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Sustainable Energy Planning at Municipal Level: A case study of Residential sector at Kirtipur Municipality

Jenish Maharjan [a], Amrit Man Nakarmi [b]

[a] *Department of Architecture, Pulchowk Campus, IOE, Tribhuvan University, Nepal*
[b] *Department of Mechanical Engineering, Institute of Engineering, Pulchowk Campus, Tribhuvan University, Nepal*
Corresponding Email: [a] jenishmaharjan123@gmail.com, [b] nakarmiamrit@gmail.com

Abstract

Rapid urbanization has made Kathmandu Valley one of the fastest growing metropolitan cities in South Asia, resulting to the need of better facilities. Energy plays a vital role for fulfilling the needs of facilities. Kirtipur municipality has the highest population growth rate of 4.47% which leads to higher energy demand in near future. The recent blockade has revealed the current energy security of Nepal. in Nepal higher energy is consumed in the household sector than in the production sectors. This research deals with the current energy consumption pattern or energy demand of Kirtipur municipality in 2018 in household sector. A primary survey was conducted with the household questionnaire and the secondary data were collected from various resources. Data collected were further analyzed on MS-excel to find out the current energy consumption the case area. The data from the excel were further analyzed on the LEAP with the energy model with bottom to top approach.

From the result it is shown that the LPG is the major source of energy. the total energy consumption of Kirtipur municipality was 261.5 TJ in 2018. Cooking was the most energy intensive end use and use of import fuel LPG has the higher demand. If none of the interventions are made in near future and the current energy consumption trend is continued the sustainable goal for multitier matrix cannot be meet by 2030 which is electricity consumption per household per year should be more than 3000Kwh. Two scenarios EHE and SDG were developed with the fuel switching to clean energy and energy efficient technology i.e. Hydro Electricity, Solar electricity and Solar energy. This switching of fuels resulting to the less energy demand due to use of energy efficient technology. The SDG scenario moreover focuses on the electricity generation from the Rooftop Solar PV resulting to 54% of Total Electricity demand to be substituted by the electricity generated through the rooftop solar PV in the Kirtipur municipality. The self-generation of electricity from the solar PV not only minimize the NEA Grid Load but also provides the energy security.

The policies should be driven by strategies for utilization of indigenous renewable resources instead of importing petroleum products. With the effective policy intervention, the energy demand and the emissions and the economic aspects can be minimized for the sustainable energy planning.

Keywords

Residential energy system, Energy consumption pattern, energy demand, energy security and energy planning

1. Introduction

For the first time in human history more than half of the world's population has been living in cities since 2007. Although covering only about 2% of the earth's surface, cities are responsible for about 75% of the world's consumption of resources. Least developed countries are expected to have the highest average urban growth rate of 3.3% per annum between 2010 and 2050 [1].Rapid urbanization has made Kathmandu Valley one of the fastest growing metropolitan cities in South Asia, resulting to the need of better facilities and infrastructure. Energy plays a vital role for fulfilling the needs of facilities and infrastructure. Energy is also recognized as essential for human kind which links economic growth, and environmental sustainability. Energy is the one of the important components for the socio-economic development of the country. Access to reliable and affordable energy services are fundamental to reduce energy poverty by the development of indigenous energy resources like hydropower. Unless the energy sector is geared up for the efficient and indigenous hydropower resources, sustainable energy development cannot be achieved. Nepal's energy resources are presently classified into three categories:

traditional, commercial and alternative. Traditional energy resources include fuel wood from forests and tree resources, agricultural residues coming from agricultural crops and animal dung in the dry form. Energy resources coming under the commercial or business practices are grouped into commercial energy resources that particularly include the coal, grid electricity and petroleum products. Biogas, solar power, wind and micro level hydropower are categorized into the alternative energy resources in Nepal.

Kathmandu valley is the largest and most populous urban agglomerate of Nepal. The valley constitutes major portions of three districts viz. – Kathmandu, Lalitpur and Bhaktapur constituting 85%, 50% and 100% land area of each districts (Pant and Dangol 2009). The overall energy consumption of Nepal is largely dominated by the use of traditional energy such as fuel-wood, agricultural residues and animal waste. About 77% of total energy consumed in Nepal is supplied from traditional sources and fuel- wood alone shares 70%. These fuels are mostly consumed in residential sector. Firewood is the primary fuel used for cooking food in most part of the country. Overall, 64% of households use firewood as their main source of cooking fuel. Other fuels used for cooking are: LPG (18%), cow-dung/leaves (14%), and other fuels (4%). Type of stove used for cooking is related to the issue of indoor pollution and the quality of life. 62% of urban areas households use gas stove and 58% of rural areas households use mud stove for cooking (CBS 2011). Looking at scenario of Kathmandu valley 69% of energy is consumed for only cooking purpose in which LPG is highly in used which is 46% [2].

2. Problem Statement

Kirtipur municipality is a semi urban area which is an ancient city having traditional settlements. It is rapidly growing in the periphery of the traditional settlement by the population growth rate of 4.47%. The LPG is major source of energy for cooking as it is easily available. LPG fuel is considered as a modern source of energy. But for a country like Nepal, where all the fossil fuels such as LPG and petroleum fuels are imported from neighboring countries such type of energy shifting is not suitable in term of energy security. Fully depending on imported LPG for cooking will face the problem of LPG import disruption and also rise oil price. So, use of energy efficient technologies and fuel shifting to clean energy is important in order to reduce energy consumption.

3. Need and Importance of Research

Residential sector is one of the major contributors in the energy consumption amongst all other sectors such as industries, commercial, transportation, etc. The total energy consumed by the residential sector in Nepal is 81.9%. Kirtipur municipality with one of the highest population growth rates of 4.47% reveals the energy consumption is going to more on near future. The problem of energy crisis has continued recently in 2016 which also shows the condition of energy security of Nepal. Switching to renewable energy and self-relying on hydropower is the best option for energy security in Nepal. i.e. economically viable hydropower capacity is 42,000 MW in Nepal. Energy scenario and policy analysis is highly in need for the better energy management and energy security. Energy have the direct impact on the people, their economy, Environment and society. Therefore, for the further development of the country in the sustainable manner, the energy crisis should be considered from the beginning.

In context of Nepal most of the research and the energy analysis has been done only in national level and not in local level as the objective of this research. The energy analysis done in national level may not be similar to the context of local level. It cannot be generalized from the point of view of national level. The requirement and the demand of the local level may be different than that of the national level. Therefore, it will be more appropriate to do the energy analysis from local level rather than from national level. It will be more contextual to draw out the result from local level and then only taken to national level rather than from national level to local level and then trying to solve the problem of local level. For example, requirement of Himalayan region will be different than of Terai and in such case data taken from the result of national level will be useless. That is why such research and analysis should be done from local level as purpose of this report which will we more appropriate and useful in context of Nepal.

4. Research Objective

The main objective of the study is to analyze different energy scenario of household sector in Kirtipur

Municipality for sustainable energy development for energy security with implementation of decentralized solar home system.

Specific Objectives

- To find out the different energy sources and consumption pattern for household sector in the case area and projection of energy consumption to the year 2050.
- To find the potential GHGs and local air pollutants emissions to formulate energy plan with scenarios as a basis for GHGs emission reduction.
- Development of modular design with implementation of renewable energy (Solar PV) for self energy generation to achieve energy security.
- To analyze different scenarios for sustainable energy development.

5. Study Limitation

- The end use efficiency will be assumed to remain constant throughout the study period.
- The energy consumption by the private vehicles like motor bikes and cars will not consider in the study.
- Environmental impact in term of GHGs emissions from energy consumption by household sector will only be calculated. Other impacts such as deforestation, soil erosion will not consider.
- The study is limited to the administrative boundary of Kirtipur municipality.

6. Literature Review

6.1 Energy

Energy is key to growth and sustainability. Energy is in the center of almost every global opportunity and challenge the world faces today. It is becoming a basic need, just like water, food, clothing, health care and education. Unfortunately, not everyone is enjoying the benefits of this all-important innovation as one in five people worldwide still lacks access to modern electricity while 3 billion, some of whom have electricity connection in their homes, still rely on animal waste, charcoal, coal and wood for heating and cooking. Energy consumption has been directly related to the gross national product, which is a measure of the market value of the total national output of goods and services. World-wide, about 80% of all energy used is currently from fossil fuels. There is simply not enough non-fossil fuel available for this. In order to mitigate the problem, we have to use the available energy much more efficiently. But this won't be enough either: We will have to change our behavior to reduce our personal energy consumption. We must change our current life style and seriously strive for a sustainable living. Large differences exist in terms of energy consumption between some of the most developed economies, largely due to the differences in attitudes towards implementing energy efficiency measures.

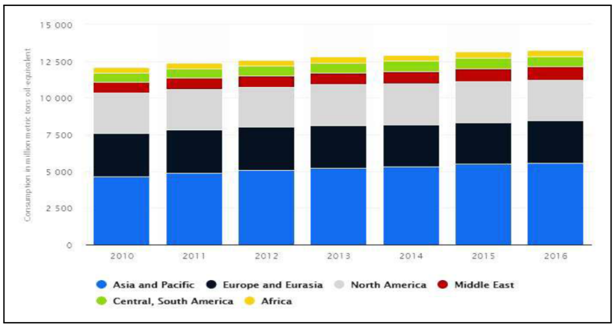

Figure 1: Primary energy consumption worldwide between 2010 and 2016, by region (Source: Energypedia 2017)

Nepal has faced an increasing gulf between the demand and supply of energy in the past several years. More than a third of the population does not have access to electricity and is forced to depend on traditional fuels for energy requirements. Furthermore, Nepal's electricity intensity is around 175KWh per capita, one of the lowest in the world.

Energy Consumption Nepal's energy sources have been categorized under three broad types:

1. Traditional energy sources
2. Commercial energy sources
3. Alternative energy sources

Alternative energy is synonymous with new, renewable and non-conventional forms of energy. This categorization pertains to the modality of use of the resources in abstracting the inherent energy contents. Traditional source of energy includes biomass fuels particularly fuel wood, agricultural residues and animal dung used in the traditional way which is direct combustion, wherein traditional energy sources undergo transformations into modern types of fuels. Commercial sources of energy are fossil fuels and electricity. Alternative 4 sources of energy include micro hydro, solar, wind power, biogas and briquettes etc. Biomass, hydropower and Solar are the three major indigenous energy resource bases in the country. Though Nepal has a huge potential for hydropower production, its exploitation has been to a very minimal, and therefore, significant amount of energy supply comes from traditional energy sources such as biomass. Heavy dependence for energy on biomass resources has accelerated the depletion of natural resources and contributed to the degradation of natural environment. It is the biomass sector which dominates the overall energy supply and consumption in the country.

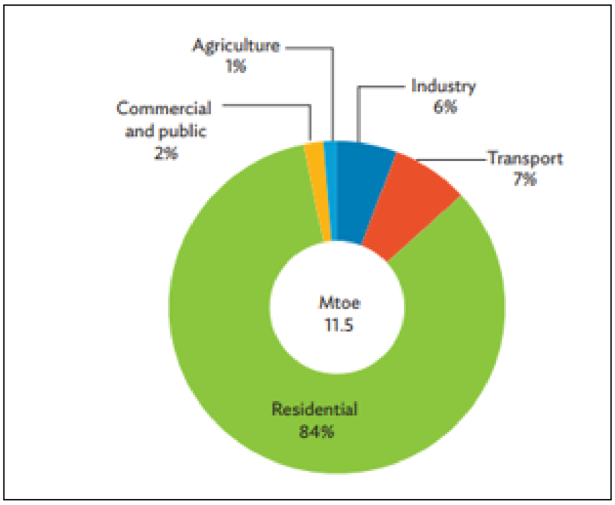

Figure 2: Final Energy consumption mix (ADB,2014)

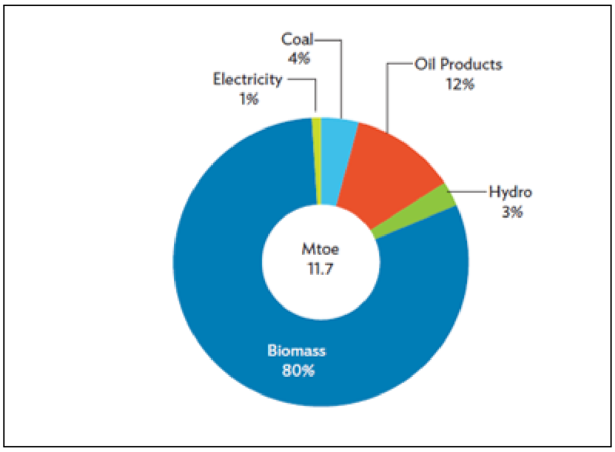

Figure 3: Primary energy supply mix(ADB,2014)

The largest share of energy consumption goes to the residential sector. The share of industry and transport is now small, but these sectors are growing fast. Figures 2 and 3 presents the share of each sector in total final energy consumption in 2014 and the major energy sources and their percentage share of the total supply of primary energy in 2014. Energy efficiency has become a growing issue all over the world. In terms of primary energy consumption, buildings represent around 40 per cent in most of the countries and 65 per cent of the total electric consumption. The residential buildings in the urban centers of Nepal mainly use electricity and LPG for lighting, heating and cooling purposes.

6.2 Energy consumption in cooking

Liquefied Petroleum Gas (LPG) has increased by 3.3 times as an alternate cooking fuel to kerosene and firewood. The growing subsidy burden to endorse modern fuel switching from traditional energy sources and high import of LPG are challenges for sustainability and energy security [3]. Despite the huge potential of hydropower and solar energy, only about 70% of the country's population had access to electricity in 2015. The residential sector has now the major share in country's energy consumption. Cooking has more than a 61% share of residential energy consumption, whereas that for heating is about 14%. Electricity in the residential sector is mainly used for lighting purposes. In the fiscal year 2004/05, about 77,594 tons of LPG was imported from India. Over ten-year period, the demand for LPG grew exponentially and imports reached 258,299 tons in the fiscal year 2014/15 [3].

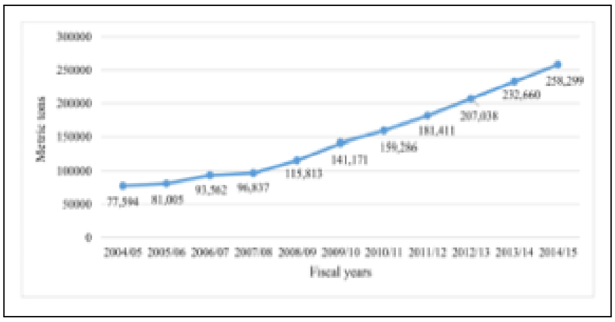

Figure 4: Historical trend of LPG consumption

6.3 GHG Emission

Residential sector is the major energy consuming sector which is about 80% of total national energy consumption of which 88% is traditional fuel (basically biomass). The use of cooking stoves or energy conversion technology practice in Nepal is generally open cooking stoves having efficiency of around 5%-7%. This implies that lots of energy is lost in the surroundings and at the same time emitting higher amounts of pollutants creating indoor air pollution. The figure shows that transport sector is the major carbon emission sector which accounts about 49% then emission in the year 2008/2009. followed by industry sector 25% and residential sector by 12% of total carbon emission in the year 2008/2009.

6.4 Leap long-range energy alternatives planning system energy model

The Long-range Energy Alternatives Planning system (LEAP) is a scenario-based energy environment modeling tool. Its scenarios are based on comprehensive accounting of how energy is consumed.

7. Research Methodology

In this research, Quantitative Approach has been applied for collection and analysis of data related to household energy consumption. This study consists the analysis of energy demand from the primary data collection. The research was carried out as per the flow chart given in Figure 5.

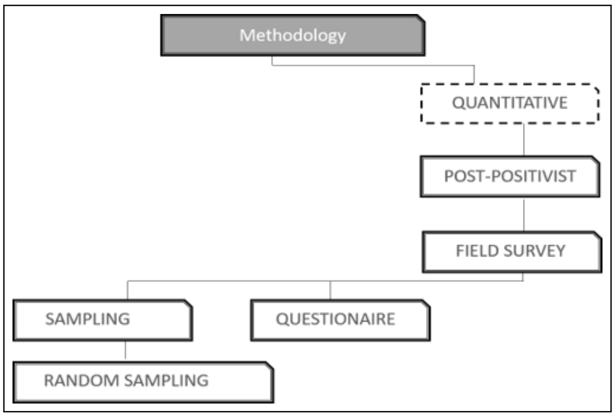

Figure 5: Graph of Research Methodology

7.1 Sample size determination

As per the Central Bureau of Statistics-2011, There are about 65602 population in Kirtipur Municipality. There are various formulas for calculating the required sample size based on the data collected is to be of a categorical or quantitative nature. The sample size was calculated using the following formula [4].

$$x = \frac{x2NP(1-P)}{[e2(n-1)+x2P(1-P)]} \quad (1)$$

Where,

S = Required sample size

x2= Table value of chi-square for 1 degree of freedom at the desired confidence level

N = population size

P = population proportion

e = Error Percentage

It consists of 10 wards and about 65602. With the confidence level of 95% and the degree of accuracy (e) 8%, the sample size would be 155 households. After the determination of sample size i.e. 155 households, the number of households were determined on the basis of proportion of household distribution in each ward. So that data collection would cover households from all wards of Kirtipur Municipality.

7.2 Questionnaire development

Questionnaires are typically used to collect primary data and to determine the current status or to estimate the distribution of characteristics in a population. Questionnaire was developed to collect primary data on the final household energy consumption of Kirtipur Municipality. Questionnaire was prepared on the basis of the energy consumption by fuel types such as firewood, LPG, kerosene, electricity, solar, agricultural residue etc. and energy consumption by end use such as cooking, lighting, water heating room heating/ cooling and other electric appliances. The primary data was collected in the hardcopy of questionnaire. The collected data was used as input in the LEAP software.

7.3 Data collection

Primary data collection is the main part of the study. The household survey was conducted through quantitative method. The primary data collections were divided into two sectors which were energy consumption data of houses of traditional settlement and newly developed settlement. The collected data includes the energy consumption of households by end-use such as cooking, lighting, room heating, cooling etc. and by fuel type such as LPG, agricultural residue, electricity etc.

7.4 Scenario Development

7.4.1 Business as Usual (BAU)

Business as usual scenario is the base line scenario which assumes that the past trends will continue in the near future year and no additional measurement will be put into practice. Thus, the share of each demand technology in the energy supply in future years will be same as in the base year. In this scenario, population growth rate and GDP growth rate will be same as base year.

7.4.2 All electrification scenario (AEL)

All Electrification Scenario follows the principle objectives of sustainable energy for all that promote access of electricity for all. In this scenario, there will be access of uninterrupted electricity supply policy. This scenario promotes the potential of electricity generation from hydropower and solar PV. The inefficient fuel as well as fossil fuel will gradually replace by electricity and solar. The end-use inefficient technologies will gradually replace by the energy efficient technologies such as LED is penetrated replacing incandescent bulbs and fluorescent tube lights. The population growth and GDP growth rate will be same as Business-as-Usual scenario

7.4.3 Sustainable development Goal (SDG))

Sustainable Development scenario also follows the principle objectives of sustainable energy for all that promoted electricity and solar energy for sustainable development. Traditional and fossil fuels will gradually replace by clean fuels: electricity and solar in order to reduce GHGs and local air pollutants emission. In this scenario the total energy consumption is targeted to more 3,000KWh per household. The population growth will be same as in BAU scenario. This scenario is developed in order to make comparable with the energy consumption at all with that of households in Kathmandu valley and to meet tier 5 as in “Beyond Connection: Energy Access Redefined

8. Findings

8.1 Energy Scenario in the Base Year

8.1.1 Energy balance 2018 - Sankey Diagram

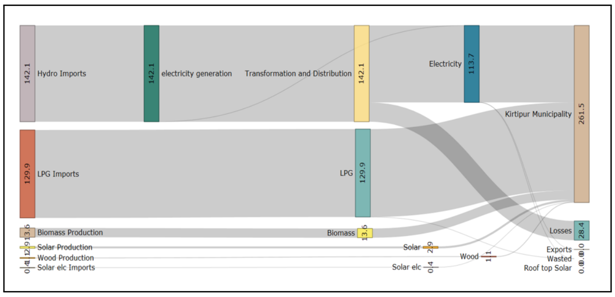

Figure 6: Energy balance 2018

8.1.2 Per Capita Energy Consumption

The energy consumption of Kathmandu valley is 3 GJ per capita in 2014 [2]. A figure shows that the per capita energy consumption of Kirtipur municipality is 3.14GJ which shows that the per capita consumption energy is similar to the study of Kathmandu valley which was done in the 2014. From this figure it can be seen that the energy consumption in the houses of traditional settlement is quite less than the energy consumption in the houses of newly development settlement which are 2.73 GJ and 3.24 GJ respectively in 2018. These difference in energy consumption is due to the living style, use of appliances of the people in the traditional settlement and the newly development settlement.

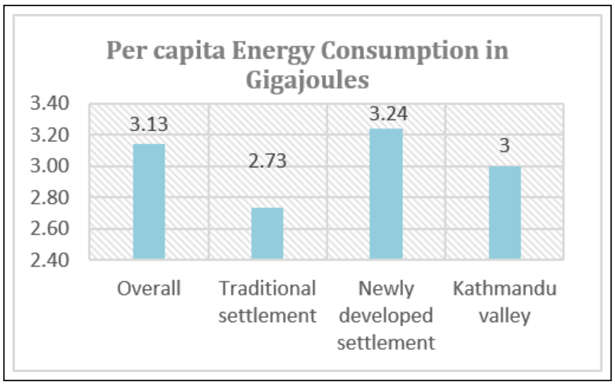

Figure 7: Per capita Energy Consumption in Gigajoules

8.1.3 Final Energy Demand by End Use

The final energy demand by end use type in 2018 It is seen that cooking is the most energy intensive end-use which accounts for 51% of total energy demand. It is followed by electrical appliances (30%), Lighting (9%)and Alcohol Preparation (5%). Space heating and space cooling accounts 2% and 1% total energy consumed.

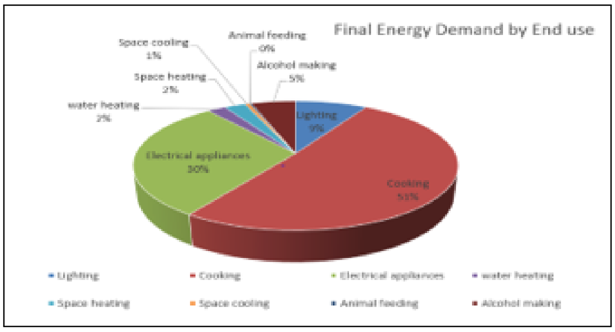

Figure 8: Final Energy Demand by Enduse

8.1.4 Final energy demand by Fuel Types

Figure 9 shows the final energy demand by Fuel type. It is seen that LPG is the most energy intensive fuel type which accounts for 50% of total energy demand. It is followed by electricity (45%), Agricultural residue (5%). From this chart we can see the most used fuel is LPG and electricity respectively.

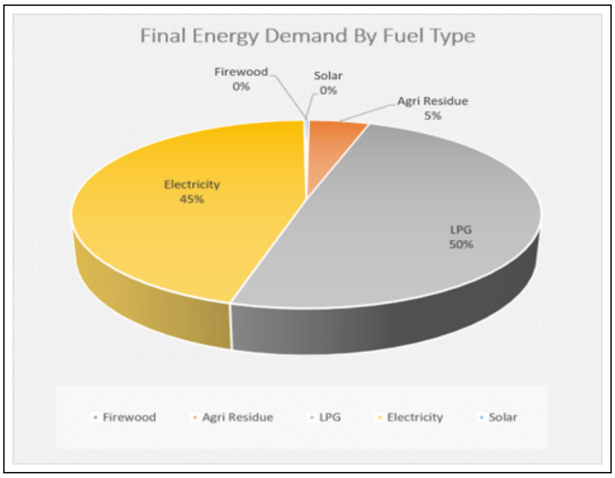

Figure 9: Final energy demand by Fuel Types

8.1.5 Electricity User Ratio 5 AMP and 15 AMP

Figure 10 shows the electricity user ratio of 5 Ampere and 15 Ampere in Kirtipur municipality in both the settlements. From the chart,15 ampere (58%) electricity users are more than the 5 Ampere i.e. 42%. 26% of 5 Amp electricity users consumes 50Kwh – 250kwh per month.

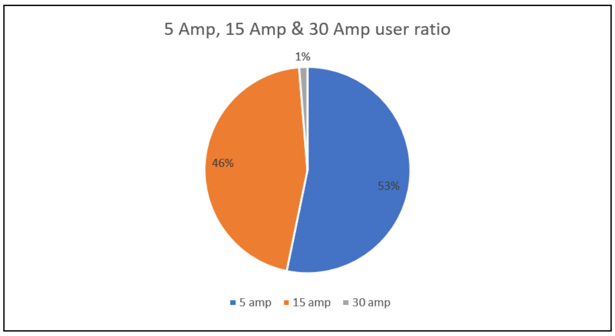

Figure 10: Electricity User Ratio 5 AMP and 15 AMP

8.1.6 Electricity Consumption In 2018 (Kwh)

The bar graph above shows the electricity consumed per household in 2018 in Kirtipur municipality between three different types of houses i.e. traditional houses, mixed use houses and modern houses. Electricity consumed per capita in traditional houses, mixed use houses and modern houses are 800.65 Kwh, 689.91 Kwh and 2586.24 Kwh respectively. The electricity consumed per household in Kirtipur Municipality is 1772.46 KwH in the year 2018.

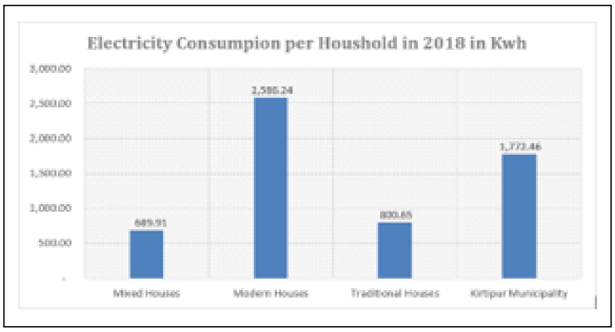

Figure 11: Electricity Consumption Per Household in 2018 in Kwh

8.1.7 Energy Balance in 2018

The energy balance of Kirtipur municipality for year 2018 show s that the total energy demand for Kirtipur municipality is 261.5 TJ. Total electricity import for Kirtipur municipality is 142.1 TJ with transmission and Distribution loss of 20

Table 1: Energy Balance for Kirtipur municipality in 2018

Energy Balance for Area in 2018 "Kirtipur Municipality"						
Scenario: Current scenario, Year: 2018, Units: Thousand Gigajoule						
	Electricity	LPG	Wood	Solar	Agri-Residue	Total
Production	-	-	1.1	3.3	13.6	18.0
Imports	142.1	129.9	-	-	-	272.0
Exports	-	-	-	-	-	-
Total Primary Supply	142.1	129.9	1.1	3.3	13.6	289.9
Transformation and Distribution	-28.4	-	-	-	-	-28.4
Total Transformation	-28.4	-	-	-	-	-28.4
Kirtipur Municipality	113.7	129.9	1.1	3.3	13.6	261.5
Total Demand	113.7	129.9	1.1	3.3	13.6	261.5

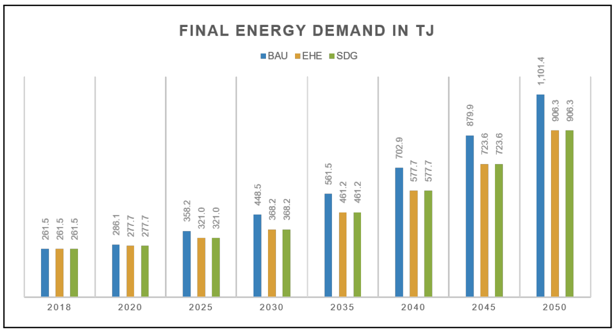

Figure 12: Final energy demand BAU, EHE, and SDG scenario

9. Analysis

9.1 Scenario Analysis

Table 2: EHE scenario

End Use Activity	Fuel Switching		Technology Switching	
	Existing	EHE Scenario	Existing	EHE Scenario
Cooking	LPG and Electricity	Hydro Electricity	LPG stove, Rice Cooker and Induction cooker	Induction cooker
Lighting	Hydro electricity , Solar Electricity	Solar Electricity	Incandescent Bulb, Fluroscent LIGht, CFL and LED	LED
Electrical Appliances	-	-	-	-
Water Heating	Hydro Electricity, LPG, Solar Thermal	Solar Thermal	Gas Gaser, Electric Heater	Solar Thermal water heater
Space Heating	Hydro electricity and LPG	Hydro Electricity	LPG Heater , Electric Heater	Electric Heater
Space cooling	Hydro Electricity	Hydro Electricity	-	-
Others	Biomass (Agri-Residue, Firewood)	Biomass (Agri- Residue, Firewood)	-	-

Table 3: SDG Scenario

End Use Activity	Fuel Switching		Technology Switching	
	Existing	SDG Scenario	Existing	SDG Scenario
Cooking	LPG and Electricity	Hydro Electricity	LPG stove, Rice Cooker and Induction cooker	Induction cooker
Lighting	Hydro electricity , Solar Electricity	Solar Electricity	Incandescent Bulb, Fluroscent LIGht, CFL and LED	LED
Electrical Appliances	Hydro electricity	85 % to Solar Electricity, 15 % to Hydroelectricity	-	-
Water Heating	Hydro Electricity, LPG, Solar Thermal	Solar Thermal	Gas Gaser, Electric Heater	Solar Thermal water heater
Space Heating	Hydro electricity and LPG	Hydro Electricity	LPG Heater , Electric Heater	Electric Heater
Space cooling	Hydro Electricity	Hydro Electricity	-	-
Others	Biomass (Agri-Residue, Firewood)	Biomass (Agri- Residue, Firewood)	-	-

9.1.1 Final Energy Demand

Energy consumption can be reduced to 368.2.3TJ from 448.5TJ by 2030 and switching different fuel to clean renewable energy and use of energy efficient technology.

9.1.2 Energy Demand Per capita

Energy demand per capitia can be reduced up to 2.5 GJ per capita from 3.1 GJ per capita in 2050.

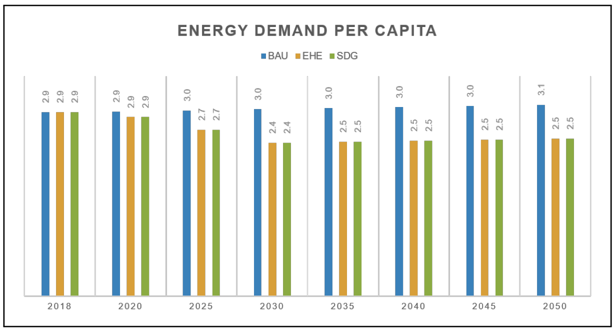

Figure 13: Energy Demand Per capita BAU, EHE, and SDG scenario

9.1.3 Electricity Demand Per capita

The electricity demand per household must be 3000kwh to meet the multi tier matrix of sustainable development goal. As we can see in the bau scenario the electricity demand per household will only reach upto 1825 kwh which will not meet the muti tier matrix. If the policy invetervention is implemented as in EHE with the fuel switching to clean fuels like electricity the electricity demand in 2030 will reach upto 3033.6Kwh to achieve the tier 5 of multi tier matrix. And in the SDG scenario as the fuels are switched to hydro electricity and solar Pv the electricity demand is fulfilled from both hydro electricity and solar pv where the hydro electricity demand in 2030 is 1766.9 Kwh and the solar electricity demand in 2030 is 1266.7 Kwh where the total electricity demand is 3033.6 Kwh pee household which meets the multi tier matrix tier 5 doe sustainable development goal.

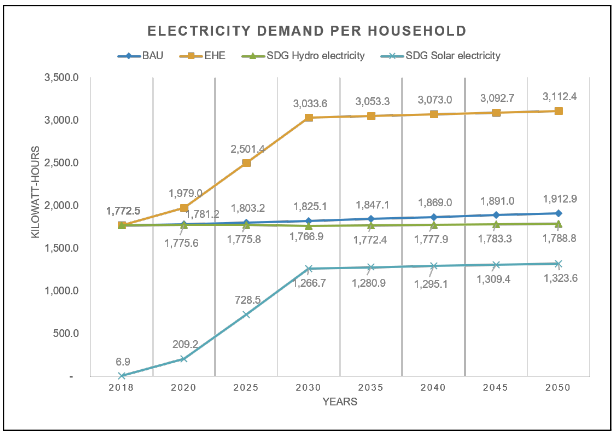

Figure 14: Electricity Demand Per Household BAU, EHE, and SDG scenario

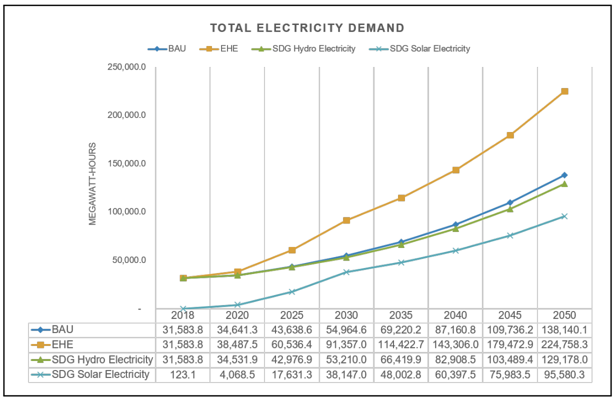

Figure 15: Total Electricity Demand

Solar Home System capacity calculation

Total House in 2030 in Kirtipur Municipality	18701	
Total house less than area 50 sq m	4032	
Total houses shaded by hills and other houses	793	
Total eligible houses for SHS	18701- 4032 - 793 =13876	
Average upper terrace area of residential buildings:	35	Sqm
Average overhead tank space	5.5	Sqm
Average Solar water heater space	2.6	Sqm
Total available space for SHS in a house	35 - 5.5- 2.6 = 26.9	Sqm

Table 4: Solar Home System capacity calculation

- Total available space for SHS in Kirtipur municipality = Total eligible houses for SHS x Total available space for SHS in a house = 13786 x 26.9 Sq.m = 373264.4 sq.m
- Area require for 1kw solar Panel = 10 sq.m
- Total capacity of SHS = 373264.4 / 10 = 37326.4 Kw = 37.3 Mw
- Final Electricity generated by SHS in an hour = 5.59 Mwh (Total capacity 8 availability factor)
- Final Electricity generated by SHS in a year = 49046.9 Mwh

9.1.4 Total Electricity Demand

The total electricity demand per year in 2030 in SDG scenario the hydro electricity demand is 53210 Mwh where as the solar electricity demand is 38147 Mwh. the solar electricity generation in 2030 from roof top solar PV in a year is 49046 Mwh which is higher than the solar electricity demand in SDG scenari.

Levelized cost of Electricity from Solar PV

Levelized cost of Electricity from Solar PV			
Capacity	Cost	Discount Rate	Life
1kw In 2030	150,000 (IRENA 2012)	10%	25
Annuity	16525.21		
Annual Maintainance	495.76	3% of Annual cost	
Total annual expense	17020.97	Annual cost + Maintainance cost	
Daily Electricity generation	6.67	KWh (Efficiency 15%)	
Electricity generation	2433.33	Kwh per year	
Unit cost of electricity by solar PV in 2030	7.0		
Unit Cost of Electricity by NEA	10		

Table 5: Levelized cost of Electricity from Solar PV

9.1.5 Energy Demand cost comparison in BAU and SDG

In both the scenario the total energy demand are different. In the BAU scenario if any inteeventions are not done in the near future 2050 the total energy demand coat will reach up to 2.48 billion Nrs. Which can be significantly reduced by implementing policy scenario as in the SDG Scenario with switching the fuels to the cleaner and renewable energy like hydro electricity and solar electricity and switching of technology to high energy efficient technology the energy demand cost is reduced up to 1.95 billion Nrs. In 2050. So from the chart it can be seen that with the implementation of SDG Scenario the total energy demand coat in 2050 can be reduced by 500 million Nrs.

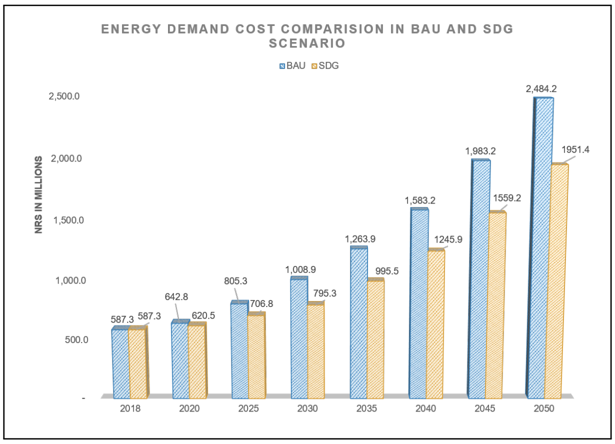

Figure 16: Energy Demand cost comparison in BAU and SDG scenario

9.1.6 Peak Power plant Requirement

The peak power requirement will reach to 13 mw by 2030 due to use of higher LPG fuels but in the EHE scenario due to electrification the peak power plan requirement may reach up to 27.1 Mw by 2030. but in the SDG scenario as the Solar pv substitues the hydro electricity for LIghting and 85% of electricial appliiances purpose the peak hydro power plan can be minimized up to 14.2 Mw.

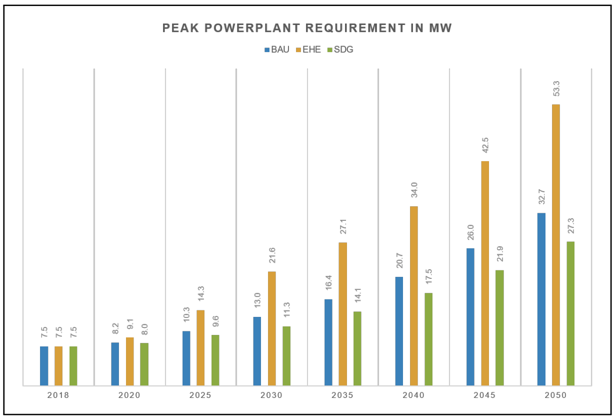

Figure 17: Peak Power plant Requirement in MW

9.1.7 GHG Emission

GHG Emission can be gradually reduced from 9.7 Kilo tonnes to 0.2 kilo tonnes by switching to the cleaner Renewable energy like Electricity from hydropower and Solar Pv.

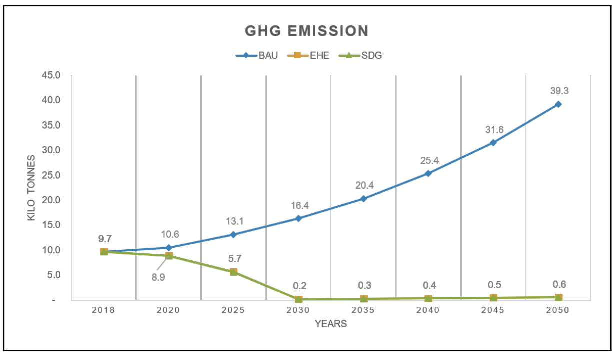

Figure 18: GHG Emission

10. Conclusion

It has been a long time since Nepal has faced problems with the demand and supply of energy. More than a third of the population does not have access to electricity and is forced to depend on traditional fuels for energy requirements. The Residential energy consumption in Nepal is found to be around 80% as per the literature. Energy consumption pattern in case of kirtipur municipality is found to be constantly increasing from the base year to the end in the study in BAU scenario. If any policy intervention is not introduced or intervened then the energy consumption will rapidly go on increasing. So, it is very important for the policy intervention especially in case of Nepal. As Nepal has the capacity to generate its own electricity, so the policy intervention should be accordingly for the sustainable future reducing the energy consumption.

It has been found that the total energy consumption of Kirtipur municipality was 261.5 TJ in the year 2018 accounting 2.9 GJ per capita. The energy demand will increase annually at the rate of 4.47% to 1101.4 TJ by 2050 if none of the interventions are made as in the BAU scenario where as in the EHE and SDG scenario the energy demand will reach up to 1046.9 TJ resulting less final energy demand than in the BAU scenario.

Two scenarios EHE and SDG were developed with the fuel switching to clean energy and energy efficient technology i.e Hydro Electricity, Solar electricity and Solar energy. This switching of fuels resulting to the less energy demand due to use of energy efficient technology. The SDG scenario moreover focuses on the electricity generation from the Rooftop Solar PV resulting to 54% of Total Electricity demand to be substituted by the electricity generated through the rooftop solar PV in the Kirtipur municipality. The self-generation of electricity from the solar PV not only minimize the NEA Grid Load but also provides the energy security.

The scenario analysis shows with the proper policy implementation and technology intervention the final energy demand can be reduced significantly. With availability and accessibility to cleaner and renewable energy the emissions can be reduced as well. The development of solar PV system and use of electricity can not only reduce the emission but also can significantly save the fuel expenditure. It has been found that the total energy consumption of Kirtipur municipality was 261.5 TJ in the year 2018 accounting 2.9 GJ per capita. The energy demand will increase annually at the rate of 4.47% to 1101.4 TJ by 2050 if none of the interventions are made as in the BAU scenario where as in the EHE and SDG scenario the energy demand will reach up to 1046.9 TJ resulting less final energy demand than in the BAU scenario.

Two scenarios EHE and SDG were developed with the fuel switching to clean energy and energy efficient technology i.e Hydro Electricity, Solar electricity and Solar energy. This switching of fuels resulting to the less energy demand due to use of energy efficient technology. The SDG scenario moreover focuses on the electricity generation from the Rooftop Solar PV resulting to 52% of Total Electricity demand to be substituted by the electricity generated through the rooftop solar PV in the Kirtipur municipality. The self-generation of electricity from the solar PV not only minimize the NEA Grid Load but also provides the energy security.

The scenario analysis shows with the proper policy implementation and technology intervention the final energy demand can be reduced significantly. With availability and accessibility to cleaner and renewable energy the emissions can be reduced as well. The development of solar pv system and use of electricity can not only reduce the emission but also can significantly save the fuel expenditure.

11. Recommendation

Residential sector is the major energy consuming sector in case of Nepal. Since Kirtipur municipality has one of the higher population growth rates of 4.47% in the near future the not only the residential sectors there will also be need of more infrastructure and facilities as well in which energy plays the vital role for the fulfillment of infrastructure and facilities. There are also other sectors such as transportation, commercial, industrial and agriculture sector as well which are consuming energy so, the study of these sectors is also important in order to find the total energy demand of Kirtipur municipality. For the further finding of the total energy demand of Kirtipur municipality this research can be the part of further studies.The analysis of the emission is based on the only energy consumption in the residential sectors. the emissions from the other sectors as well can be undertaken for the further studies. From the questionnaire and field visit it was found that the household had the NEA grid connection with the capacity of only 5A. For the policy intervention to be implemented as switching of fuels to the electricity these connections with the capacity 5A are to be replaced by the 15 A connection. Since 5A capacity connection is not enough for cooking in electricity by use of induction heater.

For the implementation of policy intervention, change in bye laws can be the part of futher policy interventions implementation. The change in bye laws can be made as with the new construction of building there must be the compulsory of solar PV installation for the self-generation of energy as solar is the free source of energy.

Further street lights planning can be done for the sustainable energy planning at municipal level since there are no sufficient street lighting in the Kirtipur municipality whereas the street lights are one of the important factors in urban and energy planning.

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