Waste to Energy Wealth Potential

Neha Sinha
Department of Mechanical Engineering
Delhi Technological University

Abstract: Waste is a Resource lying at wrong place. Waste to Energy (WTE) projects generally involve higher capital investment and are more complex when compared to other options of waste disposal, but gains in terms of waste reduction, energy, etc. are also higher. Such plants are financially viable in developed countries. Most cities generate sufficient waste quantities to enable projects of total power generation capacities ranging from 5– 50 MW, which corresponds to MSW generation ranging from 500–5000 TPD. Technologically it is feasible to set up even smaller capacity projects of the 1–5 MW range, corresponding to around 100–500 TPD waste treatment. However, economies of scale generally favour centralized, large-scale projects. Waste from a number of adjoining regions/cities could be treated at a common WTE facility; however, in such cases the costs of waste transportation versus projects benefits must be carefully evaluated. Incineration is commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc.

It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odourless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation. World Wide more than 600 WTE projects are in operation. The objective of the paper is to illustrate the concept to utilize wasted domestic resources such as Municipal Solid Waste (MSW) and agricultural wastes, industrial waste such as sludge, packaging materials and convert them in a practical and environmentally safe manner into renewable energy. The paper discuss potential of energy from waste, Global W2E Scenario, electricity from MSW, potential of power generation, W2E technology and environmental benefits.

Keywords: W2E, RDF, Gasification, Incinerator, ESP.

1. INTRODUCTION

Waste to Energy (WTE) projects generally involve higher capital investment and are more complex when compared to other options of waste disposal, but gains in terms of waste reduction, energy, etc. are also higher. Such plants are financially viable in developed countries. Most cities generate sufficient waste quantities to enable projects of total power generation capacities ranging from 5– 50 MW, which corresponds to MSW generation ranging from 500–5000 TPD. Technologically it is feasible to set up even smaller capacity projects of the 1–5 MW range, corresponding to around 100–500 TPD waste treatment. However, economies of scale generally favour centralized, large-scale projects. Waste from a number of adjoining regions/cities could be treated at a common WTE facility; however, in such cases the costs of waste transportation versus projects benefits must be carefully evaluated. Waste is a resource lying at wrong place. Urban India Generates about 1.5 lakh MT/day of MSW, 60 Million Cum./annum Sewage and other wastes including segregated green waste, slaughterhouse waste, cattle dung from dairy colonies, etc. Mix of processes and technologies for processing and treatment necessary due to heterogeneous nature of wastes. Given the paucity of land and competing demands from agriculture, industry and housing, landfilling of entire waste is not an option. MSW dumping is leading to Increased cost of waste management due to shifting of dump sites away from cities besides continuing demand for more land.

Fabrication of particle board from agriculture waste: Agri/forest waste put to furnace for making charcoal, Biodiesel from used oil, Polyolefin wood fibre composite from agro/forest waste, MSW&Multi feed stock bio methanation plant, Diesel/Fuel oil from waste plastic through MW assisted depolymerisation, Precipated silica from rice husk, Liquid coolant recovery system, Synthesis of carbon nano materials from waste plastics, Biomass to biofuel, Recycling of E-waste, High value pharmaceutical product from food industry waste, Recycling PET into value added products, Biodiesel from algae.

1.2. WTE Technologies are such as Bio-methanation, Incineration, RDF, Gasification, Integrated systems, Pelletisation and Composting Biochemical conversion. The most suitable way to recycle or utilized it in present Indian scenario with low investment is aerobic composting using windrows. Waste is treated with air/oxygen under sub-stoichiometric conditions at elevated temperature. Solid waste transforms into gaseous fuel – Syn. Gas - containing mainly CO and H2 as combustible components. Syn.Gas is cleaned to remove particulates, chlorine compounds, sulfur compounds and nitrogen compounds. Syn.Gas contains energy in the range of 100 to 300 BTU/SCF. Syn.Gas is utilized in boiler or gas turbines to generate electricity. Syn.Gas burns cleaner than natural gas.

Incineration: This method, commonly used in developed countries is most suitable for high calorific value waste with a large component of paper, plastic, packaging material, pathological wastes, etc. It can reduce waste volumes by over 90 per cent and convert waste to innocuous material, with energy recovery. The method is relatively hygienic, noiseless, and odourless, and land requirements are minimal. The plant can be located within city limits, reducing the cost of waste transportation. This method, however, is least suitable for disposal of chlorinated waste and aqueous/high moisture content/low calorific value waste as supplementary fuel may be needed to sustain combustion, adversely affecting net energy recovery. The plant requires large capital and entails substantial operation and maintenance costs. Skilled personnel are required for plant operation and maintenance. Emission of particulates, SO_x, NOx, chlorinated compounds in air and toxic metals in particulates concentrated in the ash have raised concerns.

Production of Refuse Derived Fuel (RDF) or Pelletization: It is basically a processing method for mixed MSW, which can be very effective in preparing an enriched fuel feed for thermal processes like incineration. The RDF pellets can be conveniently stored and transported long distances and can be used as a coal substitute at a lower price. As pelletization involves significant MSW sorting operations, it provides a greater opportunity to remove environmentally harmful materials from the incoming waste prior to combustion. The process, however, is energy intensive and not suitable for wet MSW during rainy season. If RDF fluff/pellets are contaminated by toxic/hazardous material, the pellets are not safe for burning in the open or for domestic use. Waste is mechanically pre-processed before burning in steam boiler or modular two stage system. More by-pass waste to landfill. More equipment, therefore more expensive to build and operate than mass-burn.

Pyrolysis/Gasification: Pyrolysis gasification processes are established for homogenous organic matter like wood, pulp, etc., while plasma pyrolysis vitrification is a relatively new technology for disposal of particularly hazardous wastes, radioactive wastes, etc. Toxic materials get encapsulated in solid mass, which is relatively much safer to handle than incinerator/gasifier ash. These are now being offered as an attractive option for disposal of MSW also. In all these processes, besides net energy recovery, proper destruction of the waste is also ensured. These processes, therefore, have an edge over incineration. This process produces fuel gas/fuel oil, which replace fossil fuels and compared to incineration, atmospheric pollution can be controlled at the plant level. NO and SO gas emissions do not occur in normal operations due to the lack of oxygen in the system. It is a capital and energy intensive process and net energy recovery may suffer in case of wastes with excessive moisture and inert content. High viscosity of Pyrolysis oil maybe problematic for its transportation and burning. Concentration of toxic/hazardous matter in gasifier ash needs care in handling and disposal. Gasification Temperatures up to 1400 deg. C in low oxygen atmosphere Syngas and inert solid residue. Pyrolysis Temperatures in excess of 200 deg. C in absence of oxygen Char, liquids (oxygenated oils), syn. Gas. It converts any waste through partial oxidation with air into Syn. Gas - a mixture of combustible gases (CO, H_2, CO_2, H_20, N_2 and some HC). Not Incineration or mass burn

Its advantages are Avoids formation of carcinogens such as dioxins and furans (always associated with ncineration). Easier and cheaper to clean off-gas or Syn. Gas - Gas volumes are very low compared to incineration, Smaller Capital requirement because of lower gas flows, Syn. Gas allows multiple use for energy - easily piped for combustion or other thermal process, Practical and economical even at small scale of operation, Simple permit process because Syn. Gas is clean-burning fuel (similar to natural gas)

Plasma: Temp greater than 3, 000 deg. C in oxygen-starved environment Sygnas and vitrified solid residue.

De- Polymerization: Microwaves in nitrogen atmosphere at temperatures up to 350 deg. C Syngas, liquid waste, and solid waste (metals, glass, ceramic)

Integrated Approach: Treatment of solid and liquid wastes at same complex. Integration of treatment processes (Biomethanation, Compost, RDF, Sewage treatment., etc.). Treat each waste by using appropriate technology. Exploit synergies of integration

1.3. The recommended hierarchy are Waste minimisation-Reduce, Resource recovery through sorting and recycling, Resource recovery through processing and treatment- Reuse, Waste transformation to make it suitable for final disposal-Recycle, Mechanism to rebuy the recycled product and used as fertlizers etc., Landfilling – not for bio- degradables. This should be used as compost, Reuse and Recycle Waste Management Options

2.1. Potential of Energy from Waste includes Municipal Wastes: 2600 MW, Industrial Waste: 1300 MW, Livestock waste: 1000 MW

Potential of Power Generation: Urban and Municipal Waste about 1000 MW, Industrial Wastes Dairy, Distillery, Press Mud, Tannery, Pulp & Paper and Food Processing Industries 700 MW and total 1700MW.

WASTE UTILIZATION: Minimum 1000 BTU/lb (555 Kcal/Kg) of Calorific Value - adjust by mixing (*eg*. sewage 3500 BTU/lb- tires 21018 BTU/lb). 60 to 70% of energy value carried with Syn. Gas. Energy depends on system used for power generation - typically 25 Tons of MSW per Day gives 1 MW power.

ISBN: 978-81-93024-71-3

2.2. Global Waste-to-Energy Scenario

US and EU: WTE emerging as one of the important processing options due to increasing emphasis on reducing landfilling, considered last resort of waste disposal

Asia: J apan - ~ 2, 000 plants and 80% WTE, Taiwan – moving to 100% WTE, China – Highest growth with high environmental performance criteria driven by 2008 Olympics, Singapore – 92% WTE

Running & Upcoming Plants: India – Cochin, Alaska, Korea, New York, India-Coimbatore

2.3. Projects Installed for Energy from Urban Wastes are 3 MW Incinerator in Delhi in mid- eighties, 6.6 MW project based on MSW at Hyderabad, 6 MW project based on MSW at Vijayawada, 5 MW project based on MSW at Lucknow, 1 MW power from Cattle Dung at Ludhiana, 150 kW plant for Veg. Market, sewage and slaughterhouse waste at Vijayawada, 250 kW power from Veg. Market wastes at Chennai, 3.5 MW power from biogas at STPs in Surat.

Fig 1: 1.0 MW power project based on cattle dung at Haebowal Dairy Complex Ludhiana, Punjab

Fig 2 : 0.15 MW Power Project Utilizing Vegetable Market and Slaughterhouse Wastes at Vijayawada, A.P.

Fig 3: 3000 cum bio-methanation project for solid waste at Slaughterhouse in Andhra Pradesh

Project Viability depends upon Revenue sources such as Sale of Power, Sale of Manure /compost, Tipping / Treatment Fee, CER trading under CDM and Supports available such as Direct subsidy and Higher price for power or manure. Financial Assistance available For Energy from U&I Wastes such as Municipal Solid Waste, Other Wastes : cattle dung, vegetable market waste, slaughterhouse waste, agricultural residues, Biogas generated at Sewage Treatment Plants, Small scale de- centralized projects in urban areas, Industrial Wastes and effluents, Research and Development, Government support.

Provisions in the Electricity Act 2003: Preferential tariffs by State regulators, Targets for RE power, Captive generation decontrolled, Open access to grid for RE power

Fiscal Incentives / Concessions: Customs duty for imports, Excise duty for manufacture of RE devices, Income Tax exemption

Electricity from Municipal Solid Waste: Worldwide more than 600 WTE projects are in operation, Waste to Energy has a 50 plus years history with clean environmental track record. Technically superior, because it coverts total MSW in to 10% ash. Addresses both bio- degradable as well as non-biodegradable organic waste to be combusted. MNRE, Govt. of India, promotes energy recovery from MSW as National Policy. A very high volume of the MSW is disposed and reduces the burden on land fill.

2. ISSUES FACING WTE

Policy issues : Policy changes too fast and is not held sacrosanct from time of tendering to time of execution of a Project. Policy on sale of electricity varies from State to State. Developer must be given freedom to sell his power either for captive use or third party sale. Tariff based bidding being practiced currently is encouraging unhealthy competition and is making these projects unviable even before implementation. Local bodies are still not serious in facilitating speedy implementation of these projects. There is still no concept of tipping fee for WTE in India.

Relevance of WTE option in India: Cost of land in our cities is increasing making landfill very expensive. Urbanization & Cities becoming denser thereby quantity of garbage is also increasing by the year. This makes reduction in volume very crucial and WTE reduces the volume to 10%. Growing power needs and not having enough fossil reserves.

Technological Problems: No appropriate fuel feeding system and combustion grate available in India. Imported technologies are highly expensive. Financial institutions have poor knowledge in assessing real capital cost of the project. Project developers forced to compromise with the capital cost of the project due to lack of support from FI's. Because of the above reasons no real true, exemplary demonstrative plants operational in the country. Using indigenous technology for boiler and grate not technically established.

3.1. Analysis of Waste to Energy

Challenges: Growing concerns (often exaggerated) on Dioxin / Furan emissions – but no legislation as yet. No proper funding mechanism in place as banks are still reluctant to fund this sector.

WTE Opportunities in India: Potential exists for at least 30 projects in next 5- 7 years. Incentives from Governments. Eligible for Carbon credit finance for both renewable energy and methane mitigation

Threats: Increasing public & institutional agitation located near Cities. Litigation risks from public, NGOs and political opportunism. Hostile opposition from ill- informed Pressure groups. Small, simple and inexpensive to manufacture, install and operate. Low emissions - easy to comply with regulations. Partners from public, private - end users or investors.

3.2. W2E TARGET WASTES: Agriculture Wastes including Rendering materials, Chicken litter. Biomass Materials including Wood, Cellulosic feed-stocks, Low-Quality Coal. Municipal Solid Wastes (MSW) including Paper & Plastics, any carbonaceous material. Industrial Wastes including Sludge, Packaging materials, Waste oil, Used Tires

VALUE PROPOSITION: The W2E system can accept any non-radioactive waste . Syngas generated is cleaner than natural gas, with less potential for issues with emissions. Small footprint, plant size of less than an acre (40, 000 sqft) for 50TPD. Return on investment of 2 to 5 years. Rapid plant setup - 6 months from land acquisition. Design variations are minimized by using standardized sub-systems. Waste transportation costs eliminated or vastly reduced by distributed locations of small-footprint plants. Energy security for community or facility by generating energy near to end-user.

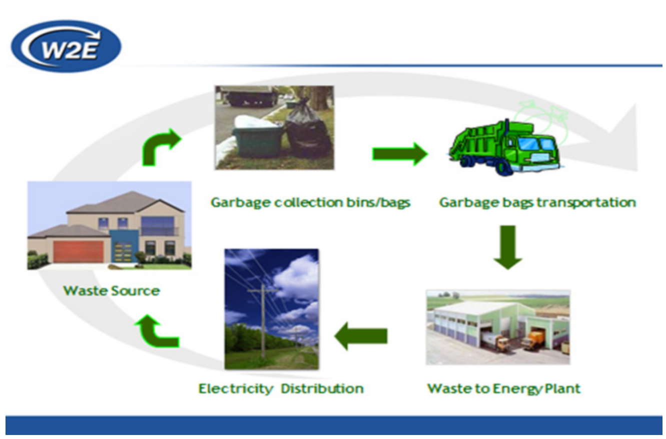


Fig. 4. W2E

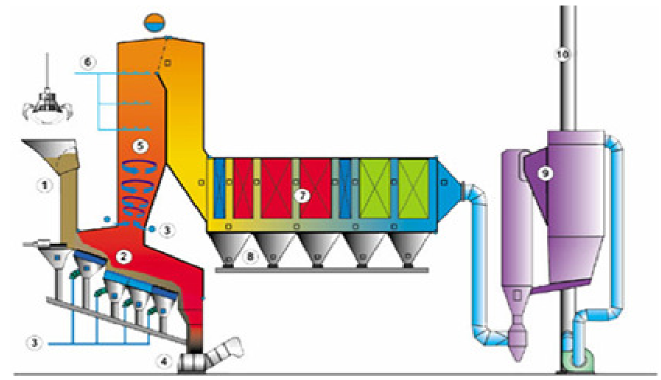


Fig. 5. WTE Plant Boiler

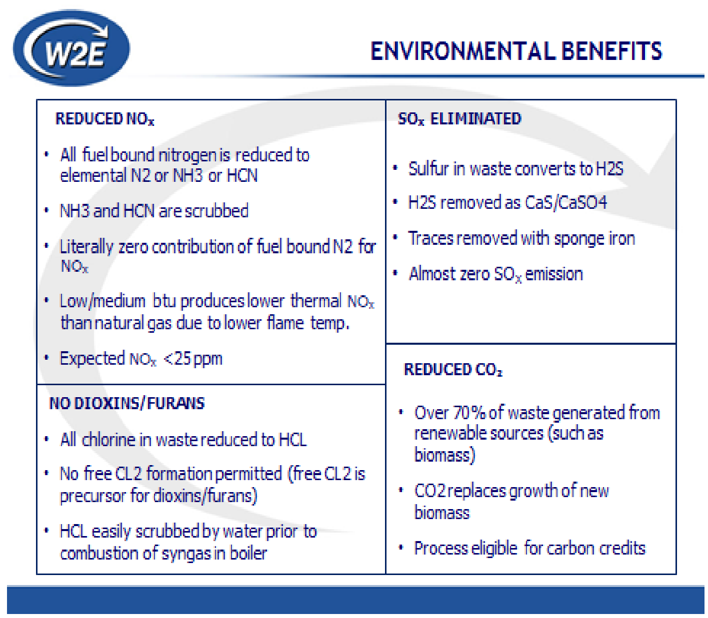


Fig. 6. Environmental Benefits

3. WASTE TREATMENT CYCLE

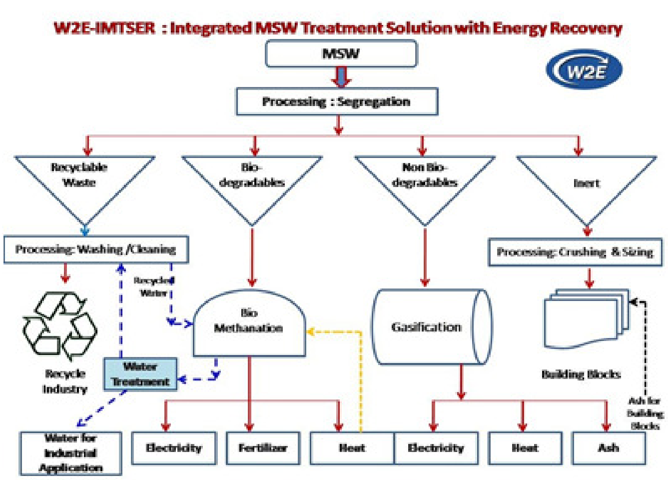


Fig. 7. Waste Treatment Cycle

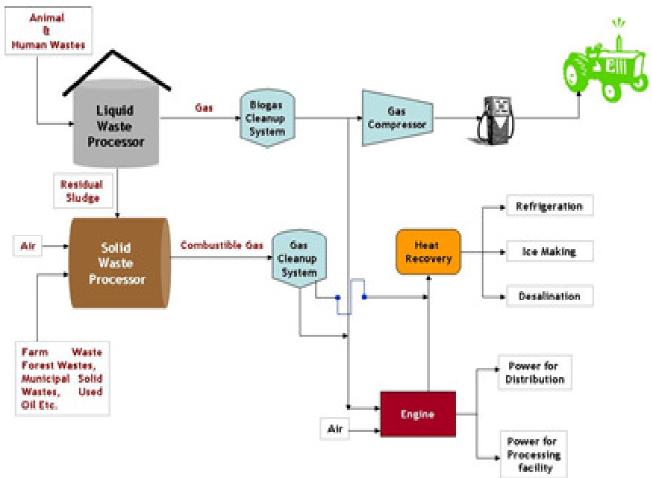
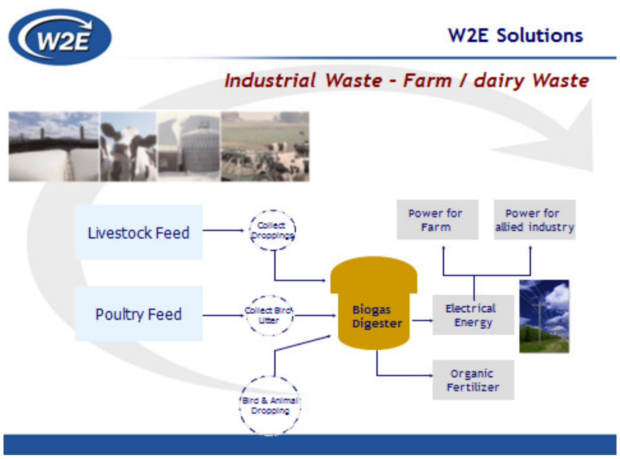
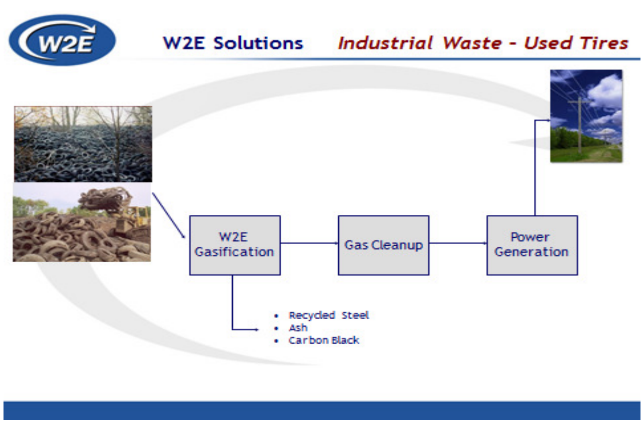


Fig. 8. Waste Treatment Cycle





REFERENCES

[1] Manual4 on Municipal Solid Waste Management, Ministry of Urban Development, Government of India, 2000

[2] Environmental Engineering By A Kamala, D L Kanth Rao, tata Mc Graw – Hill Publisihing Company Limited

[3] Elements of Environmental Science and Engineering By P. Meenakshi, Prentice Hall of India private Limited.

[4] Environmental Science By Dr. Jyoti Sinha

[5] Handbook of Solid Waste Management By Frank Kreith.

[6] Foundation of Environmental Studies By Prof. Dr. Devendra S. Bhargava

[7] Air PollutionVolume IV Engineering Control of Air pollution By Arthur C. Stern

[8] Data from Ministry of New & Renewable Energy and RDF Power Project Limited, Hyderabad

ISBN: 978-81-93024-71-3