Analysis of the Potential MSW to Energy Generation in the State of Sikkim

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Abstract—The feasibility of the best available Waste to Energy (WTE) technologies was studies. The disposal of waste is a major problem in the state of Sikkim and this feasibility study gives a direction as to one of the remedies for the usage of waste. It gives a theoretical value as to techno feasibility of running a Waste to Energy plant in the state.

Keywords-*Municipal Solid Waste (MSW); Techno-Economic feasibility; Waste-to-Energy (WTE)*

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I. INTRODUCTION

Municipal Solid Waste (MSW) is usually defined in India as the waste which in non-industrial, non-hazardous solid waste. As per the Municipal Solid Wastes (Management and Handling) Rules, 2000, Land filling shall be restricted to non-biodegradable, inert waste and other waste not suitable for either recycling or for biological processing"

The unavailability of land for filling a small state like Sikkim in which around 70% of the land comes under the protected area of forests, is a huge problem.

The MSW in the state, as per the report presented by Urban Development & Housing Department of the state (http://www.sikkimudhd.org/Part%204_SKFinal%20Report%20101008%20[Compatibility%20Mode].pdf)in the year 2015 stood at 106MT/day which is to grow to 142MT/day.

With the ever increasing production of MSW and un-availability of land for landfills, Waste to energy technologies if feasible would be the ultimate solution for the problem

II. RELATED WORKS

There has been a lot of commendable research work has been done in the field of Waste to energy production. Afew has been selected for study related to the subject.

Saini et. al [1] in their research has made a techno-economic feasibility study of the besta available WTE technologies across the world. They have made a study for 75 Indian studies. They have also attempted to calculate the WTE potential from MSW for majority of the Indian Studies. The authors also recommend what needs to be done in terms of policy modifications and rules that need to be adhered to for MSW management in order to make WTE a success for India.

Vijet. al [2]has in his research highlighted the problem which Urbanisation has created in the form of waste. The author has also highlighted the current practices prevalent in India for dealing with solid waste that he problems associated with it.

Mani et al [3]in their paper have also highlighted the problems faced by Urban Local bodies in management of solid waste. The authors in their paper provides a comprehensive view of SWM and most importantly highlights some major points of the policies/programmes initiated by the Government of India to overcome the challenges of solid waste management in our country.

All the research presented above highlights as MSW being a major problem of urban India. The same is the case of the state of Sikkim, Although the waste generated is comparatively very small when compared to the rest of the states or even major cities of the country, the problem is however as large owing to the fact of unavailability of land.

III. METHODOLOGY

The physical and chemical composition of the MSW produced in the State of Sikkim has been taken up from report generated under the North-Eastern Region Capital Cities Development Investment Program – Gangtok Solid Waste Management Subproject. The potential of MSW to Energy has been calculated using values taken from literature reviews of several research. The projected MSW to Waste potential for the state of Sikkim has been calculated.

IV. MSW TO ENERGY TECHNOLOGIES

A. Energy recovery potential from various technologies

a. Biomethanation / Anaerobic Digestion (AD)

In biomethanation, organic biodegradable fraction is decomposed (enzymatically) with the help of microbial action and this method is predominantly used for wastes containing high percentage of organic biodegradable matter (>35%) and high level of moisture (>45%) along with C/N ratio of 20-30%. The power produced from MSW is

calculated using the following mathematical (Rao *et al* 2000) [4]:

Net Power Generation Potential (kW) = P x Q (1)

Where, $P = X \times Y \times Z \times L \times W_1 \times 10^3$ (2)

$Q = W_2 \times CV \times h$ (3)

X = Biogas produced (m^3 per kg of volatile solids per day)
Y = Digester efficiency (%)
Z = Total organic fraction (%)
L = Organic biodegradable fraction (%)
W_1 = Total Waste generated everyday (tones)
h = Conversion efficiency (%)
W_2 = is a constant = $(860 \times 24)^{-1}$
CV = Calorific Value of MSW (kcal/m^3)

The operating parameters shown below in Table 1 are required in order to calculate the power generation potential of the MSW.
The table shows an average value calculations which has been done using equations 1,2 & 3 and presented by Rao et al [4] and is based upon the literature of various researchers

Sr. No	X	Y	Z	L	CV
Minimum	0.2	45%	40%	35%	3,500
Maximum	0.8	70%	60%	60%	5,000

Table 1: Power Generation Potential of MSW (for one ton) with given range of operating parameters (Rao *et al* 2000)

		POWER
25%		5.34 kW
35%		17.09 kW

In general, it is being calculated that 100 tonnes of raw MSW which has around 40-60% as organic matter is able to generate about 0.534-1.71 MW power which however is also dependent upon the chemical characteristic of the waste.

V. CONTENT OF MSW GENERATED IN SIKKIM

As per the report of the North-Eastern Region Capital Cities Development Investment Program – Gangtok Solid Waste Management Subproject, the following is the composition of MSW generated in Gangtok.

No.	Physical Parameters	Average
1	Bulk Density	410.68 Kg/m3
2	Paper	6.42 %
3	Textile	3.72 %
4	Plastic and Rubber	3.99 %
5	Metals	1.31 %
6	Glass	1.96 %
7	Stone, Brick etc	1.78 %
8	Ash and Fine Earth	13.22 %
9	Leaves and Wood	4.11 %
10	Food Waste	63.49%
No.	**Chemical Parameters**	**Average**
1	Moisture	44.77 %
2	pH	7.23
3	Ash Content	23.16 %
4	Carbon as C	35.70 %
5	Nitrogen as N	1.65 %
6	Volatile Matter	24.73 %
7	Phosphorous as P	0.65 %
8	Gross Calorific value	1043.31 KCal/Kg

Table 2: Physical and Chemical Characteristics of MSW in Gangtok

VI. EXPERIMENTAL VALUE

A. *Calculation of potential of energy which can be produced by MSW generated in the state of Sikkim*

The calculation is based upon the equations 1,2 & 3 given above and is for the MSW generated in the year 2015 in whole of the state of Sikkim.

Net Power Generation Potential (kW) = P x Q (1)

Where, $P = X \times Y \times Z \times L \times W_1 \times 10^3$ (2)

$Q = W_2 \times CV \times h$ (3)

X_h = 7.65 (calculated as per http://www.fovbiogas.com/biogas-calculator/)
Y = 0.75 (as per http://www.fovbiogas.com/biogas-calculator/)
Z = 0.9 (as per Table 2)
L = 0.63 (as per table 2)
W_1 = 106 (data as per year 2015)
h = 0.6 (assumed)
W_2 = is a constant = $(860 \times 24)^{-1}$
CV = 1043.31 Kcal/kg (as per table 2)

From the above – P = 325316.25, Q = 0.001258721
ThusNet Power Generation potential = **409.4823 kW**
= 0.409 MW

B. *Cost of production*

As per Table 3 Comparison of WTE technologies in India (Lal & Reddy 2009; *MSW Manual 2000; **Matt Crowe *et al* 2002)

Description	Mass Incineration
MSW Treatment Capacity (TPD)	500
Quantity of Final MSW treated (TPD)	160
Land Requirement (acres)	9-10 / MW
Level of Automation	Moderate
Power Generation Capacity (MW/100TPD)	6MW (1.2)
PLF %	70%
Capital Cost in crores (million Rs/MW)	25 (41.6)
Cost of Power Generation (Rs/kWh)	2.6 – 2.8
Land Required for 300TPD	0.8 hectares

plant*	
Waste Acceptance**	All Waste since air cleaning technology is good
Water Requirement**	Medium-High

Table 3. Comparison of WTE technologies in India (Lal & Reddy 2009; *MSW Manual 2000; **Matt Crowe *et al* 2002)

The cost of production calculated as per the table 3 given above is approximated as follows:-

- Cost of capital = Rs. 25 crores
- Cost of Land = Rs. 15 crore
- Therefore total cost of installation = Rs. 40 crore
- Cost of Power Generation (assumed @ 2.8 Rs/KwH) = Rs. 48 per hour i.e. Rs. 35,000 per month
- Power generation per month @409 KW per day = 12284.5 KW

Power consumption in Sikkim is on an average of 262 kWh in rural and 482 kWh in urban areas

Thus as per the data above the power generated from garbage alone can power upto 76 urban homes or 130 rural homes (calculated as per 4 members per household)

VII. CONCLUSION

The above calculations shows that MSW to energy plants are feasible in the state of Sikkim.

However having said that, with the vision of the state being a clean and green Sikkim, care must be taken to install proper flue gas treatment in order to save the environment from the harmful emissions of gases which are generated by incineration techniques.

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