MUNICIPAL WASTE ENERGY RECOVERY

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1.0 INTRODUCTION

The idea of utilizing municipal solid waste (MSW) to supplement energy supplies is gaining increasing acceptance in our urban areas. Cities and their developed regions are where energy demands are greatest, most concentrated and the most diverse, where waste disposal is becoming ever more difficult and expensive, and where environmental problems require the greatest attention. While solid wastes are usually disposed of by direct incineration, landfilling or ocean dumping, the environmental impact of these practices is becoming increasingly unacceptable and is escalating rapdily.

The recovery of energy from wastes stands as an important energy conservation strategy, but it also represents one of very limited options cities have in addressing issues of the cost and environmental impact of waste disposal. Currently it is estimated that the U.S. spends approximately $5.5 billion per year for municipal solid waste management - or about $43 per ton. Collection and transportation of wastes account for 80 percent of these costs and are components which rise with the cost of energy. The land disposal provisions of the Resource Conservation and Recovery Act (1976), though not yet imposed, are also expected to drive up the costs of waste management.

In all, increased environmental regulations, rising cost of land, siting difficulties and greater transportation have combined to create a solid waste management crisis for many cities. This

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has caused both public and corporate interests to search for new waste management and disposal opportunities. Of necessity, many municipalities are turning to energy and materials recovery from MSW as an integrated means of treating multiple issues. While energy recovery projects are on the increase nationally, a number of technical, economic, environmental and institutional barriers constrain its widespread application. This paper discusses the most important barriers and issues which relate to energy recovery from waste in our urban areas.

2.0 Energy Recovery Practices and Processes

Decisions for energy-from-waste recovery projects are always made in response to local waste management problems, and successful projects must be tailored to meet specific local needs and opportunities for real cost and energy savings. A number of choices, either alone or in combination, are available to municipal waste managers.

2.1 Source Separation

Source spearation is a non-waste-conversion management practice with significant energy savings and particularly appropriate application in many cities. It involves setting aside recyclable waste materials at the point of generation or just prior to disposal or processing. It is currently the primary method of resource recovery. Most of the twelve million tons (out of 148 tons MSW) of material recovered (primarily paper) in 1977 was retrieved through source separation rather than mixed-waste processing.[1/] Other common materials separated in MSW before incineration or processing are aluminum and steel cans. These programs are generally conducted by the associated industries in areas where processing and shipping capacity exists for that industry, usually with a manufacturing facility nearby. Increasingly, though, municipalities are initiating city-wide source separation programs to lessen land fill disposal. Although the primary resource recovery practice at present, source separation achieves only a small percentage of its potential savings.

1/ U.S. Environmental Protection Agency, Fourth Report to Congress: Resource Recovery and Waste Reduction, SW-600, U.S. EPA, 1977 Wash. D.C.

As energy recovery from solid waste increases, questions have been raised regarding the compatibility of source separation, primarily of paper, with MSW energy systems. There is concern that reducing the combustible portion of the waste stream, by separating out paper, may significantly lower the heat content of waste energy forms and thus hurt their market prospects. Current analysis, however, suggests that the impact would be small. Source separation of paper is not conducted on a scale yet to seriously hamper the potential of energy reporcessing facilities. Even a seven percent reduction the the quantity of solid waste through source separation of paper, for instance, would reduce the heating value of raw MSW by only three percent (4600 Btu/lb vs 4450 Btu/lb on average). The economic impact of paper separation on a resource recovery facility would be minimal and could be alleviated with a slight (2-3%) increase in tipping (disposal) fees at the plant. Analyzing these economics and determining the compatibility of source separation and energy recovery are important planning functions for cities considering these options, however, and should be addressed from the outset of local resource recovery project consideration.

2.2 MSW Energy Conversion Processes

There are four basic processes available to convert MSW to energy:

1) Incineration--burns the raw refuse without any prior material separation or conversion to produce steam for heat or industrial processes, or to drive generators to produce electricity.

2) RDF (Refuse-Derived Fuel) Production--produces from the organic waste a relatively homogenous fuel for combustion separately, or jointly with coal, in a suspension-fired boiler. The RDF can be densified for use in stoker boilers, and for easier storage.

3) Pyrolysis--the heating of the refuse in the absence of oxygen so that it will be converted into solid, liquid, or gaseous fuels with a high heat content.

4) Anaerobic Digestion--the bacterial decomposition of organic waste without oxygen. From this decomposition is produced a methane gas which can be substituted for natural gas in most applications.

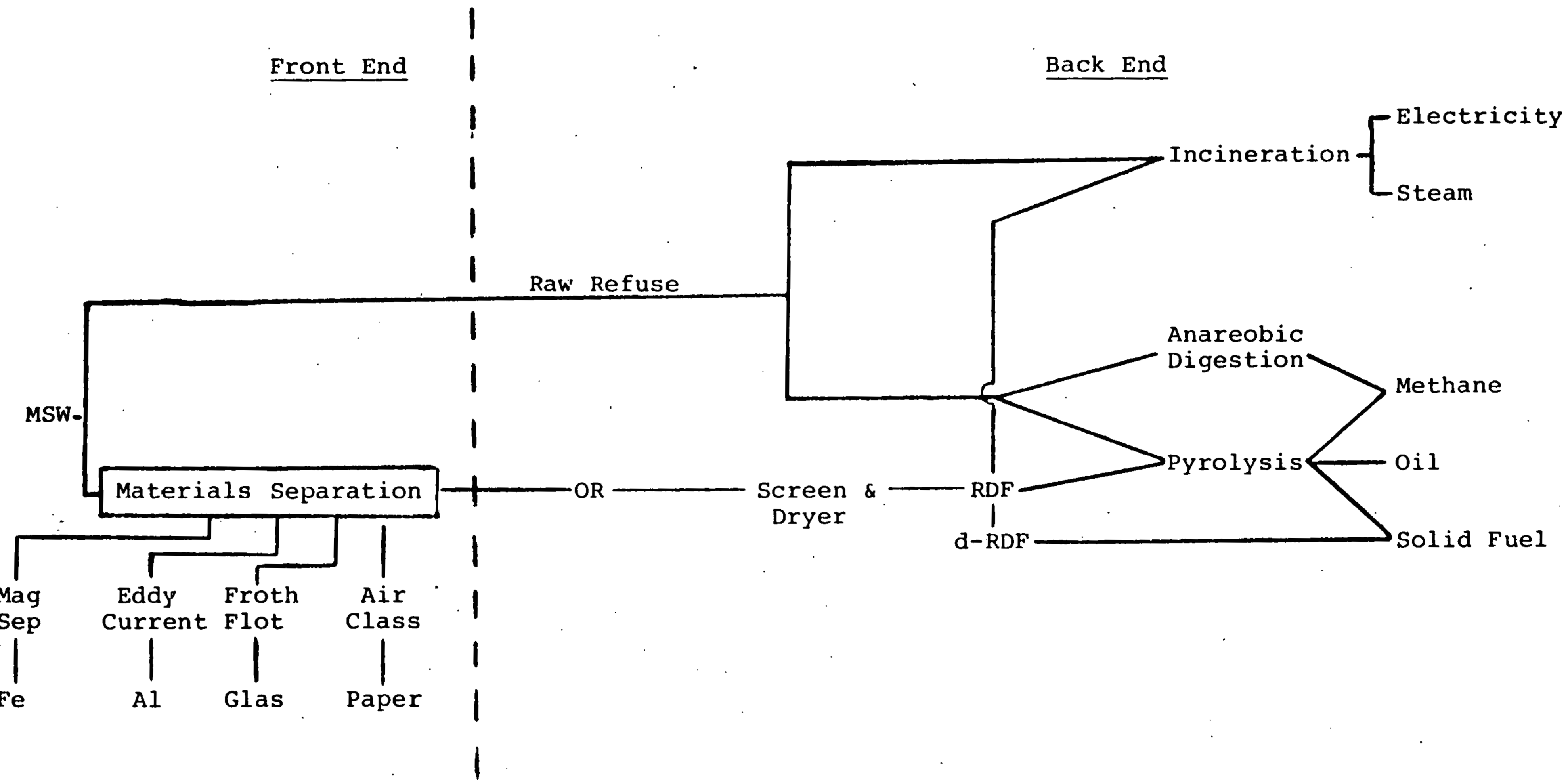
Conversion processes, with the exception of incineration, are generally preceded by a "front end" process which separates the marketable inorganic materials from the organic fraction of the initial MSW input. These are technologies such as trommels, shredders, air classifiers, magentic separation and froth flotation. While there is no direct energy production from the front end of MSW recovery, the recovered materials can be translated into energy savings. For instance, a ton of recovered aluminum represents tremendous energy savings since the production of aluminum is such an energy-intensive process. Using recycled materials rather than virgin resources saves energy in the following proportions:

- Aluminum	-- 1/20	of	energy	is	needed.
- Steel	-- 1/3	"	"	"	"
- Paper	-- 1/3	"	"	"	"
- Glass	-- 4/5	"	"	"	"

In addition, the market value of these materials will be an important revenue component in a city's recovery program. The MSW energy recovery cycle is depicted in Figure 1.

The technologies to convert MSW to energy are in different stages of development and commercial application. Some are available today at costs competitive to present energy prices and

Figure 1: MSW Energy Recovery Cycle



present disposal costs, suggesting that accelerated rates of application are desirable. However, many MSW recovery systems are still experiencing significant operational problems pointing to the need for progress in:

- technology development and adaptation;
- economic analysis;
- materials flow planning; and
- local logistical planning (waste collection and delivery).

Many cities, in particular, have failed to make accurate waste projections or to provide for efficient and adequate waste collection and delivery.

The combinations and options for structuring MSW recovery systems vary widely according to the demands of the community served by the MSW facility. Thus, RDF production for a utility boiler may work in St. Louis, while incinerator steam generation for an industrial facility is a viable operation in Saugus, Massachusetts. Technical barriers are not seen as major impediments to MSW energy recovery, but careful technology choices and system planning must be executed in each city's MSW energy program.

3.0 Environmental Issues

The majority of MSW energy recovery plants are municipal or private ventures, but there has also been a strong Federal role in the development and commercialization of these systems. The Environmental Protection Agency has held the primary Federal responsibility to date, with a focus on promoting waste-to-energy systems as a means of addressing multiple environmental issues, particularly in the urban environment. Environmental advantages include reduced land requirements and water contamination from landfills, reduced incinerator air emissions, conservation of resources and the production of clean low-sulfur energy forms. As such, MSW energy recovery overall is an environmentally desirable waste management strategy for cities.

A number of important environment and safety issues still remain unresolved, however, and could continue to impede the commercialization of MSW energy recovery systems. The environment and safety effects vary with the types of system, as does the state of knowledge on known effects since many waste-to-energy systems are in pilot or demonstration stages and have yielded incomplete environment and safety information. In general, MSW energy recovery processes generate air emissions, waste-water, solid residues, workplace hazards, noise emissions and some potentially pathogenic micro-organism emissions. In some facilities environmental problems have been serious enough to shut down operations for considerable periods. It appears that most of these potential hazards can be eliminated with current technology and improvements in handling practices, but uncertainties exist over the developing nature and increasing stringency of Federal and state regulation of air and water pollution as well as workplace health and safety.

3.1 Occupational Health and Safety

In general, MSW operations present a variety of unattended occupational safety and health problems. There is a distinct lack of research and information on the subject, and most facilities have only informal safety training and limited personal health protection practices. Much work needs to be done on sampling and analysis of workplace air quality, equipment safety evaluation and possibly design changes, air quality control methods, and health and safety training of MSW facility personnel, for example. But in employee safety training, a city MSW energy program could play an important role in helping to insure the program's success. While health and safety concerns will not halt MSW reprocessing industry development, the anticipation and early correction of problems could prevent serious intervention by occupational health and safety regulators.

3.2 Environmental Considerations

The primary questions surrounding the environmental acceptability of MSW energy systems concern the probability of future standards for currently unregulated emissions, and uncertainty over the actual cost of pollution control. While there are no foreseeable technical environmental barriers facing refuse conversion technologies, the cost of meeting applicable Federal and state air and water emissions requirements, especially in urban areas, could stall the growth of MSW energy recovery in cities.

As with occupational health and safety concerns, knowledge of pollutants and quantities is restricted because the processes are still not well characterized for environmental effects. This knowledge also depends on the development status of the process. A good deal is known about incinerator emissions, for example, and incinerator-specific standards are in effect; but newer technologies such as pyrolysis require significant environmental assessment as yet. The combustion of MSW fuels offers a reduction in overall quantities of pollutants discharged to the air compared to fossil fuels, but some new contaminants, present in the waste stream, are often introduced. Other environmental effects derive from MSW reprocessing operations. These are listed together in Table I.

Table I. Major Pollutants from MSW Processing and Combustion 2/.

Emissions to air	Discharges to water	Residuals to land
NO_x and SO_x	Suspended solids	Metals
HCl	Ash	Inorganics
H_2S	Trace metals and salts	Nondecomposed organics
NH_3	Organics	Bacteria, virus
CO and HC	NH_3	
Particulates	Acids	
Fly ash		
Trace metals		
Noise and dust		
Organic components (phenols, halides, aldehydes, and unknown organics)		

2/ Aerospace Corporation, "Energy Recovery from Municipal Solid Waste, an Environmental and Safety Mini-Overview Survey," ERDA, Contract #E(04-3)1101, Washington, D.C., 1976, p. 15.

- Air Emissions

Air emissions encompass the most complex urban environmental issues relating to waste-to-energy processes. Of those listed in Table I, standards exist only for nitrogen oxides, sulfur dioxide, fly ash and particulates. Standards can be expected for other pollutants in the future, but environmental R&D can be conducted within the time frame for technology development. Pollutants such as hydrogen chlorides, trace metals and organics are known to be present in the emissions from refuse burning and have been measured in many metropolitan areas, but their quantities vary with refuse composition and little is known on their composition, health impact and transport. As potential health hazards, they will be of increasing concern in standards development as MSW facilities increase.

Perhaps a more complex area of air emission barriers is that of applicable standards and Federal/state authority. Emissions standards can determine the technological and economic feasibility of compliance by MSW plants. For example, in many urban non-attainment areas the cost of compliance could mean purchasing emissions "credits" from other local polluters under current regulations or applying even more expensive control systems. Also, the states have final review authority on new projects and can impose more stringent standards than Federal emissions limitations. Maryland's 0.03 grain/scfm particulate standard was largely responsible for the delays and added control costs for Baltimore's pyrolysis project, although it met the Federal standard (0.08 grain/scfm) in numerous tests.

New Source Performance Standards (NSPS) for various emissions will apply to all MSW facilities, but states can set and interpret them individually. DOE anticipates that current and projected standards for incineration, which gives off all classes of pollutants, will apply to RDF and pyrolysis facilities as well, but state discretionary power is considerable. States can also apply new air emission regulations to existing as well as new sources. The uncertainty and potential confusion in this situation acts as another barrier to MSW energy recovery.

4.0 MSW Market Economics

Although there are several aspects of MSW technology that still have large technical risks associated with them, most people in the industry feel fairly confident of solving the remaining technical problems. Unfortunately, this is not true with the economics of MSW processing, for there are seemingly intractable problems with achieving cost-effectiveness with a MSW facility. Time after time a city constructs a MSW facility only to reveal that it is an economic burden on the local government or taxpayers. Thus, a large part of the technical and planning work currently being conducted is devoted to improving the overall economics of MSW facilities in comparison to landfill disposal or incineration of raw refuse.

In effective MSW recovery planning, calculations must be made upon site specific criteria, and careful planning is necessary to account for two important components in a MSW recovery cycle: 1) the supply of MSW in the given locale, and 2) the demand for the products of a MSW facility. Whether the products are recovered materials, RDF, or energy, the success of a resource recovery facility is extremely sensitive to the fluctuations in local MSW supply and product demand. For instance, even when the cost is competitive, the generation of steam in an MSW incinerator often cannot be controlled closely enough to meet changing load conditions because steam generation is dependent to a large degree on the supply of MSW. Steam generation must, within bounds, keep up with the flow of waste material delivered to the plant regardless of steam demand, because MSW cannot be stored for long periods of time. Thus, experience has shown that the additional cost of equipment to abate the problems of erratic supply and demand is justified only when there can be found firm markets for MSW-generated steam.

The local electric utility ought to be an ideal market for MSW steam. However, it is always the case because of economies of scale, that the utility can generate higher quality steam cheaper and more reliably than a MSW facility. While utilities are willing to buy energy from MSW facilities, whether steam, electricity or even RDF, MSW energy supplies must fit in with the utility's energy needs, load characteristics and reliability standards. Under strict reliability requirements and intense financial regulation, a utility is forced to view MSW energy as a risk and to pay a commensurate price for it. Thus, the utility market is very limited and requires a high degree of MSW system planning on the part of city officials, state public utility commissions and utility managers.

A similar problem with markets for recovered materials is that the recovered product is usually lower in quality than the virgin stock. Glass cullet consists of a mixed variety of colored and clear glass which is unacceptable for use by many container manufacturers. Similarly, recycled paper is unacceptable in many applications because the cellulose fiber has been shortened by the recycling processes. Thus, finding markets which will pay an acceptable rate for recovered materials is a significant task and must be considered thoroughly before beginning any MSW recovery project.

The problems associated with marketing recovered materials often make RDF production a much more attractive alternative to a MSW recovery planner. However, RDF marketing presents several difficult problems of its own. Although a certain locale may contain a large prospective market for RDF, the actual economics of RDF production may not be favorable because the economics of firing RDF is highly dependent on the costs of either building or retrofitting boilers in which the RDF will be used. Typically, whatever is gained or lost in producing the RDF (or d-RDF) is offset by the costs of modifying a boiler.

When assessing RDF economics, it is also necessary to point out the significant differences between the typical industrial user and a utility user. Viewed from the perspective of alternative fuel costs, industrial users would pay higher prices than utilities for the same amount of energy. Since coal-burning utilities make very large purchases, they generally procure their fuel at a lower cost than the smaller industrial users. The higher fuel prices that industrial customers face make RDF a more attractive energy source. In evaluating the economic viability of MSW energy recovery systems it is necessary that municipal officials make this kind of demand market determination for the recovered energy product.

5.0 Conclusions

Materials and energy recovery from municipal solid waste offer at least a partial solution to a city's solid waste management and disposal problems. It is also capable of providing some energy benefits by using a previously unutilized energy resource, and environmental benefits by reducing emissions from the burning of fossil fuels. Institutional, technical and environmental barriers to greater MSW recovery market penetration exist, but none appear insurmountable. As such, MSW energy recovery is an important waste management option which warrants the serious concern of DOE policy makers, concerned with urban energy policy.

The technologies to convert refuse to energy forms, or energy savings through materials recycle, are developing rapidly. The cost of energy recovery remains high, though; it seems to be competitive only in areas where there are firm markets for both the energy produced and the secondary materials recycled, and where disposal fees are fairly high. MSW energy projects are based on local waste management decisions, however, and it may be that local requirements or state regulatory policy demand that waste-to-energy systems be given serious consideration despite the existence of some economic disincentives. A multi-faceted approach to MSW energy recovery planning, emphasizing integrated institutional, economic, environmental and technical planning, must be employed by municipal waste management officials.

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