DevPart-Nepal. **Research Study on Optional Biogas Plant Size, Daily Consumption Pattern and Conventional Fuel Saving**. **Final Report**. Biogas Support Programme. March 2001. 100p. BSP Lib Temp No. 52

Objectives

The objectives of this study were: (a) to obtain reliable data regarding the actual savings on conventional fuel for an average biogas household in the hills and Terai; (b) to obtain reliable data regarding the replacement value of biogas vs. conventional creating fuels; (c) to determine which plant volume is the most efficient (cost effective) given average annual temperature and daily feeding; and (d) to collect accurate data regarding the daily consumption patterns for different family consumption, climatic zones and seasons.

Realizing the fact that the present cost of biogas plant could not be brought down by other means than by using the generated gas more efficiently, a research study on 'Optimum Biogas Plant-size, Biogas Use Pattern and Conventional Fuel Saving' was proposed by BSP. The outcome of this study is expected to be used to convince actors in the sector like biogas companies and banks to construct appropriate size of plant given availability of dung and draw up stricter quality norms regarding size selection.

Approach and Methodology

DevPart Consult Pvt. Ltd. carried out the study in 80 biogas and 40 non-biogas households for complete one-year cycle in Syangja, Nuwakot, Chitwan and Morang districts that represented High-hills, Mid-hills and Terai regions of the country. Major activities of this programme included: orientation to the research assistants and members of households selected for study on the aim and objective of study and their roles in successful completion of the study; installation of gas metres, thermometers and other appliances as required, and delivery of other necessary equipment to the biogas households that are selected for the study; accurate measurement of conventional fuel use, quantity of gas use, recording of digester as well as ambient temperatures; laboratory analysis of total and volatile solids in slurry and digested slurry; and in-depth analysis of field findings and preparation of final research report.

Main Findings

Characteristic of Biogas Households

The majority of the biogas households under study were that of Brahmins and Chhetris (80%) followed by Newars (11.25%), Tamang (3.75%), Giri (2.5%), Magars (1.25%) and Gurungs (1.25%). Similarly, the ethnicity of sampled non-biogas households was Brahmins and Chhetris (82.5%), Newars (5%), Kumals (5%), Giris (2.5%), Chaudharies (2.5%) and Damais (1%). The average family size was 5.85 person per household for biogas households and 7.57 for non-biogas households. The families in both the cases had agriculture as the main source of income. Majority of the biogas household (79%) had at least one person involved in cash earning from their jobs. This figure for non-biogas households was 74 percent.

The average landholding size per family was 21.5 ropani (1.07 ha.) for biogas households and 18.6 ropani (0.93 ha.) for non-biogas household, which was to some extent similar to the national landholding size per family being 19.2 ropani or 0.96 ha. Similarly, the average cattle-holding size was 5.4 and 6.2 for biogas and non-biogas households respectively. The literacy rate of the selected biogas households was found to be 88.7 percent and that for non-biogas households is 87.0 percent. The average family size, ethnicity, landholdings, production and consumption pattern, livestock ownership, literacy pattern etc. appeared quite similar in both biogas and non-biogas households.

Feeding of Bio-digester

The outcome of the study indicated that the whole quantity of dung produced is not collected and the collected amount is also not entirely fed into the plant. It showed that out of the average theoretical available dung (calculated based upon number of cattle) of 40 kg, 36.87 kg (92.2%) is

collected and 33.8 kg (83.4%) of theoretical available quantity and 90.5 percent of the collected dung) is fed into the digester. The average feeding rate comes to be 4.77 kg per m^3 volume of the digester, which is far less than the prescribed quantities of 6 and 7.5 kg in hills and Terai respectively. The average feeding is 74.6 percent of the prescribed rate.

67.5 percent of the total plants are fed with appropriate quantity of water; 5 percent of the plants are fed with lesser quantity of water than the prescribed one and the remaining 27.5 percent plants receive more water.

42 plants (52%) out of the sampled 80 were attached with latrines. There exists a relationship between latrine attachment and dung feeding. The owners believe that when latrine is attached to the plant, lesser quantity of dung than prescribed would be sufficient.

Average quantity of dung available in all the four study areas did not differ much. Households in Chitwan produced an average of 40.05 kg of dung per day whereas that in Morang is 36.75 kg. In all the cases, the recommended size of plant is calculated to be 6 m^3 based upon the average quantity of dung available and the hydraulic retention time (HRT) of 70 days for hilly regions and 55 days for Terai regions.

Efficiency of Gas production

The total amount of gas production from biogas plants under study has been assessed based upon stove and light burning hours and also based upon the meter readings. Out of the total 80 plants under study, 12 have efficiencies less than 40 percent, 25 have efficiencies in between 40 to 60 percent and 26 have efficiencies in between 60 and 80 percent. The remaining 17 plants have more than 80 percent efficiency.

It is encouraging to note that the reduction in gas production during winter months (Magh, Falgun) is not too much. The average gas production is maximum (1020 litre/day/plant) during the month of Shravan (July – August) and minimum 840 litre/day/plant) during the month of Magh (January/February).

Top filling over dome influences gas production to some extent. In the first case, 15 out of 17 plants that have efficiency more than 80 percent have top filling more than 26 cm and in the second case, out of 41 plants that have efficiency more than 80 percent, 32 plants (78.0%) have more than 26 cm deep top filling over dome.

The study outcome indicated that plant efficiency increases with the latrine attachment. Out of the 41 plants that have efficiency more than 80 percent, 24 have latrine attached. Similarly, out of 11 plants that have efficiency less than 40 percent, 8 have no latrine attached.

Biogas production per kg of dung was observed to be 40, 33, 38 and 54 litre for latrine attached plants in Syangja, Nuwakot, Chitwan and Morang respectively. The corresponding figures for plants without latrine attachment are 34, 33, 30 and 32 litre respectively. The average value is 43 litre for latrine attached and 33 litre for plants without latrine attachment.

The outcome of the study suggested that a biogas stove consumes a maximum of 443 litre and a minimum of 210 litres of gas per hour. The average figure is 290 litre. Similarly, in the case of lamp it is 166 litres per hour. The average figure in the case of biogas stove seems to be too low.

Non-biogas households needed more than 4 hours time in all the four study areas to cook food whereas the corresponding time for biogas households was about 3 hours. The average saving of time to cook due to the installation is found to be 1 hour 36 minutes, 48 minutes, 1 hour 3 minutes and 1 hour 9 minutes respectively for Syangja, Nuwakot, Chitwan and Morang respectively. The average time saving is 1 hour 9 minutes.

Use of Firewood, Dung Cake, Agricultural Residue and Kerosene

The use of firewood for biogas households was found to be 1.61 kg (Chaitra) to 2.24 (Magh) kg per day. Non-biogas household used firewood in the range of 5.69 kg to 6.32 kg.

The outcome of the study indicated that an average of 49.21 (Magh) to 118.14 (Shravan) ml of kerosene was consumed by the biogas households in a day, whereas the non-biogas households used 72.87 to 196.09 ml. In an average non-biogas households used 153.76, 141.85, 140.32 and 135.57 ml of kerosene per day in Syangja, Nuwakot, Chitwan and Morang respectively. The corresponding figures for biogas households were 113.64, 47.78, 81.22 and 35.62 ml. The saving thus, were 40.12, 94.07, 59.10 and 99.95 ml per day respectively. The total saving was calculated to be 27 litres per year per households. There is no specific co-relation between average use of firewood and kerosene and the family size.

The average use of dung cake was observed to be 0.3 kg per day per households in non-biogas households and 0.04 kg in biogas households, which gave a total saving of 0.26 kg per day per household. The average use of agricultural residues was 0.87 kg for non-biogas households and 0.10 kg for biogas households.

Family Size Versus Plant Capacity

The results of study showed that for a family having four or less members, 4 m^3 capacity plant are enough. In other words, smaller sized plant is sufficient to fulfill demands in Terai regions in comparison to those in hilly regions. The biggest size needed is 8 m^3 capacity for families having more than 10 members in Chitwan and Nuwakot.

The analysis of gas use pattern showed that the minimum capacities of gas storage tank needed are 42 percent, 45 percent, 40 percent and 35 percent of the daily gas production respectively for Syangja, Nuwakot, Chitwan and Morang. The maximum capacity is, thus determined by the value in Nuwakot, which is highest of all the values. Therefore, the dome should be able to store 45 percent of the daily gas production to fulfill the demand of peak hours.

As in the case of volume of dome, the volume of outlet could also be decreased by a considerable quantity. The percentage of decrease ranges from 7 percent to 32 percent in Terai regions and 26 to 46 percent in the hilly regions for plans of different capacities.

The main outcome of the study is that there are possibilities of reducing the size of gas storage tank (dome) and outlet (displacement chamber). Similarly, there are possibilities to jump into smaller sized biogas plant from the presently adopted ones to achieve the same magnitude of benefits that is being received from existing plants of bigger sizes.

All the plants are financially viable in Syangja. The cost per m^3 of biogas generation is only Rs. 6.68 for 4-m3 plant in comparison to Rs. 9.39 for 8-m3 plant. The C/B ratio is very high (1.78) for 4-m3 plant and that for 8-m3 plant is 1.27. 4 m^3 plants are most cost-effective in Syangja. Similarly, for Nuwakot too, all the plants have B/C ratio more than 1, and 6 m^3 capacity plant is most cost-effective. 10 m^3 capacity plants are most cost-effective