Iranica Journal of Energy & Environment 2 (4): 326-330, 2011
ISSN 2079-2115
IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology
DOI:10.5829/idosi.ijee.2011.02.04.2044

BUT

Energy Resource Allocation for Sustainable Development: A Case Study

[1]H.B. Suresh, [2]L.K. Sreepathi and [3]H.M. Ravikumar

[1]Department of Electrical & Electronics Engineering,
J.N.N. College of Engineering, Shivamogga, Karnataka, India
[2]Department of Mechanical Engineering, J.N.N. College of Engineering, Shivamogga, Karnataka, India
[3]Department of Electrical Sciences, Sahyadri College of Engineering and Management,
Mangalore, Karnataka, India

(Received: July 17, 2011; Accepted: December 8, 2011)

Abstract: The focus of present research paper was to investigate the energy availability from agricultural crop residue, animal waste and present energy consumption patterns of three villages (Thudoor, Yedehalli and Bilaki) of Shivamogga District, Karnataka state. The integrated energy plan for selected villages is prepared covering geographic and demographic characteristics and present energy consumption pattern. The results indicate that, the electricity generated from crop residue using gasifier technology and fluidized bed gasification can meet about 25.6, 38.49 and 52% of the total electrical energy demand of Thudoor, Yedehalli and Bilaki villages respectively. Results of mean volume of biogas yield from the use of animal waste (cow dung) were 748.8 m^3, 883.2 m^3 and 291.84 m^3 of bio gas/day in Thudoor, Yedehalli and Bilaki villages respectively. The amount of biogas produced is sufficient to meet 100% cooking energy demand of the villages.

Key words: Agro waste · Biogas · Energy planning · Rural energy security · Sustainable development

INTRODUCTION

Electricity is sole source of energy and it has improved the quality of public lives around the world. However, the majority of the people in developing countries do not easily access electricity and, therefore, they entirely depend on solid fuel forms like wood to meet their basic needs such as cooking and lighting. Biogas production from biogenic wastes has been alternative source of fuel in most developing countries of world including India [1].

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of biofuels [2]. One type of biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, green waste and energy crops [3]. This type of biogas comprises primarily methane and carbon dioxide. The other principal type of biogas is wood gas which is created by gasification of wood or other biomass [4]. This type of biogas is comprised primarily of nitrogen, hydrogen and carbon monoxide, with trace amounts of methane. Earlier studies in India has shown that bioenergy based technologies could meet partly the rural electricity and cooking energy needs through small biomass gasifiers and community biogas [5]. In view of the above, the present study has been carried out with the following objectives. To identify the decentralized energy technology routes cater the demand of the village locally. To identify the local energy resources to meet the domestic energy needs for cooking, heating and for lighting purposes. To provide energy security for rural areas with due environmental consideration.

MATERIALS AND METHODS

For the analysis of energy availability from agricultural crop residue and animal waste, study has been conducted for typical villages (Thudoor, Yedehalli and Bilaki) of Malnad region of Shivamogga District, Karnataka state, India. The total population of the villages

Corresponding Author: H.B. Suresh, Department of Electrical & Electronics Engineering, J.N.N. College of engineering, Shivamogga, Karnataka, India. Tel: +91-91961561458.

were 1630 in 300 households of Thudoor village, 2300 in 400 households of Yedehalli village and 1169 in 200 household of Bilaki village and 90% of the houses in those villages are electrified. The geographic area of the villages were 1395, 2817 and 796 acres and net cultivated land was 613, 1200 and 583 acres respectively. The remaining were forest, waste land, non agricultural land. Mean average annual rain fall was 3100 mm, 2100 mm and 1050 mm respectively. Paddy (40%) and areca nut (20%) were the main crops grown in the villages. Irrigation was available to only 15% of cropped area. The total livestock population was 780, 920 and 304, respectively.

The major energy sources that were being used in the villages are electricity, firewood, agro waste, kerosene. These energy sources are used for energy services like lighting and luxuries in domestic sector, water pumping and ploughing in agricultural sector and also for cooking, heating and for transportation. Data from 900 households of the villages covering 100% of the families were collected. Much of the data used for the analysis was based on the data obtained from survey. The integrated energy plan for the selected village was prepared with 100% coverage basis, covering geographic and demographic characteristics of the village, economic activities and general living conditions of the people.

Survey Questioners: The survey was conducted through structural written questioners containing primary and secondary data.

Primary data:

- General household information such as number of members and occupation.
- Energy consumption details such as whether house is electrified/not, connected load, load scheduling, sources for cooking, lighting, heating and their quantities.
- How much fuel is required such as liquefied petroleum gas, kerosene, diesel and petrol.
- Energy availability includes acres of land, annual yielding and usage of agro residue, poultry and cattle.

Secondary data:

- Land holding particulars (agro; horticulture)
- Data of village demography, occupation and rainfall.
- Data of livestock population.

RESULTS AND DISCUSSION

Current Energy Consumption Pattern: The current energy consumption pattern based on the data collected and discussion held with villagers, total energy consumption and pattern of energy consumption of the three villages (Thudoor, Yedehalli and Bilaki) of Shivamogga District were analysed and mentioned in Table 1. It was observed that the total energy consumption of Thudoor, Yedehalli and Bilaki villages were 1126884, 1474892 and 975358 MJ/month, respectively. The major contributors were fire wood and agro residue. Tables 2- 4 show details regarding the type of energy used and the amount of energy used for end use services in percentage. From Table 2 it can also be seen electricity meets about 15.17% of energy demand. The other major contributors are fire wood (59.90%), agro residue (13.31%) and the other energy sources meet about 11.51% of the demand.

Table 1: Energy Consumption Pattern of Thudoor, Yedehalli and Bilaki Village.

		Energy consumption/month		
Sl. No.	Item.	Thudoor village	Yedehalli Village	Bilaki Village
1	Lighting	21600 MJ (6000Kwh)	29808 MJ (8280 Kwh)	12960 MJ (3600 Kwh)
2	Luxuries	19872 MJ (5520 Kwh)	21168 MJ (5880 kwh)	9504 MJ (2640 Kwh)
3	Irrigation	129600 MJ (36000 Kwh)	69552 MJ (19320 kwh)	34560 MJ (9600 Kwh)
4	L P G	57330 MJ (65 cylinders)	79380 MJ (90 cylinders)	35280 MJ (40 cylinders)
5	Kerosene	21500 MJ (572 Litres)	25007 MJ (665 Litres)	21951 MJ (584 Litres)
6	Petrol	39744 MJ (1200 Litres)	39744 MJ (1200 Litres)	22223 MJ (671 Litres)
7	Diesel	12238 MJ (313 Litres)	40233 MJ (1029 Litres)	13880 MJ (355 Litres)
8	Fire wood	675000 MJ (45 Tonnes)	975000 MJ (65 Tonnes)	690000 MJ (46 Tonnes)
9	Agro residue	150000 MJ (10 Tonnes)	195000 MJ (13 Tonnes)	135000 MJ (9 Tonnes)
Total		1126884 MJ	1474892 MJ	975358 MJ

Table 2: Sources and Uses of Energy in Thudoor village (in%)

	Usage						
Source	Cooking	Lighting	Heating	Transportation	Luxuries	Irrigation and cultivation	Total
Electricity		1.91			1.76	11.5	15.17
LPG	5						5
Kerosene	0.5	1	0.4				1.90
Petrol				3.53			3.53
Diesel				0.7		0.38	1.08
Fire wood	38.9		21				59.90
Agro waste	10		3.31				13.31
Total	54.4	2.91	24.7	4.23	1.76	11.88	100

Table 3: Sources and Uses of Energy in Yedehalli village (%)

	Usage						
Source	Cooking	Lighting	Heating	Transportation	Luxuries	Irrigation and cultivation	Total
Electricity		2.02			1.43	4.71	8.16
LPG	5.3						5.3
Kerosene	0.4	1	0.29				1.69
Petrol				2.69			2.69
Diesel				1.72		1	2.72
Fire wood	40		26.1				66.1
Agro waste	10		3.2				13.2
Total	55.7	3.02	29.6	4.41	1.43	5.71	100

Table 4: Sources and Uses of Energy in Bilaki village (%)

	Usage						
Source	Cooking	Lighting	Heating	Transportation	Luxuries	Irrigation and cultivation	Total
Electricity		1.32			0.97	3.54	5.73
LPG	3.61						3.61
Kerosene	0.25	1	1				2.25
Petrol				2.27			2.27
Diesel				1		0.42	1.42
Fire wood	40		30.7				70.7
Agro waste	10		3.8				13.8
Total	53.86	2.32	35.5	3.27	0.97	3.96	100

Table 5: Energy availability from agricultural crop residue and animal waste

Crop/Energy potential		Thudoor	Yedehalli	Bilaki
Paddy	Rice husk available/ Month in Kg	11437.5	18750	9375
	Electrical energy potential in Kwh	3812.5	6250	3125
Arecanut	Arecanut husk available/ month in Kg	11666.66	8166.6	5950
	Electrical energy potential in Kwh	6666.66	4666.66	3400
Coconut	Coconut fronds available/ month in Kg	3000	3450	3000
	Electrical energy potential in Kwh	1714	1971	1714
Total electrical energy Potential in Kwh		12193.1 (47520) [a]	12887.6 (33480) [a]	8239 (15840) [a]
Possible replacement using locally available resources		25.6%	38.49%	52%
Bio gas Potential in m^3/Day		748.8 [370] [b]	883.2 [522.1] [b]	291.84 [265.36] [b]

[a] Total electrical energy consumption/month of the village in Kwh.

[b] Biogas required for cooking for the village in m^3/Day.

When we look at the demand for energy services, the demand for cooking was about 54.4%, irrigation and cultivation 11.88%, lighting 2.91%, heating 24.7%, luxuries 1.76% and for transportation was 4.23%.

Energy Availability from Agricultural Crop Residue and Animal Waste: Paddy (40%), arecanut (20%) are the main crop grown in the villages. It was observed that maximum agro residue is available from paddy and arecanut crop. Using gasifier technology and fluidized bed gasification it was possible to extract the energy available in the residue. Total number of paddy cultivated land in Thudoor, Yedehalli and Bilaki villages were 305, 500 and 250 acres and annual yielding of paddy was 915, 1500 and 750 tonnes, respectively. Total number of arecanut cultivated land in those villages were 200, 140, 102 acres and annual yielding of arecanut was 200, 140, 102 tonnes. The total number of coconut cultivated land in these villages were 20, 23, 20 acres and coconut fronds available/ annum was 36, 41.4, 36 tonnes, respectively.

Energy Availability from Rice Husk: During the extraction of rice grain from the paddy crop, it was observed and measured that 100 kg of Paddy yields 15 kg of residue (Rice husk). The paddy available/month from Thudoor, Yedehalli and Bilaki villages were 76.25, 125 and 62.5 tonnes. Hence the total residue available in those villages was 11.43, 6.25 and 3.12 tonnes, respectively. It was found that, specific fuel consumption of fluidized bed gasifier was 3 kg /Kwh [6]. Therefore the net electrical energy that can be generated from available major agro residue in those villages were 3812.5, 6250 and 3125 units/month.

Energy Availability from Arecanut Husk: During the extraction of arecanut from the arecanut crop, it was observed and measured that 100 kg of arecanut yields 70 kg of residue (arecanut husk). The arecanut available/month from Thudoor, Yedehalli and Bilaki villages were 16.66, 11.66 and 8.5 tonnes. Hence the total residue available in those villages was 11.66, 8.16 and 5.95 tonnes, respectively. It is found that, specific fuel consumption of biomass gasifier was 1.75 Kg/Kwh. (by assuming the unit is operating at full load). Therefore the net electrical energy that can be generated from available major agro residue in those villages was 6666.66, 4666.66 and 3400 units/month.

Energy Availability from Coconut Fronds: From the available coconut fronds it was estimated that the total coconut frond available/month from Thudoor, Yedehalli and Bilaki villages were 3, 3.45 and 3 tonnes/month. It was found that the specific fuel consumption of biomass gasifier is 1.75 kg/Kwh. Therefore the net electrical energy that can be generated form available major agro residue in those villages was 1714, 1971 and 1714 units/ month. Table 5 gives the details of agricultural crop residue available/month, electrical energy potential and biogas potential/day of target villages. It was observed that the total electrical energy consumption/month of the target villages was 47520, 33480 and 15840 units. It also gives the electrical energy generated can meet 25.6, 38.49 and 52% of the total electrical energy demand of Thudoor, Yedehalli and Bilaki villages, respectively.

Biogas: Biogas is largely used for different purposes such as cooking and lighting. Hence the requirement of biogas for a family will have to be determined on the basis of cooking needs. The energy required for cooking will vary according to the eating habits, type of cooking, type of food. However the average gas consumption for different domestic usage is given below (Thudoor Village),

Biogas required for cooking / person / day is 0.227 m^3 [7]	
Total mass of cow dung available/day	= (Mass of cow dung/cow/day) (Number of cattle's) = (4kg/day)(780) = 3120 kg/day
Volume of biogas generated	= (Biogas yield input)(Mass of the dry input) = (0.24)(3120) = 748.8 m^3 / day
Total population of the village	= 1630
Hence gas required for cooking	= 370 m^3/day

Thus the biogas plants meet the cooking requirement for 300 families.

The above calculation was applied to the other two villages and it was found that the biogas plants meet the cooking requirement of 400 families in Yedehalli village and 200 families in Bilaki village. Biogas production is often suggested in situations where animal wastes are used as a major source of household energy [8]. At present biogas is the most immediately practicable means for powering a conventional internal combustion engine from biomass. It tends itself to small scale on farm use and there is considerable experience with technique in a number of countries [9].

The results show that the total units of electrical energy consumption per month of Thudoor, Yedehalli and Bilaki villages were 47520, 33480 and 15840 units, respectively. It was found that using gasifier technology and fluidized bed gasification 12193, 12887.6 and 8239 units of electrical energy can be generated per month by using only major agro residue. Thus it can supply about

25.6, 38.49 and 52% of the total electrical energy demand of Thudoor, Yedehalli and Bilaki villages, respectively. Animal dung available in those villages can produce 748.8 m^3, 883.2 m^3 and 291.84 m^3 of bio gas/day. This is sufficient to meet 100% energy requirement for cooking. Village people need not depend on natural forest for their energy needs. It is possible to provide energy security for the three villages in a sustainable way using local energy sources only.

CONCLUSION

Agricultural wastes and farm animal wastes were easily converted to biogas energy source. The gaseous products are considered as reliable sources of energy. It was concluded that gasification of biomass and lignocellulosic wastes may result in higher yield than any conventional processes. The produced biogas is used by farmers house-holds as utilities and often utlized for heating and cooking purposes.

ACKNOWLEDGEMENT

Authors would like to thank villagers of Thudoor, Yedehalli and Bilaki villages, Village accountants and Veterinary officers for their support during the survey. The authors also wish to acknowledge the encouragement provided by the staff and students of J.N.N. College of engineering, during the preparation of this paper.

REFERENCES

1. Sudha, P., H.I. Somashekhar, Sandhya Rao and N.H. Ravindranath, 2003. Sustainable biomass production for energy in India. Biomass and Bioenergy, 25: 501-515.
2. Jeffery, A.C., J.V. Peter, J.J.B.R. William and M.G. James, 1981. Predicting methane fermentation biodegradability. Biotechnology and Bioengineering Symposium, 11: 93-117.
3. Shelef, G., H. Grynberg and S. Kimchie, 1981. High rate thermophilic aerobic digestion of agricultural wastes, Biotechnology and Bioengineering Symposium, 11: 341-342.
4. Klass, D.l., S. Ghosh and J.R. Conrad, 1976. The conversion of grass to fuel gas. Symposium papers of clean fuels from biomass, sewage, urban, refuse agricultural wastes.
5. Ravindranath, N.H. and D.O. Hall, 1995. Biomass, Energy and Environment: a Developing Country Perspective from India. Oxford University Press, Oxford.
6. Rai G.D., 2001. Non Conventional Energy Sources. 4th ed., Khanna Publishers, New Delhi.
7. Srinivasan, R. and P. Balachandra, 1993. Micro-level energy planning in India-A case study of Bangalore North Taluk, I. J. Energy Res., 17: 621-623.
8. Aliyu, M., S.M. Dangogo and A.T. Atiku, 1996. Biogas production from pigeon droppings. Nigerian J. Renewable Energy, 4: 48-52.
9. Shelef, G.S. and H. Grynberg, 1981. High Rate Thermophilic Anaerobic Digestion of Agricultural Wastes. John Wiley and Sons, New York, pp: 341-351.