Residential Energy Consumption Pattern of a newly formed municipality: A case study of Bhojpur Municipality of Bhojpur District

Jeewan Shrestha, Amrit Man Nakarmi

Department of Mechanical Engineering, Central Campus, Pulchowk, IOE, TU, Nepal

Corresponding Email: sh.jeewan@gmail.com

Abstract: This study aims to analyse the energy situation of Bhojpur Municipality of Bhojpur District of Nepal in order to provide basic information for planning and management of energy issues. The research is mainly based on primary data. Major energy sources in the Municipality are forest covers, agricultural residues, animal dung, water resource and solar. The main fuel for consumption in the residential sector is fuelwood (93%) due to its easy availability from private, community and government forests which cover 40.6% of the municipality area. Lighting is basically done through grid electricity and kerosene, with solar panels in those areas not accessible by national grid. Cooking is mainly done using fuelwood (95.5%) on Traditional Cooking Stove (51.8%) and Improved Cooking Stove (27.1%). Use of LPG has been increasing after the municipality got connected to the road network.

Keywords: Bhojpur Municipality; fuelwood; energy consumption

1. Introduction of Bhojpur Municipality

Bhojpur Municipality is a newly formed municipality which was formally recognized on 2nd Jestha, 2071 (May 16, 2014) and which came into operation from 1st Srawan, 2071 (July 17, 2014) along with 71 other municipalities[1] (The Kathmandu Post, 2014). It was formed combining four VDCs surrounding the headquarter of the district – Bhojpur, Bhaisipankha, Bokhim and Taksar - with a total area of 68.24 sq. km. and population of 17,289 (DDC Bhojpur, 2012). The municipality currently consists of 11 wards (Table 1).

Table 1 Ward Division of Bhojpur Municipality

Municipality Ward	Consists of
1	Bhaisipankha – 6,7,8,9
2	Bhaisipankha – 1,2,3,4,5
3	Bokhim – 1,5,6,7,9
4	Bokhim – 2,3,4,8
5	Bhojpur – 4,9
6	Bhojpur – 6,7,8
7	Bhojpur – 3,5
8	Bhojpur – 1,2
9	Taksar – 1,2,3,4
10	Taksar – 5,6,7
11	Taksar – 8,9

Although accessibility to Bhojpur is limited, this is improving rapidly. The district headquarter is linked with Midhill Highway (H18) at chainage 253+000. The length of 116 km Midhill highway passess from mid of Bhojpur District serving about 13 VDCs and 1 Municipality. The existing Midhill alignment connects Dhankuta district in the east and Khotang district in the west (DoLIDAR, 2013). The municipality is accessible either by 45 minutes flight from Kathmandu, 25 minutes flight from Biratnagar or 9 hours bus ride from Dharan. The bus ride had been possible through the feeder road from Hile since 2008. The vehicle had to be ferried on the Arun River until the completion of bridge in December 2013. Also, the opening of track of Mid-hill highway has made possible connection of Bhojpur to Kathmandu through Diktel – Ghurmi – Dhulikhel. Ethnically, Newars are the major ethnic group (26.7%) followed by Chhetri (21.9%), Rai (20.2%) and Tamang (16.6%).

2. Assessment of Energy Resources

The main source of energy is fuelwood that comes from forest. The total area of forest lies at 2772.86 ha (i.e. 40.6% of total municipality area). There are three types of forest in the Municipality; community forest (86.63%), government forest (13.17%) and private forest (0.2%). A total of 42 community forests benefiting 3281 households (DFO, 2013) in the municipality have the potential of supplying 101901 cubic feet of wood, 11996.6 *bhari* of fuelwood, 500 *bhari* of *daleghas*, 9110 *bhari* of ground grass and 16315 *doko* of fallen leaves. The major trees found at the community forest are *salla*, *patle*, and *chilaune*.

People generally use agricultural residues for animal feeding followed by cooking. According to the total production in VDC in year 2011/12, there is a potential of generation of 46,600 metric tons of agricultural

[1] Criteria for municipality include minimum population of 20,000 (for hilly region 10,000), minimum annual income of NRs. 5 lacs and a semi-urban area possessing electricity, road, drinking water, communication and similar other basic facilities.

wastes from the major crops (rice, maize, wheat and millet). Among them, maize alone can produce 35,452 metric tons of agricultural wastes[2](B. Shrestha, personal communication, August 13, 2014).

From the household survey, it is found that every household (hh) has two cow/buffalo, one pig and four goats/sheep. This gives good potential in developing around 1,260 biogas plants of 4 m^3 capacity.

The municipality is rich in water resources. The major river of the municipality is Akhuwa Khola which is used as a source for drinking water, irrigation and electricity production. The other rivers bordering the municipality are Pikhuwa Khola and Shera Khola. A micro hydro power of capacity 250 kW installed at the Pikhuwa Khola provided power to the then Taksar and Bhojpur VDCs for around 10 years before the insurgency in the nation destroyed it in 2005 AD. After remaining powerless for around 5 years, the region got connected to the national grid. Then, the power plant went functionless. Now, there is a plan of developing 2.5 MW (upgraded to 5 MW) in the same river by Eastern Hydropower Company. Similarly, people of Ward nos. 3 and 7 of the then Bhaisipankha VDC have generated electricity using peltric set at their own initiation. Mahavir Khola Peltric set of capacity 5 kW installed at Ward 3 of then Bhainsipankha VDC is powering all its 38 households (R. Rai, personal communication, August 1, 2014). The set was installed one year back when all the households contributed NRs 20,000 along with a subsidy of NRs 3 lacs. Also, Peltric Set installed at Ward 7 of then Bhainsipankha VDC is powering 13 households (D. Karki, personal communication, July 31, 2014).

According to the Solar and Wind Energy Resource Assessment (SWERA) report (AEPC, 2008), Bhojpur district has annual direct solar radiation of 4.698 kWh/m^2/day, annual global solar radiation of 4.260 kWh/m^2/day, annual tilt solar radiation of 5.351 kWh/m^2/day and wind power density of 15 W/m^2. This shows a great potential in implementing solar energy.

As the municipality has such resources potential, an integrated energy plan of the municipality should be developed as it helps to identify the problems, priorities and needs of communities which will bring together different energy related stakeholders for successful implementation of the plan (Shrestha, 2003).

[2] One muri of rice, maize, millet and wheat have the potential of generating 80 kg, 300 kg, 150 kg and 80 kg of wastes, respectively

3. General Household Description

The sample size is taken to be 284 households (hhs) (8.74%) of the total population of 3,251 hhs. The samples were taken from all the 36 wards of the then VDCs that comprise the current Municipality. The majority of the household head's occupation is agriculture (75.7%) followed by business (15.1%). Most of the houses are made of stone and wood. Cemented houses are being constructed around the Bazaar area. Most of the households have access to the agriculture road where tractors run when the road is in good condition.

The average family size of the sample hhs was 5.05. Among the surveyed family members, 44.8% had been to high school, 10.7% had been to high school and 7.3% had been to campus. Majority of the hhs (243) had agriculture as their source of income followed by business (68) and service (58). 24 of the hhs with business as income source reside in Ward 7 alone. Only 23 of them informed of earning more than 5 lakhs a year.

The total land area of the surveyed households was found to be 3716.5 ropani (1.89 sq. km.) of which 83.4% of the land had access to irrigation facility, either through irrigation canal or river. In the cultivated land, on an average a household produced 500 kg of rice, 332 kg of maize, 137 kg of millet, 67 kg of potato, 14 kg of wheat and 4.5 kg of cardamom.

4. Energy Consumption

Fuelwood and animate power are the major sources of energy in the municipality. The total energy consumption of the household sector of the municipality stands at 210.81 TJ per year.

4.1 Fuel wise energy consumption

Most of fuel consumption comes from fuel wood (94%) (See Figure 1).

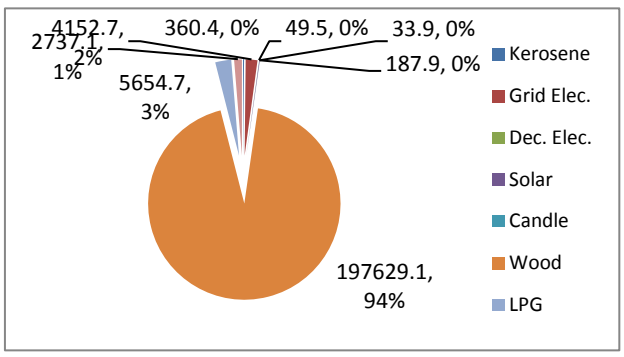

Figure 1: Energy Consumption by Fuel type, unit in GJ

To provide further insight, I separated a sub-urban area consisting of the wards around the bazaar area. Sub-urban area contributed 11% in the total consumption. It was found that the use of LPG and grid electricity is nearly 20% in the sub-urban area in comparison to a value of nearly 3 % in the rural area. The rural area has higher dependence on fuelwood, around 93%, in comparison to the sub-urban area of 80% .

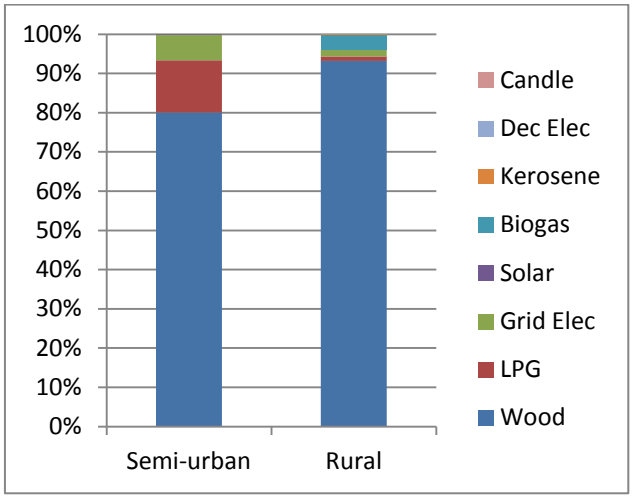

Figure 2: Fuel wise energy consumption in the semi-urban and rural area

Fuelwood is the major source of energy (almost 86% of the households have marked it as their first priority) and is utilized mainly for cooking, animal feeding, water heating and space heating. A household uses on average 9.6 kilos of fuelwood per day. 37% of the households use at least 1.5 times more fuelwood in winter season. 84.8% of the fuelwood gets collected and the rest is purchased. Collection is done from private forest (69.4%), community forest (25.7%), government forest (2.4%) and neighbor (2.5%). 75 % of the households collect some part from their private land. Some of the people from Rai ethnicity gather wood by providing meat and *raksi* called *koseli*. It takes on average 45 minutes for an adult to reach the place for collection. A household spends on average 12.3 days and NRs. 5000-6000 per year collecting fuelwood. Households utilize *khetala* for cutting and collecting wood to save time and pay them NRs. 70-300 plus meal. Some area have the habit of going *parma* (help others' work in exchange of them coming to yours) for collection. All the community forests offer a window time of 7 days to one month for its users to cut and collect the allotted fuelwood.

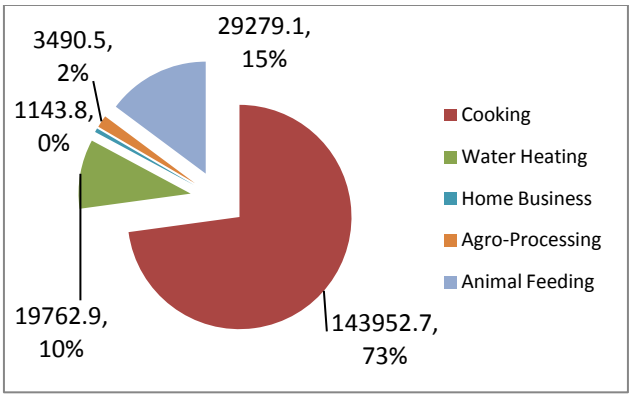

Figure 3: Distribution of fuelwood in different end uses, in GJ

LPG has been used for cooking. Of the sampled households, 36 of them had marked it as first priority and 61 of them as second priority. An average household utilized 2.5 cylinders per year. According to a local gas dealer, around NRs. 150 per cylinder gets spent in transporting from Biratnagar (B. Shrestha, personal communication, August 7, 2014). The sale price stands at NRs. 1750 per cylinder. Almost 80% of them get sold in Ward 5 and 7 i.e. around bazaar area. Almost all of the LPG is used in cooking and water heating purposes.

Electricity in the municipality comes from national grid, solar and peltric set. National grid extension has reached wards 5,6,7,8,9,10,11 and some part of ward 4. 71% of the sampled households had used national grid. Almost all of them have their own meters except 7 who had a connection from neighbor and 3 who pay as a rent. 36 households utilize it for conducting home business. A household with grid extension used, on average, 32.2 units per month. Households at ward 5 and 7 utilized the highest at 45 units per month. The electricity is mostly used for lighting followed by running electrical appliances (figure 4). Incandescent bulbs consume 55% of the lighting energy followed by CFL (41%), despite higher penetration of CFL (62.5%) than incandescent (35%).

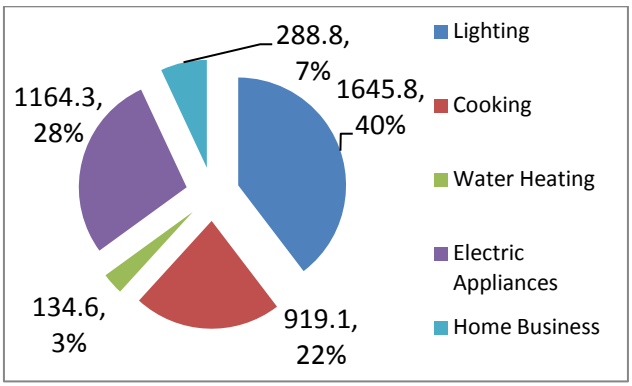

Figure 4: Consumption of grid electricity, in GJ

Six households (almost all in bazaar area) had inverter/battery system installed for lighting and running business.

Six of the sampled households use electricity generated from two peltric sets. They use it for their lighting, mobile charging and Radio/TV needs. Households of peltric set installed at the then Bhaisipankha ward 7 do not raise energy cost per month but collect from each household when required for maintenance. Whereas, households at the then Bhaisipankha ward 3 raise a minimum of NRs. 100 for 10 units.

Ninety eight of the sampled households owned a solar panel (average 39 Watt) costing them on average NRs. 28,833. Almost 75 % of the installed system were found at Ward 1,2,3 and 4 where the national grid extension is minimal. 44 households had solar tuki for lighting and mobile charging. The households had an issue with the operation and maintenance of the system. Being far from the bazaar area, it gets difficult to repair the system on time.

Candle and Kerosene are being used for lighting purposes in case the grid electricity fails. An average household uses 12 medium sized candles and 2.3 liters of kerosene per year. Kerosene is used in a wick lamp called kupi. Ward 5, 7 and 11 combined constitute 79% of the total candle consumption. Household make use of it in case of load shedding. Similarly, the use of kerosene is limited to other areas than bazaar area.

7 of the sampled households had biogas installed for cooking and water heating purposes. The installed size varied from 2 cu. m. to 6 cu. m. The feed in materials used were animal dung and toilet waste. The users had their time saved from collecting fuelwood.

4.2 End use wise energy consumption

At the end use, most of the energy is used for cooking and water heating purposes.

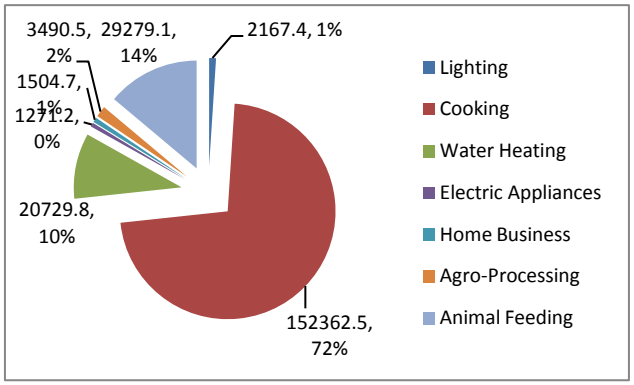

Figure 5: Energy consumption by end use, unit in GJ

The pattern of end use in semi-urban and rural area is nearly similar. The major difference lies in the significant share in home business in semi-urban area compared to rural area

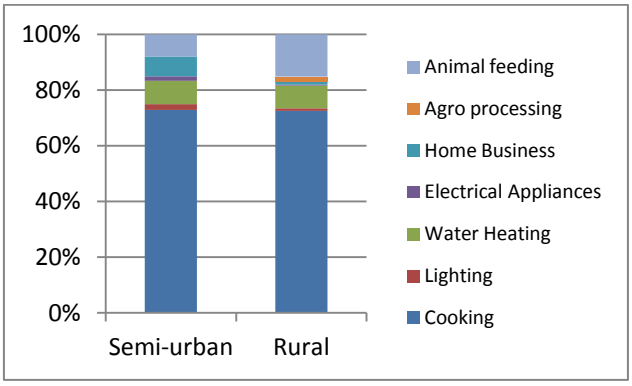

Figure 6: End-use consumption pattern in semi-urban and rural area

Lighting basically comes from grid electricity (76%) followed by kerosene (16.6%) and solar (4.8%). The rest sources are decentralized electricity (peltric set) and candle. Semi-urban area depends mostly on grid electricity, whereas the share of kerosene of around 20% is also significant after grid electricity in rural area. The incandescent bulbs share is greater in the rural area compared to the semi-urban area. One of the reason is that the average electricity consumption in the rural areas come to around 15 units which is below the minimum margin of 20 units set by NEA, so the people tend to use the cheaper incandescent bulbs rather than energy efficient bulbs.

Table 2: Share of lighting equipments on grid electricity

	Semi-urban	Rural
Incandescent	31.4%	63.0%
Tubelight	12.0%	1.0%
CFL	56.6%	35.9%

Cooking, space heating and water heating constitute around 82% of the total demand and is mostly done on fuel wood (95.5%) due to its easy availability. The other sources utilized are LPG (2.7%), Biogas (1.3%) and Grid Electricity (0.5%). Among the 505 cooking devices in the sampled households, 51.9% were Traditional Cooking Stove (TCS), 27.1% were Improved Cooking Stove (ICS), 18.4% were LPG Stove and the rest were biogas stove and coal stove. Rural areas mostly use TCS and ICS whereas the share of LPG stove is higher in the semi-urban area. The greater number of cooking devices per household is due to the fact that households generally install an extra TCS for fodder cooking purpose.

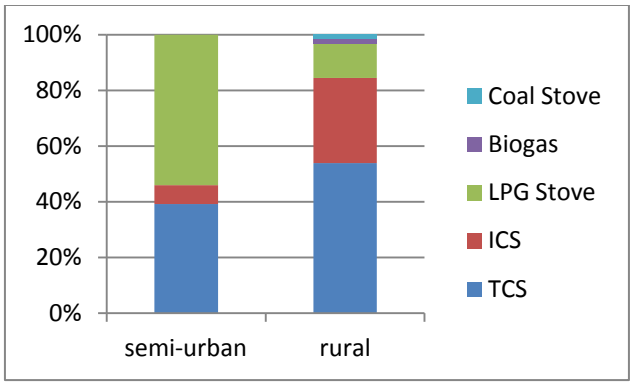

Figure 7: Cooking device share in semi-urban and rural area

Animal feeding constitute nearly 14% of the total energy consumption. As households have been rearing cows/buffaloes, goats, pig, they utilize wood to cook fodder to feed them.

Agro-processing is mainly required for cardamom. The fresh cardamom needs to be dried in an oven for storage purpose. The drying is basically done by roasting in a wood fire.

Electrical Appliances are run mostly on electricity from national grid (91.6%). Appliances such as TV, Fridge, Computer, Iron are used.

Home businesses generally done in the municipality include stores, hotels, clothing store, fancy stores. Energy consumption comes mostly comes from wood (76%) and Grid Electricity (19.2%).

4.3 Ward wise energy consumption

The ward wise energy consumption shows that the maximum consumption occurs in ward 8 followed by ward 5 and 7. The highest energy consuming wards all belong to the previous Bhojpur VDC. The share of wood is highest in ward 8 whereas the share of LPG and electricity is highest in ward 7 (bazaar area).

Table 3: Energy consumption share by ward

Ward	Energy consumption share
1	7.3%
2	5.2%
3	8.1%
4	7.8%
5	13.0%
6	11.6%
7	12.7%
8	14.6%
9	6.8%
10	7.3%
11	5.6%

From the assessment of resources and consumption of the Municipality, the following basic information was observed.

- Fuelwood is the main source of energy. It is used for cooking, water heating and space heating. It is generally collected from private forest and community forest.
- Agricultural residue is mainly used for feeding the cattle. It has not been used for other purposes.
- Animal dung is utilized as fertilizer in agricultural field. Biogas penetration is low due to easy availability of fuelwood for cooking.
- Households not connected to grid use solar panels for their lighting and mobile charging needs. Some households have utilized the river flowing nearby in generating electricity.
- Solar lights are normally lit in case of power failure in the national grid. This is due to the fact that most of the households have electricity consumption around 20 units and as they have to pay Rs. 80 anyway, they prefer to use grid to solar.
- Sale of LPG has increased 3-4 times after the construction of road. The average year household has installed the device is 2.9. People previously used to carry on their back from Hile, Dhankuta.
- Some households had discontinued the ICS due to reasons such as not properly working, house restructuring, and difficulty in fodder cooking.
- People generally cook food in ICS and LPG, and cook fodder in TCS.

4.4 Comparison with relevant regions

4.4.1 Comparison with hilly region of Eastern Development Region

Fuelwood occupies 86% of energy consumption in the hilly region of EDR. If we add agricultural residues consumption of around 8% too, the total of 94% is a match to the value of 94% used in the Bhojpur Municipality.

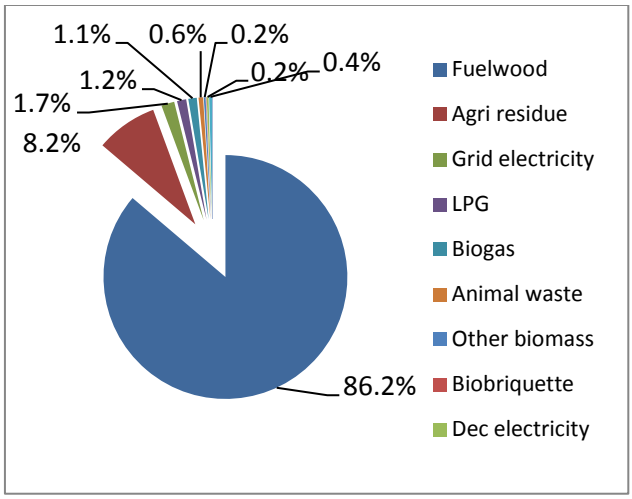

Figure 8: Fuel wise energy consumption in hilly region of EDR (ERMC, 2013)

Cooking and space heating combined contribute 75.5% in the energy consumption of hilly region of EDR. As the respondents during the survey at Bhojpur Municipality could not quantify space heating, the cooking share of 72% can be assumed to include space heating too. The share comes to be nearly the same.

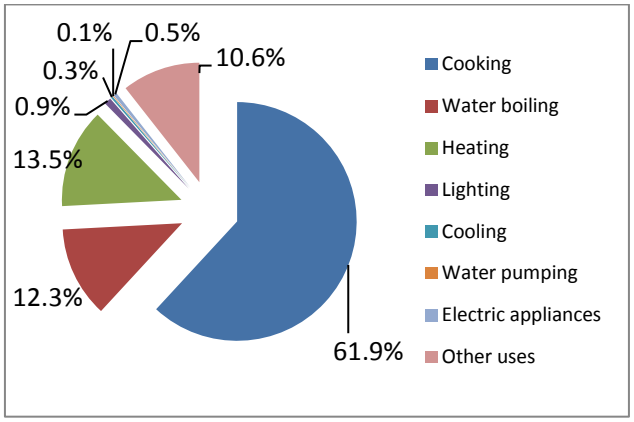

Figure 9: End use wise energy consumption in hilly region of EDR (ERMC, 2013)

4.4.2 Comparison with hilly region of Nepal

Fuelwood occupies 86% of energy consumption in the hilly region of Nepal. If we add agricultural residues consumption of around 6% too, the total of 92% is a near match to the value of 94% used in the Bhojpur Municipality.

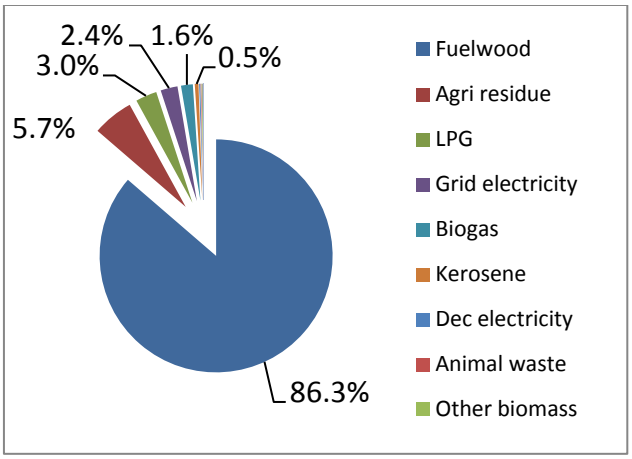

Figure 10: Fuel wise energy consumption in hilly region of Nepal (ERMC, 2013)

In terms of end use, cooking and space heating contribute around 71.5% in the hilly region of Nepal compared to the 72.3% in the municipality.

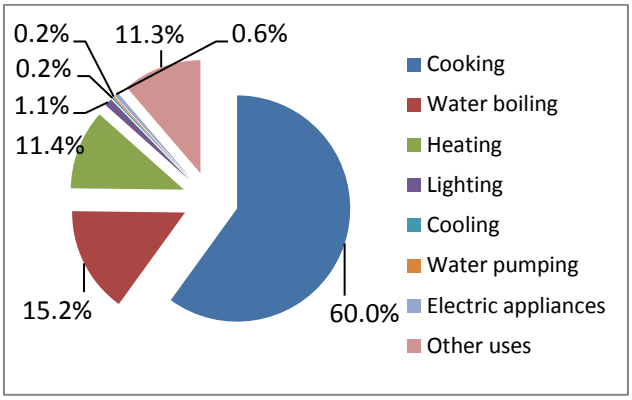

Figure 11: End use wise energy consumption in hilly region of Nepal (ERMC, 2013)

4.4.3 Comparison with Kathmandu Metropolitan City

Kathmandu Metropolitan City uses only 5 % of energy from biomass in comparison to the 94% of the municipality. Major energy resources in the KMC are LPG and Grid Electricity (87%). This indicates how the new municipalities should transform themselves.

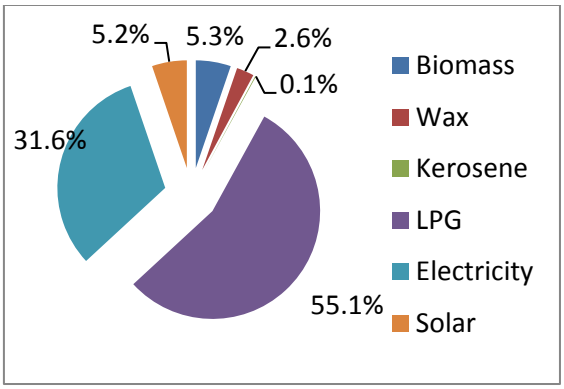

Figure 12: Fuel wise energy consumption in KMC

Cooking contributes around 60% of the energy consumption share in Kathmandu Metropolitan compared to 87% in the Bhojpur Municipality. As the development increases, share of lighting, cooling, heating and other uses increase as seen from the energy consumption pattern of both the municipalities.

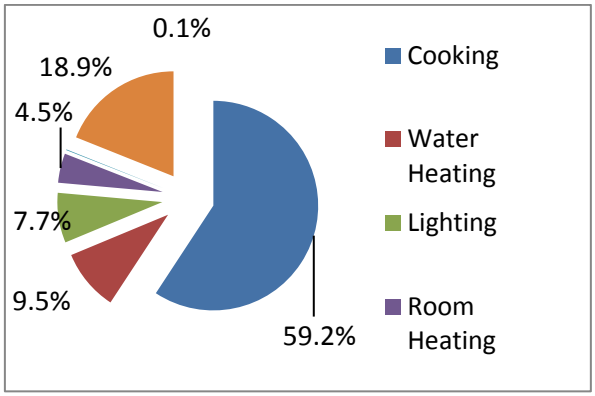

Figure 13: End use wise energy consumption in KMC

5. Conclusion and Recommendation

The following conclusions and recommendations can be drawn from the primary data collected:

- Energy consumption per capita of the municipality is 12.2 GJ per annum which is slightly lower than national average of around 14 GJ per annum.
- Fuelwood is still the major source of energy.
- Nepal Government has a policy of making Indoor Air Pollution (IAP) Free all over Nepal by 2017 (AEPC, 2013) but the district's target is to do it by 2016. Replacing all the remaining TCS with ICS has the potential of saving 22.7% or 225.6 ton of total wood[3].
- Currently, some households at ward 1 and 2 have been utilizing the river to generate electricity. There is potential for other wards to develop too. But most of them have not been doing so as the national grid connection is to be connected soon.
- 54.8% of lighting from grid electricity is done through the use of incandescent bulbs. Replacing this with energy efficient bulbs has the potential of reducing 230.6 GJ of energy.
- Use of ICS and LPG has been increasing recently; the respective average time these were installed is 3.4 years and 2.9 years back. Proper monitoring of the ICS performance and timely intervention of more efficient ICS need to be done regularly.
- There is a need to develop an integrated energy plan for the municipality as it would help identify problems, priorities and needs of communities which would bring together different energy related stakeholders for its successful implementation.

[3] The calculation is based on 35% wood saving by ICS compared to TCS (M. Bhandari, personal communication, July 22, 2014).

References

AEPC. (2013). Retrieved 09 21, 2014, from http://www.aepc.gov.np/?option=events&page=eventsdetail&cat=pevents&eid=2

AEPC. (2008). *Solar and Wind Energy Resource Assessment in Nepal.* Khumaltar: Alternative Energy Promotion Center.

DDC Bhojpur. (2012). *Bhojpur Jillako Bastugat Bibaran.* District Development Committee.

DFO. (2013). *Samudayik Ban Bikash Karyakram - Anugaman tatha Nirikshan Pratiwedan 2069/070.* Bhojpur: District Forest Office.

DoLIDAR. (2013). *District Transport Master Plan.* Bhojpur: Ministry of Federal Affairs and Local Development.

ERMC. (2013). *National Survey of Energy Consumption and Supply Situation in Nepal.* Environment and Resource Management Consultant.

Shrestha, P. (2003). Assessment of Rural Energy Planning and Management: A case study of Thampalkot VDC in Sindhupalchowk District, Nepal. *Renewable Energy Technology for Rural Development* (pp. 68-72). Pulchowk: Center for Energy Studies.

The Kathmandu Post. (2014, 05 08). Retrieved 09 21, 2014, from http://www.ekantipur.com/the-kathmandu-post/2014/05/08/news/govt-announces-72-new-municipalities/262559.html