VIABILITY OF BIOGAS: AN OPTION FOR HOUSEHOLD ENERGY

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INTRODUCTION

Most of the households, with different family size in Nepal, are scattered through out the country with uneven and unscientific distribution pattern. Due to the settlement pattern and other influencing factors consumption pattern and demand structure of goods and services varies by ecological belt, development region and rural urban variation. Similarly it is influenced by caste, ethnicity, occupational structure, living standard and so on. Among their various demanded items, fuel energy is prominent one. They use fuel energy for cooking rice and kitchen items preparing animal feed and for heat in the high altitude where climate is cold. The fooding system of the society has established fuel energy as one of the important aspect of life style. Some of the rural industries such as processing ghee, sugarcane juice citrus fruits juice and so on activities needs to have energy which is supplied by various sources. Till now most of the rural as well as urban habitants are using fuelwood. But the forest resource is depleting over the years and indicate no longer viable if this process is continued. In this connection, this article has tried to assess the present energy structure and necessity and viability of biogas particularly gobargas in the country.

SOURCES OF ENERGY AND THEIR USES

Household energy consumption in Nepal heavily relied upon forest resource but scenario is changing over the years in quantity and structure. The energy sources and consumption pattern can be classified broadly into two group i.e. traditional and commercial. Traditional energy substances includes fuelwood, agricultural waste and residues and animal dung and urine. Fuelwood basically supplied from forest and agriculture waste and residue from land. Animal dung and urine from livestock is being used in different ways through out the country. Commercial source include petroleum coal and electricity and former two are imported from abroad. Electricity is generated to some extent but the quantity supplied is far below the demand level and seems likely to remain constant in the years to come due to slow growth process in spite of huge potentiality.

Information available on energy source and consumption pattern clearly indicate the dominance of traditional source which includes fuelwood, agriculture waste and residues, animal dung and urine had constituted about 90 percent. In the fiscal year 1980/81, it had constituted about 96 percent and shows the changing pattern. Among the various components of traditional source fuel has significant place and it constitutes about two third share in total energy and 75 percent share in traditional source in the fiscal year 1996/97. Agriculture waste and residues have second position in total energy consumption and followed by animal dung and urine. Agricultural waste and commercial component's consumption as fuel is increasing but the share of animal dung in this regard has decreased, though volume has increased over the years gradually.

Table-1: Structure of Energy Consumption 1980/81 - 1996/97

	Traditional Sources					
	Agricultural				Commer-cial	Grand Total
Year	Fuelwood	Agricultural Waste	Animal Dung	Total		
1980/81	3382 (73.6)	584 (12.7)	445 (9.7)	4411 (96.1)	180 (3.9)	4591
1981/82	3491 (74.2)	593 (12.2)	452 (9.6)	4536 (96.5)	166 (3.5)	4702
1982/83	3572 (74.0)	602 (12.5)	459 (9.5)	4633 (96.0)	195 (4.0)	4828
1983/84	3645 (73.2)	611 (12.3)	466 (9.4)	4722 (94.9)	253 (5.1)	4977
1984/85	3720 (73.2)	620 (12.2)	473 (9.3)	4813 (94.7)	267 (5.3)	5080
1985/86	3800 (74.3)	630 (12.3)	480 (9.4)	4910 (96.0)	201 (4.0)	5111
1986/87	3839 (72.8)	672 (12.7)	485 (9.2)	4996 (94.7)	279 (5.3)	5275
1987/88	3912 (72.6)	711 (13.2)	490 (9.1)	5113 (94.9)	274 (5.1)	5387
1988/89	3986 (72.2)	753 (10.4)	495 (9.0)	5234 (94.8)	289 (5.2)	5323
1989/90	4031 (71.7)	798 (14.2)	500 (8.9)	5329 (94.8)	293 (5.2)	5622
1990/91	4128 (70.9)	844 (14.5)	506 (8.7)	5478 (94.1)	346 (5.9)	5821
1991/92	4236 (69.1)	893 (14.6)	511 (8.3)	5640 (92.0)	493 (8.0)	6133
1992/93	4315 (67.9)	945 (14.9)	576 (8.1)	5776 (90.9)	580 (9.1)	6356
1993/94	4504 (82.9)	969 (14.7)	535 (8.2)	6008 (92.2)	509 (7.8)	6517
1994/95	4604 (68.7)	1007 (15.0)	543 (8.1)	6154 (91.8)	547 (8.2)	6701
1995/96	4692 (67.5)	1042 (15.0)	549 (7.9)	6283 (90.5)	663 (9.5)	6946
1996/97	4782 (66.9)	1080 (15.1)	557 (7.8)	6419 (89.8)	727 (10.2)	7146

Source: Economic Survey, 1996/97, HMG/MOF

- Figures in Paren thesis indicate the percent of Grand Total
- Data indicate thousand tone of oil equivalent.

The Living Standard Survey Report, 1996 carried out by Central Bureau of Statistics (CBS/NPC/HMG/Nepal) has also indicated the highest importance of fuelwood for energy consumption. Cowdung, leaves, straw and thatch have second position and commercial source has less than seven percent contribution in overall country.

Table- 2: Main Fuel Used for Cooking by Ecological Belt alongwith Rural-Urban Distribution (in %)

Regional Settlement	Wood	Cowdung Leaves, Straw Thatch	Gas Cylinder	Kero-sene	Other Fuels	Total
Mountain	98.81	6.65	0.00	0.54	0.00	100.00
Hill	86.75	3.01	1.84	7.54	0.86	100.00
Terai	43.22	53.06	0.32	2.44	0.96	100.00
Urban	31.34	13.71	10.84	42.01	2.12	100.00
Rural	70.60	26.77	0.21	1.68	0.73	100.00
Nepal:	67.74	25.82	0.99	4.62	0.83	100.00

Source: Nepal Living Standard Survey Report, 1996, HMG/CBS.

Energy consumption pattern seems different by ecological belts and rural urban settlement. Fuelwood consumption position is highest in mountain due to lack of alternative substances followed by hill and the Terai respectively. Cowdung leaves, litter, straw, thatch and other bi-products of agricultural production have significant contribution in the Terai regions, which is zero in mountain and very few in the hill region. The study of rural urban energy consumption shows the vast differences in Nepal. Urban population is going to be dependent on commercial source such as gas and kerosene. Rural household households energy demand is still supplied by traditional sources constitutes about 97 percent which is much greater than demand 45 percent.

According to the estimation, in course of preparing forestry sector master plan, there is acute shortage of biomass energy in Nepal. Hill and Terai are failed in crisis where as high *himal*, high mountain and Siwalik enjoying surplus. This situation seems likely to be remained in the years to come.

Table-3: Energy Deficit and Balance Situation and Trend in Nepal (000 mt)

Region	1985-86	1990-91	2000-01	2010-11
High Himal	3	3	8	15
High Mountain	352	387	558	878
Middle Mountain	-343	-937	-1530	-1336
Siwalik	108	6	-97	181
Terai	-2224	-2423	-2008	-1166
Nepal	-2104	2964	-3051	-1428

***Source*: Master Plan for the Forestry Sector, Nepal, p. 49.**

In high Himal and high mountain there is energy surplus situation but due to absence of easy and cheap transportation it cannot help to reduce the problem and deficit of other region. In the hill and the Terai, due to demand for fuelwood forest resource is depleting over the years, with population growth and industrialisation which needs fuelwood, gradually.

BIO-GAS: SITUATION AND POSSIBILITY

Bio-gas installation is one of the important means for reducing dependency on forest and private trees for household energy. The capacity and potentiality depends on the animal dung i.e. cattle and buffaloes which have significant prospects in Nepal. The cattle and buffaloes population in Nepal, in comparison with other countries is high and increasing over the years. These two are important means for dung production and about 10 and 18 percent of cattle and buffaloes are added up to 1996/97 in the population of the year 1984/85 respectively.

Table-4: Cattle and Buffalo Population in Nepal in Various Years (in 000 heads)

Year	Cattle	Buffalo
1984/85	6357	2839
1985/86	6372	2891
1986/87	6363	2918
1987/88	6343	2952
1988/89	6285	3003
1989/90	6281	3013
1990/91	6255	3044
1991/92	6246	3055
1992/93	6237	3073
1993/94	6546	3176
1994/95	6838	3278
1995/96	7008	3302
1996/97	7025	3362

Source: Agricultural Statistics of Nepal 1992/93 and Statistical Information on Nepalese Agriculture, 1996/97.

Cattle and buffalo population is widely distributed in the country through out the region and sub-region. Highest number of cattle and buffaloes are distributed in the hill region i.e. 48.8 percent cattle and 57.0% of buffaloes followed by the Terai and mountain respectively. Cattle and buffaloes are widely accepted animal species in Nepal than other and widely distributed among the households irrespective of ecological belts. According to the agricultural census of 1991/92 75.6 and 47.8 percent households have raised cattle and buffaloes in Nepal out of total 2736.1 thousand holdings. The figure among ecological belt seems different.

Table-5: Distribution of Cattle and Buffaloes in Various Ecological Region in 1996/97 in (000 heads)

Species	Mountain	Hill	Terai	Total
Cattle	826 (11.8)	3428 (48.8)	2769 (39.4)	7024 (100.00)
Buffalo	305 (9.1)	1919 (57.0)	1139 (33.9)	3363 (100.00)
Total Holding	260.7	1357.7	1117.6	2736.1

Source:- Statistical Information on Nepalese Agriculture, 1996/97.

Note:- **Figures in Parentheses Indicates Percent of their Total.**

Table-6: Number and Percent of Holdings with Cattle and Buffaloes Various Ecological Belts. Holdings in (000)

Livestock Type	Mountain	Hill	Terai	Total
Cattle	215.7 (82.7)	1019.6 (75.1)	831.9 (74.4)	2067 (75.6)
Buffalo	115.6 (44.4)	791 (58.3)	400.3 (35.8)	1307.8 (45.8)
Total Holding	260.7	1357.7	1117.6	2736.1

Source: National Sample Census of Agriculture Nepal, 1991/92, CBS.

Note:- Figure in Bracket indicate the percent of total holding of the region

National Sample Census of agriculture has indicated that out of total households of the region 82.7, 75.1 and 74.4 percent have raised cattle in mountain, hill and the Terai respectively. Similarly highest percent of hill families have kept buffaloes followed by mountain and the Terai respectively.

Cattle and buffaloes are main source of dung production. Chauries produce dung but is not widely spreaded, which indicate limited economic value than the cattle and buffaloes. In this regard determination of biogas plants and operation capacity depends only upon cattle and buffaloes.

The dung production is scattered through out the country irrespective of ecological belt as with the cattle and buffaloes. Cattle produce 3 kg of dung per day where as buffaloes capacity is 3.7 kg in same time. Daily dung production in Nepal is about 33511.8 mt. where as hill region has constituted more than 50% share on total production followed by Terai and mountain respectively. Between cattle and buffaloes cattle constitutes about two third share in total dung production. Cattle share in this regard is due to the higher population and can be increased if the stall feeding is widely distributed.

Biogas plants in different capacities can be established. Dung requirement for plant operation depends on the size of plant. In this situation how much plant can be established depends upon the plant size. Dome model biogas plant requires 6 kg dung per cube meter per day. If the plant having to cube meter capacity is constructed 5,58,530 plants can be established in the country altogether of three ecological belts. Similarly if plant size are smaller, more plants can be established.

Table-7: Dung Production Capacity and Production Situation in Nepal by Ecological Belt in 1996/97

Region	Population 000	Average Production per day per animal (kg)	Per day Production mt.	Per Year Production mt.
Mountain				
Cattle	826	3.0	2478	904470
Buffalo	305	3.7	1128.5	411903
Hill				
Cattle	3428	3.0	10284	3753660
Buffalo	1919	3.7	7100.3	2591610
Terai				
Cattle	2769	3.0	8307	3032053
Buffalo	1139	3.7	4214.3	1538220
Total:	-	-	33511.8	12231918

Source: Statistical Information on Nepalese Agriculture, 1996/97

Note:- Per day dung production is calculated using the table estimated by WECS from Alternative Every Technology, an over view and Assessment 1994/95.

Table-8: Bio-gas design, capacity, Dung Requirement for Plant Operation and Possible Establishment. Daily Dung Production is 33511.8 mt. According to the Cattle and Buffalo Population of 1996/97.

Design	Capacity m^3	Dung input per day	Possibility of No. of Establishment
Dome	4	24	1396325
	6	36	930833
	8	48	698162
	10	60	558530
	15	90	372353
	20	120	279265
	35	210	159580
Drum	50	300	111706
	750 c.ft.	440	76163
	1000 c.ft.	885	37866

Source: Alternative Energy Technology, an Overview and Assessment, WECS, 1994/95

EFFORTS ON BIOGAS DEVELOPMENT

The history of bio-gas installation in Nepal starts since 1960, a school teacher established a 'Gobar'gas' plant in Nepal (New Era: 1985). At that time,

government was not so much aware for it due to sufficient supply of forest fuelwood for energy. But as the forest resource was declining due to extraction of fuelwood for energy, government became aware slowly and started to search the viable substitute for fuelwood. After 15 years of first installation, government started to initiate the extension of bio-gas installation to control of check the deforestation process.

Agricultural department of HMG took responsibility for launching the Gobar-gas plant construction programme. During the agriculture year 2032 (1975/76) the ADB/N provided free interest credit to install 196 plants, against a target of 250 drum type gas plants. All these plants were constructed in the Terai region on the contract basis by the contractors. The materials required for plant installation were manufactured by Butwal Engineering Works of Butwal, Balaju Yantrasala of Kathmandu and Agricultural tools Factory Birgunj (WECS, 1994/95).

To promote the establishment of Gobar-gas plants in an organised and systematic way, throughout the country a private corporation Gobar-gas. Tatha Krishi Yantra Vikash (Pvt.) (Ltd.), (Gobar-gas Company) was established in 1977 with three main shareholders, the ADB/N, the Fund Corporation Nepal (FCN) and UMN. After the establishment of Goabar-gas Company, it has been solely responsible for biogas development. At the initial years it has applied dome type model but later it changed to drum (WECS, 1994/95).

Biogas plant installation is increasing over the years with the government initiation. Government has promoted credit facilities to the people in the provision of land ownership certificate through ADB/N. Government is supporting to various organisation and agencies for its development. Bio-gas has been promoted by various companies and financial assistance is receiving from various donor and agencies.

Since the fiscal year 1983 HMG/N introduced a subsidy programme to stimulate the biogas installation in the country. The amount of subsidy was 50 percent in the interest of 15 percent but in few years after, it was reduced to 25 percent of the interest. The structure of subsidy programme changed in the latter years. Since 1989, government started to provide the charity on the basis of cash incentives for installation in the hills. All the subsidy programms are administering through (ADB/N. All the subsidy programmes are administering through) ADB/N. (WECS 1994/95)

Government has been aware to protect the forest resources in the recent years. For this, various programmes concerning for reducing the burden on forest are introduced. Biogas installation is one of them. Government is trying to receive support from other countries and donor agencies. In this course the Dutch Government has provided some financial assistance to boost up the bio-gas development actives and this is a joint programme of ADB/N, Gobar Gas Company and Netherlands Devleopment Organisation. This bio-gas support programme was devided into two phases. The duration of first phase was 2.5 years ending in July 1994, and second phase had a duration of 3 years July 1994-97 (WECS 1994/95).

As the forest resources is decreasing, threatening the environmental problem, government is being aware to develop the bio-gas installation activities, including national plan process. Bio-gas installation programme was incorporated in seventh five year plan (1985-90) (NPC:1985=90). In the eighth five year plan, government had provided some emphasis and target was increased than previous plan. Similar emphasis is provided in nineth plan. In this course HMG/N has also made strategies for the further development of bio-gas. Privatisation policy is becoming the key effort to the government to increase bio-gas plants in the country. (WECS:1994/95)

Bio-gas installation programme needs financial assistance due to the low level of savings of the rural people. Government has recognised this problem and aware to provide credit facilities. ADB/N is providing financial support as in the term of credit over the years. Since 1975/76 it has been providing loan where as special subsidy in introduced in the recent years. The investment amount is increasing over the years for bio-gas purpose.

Table-9: ADB/N's Investment on Bio-gas plant Development in Different Fiscal Years

(Rs. in '000)

Year	Loan disbursement	Year	Loan disbursement
1975/76	648	1986/87	10560
1976/77	917	1987/88	19233
1977/78	1602	1988/89	32783
1978/79	1906	1989/90	44494
1979/80	1533	1990/91	27036
1980/81	1801	1991/92	63552
1981/82	3028	1992/93	95095
1982/83	3606	1993/94	114354
1983/84	3063	1994/95(a)	88690
1984/85	5162	1995/96/(b)	125180
1985/86	12057	1996/97(b)	129579

Source:- ADB/N,
(a) Revised data,
(b) Provisional data.

SOCIO-ECONOMIC CONSEQUENCES OF BIOGAS INSTALLATION IN NEPAL

The bio-gas is important alternative energy where the livestock raising has significance in the economy. This programme or bio-gas development activities and use of gas stoves affect the social and economic life of people in various ways. These effects can be outlined as below.

POSITIVE IMPACT

(1) Bio-gas use in cooking may be smokeless. Housewives, and women may feel relief in this regard. This helps to reduce the occurrence of eye and lung diseases.

(2) Gobar-gas stove is easy and comfortable to operate and doesnot require blow of fire continousouly. It may help to reduce the work burden, i.e. Kitchen load of housewives.

(3) Bio-Gas using in cooking make the utensils less dirty than firewood. Therefore clearing this is easy which is reduction of work burden and material coast such as surf, soap etc.

(4) Cooking with -bio gas is easy and the work can be carried out faster than using firewood.

(5) Biogas installation reduce the necessity of firewood collection. People specially women do not need to go jungle for firewood collection continuously which is reduction of work burden.

(6) Nepal has male dominated society. In this situation household works, top to bottom, is to be done by female. They have to go to jungle for firewood collection. Specially the girls and women have to go in this course. Bio-gas installation may reduce their work. So that they can be involved in other creative work or activities. The girls who are involved in firewood collection regularly for consumption may get chance to go school.

(7) Bio-gas installation reduces the demand for wood which is the key cause of deforestation. It makes possible for forest preservation and environmental rehabilitation.

(8) Bio-gas installation helps to save the income of firewood purchaser.

(9) Bio-gas installation induces to promote stall feeding of large ruminents. In this situation environmental degradation can be reduced which happens due to grazing and trampling of soil in course of animal mobility.

NEGATIVE IMPACT

(1) Bio-gas installation and effective operation requires stall feeding of cattle and buffaloes. In this situation, people have to devote their time for grass and feed collection. The daily collection of grasses and feed increases the world burden of female in household.

(2) Bio-gas requires certain amount of water per day. For this women have to devote time for water collection. The daily collection of water for bio-gas operation would be additional workload for women. In the hill areas when water resources and supply is poor in condition, this problem would be more serious.

(3) In the Terai region, some of the people are engaged for dung drying for income. Large number of bio-gas installation may reduce these opportunities.

(4) Bio-gas installation induces stall feedings. If this is done for a long time, forest resource losses the fertility which would have happened in grazing. This may reduce the forest land fertility.

ECONOMIC ANALYSIS

Economic analysis for bio-gas installation is necessary. Bio-gas production process does not provide directly monetary profit but saving of energy by this can be calculated in monetary terms. Bio-gas installation cost differs by bio-gas companies and amount of cost is positively associated with the capacity. The comparative study of installation cost shows that cost of 'Bio-gas Company' is higher than other company.

Table-10: Cost of Bio-gas Installation by Various Bio-gas Companies

Name of Companies	Capacity					
	$4m^3$	$6m^3$	$8m^3$	$10m^3$	$15m^3$	$20m^3$
Bio-gas Company	14,712	16,986	20,237	23,558	30,164	36,620
Kishan Gobar Gas	14,030	16,474	19,974	24,394	29,885	35,050
Nepal Gobar Bistar & Rastriya Gobar Gas	14,612	16,836	20.037	23,358	30,024	36,420

Source: WECS, Alternative Energy Technology, An Overview and Assessment 1994/95, Water and Energy Commission Secretariat (WECS), Kathmandu, p. 76.

Bio-gas plant should operate regularly and it incurs cost every day. WECS has estimated cost and returns of bio-gas plants of different sizes. In the cost, annual operation charges such as depreciation, interest of initial investment, repair and maintenance cost, labour charge are included. Similarly return includes benefit from various sizes, which can be measured in monetary terms for the purpose of analysis.

The amount of profit, received by bio-gas plants, positively associated with the size (capacity). The bio-gas plant with $4m^3$ capacity provides Rs. 4,121 net profit, where as $20m^3$ provides 22,187 net profit, higher than the proportion of plant size. This clearly indicate that plant size with higher capacity are more profitable than smaller.

Table-11: Benefits from Various Sizes of Bio-gas Plants.

Particular	Unit	Capacity					
		$4m^3$	$6m^3$	$8m^3$	$10m^3$	$15m^3$	$20m^3$
Construction Cost	Rs.	12,627	15,781	18,364	21,625	27,499	34,570
Dung Used/Annum	Kg.	8,760	13,140	17,520	21,900	32,850	43,800
Bio-gas Production/yr.	m^3	415	670	824	1083	1702	2312
Slurry Production	kg.	5,256	7,884	10,512	13,140	19,710	26,280
Savings in Nutrients loss							
Nitrogen	kg.	58	87	116	145	217	289
Phosphorus	kg.	42	63	84	105	58	210

Potash	kg.	11	16	21	26	39	53
	Capacity						
Particular	Unit	$4m^3$	$6m^3$	$8m^3$	$10m^3$	$15m^3$	$20m^3$
Saving in Nutrient Loss	Rs.	1,353	2,029	2,705	3,381	5,072	6,763
Nitrogen	kg.	704	1,055	1,407	1,759	2,639	3,518
Phosphorus	kg.	500	750	1,000	1,250	1,874	2,500
Potash	kg.	143	223	298	372	559	745
Gas Used for Cooking	m3	291	469	577	758	1,191	1,618
Gas Used for Lighting	m3	125	201	247	325	511	694
Fuelwood Equivalent	kg.	1,008	1,627	2,002	2,631	4134	5616
Value of Fuelwood	Rs.	2,016	3,255	4,003	5,261	8,268	11,232
Kerosene Equivalent	L	77	125	153	201	317	430
Value of Kerosens	Rs.	753	1,215	1,494	1,964	3,087	4,193
Total Benefit	Rs.	4,121	6,497	8,202	10,607	14,427	12,187

Source: Source of the Table 10, p. 80.

CONCLUSION

Bio-gas is being popular in recent years in Nepal. Each and every household keep cattle and buffaloes and possibility of establishment of bio-gas is high in Nepal. If bio-gas plants are established through out the country, it can be the special means for forest resource protection. In spite of its negative and positive effects, most of the people are accepting it in all ecological belt. Government has taken some initiation for its development but is not sufficient as required. In this situation, more efforts are needed. If proper strategy in adopted in time for its development, it will be helpful for sustainable development.

Various factors determine the installation of biogas plants in addition to availability of dung from animals. Economic factor is important in this regard. In the long-run, it provides profits, but initial investment is quite high in comparison to purchasing capacity of farmers. In this situation, a bulky amount of subsidy is necessary. Government, through institutional channel, providing subsidy but is not sufficient to meet the needs. In this situation if government become able to provide sufficient subsidy, for bio-gas installation, it can be developed as a viable energy source, through out the country. Due to various constrains, it cannot be an attentive way, but helps to reduce the energy cost, through out the country.

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