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Food as Fuel: Prospects of Biogas Generation from Food Waste

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ABSTRACT

Biogas is a valuable renewable energy source containing 55% methane and a sustainable mode of waste disposal. It does not have any geographical limitations nor does it require advanced technology for producing energy, also it is very simple to use and apply but is yet to achieve its true potential. These resources, coupled with new and emerging conversion technologies and appropriate energy policy, can make biogas a powerful addition to the renewable energy landscape. Biogas can help decentralize energy generation and immediate benefit from owning a compact biogas system is the savings in cost as compared to the use of kerosene or LPG for cooking. Biogas systems that take kitchen wastes are 800 times efficient than conventional biogas systems. Kitchen waste has high calorific value and nutritive value to microbes due to which efficiency of methane production can be increased by several orders of magnitude. Delhi Technological University (D.T.U) has a bounty of resource for producing biogas in food waste. A thorough study of the food practices in the 5 hostel mess was done. Surveys were conducted and the caretakers questioned about the food waste being generated daily. 5 messes catering to 1700 students generate 300-400 kg of food waste per day. Biogas potential of the campus is found to be large and thus calculated using the values in the literature in terms of LPG cylinders saved per day.

Keywords- biogas;kitchen waste; LPG

1. INTRODUCTION

Mahatma Gandhi, in his vision for India, envisaged a system of devolved, self-sufficient communities, sustaining their needs from the local environment, and organizing income generating ventures around co-operative structures. Sixty years on, and Gandhi's vision of Swadeshi (self-sufficiency) for India, despite interpreted by some as a romantic and bucolic notion, is perhaps more urgent than ever. India's increasing energy demand, and its inability to step up production to meet demand necessitates a coordinated effort by the people and the state to supply itself with a dependable and sustainable source of energy. The gas created as a product of anaerobic digestion of organic materials has enormous potential of 17,000 MW [1].The production and use of biogas is an established technology with a long history, but biogas currently only comprises a small percentage of the total energy used in most industrial countries. At the same time, new technologies and approaches to produce and use biogas are expanding rapidly. Unfortunately, biogas has been overshadowed by other renewable energy resources, including wind, solar, and ethanol due to lack of renewable energy policies that either ignore important uses of biogas or fail to reward the high performance of various biogas energy systems. Biogas is a valuable vehicle of energy containing 55-70% methane and 30-45% carbon dioxide as well as small quantity of other gases with a calorific value of 20MJ/cubic meter [2].It is a cheap and clean fuel gas which burns with a soot free blue flame.

The gas is useful as a fuel substitute for firewood, dung, agricultural residues, petrol, diesel, and electricity, depending on the nature of the task, and local supply conditions and constraints, thus supplying energy for cooking and lighting. Biogas systems also provide a residue organic waste, after anaerobic digestion that has superior nutrient qualities over the usual organic fertilizer, cattle dung, as it is in the form of Ammonia. Anaerobic digesters also function as a waste disposal system, particularly for human waste, and can, therefore, prevent potential sources of environmental contamination and the spread of pathogens. With increased biogas production, the supplemental biogas can be beneficially used for power generation, as a vehicle fuel, in gas network, and in industries such as sugar refineries, distilleries, dairies and paper mills .It can be provided as a fuel for combined heat and power applications.

Table 1-Possible applications of biogas

4 meter cube Biogas	5 KWh electricity
	Mantle lamp 25-28 hours
	Cooking for 25 people
	5 hp engine for 1.5 hours

2. FOOD AS FUEL

Globally, researchers at the United Nations have estimated that as much as 50% of the food produced is wasted or discarded [3].Biogas systems take organic material (feedstock) into an air-tight tank, where bacteria break down the material and release biogas. It has been demonstrated that by using feedstock having high calorific and nutritive value to microbes, the efficiency of methane generation can be increased by several orders of magnitude [4]. Kitchen waste fulfills this condition and boosts biogas production and also reduces size of reactor and cost of biogas production. From the point of view of conversion of feedstock into methane, the system that uses food waste is 20 times as efficient as the conventional system, and from the point of view of reaction time, it is 40 times as efficient. Thus the system is 800 times as efficient as the conventional biogas system [5].Food waste has high water content and low lignin and lingo cellulose content that make it ideal for this digestive process. By adding food waste to a plant's anaerobic digestion process, it can be expected that the plant will see a reduction in expenditure. These costs savings include reduced energy costs due to production of on-site power and a tipping fee for accepting the food waste. Also, the tipping fee can be set so that the food waste supplier sees a cost savings and the treatment plant may see revenue that can offset transportation costs [6]. Moreover Kitchen waste if disposed in landfills cause public health hazards and diseases like malaria, cholera, typhoid, breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it leads to ground water contamination and emits unpleasant odors. Methane which is a major greenhouse gas is 21 times more powerful at trapping heat and warming the atmosphere than carbon dioxide which makes methane a substantial contributor to the possibility of climate change (USEPA Methane webpage). Diverting food waste from landfills allows for the methane to be captured and used beneficially while reducing the methane released from landfills [7]. The dumping of uncooked food in unmanned area may not be very civilized. It can also lead to population growth of nuisance animals. It is undoubtedly unhygienic and can pose threat to the habitat [8]. Thus we conclude the efficient disposal of food waste not only makes anaerobic digestion desirable but makes it cost efficient, reduces greenhouse gas emissions at landfills, utilizes existing infrastructure for food waste diversion and meets local and state waste diversion goals.

Table 2: Comparison of conventional biogas and kitchen waste biogas [4]

Comparison with Conventional Bio-Gas Plants	**Conventional Bio-Gas Systems**	**Kitchen Waste Bio-Gas System**
Amount of feedstock	40kg + 40 L water	1.5 – 2 kg + water
Nature of feedstock	Cow-Dung	Starchy & sugary material
Amount and nature of slurry to be disposed	80 L sludge	12 L , watery
Reaction time for full utilization of feedstock	40 days	52 hours
Standard size to be installed	4,000 L	1,000 L

3. FOOD TO ENERGY POTENTIAL OF DTU CAMPUS – CASE STUDY

3.1 DTU Statistics

Table 3: DTU Statistics

No. of hostels	9(boys)+5(girls)=14
No. of mess	4(boys) + 1(girls) mess+1canteen =6
No. of hostler students	1311(boys)+400(girls)=1711
LPG cylinders used per day	4(girls mess) + 20(boys mess) +5(canteen)=29
Food waste produced per day*	300-400 kg

*Assuming that waste generated per capita per day is 10% of the total meal size.

According to literature review 3 digesters of 1000 liters each would be adequate to cater to the food waste at the campus. These digesters would be placed at the backyards of the mess so that kitchen waste and other food waste can be directly used as feedstock. We can produce 650 lit of biogas daily in 1000 lit reactor, under ideal conditions (like maintaining pH, VFA, Alkalinity, etc.) [10]

3.2 Estimating LPG cylinders saved

Table 4: Estimating LPG cylinders saved

Calorific value of Biogas	21.6 KJ/L
Calorific value of LPG	94 KJ/L
Specific heat of water	4.186 Joule/gram degree celcius
Density of LPG	0.557 Kg/L
Energy Required for heating 100ml of water from 30 degree to 100 degree Celsius	29.302 KJ
Amount of biogas required for heating 100ml of water from 30 degree to 100 degree Celsius	1.3566 L
Amount of LPG required for heating 100ml of water from 30 degree to 100 degree Celsius	0.3117 L
Quantity of water that can be heated by 650 L of biogas	48 L
Quantity of LPG required for heating 48L of water	149.616 L or 83.3361Kg
Amount of LPG in standard cylinder in India	14.2 kg
Amount of LPG cylinders saved per Digester	6

LPG cylinder that can be saved per day from each 1000L digester = **6**

Total LPG cylinders that can be saved from 3 digesters of 1000L digester = **18**

4. CONCLUSION

Food waste to biogas can be effectively used as a sustainable approach towards renewable energy and waste disposal and steps should be taken by the government to promote community level biogas plants. The large potential of Biogas from food waste was highlighted by the case of Delhi Technological University Campus and we concluded that biogas from food waste can save at least 50 % of the LPG gas consumption of the campus and also provide substantial amount of manure for gardening purposes in the campus.

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