A Multi Criteria Ranking of Different Technologies for the Waste to Energy of Municipal Solid Waste in the City Of Kolhapur

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Abstract-- This paper describe a conceptual framework and methodological tool developed for evaluation of different waste to energy technology suitable for treating municipal solid waste, by introducing the multi criteria decision support method MATLAB computing software and demonstrating its related applicability via test application. The solid waste quantity in the Kolhapur city, Maharashtra, India, per day and calorific value of waste, physical and chemical characteristic of waste etc are evaluated with generation potentiality of energy through. In this work multi criteria exercise, using MATLAB tool is presented for comparing a ranking of 5 selected alternatives for WTE technologies and final result are achieved. In conclusion, multi criteria approach is found to be a practical and feasible method for the integrated assessment and ranking WTE technologies it can help decide, uncertainties in decision making process.

Keywords-- Calorific Value, MSW, MATLAB, Multi Criteria, Net power Generation, WTE

I. INTRODUCTION

Municipal Solid Waste (MSW) includes commercial and residential wastes generated in municipal or notified areas in either solid or semi-solid form. It consists of household waste, construction and demolition debris, sanitation residue, waste from streets and so forth. The mainly garbage is generated from residential, commercial, institutional, industrial sources that falls into six categories: durable goods, non durable goods, containers and packaging, food wastes, yard trimming, miscellaneous organic and inorganic wastes. MSW is a referred to a common parlance as garbage is a commonly known as common trash and includes everyday items such as paper, product packaging, lawn clipping, bottles and appliances.

Kolhapur city is known as Karveer Nagari. Kolhapur is located on the Sahayadri mountain range and south western part of the Maharashtra state. The city is close to the Konkan coast which is connected by 12 Ghats going through Western Ghats.

This city has spread in between area of about 6682 hectares in the Southern part of Maharashtra in the Western Ghats 550 m above mean sea level and between 16° 42” N Latitude to 74° 14” E Longitude. The average temperature is 27° C and Min 15° C, Max 40° C. [3]

A. MSW Availability With Physical And Chemical And Characteristics Of Kolhapur MSW

The local government of Kolhapur city is handled by the Kolhapur Municipal Corporation. Total population of Kolhapur city according to 2001 census is 4, 85,183 and projected increase in 2011 years is 5, 49,283. About 165 metric ton / day and per capita per day generation are 310 gms. The following tables are shown detail Performa of city. The dry waste generation is in commercial area while the wet waste generation is in residential area, hotels and food industry.

<table>
<thead>
<tr>
<th>Table No 1: Generation of Solid Waste</th>
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<tbody>
<tr>
<td>MSW Generated Per Day</td>
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<tr>
<td>MSW Generated Per Person Per Day</td>
</tr>
</tbody>
</table>

**MSW Generation Of KMC**

| Quantity Of Domestic Solid Waste      | 110 MT |
| Quantity Of Commercial Waste (Such As Shops And Offices) | 15 MT |
| Quantity Of Waste From Market Area    | 30 MT |
Graph No 1: Physical and Chemical Characteristics of Kolhapur MSW

The increasing population and industrial developments, the collection, transportation and disposal of generated solid waste is a challenging task of Kolhapur Municipal Corporation. The above data shows remind the concept of waste to energy and future power generation to necessary sustainability of waste management.

II. METHODOLOGY

Multi criteria based Optimization process as following process,
A. The Determine calorific value of the MSW will be calculated with analysis of Net Power Generation Potential.
B. Evaluation of Waste to Energy (WTE) Scenario- 5 numbers with Technological Option.
C. Model development through maximum output with least cost and least environmental effect.

A. Determine Calculation Of Calorific Value With Net Power Generation Potential

Calorific Value (CV) of Sample:

\[
CVS = \frac{T \times W - (CVT + CVW)}{M}
\]

Where,
- \( T \) = Rise In Temp. (\( T_n - T_0 \)) = 1.2°C
- \( W \) = Water Equivalent 2718.52 Cal/C
- \( M \) = Mass of Sample 1.6 Gms.

CVT=Calorific Value of Thread 2.1 Cal/Cm.
CVW=Calorific Value of Nichrome Wire (2.33 Cal/Cm.)
CVT=2.1 x 10=21 Cal/Cm
CVW=2.33 x 4=9.32 Cal/Cm,
Sample Used= MSW

The calorific value of waste is determined by help of Bomb Calorimeter is 2938 cal/gm. We carrying 22 experiment of calorific value are same above method, also known as Net Calorific value. The Net Calorific Value (NCV) of waste is 1601.29 Kcal/kg. [4], [5]

Potential of recovery of energy form MSW through different treatment methods can be made from its calorific value and organic fraction as under:

In thermo chemical,

- Total waste quantity \( W \): 1 tonnes
- Net Calorific Value \( NCV \), k-cal/kg.
- Energy recovery potential (kWh)
  \[ = \frac{NCV \times W \times 1000}{860} = 1.16 \times NCV \times W \]
- Power generation potential (kW)
  \[ = \frac{1.16 \times NCV \times W}{24} = 0.048 \times NCV \times W \]
- Conversion Efficiency = 25%
- Net power generation potential (kW)
  \[ = 0.012 \times NCV \times W \]
- If NCV = 1601.29 k-cal/kg., then
  Net power generation potential
  = 19.21 kW

In biochemical,

- Total waste quantity \( W \): 1 tonnes
- Total Organic / Volatile Solids: VS = 50 %
- Organic bio-degradable fraction:
  \[ = 0.80 \times 0.60 \times 0.33 \times W \times 1000 = 158.4 \times W \]
- Calorific Value of bio-gas = 5000 kcal/m3
B. Scenario of Waste To Energy With Technological Option

There are various technological option which can be employed for recovery of energy from MSW either thermo chemical or biochemical. In thermo chemical process mainly Incineration, Gasification, Plasma Gasification and Refuse Derived Fuel (RDF) from raw msw. In bio chemical process is Biomethanation with waste digested anaerobically. [7]

1. Scenario of Incineration Technology

Incineration technology is the control combustion of waste with recovery of heat to produce steam that in turn produces power through steam turbine.

Method: Thermo chemical
Process Principle: complete oxidative conversion
Feedstock Requirements: dry wastes of synthetic and biological origin
Feedstock Preprocessing Method: drying and pelletization
Permitted moisture content of feedstock: 25-30%
Temperature Requirements (°C): 700-1400
Role for catalysts: Non catalytic
End-Products: Heat and ash
Environmental issues: Ash discharges and evolution of toxic gases from partial Combustion as limitations
Cost (Capital & O&M): Medium – High
Efficiency (%): 50-60
Application of fuel products: heat and power application
Future Potential: Moderate

2. Scenario of Gasification Technology

A gasification technology involves pyrolysis under limited air in the first stage, followed be higher temperature reaction of the pyrolysis to generate low molecular weight gases. These gases could be use in internal combustion engine to produce power.

Method: Thermo chemical
Process Principle: partial oxidative conversion
Feedstock Requirements: dry wastes of synthetic origin
Feedstock Preprocessing Method: shredding and drying
Permitted moisture content of feedstock: below than 15%
Temperature Requirements (°C): 500-1300
Role for catalysts: Non catalytic
End-Products: Producer gas (Syngas), char
Environmental issues: Concerns with toxic gases, organic compounds emissions and char generation.
Cost (Capital & O&M): High
Efficiency (%): 70-80
Application of fuel products: heat and power application, transport fuel
Future Potential: High Potential

3. Scenario of Biomethanation Technology:

The putrescible fraction of waste is digested anaerobically (in absence of air), in specially design digesters. Under this active bacterial activity, the digested pulp produces the combustible gas methane and inert gas carbon dioxide. The remaining digestive a good quality soil conditioner.

Method: Biochemical
Process Principle: Anoxygenic microbial transformation
Feedstock Requirements: fluid rich biodegradable waste
Feedstock Preprocessing Method: sedimentation organic wastes Permitted moisture content of feedstock: 50-60%
Temperature Requirements (°C): 35-70
Role for catalysts: catalytic decomposition of methane to yield Syngas
End-Products: methane and compost
Environmental issues: Probability for liberation of irresistible, pungent odor from wastes
Cost (Capital & O&M): Medium – High
Efficiency (%): 50-70
Application of fuel products: fuel for heat, electricity, transport fuel, Syngas generation
Future Potential: High Potential

4. Scenario of Plasma Gasification Technology

Plasma gasification is emerging technology in India for municipal solid waste. This system uses a heat source called a plasma arc flame. Two electrodes are precisely shaped and distanced. A highly ionized gas is passed between them and high voltage discharged occurs between of electrode causing a hot plasma zone to be created.

Method: Thermo chemical
Process Principle: partial oxidative conversion
Feedstock Requirements: wastes of synthetic and biological origin
Feedstock Preprocessing Method: Pre-sorting, Shredding
Permitted moisture content of feedstock: no problem with any type of waste is permitted
Temperature Requirements (°C): 1500-5000
Role for catalysts: Non catalytic
End-Products: High quality Producer gas, Syngas, solid slag
Environmental issues: Concerns with toxic gases, slag generation
Cost (Capital & O&M): very high cost
Efficiency (%): 90
Application of fuel products: Fuel for heat, electricity, transport fuel, Syngas generation
Future Potential: High Potential

5. **Refuse Derived Fuel (RDF):**

RDF is a process producing fuel pellets from raw solid waste. The complete process involves drying, removal of non combustibles, grinding, mixing, and production pellets under high pressure. The calorific value of raw garbage is around 1000 kcal/kg while the pellets also known as RDF have the calorific value around 4000 Kcal/kg and also used in thermo chemical process.

Method: Physical
Process Principle: Mechanical conversion, Non thermal and non biochemical
Feedstock Requirements: Raw garbage waste (MSW)
Feedstock Preprocessing Method: Drying, separation, size reduction, pelletization
Permitted moisture content of feedstock: below 10 %
Temperature Requirements (°C): this method also work in room temperature
Role for catalysts: non catalytic
End-Products: High calorific Pellets, inert material, ferrous and non ferrous
Environmental issues: Favorable in areas having lower rainfall, High energy consumption for crushing and drying of waste
Cost (Capital & O&M): High
Efficiency (%): 60
Application of fuel products: Heat and power applications, substitute coal based industry
Future Potential: High potential

For the model development numerical computing are necessary, so using Multi paradigm numerical computing environment and fourth generation programming language i.e. **MATLAB (matrix laboratory)**. Developed by MathWorks MATLAB allows matrix manipulation, plotting of functions and data, implementations of algorithms, Creation of user interfaces, and interfacing with programs written in other languages.

Model formulation, calculation and programming are done by MATLAB software with following format. [10]

For the ranking of the above examined processes, criteria were used: calorific value temperature, moisture content, Economic, future potential, It is the set of input-output that can be predicted in table no. 2. It was decided to use multiple criteria in an attempt to encompass different points of view explicitly and quantitatively into the process especially for the particular case study area for the results of the presented analysis, namely Kolhapur city where very controversial interests, conflicting view points and particular constraints exist in their MSW management as well as energy sector and the challenges that it currently faces.

Based on the literature, observations and data system for each treatment method was set up. The choices of the different systems were based recent research on in developing countries and on literature. The aim of the study was not to find the optimal system, but to choose a system for each method of MSW management based on methodology and Weighing of the factors mentioned above, and to evaluate the chosen system through Multi criteria evaluation.

**Table No 2:**

**Set of Input Output variables that can be predicted**

<table>
<thead>
<tr>
<th>Input Data</th>
<th>Waste To Energy</th>
<th>Output Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Waste generation</td>
<td>- Heat</td>
<td>-Producer gas</td>
</tr>
<tr>
<td>- waste characteristic</td>
<td>-Producer gas</td>
<td>-High calorific Pellets</td>
</tr>
<tr>
<td>-MSW technology</td>
<td>-High temperature</td>
<td>-High temperature gas</td>
</tr>
<tr>
<td>specification</td>
<td>-Incineration</td>
<td>-CH4,CO2,NO,H2</td>
</tr>
<tr>
<td>calorific value</td>
<td>Gasification</td>
<td>-Ash, char solid slag</td>
</tr>
<tr>
<td>temperature</td>
<td>Plasma Gasification</td>
<td>-Biomethanation</td>
</tr>
<tr>
<td>moisture content</td>
<td>RDF</td>
<td></td>
</tr>
</tbody>
</table>
A conceptual framework and methodological tool programming in MATLAB for the evaluation of different WTE technologies was presented in this paper for 5 selected commercial processes.

Aim of the paper was to implement the Multi-Criteria method for performing program in MATLAB then the analysis, which gave the ranking results, in order to consider different preferences of various possible decision makers towards the used criteria. These were operation by using different combinations of criteria weights, aiming to illustrate of the ranking results towards potentially different priorities.

The thermo chemical treatment of MSW is greater than biochemical treatment. It is clear that thermo chemical treatment is best opinion to generation of power from above graph. In graph no.3 the final ranking of scenario of processes was performed by means of selected criteria, which addressed both targets of current waste management trends as well as energy recovery.

It is obvious from the above discussion that no technology is perfect. All of them have merits and demerits. The choice of technology has to be made based on the waste quality and local conditions. The best compromise would be to choose the technology that fulfils these criteria such as lowest life cycle cost, Causes practically no air and land pollution produces more power with less waste Causes maximum volume reduction.

REFERENCES


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