The New Energy Economy

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CHAPTER

7

The Power of Waste

Sudhir Kumar

Introduction

Waste is the by-product of civilization. But now it has been realized that this useless unwanted matter known as 'waste material' has evolved from useful products and still possesses utilizable energy. Such transformation of concepts resulted in change of perception and the same waste is now accorded the status of 'resource' rather than 'reject'. The objective of the present chapter is to show how waste material can actually be a valuable source of energy. Energy generation and pollution control go hand in hand. The present trend is... 'no more wasting the waste'.

Waste is defined as unwanted solid or liquid material rejected after domestic, social or industrial activities. Identified by their characteristics, waste materials are broadly classified as urban and industrial waste. Both the categories have solid and liquid types. Industrial waste is further classified as hazardous and non-hazardous waste. In fact, all the wastes are inherently dangerous to human health and environment, no matter how they are managed. But hazardous industrial wastes, as defined by the pollution control regulatory body, pose immediate danger and need special kind of treatment under the enforcement of law of the land. Discussion on hazardous industrial waste is beyond the scope of this chapter. Non-hazardous urban and industrial waste that could be gainfully managed and converted into energy is the focal point of this chapter.

Only those waste materials which have organic matter have the potential to be converted into energy. Under the category of urban solid waste, the average quantity of municipal solid waste (MSW) is estimated to be 0.5 kg/capita/day for typical Indian cities.[1] Citizens of the developed world produce more MSW per person i.e.1.0 kg/capita/day. Organic matter (OM), the energy-generating constituent, is in the proportion of 50% in garbage found in Indian cities, while the same in the west is 80%.[2] Power generating potential of MSW is 600 kWh - 700 kWh (units)/ ton OM, considering the efficiencies of prevailing waste-to-energy technologies.[3]

The urban liquid waste i.e. sewage is estimated at 100 litres/capita/day practically all over the world.[4] Being highly dilute in nature, the organic matter in the liquid is more comfortably defined by chemical oxygen demand (COD). Average COD of the city sewage is 500 ppm.[4] A city of one million population will reject 100 million litres per day (MLD) with total 50,000 kg COD load. The latest Upward Anaerobic Sludge Blanket (UASB) technology promises power generation of 0.7 kWh/kg COD load.[5]

As regards organic industrial wastes, they are mainly from food processing, distilleries, milk products, paper making industries and vegetable/fruit markets. The amount of solid and liquid waste per kg of finished product depends upon the type of industry. Basic principles of power generation per unit of industrial waste quantity are same as those of urban solid and liquid waste. Accordingly, the potential of power generation from waste-to-energy (WTE) projects in India is given in Table 7.1 below.

Table 7.1
Potential for Power Generation from Waste

Sr. No.	Waste	Potential MW India
1.	Urban-solid waste and Liquid Waste	1700
2.	Industrial-solid and Liquid Waste (fruit and vegetable market, industrial kitchen waste, pulp and paper, filter sludge, sugarcane press-mud, starch extraction)	1000
	Total	**2700**

Source: MNES *Annual Report*, 2004-05.

The current status of implementation of the waste-to-energy programme in India is given below in Box 7.1.

Box 7.1

Waste-to-Energy Projects: Current Status

India has the potential to generate about 1,700 MW of power from urban and municipal wastes and about 1000 MW from industrial waste. The aggregate waste-to-energy installed capacity in the country is currently assessed at 46.5 MWe.

MNES is promoting setting up of waste-to-energy projects through two schemes namely:

1. National programme on Energy Recovery from Urban and Industrial Wastes. Its objectives are: a) To promote setting up of projects for recovery of energy from wastes of renewable nature from urban and industrial sectors; b) To create conducive conditions and environment, with fiscal and financial regime, to develop, demonstrate and disseminate utilization of wastes for recovery of energy; and c) To develop and demonstrate new technologies on waste-to-energy through R&D projects and pilot plants.
2. UNDP/GEF assisted project on Development of High Rate Biomethanation Processes as a means of reducing GHG emissions: A National Master Plan (NMP) for development of a 'Waste-to-Energy' programme (as part of the UNDP / GEF assisted project) is currently being formulated by MNES. The plan is essentially a road map for recovery of energy from wastes during the next 15 years.

Two projects were completed and commissioned under the National Programme on Energy Recovery from Urban and Industrial wastes during the year. These include : a) A 3.0 MW power project based on palm oil industry waste set up by M/s Sai Renewable Power Pvt. Ltd. Hyderabad, at Eluru in West Godavari district of Andhra Pradesh; and b) A 1.5 MW power project based on poultry droppings, installed at Namakkal in Tamil Nadu by M/s G K Bio-Energy Pvt. Ltd. In addition to these two projects, a 2.5 MW power generation project based on poultry droppings has been sanctioned to M/s Subhashri Bio-energies Pvt. Ltd, Namakkal, Tamil Nadu.

Under the UNDP/GEF project, one project was commissioned this year, which was a 1.0 MW power project based on cattle manure at Haebowal Dairy Complex in Ludhiana, Punjab. Two other projects which are under various stages of implementation are : a) A 0.5 MW power project based on slaughterhouse solid waste, being set by M/s Hind Agro Ltd., Aligarh, Uttar Pradesh, and b) A 0.3 MW power project utilizing vegetable market wastes, which is being set up at Koyembedu market complex at Chennai.

Source: MNES *Annual Report*, 2004-05.

Why Energy Route

Waste can be successfully managed by vermicomposting, mechanical composting and energy generation. Due to its nature friendliness and ecological suitability, vermicomposting is the most preferred option.[6] However, it suffers from some inherent demerits. These are:

1. It is unmanageable on a large-scale basis for more than 10 TPD.
2. It is difficult to operate during rainy seasons with high costs of shed for large areas.
3. It comprises a 15 day cycle of composting, resulting in piling of garbage.
4. Exposure of workers to pathogens.
5. Only soft and untraceable biomass used, hence poor volume reduction (only 30% - 40 %).
6. Production of inferior quality of fertilizer needs further addition of nutrients, thus increasing the cost.
7. No ready purchaser of organic compost, no established market – making the project a commercial failure.

Mechanical Composting has been tried on a larger scale abroad, but with hardly any success stories since:

1. Organic fertilizers from waste are feared to contain elements harmful to soil. Any compost from waste must conform to the schedule IV of MSW rules, 1999 of Government of India, which is practically difficult to achieve.
2. 7-10 days cycle of maturity (30% - 40%) making it unsuitable for large-scale handling.
3. Low volume reduction (30% - 40%).
4. Requirement of energy is 70 - 90 units/ton of compost for aeration – additional cost.
5. Further addition of nutrients required to make it ideal for soil.
6. No guarantee of sale of organic fertilizer – making it commercially unviable.

The Energy Route of waste management has the commercial experience of more than a decade. As on today, they are the only commercially viable options due to:

1. Large volume reduction (80% - 90 %).
2. Consumption of waste on a daily basis.
3. Favourable commercial viability on a larger scale.
4. Pathogen free process.
5. Choice of different technologies with customized design.

6. Capability of treating even non-putriciable organic matters such as rubber, wood, plastic, etc.
7. Ready market for energy, making them commercially viable.

Hundreds of waste-to-energy plants are working in USA, Canada and Europe. The teething troubles in some cases of air pollution have been solved by offering environmentally sound technologies. Due to increased awareness, Government of India MSW (Management and Handling) Rules, 1999 recognized biogas from MSW as a viable route vide item 5 of schedule II.[7] Obviously, the energy route of waste management is the only practical option available to us for larger plants of more than 100 TPD.

Technology Status

The main technology options for MSW to energy projects are:

- Sanitary landfill.
- Incineration.
- Gasification.
- Anaerobic digestion.
- Other new technologies.

Each of the technologies has its own merits and demerits. However, the judicious choice of technology has to be made based on the waste quality and local condition. The best compromise would be to choose the technology if it fulfills these criteria:

- Lowest life cycle cost.
- Needs least land area.
- Causes practically no air and land pollution.
- Produces more power with less waste.
- Achieves maximum volume reduction.

Large number of success stories have been documented.[8,9] Above information indicates that most of the projects were commercially run by private agencies with or without government support. Fortunately, ongoing research provides environmentally and financially foolproof technology. As a result, some emerging processes with exciting features are on the verge of commercialization. Some of these are[10]:

a. **SWERF** at Woollingong City, Australia, where unsorted waste is sterilized, sorted, shredded, palletized and gasified. The plant is working successfully since May 2000.

b. **Pyrolysis** i.e. incineration in absence of oxygen, produces oil like product with high energy efficiency process. A pilot plant is working at Toshiba factory at Japan to produce a range of oil substitutes.

c. **Enersludge:** An innovative method converts sewage sludge into useful bio-oil. It is working since 1997 in Perth CBD, Australia.

d. **Slurry Carb:** 20 ton/day demonstration plant has established the technical viability at Mitsubishi Corp. in Ube city, Japan. The sewage sludge with high moisture content is co-fired to coal boilers.

e. **Convertech** technology converts organic waste into volatile oil and stable refuse derived fuel (RDF) through steam distillation. This process is yet to be tested on a pilot scale.

f. **Fast Pyrolysis** refers to the heat treatment of particulate organic matter at 300^{0}C - 1300^{0}C under steam and pressure ranging from atmospheric to above 30 bars to produce pyrolytic oils and medium energy gases.

g. **Solvolysis** refers to the use of organic solvents at 200^{0}C - 300^{0}C to dissolve the solid into an oil like product (bio-oil).

h. **Ion Dissociation** technology is claimed to be highly efficient, with zero pollution factor and faster, using high-speed atomization of waste. If proven commercially viable, it promises to be the most exciting future technology for waste energy.

i. **Waterwide Gasifier** claims to achieve payback less than two years (profitable business) with minimum emission, very high efficiency, modularity and acceptance of fuel without pre-treatment.

As per market analysis, worldwide development of WTE projects by 2010 is estimated to be 5500 MWe, with EU countries having a share of 2000 MWe.[3] It may be noted that North American countries have already achieved more than 3000 MWe and OECD Pacific countries 200 MWe. There is negligible share from African and Asian countries. These are indicators of great market potential in the changed positive environment, wherein public fears and misconceptions regarding WTE plants are vanishing day by day.

Economics of Waste and the Environment

The whole issue of WTE projects is a classic case of inner struggle of man to overcome the dilemma of environment and economics. Nearly every economic benefit has an environmental cost. The high entropy of urban/industrial wastes poses grave danger to the society causing health hazards and disturbed environment by enhancing global warming.[11] The waste material in conjunction with other factors of environmental degradation are estimated to be responsible for 3% of GNP for environmental clean up in USA. In India, estimates of economic value of degradation and depletion are alarming as shown in Table 7.2.[12]

Pollution abatement cost is no more a notional value and countries have begun to budget for ecological restoration. Characterized by the non-internalization of external cost of energy production, costs of renewable energy technology (RET) based power tend to be significantly higher than that of conventional power. However, RET based power outweighs conventional power on account of its environmental friendliness and social implications of development.

Table 7.2
India: Economic Value of Degradation of Natural Resources

No.	Problem	Annual economic value (Rs billion) (1997)
1.	Preventing adverse effects of poor quality of drinking water on human health	122
2.	Loss of crop productivity due to degradation of soil	89-232
3.	Loss of woods due to degradation of forests	57
4.	Adverse effect on human health due to polluted air	885-4250

Source: *Looking Back to Think Ahead: Green India 2047*, TERI, 1998.

Criticisms and Solutions

Some environmentalists have unfounded apprehensions that the energy route of waste management will result in more pollution. An article, "Another Bhopal in the making in Mumbai?", published in the Business Standard, 27 May 2000, is one such example of misgivings. There seems to be a misunderstanding that all WTE power projects are incineration based while the fact is that there are 5 to 6 different technologies and some of them are 100% pollution free. One just needs to choose the best.

The compost route is practically not viable for either local government or for private investors due to the lack of ready market for organic compost that does not have the required proportion of NPK and needs to be further supplemented with additional nutrients. Moreover, producing organic compost, which conforms to the set standard having no glass/metal particles needs sophisticated treatment that increases the cost of finished product to an unaffordable extent. Many such MSW to compost plants have failed in the state of Maharashtra, such as those in Thane, Aurangabad and Pune.

It is due to unfounded doubts that ordinary land filling is going on and unscientific landfill sites are causing unchecked pollution. Rainwater allows the pollutant chemicals to dissolve and flow into groundwater reserves, which is later used for drinking in nearby areas. Toxic gases emitted from landfills are dangerous for nearby vegetation and population. Unchecked methane, which has 21 times more potential than CO_2 for global warming, keeps on being released in the environment from open dumping sites. It is estimated that methane released just due to waste materials in India is 3288 Gg i.e. equivalent to 69,048 Gg of CO_2.[11] Alarmed by these factors, ordinary landfills were legally banned in the US vide regulations FR-5/91 and similar regulations in EU countries.[9]

The only positive thing to happen is the notification by India's Ministry of Environment and Forests i.e. The Municipal Solid Wastes (Management and Handling) Rules, 2000, New Delhi, 25 September 2000, which has fixed the timetable for local governments to have waste treatment facilities by 31 December 2002.

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