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Use of Energy Alternatives for the Optimization of active energy consumption in rural residential building: A Case study of Tadi-2 Rural Municipality, Nuwakot, Nepal

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Abstract

People in the rural areas of Nepal have been using fossil fuels, guitha, wood, kerosene as the main source of energy for cooking purpose. LPG gas is also used in some places as per the availability and access. Even though these source of energy have lot of disadvantages, people are obliged to use them. Biogas is one of the finest alternative source of energy in the rural areas who are mostly dependent on cattle farming and agriculture. For the Lighting purpose, the rural population use grid electricity due to its accessibility. The study area chosen in this article is Tadi-2 Rural Municipality located at Nuwakot, Nepal where people are dependent on cattle farming and agriculture. Using Stratified sampling for questionnaire survey, data for feasibility study of biogas utilization, solar panel and Improved Gas Stove was collected and several calculations for technical and financial feasibility were done. This article concludes on the feasibility of biogas in the rural residential areas which helps to optimize the active energy used by designing the energy as well as cost effective cooking alternative and unfeasible solar pv panel for grid electricity alternative. From this article, it seems biogas to be feasible in the study area.

Keywords

Biogas, Solar PV, Improved Cooking Stove, Optimization, Active Energy, Rural Residence, Payback Period

1. Introduction

Energy optimization could be defined as an applied technique in energy utilization without affecting the standard of living in the society. Worldwide around 40% of energy is consumed in building [**?**]. Modern society is so much dependent upon the use of active energy that it has become a part and parcel of our life.

Nepal relies heavily on biomass fuel as a result of the lack of development of other energy alternatives and the overall poor economic condition of the nation [1].Among the total energy consumption of 288 million GJ in rural Nepal, biomass accounts for 98% while electricity accounts for only 0.1% of the total energy consumes and petroleum products comprise 1.6% and renewable source 0.5% of the total energy consumed [2].

Forest resources are under increasing threat from the burgeoning human and live stock populations and their need to meet annual requirements for fuel wood, folder, timber, and other minor forest products. About 44,000 ha of forest area is believed to be degraded and deforested annually, while only about 4,000 hectares are reforested. In 1994/95, the supply of crop residues in the country that could be used as energy was estimated to be 112.13 million tonnes [3]. Likewise the country has 4.8 million tonnes of animal dung annually potentially available as fuel.

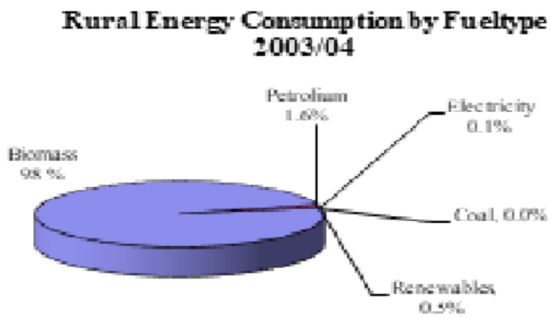

Figure 1: Rural Energy Consumption

About 84% of Nepal population lives in rural areas, and agricultural work is the mainstay of the rural population. For the year 2003/04, total rural energy consumption is 288 million GJ of which the rural residential consumed 97%. From end use perspective, of the total energy consumed in rural Nepal, 63.9% was used for cooking, heating accounted for 8.5%, lighting 1.31%, agro processing 3.4%, animal feed preparation 16.5% and others such as religious occasions and ceremonies 4.3% [2].

2. Literature Review

Solar Energy is the grid energy alternative. Solar PV panel, battery, Inverter and different charge controller devices required for the solar PV system results in high installation cost of the grid energy alternative. Though different subsidy policy has been introduced by the Alternative Energy Promotion Centre, the interest in it when grid energy is available is minimum.

The domestic biogas plant has been installed in the rural part of Nepalas the rural population of Nepal is fully dependent on cattle farming and agriculture. The domestic dungs and human excreta are the primary feeding material source for this biogas system. The slurry as a by-product of this system is being more effective on organic and sustainable productions in Nepal, the proper use of which is replacing the use of chemical fertilizer that ultimately has saved money and maintained the clean and green surroundings/environment. GoN has been promoting biogas plants of different capacity under this system, such as 2cu m, 4cu m, 6cu m and 8cu m plants fall under this category. For those plants, GGC 2047 and modified design of GGC 2047 are being implied [4].

In rural Nepal, more than 85% of households are reliant on biomass fuels burnt using traditional stoves [**?**]. Women in these households, who for cultural reasons start cooking from an early age, are exposed to very high levels of household air pollution (HAP). Peak con-centration of respirable particles inside kitchens at times are as high as 60,000 mg/m3 (Devkumar, et al., 2014) while 24-h kitchen concentrations average several hundred mg/m3 [5].

Up to now, the plants at around figure of 0.3 million have been already installed all around Nepal with a common initiative of GoN, development partners and partner agencies. The role of biogas companies is most crucial on development of the biogas sector. Now in Nepal, around 100 biogas companies are carrying their construction/promotional activities with the Pre-Qualification (PQ) identity [4].

Biogas is a type of biofuel that is naturally produced from the decomposition of organic waste. When organic matter, such as food scraps and animal waste, break down in an anaerobic environment (an environment absents of oxygen) they release a blend of gases, primarily methane and carbon dioxide. Because this decomposition happens in an anaerobic environment, the process of producing biogas is also known as anaerobic digestion.

Anaerobic digestion is a natural form of waste-to-energy that uses the process of fermentation to breakdown organic matter. Animal manure, food scraps, wastewater, and sewage are all examples of organic matter that can produce biogas by anaerobic digestion. Due to the high content of methane in biogas (typically 50-75

The subsidy scheme per plant per household for the domestic biogas plant, using animal dung as the main fuel, is as follows:

Table 1: Subsidy Scheme

Region	Subsidy Amount		
	2cum	4cum	6cum & above
Mountain District as specified by GON	25000	30000	35000
Hill District as specified by GON	20000	25000	30000
Terai District as specified by GON	16000	20000	24000

However, the subsidy amount specified above for 6 cum and above domestic biogas plant will be reduced by 5% every year up for 3 years from FY 2074/75.Additional 10% of the subsidy amount specified above per plant per household will be provided to the “targeted beneficiary groups”.

In case of biogas plants using kitchen waste and other household bio-degradable waste, subsidy amount of up to 50% of the total cost but not exceeding Rs. 10,000 will be provided to specific designs of domestic biogas plants with capacity 4 cum or less in order to improve urban environment and reduce consumption of imported fuel [4].

Improved Cooking Stove is the modified version of traditional method of preparation of Cooking stove in which the smoke released to the indoor-atmosphere is minimized. As wood requirement for cooking only decreases (not eradicate), no direct subsidy will be provided for the promotion of household mud improved cooking stoves. However, local bodies are encouraged to provide financial support to install mud ICS to targeted beneficiaries like women-led households with dependent children, earthquake victims, endangered indigenous community identified by GoN.

Bio-gas Production: A biogas plant consists of five main structure or components. The required quantity of dung and water is mixed in the inlet tank and this mix in the form of slurry is allowed to be digested inside the digester. The gas produced in the digester is collected in the dome, called as the gasholder. The digested slurry flows to the outlet tank from the dig through the manhole. The slurry then flows through overflow opening to the compost pit where it is collected and composted. The gas is supplied to the point of application through the pipeline.

Before deciding the size of plant, it is necessary to collect dung for several days to determine what the average daily dung production. The amount of dung daily available helps in determining the capacity of the plant. For example, if 55 kg of dung is collected daily, a 8m3 plant has to be selected. It should be kept in mind that at least six kg dung is required for 1m3 of plant capacity. If a plant is underfed, the gas production will be low; in this case, the pressure of the gas might not be sufficient to displace the slurry in the outlet chamber. This means that amount of slurry fed into the digester is more than the amount of slurry thrown out from the outlet. This will cause the slurry level to rise in the digester; gasholder and it may eventually enter to the gas pipe and sometimes, to the gas stove and lamp while opening the main valve. Therefore, the slurry should always be fed according to the prescribed amount as indicated, in the above table" (Sundar, 1994).

The major environmental and operational considerations for the production of biogas alternative are Raw Materials, Influent Solids Content, Loading, Seeding, pH, Temperature, Nutrients, Toxic Materials, Stirring and Retention Time (Anon., 2007). As biogas plant utilizes locally available raw materials, the gas obtained from it can be cheaper and reliable. Possible uses of biogas as energy source are Cooking, Electricity Generation, Lighting, Availability of Fertilizer, etc. The reasons for installing the biogas plants in rural parts of Nepal are to build toilet and keep households environment clean and healthy, to make cooking easier and faster, to make smokeless kitchen, to make easier to clean cooking pots, to avoid difficulties of cooking on firewood, to reduce firewood consumption, and to build up a social prestige. Focus group discussion of biogas users revealed the following benefits they have achieved from biogas plants are:

- Saving of firewood,
- Easy for cooking and smokeless indoor environment,
- Reduction of workload mainly of women and school girls,
- Saving of time,
- Extra time availability for school children,
- Clean and healthy environment,
- Proper management of toilet,
- Raising living standard,
- Forest protection, and
- Easier for cleaning utensils.

3. Research Context

The total household of the Tadi-2 Rural Municipality was 760 [6]. Among them more than 600 beneficiary completed their houses and remaining beneficiary are under in the reconstruction stage.The population by the caste type was; Tamang (53 Percent), Chhetri (18 Pervent), Newar (9.5 Percent), Brahmin (9 Percent), Dalit (6 Percent) and others (4.5 Percent). Physiographical condition of the Study area (Tadi-2 RM) is characterized by mountain, subtropical climate, surrounded by community forest in uphill area. This study was carried out on use of biogas energy optimize the active energy consumption and the general objectives of this study is to find out the feasibility of biogas plant for optimizing the active energy in the rural residential building sector. The research methodology had been implied as selecting a small area of survey, however it is good enough topic to discuss as well as arise the development issue of biogas in Nepal.

4. Methodolody

This research has been held on the houses that used biogas for the cooking purpose. The universe of the study was Tadi-2 Rural Municipality of Nuwakot district. Using the stratified random sampling, 12 households of biogas users were sampled. The total number of respondents were 12 including both male and female of different age groups. The respondents were chosen by using random sampling method. Both the primary and secondary data were various sources. The primary data collection tools were; the structured questionnaire, semi or unstructured interviews; and observation as well as group discussion with local people and key informant interview. Simple statistical tools on excel were used while analyzing the data. For the Questionnaire survey, the variables that required qualitative description, qualitative data collection technique was used and for this interview, checklist was prepared. For quantitative data collection, close-ended structured questionnaire survey was conducted on the field for the data collection. For the secondary data like equivalent quantitative energy consumption of biogas and different cooking alternatives, various standards, available in the websites, were used. The cost of biogas plants were taken from the biogas plants constructed in the case area. As the public of the case area used woods directly from the forest, the exact rate of the wooden cooking stoves was tough to obtain and so, the standards for energy consumption were followed. Solar PV panel sizing has also been included and the feasibility based on the payback period has been calculated.

Even though we have used stratified sampling, due to short time constraint, the results and information does not imply expected outcome. Moreover, the community itself has not developed the biogas for the optimization of active energy. Furthermore, the result cannot be generalized for whole community in Tadi-2 Rural Municipality.

5. Data and analysis

Analyzing the questionnaire survey carried out in Tadi VDC of Nuwakot, the average Energy consumption of 191W peak power and 575Wh/day is obtained the breakdown of the cost of the equipment results in the following amount.

Table 2: Cost breakdown of equipments

SN	Item	Rate	Qty	Amount
1	Solar Panel.	6250	2	12500
2	Solar Inverter	4500	1	4500
3	Solar Tubular Battery	24889	1	24889
4	Installation Materia	12128	1	12128
5	Mounting Structure	8616	1	8616
6	Installation Service	28000	1	28000
	Total Cost		100860	

Total initial investment for the installation of the solar is around Nrs 100860 in which VAT is included. Due to the avaibility of grid system in Tadi-2 Rural Municipality, the cost same amount of energy supplied from the grid system, the yearly expenses of the electricity is around Nrs.2277 in which per unit cost of electricity is considered Nrs.11, then the payback period was found to be more than 44 years,hence the installation of solar PV system at Tadi-2 Rural Municipality is not feasible.

To construct a Biogas Plant of capacity 6M3, the daily dung production of buffalo, goat and the human excreta results the total of 37 Kg/day which is sufficient for 6M3 biogas plant. From the observations made, it is calculated that 1.48M3 of biogas will produce 1.702 kg of biogas each day. 32M3 biogas equals 1Lpg gas that is 14.5 kg of lpg gas [7]. Thus, Biogas produce in 30 days is 44.4 M3. In the rural residential sector, if per month LPG consumption of Lpg gas 2/3 rd of a cylinder, and the cost of per cylinder is around Nrs 1500, and per month consumption charge of cooking is around Nrs 1000. In a month, biogas produced is 44.4M3 which equals 1.38 numbers of LPG cylinder. From calculation, we can obtain that the biogas required for cooking per month is 29.6M3. the remaining 14.4m3 (0.48 m3/day) of biogas per month can be converted to light energy to burn lamp. It is obtained that 60W biogas lamp consumes 120-145 lit of biogas per hour resulting in the burning of lamp for 3.3 to 4 hr. Hence, a biogas lamp of 60W can be burn for 3 to 4hours per day and complete cooking requirement for a family of 5 members using 6 m3 of Biogas Plant.

Tentative cost of construction of 6M3 biogas at tadi-2 Rural Municipality, Nuwakot is NRs. 64000 which results in the annual saving by using biogas after replacing Lpg gas Nrs 1000 per month i.e. yearly Saving on cooking is Nrs 12000. For the lighting requirement, if 60 W lamp burns for 3 hr per day i.e. 65.7 kWh consumption per year and charge of electricity per unit is Rs 10, hence, the annual saving by lighting is Nrs. 657 i.e. total saving per year for both cooking and lighting is NRs. 12,657. The payback period are:

For Cooking, the payback period = 5.34 year

When Lighting is included, payback period = 5.05 year

If Subsidy of NRs. 30000 for Biogas is provided,

For gas use for cooking and lighting, payback period = 2.69 year

6. Discussion

This research shows that the biogas Plant Size is depend on the no. of peoples in the family as well as the daily available animal dungs. The bar-chart show that if no of family member lies in between two to four then they choose 4cum biogas plant, if member is 4 to 6 then they choose 6cum biogas and if the member lies in between 6 to 7 then they choose to prefer the biogas plant of capacity 8 cubic meter.

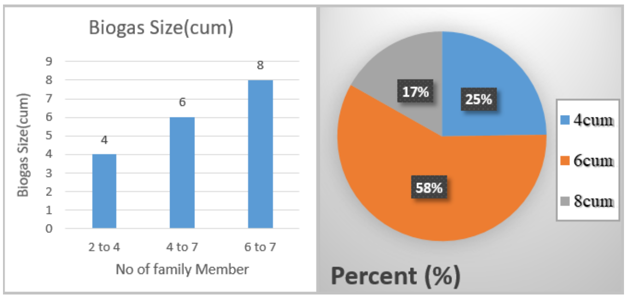

Figure 2: Bio-gas Size vs Preference

This field study research shows that, 25 % households used 4 cubic meter biogas plant, the highest number 58% households preferred to uses 6 cubic meter biogas plant and remaining 17% households uses the 8 cubic meter biogas plant, which is clearly shown in the pie chart. Hence,the most household preferred the six cubic meter biogas plant so I study the feasibility of 6 cum bio-gas plant.

7. Conclusion

The study concludes that regarding the feasibility of different energy alternatives, the Solar Panel is uneconomical for the rural residence like Tadi-2 Rural Municipality where the grid electricity is available. Though portable solar panel is costly, due to high load shedding, it is recommended to be available at each household for the case of emergency. This research also concludes that the payback period for the biogas plant is within 5.5 years. The cost of LPG with the government's subsidize rate is Nrs.97 per kg whereas for gas produce from biogas plant falls below NRs. 20 per kg. During the construction phase of biogas, the government provides the subsidy amount of Nrs.30000 for the hilly regions resulting in the payback period reduced to two years and 8 months. Hence, biogas in Rural area of Nepal is found to be the most feasible energy alternative.

References

[1] National energy situation survey report, 2005.

[2] National training workshop on the integration of energy and rural development of policies and program in nepal. 2004.

[3] Papers presented at the national training workshop in the integration of energy and rural development pf policies and programs in nepal. 1994.

[4] Alternative energy promotion centre. 2019.

[5] Reduced lung function due to biomass smoke exposure in young adults in rural nepal.

[6] National reconstruction authority, 2015.

[7] http://vikaspedia.in/energy/energy-production/bio-energy/biogas. 81.