supply:

The bulk of an energy supply is from traditional energy sources which includes firewood, agriculture residue, cow dung cake accounting 69% of the total energy supply, commercial energy sources cover 29% includes coal, petroleum products, an electricity and the renewable energy sources covers 2% of the total energy supply. The total energy supply in 2019 is 14014.13 thousand ToE.

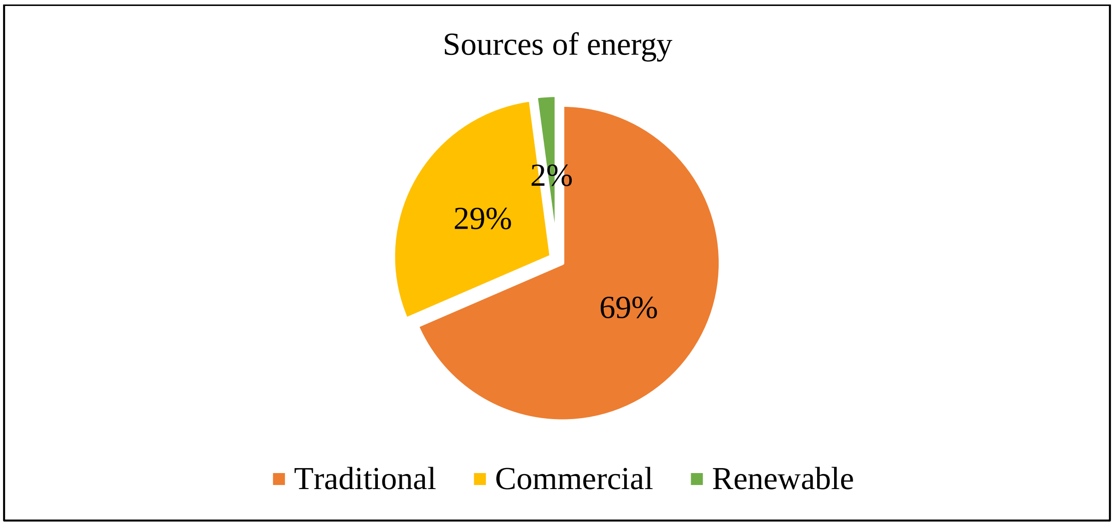

Figure 2-1 Energy supply mix in Nepal -1

(Source: MoF, 2020)

The figure 2-2 shows the share of energy supply based on the sources of energy. Firewood shares the maximum fuel share which is 62% followed by petroleum products 19% and renewable shares the minimum of 2% fuel share in the total energy supply mix. The electricity has the share of 4%, coal has share of 7%, agricultural residue and cow dung cake both has share of 3%.

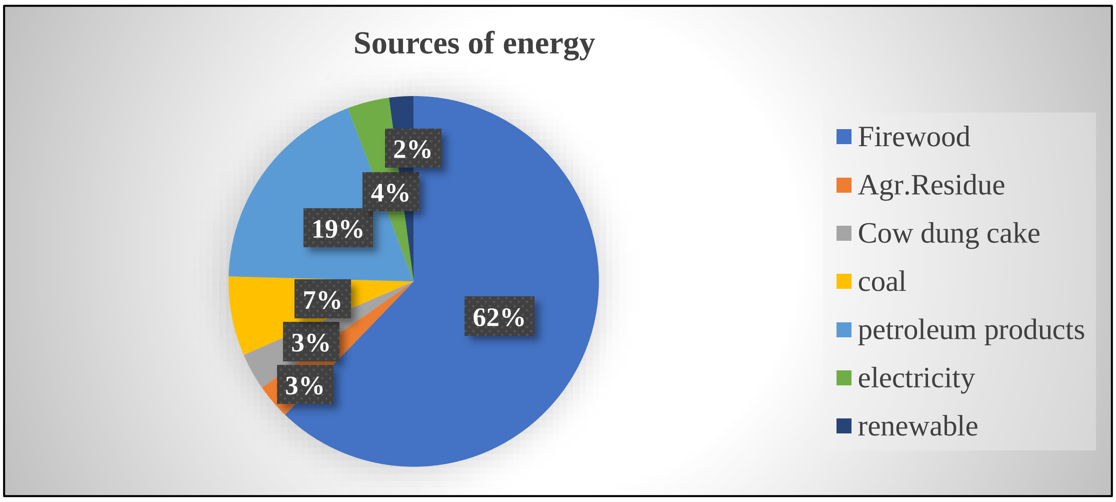

Figure2-2 Energy supply mix in Nepal -2

(Source: MoF, 2020)

The import of Petroleum products in the country has found to be increasing per year as per statistical data of Nepal Oil Corporation (NOC), the only one importer of Petroleum Products in the nation. Diesel, Petrol and LPG Gas bears the highest share in the import of Petroleum Product, as Nepal is heavily dependent on petroleum products on Transportation Sector and Household use of LPG Gas. The figure 2-3 shows the bar graph of import of petroleum products.

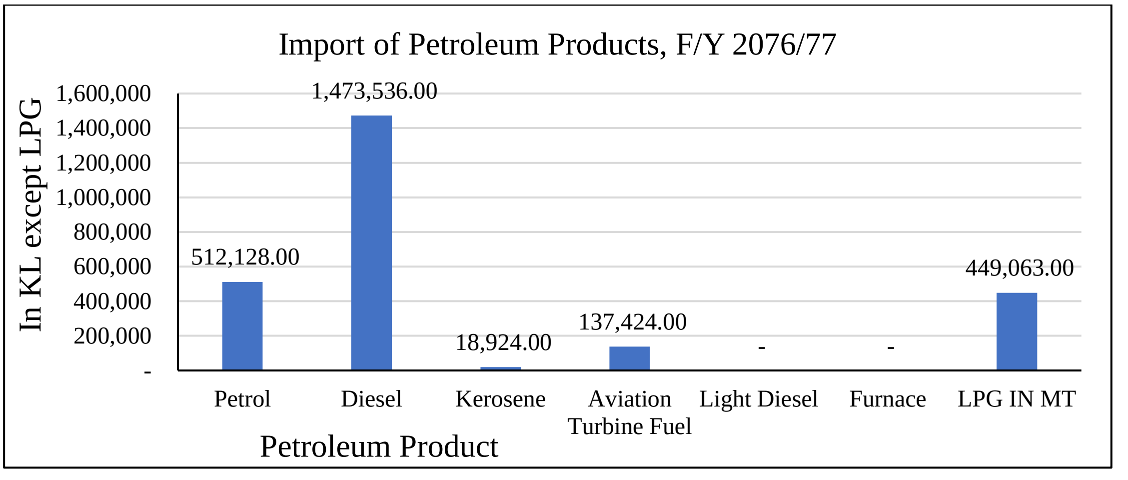

Figure 2-3 Import of Petroleum Products, F/Y 2076/77

(Source: NOC,2020)

The figure 2-4 shows the historical data of petroleum products imports except LPG. This shows that the import of petroleum product import is in increasing trend. The devastating earthquake has affected in the flow of import of petroleum products.

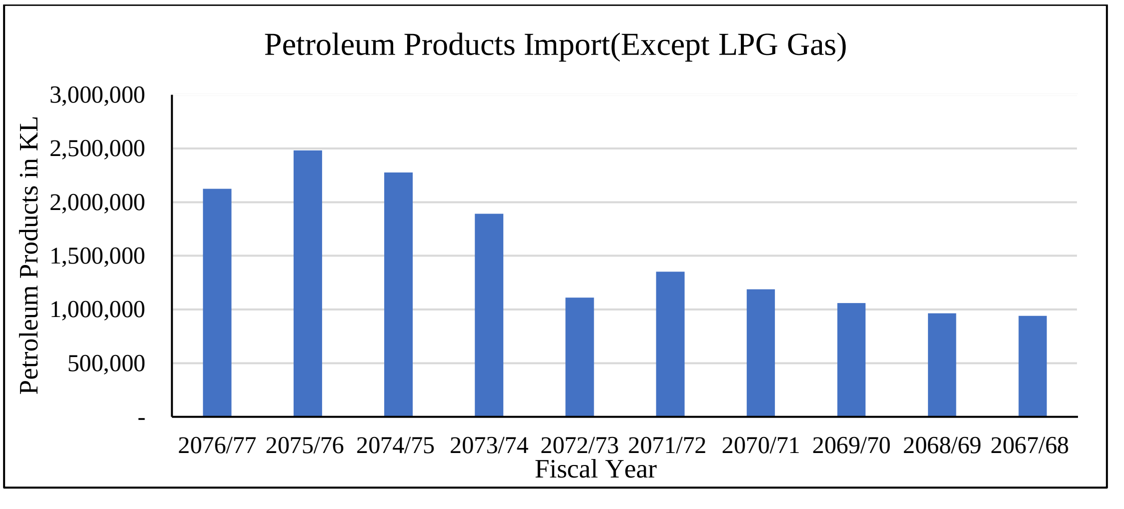

Figure2-4 Petroleum Products Import (Except LPG Gas)

(Source: NOC,2020)

The figure 2-5 shows the increasing trend of LPG import in Nepal. The consumption pattern in 2071/72 is affected by the devastating earthquake.

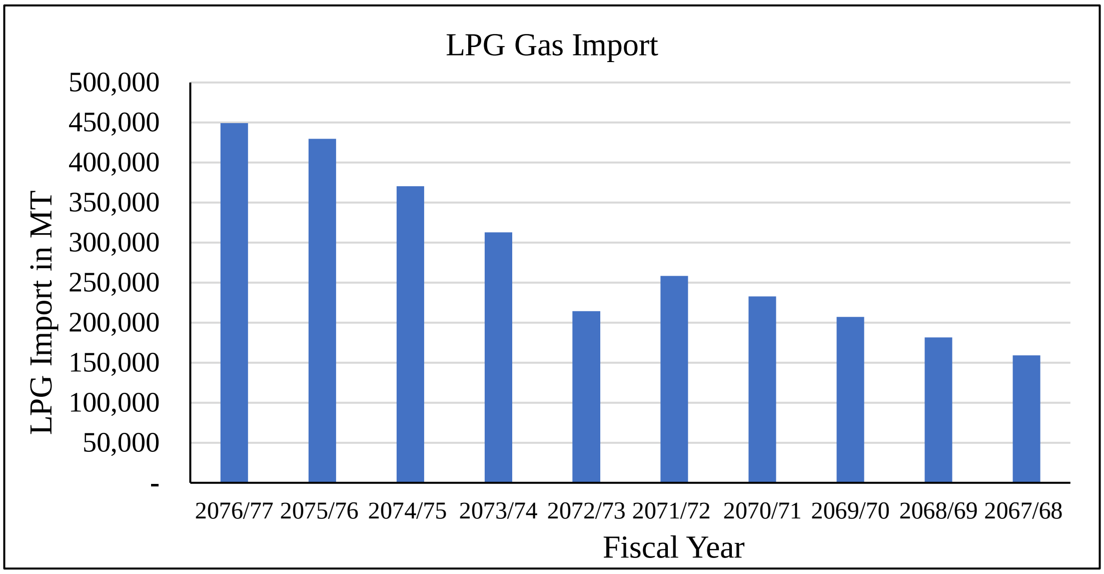

Figure 2-5 LPG Gas Import

(Source: NOC,2020)

2.3 Sustainable Development

2.3.1 Sustainable Development Goals 2030

The 2030 Agenda for sustainable development, which contains 17 Sustainable Development Goals, was adopted by the United Nations General Assembly in September 2015. The current agenda emphasizes a holistic approach to achieving sustainable development for all, based on the principle of "leaving no one behind." Nepal is an initiative member for the sustainable development and it has been observing the dialogues over the Sustainable Development Goals (SDGs) with interest. It anticipates the further crystallization of global goals as well as national adaptation to adopt them for the country's inclusive long-term growth. As we are looking for planning of sustainable energy, this Goal 7 which details the sustainable energy objectives. The SDG7 goals include achieving universal access to sustainable, secure, and modern energy services by 2030, significantly raising the share of renewable energy in the global energy mix, and doubling the universal rate of energy efficiency progress.

The SDG7 targets are;

Target 7.1 By 2030, ensure universal access to affordable, reliable and modern energy Services.

Under this target the population with electricity access will be increased to 99% by 2030. Reliance of the population on clean fuels will be increased in the similar time frame. This includes usage of solid fuel for cooking as a primary source be decrease to 30% where uses of liquid and petroleum fuel will be increased to 39% and per capita electricity consumption will be increased to 1500 units.

Target 7.2 By 2030, Increase substantially the share of renewable energy in the global energy mix.

This target includes the increment in the renewable energy consumption in overall energy consumption. Contribution of renewable energy is targeted to hold 50% of share in total energy consumption. For this installed capacity of hydropower will be increased to 15000MW.

Target 7.3 By 2030, double the global rate of improvement in energy efficiency.

In this target energy efficient appliances are targeted to be used where efficiency will be increased to 60% and 50% of the vehicle will be electric in public transportation. (NPC, 2015)

2.4 Multi- Tier Energy Matrix

Table 2-1 Multi-Tier Framework for Household Electricity Access

<table>
<tr><td colspan="9">Multi-Tier Matrix for Access to Household Electricity Supply</td></tr>
<tr><th>S.N.</th><th></th><th></th><th>Tier 0</th><th>Tier 1</th><th>Tier 2</th><th>Tier 3</th><th>Tier 4</th><th>Tier 5</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Capacity</td><td>Power</td><td></td><td>Very Low Power Min 3 W</td><td>Low Power Min 50 W</td><td>Medium Power Min 200 W</td><td>High Power Min 800 W</td><td>Very High Power Min 2kW</td></tr>
<tr><td>AND Daily Capacity</td><td></td><td>Min 12 Wh</td><td>Min 200 Wh</td><td>Min 1.0 kWh</td><td>Min 3.4 kWh</td><td>Min 8.2 kWh</td></tr>
<tr><td>OR Services</td><td></td><td>Lighting of 1000 lmhrs per day and phone charging</td><td>Electrical Lighting, Air Circulation, Television and Phone charging are possible</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Duration</td><td>Hours per day</td><td></td><td>Min 4 hrs</td><td>Min 4 hrs</td><td>Min 8 hrs</td><td>Min 16 hrs</td><td>Min 23 hrs</td></tr>
<tr><td>Hours per evening</td><td></td><td>Min 1 hrs</td><td>Min 2 hrs</td><td>Min 3 hrs</td><td>Min 4 hrs</td><td>Min 4 hrs</td></tr>
<tr><td>3</td><td>Reliability</td><td></td><td></td><td></td><td></td><td></td><td>Max 14 Disruptions per week</td><td>Max 3 disruptions per week of total duration < 2 hours</td></tr>
<tr><td>4</td><td>Quality</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Voltage problems do not affect the use of desired appliances</td></tr>
<tr><td>5</td><td>Affordability</td><td></td><td></td><td></td><td></td><td colspan="3">Cost of standard consumption package of 365 kWh per annum is less than 5% of HH Income</td></tr>
<tr><td>6</td><td>Legality</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Bill is paid to the utility, prepaid card seller or authorised representative</td></tr>
<tr><td>7</td><td>Health and Safety</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Absence of past accidents and perception of high risk in the future</td></tr>
</table>

Multi-tier Matrix for Access to Household Electricity Services						
	Tier 0	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Tier Criteria	Not Applicable	Task lighting Phone charging	General lighting, Television, Fan (if needed)	Tier 2 and any Medium power appliances	Tier 3 and any high-power appliances	Tier 4 and any very high-power appliances

Multi-tier Matrix for Electricity Consumption						
	Tier 0	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Annual Consumption Levels, in kilowatt-hours(kWh)	<4.5	≥ 4.5	≥ 73	≥ 365	≥ 1250	≥ 3000
Daily Consumption Levels, in kilowatt-hours (kWh)	<12	≥ 12	≥ 200	≥ 1000	≥ 3425	≥ 8219

	Tier 0	**Tier 1**	**Tier 2**	**Tier 3**	**Tier 4**	**Tier 5**
Electricity Services	None	Electric Lighting, radio, mobile phone charging	Tier 1 + Multi bulb lighting, air circulation, television	Tier 2 + rice cooking, water heater	Tier 3 + Refrigeration, mechanical loads	Tier 4 + Electric cooking, space heating and cooling
Energy Supply Attributes	Continuous spectrum of Improving energy supply attributes including: quantity (watts), duration (hours),					
Possible Electricity Supply Technologies	None	Solar Lantern, rechargeable batteries, home system	Rechargeable batteries, home system	Home system, minigrid, grid	Home system, minigrid, grid	Home system, minigrid, grid

(Source:ADB, 2018)

2.5 Gross Domestic Product

The market value of all finished goods and services produced within a country's geographic borders in a given time span is referred to as GDP. It is one of the most important metrics for determining a country's economic health. GDP per capita & GDP growth are nation's economic indicators. The GDP growth rate indicates how quickly a country's economy is expanding. GDP per capita is an indicator of a country's standard of living and is the most accurate way to correlate GDP between countries. Nepal's economy is largely reliant on foreign assistance. Agriculture is the most important field of the economy, employing more than Seventy percentage of the population and accounting for 33% of GDP. In 2019, the GDP per capita of Nepal has increased to 1,071.051 USD, up from 1038.65 USD in 2018.The GDP per capita in Nepal is equivalent to 6% of the world’s average. GDP per capita reached an all-time high of 1,071.051 USD in 2019 and a record low of 46.243 in 1964. (World bank,2021)

2.6 Low Emission Analysis Platform

The Stockholm Environment Institute's Low Emissions Analysis Platform (LEAP) is a commonly used accounting simulation modeling tool. For integrated resource planning & GHGs mitigation evaluations, it has been widely embraced by developed countries. More than 85 signatories to the United Nations Framework Convention on Climate Change (UNFCCC) use LEAP tool to report their GHG inventories, demonstrating that it is a useful modeling method. (Heaps,2016). As a consequence, LEAP is used to handle data and outcomes as a modeling tool.

LEAP uses an end-user demand-driven method, which ensures that the study starts with a structure for end-use accounting. The market for goods and services divides society into a hierarchical tree structure. It's used to make models that cover anything from energy resources to production, transmission, and end-use. It is used as a database, a modeling tool, and a tool for policy analysis. It also promotes historical energy system research as well as economic and environmental impact assessments.

LEAP in also is a forecasting modelling tool for energy system scenarios. It was created to project energy over 20-50 year time period and can be used to analyses and measure the effect of energy and environmental policies. Policies may be modelled to investigate the physical, environmental and economic consequences of various policy scenarios.

LEAP scenarios are based on various assumptions about technological advancement, economic development, population, energy prices and environmental constraints etc.

LEAP is user friendly and adaptable modelling tool. Energy and environmental forecasts can be made eliminating the entering of cost data. LEAP is used to create top-down or bottom-up energy, emission and economic analyses due to its versatility. As a result, the input criteria for building a given model are largely determined by the nature and scale of the analysis. Data can be grouped as demographic data, economic data and energy data. The modelling in LEAP operates at two levels:

(i) inbuilt basic accounting relationships, such as energy supply and demand, environment emissions, transmission, capacity enhancement and costing; and

(ii) extra features that modelers can add like addition of innovative technologies as a function of income level, prices and policy instruments.

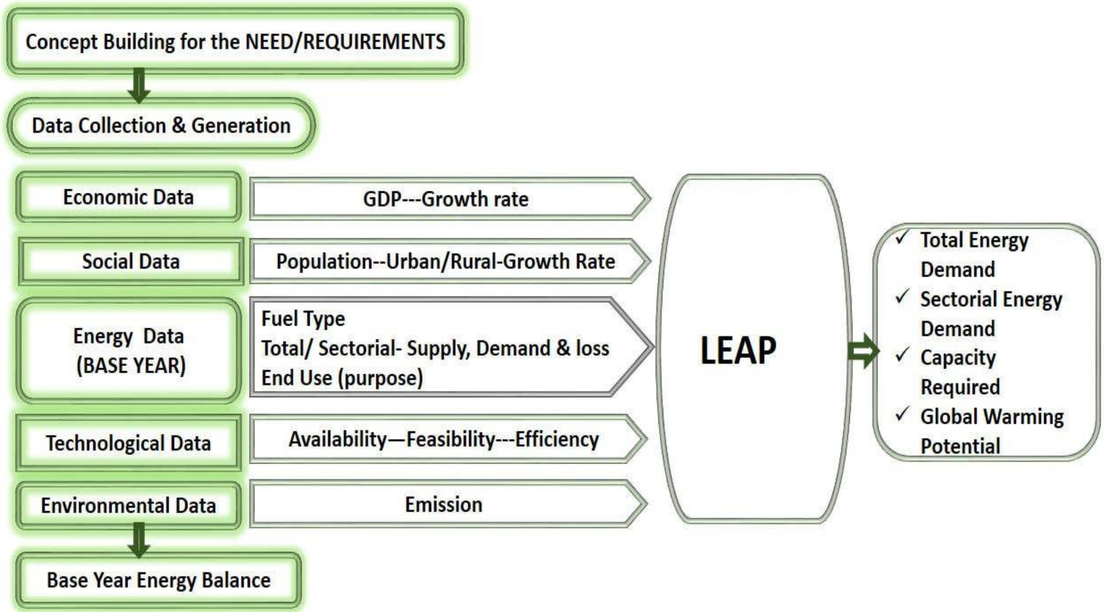

Figure 2-6 Leap Modelling Framework

Key characteristics of LEAP

- Simple software scenario-based modeling of energy planning and greenhouse gases mitigation assessment.

- Wide scope: extraction of resources, greenhouse gases, demand, transformation and local air
- Pollutants emissions, social, B/C analysis, non-energy sector resources & sinks.
- Different energy mechanism modeling tool.
- Support for multiple methodologies i.e. transport stock-turnover modeling, , econometric & simulation models, electric sector load forecasting.
- Requirements of lesser data at beginning phase and majority of the aspects are optional.
- Links to Microsoft Office Packages i.e., MS Word, MS PowerPoint, MS Excel
- Applicability in different level planning ie. Local (Cities/States), National, Regional & Global.(Gaire & Shakya, 2015)

2.7 Energy Conversion

Here is some multiplier expressed to convert from one unit to another:

10^6 kWh = 1 GWh

1 GWh = 3.6*10^3 GJ

1 kg coal = 1.890 kWh

1 kWh = 0.9630 kg CO_2

1 kWh = 1.260 lit. of water used.

1 kilowatt-hour (kWh) is 1 (One) unit of electricity.

2.8 Sample Size Determination

For sample size determination, (Robert et al., 1970) has determined the following formula in the article named “Small Sample Techniques”, published by the National Education Association (Research Division).

The mathematical formulae is;

$S = \frac{X2\ NP(1-P)}{d2(N-1)+X2P(1-P)}$ ……………………. Equation:2-1, where,

S = sample size required.

$X2$ = value of chi-square (Table Value) for 1 DOF (degree of freedom) at a desired confidence level (3.841).

N = size of population.

P = proportion of population (assumed as 0.5).

d = degree of accuracy expresses in terms of a proportion (0.05).

2.9 Sustainable Energy Access Planning

Sustainable Energy Access Planning (SEAP) is basically aimed for development of socially inclusive supply of energy system for both poor and non-poor people, which provides sustainable access of at least the basic amount of energy. It covers the wide energy framing networks that are different and distinct from the traditional energy planning.

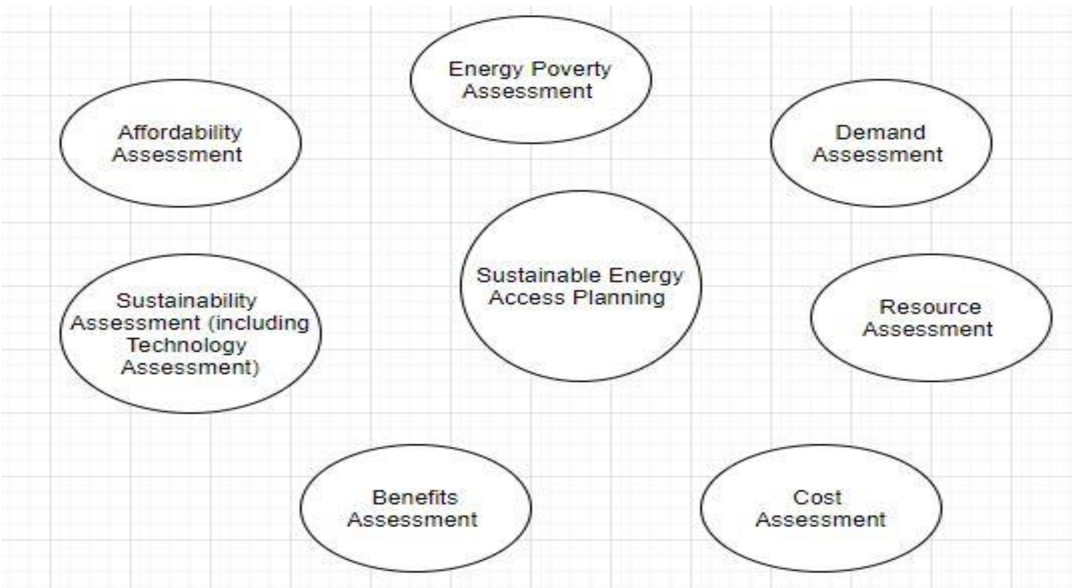

Figure 2-7 Elements of SEAP

(Source:Asian Development Bank, 2018)

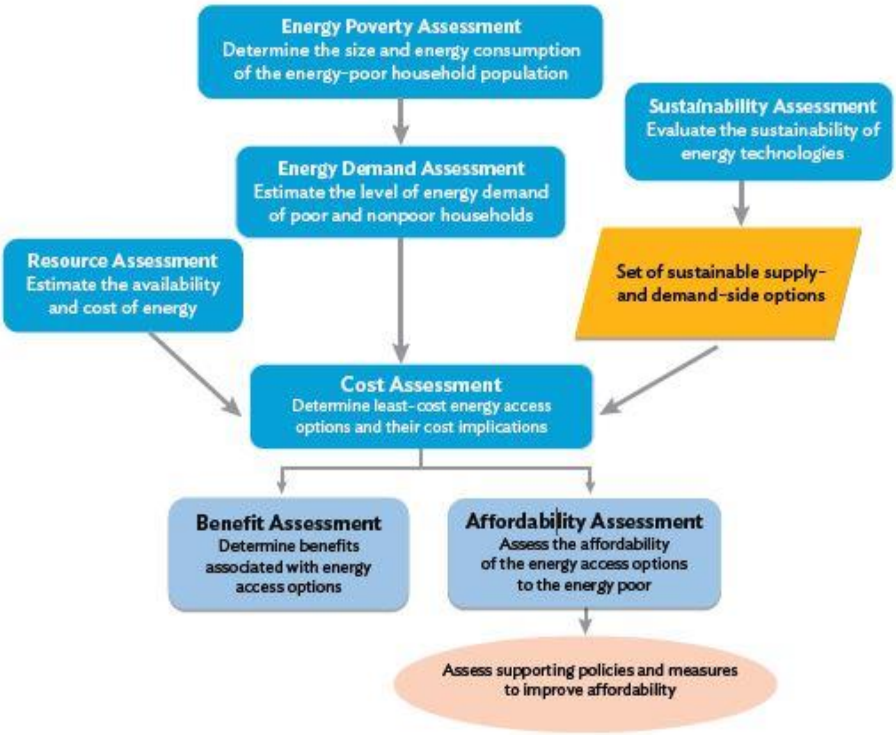

Figure 2-8 SEAP Flow Diagram

(Source: Asian Development Bank, 2018)

Here are some descriptions of the literature that are reviewed for the purpose of this research.

Table2-2 Literature Review

S.N.	Author	Title of Paper	Result/Conclusion
1	(Shrestha & Nakarmi, 2014)	Residential Energy Consumption Pattern of a newly formed municipality: A case study of Bhojpur Municipality of Bhojpur District	This research analyzed the energy situation of Bhojpur Municipality. Firewood (93%) is the main fuel. Cooking was found to be done mainly using firewood and lighting was done through grid connection.

2	(Shrestha et al., 2016)	Study of Current Energy Consumption of Dhulikhel Municipality	The study was done in 32 urban and semi-urban and 12 rural sampled households and was analyzed using R Commander (Rcmdr version 2.2-3) package in R software (Version 3.2.3). Cooking was the most energy intensive end use, accounting for 75% of urban and 90% of rural energy consumption.
3	(Adhikari et al., 2014)	Analysis of Rural Electrification Policy Provisions in Nepal	This paper concluded that Hydropower Policy 1992 and Electricity Act 1992 were the main act and policy documents which have described the different criteria of distribution and generation of hydroelectricity. In the enhancement and use of renewable energy technologies and rural electrification Rural Energy Policy 2006 was dedicated.
4	(Brandoni & Polonara, 2012)	The role of municipal energy planning in the regional energy-planning process.	This research was done by analysis of the twelve municipality energy plans and policies developed in the Italy to upgrade the understanding of the role played by municipal planning in the regional energy-planning process. Municipal energy saving and demand reduction can help to achieve the national energy policy targets.
5	(Shakya, 2012)	Analysis of Low Carbon Development Strategies: Role of Transport Sector	This study indicated that energy consumption and GHG emission would decrease abundantly if Carbon tax policy is executed in Nepal but there

		Electrification and Carbon Tax In Nepal	will be moderate loss in GDP and household welfare.
6	(Bajracharya & Nakarmi, 2014)	Current Energy Consumption in Bhaktapur District	This paper studied the current energy consumption of Bhaktapur. It was found that water heating was used by 25% of urban and rural household. In rural household, majority of them uses firewood which is 70% whereas in urban households, LPG is used for water heating accounting 75%.
7	(Darlami, 2006)	Integrated Energy Planning of Karnali Zone	LEAP has been used for energy planning. For planning, available resources, existing consumption trend and driving variables has been collected from primary and secondary data.
8.	(Pachauri & Spreng, 2003)	Energy use and energy access in relation to poverty.	The paper presented how energy poverty might be measured. It involved the assessment of minimum energy needs of a residential on the basis of mathematical calculations and basic normative consideration and poverty in relation to access to different sources of energy. They found that economically poor households have less access to electricity.

9.	(Panthi & Bhattarai, 2018)	Energy and Emission Analysis of Residential Sector: A Case Study for Reshunga Municipality in Nepal	This paper studied the energy and emission of Reshunga Municipality in LEAP based on the BAU, DSM, BSP and SDG scenario. The total energy consumption was 214.8 TJ. In SDG scenario demand was reduced by 23.14% and emission is reduced to 47.79K $tCO_{2e.}$
10.	(Surendra et al., 2011)	Current status of renewable energy in Nepal: Opportunities and challenges	The paper presented that only 1.0% of renewable energy are being utilized though having vast number of natural resources due to geophysical, political, technical and economic reasons. Nepal has high potential of use of RETs. 8 GWh/day solar electricity can be generated considering 4.5 per day peak sunshine.
11.	(Shree Rajbhandari & Man Nakarmi, 2014)	Energy consumption and scenario analysis of Residential sector using Optimization Model -A case study of Kathmandu valley	The energy model was developed using MAED and MARCAL. Current energy demand would put high pressure on energy demand and in national economy. The final energy demand of residential sector is about 7500TJ which is dominated by petroleum products (48%) and renewable with 33% of share.
12.	(Gaire & Shakya, 2015)	Energy and Environmental implication of graduating Nepal from -Least	This research studied the preliminarily energy mix up, desired future energy demand considering different scenario and its effects on graduation of Nepal. Study found that to graduate Nepal energy consumption per capita must be

		Developed to Developing country.	20.5 GJ and the commercial consumption of energy per capita must be 6.5 GJ.
13.	(Mundaca, L., & Neij, L. (2009))	Energy-economy models and energy efficiency policy evaluation for the household sector.	The paper laid the basis for the different dimensions: i) modelling issues; (ii) human-behavioral factors; (iii) techno-economic aspects and (iv) policy considerations. This paper evaluated the different energy models based on various criteria of assumptions, technological databases, research framework, geographical scope, modeling tools, etc.
14.	(Dhaubanjar et al., 2019)	Energy scenarios of household sector in panauti municipality for sustainable development and energy security	The final consumption of energy in panauti municipality is 147TJ in year 2016. The studied found that all total electrification in all end use service can decrease the demand of energy by 57% AEL and 35% in SDG scenario, and the about NRs.235 million is saved on fuel import.
15.	(Shakya et al., 2014)	Role of renewable energy technology in climate change adaption and mitigation in Nepal.	Nepal is one of the countries which is exposed to the risk of climate change. Studies shows that 4.45 million tons of CO_{2e} of the GHG emission can be reduced per year if all the renewable technologies are deployed.

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter describes the research methods related to this work. The main purpose of the study is based on an achievement of sustainable energy in the residential sector is based on Sustainable Energy Access Planning Framework. The methodology is divided into different sub topics which in detail describe the framework for the research.

3.1 Overview and Research Study Paradigm

This research framework is established to find out the concerns related to national energy planning and also to find the matters related to municipal energy planning as well as to assess the energy demands in the residential sector of Bhanu municipality. The research focused on current scenario analysis of municipality and future energy projection. The fine and foremost step of research methodology is the literature review. To identify a set of objectives and to know about the existing scenario of an energy consumption on central level and local level, a literature review was initially completed. Through the extensive study of various papers, journals, books, websites, etc. the research gap was identified and according to that a set of main and specific objectives were formulated.

The questionnaire was made based on GIZ and SEAP framework. Data collection was done through the primary survey on the formatted questionnaire. The collected data were at first entered in excel for pre liminary evaluation and then the data were made ready to enter on LEAP.

The energy model LEAP is used for the energy projection and analysis of current scenario of municipality. GHGs emission was calculated based on the current scenario and based on the current scenario plan is done to achieve the national targets of SDG for low emission. The results obtained were then extracted in charts and tables for easy understanding. Based on that the plans and suggestions were made.

The figure3-1 describe the chronological order of research methodology.

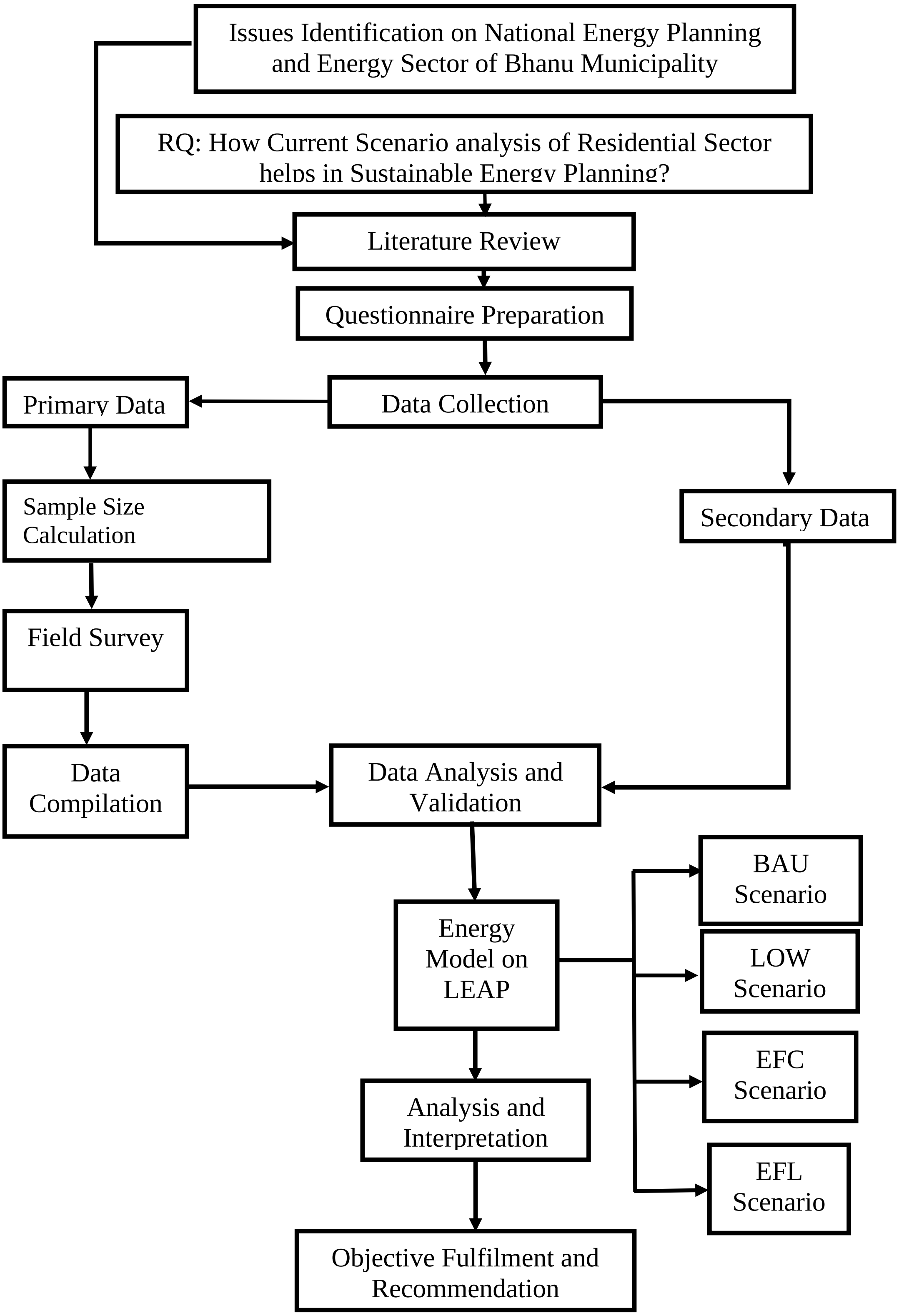

Figure 3-1 Research Framework

3.2 Study Area

Bhanu Municipality

Bhanu Municipality is situated in Tanahun District of Gandaki Province. The municipality was established by the government of Nepal on 2073/11/27 in the name of legendry poet Adikabi Bhanubhakta Acharya by merging previous Bhanu Municipality, Basantapur VDC, Mirlung VDC, Risti VDC (Ward no.6), Satiswara VDC (ward 1-5), Tanahusur VDC(Ward 1-3), Chowk Chisapani VDC, Rupakot VDC.

The municipality is bordered by Gorkha and Lamjung district in the east, Byas Municipality in the west, Lamjung District in the north and Bandipur rural municipality and Gorkha district in the south. It comprises 13 wards and has an area of 184 sq.km. The total population according to the census of 2011 is 45,792 and total number of the households is 12,097. (Bhanu Municipality, 2020)

Table 3-1 Population and Household distribution of Gandaki province.

Gandaki Province	Household	Population		
		Total	Male	Female
Metropolitian City	105,630	402,995	192,977	210,018
Municipality	255,622	1,042,011	462,022	579,989
Rural Municipality	216,430	932,348	414,476	517,872
Institutional	537	26,403	21,333	5,070

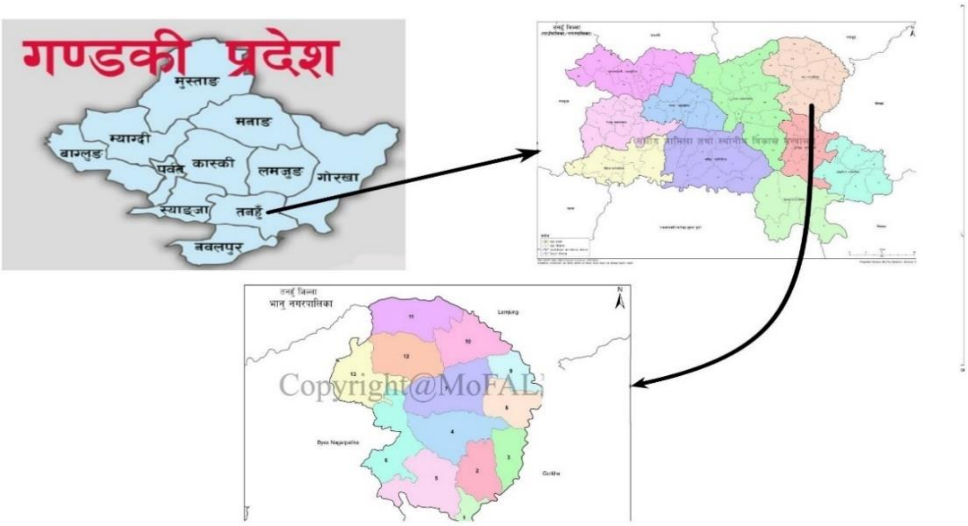

Figure 3-2 Map of Gandaki Pradesh, Tanahun district and Bhanu Municipality

(Source:MOFAGA,2021)

Table 3-2 Ward Merged and Reformed Wards

Recent Ward No	Inclusions of previous VDC and Municipality	Previous Ward No
1	Bhanu	1
2	Bhanu	2
3	Bhanu	3
4	Bhanu	4,5
5	Bhanu	6,8
6	Bhanu	9
	Tanahusur	1-3
	Satiswara	1
7	Basantapur	1-9
8	Purkot	4,6-9
9	Purkot	1-3,5
10	Chowk Chisapani	1-9
11	Rupakot	1-9
12	Mirlung	1-6
13	Mirlung	7-9
	Risti	6
	Satiswara	2-5

(Source: Bhanu Municipality,2021)

3.3 Sample size and field Survey

The sample size was calculated based on the formula proposed by krejicie and morgan. The following mathematical formula was used to determine the sample size.

$S = \frac{X2\ NP(1-P)}{d2(N-1)+X2P(1-P)}$ ……………………………………………………..Equation 3-1

where,

S = required sample size.

$X2$ = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P = the population proportion (assumed to be 0.50).

d = the degree of accuracy expressed as a proportion (0.05).

Field Survey was done on different household of each wards based on the sample size located to each ward. In order to include the sample of different family size, different level of income, rural and urban area household, consultation with different ward president was done and then according to the recommendations sample were collected.

Bhanu Municipality consists of 13 Wards and has 46179 populations. With the confidence level of 95% and the degree of accuracy 8%, the sample size found to be 149 households. After the selection of sample size i.e., 149 households, the number of households were determined in each ward using stratified random sampling. So that data collection will enfold households from all wards of Bhanu Municipality. The fractional values of samples were adjusted to its upper value for simplicity. The numbers of samples from each ward are shown in Table 3-3.

Table 3-3 Sample Size distribution according to the wards

Ward no.	No. of household	Population	%	Sample Size
1	842	3234	7.06	11
2	807	3274	7.15	11
3	934	3643	7.96	12
4	894	3319	7.25	11
5	931	3496	7.63	11
6	881	3439	7.51	11
7	868	3415	7.46	11
8	942	3605	7.87	12
9	952	3583	7.82	12
10	1028	3835	8.37	13
11	1125	4264	9.31	14
12	1052	3873	8.46	13
13	841	3199	6.99	10
Total	12097	46179	100	152

3.4 Questionnaire Development

The research initially uses the survey-based method that focuses on residential energy use patterns of Bhanu municipality. The questionnaire was prepared based on SEAP framework and GIZ household questionnaire survey. The questionnaire was disaggregated to different sections in order to calculate the end use demand properly.

3.5 Energy Demand

For modelling in LEAP, energy demand of residential sector was sub divided into eight end uses:

a. Cooking
b. Lighting
c. Animal meal Preparation
d. Preparation of local alcohol

e. Space Heating
f. Space Cooling
g. Electrical Appliances
h. Water Heating

Further end use categories were divided on the basis of fuel types. As the energy demand preliminary depends on the demographic parameter. The total energy demand is the product of energy intensity and demographic parameter. Here demographic parameters refer to the number of households. Energy intensity is calculated from the survey data and secondary data.

Energy demand= energy intensity ×demographic parameter……………. Equation 3-2

3.6 Service Demand Projection

The projection of energy demand in this study is based on the population and GDP per capita. The relationship of service demand in residential sector with population and GDP per capita is shown below:

$$SDi,t = SDi,0 \times \left(\frac{POPt}{POPo}\right)^{\alpha i} \times \left(\frac{GDPt}{GDPo}\right)^{\beta i}$$ ……...............................Equation 3-3

Where,

$SD_{i,t}$ and SDi,0 = service demand of sub sector i in year t and the base year respectively.

POPt and POP0 = population of the municipality in year t and the base year respectively.

αi and $_{\beta}$i = population and GDP elasticities of service demand of sub sector i respectively.

The values of service demand elasticity are taken from the study of (Shakya & Shrestha, 2011) which have estimated from regression analysis taking service demand as the dependent variable and GDP and population as the independent variable. The values of population and GDP elasticities are shown in Table 3-4.

Table 3-4 Elasticity value of end- uses

Residential End- use	GDP	Population
Lighting	0.03	0.98
Cooking	0.03	0.98
Space Heating	0.26	2.85
Space Cooling	0.26	2.85
Cooking Animal meals	0.03	0.98
Preparation of local alcohol	0.03	0.98
Electrical Appliances	0.26	2.85
Water Heating	0.03	0.98

(Source:Shakya & Shrestha, 2011)

3.7 LEAP Scenario development

Scenario planning is a forecast methodology which gives the potential future energy demand and supply requirements. Energy scenarios gives the concepts for finding the future energy outlook, counting various combination of technology options and their implication. Hence, it makes sense of an unknown future.

For the scenario analysis, 2020 was taken as a base year. The future final energy demand of Bhanu Municipality was projected to the year 2050. The population and GDP are taken as the key drivers of the residential energy demand. The population growth rate is taken as the average growth rate of two consecutive census, due to unavailability of GDP growth rate of municipality, the national average GDP growth rate is taken into account. The scenarios are made based on the national and municipal plans and targets. The detailed description of the different scenarios is described under different heading.

3.7.1 Business-As-Usual Scenario

Business-As-Usual Scenario **(**BAU) is the baseline scenario which suppose that the same trend will follow in the future without the intervention of new technologies and policies. Hence, the use of every demand technology in the energy supply in the upcoming years would be same as in the current study year. Under this scenario, the GDP growth rate and population growth rate would be same as the base year. The population growth rate is taken as 0.94% and GDP growth rate is taken as 4.8%.

3.7.2 Efficient Cooking Scenario

Efficient Cooking Scenario (EFC) follows the principal target of achievement of sustainable development goal by 2030. Here, the firewood share is reduced by the efficient technology shifting to ICS and replacing it with biogas and electricity by 2030. The population growth is taken same as of BAU which is 0.94% and GDP growth rate 7%. Likewise, the policy intervention is done to replace firewood by 10% and all cooking fuel by electricity in the end year.

3.7.3 Efficient Lighting Scenario

Efficient Lighting Scenario (EFL) also follows the national target of achievement of sustainable development goal by 2030. This scenario is based on replacing the inefficient lighting technologies by the LED with the 80% share of grid electricity and 20% share of solar PV. The population growth is taken same as of BAU and GDP growth rate of 7% according to the target of SDG.

3.7.4 Low Carbon Scenario

Low Carbon Scenario (LOW) is based on the aim to limit the emission of GHGs. This scenario sets the targets to electrify all the end use demands by the end of 2050. Here the GHG emitting fuels are replaced by electricity gradually. This assumes the GDP growth rate of 7%.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Energy Resource Assessment

Nepal is rich in hydropower resources. There is an abundance of renewable sources of energy but no economically feasible petroleum sources have been found yet. The main energy sources are biomass than followed by petroleum and electricity. The energy resources available in Bhanu Municipality are:

4.1.1 Fuelwood

In the Bhanu Municipality, Fuelwoods are majorly used for cooking meal for human and animals and water heating. Fuelwood is also consumed in maximum amount for preparation of local alcohol and also used for various household purposes. Mainly fuelwood is collected from their private forest/land or from community forests. Hence, it is economic source of energy than others.

4.1.2 Biogas

Some households having domestic animals in their house use animal residue as the source of energy. The dung is being used for the production of biogas. In Bhanu Municipality, during the field survey; 44 household use biogas plants.

4.1.3. Petroleum and Natural Gas Resources

All the petroleum products consumed in Nepal are imported in large amount from India and also from overseas. Bhanu Municipality also uses imported fossil fuels for cooking purpose and running vehicles. LPG is one of the major fossils fuels consumed in the residential sector and mostly used for cooking and water heating purposes. Bhanu Municipality is a mix of semi-urban and rural areas, all the wards have access to the roads and hence the transportation of LPG is easy and hence the rate of use of LPG is increasing.

4.1.4. Solar Energy

In Nepal, the country receives a large number of solar radiations with an average of 3.6-6.2 kWh/m^2/day and the sun shines for about 300 days per year. Though Tanahun district have enough solar radiations to convert it into the useful energy but it is not utilized in its maximum capacity.

4.2 Energy Consumption Scenario of Surveyed Households

All the households were found to be using electricity and other sources of energy used such as wood, biomass, LPG etc. Wood was the most economic sources of fuel in use due to easily accessible from the private, government and the local forests. The 128 number of households use LPG for cooking meal, followed by 98 households use wood, 55 households use rice cooker ,44 households have Bio-gas and only one household use induction heater for cooking.

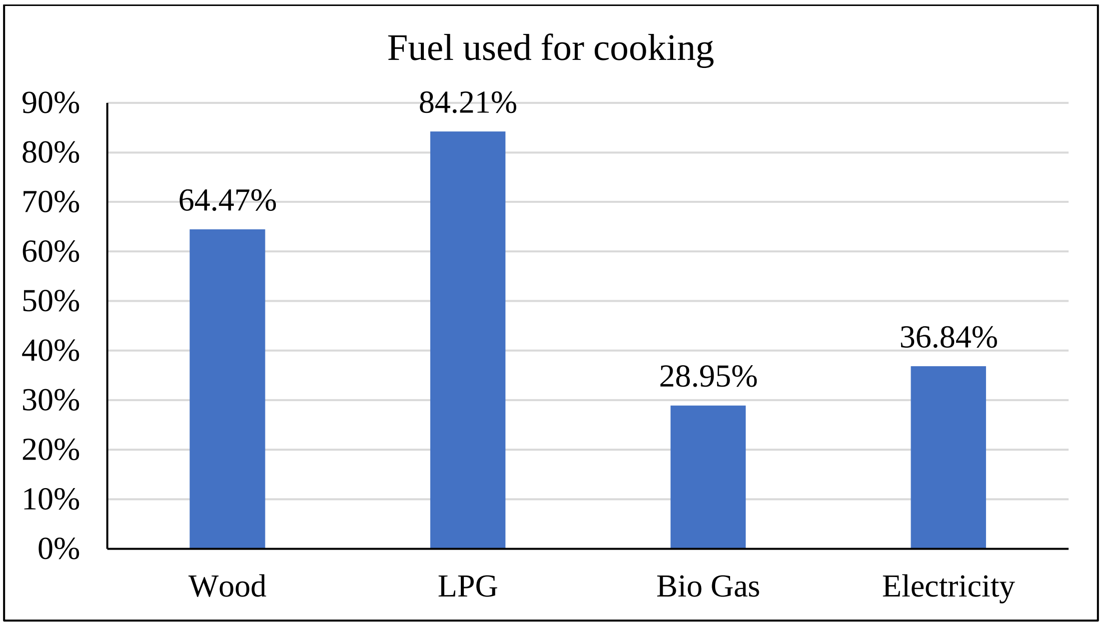

Figure4-1: Percentage of HH using different fuel for cooking

Maximum number of households i.e., 136 HH use LED light followed by 42 households use incandescent lamps and 32 households use CFL for lighting. The use of Solar PV for lighting is found in 7 households. The use of incandescent lamp was specially for heating and lighting to chickens.

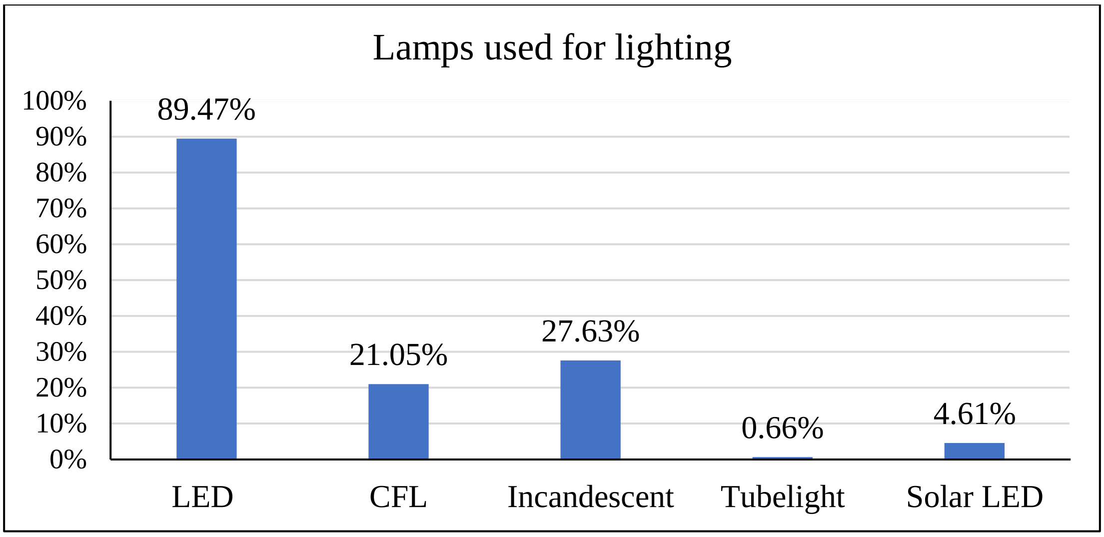

Figure4-2: Percentage HH using different lamps for lighting

The mostly used electrical appliances are Desktop, T.V, laptop, Fridge, Mobile, Water pump, Heater, Fan, Radio, Router, Kitchen grinder etc. Almost all the households use mobile for communication purpose. 68 households use CRT TV, 39 households use LED TV and 27 households use LCD TV and hence 135 households were accessible with TV, 34 households use Water pump.

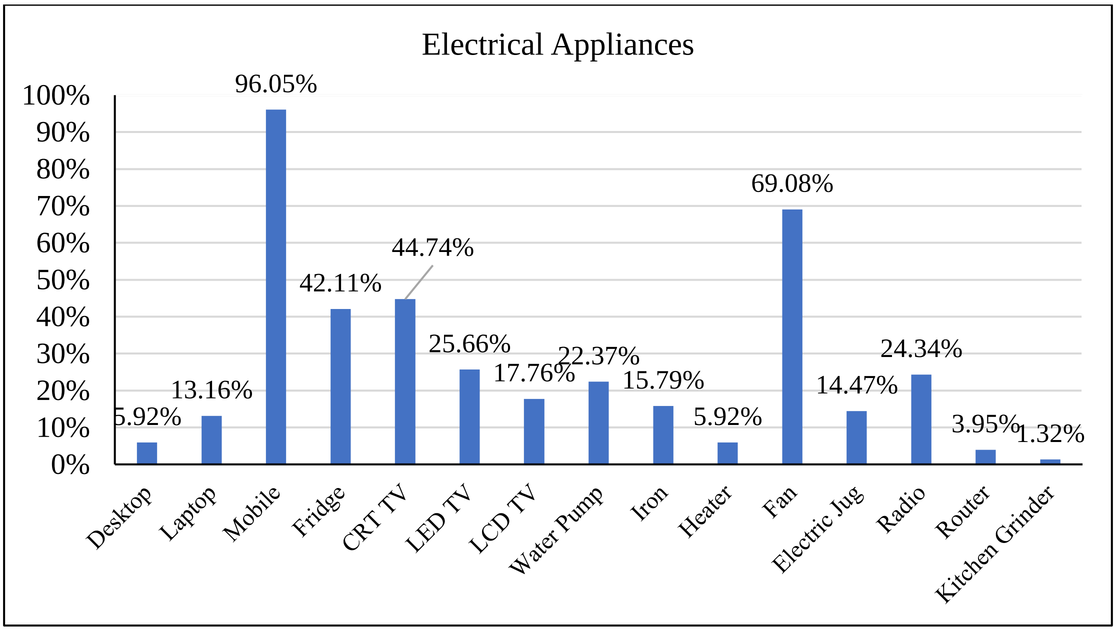

Figure 4-3: Percentage HH using different Electrical Appliances

Wood was the most consumed source of fuel in animal meal preparation and preparation of local alcohol. People consume alcohol during festivals and for daily used in Gurung, Kumal, Tamang communities.

4.3 Total Energy Consumption

The total energy consumption of the residential sector of the municipality is 635.67TJ in the base year 2020 accounting for 12.69 GJ/capita. The Table 10 shows the overall energy demand of the residential sector of the Municipality.

Table 4-1:Final energy Demand (TJ)

End use/Fuels	Electricity	Firewood	Biogas	LPG	Solar	Total (TJ/Year)
Cooking	0.83	184.71	0.02	44.16	0.00	**229.72**
Lighting	5.46	0.00	0.00	0.00	0.01	**5.47**
Animal Meal Preparation	0.00	257.45	0.00	0.00	0.00	**257.45**
Space Heating	0.36	26.08	0.00	0.00	0.00	**26.44**
Space Cooling	6.41	0.00	0.00	0.00	0.00	**6.41**
Electric Appliances	9.48	0.00	0.00	0.00	0.00	**9.48**
Water Heating	0.00	17.6	0.00	0.00	0.00	**17.6**
Alcohol Preparation	0.00	83.09	0.00	0.00	0.00	**83.09**
Total	**22.54**	**568.93**	**0.02**	**44.16**	**0.01**	**635.66**

4.4 Fuel wise energy consumption

Firewood for cooking and electricity for lighting are the main sources of energy in the municipality. The main fuels used in the municipality are firewood, LPG, electricity and biogas. Firewood shares the 89% of total energy consumption. Firewood is used mainly in cooking. People use firewood which are easily available in private or government forests and does not cost much. Firewood is utilized in maximum amount for cooking animals' meal and preparation of local alcohol. Since, forest covered area is 38% of total land covered of municipality firewood is cheaper source for these end use demands considering the availability and monetary point of view. The use of LPG is increasing day by day due to its ease in use. Firewood, LPG, biogas are the sources of GHGs emissions. Hence, this research focuses on sustainable development by switching to the efficient fuel and technology. The figure 4-4 shows the fuel share of municipality in base year.

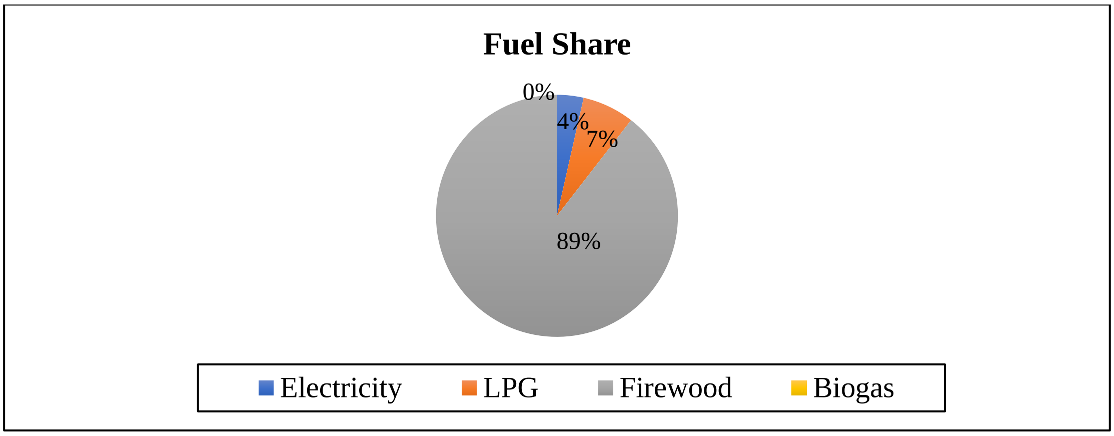

Figure 4-4 Fuel share by end use demand

4.5 Final energy demand by end use

Figure 4-5 shows the final energy demand by end use type. Where, cooking animal meal shares the maximum end use demand which is 257.45TJ which is followed by cooking 229.43TJ. Preparation of local alcohol follows the cooking and has demand of 83.09TJ, lighting has the minimum end use demand of 5.47TJ. Water heating, space cooling, space heating and electrical appliances has the energy demand of 17.60TJ, 6.41TJ, 26.44TJ, 9.48TJ respectively.

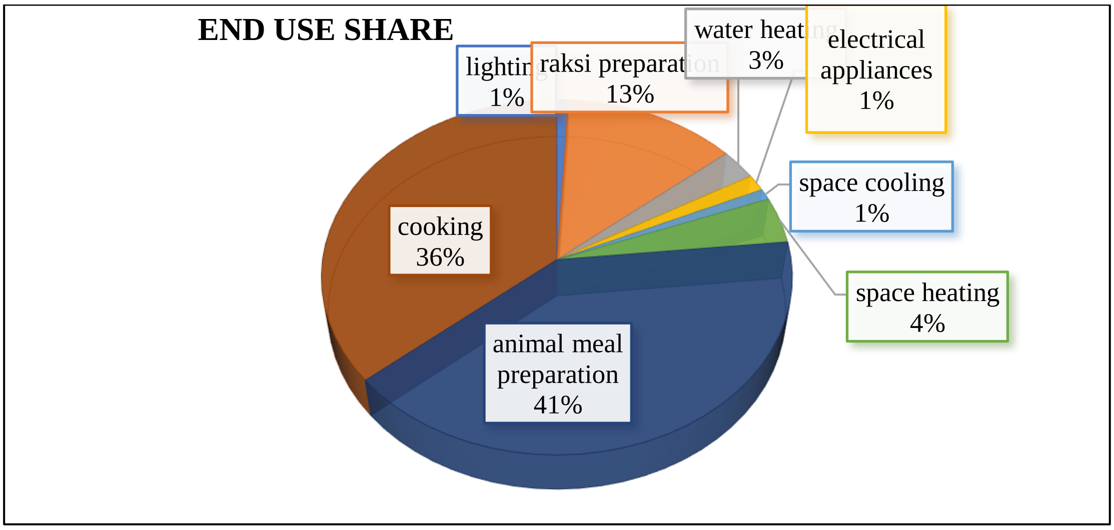

Figure 4-5 End use energy share

4.5.1 Energy consumed by end use cooking

Figure 17 shows the types of fuels used for cooking purpose. The highest energy consuming end use is cooking which has highest share of firewood followed by LPG, biogas and electricity.

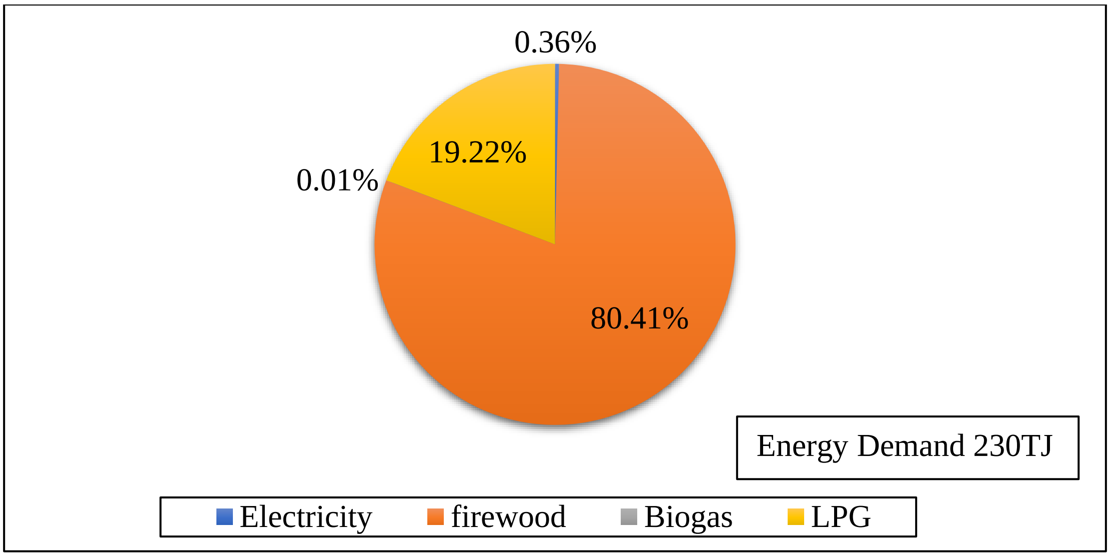

Figure 4-6 Energy share by fuel type in cooking

4.5.2 Energy consumed by end use lighting

The energy share by different types of lamps is shown in figure 18. Electricity accounts the 99% of share of lighting and 1% of lighting is done through solar PV. LED shares the highest energy in lighting accounting 45% is followed by incandescent. Solar LED and tube light shares the equal of 0.18% and the CFL share is 10.79%. The total energy demand is 5.47TJ in lighting.

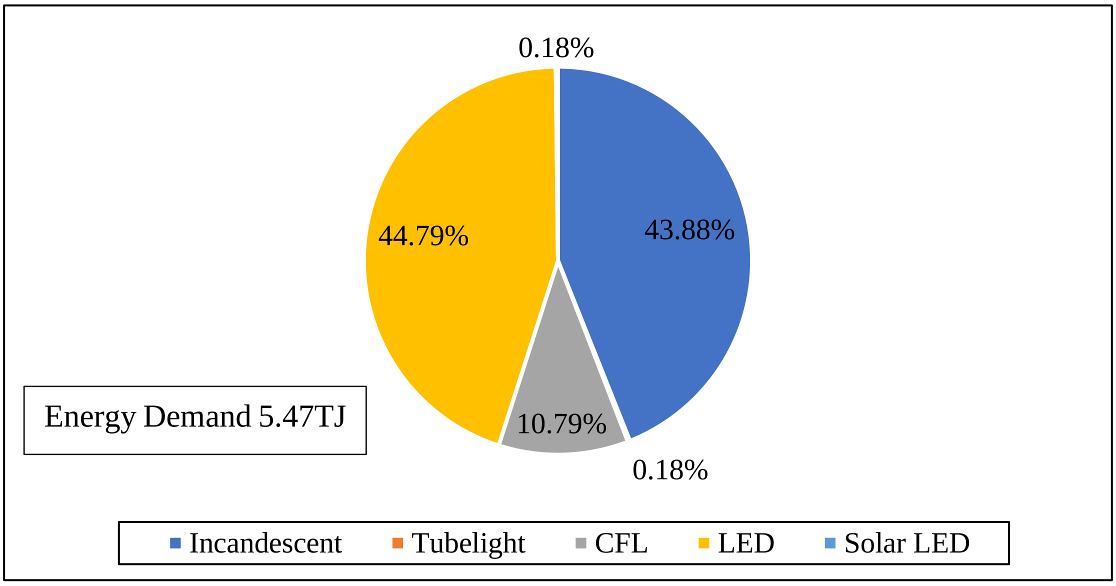

Figure4-7 Energy share by different lamps for lighting

4.5.3 Energy consumed by electrical appliances

The figure 4-8 shows the energy consumed by different electrical appliances. TV shares the highest energy among all the electrical appliances followed by mobile charging. The least energy is consumed by kitchen grinder and router.

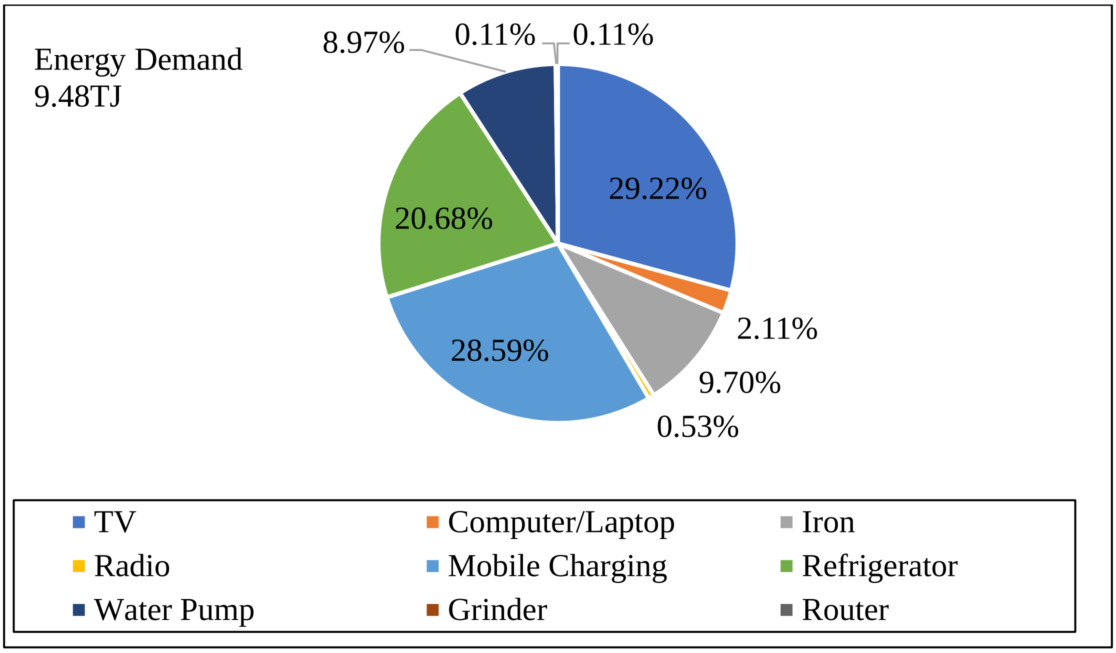

Figure 4-8 Energy share by different electrical appliances

The base year energy balance is shown in table 4-2. This shows that electricity and LPG are not produced within the Municipality or are imported outside the municipality. Wood, biogas and solar demand are met from within the municipality. Hence, the total production of 571.45 TJ and import of 71.85 TJ has the total primary supply of 640.82TJ. There is transmission and distribution loss of 5.15TJ resulting in total residential demand of 635.67TJ.

Table 4-2 Base year energy balance- TJ

Energy Balance for Area "BHANU MUNICIPALITY"							
Scenario: Business-As-Usual, Year: 2020, Units: Terajoule							
	Electricity	LPG	Wood	Biogas	Solar	Off_grid electricity	Total
Production	-	-	568.93	0.02	2.50	-	571.45
Imports	27.69	44.16	-	-	-	-	71.85
Exports	-	-	-	-	-	2.49	2.49
Total Primary Supply	27.69	44.16	568.93	0.02	2.50	2.49	640.82
Off grid electricity	-	-	-	-	2.50	2.50	-
Grid electricity	-	-	-	-	-	-	-
Transmission and Distribution	-5.15	-	-	-	-	0.00	5.15
Total Transformation	-5.15	-	-	-	- 2.50	2.50	- 5.15
Residential sector	22.54	44.16	568.93	0.02	-	0.01	635.67
Total Demand	22.54	44.16	568.93	0.02	-	0.01	635.67

4.6 Scenario Analysis

The scenarios are developed from the primary data survey and secondary data on resources, demography and technologies. The targets of scenario analysis are to explore the effects of policy intervention and helps to implement the plans. The summary of scenarios is discussed on the Table 4-3.

Table 4-3 Scenario Summaries

Scenario name		Assumptions
BAU	Business-as-usual Scenario	Population Growth=0.94%, economic growth rate=4.8%, energy intensity and energy mix remain constant.
EFC	Efficient cooking	Population Growth=0.94%, economic growth rate=7%, Traditional cook stove is replaced by ICS by 10% in end year. Limits the share of LPG to 10% in the 2030 and zero at the end year. 90% electrification in cooking by the end year.
EFL	Efficient lighting	Population Growth=0.95%, economic growth rate=7%, replacing inefficient lamps by LED with 80% share and solar PV LED by 20% share in 2030 based on national goal of SDG 7.
LOW	low carbon emission	Population Growth=0.94%, economic growth rate=7% electrification in all end use demand by year 2050.

4.6.1 Business-As-Usual Scenario

The Business as Usual (BAU) Scenario describes the future energy consumption pattern based on the current pattern of energy consumption without any policy and technologies intervention. The scenario calculates the likely future development without any governmental policy to limit the use of fossils fuels, to increase the energy consumption etc. The energy demands furthermore continue with the same GDP growth of 4.8% and population growth of 0.94%. The final energy demand for the base year in

2020 was 635.67TJ. This final energy demand in the BAU scenario will increase to 1264.86TJ in the end year 2050. The per capita final energy demand for the base year was 12.69GJ to 19.07 TJ GJ by the end of the study period. With the same population growth and GDP growth the final energy demand in the study period will increase up to two times of the energy demand of the base year. A study by Shrestha (2016), found that the average energy consumption per capita of residential sector of Dhulikhel Municipality was 5GJ per year and final energy demand was 72TJ per year. According to the study conducted by KC (2019) the per capita energy consumption is 3.28GJ per year with final energy consumption 295TJ in the Bhaktapur Municipality of the residential sector. The figure 4-9 shows the energy demand of different years based on BAU scenario.

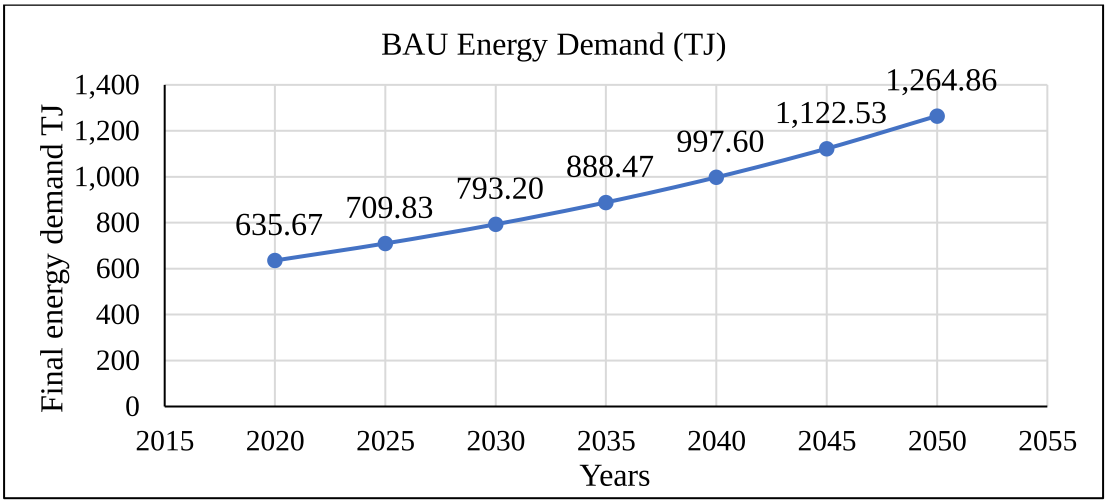

Figure 4-9 Final energy Demand BAU

Table 4-4 shows the annual energy consumed in end uses. The share of energy mix will be same as of current scenario. The majority of energy shared by cooking in the base year of 229.73TJ to 417.73TJ in the end year of study period.

Table 4-4 Final energy demand by end use BAU

Energy Demand Final Units							
Scenario: Business-As-Usual, All Fuels							
Branch: Demand\Residential sector\Bhanu Municipality							
Units: Terajoules							
Branch	2020	2025	2030	2035	2040	2045	2050
Cooking	229.73	253.88	280.49	309.88	342.36	378.24	417.73
Lighting	5.47	6.04	6.57	7.84	9.98	12.70	16.10
Animal Meal Preparation	257.45	284.51	314.33	347.27	383.66	423.86	468.12
Space Heating	26.44	33.80	43.02	54.74	69.67	88.66	112.32
Space Cooling	6.41	8.19	10.43	13.27	16.89	21.49	27.23
Electric Appliances	9.48	12.12	15.43	19.63	24.98	31.79	40.28
Water Heating	17.60	19.45	21.49	23.74	26.23	28.98	32.00
Alcohol preparation	83.09	91.83	101.45	112.08	123.83	136.81	151.09
Total	635.67	709.83	793.20	888.47	997.60	1,122.53	1,264.86

The Table 4-5 shows the energy demand by fuel types. The energy demand is based on the demographic and economic parameter. The share of wood continues to rise up to the end of study period. The electricity demand is increased by 3.84 times the base year energy demand.

Table 4-5 Final energy demand (TJ) by fuel type BAU

Energy Demand Final Units							
Scenario: Business-As-Usual							
Branch: Demand\Residential sector\Bhanu Municipality							
Units: Terajoules							
Fuel	2020	2025	2030	2035	2040	2045	2050
Electricity	22.54	27.73	34.01	42.60	54.03	68.55	86.62
LPG	44.16	48.81	53.92	59.57	65.82	72.71	80.31
Wood	568.93	633.26	705.22	786.25	877.70	981.21	1,097.87
Biogas	0.02	0.03	0.03	0.03	0.03	0.04	0.04
Off-grid electricity	0.01	0.01	0.01	0.01	0.02	0.02	0.03
Total	635.67	709.83	793.20	888.47	997.60	1,122.53	1,264.86

Figure 4-10 shows the GHGs emission of different fuels based on the BAU scenario. At the base year the emission from different fuels is 3627.60 metric tonnes of CO_2 equivalent and at the end of study period the emission will reached to 7233.67 metric tonnes of CO_2 equivalent. The per capita GHG emission at the base year is 72.43Kg and will rise to 109.08 Kg at the end of study period.

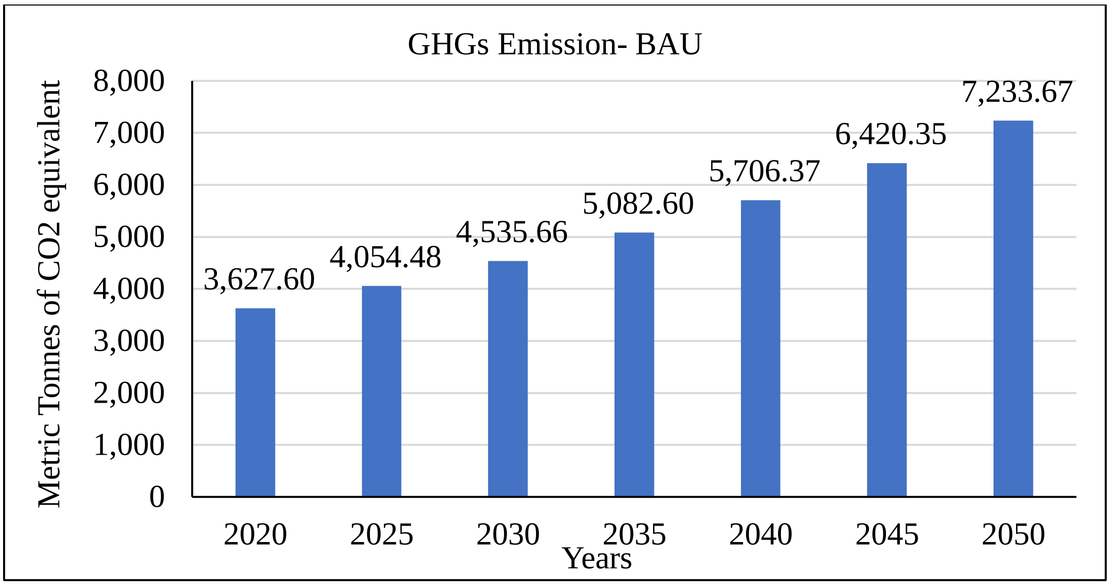

Figure4-10 GHGs emission -BAU

Table 4-6 shows the GHG emissions from fuels used such as biogas, wood LPG. The emission from LPG is highest and followed by wood emits 837.80 metric tonnes of CO_2 equivalent.

Table 4-6 GHG emission by different fuels in different end use

Direct (At Point of Emissions)				
Scenario: Business-As-Usual, 2020, All GHGs				
Branch: Demand\Residential sector\Bhanu Municipality				
Units: Metric Tonnes CO_2 Equivalent				
Branch	Biogas	Wood	LPG	Total
Cooking	0.02	195.80	2,789.78	2,985.60
Animal Meal Preparation	-	272.89	-	272.89
Space Heating	-	262.38	-	262.38
Water Heating	-	18.65	-	18.65
Alcohol Preparation	-	88.08	-	88.08
Total	0.02	837.80	2,789.78	3,627.60

4.6.2 Efficient Cooking Scenario

The Efficient Cooking Scenario (EFC) produces a result based on the population growth of 0.94% and GDP growth rate of 7% as assumed by nation to achieve sustainable development goal. In this scenario the inefficient cooking fuels were replaced by efficient ones. The traditional cookstove which used firewood was replaced by ICS by 20% in 2030 and 10% in 2050. The share of LPG is limited to 0 at the end of study period. All other fuels are replaced by electricity for cooking by 2050. So that, there was decrease in the final energy demand in EFC scenario as compared to BAU scenario and hence the total final energy demand at the end of study period was 1015TJ.

The figure 4-11 shows the final energy demand based on EFC scenario. There was constant growth up to year 2030 and thereafter energy demand increased linearly. It is due to the intervention of the shifting of technology of fuel firewood from traditional stove to ICS and accelerated growth is due to replacing other fuel by electricity. The per capita energy at the end of study period is 15.31 GJ.

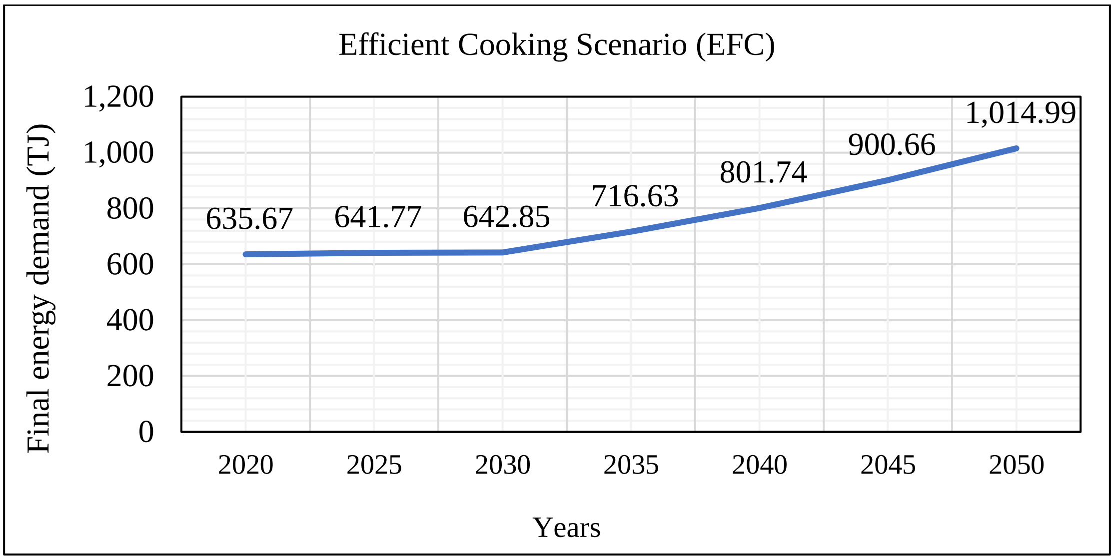

Figure 4-11 Final energy demand- EFC

Table 4-7 shows the GHG emission of different years from different fuels. The emission is reduced to 254.82 metric tonnes of CO_2 equivalent in 2050 from 2985.60 metric tonnes of CO_2 equivalent emission in the base year. The per capita emission was reduced to 34.28 kg per capita in the end of study period.

Table 4-7 GHG emission -EFC

Direct (At Point of Emissions)				
Scenario: Efficient cooking, All GHGs				
Branch: Demand\Residential sector\Bhanu Municipality\Cooking				
Units: Metric Tonnes CO_2 Equivalent				
Year	Biogas	Wood	LPG	Total
2050	-	254.82	-	254.82
2045	3.53	298.13	194.44	496.10
2040	6.38	330.47	350.89	687.74
2035	8.63	353.65	474.93	837.21
2030	10.39	369.15	571.39	950.92
2025	4.70	275.08	1,804.24	2,084.03
2020	0.02	195.80	2,789.78	2,985.60

4.6.3 Efficient Lighting Scenario

Efficient Lighting Scenario (EFL) assumes the population and GDP growth rate of 0.94% and 7% respectively for the period of 2020-2050. The EFL scenario replaces the inefficient lamps used in lighting by the LED. In order to increase the share of renewable energy to achieve the target of sustainable development goal 7, the share of solar PV was introduced to 20% at the end of study period. The figure 4-12 shows the final energy demand on EFL scenario. The final energy demand will be 1312.22 TJ in the end of study period which is greater than BAU scenario final energy demand at the end of study period. It is due to increase in the GDP growth rate.

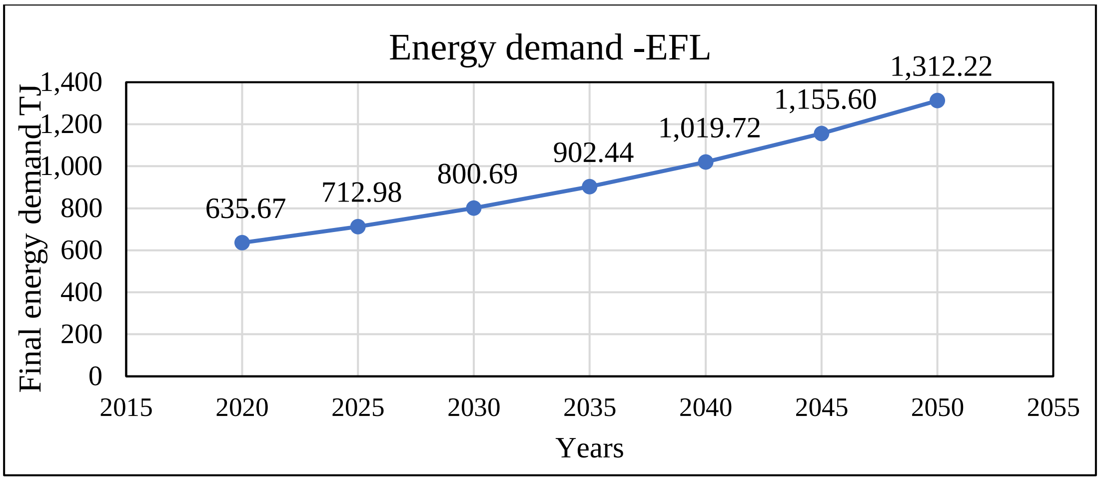

Figure 4-12 Final energy demand

Table 4-8 shows the final energy demand of different lamps in the base year and at the end of study period. The base year shows the energy demand of the different lamps whereas by the intervention of policy the study end year has only the share of solar and grid electricity LED. The energy demand in lighting in the base year is found to be 5.47TJ and 7.11TJ in 2050.

Table 4-8 Energy demand by Different lamps-EFL

Energy Demand Final Units		
Scenario: Efficient Lighting		
Units: Terajoules		
Branch	2050	2020
Incandescent	-	2.40
Electric FTL Tube light	-	0.01
Electric CFL	-	0.59
Electric LED	5.08	2.45
Solar PV LED	2.03	0.01
Total	7.11	5.47

4.6.4 Low Carbon Emission Scenario

Low carbon emission scenario (LOW) assumes the population growth of 0.94% and GDP growth rate 10.5% based on the vision 2043 under the fifteenth plan. Here all the fuels are replaced by electricity in order to limit the GHG emission. The figure 4-13 shows the final energy demand based on LOW scenario. The energy demand is lowest in the year 2030 and increases thereafter.

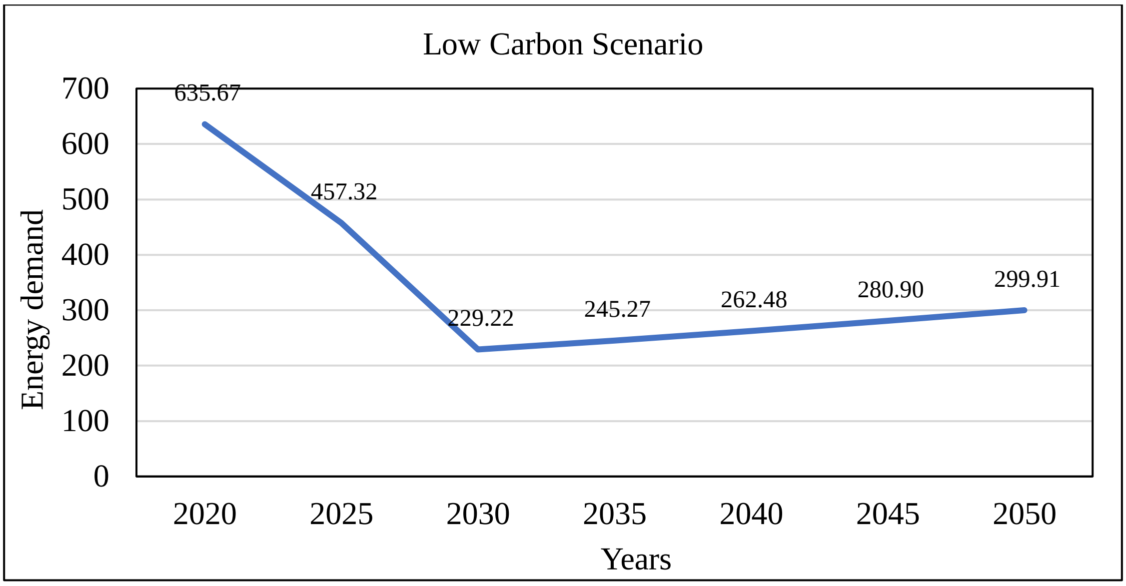

Figure 4-13 Final energy demand -LOW

The Table 4-9 shows the energy demand based on LOW scenario. This shows that energy demand will be decreased in the end year of study period. The energy demand of the year 2050 is 332.10 TJ. The per capita energy consumption in 2050 is 5.01 GJ which is decreased value from base year 2020 of 12.69GJ per capita.

Table 4-9 Energy demand by fuel types LOW

Energy Demand Final Units						
Scenario: Low Carbon Emission						
Branch: Demand\Residential sector\Bhanu Municipality						
Units: Terajoules						
Year	Solar	Biogas	Wood	LPG	Electricity	Total
2020	0.01	0.02	568.93	44.16	22.54	635.67
2025	0.06	2.22	353.77	25.30	75.97	457.32
2030	0.12	4.90	80.75	1.81	141.63	229.22
2035	0.20	4.07	68.70	1.50	170.80	245.27

2040	0.29	3.01	52.13	1.11	205.94	262.48
2045	0.40	1.67	29.79	0.62	248.43	280.90
2050	0.53	-	-	-	299.38	299.91

Table 4-10 shows the GHG emission under the LOW scenario. The emission in the base year is 3627.60 metric tonnes of CO_2 equivalent and is reduced to 0 at the end of study period. This shows that cooking emits the maximum GHGs among other end use.

Table 4-10 GHG Emission by End Use LOW

100- Year GWP:Direct (At Point of Emission)						
Scenario: low Carbon Emission, All Fuels, All GHGs						
Branch: Demand\Residential sector\Bhanu Municipality						
Units: Metric Tonnes CO_2 Equivalent						
Year	Alcohol preparation	Water Heating	Space Heating	Animal Meal Preparation	Cooking	Total
2020	88.08	18.65	262.38	272.89	2,985.60	3,627.60
2025	67.48	17.23	213.18	208.69	1,793.58	2,300.17
2030	41.36	15.28	106.33	127.28	307.16	597.41
2035	34.38	12.7	104.27	105.8	255.31	512.44
2040	25.4	9.38	90.88	78.17	188.63	392.45
2045	14.07	5.2	59.41	43.31	104.52	226.52
2050	-	-	-	-	-	-

4.7 Comparison of different scenario

4.7.1 Energy Demand Projection

The final energy demand projection is done under the BAU, EFC, EFL, LOW scenarios. The Table 4-11 shows the energy demand projection in terajoule. Final energy demand in 2050 is highest in EFL scenario which is 1312.23TJ followed by BAU 1263 TJ followed by EFC 1015TJ and LOW 299.91 TJ. The reference scenario assumes the GDP growth rate of 7% without any policy intervention. The energy projection of 2050 based on reference scenario is 1310.72 TJ. The combined scenario assumes the combined effect of EFC and EFL and has energy projection of 1006.95TJ at the end of study period.

Table 4-11 Energy demand projection based on different Scenario

Scenarios	2020	2025	2030	2035	2040	2045	2050
BAU	635.67	709.66	792.81	887.82	996.62	1121.15	1263
Reference Scenario	635.67	713.47	801.78	903.07	1019.77	1154.95	1310.72
EFC	635.67	641.77	642.86	716.64	801.75	900.67	1015
EFL	635.67	712.99	800.7	902.44	1019.72	1155.61	1312.23
Combined Scenario	635.67	640.32	639.65	712.50	796.50	894.13	1006.95
LOW	635.67	457.32	229.22	245.27	262.48	280.90	299.91

4.7.2 Emission Analysis

The mitigation of GHGs emission is global concern of today. Figure 4-14 shows the GHGs emissions for different scenario. The per capita GHG emission in BAU scenario in base year is 72.43 kg. The BAU and EFL shows the gradual increase of GHG emission. Since, there is no intervention on fuels emitting GHGs. EFL intervenes only on efficient lighting scenario. In EFC scenario there is gradual decrease in GHG emission. LOW scenario is the policy intervention scenario where we want to reduce GHGs emission to very low value by electrifying in all end use demands. This graph shows step by step replacement of conventional and fossil fuels by solar and electricity. Hence, this decreases the emissions of GHGs and also local air pollutants. This decrease in GHGs and local air pollutants denotes the reduction in hazardous impact on health of living beings and environment.

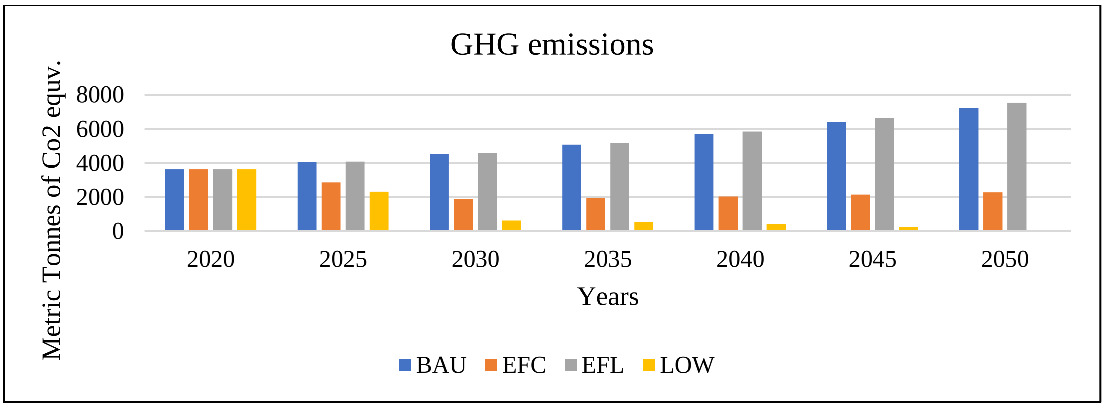

Figure 4-14 GHGs emission projection under different scenario

Table 4-12 shows the comparative table under different scenario of the year 2050. The emission of Particulates PM2.5 and black carbon are taken into account. There will be high emission of PM2.5 than black carbon in Efficient lighting scenario.

Table 4-12 Comparison of Environmental Effect on different scenario

Environmental Effects (Emissions) in Physical Units					
2050, All Fuels					
Branch: Demand\Residential sector\Bhanu Municipality					
Units: Metric Tonnes					
Effect	Business as Usual	Efficient cooking	Efficient lighting	low Carbon Emission	Total
Particulates PM2pt5	277.06	104.48	284.67	-	666.21
Black Carbon	38.02	14.34	39.07	-	91.43
Total	315.08	118.82	323.74	-	757.64

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the detailed study of the energy situation and analysis of the future energy demands in residential sector of Bhanu Municipality, different scenarios were developed in LEAP which were Business as Usual Scenario (BAU), Efficient Cooking Scenario (EFC), Efficient Lighting Scenario (EFL), Low Carbon Emission Scenario (LOW). The demand forecasting for all the scenarios were developed from the base year 2020 up to the year 2050. The efficient fuel and technology switching was done in efficient cooking scenario and all other lamps were replaced by LED. The share of solar was increased up to 20% at the end of study period. In low carbon emission scenario, all fuels were replaced by the electricity. The population and GDP growth rate were taken as the driving factor for the change in energy service demand on the years of study period.

The preliminary energy situation was analyzed after conducting the detailed survey of Bhanu Municipality. The total energy consumption in the base year was found to be 635.67TJ where the largest fuel share was from firewood 89.5% followed by LPG 6.95%. The share of electricity consumption was 3.55% only. The most energy consuming area was for the preparation of animal meal with the share 40.50% of the total energy consumption. There was high demand of energy consumption in cooking with the share in base year 36.09% of total energy consumption. From the detailed analysis of the current scenario of energy consumption in the residential sector of Bhanu Municipality, it was found and concluded that the consumption of firewood and LPG were the major source of emitting GHGs in the municipality. The 42% of the surveyed households had their monthly income less than 15 thousand, 40% of the households had income between 15-30 thousand and 12% of the household had the income range of 30-45 % and 6% of the households had income 45-60 thousand. No household was found having monthly income range above 60 thousand. About 60% of the total surveyed households were supplied from 5 Ampere fuse whereas the remaining households were using 16 Ampere fuses. In BAU scenario, the recent trend of energy consumption was allowed to continue with the average national GDP growth of past years which is 4.8% and the municipal population growth rate of 0.94%. The final energy demand in the base year was 635.67TJ which will be increased up to 1263TJ in the 2050. The per capita energy demand in the base year was 12.69GJ and in the base year it will be 19.07 GJ. The per capita emission in the base year was 72.43 kg per capita and it will be 109.08 kg per capita in the end of study period. The total emission will be 7233.67 metric tonnes of CO_2 equivalent in year 2050 which was increased value from the base year of 3627.60 metric tonnes of CO_2 equivalent.

The EFC and EFL scenarios were carried out according to the targets of Sustainable development goal. In EFC scenario the final energy demand will be 1014.99 TJ likewise in EFL scenario it will be 1312.22 TJ. The per capita emission will be reduced to 34.28 Kg in EFC scenario and the per capita energy will be 15.31 GJ. In EFL scenario the energy per household will be 108.48 GJ in 2050 and per capita energy will be 19.79 GJ.

In LOW scenario, policy intervention was done in order to reduce the emission of GHG. The final energy demand will be reduced to 229.91 TJ in year 2050. The all the GHGs were reduced to 0 in 2050. The energy per household will be 24.79 GJ in 2050 and per capita energy will be 4.52GJ in 2050. With the analysis of different scenario, it is concluded that the LOW scenario was found to be beneficial looking from every aspect i.e., energy and emission. Hence, sustainable development plan for Bhanu Municipality is recommended by this study.

5.2 Further study and Recommendations

This study has many shortcomings and limitations due to various factors. During the study, certain assumptions were made. This study is limited to only the residential sector of Bhanu Municipality. There are a lot of Municipalities whose energy planning is not done yet. With referencing to this study, further studies could be done. Some of the which are as follows:

i. In this research, only the residential demand is analyzed. Further research can be carried out including other sectors of energy demand like industrial, commercial and transport sector, which can give more detail understanding of the energy consumption in Bhanu Municipality.

ii. The survey was done based on random sampling of households, which does not include the different energy consumption. The surveying of all household can give the more accurate data.

iii. An experimental set up can be prepared in the sample house in order to measure the exact energy consumption with the help of energy measuring devices.

iv. During the study of the municipality, some of the data were taken from national data due to unavailability of municipal data. The study would be more accurate if we could incorporate all the parameters from municipality.

v. The emission analysis is based on residential data only. Incorporation of the other energy sector data and non- energy sector data would give the more accurate data on emission.

vi. The detailed cost analysis can be incorporated in the study.

vii. The local government may look for assistance and subsidies from governmental and other agencies to install renewable sources of energy.

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ANNEX

Annex A Residential energy consumption Survey Questionnaire

घरधुरी सर्भेक्षण प्रश्नावली (Household Survey Questionnaire)

गण्डकी प्रदेश, तनहुँ जिल्ला स्थित भानु नगरपालिका क्षेत्र भित्रका सबै १३ वडाहरुमा रहेका घरहरुमा अहिले कुन उर्जा कति खपत भएको छ। भविष्यमा आवश्यक पर्ने उर्जाको विकास र व्यवस्था गर्न सहयोग पुऱ्याउने उद्देश्यका साथ यस नगरपालिकाका जनताहरुको व्यक्तिगत तथा उर्जा सर्भेक्षण तालिका :

समुह १: उत्तरदाताको सामान्य जानकारी

क्र.सँ.	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस् ।
१.१	तपाईको पूरा नाम के हो ?	
१.२	लिङ्ग	१. पुरुष २. महिला ३. तेश्रो लिङ्गी
१.३	तपाईको उमेर कति भयो ?	………… वर्ष
१.४	तपाई कुन जाति/जनजाति समुहमा पर्नु हुन्छ ?	१.दलित २.जनजाति ३.बाहुन/क्षत्री ४.सिमान्तकृत ५.अन्य
१.५	तपाईका घर कति वडा नम्बरमा पर्छ ?	भानु नगरपालिका वडा नम्बर…….

१.६	तपाईको परिवारमा कति जना सदस्य हुनुहुन्छ ?	१.पुरुष .... जम्मा................ २.महिला ....
१.७	तपाईको घरको प्रकार कस्तो छ ?	१. नयाँ २. पुरानो ३.मिश्रित ४. अन्य
१.८	यो कस्तो प्रकारको बस्ती हो?	१.पुरानो २. नयाँ
१.९	तपाईको औसत पारिवारिक मासिक आम्दानी कति छ?	१. १५ हजारभन्दा कम २. १५ हजार देखि ३० हजार सम्म ३. ३० हजार देखि ४५ हजार सम्म ४. ४५ हजार देखि ६० हजार सम्म ५. ६० हजार भन्दा माथि

समूह २. उर्जा सम्बन्धी जानकारी

२.१ तपाईले घरमा बत्ती बाल्न प्रयोग हुने सामानहरुको विवरण:

क्र.स.	इन्धन प्रकार	नाम	वाट	संख्या	दैनिक बाल्ने समय (मिनेट/घण्टा)	
					घण्टा	मिनेट
१.	बिजुली	बिजुली चिम (Incandescent lamp)	१.१५ वाट			
			२.२५ वाट			
			३.४० वाट			
			४.६० वाट			
			५.१०० वाट			
			६.अन्य			
			१.४० वाट(मोटो)			

		ट्युबलाईट(Tube light)	२.३६ वाट(मसिनो)			
			३.अन्य			
		सिएफएल(CFL Light)	१.			
			२.			
			३.			
		लेडलाईट(LED Light)	१.			
			२.			
२.	सोलार	ट्युबलाईट(Tube light)	१.४० वाट(मोटो)			
			२.३६ वाट(मसिनो)			
			३.अन्य			
		सिएफएल(CFL Light)	१.			
			२.			
			३.			
		लेड लाईट(LED Light)	१.			
			२.			

३. मट्टीतेल.............. टुकी/पानस........... लाल्टिन.................

मैन्टोल................. अन्य ....

४. मैनबत्ति ....गोटा प्रति महिना

अन्य ....

५. गोबर ग्यास क्षमता/आकार.................... cu.m.

६.		चार्ज गर्न मिल्ने				चार्ज गर्न नमिल्ने	
		टर्च लाईट		इमर्जेन्सी लाईट			
		संख्या	दैनिक चार्ज समय	संख्या	दैनिक चार्ज समय	संख्या	Battery संख्या प्रति महिना

माथि उल्लेख भएका बाहेकका कुनै अरु इन्धन बत्ति बाल्न प्रयोगगर्नुभएको भए सो को नाम र प्रयोग हुने इन्धनको मात्रा उल्लेख गर्नुहोस.

इन्धनको नाम: .... खर्चको मात्रा : .... प्रति महिना

२.१.१. भबिष्यमा बत्ति बाल्न कुन इन्धन र बिध्युतीय उपकरण प्रयोग गर्न चाहनुहुन्छ?

इन्धन १.सोलार २. बिजुली

चिम १. बिजुली चिम (incandescent lamp)

२.ट्युबलाईट(Tubelight)

३. सिएफएल चिम(CFL Light)

४.लेड लाईट(LED Light)

५. अन्य...

२.२ खाना पकाउन प्रयोग गर्ने इन्धन र त्यसबारे अन्य जानकारी:

क्र.सँ	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस् ।				
१.	तपाई खाना पकाउन कुन श्रोत प्रयोग गर्नु हुन्छ ?	श्रोत	महिनामा कति खपत गर्नुहुन्छ?			महिनामा कति खर्च हुन्छ? ने. रु.मा
			एकाइ	मात्रा	संकलनको लागि लाग्ने समय	

		१. झार पात	kg			
		२. गुइठा	kg			
		३. दाउरा	kg			
		४. ब्रिकेट	kg			
		५. मट्टितेल	liter			
		६. एल.पि.जी. ग्याँस	Number			
		७. गोबर ग्याँस	Cu.m.			
		८.बिजुली हिटर	Kwh			
		९.राईस कुकर	Kwh			
		१०.अन्य.............				
२.	निकट भविष्यमा तपाईलाई घरमा कुन खाना पकाउने चुलो चलाउन मन छ ?	१. माटोको सुधारियको चुलो (mud improved cook stove) २. फलामको चुलो (metallic ICS) ३. ब्रिकेट चुलो (Briquette stove) ४. मट्टितेल (Kerosene stove) ५. एल.पि.जी. ग्याँस (LPG gas) ६. गोबर ग्याँस (Bio-gas) ७. विद्युतिय चुलो (electrical stove) ८. अन्य..				

२.३ घरका कोठा तातो/ चिसो गराउन प्रयोग गरिएका इन्धनहरुको विवरण:

क.सँ	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस् ।				
१.	तपाई कोठा तताउन/ चिसाउन कुन श्रोत प्रयोग गर्नु हुन्छ?	श्रोत	महिनामा कति खपत गर्नुहुन्छ?			महिनामा कति खर्च हुन्छ? ने. रु.मा
			एकाइ	मात्रा	संकलनको लागि लाग्ने समय	
		१. कोइला	kg			

		२. गुइठा	kg			
		३. दाउरा	kg			
		४. ब्रिकेट	kg			
		५. मट्टितेल	liter			
		६. एल.पि.जी. ग्याँस	Number			
		७. गोबर ग्याँस	Cu.m.			
		८.बिजुली हिटर	Kwh			
		९.बिजुली पंखा	Kwh			
		१०.अन्य.............				
२.	निकट भविष्यमा तपाई कोठा तताउन/चिसाउन कुन प्रबिधि प्रयोग गर्ने मन छ?	१. माटोको सुधारियको चुलो (mud improved cook stove) २. फलामको चुलो (metallic ICS) ३. ब्रिकेट चुलो (Briquette stove) ४. मट्टितेल (Kerosene stove) ५. एल.पि.जी. ग्याँस (LPG gas) ६. गोबर ग्याँस (Bio-gas) ७. विद्युतिय चुलो (electrical stove) ८. बिजुली हिटर (electric heater) ९. बिजुली पंखा (electric fan) १०. अन्य...				

२.४ घरमा पानी तताउन प्रयोग गरिएका इन्धनहरूको विवरण:

क.सँ	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस् ।				
१.	तपाई पानी तताउन कुन श्रोत प्रयोग गर्नु हुन्छ?	श्रोत	महिनामा कति खपत गर्नुहुन्छ?			महिनामा कति खर्च हुन्छ? ने. रु.मा
			एकाइ	मात्रा	संकलनको लागि लाग्ने समय	
		१. कोइला	kg			

		२. गुइठा	kg			
		३. दाउरा	kg			
		४. ब्रिकेट	kg			
		५. मट्टितेल	liter			
		६. एल.पि.जी. ग्याँस	Number			
		७. गोबर ग्याँस	Cu.m.			
		८.इलेक्ट्रीक जग	Kwh			
		९.बिजुली चुलो	Kwh			
		१०.अन्य.............				
२.	निकट भविष्यमा तपाई पानी तताउन कुन प्रबिधि प्रयोग गर्ने मन छ?	१. माटोको सुधारियको चुलो (mud improved cook stove) २. फलामको चुलो (metallic ICS) ३. ब्रिकेट चुलो (Briquette stove) ४. मट्टितेल (Kerosene stove) ५. एल.पि.जी. ग्याँस (LPG gas) ६. गोबर ग्याँस (Bio-gas) ७. विद्युतिय चुलो (electrical stove) ८. सोलार (solar thermal) ९. अन्य...				

२.५ घरमा गाईबस्तुलाई खाना पकाउन प्रयोग गरिएका इन्धनहरूको विवरण:

क.सँ	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस् ।				
१.	तपाई गाईवस्तुको खाना पकाउन कुन श्रोत प्रयोग गर्नु हुन्छ ?	श्रोत	महिनामा कति खपत गर्नुहुन्छ?			महिनामा कति खर्च हुन्छ? ने. रु.मा
			एकाइ	मात्रा	संकलनको लागि लाग्ने समय	
		१. कोइला	kg			

		२. गुइठा	kg			
		३. दाउरा	kg			
		४. ब्रिकेट	kg			
		५. मट्टितेल	liter			
		६.गोबर ग्याँस	kg			
		७.अन्य.............				

२.६ घरमा प्रयोगमा आउने सेवाका साधनहरुको विवरण:

विवरण	टि.भी.(इन्च)			रेडियो	फ्रिज	पानी पम्प	इस्त्री	कम्पुटर	ल्यापटप	मोबाइल	पंखा	अन्य
	सादा	रंगिन	LCD / LED									
वाट/हर्सपावर/इन्च												
संख्या												
संचालन(घण्टा/दिन)												
संचालन(घण्टा/महिना)												
उर्जाको श्रोत(उल्लेख गर्ने जस्तै ब्याट्री,बिधुत,सौर्य												

२.७ घरको सामाजिक तथा धार्मिक कार्यमा एक वर्षमा खपत हुने इन्धन उल्लेख गर्नुहोस:

इन्धनको प्रकार	दाउरा	मट्टितेल	बिजुली	LPG	कृषिजन्य भुस	गुइठा	ब्रिकेट	कोइला	अन्य
इकाई	kg	liter	Kwh	Nos.	kg	Nos.	kg	kg	
मात्रा									

२.८ राष्ट्रिय बिधुत प्रसारणबारे सामान्य जानकारी:

क्र.सँ.	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस्
२.८.१	एक दिनमा राष्ट्रिय विद्युत प्रसारण बाट कति घण्टा विजुली पाउनुहुन्छ?	४ घण्टा भन्दा कम न्यूनतम ४ घण्टा न्यूनतम ८ घण्टा न्यूनतम १६ घण्टा न्यूनतम २३ घण्टा
२.८.२	साँझमा कति घण्टा विजुली आउछ? (६ बजे देखि १० बजे सम्म)	१ घण्टा भन्दा कम न्यूनतम २ घण्टा न्यूनतम ३ घण्टा न्यूनतम ४ घण्टा
२.८.३	के राष्ट्रिय विद्युत प्रसारण लाईन विश्वसनीय छ? कम विश्वसनीय: हप्ताको १४ पटक भन्दा बढी अवरोध हुने मध्यम विश्वसनीय: हप्ताको अधिकतममा १४ पटक अवरोध हुने राम्रो छ : हप्ताको अधिकतममा ३ पटक अवरोध हुने र त्यो पनि २ घण्टा भन्दा कम	कम विश्वासनीय मध्यम विश्वासनीय राम्रो छ
२.८.४	तपाईको घरमा कति एम्पियरको फ्यूज छ?	५ एम्पियर १६ एम्पियर ३० एम्पियर वा त्यो भन्दा माथि फ्यूज छैन .

क.सँ.	प्रश्नहरु	गोलो घेरा लगाउनुहोस् वा आवश्यकता अनुसार लेख्नुहोस्
२.८.५	तपाईलाई भोल्टेज समस्याको कारणले कुनै विद्युतीय उपकरण चलाउन गाह्रो भईराखेको छ?	छ छैन
२.८.६	के तपाईलाई विद्युतको महशुल तिर्न आर्थिक कठिन छः?	छ छैन
२.८.७	तपाईले विद्युतको महशुल कता तिर्नु हुन्छः?	विद्युतको कार्यलयमा वा विद्युतको कर्मचारीलाई प्रिपेड मिटरबाट अन्य
२.८.८	अहिले सम्म कुनै विद्युतीय घटना घटेको छ वा कुनै जोखिम छ?	छ छैन
२.८.९	औसत मासिक बिजुली खपत कति हुन्छ?	.... बर्खा ....हिउद

२.९ **राष्ट्रिय विद्युत प्रसारण लाइन बाहेक अन्य कुनै श्रोतबाट बिजुली उपभोग गर्नुभएको भए सो को विवरण:**

क.सँ.	श्रोत	औसत उपयोग प्रति दिन/महिना	औसत मासिक खर्च
१.	मिनि/लघु/पिको जल विद्युत (mini/micro/pico hydro)		
२.	घरेलु सौर्य प्रणाली (Solar home system)		
३.	सोलार माईक्रो ग्रिड (Solar micro grid)		
४.	वायु ऊर्जा (Wind power)		
५.	अन्य (खुलाउनुहोस) Other (Specify)		

३. तपाईले भोग्दै आउनुभएको उर्जा समस्याहरु के के छन्?

Annex-B Photographs

Figure7-1 People Carrying LPG Cylinder Gas to Distant Villages by Bus

Figure7-2 Villagers Cutting Firewood for Residential Use

Figure7-3 Firewood used for Preparation of Local "*Raksi*"

Figure7-4 Electric Motor used for Pumping Water

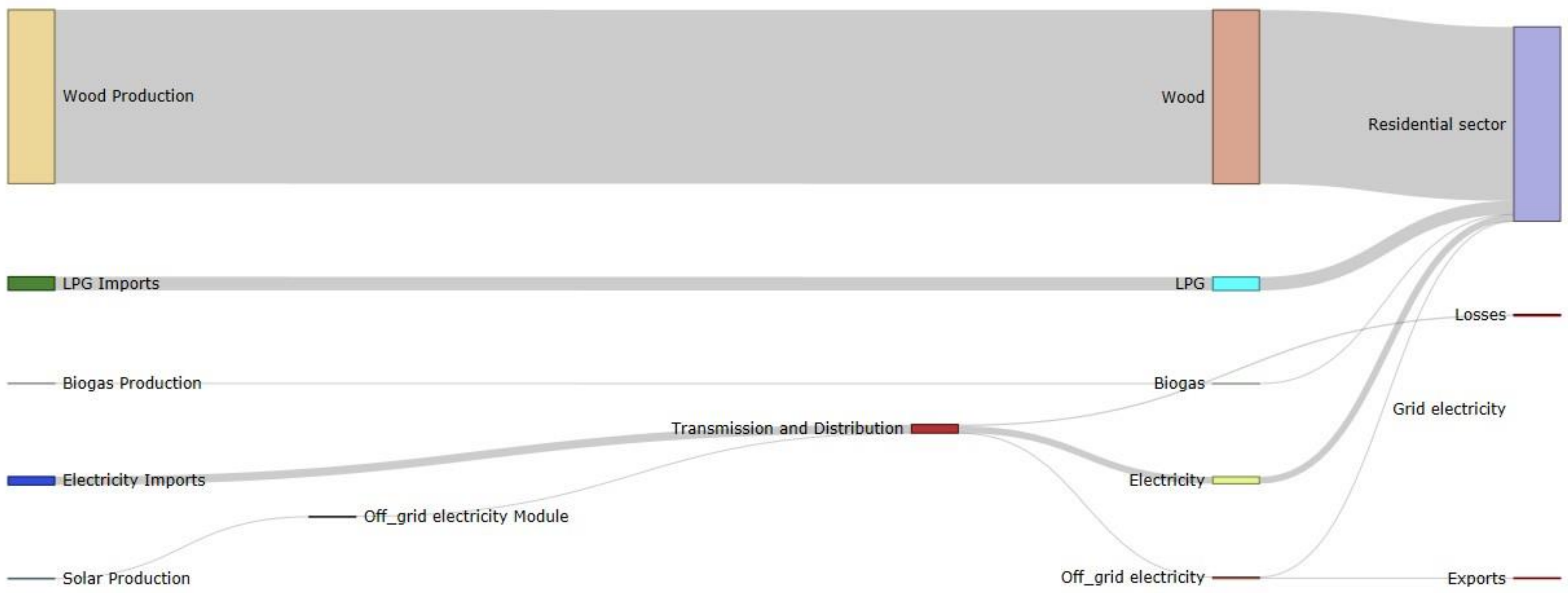
Figure7-5 Residential Survey-1

Figure7-6 Residential Survey-2

Figure7-7 Residential Survey-3

Annex C: Sankey diagram

BAU Scenario 2020



LOW Scenario 2050