Energy Recovery from Waste – A Review

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Abstract: The rapid advancement of the human civilization and the booming technological progress has left the world with a lot of concerns, the chief among them being the management of the wastes and the overutilization of the non-renewable resources. The rate of waste production is increasing at an alarming rate thereby leading to the development of various technologies for the safe disposal of wastes. At the same time, concerns over the depletion of the non-renewable sources of energy have also led to the development of many such useful techniques which can be employed in order to harness energy in various forms. In this report, these two major problems of the modern era have been amalgamated and a new technology developed as a solution to these problems has been discussed, i.e., WASTE TO ENERGY technology. This technology ensures the proper disposal of the wastes generated by the conversion of wastes to energy, i.e., harnessing energy from non-recyclable wastes. Many developed countries around the world have employed this technology while the developing countries are still in the process of setting up the waste to energy plants on a larger scale.

Keywords: Energy Recovery, non- recyclable waste, overutilization, landfill gas.

1. INTRODUCTION

Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolysis, anaerobic digestion, and landfill gas recovery. This process is often called waste-to-energy (WTE). Energy recovery from waste is part of the non-hazardous waste management hierarchy. Converting non-recyclable waste materials into electricity and heat generates a renewable energy source and reduces carbon emissions by offsetting the need for energy from fossil sources and reduces methane generation from landfills. The energy recovery from waste also serves a few additional benefits such as:-the total quantity of wastes gets reduced by 60% to over 90%, depending upon the waste composition and adopted technology. Demand for land, which is already scarce in cities, for land filling is reduced. The cost of transportation of wastes to far-away landfill sites also gets reduced proportionately .Net reduction in environmental pollution. **Parameters affecting energy recovery**:-**Quantity of waste, Physical and chemical characteristics of the waste.** The important **physical** parameters to be considered are as follows- **Size of constituents, Density, High moisture**

content. The important chemical parameters to be considered are:-**Volatile solids, Fixed carbon content, Calorific value, C/N ratio, Toxicity Inert**

METHODS OF WASTE TREATMENT, PRINCIPLE, WASTE PARAMETERS AND THEIR RANGE:

Waste Treatment Method	Basic Principle	Important Waste Parameters	Desirable Range
Thermo-chemical Conversion -Incineration -Pyrolysis -Gasification	Decomposition of organic matter by heat	Moisture content Organic/Volatile matter Fixed Carbon Total Inerts Calorific Value	<45% >40% <15% <35% >1200 k-cal/kg
Bio-chemical conversion -Anaerobic digestion/ Bio-methanation	Decomposition of organic matter by microbial action	Moisture content Organic/Volatile matter C/N ratio	>50% >40% 25-30

Source: Ministry of Urban Development, Government of India.

CASE STUDIES: Now let us focus on the **Waste to Energy conversion going on in India**. A number of research studies have shown that we produce about 300 to 600 gm of solid waste per person per day in our country. With a population that accounts to nearly 17% of the world's overall count, the amount of waste generated in India is quite imaginable. Urban India produces about 188,500 tonnes per day of waste at an average rate of 0.5 kg of waste per person per day .It is also seen that due to increased income and change in lifestyle, per capita waste generation has increased in the past decade.

Table 1: Waste Generation Data In Countries Depending On Their Income

Countries	Per Capita Urban MSW (kilogram/day)	
	1995(Records)	2025(Calculated Assumptions)
Low-Income	0.45-0.90	0.60-1.00
Middle-Income	0.52-1.10	0.80-1.50
High-Income	1.10-5.07	1.10-4.50

Table 2: Population Growth And Impact On Overall Urban Waste Generation And Future Predictions Until 2041

Year	Population(in Millions)	Per Capita Waste Generation	Total Waste Generation Thousand Tons/year
2001	197.3	0.439	31.63
2011	260.1	0.498	47.3
2021	342.8	0.569	71.15
2031	451.8	0.649	107.01
2036	518.6	0.693	131.24
2041	595.4	0.741	160.96

WASTE TO ENERGY TECHNIQUES:

There are many techniques which get organic elements of waste transformed into useful energy. The most common are: **Anaerobic Compositing, Refuse Derived Fuel, Waste to Energy Combustion.** The only difference between **RDF** generation and **WTE** combustion is that the purpose of later is volume reduction of waste rather than production of energy. Since most of the waste in India is organic (about 52%) and about 10 % of it is paper, MSW is therefore renewable and hence waste to energy is recognized as renewable source of energy by the Govt. of India.

Table 3: Waste to Energy Techniques Practiced in Major Cities in India

City	MSW Generated(in TPD)	Present Waste Handling Techniques	
		RDF/WTE (TPD)	Biomethanation (TPD)
Mumbai	11.645	80	Yes
Kolkata	12.060	Nil	Nil
New Delhi	11.558	825	Yes
Chennai	6.404	Nil	Nil
Chandigarh	509	500	Yes
Pune	2.724	600	Yes
TPD=Tonnes/day			
No Biomethanation Quantity mentioned			

Table 4: Power Generating Potential From MSW in India

Period	MSW Generated (TPD)	Power Generation Potential (MW)
2002	97.174	1.638
2007	130.927	2.266
2012	189.986	3.276
2017	265.834	4.566

Table 5: Potential for Energy Generation from MSW and Fossil Fuel Displacement

City	MSW Generated (TPD)	Calorific Value (MJ/kg)	Power Production Potential (MW)	Coal Substituted (TPY)
New Delhi	11.040	7.50	186.80	2078.043
Kolkata	11.520	5.00	129.90	1445.194
Mumbai	11.124	7.50	186.60	2075.263
Nagpur	8.1	11.00	19.80	220.216
Hyderabad	4.923	8.20	91.00	1012.526
Chennai	6.118	10.90	149.00	1657.716
MJ/kg = Mega Joules per kg				
TPY = Tonnes per Year				

Sources:

- Report "Sustainable Solid Waste Management in India" by Ranjith Kharvel Annepu (Columbia University)
- Report "MSW to energy in India: The scenario and expectations", by N B Mazumdar
- Ministry of New and Renewable Energy, India

CASE STUDIES:

Gujarat is a fast developing state and have huge gap in demand & supply of electricity generated by conventional sources. To reduce the gap partly non- conventional energy sources should be taped. In order to recover energy from municipal solid waste (MSW) and liquid waste (MLW), Gujarat Energy Development Agency (GEDA) Vadodara, had carried out the Prefeasibility Studies in total seven cities (i.e. Ahmedabad, Bhavnagar, Vadodara, Rajkot, Bhuj, Bharuch & Valsad) under ***"National Programme on "Energy Recovery from Urban, Municipal & Industrial Wastes"*** launched by Ministry of Non-Conventional Energy Sources (MNES) Govt. of India. Finally, GEDA implemented the following projects under MNES Waste to Energy scheme:-**2.0 MW**

capacity Bio-gas based Power Generation Project at M/S Kanoria Chemicals Industries Ltd., Ankleshwar. This project was commissioned during **November (5.11.98) 1997-98 financial year** under MNES capital investment subsidy scheme on WTE projects. The distillery having capacity of **55KLPD** is generating about **675 M3/day** spent wash per day. This spent wash is being treated in 2 Anaerobic Digesters for Bio-methanation. Approximately **21000 to 24000 nm3 /day Bio-gas** (containing **60 – 62 % Methane**) is produced daily. The produced gas is further treated for H2S removal and clean gas is supplied to **2MW** Power Plant consisting of **2 generators of 1.003 MW each**. The Power plant is connected to existing Electrical Power Supply System. In order to have maximum benefits the Waste Heat Recovery System has also been installed and about **1700 Kg/hr (at 10Kg/Cm2 pressure)** steam generation takes place daily. Further, the biological sludge /slurry from distillery ETP is piped to ETP sludge receiving tank and after dewatering mixing with press mud is transformed into Bio-Compost Windrows for **30-45 days** to get Bio-Fertilizer. The Power plant is working since on average **68.5 to 72.3 PLF** having average **monthly generation of 1005000 units**.

2. FAILURE IN INDIA

The best way to handle mixed waste, as in India, is the conversion of waste to energy. However, most of the attempts to install these in the country have collapsed down. A WTE project in 1980s, a large scale biomethanation project, and two RDF projects in 2003 have failed. Some of the **probable causes for these failures** are:-**Improper Segregation**- India lacks a source separated waste stream. The organic waste is mixed with the other two types. Hence the operations of the W2E techniques are hindered and a lack of smoothness causes the attempts to be short lived. A large scale biomethanation plant built in Lucknow to generate 6 MW of electricity, failed to run because of this. **Logistical Errors-** It is seen that the WTE plants built are technologically correct. However they fail to sensibly connect theory with practice. The plants are designed for handling more waste than can be acquired and the local conditions are not considered while importing the plant technology. **Lack of Funds-** There has been no allocation of funds for plant maintenance, thereby creating obvious grounds for their wreckage.

3. CONCLUSION

The technologies involving the recovery of waste from MSW are being widely used across the world for their multiple benefits. It is necessary for the success of these technologies in India to evolve an Integrated Solid Waste Management System. A detailed feasibility study needs to be conducted in each case, thereby taking into account the available waste quantities and characteristics and the local conditions as well as the relative assessment of different waste disposal options. Suitable safeguards as well as pollution control measures need to be incorporated in the design of each facility to fully comply with the environmental regulations and safeguard public health. The Waste-to-Energy facilities when set up with such considerations can effectively bridge the gap between waste recycling, composting and landfilling, for tackling the increasing number of waste disposal problems in urban areas in an environmentally benign manner, besides augmenting power generation in the country.

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