Estimation of Electrical Energy Generation from Anaerobic Digestion Technology

Shubham Gupta*, Prof. R. S. Mishra#

*Post Graduate Student, Department of Mechanical Engineering Delhi Technological University, Delhi-110042, India

#Department of Mechanical Engineering Delhi Technological University, Delhi-110042, India

***Abstract*: - The growth of Municipal Solid Waste (MSW) has been skyrocketing as a result of growing urban population and industrialization. Day to day increase in waste generation demands Renewable technology for solid waste management for an effective economic and social growth of the people. Anaerobic digestion is a biological method used to convert organic wastes into a stable product for different applications such as cooking, electricity generation, etc. with reduced environmental impacts. The biogas produced can be used as an alternative renewable energy source.Biogas productions is a great substitute for fossil fuels. This process can also utilize MSW for production of electricity. Electricity generation through biogas helps in solving environmental issues, electricity shortage and Solid waste management problem. This paper focuses on technical feasibility and electrical potential mappingof Haridwar City through Anaerobic Digestion Technology.**

***Key Words:* Waste to Energy, Anaerobic Digestion, Municipal Solid Waste, Solid Waste Management, Electricity Generation, Renewable Energy**

I. INTRODUCTION

The current trend of economic growth and standard of living of people increases municipal solid waste (MSW) generation and effects on current landfill scenario, unavailability of land, open burning landfill causes pollution and has greatly effects on public health. There is an urgency for an effective solid waste management due to all of these reasons. WTE incineration helps in reducing greenhouse gases (GHGs) by avoiding dumping to landfill, foils the methane emission from landfill and generating renewable energy in form of electricity which further helps in reducing dependency on fossil fuels. In Incineration Technology MSW is combusted in presence of oxygen. Heat produced then utilized to produce steam which turns the turbine and then alternator to produce electricity. Harmful flue gases are treated and then released in atmosphere. By product is utilized in cement factory. In Landfill gas recovery Anaerobic biodegradation results in methane production in landfill which is recovered to produce either electricity or heat. In Biomethanation technology. Organic matter of MSW is converted to biogas by means of anaerobic digestion in presence of methanogenic bacteria. This biogas can further be utilized for cooking or electricity production. In Refuse Derived Fuel technology fuses whole MSW irrespective of individual calorific value of organic and inorganic matter. It forms briquettes and pellets which can be used further as a fuel in many applications. Currently largest source of GHGs emissions in the world are landfills with an assessment of almost 21% of the total methane production. As a GHG Methane is 21 times stronger than carbon dioxide.

II. LITERATURE REVIEW

Mufeed Sharholy et.al (2007)[1]used ArcGIS technique which included MSW sample collection and questioner survey on randomly selected houses and concluded that 45.3% of organic matter and 40% miscellaneous material (glass, paper, plastics etc.) and mentioned the qualitative and quantitative characteristics of MSW for MSWM for developing GIS maps for city of Allahabad. He also explained MSWSM collection, storage and disposal methods. Tsai et.al (2014)[2]did content and chemical analysis of MSW from year 2008 to 2012 with the use of CHP technology and compared the efficiency of plants of Taiwan with different parts of Europe, Germany and Netherlands. He also classified plants on the basis of capacity of waste handling, power generation and efficiency was done and discussed use of district heating and cooling and its use and advantage. S Rathi et.al (2014)[3] used Dulong Formulae heat energy in incineration technology to calculate and analyse potential generation of electricity in Kanpur city of 33MW from MSW of 1200 tonnes/day by considering conversion efficiency, station allowance, unaccounted heat loss and net power generated and classified solid wastes on physical and chemical composition. NIE et.al (2008)[4]explained new technology of circulating fluidized bed and emission of reduction by using equipment such as house filtration, flue gas cleaning and activated carbon in incinerator, adopted by 30 plants for development of China. Biodegradable matter shares 31-36% of total MSW in big cities and 65% in small cities having calorific value of around 5000KJ/Kg. Dioxin emission was limited to 1.0ng TEQ/Nm^3. Ojha et.al (2011)[5] explained, classified and compared cities on the basis of population, MSW composition, total waste generated; very big city, big city, medium city, small city and calculated potential of 1700 MW electricity from WTE incineration with some solutions and suggestion to problems occurring in MSWM. Arena et.al (2015)[6]proposed the opinion to solve waste problem as using it as a resource. He explained WTE technology was successful and reliable because of thermal conversion, heat recovery and air pollution

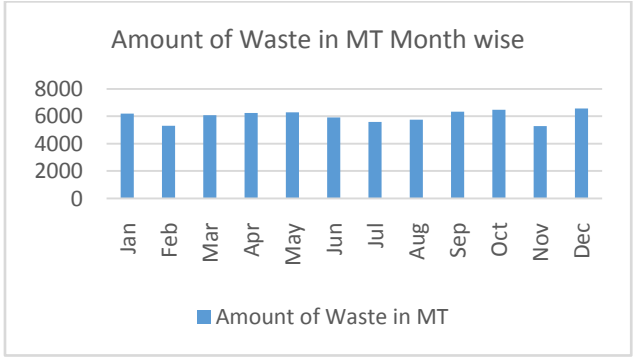
technique to reduce health and environmental risk, landfill substitute. Vikash Talyan et.al (2008)[8]discussed first incineration in Delhi, setup in 1989 at Timarpur to produce 3.7MW from 300 Tonnes of waste of calorific value higher 1000 Kcal/Kg but was closed in 21 days only due to falling of calorific value. First composting plant was setup in 1980 in Okhla and was shut down due to absence of market and high production cost. He explained three landfills in at Gazipur, Okhla and Bhalswa with LFG potential of energy generation $12.98*10^5$ Kwh/year. Ityona Amber et.al (2012)[7] calculated potential generation of 700KWh/tonne of electricity with calorific value of 17.23 MJ/Kg and conversion efficiency of 25% from incineration technology in Nigeria by considering methodology of analysing 5 samples of 10 Kg each of waste and evaluated that 43% of total MSW organic components are present while 8% are paper, cardboard, plastics. V G Sister (2006)[9] simulated plant model to improve the performance of waste incineration plant by considered gas turbine and steam cycle heat from outgoing fuel gases which resulted in efficiency of binary system gas incinerator of 42-45%. In addition, he said Pyrolysis in incineration increases its efficiency by providing high yield of components of CO, H_2, and CH_4.In addition, he compared conventional plant's energy content which was much higher than of Municipal Solid Waste (MSW) and also conventional power plants had higher efficiency than incineration plants. Dioxins emissions from incineration plants cause health issues.

III. CASE STUDY UNDERTAKEN

"Haridwar is a city in, Uttarakhand that is spread over a flat terrain with the grand spectacle of Himalayas ranges flanking it in the East and the North-east." It generates around 200 tonnes of waste daily

IV. AMOUNT OF WASTE GENERATED

The city generates, on an average, about 200MT of MSW per day. The major sources of MSW generation of the city are domestic, shops and commercial establishments, hotels, restaurants, dharamsalas and fruit and vegetable markets.



V. COMPUTATION OF ENERGY POTENTIAL

Only biodegradable fraction of total waste can be digested to produce gases so total amount of waste needs to be taken to generate 220 gm of CH_4 and 512.6 gm of CO_2 will be:

$$C_{25.41}H_{39.88}O_{14.25}N + 9.06\ H_2O = 13.75\ CH_4 + 11.65\ CO_2 + NH_3$$

Total amount of waste × .65 = 573.8 (mass of hydrocarbon)

Total Amount of Waste = 882.76 gm

Weight of CH_4 = (220/882.76)×22.39 = 5.57 Kg

Weight of CO_2 = (512.6/882.76)×22.39 = 13 Kg

Density of CH_4 and CO_2 are taken as 0.7167 g/l and 1.9768 g/l respectively.

Volume of CH_4= (5.57 / 0.7167) = 7.77 m^3

Volume of CO_2 = (13 / 1.9768) = 6.57 m^3

Total Volume of gas generated = 7.77+6.57=14.34 m^3

Percentage of CH_4 = (7.77/14.34) × 100 = 54.18 %

Percentage of CO_2 = (6.57/14.34) × 100 = 45.82 %

Amount of gas generated per kg = 14.34/100 = .1434 m^3/Kg.

Amount of waste generated in Haridwar City = 200000 Kg per day

Therefore, total biogas generated = 200000 × 0.1434 = 28680 m^3/day

Considering 60% digestion efficiency = 0.6×28680 = 17208 m^3/day

Net Calorific Value of Biogas = 5000 Kcal/m^3

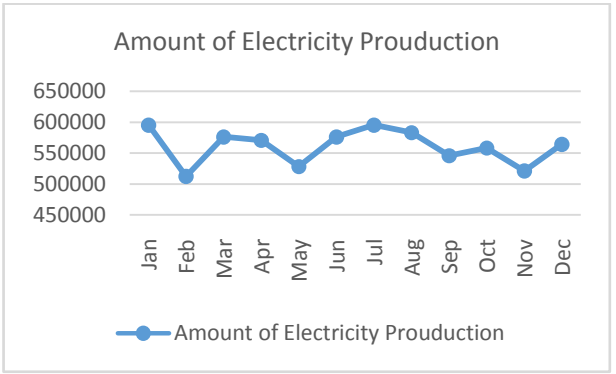
Energy Potential = 5000 × 17208 × 0.00116 = 99806.4 KWH

Power Generation = 99806.4/24 = 4158.6 KW

Conversion Efficiency (30 %)= 0.3 × 4158.6 = 1247.58 KW.

Considering Heat Loss (35 %) so net output =

0.65 × 1247.58 = **0.8 MW**



VI. RESULTS & DISCUSSION

The numerical computation has been carried out and following total energy potential is calculated which provides the feasibility of the Anaerobic Digestion in Haridwar City.

Total electricity production is 0.8 MW for 24hrs operation which can provides 6Lacunits monthly, which fulfil the 10% of total energy need of Haridwar city.

VII. CONCLUSION

It is a great step towards sustainable development as it saves coal resources which can be used by future generation while eliminating solid waste management problem which solves the land shortage problem and that extra land can be used to any fruitful work without Solid Waste Management that land is wasted as huge piles of solid waste just cover land making them useless and toxic. Also leachate problem is solved by waste management as open dump cause leachate to develop which even pollute the underground water. None of the single solution is capable of solving the entire solid waste management problem, although by favourable use of methodology of combined technologies- decrease at source, reutilizing, composting and incineration can be supportive. Decreasing the waste generation at source level only. Recycling & reprocessing new materials from used matter like paper, plastics, metals, glass, etc. By decomposing organic matter like kitchen waste, food waste in aerobic or anaerobic way compost can be prepared which further can be utilized as a fertilizer for soil. Combustion of waste in presence of air at high temperatures in Incinerator technology, it lowers the volume of waste up to 90%. Therefore, landfill can be avoided completely by above technologies. But from decades in India definition of energy means electricity and scarcity of electricity creates hindrance to growth and development so Anaerobic Digestion should be used for solid waste management as it provides all kind of process- reduce, recycle and regeneration.

REFERENCES

[1]. MufeedSharholy, k. A. (2007). Municipal solid waste characteristics and management in Allahabad, India. Waste Management, 490-496.
[2]. Tsai, W.-T. (2014). Analysis of Municipal solid waste incineration plants for promoting power generation efficiency in Taiwan. Master Cycles Waste Management.
[3]. S Rathi, D. P. (2014). Electrical Energy Recovery from Municipal Solid Waste of Kanpur City. International Journal of Scientific Research Engineering & technology (IJSRET), 923-929.
[4]. NIE, Y. (2008). Development and prospects of municipal solid waste (MSW) incineration in China. Environment Science Engineering China, 1-7.
[5]. Ojha, K. (2011). Status of MSW management system in northern India-an overview. Environmental Development Sustainable, 203-215.
[6]. Arena, U. (2015). From waste-to-energy to waste-to-resources: The new role of thermal treatments of solid waste in the Recycling Society Waste Management.
[7]. Ityona Amber, D. M. (2012). Generation, characteristics and energy potential of solid municipal waste in Nigeria. Journal of Energy in South Africa, 47-51.
[8]. VikashTalyan, R. P. (2008). Status of municipal solid waste management in Delhi, the capital of India. Waste Management, 1276-1287.
[9]. V G Sister, L. V. (2006). Ways of improving the performance of energy producing equipment at waste incineration plant. Chemical and Petroleum Engineering, 3-4.