TECHNICAL PAPER ON SOURCE REDUCTION

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

BACKGROUND

The National Recycling Coalition defines "source reduction" as "any action that avoids the creation of waste by reducing waste at its source, including redesigning of products or packaging so that less material is used; making voluntary or imposed behavioral changes in the use of materials; or increasing the durability or re-usability of materials." The Congress of the United States Office of Technology Assessment (OTA) defines municipal solid waste (MSW) prevention as activities that reduce the toxicity or quantity of discarded products before the products are purchased, used, and discarded. OTA reports that their are two basic routes to MSW prevention - manufacturers can change the design of products and the way they are packaged, and consumers can alter purchasing decisions about existing products and the way they use and discard products. OTA also reports that the amount of MSW generated in the United States increases by approximately one percent a year. Population growth accounts for two-thirds of this annual increase; increased consumption accounts for the remainder.

All recent State of Indiana solid waste legislation cites source reduction (sometimes referred to as waste reduction) as an important solid waste management option, often placing it at the top of a waste management hierarchy. Source reduction programs have not received significant funding in comparison to other waste management programs, such as solid waste recycling since source reduction programs generally do not generate revenues.

This report focuses on source reduction waste management options and on case studies of six states that have developed source reduction programs. All of the state supported source reduction programs are new; therefore, data on the impact and success of each program is not currently available. An overview of specific source reduction strategies.

SOURCE REDUCTION STRATEGIES

Although source reduction strategies vary widely, the strategies can generally be categorized into five groups:

- Waste Disposal Fees
- Advanced Disposal Fees or Deposits
- Disposal Bans
- Product Bans
- Source Reduction Education

Most source reduction strategies require legislative and regulatory initiative for action on the state level, or regulatory initiative for action on the local level. A discussion of source reduction strategies follows. Note that composting of organic waste, an important source reduction strategy, warrants a separate detailed discussion; and is therefore is reviewed separately.

VARIABLE RATE PROGRAMS

Cities throughout the nation have developed volume-based waste collection rates in an effort to encourage citizens to reduce solid waste generation. Historically, most cities have used either flat fee systems or non-direct billing (property tax) systems for charging residents for solid waste collection and disposal. Due to the flat fee structure, these billing systems fail to provide a penalty for excessive waste generation or an incentive for minimizing waste generation. The purpose of a volume or weight-based rate system is to provide citizens with an economic incentive for reducing waste generation.

The City of Seattle has developed a variable can (volume-based) rate structure whereby citizens pay for collection and disposal based on the volume of garbage each produces. As a citizen reduces the volume of garbage he produces and sets-out for collection, he is rewarded with a lower garbage collection bill. This system has proven to be an incentive for recycling and waste reduction. A recent analysis, "Volume-Based Rates in Solid Waste: Seattle's Experience" demonstrated that more garbage would have been generated and disposed if the City had not imposed a variable rate structure. The City of Seattle's goal was to expand the service-level options to the public, while maintaining a flexible system. The variable rate system permits customers to choose the service they need, giving them a more direct relationship between their recycling, waste reduction, and waste separation actions and the size of the waste collection bill they pay. Currently, Seattle resident pays $13.75 per month for collection of a standard 30 gallon trash can on a weekly basis; the second and third can cost $9.00 each for collection. This system was developed to provide an increased incentive for waste reduction and recycling. The City also provides a mini-can rate for a 19 gallon can, nicknamed the "Super Recycler" rate. The 19-gallon mini-can service is available for residents who produce small volumes of waste and/or recycle and compost most of their waste. This rate provides a significant incentive for waste reduction and recycling to customers who were not filling one 30-gallon garbage can. Some cities are considering to system whereby the individual resident's trash container would be weighed on the collection truck and, by means of a bar code system, would be charged by weight for waste collection and disposal.

Table V-1-1 provides the City of Seattle monthly billing rates for trash collection. The majority of the Seattle residential population uses 30 gallon sized or smaller service.

Table V-1-1. City of Seattle Monthly Residential Rates

Container Size	**1989 Rate**
Mini-Can (19 gallon)	$10.70
One-Can (30 gallon)	13.75
Two-Can (60 gallon)	22.75
Three-Can (90 gallon)	31.75
Each Additional Can (30 gallons)	9.00

The Seattle program has demonstrated that there is a correlation between the pricing and the amount of waste generated. Approximately twenty-five percent of the city's customers are using the 19 gallon trash container.

The implementation of a variable can rate program is easier when a city controls the collection of waste, either directly by means of provision of collection services or indirectly by means of contractual agreement, as is the case in Seattle. Therefore, consideration of volume or weight-based systems for local governments requires designing the system to the community's needs. A community that provides its own collection, bills residents directly on a quarterly or monthly basis, and provides a standard size can is capable of developing a variable rate system without major program modification. However, the conversion to a variable rate system is more complex for a community that provides trash collection service paid by means of property tax. Beyond public sector haulers, private-sector haulers would potentially be required to dramatically change their systems if a volume based system were developed. Implementation of a statewide program requiring public and private sector waste collectors to develop volume- or weight-based variable rates would require adequate time for conversion from existing systems. Citizen participation in variable can programs demonstrates that citizens will reduce waste by means of modifying purchasing decisions, recycling, and composting. As waste collection and disposal rates continue to escalate, citizens should welcome the opportunity to reduce the financial impact of waste collection and disposal.

The variable rate systems generally work effectively only when accompanied by provision of waste reduction services such as curbside recycling collections and yard waste collections. Therefore, the provision of the waste reduction service should precede variable can rates (see Recycling paper).

The increase in waste collection rates at the residential level will cause some citizens to explore illegal dumping options, and disposing of household waste in neighborhood commercial dumpsters. Therefore, local government enforcement mechanisms must be developed to discourage illegal dumping.

Some local governments provide waste collection services as part of their general utility service program using property tax income. In this case, the resident does not usually receive a billing and is not aware of the portion of their tax dedicated to waste collection and disposal. In fact, citizens often think that the service is free of charge. By providing quarterly billings, as private sector haulers usually do, the resident becomes aware of the direct waste disposal costs and the significant inflation of disposal costs (sticker shock) over time.

To a large degree, the commercial sector already has variable rates for collection of solid waste, since private haulers provide collection based on the size of containers or the number of pulls (collections). Variable waste collection and disposal rates should be considered for areas where the commercial sector does not pay variable rates.

Variable rate programs have been used by public and private utilities successfully for many years to create energy and water usage conservation behavior. The concept of solid waste-based conservation by means of variable volume rates, or weight metering rates, is relatively new. The State of Indiana is attempting to conserve existing landfill space and to preserve land areas that may need to be developed into landfills. Educating the public about the true costs of waste management and the individual's opportunities for reduction of costs will be key to the success of variable rate based pricing programs.

ADVANCED DISPOSAL FEES

Historically, the economics of recycling solid waste have been marginal for many components of the waste stream. While some materials like scrap aluminum and waste computer paper command good prices, the majority of materials in the waste stream do not provide significant enough sales value to cover the expense of collection and processing for recovery. Numerous states are working on market development programs for recyclable and compostable materials that will improve long-term demand for these products. Some states are creating economic change by means of advanced disposal fees (ADF) which are product disposal charges. The basic theory is that the consumer, or in some cases the manufacturer, will pay the cost for progressive solid waste management of specific products up-front, thereby paying the cradle-to-grave costs for environmentally sound management of the product. The states of Florida and Washington have developed ADF programs for tires, and Florida will implement ADFs for beverage containers if state recovery goals are not met. In these two states, the consumer pays a $1.00 fee (ADF) for each tire purchased. The fee is deposited in a state solid waste trust fund and the funds are utilized to financially support the recovery of tires. This support can take a variety of different forms, including contracting with existing tire recovery firms or providing start-up funding for new firms.

By means of ADF's, states are charging the citizens the true cost of environmentally sound progressive solid waste management. Historically, citizens in numerous states paid disposal costs based on what a private sector operator was charging or on the local government rate for operation of the landfill. These charges have not always covered the full cost of proper monitoring, insuring and closure, and clean-up of the facilities. Today, some state governments believe that the ADF is a technique to equally tax citizens to pay for progressive waste management. The State of Maine's new solid waste legislation places a $15.00 ADF on new appliances. The collected funds will allow the scrap metal recycling firms to recover the appliances based on the income from the sale of the recovered materials and the $15.00 state support. Historically, the scrap metal dealer in most regions of the nation could not recover the materials because of marginal economics. In essence, Maine is mandating that the consumer pay part of the disposal (recycling) charge up-front; the state acts as banker and the market is financially supported, all to avoid traditional landfill disposal.

Numerous states have developed successful waste reduction programs with landfill surcharge financial programs. The State of Indiana has developed an effective method of funding waste reduction with the new fifty cents per ton disposal surcharge that is deposited to the Indiana Solid Waste Management Fund. The implementation of an Indiana ADF program could provide additional funding to support the aggressive implementation of waste reduction programs at the local government level. The landfill surcharge income will decrease over time as citizens develop waste reduction habits. Fees collected from ADF programs could be used to financially support recovery of all products on which the ADFs are placed. With an effective ADF program, citizens avoid paying a surcharge for final disposal of a product, since the ADF collected on the product ensures that the product is recycled, rather than disposed. An ADF could be applied at a high per unit rate for significant waste contributors such as tires and appliances, for example, $1.00 per unit. For smaller volume items, such as a magazine or newspaper, a lower ADF could be charged, for example, one cent per unit.

DISPOSAL BANS

In the interest of waste reduction and source reduction, some states have begun to implement disposal bans for specific materials. The 1988 State of Florida legislation includes bans for disposal of white goods, demolition waste, whole tires, yard waste, and motor oil. The 1990 Wisconsin legislation bans disposal of newspapers, magazines, lead-acid batteries, white goods, tires, corrugated cardboard, plastic containers, foam polystyrene, and metal cans. By means of disposal bans, these and other states are attempting to encourage citizen and industry participation in source reduction and recycling. The State of Rhode Island physically inspects waste collection vehicles on a random basis to be certain they are in compliance with recycling laws. If a trash truck has too high a percentage of recyclable materials in the mixed waste, the truck is not permitted to unload its waste at the landfill.

Enforced disposal bans are a mechanism for significantly reducing the volume of waste disposed in landfills or incinerated. As a source reduction method, disposal bans encourage efficient packaging constructed from recyclable materials. For a disposal ban to be effective, the public, the commercial sector, and the waste haulers must have alternative disposal (recovery) mechanisms available for banned materials. Currently in Indiana, the recovery mechanisms are not in place to recycle all of the materials that could potentially be banned from landfilling (see Recycling paper). Therefore, markets for recyclable commodities need to be developed in Indiana. The State of Indiana may need to play an aggressive role in funding solutions and supporting industry to build and maintain adequate markets.

For some materials, the value of the material supports recovery, as is the case with aluminum and high-grade computer paper. Other materials, such as tires, are not economically recoverable based on the income from the sale of material, after factoring in collection and processing costs. Therefore, numerous states have developed advanced disposal fees (product charge) on materials with marginal values; the fees are placed in a state fund used to support waste reduction and recycling of the materials. Financial support mechanisms for recovery of marginally valued materials are generally necessary if the disposal bans on the materials are to be successful. Otherwise, exceptions to the bans may be necessary. In Florida, if recovery options are not available, a tire can be landfilled only after shredding.

For a disposal ban to be successful it will be necessary to have fully developed the infrastructure of processing and marketing services. Otherwise the generator or waste hauler is faced with the problem of proper disposal. Similar to variable can rates, if viable recovery options are not available, then illegal dumping becomes a problem. Certainly disposal bans send a message to everyone that the state is serious about waste and source reduction. Some states like Rhode Island have assured that the processing and marketing infrastructure are in place by means of funding a state network of material recovery facilities (MRFs) to process collected recyclables.

Enforcement of disposal bans by means of substantial fines or refusal to allow unloading of mixed loads of waste with banned materials is also necessary for disposal bans to be effective. Once a material is banned from landfilling, the private citizen will request alternative services for waste materials he generates. In other urban areas, this has been accomplished by means of residential collection for yard waste and recyclable materials. These services are provided by either the local government or by private sector contracts with local government. Some states, including Oregon and Pennsylvania, have legislatively mandated that local government provide residential collection service. These laws are referred to as the "Recycling Opportunity Act" in that they mandate the provision of collection service to the public, so that each citizen has the opportunity to participate in waste management programs. Therefore, when considering implementation of disposal bans, a state should determine how to best provide support, in the form of alternative collection and processing mechanisms, to local government and the public. The collection, processing, and marketing of recyclable materials is reviewed in the recycling paper. The compostable collection, processing and marketing options are reviewed in the composting paper.

Support of a collection, processing, and marked infrastructure for recyclable and compostable materials in states that have developed effective programs has been accomplished by means of matching grant programs with local government for equipment and facilities. A disposal ban on specific materials without development of the collection, processing, and market infrastructures would likely accomplish insignificant waste reduction and would place a burden on local government, the waste haulers, and ultimately, the citizens. Disposal bans generally require extensive education to inform the public about waste materials that can no longer be disposed and appropriate management methods for such materials. Landfill disposal of many waste items is not the sensible solution based on environmental and financial concerns. Disposal bans are waste management actions that can support the State of Indiana's legislation for environmental protection and resource management through source reduction and recycling. The State of Indiana comprehensive solid waste law (HB1240) allows for banning or restrictions of disposal of recyclable materials with effective dates to be determined by the Solid Waste Management Board.

Other states have utilized recycling laws to regulate out-of-state waste. The State of Oregon permits out-of-state waste disposal in Oregon only if the municipality generating the waste has recycling laws in place similar to Oregon's. Therefore, the State of Indiana should be able to have out-of-state generators comply with the State of Indiana recycling, composting and source reduction laws.

PRODUCT BANS

Some states have actually banned the sale of a product within the state because of disposal difficulties and non-recyclability of the product in the region. Some governments have developed economic disincentives to discourage consumer purchase of difficult to recycle products. By means of product bans or economic disincentives, government is attempting to change manufacturers' behavior, primarily related to the manufacture of packaging products and the manufacturers' role in recycling. By banning the sale of a product that is not, or cannot be recycled or recovered to full potential, government is attempting to force the redesign of the product using recyclable materials recovery goals. This technique for legislative product banning promotes source reduction and recycling.

Economic disincentives must be targeted to the appropriate manufacturers that are capable of creating the desired product change. The new State of Indiana Packaging Waste Reduction Task Force will be reviewing many of these issues. One method of creating a financial disincentive is to tax or place a surcharge on undesirable products or materials, making the favored products or materials more economically attractive. Though this form of disincentive has rarely been applied for waste reduction purposes, it is commonly used to encourage the purchase of products manufactured domestically versus foreign products.

Examples of products that have been targets of proposed regulations using product bans or requiring product redesign or labeling include:

- Non-refillable beverage containers
- Non-recyclable packaging
- Disposable diapers
- Assorted plastic products

Product bans that have been implemented on the state or national level include:

- Bans on non-refillable beverage containers (Denmark, Saskatchewan)
- Ban on non-degradable plastic shopping bags (Italy)
- Bans on non-degradable six-pack carrier rings (Alaska, California, Maine, New York, Oregon, Vermont)
- Ban on polystyrene foam products (Portland, Oregon; Bainbridge Island, Washington)

The cities of Berkeley, California and Portland, Oregon have passed polystyrene foam container bans. Suffolk County, New York attempted to develop a similar ban and the plastic industry filed a lawsuit. The judge required the county to develop an environmental impact statement (EIS). The county decided not to proceed with the EIS, and therefore is currently not permitted to ban the product. Some industries have filed lawsuits in response to regulatory action that they feel unfairly obstructs their right to conduct business. The Indiana Packaging Waste Task Force will need to monitor this activity as it reviews source reduction options.

Product bans are more effective at the state level then at the local level. Therefore, product bans should be targeted for implementation at the state level. Similar to disposal bans, product bans certainly communicate to the manufacturer and the consumer that the state is serious about obtaining its target waste reduction goals.

EDUCATION

The State of Indiana solid waste legislation HB1240 requires the Indiana Department of Environmental Management (IDEM) to cooperate with other state agencies to develop and establish programs to educate students, consumers, and businesses about the benefits of solid waste source reduction and recycling. As the Office of Technology Assessment has reported, consumers can play a powerful role in waste prevention through their purchasing decisions, which can ultimately shape demand for products and influence product design. However, little information exists to guide consumers or offer incentives to exercise that power - even motivated consumers are limited in such circumstances.

The appropriate state agencies, including the IDEM and the Department of Education, can develop and implement a solid waste educational curriculum for school children grades K-12 that includes source reduction education. Other states have developed successful solid waste programs, including California, Michigan, Ohio, Rhode Island, Washington and Oregon. The Michigan WISE curriculum focuses on integrated solid waste management and therefore, addresses source reduction, recycling, composting, landfilling and incineration. The goal of all educational programs is to encourage children to participate in source reduction, recycling and composting activities. Also, there is an expectation that the children will encourage other family members to participate in waste reduction activities.

Development of on-campus waste reduction programs for all state universities and colleges could also be considered as part of a comprehensive source reduction program. For states that set specific waste reduction goals, state supported institutions, as well as state agencies, could be required to meet state waste reduction goals. The state could also encourage private institutions to meet the state goals. The state can play a role in developing and funding educational/informational campaigns specific to college students.

The education of consumers about source reduction is a significant task. Some communities have implemented "Precycle" campaigns to encourage citizen participation in source reduction. Precycle means making environmentally sound and effective waste management decisions at the point of purchase. Campaigns usually encourage consumers to carefully select products, to avoid overpackaged products, to avoid disposables, to buy in bulk, to reuse and repair products, and to compost. Consumers are encouraged to purchase products that can be recycled in their community. The Precycle campaigns are relatively new and their level of effectiveness is difficult to determine. However, as state and local governments work to encourage citizens to participate in waste reduction behavior, it is logical to encourage citizens to participate in source reduction activities by means of precycling. A precycle campaign could be developed for state-wide media including newspapers, radio, and television.

As for the education of the business sector, The business sector is responsible for generation of a significant portion of the solid waste stream. Often times, businesses are so busy delivering a particular service that they do not focus attention on the volume of waste they generate or the costs associated with the waste. These costs are passed along to the consumer of the product or service. Some industries have developed very successful source reduction programs. The auto industry (all four U.S. automakers) has developed returnable delivery systems for automobile parts versus using corrugated cardboard. Collectively, the automakers are saving over twenty million dollars per year in disposal charges and labor. Some states including Maine and Rhode Island have mandated corporate participation in the recycling of specific materials.

OTHER STRATEGIES

Several other source reduction strategies but do not fall with the aforementioned categories. Discussion of these strategies follows:

Recycled Content Standards

In 1989, eighteen states began to introduce minimum recycled content standard legislation to stimulate demand for specific products, most often waste paper. During 1988 and 1989, the market for waste newspaper had been economically recessed throughout the United States and depressed in the Northeast. The states of Connecticut and California were the first to introduce recycled content legislation. Publishers of newspapers in each of these states are required to print a percentage of their papers using recycled content newsprint and the targets increase over time. The California legislation will be implemented in 1991, when publishers will be required to purchase forty percent recycled content newsprint for twenty-five percent of their newsprint requirements By the year 2000, California will require publishers to meet 50 percent of their newsprint requirements with recycled newsprint. Most state's newspaper content formulas begin requiring recycled content in the early 1990's, with an expectation that the publisher will print the majority of their newspaper (approximately 50-80%) on recycled content paper by the year 2000. While content legislation is not exactly source reduction, it warrants review in this section since the creation of demand for recycled content reduces the demand for virgin based content at the source. By increasing demand for recycled content, the demand for recycled waste paper increases and less material is landfilled. Recycled content legislation is truly a market development tool. In the last few years, local and state governments have been effective at encouraging citizen participation in newspaper recycling. However, waste newspaper markets have not kept pace with recovery of the material.

Since minimum content legislation at the state level is a new activity, it is not possible to determine its exact effect. However, numerous newsprint mills have announced that they will be manufacturing additional quantities of recycled content newsprint, evidenced by the estimated $1.1 billion which is slated to be spent by mills in the next five years for de-inking capacity. Also, some states like New York have developed voluntary agreements between publishers and the state for the use of recycled content newsprint. The State of New York and the New York Newspaper Publishers Association have agreed that the newspaper industry will increase consumption of waste newsprint from seven percent to forty percent by the year 2000. In Pennsylvania, publishers have agreed to use at least fifty percent recycled newsprint by 1995. To date, no lawsuits have been filed to protest recycled paper content legislation at the state level.

The majority of recycle content legislation has focused on waste newspaper and newspaper publishers. The State of Rhode Island has a proposed content legislation bill for phone books, and California has a proposed bill for glass containers. California also has a proposed bill that would mandate that envelopes be manufactured with only one material, thereby making them more recyclable.

Content legislation allows state government to play a role in market development in an attempt to assure a market for recyclable commodities collected throughout the state. As state governments continue to develop waste reduction programs, and services are delivered at the local level, markets for some commodities will have a difficult time consuming the increased volume of materials. Content legislation or voluntary agreements assure state and local governments of an industry commitment to purchase these materials, up to a certain content volume point. However, content legislation and industry compliance does not always mean direct stimulation of in-state markets. If Indiana were to develop recycle content regulations for phone books and the phone books were manufactured out-of-state, then demand for waste paper in Indiana may not increase. Glass demand within Indiana would likely increase if glass recycle content legislation is developed, due to the large volumes of container glass manufactured in the state.

To date, no state has developed a comprehensive package of content legislation for a variety of post-consumer products. With the new Packaging Waste Reduction Task Force and the Recycled Paper Task Force, the State of Indiana has an opportunity to determine a future course of action in relation to minimum recycled content legislation for a variety of materials.

State Agencies

The yearly purchases of the federal, state, and local governments represents approximately twenty percent of the gross national product. Therefore, there exists an opportunity for government to practice source reduction and to procure products with recycled content. The State of Rhode Island, for instance, is proposing to purchase copying machines that provide duplex copying services, will train all staff to use the machines, and will require double-sided copies of all materials. Similarly, some states require the purchasing of the highest mileage rated tires when purchasing tires for state vehicles.

The State of Indiana has begun a program that provides a price preference to suppliers of recycled paper and other recycled products, in the interest of procuring recycled materials. State agencies throughout the nation are taking hundreds of actions to reduce waste at the source and to increase the recyclability of the materials of which they dispose. A sample of these actions follows:

- State agencies purchasing new carpet retain unworn sections of old carpet for use as walk-off mats in hallways and entryways.

- White envelopes are purchased windowless and without self-adhesive glues, making the envelopes more easily recycled.

- Agencies encourage reuse of file folders and binders.

- Telephone directories are printed to be recycling friendly, as well as forms, documents, and publications.

- Highway departments recycle asphalt and construction and demolition waste.

- Single use items, such as disposable utensils and plates, are banned from specific usage in state cafeterias.

- License plates are manufactured out of recyclable aluminum.

- Highway departments operate as a market for compost products.

- The State of California has an aggressive reuse and recycle program for all materials.

In addition to reducing the waste stream and potentially reducing costs, an effective state source reduction/waste reduction program demonstrates leadership which will be important as the state proceeds to encourage residents and businesses to participate in waste reduction programs. The primary areas that the Indiana state agencies can participate in waste reduction/source reduction are development of source reduction programs, development of recycling and composting programs, procurement of recycled products for State use, and market development whereby the State actually becomes the market for products (glasphalt, compost). A coordinator for the state may be needed to participate in developing and implementing these activities and would be responsible for source reduction, recycling, and composting; as well as procurement assistance for State purchasing agents and internal market development activities.

Typically, a state source reduction coordinator would: (1) work with staff throughout the state to develop in-house recycling programs for wastepaper and other materials; (2) work with department managers to develop source reduction opportunities and incorporate their recommendations as part of the yearly budget preparation process; (3) work with state purchasing agents in an effort to not only procure recycled paper, but also to procure products that would be easily recyclable; (4) would be responsible for training programs, like a Rhode Island program to teach staff how to maintain tires to maximize durability; and (5) would be responsible for an educational campaign for state employees to encourage their participation in reuse, source reduction, and recycling.

Commercial Source Reduction

The business community is responsible for a significant portion of the generation of solid waste in the State of Indiana. Historically, large generators of specific waste commodities have recycled large volumes of materials because it was economically viable. For the State of Indiana to meet the aggressive waste reduction goal, the commercial sector is going to have to assist by means of reducing its waste stream. Source reduction is a concept with which most business representatives are not familiar. Sometimes large businesses like the auto industry have developed effective source reduction programs. However, most businesses appear to be too busy providing their service to spend time and resources focusing on waste reduction. Therefore, it is likely that the State will meet with some lack of interest from the commercial sector in developing effective waste reduction programs. Fortunately, a large portion of the commercial sector already pays for collection and disposal of waste on a variable rate program based on generated volume.

Some states like Rhode Island require corporate participation in source reduction and recycling programs. The State of Rhode Island requires, by law, that corporations in the state author a source reduction and recycling plan that must be presented to the state on a specific date. While this is an option the State of Indiana can explore, the proposed disposal ban would encourage industry to recover recyclable materials without legislating industry directly. Requiring industries' direct participation in source reduction planning could be difficult since the concept would be so new to most business owners. Therefore, states planning to assist with the development of business source reduction programs will need to consider playing a technical assistance role.

The logical role for a state to play in source reduction is a hands-on technical assistance and educational role, whereby the state would meet with industry representatives and perform a commercial waste audit. Similar to an energy audit, waste audits are designed to study the flow of waste in a corporation and make recommendations for source and waste reduction. After completion of a waste audit, the state would meet with corporate representatives to review source reduction implementation options. While attempting to meet with every business in the state would be difficult due to staffing requirements, a state could focus on large businesses employing two hundred persons or more. Local governments could be encouraged to focus on smaller businesses. A state offering waste audits might also produce a source reduction guide to be used by its staff and local government and businesses to encourage corporate waste reduction. The state could also consider some form of temporary tax relief to corporations that develop a costly system of source reduction, such as the returnable container system used by the auto industry.

CASE STUDIES

The case studies presented herein describe the legislative initiatives taken by a representative sample of states to encourage and promote source reduction.

STATE OF MAINE

Maine public law 38 MRSA 1310 created the State's Office of Waste Recycling and Reduction Initiatives (the "Office") which has the responsibility to assess current activities in the areas of waste reduction and to recommend programs to decrease the volume of waste going to the State's incinerators and landfills. Maine's most recent solid waste legislation, PL 1989 Chapter 585, includes four provisions which address source reduction.

First, the Office will take the lead in providing education for source reduction. The Office will build and maintain files on source reduction options for business and industry. The files will include location of activities, costs and benefits of various programs, and who the leaders in the field are. The Office will also develop a consumer education program to encourage source reduction. A special program of technical assistance to businesses is also being created, modeled on Vermont's Waste Cap Program (see below).

Second, the legislation includes product bans. Multilayer (aseptic) juice containers, plastic cans, and plastic yoke connectors are banned in Maine. The State's bottle deposit bill was also expanded to include all single serving beverage containers manufactured from glass, PET (plastic pop bottles), aluminum, steel and tin, and HDPE (plastic milk jugs), as well as wine and liquor containers.

Third, the State government and the University of Maine are required to develop and implement source reduction programs to decrease the amount of waste they generate.

ADFs will be charged at the time of purchase for hard-to-dispose items such as tires, appliances, electronic goods, and lead-acid batteries. The funds are retained in a state trust fund to support recovery options.

STATE OF FLORIDA

SB 1192, Florida's sweeping solid waste management bill mandates recycling and prohibits certain materials - yard waste, whole tires, waste oil, and lead-acid batteries - from landfills and resource recovery incineration facilities. The law also bans specific products, such as metal cans with detachable metal rings. Other types of plastic products including bags, coated paper, and polystyrene foam will also be prohibited unless they are biodegradable within a specified period of time.

ADFs on containers made of plastic, glass, aluminum, and plastic-coated paper will be implemented in 1992 if it appears that these materials are not being recycled at the rate of 50% of the generation ratio.

STATE OF NEW YORK

New York State's Chapter 70 Bill, passed in May of 1988, sets a goal of a 10% reduction in the State's solid waste stream through source reduction. Another 40% of the waste stream is to be diverted through mandatory source separation.

The 10% reduction in the waste stream will be achieved through the existing bottle deposit bill. The State estimates that the bottle bill currently reduces the waste stream by 5% to 6%. An expansion of the bottle bill, adding wine coolers and liquor bottles, will take effect in 1992.

The State is also participating in the Coalition of Northeastern Governors (CONEG) efforts in source reduction (see below). The model legislation developed by CONEG's Source Reduction Council to reduce toxicity in packaging is now being debated in the New York State House.

Associated with source reduction, New York plans to develop an environmental emblem and associated standards to identify products which are reusable, recyclable, or recycled. The program will be voluntary, manufacturers can apply to the State for use of the emblem(s) on their products. If the submitted product(s) meet the State's standards, the products will be permitted to bear the State emblem(s).

A mandatory packaging tax which would place a $.03 tax on any package which is not reusable, recyclable, or recycled has been reviewed for the past three years, but has not been acted on as yet.

COALITION OF NORTHEASTERN GOVERNORS (CONEG)

CONEG brings together representatives of nine northeastern states to address the solid waste crisis facing their states. The first area which CONEG chose to address is source reduction and has created a Source Reduction Council for this purpose. The Council has considered reduction of toxicity in packaging and has developed model legislation to reduce the amounts of mercury, cadmium, and other toxins in packaging. The Council is now working in this area.

VERMONT

The main thrust of Vermont's source reduction efforts are educational. The State is promoting the use of cloth diapers through a flyer being sent to hospitals and day care centers. An environmental shopping campaign is being developed through grocers in Vermont and the State Office of Recycling. The idea of the campaign is to encourage environmentally sound purchasing habits, including buying products which are reusable, recyclable, or will result in less waste.

A state-wide waste exchange for recyclable materials is also being developed, although this is currently only in the planning stages. A grant program for businesses and other organizations will soon be implemented which will provide funds to support source reduction initiatives. Vermont has adopted CONEG's model legislation on reducing toxicity in packaging.

SATE OF WASHINGTON

Washington State's comprehensive solid waste legislation ("1671") defines waste reduction (not source reduction) as the reduction of waste, reuse of materials and products, and reduction of toxicity. The State's Department of Ecology is developing programs in the following areas:

- Citizen education, including environmentally sound purchasing habits and backyard composting.
- Technical assistance to business.
- Reduction in packaging; manufacturers have 5 years (from 1989) to develop a plan to reduce the waste associated with packaging. During this period there will be no bans on packaging.

Washington's Department of Energy is supporting a "Master Recycler" program which trains volunteers in source reduction and recycling. In exchange for 40 to 50 hours of training, volunteers are asked to go out into the community and work with others. One of the objectives of the program is to initiate changes in behavior to encourage source reduction. Students are asked to focus on three areas:

- Decisions about needs, i.e. do I really need this product?
- Alternatives to new products, i.e. can I rent, borrow, or reuse?
- Shopping selectively, i.e. what is the most environmentally sound product I can purchase, given my need for the product and the lack of another alternative.

The City of Seattle has a very active source reduction program which includes the following:

- A backyard composting program which provides composting bins and one hour of instruction for residents who request it. Nine thousand bins have been distributed and seven composting trainers have been utilized in training residents.
- A survey to measure the effectiveness of the source reduction program. Because the effects of source reduction on the waste stream are difficult to measure, this survey is being conducted to measure the baseline attitudes and behavior. A similar survey will be conducted periodically to determine how effective the source reduction programs are.
- An annotated directory of second-hand, rental, and repair businesses is being developed to assist residents and businesses in finding alternatives to purchasing new products.
- Cooperative programs with food retailers which include a $.03 rebate for customers that reuse their bags, the sale of cloth grocery bags, in-store presentations on environmentally sound buying, and jointly sponsored billboards encouraging source reduction.
- A series of posters and brochures that have been hand delivered to most offices in downtown Seattle. Brochures cover issues such as two-sided copying, use of

single-sided copies as scratch paper, storing information on computer disks, and "bring your own mug to the office".

STATE OF RHODE ISLAND

The State of Rhode Island passed mandatory recycling legislation in 1986 that requires both residential and commercial participation in recycling of solid waste. In July 1989, Rhode Island residents began paying a five dollar deposit on new lead-acid batteries; refundable when the batteries are returned for recycling. Metal beverage containers are banned, as are plastic food or beverage containers manufactured with more than one resin.

The Rhode Island State Legislature is considering source reduction legislation during the 1990 session. Rhode Island bill 90-H 9136 - "Relating to State Agency Purchasing Practices" - would require state agencies to submit a plan for eliminating single-use products and encourage state agencies to purchase used furniture. The bill also requires purchase of duplex copy machines and training of employees on this equipment, and mandates double sided usage of paper. The bill also requires purchase of the highest available mileage tire when purchasing tires at the state level.

Rhode Island bill 90-H 9133 "Relating to Degradable Plastic" - would require new products be sold in rigid plastic containers that are degradable, biodegradable or photodegradable. The same requirement would apply for vendors in relation to plastic retail carry-out bags. Bill 90 H-9148 "Relating to Waste Recycling" - Telephone Directories requires that directories be bound with glues compatible with recycling and that directory manufacturers must use a minimum of 40% post-consumer recycled paper.

BARRIERS TO SOURCE REDUCTION

Barriers to effective source reduction exist in Indiana on many levels. Development of a successful source reduction program will require that many of these obstacles be reviewed and addresses in the final program design. Some of the barriers to source reduction are reviewed herein.

LACK OF AWARENESS AND MOTIVATION

Source reduction efforts hinge on both the population's awareness of the need to reduce waste at the point of generation and on reasons for the population to reduce waste. Both producers and consumers must be educated regarding the desirability of source reduction. In addition, methods to provide motivate both the producers and consumers to practice source reduction, such as disposal or product bans, are necessary.

LACK OF ECONOMIC INCENTIVE TO REDUCE WASTE

The increasing cost of waste disposal has not been fully quantified and is not reflected in either disposal charges or in product prices. Economic incentives to manufactures to reduce packaging waste, produce uniform packaging such as a standard bottle type, and to produce products from re-usable materials are required. Similarly, economic incentives to consumers to purchase products that incorporate source reduction principles are required. These incentives, possibly in the form of ADFs or increased waste disposal fees, send and "economic signal" to producers and consumers that increases the desirability of source reduction.

WASTE DISPOSAL BILLING SYSTEMS

The current waste disposal billing systems used by the majority of the state will be difficult to convert to a volume- or weight-based billing system. The crucial economic role of source reduction in solid waste management is not currently recognized; conversion of waste disposal billing to a volume-based or weight-based system is necessary to educate the public about the actual cost of waste disposal.

LACK OF MODEL PROGRAMS

Nationally, source reduction strategies are only just beginning to be incorporated into solid waste management plans. Therefore, few models of successful city and state programs exist from which to base new source reduction programs.

LACK OF LOCAL GOVERNMENT FUNDING

Generally, source reduction efforts have not received local funding. Without some local government funding, development of successful source reduction programs is likely to be limited.

TECHNICAL PAPER ON RECYCLING

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

BACKGROUND

INTRODUCTION

As a society, the population of the United States has been encouraged to be wasteful, generating and disposing of wastes at rates higher than many other industrialized countries. Historically, the wastefulness of U.S. citizens and businesses can be attributed to three factors: (1) the high availability of inexpensive raw or virgin materials for product manufacturing; (2) the profitability to manufacturers for the production of and marketing of disposable goods made from inexpensive virgin materials; and (3) the low cost for disposal of such products. Until recently, most local governments and waste haulers providing solid waste collection and disposal services have encouraged mixing of wastes, then land disposal. Time has demonstrated that this simple system of waste disposal is not always financially or environmentally sound. Dwindling landfill capacity and a trend towards more restrictive landfill siting due to potential environmental complications has caused a significant increase in the costs of waste disposal and a corresponding evolution of more efficient and responsible waste management methods. Thus, numerous cities and states have developed effective waste reduction programs in the past few years.

As with other states, the development of strategies for cost- and resource-effective waste management in the State of Indiana that will accomplish significant waste reduction in line with the State's goal of 35% by 1996 and 50% by the year 2000 will have to be tailored to each community's needs.

Recycling is a waste management method whereby waste materials are collected and reprocessed into new goods, rather than being landfilled or incinerated. Solid waste recycling methods differ for a variety of reasons, including population size and density to be serviced, who or what entity is to provide collection and disposal services, the availability of local markets to utilize recovered materials, and the desired results of a waste reduction program.

Strategies that have typically been utilized by state and/or local governments of differing population sizes to accomplish waste recycling are presented below.

Major Urban Areas

Numerous major population base cities are proceeding with development of waste reduction and recycling programs because of a lack of landfill capacity and the escalating cost of disposal. The typical program includes provision of residential curbside recycling services, along with additional programs to reduce waste generated by the commercial sector. Cities like Cincinnati, Miami, Philadelphia, San Francisco, and Seattle are providing residential recycling services to their residents. Many other large urban areas are also delivering or are planning to deliver recycling services. In some cases, the recycling service is provided by local government, as is the case in New York, Philadelphia, and Austin. However, most cities are contracting with the private sector for the provision of service. The majority of cities offering curbside recycling service provide residents with plastic household recycling containers and provide collection once per week. Many cities have encouraged the majority of their citizens to participate in curbside recycling programs since residents only need to separate recyclable materials from other waste and place the materials out for collection. Some cities collect recyclable materials separated by material type and some collect co-mingled materials. The collection technique is generally dependent upon local markets, labor costs, processing facility capabilities, and the service provider's preference. Most curbside collection programs deliver service to single-family homes and small apartment complexes. Some cities, including Seattle and San Jose, have demonstrated an overall system cost reduction based on delivery of recycling service. The cost for delivery of service varies widely throughout the nation; however, the range is approximately $15-24 per year for service to each household.

Service delivery to large multi-family housing units has been more problematical due to additional equipment requirements. Multi-family units typically require large storage containers which are costly. Tenants in these buildings usually do not have storage space for recyclable materials, and therefore do not participate as vigorously as residents of smaller unit complexes. However, major urban areas are beginning to deliver recycling collection service to multi-family housing. New York City is one-third of the way into its implementation program, serving over one million households.

Large urban areas are also encouraging the participation by the commercial sector. While most city governments do not provide collection to private sector businesses, they encourage recycling firms and waste haulers to do so.

Before the widespread implementation of curbside collection systems, communities intent upon recycling established recycling drop-off centers. These centers, which are usually unstaffed, are places where residents can deposit recyclable materials. Privately operated buy-back depots require residents to bring materials to a location, normally staffed, where they are paid for specific materials.

Drop-off centers are often operated as a fund-raising service by civic organizations. Drop-off and buy-back centers generally receive recyclables generated from the residential waste stream. Both drop-off and buy-back centers are valuable components of urban recycling programs, especially since buy-back centers service a portion of the population that would rather sell materials then simply dispose of the materials.

All recyclable materials must be processed prior to shipment to the final end-user. Processing of materials can be managed in a variety of ways. One of the strategies for major urban areas is the material recovery facility (MRF). MRFs are a relatively new approach to processing recyclable materials. It is estimated that there will be approximately 100 operational MRFs in the United States by the end of 1990. MRFs are designed to process recyclable materials collected from the residential sector. Some communities design their MRFs to perform additional functions including: wood waste processing, household hazardous waste management, demolition waste processing and commercial waste processing. The majority of MRFs are either owned and operated by the private sector, as is the case in Seattle and San Jose, or are owned by the public sector and operated by the private sector under contractual agreement. Many communities are planning to construct MRFs to process residential recyclable materials. After the materials are processed, they are then transported to mills and end-users. Some cities are not building MRFs, instead choosing to rely on traditional wastepaper dealers and scrap metal brokers to process and sell materials.

Medium-sized Cities

The primary strategies for delivery of recycling services in medium-sized cities and the suburbs is basically the same as the delivery of services to large urban areas. Over 1,600 cities nationwide are providing residential curbside recycling services to residents. The delivery of these services is easier in less urban areas where collection vehicles and collectors can provide individualized service. Some medium-sized cities work cooperatively on processing facilities versus constructing independent facilities. The State of Rhode Island has one operational facility and plans to construct two more to process all of the residential recyclable waste in the state. Many medium-sized cities are also beginning to provide residential collections of yard waste. The economies of scale for recycling and yard waste collections work well in higher population-based areas. Similar to large urban areas, medium-sized cities are encouraging private-sector participation in commercial collections. Also, many medium-sized cities have drop-off and buy-back recycling opportunities for their citizens.

Small Towns

Less populated communities are encountering more difficulties in attempting to deliver waste reduction services. This is the case because residential collections can be costly when based on a limited service population. Also, processing of materials can be expensive, as can transport of the materials to market, due to the small volumes of recovered materials. Therefore, smaller communities usually provide drop-off recycling services for residents to minimize collection costs. Unfortunately, usually only a small percentage of the population participates in drop-off programs because of the work and inconvenience required to deliver materials. Some small communities have buy-back centers that develop higher citizen participation due to the economic incentive. If either the private sector or a waste hauler is providing waste hauling services, a recycling collection program should be feasible.

Rural Areas

Similar to smaller towns, rural areas often have very limited waste reduction/recycling opportunities due to the cost of providing collection services and the expense of processing and transporting materials to market. Most rural areas that provide recycling services do so by means of drop-off centers. Some states mandate the provision of recycling drop-off services at landfills and transfer stations throughout the state. Some rural area communities work cooperatively to develop small material processing facilities. Disposal bans have been effective in rural communities such as Wilton, New Hampshire, encouraging citizen use of recycling drop-off centers. Some rural communities can work with existing waste haulers to develop limited collection programs.

EXISTING RECYCLING PROGRAMS

Recycling services provided in Indiana include residential curbside collection, as well as drop-off and buy-back services. Present and future curbside collection programs have been identified by the Consultant through personal interviews and telephone surveys. Table V-2-1 provides a graphic representation of information gathered by the Consultant.

Table V-2-1. Solid Waste Recycling Programs in Indiana

LOCATION	RESIDENT CURBSIDE SERVICE	MATERIALS COLLECTED	COMMENTS
Auburn		A, G, N, P, T	Drop-off program. Curbside in the future.
Butler		A, G, N, P	Drop-off program. Curbside in the future.
Chesterton		A, G, N, P	Drop-off containers.
Columbus		A, G, N, P, WG, CC	Buy-back center and drop-off. Curbside in the future.
Crown Point			Looking into developing city-wide curbside program.
Delphi	1,200	A, G, N, P, T	City also operates commercial recycling program.
Elkhart	2,300	A, G, N, P	Pilot program. Expanding to 13,000 homes in the future. Six drop-off facilities.
Evansville	7,000	A, G, N, P	Pilot program. Expanding to 41,000.
Flora	800	A, G, N, P	Program beginning soon.
Fowler		A, G, N, P, TC, C	Drop-off facilities. Will start curbside in Sept.

Aluminum = A; Glass = G; Newspaper = N; Plastics = P; Tin (steel cans) = T; Corrugated Cardboard = CC; and White Goods = WG.

Table V-2-1. Solid Waste Recycling Programs in Indiana (Continued)

LOCATION	RESIDENT CURBSIDE SERVICE	MATERIALS COLLECTED	COMMENTS
Hammond	2,900	A, G, N, P, T	Pilot curbside will begin soon. Planning to expand to 30,000.
Huntingburg	5,600	A, N, P, T	Collect glass at drop-off facilities.
Huntington	1,650	A, G, N, P, T	Heading towards city-wide program. Commercial sector recycling program.
La Porte	7,500	A, G, N, P, T	Commercial sector recycling program.
Long Beach	1,000	A, G, N, T	Negotiating curbside contract.
Michigan City		A, G, N, T	Negotiating curbside contract.
Monticello	1,400	A, G, N, P, T	
Munster	6,900	A, G, N, P, T	Program begins in June.
South Bend	2,900	A, G, N, P, T, CC	Plans to increase to city-wide collection (16,100).
Tipton	300	A, G, N, P, T	Pilot program. Planning to expand to 5,000.
West Lafayette	3,300	A, G, N, T	Planning to go city-wide. Hope to include plastics.

Recyclable materials are abbreviated as Aluminum = A; Glass = G; Newspaper = N; Plastics = P; Tin (steel cans) = T; Corrugated Cardboard = CC; and White Goods = WG.

MARKETS FOR RECYCLABLE COMMODITIES

Successful recycling of solid waste represents the act of removing materials from the waste stream, processing them, and returning them to the stream of commerce. The State of Indiana and the Great Lakes Region has numerous mills and end-users that are dependent upon waste materials as a feedstock for production of goods. Many recyclable commodities have sliding scale prices based on the true supply and demand of the material. Therefore, conservative pricing projections of income available from the sale of these commodities is recommended. Purchasers of the materials set the price, not the supplier. Therefore, commodity suppliers in the State of Indiana are dependent upon market forces, which determine commodity pricing. Projections of commodity prices beyond one or two years are not reliable. Historic data usually present a picture of market trends. Expansion of market capacity within a region usually represents an opportunity for suppliers to recover additional volumes of materials from the waste stream.

The market system for recyclable materials is very similar to market systems for other commodities. The many components of the complex market system must work cooperatively to move the recyclable materials through the system so that recyclable materials are reused, rather than disposed as waste.

The first marketing steps include the collection and transportation of recyclable materials to a processor who cleans, classifies, and prepares the materials for sale and shipment to end-users. End-users are product manufacturers who purchase recyclable materials and use them as raw materials, transforming them into new products. The new products then are sold to consumers. Brokers and dealers often arrange transactions between sellers and buyers of the processed recyclable materials. New products may be wholly or partially made of recyclable materials.

The price paid for materials at the various steps depends on the value of the particular recyclable material involved. If the value of a material is low, then there may be a net charge necessary to prompt the transaction and make the recyclable material worth transporting. If the value of the material is high, then a net payment may facilitate the transaction. All participants have to work together or the market system for recyclables will not work; if one of the participants is missing, the market system breaks down.

The following characteristics of markets for recyclable materials generally determine their proper functioning, strength, and potential for future development:

- Materials must be sorted and processed into specific grades to be used successfully as a raw material.

- Materials must be free of contaminants. (Contamination may result from product design, mixing during collection, or inadequate processing.)

- Some materials have a marginal raw-material value to begin with; values drop exponentially as materials are classified as lower grades, mixed, or contaminated. At certain points, materials become worthless.

- Some materials must be sorted into sub-categories to screen out prohibited materials; this is labor intensive and, therefore, cost prohibitive in many cases.

- Processing often results in residual waste (i.e., contaminants and unusable materials) that are discharged as sewage or solid waste.

- Technology for dealing with contaminants has been improving; however, controlling the number and variety of contaminants is one of the main costs of processing recyclable materials.

- Materials must generally be baled (compacted and banded) to facilitate handling and shipping; other processing and preparation may be required for specific materials.

- Transportation costs are significant, relative to material value; high transportation costs block the movement of low value materials.

- Market conditions for recyclable materials can be highly volatile and cyclical. Dramatic price swings for a material have traditionally led to periodic shortages or gluts of the material. Changes in the prices for virgin materials add to the generally unstable market conditions. Considerable skill and flexibility is required to weather the ups and downs of these variable conditions.

- The recycling industry is also affected by normal business cycles. When demand is high, the industry increases production to higher levels of capacity and profits increase. During these periods of expansion, the industry accumulates capital that is then invested in upgrading facilities or in expanding to provide new capacity. The addition of new capacity results in increases in supply and decreases in prices, and the industry enters a period when little money is invested in capital plant. Policy makers should be aware of these alternating phases of expansion and stasis. Changing production processes to use recyclable materials requires an investment in capital plant. Policy makers can best direct efforts to encourage this type of investment by anticipating periods of expansion, and creating policies and programs that coincide with the momentum for capital investment during these periods. Alternatively, policies designed to encourage investment in new equipment for processing recyclable materials are likely to have little positive effect during static phases.

- The markets for some materials (wastepaper, aluminum and ferrous metals) are affected significantly by national and international market trends because these materials are traded worldwide. Other materials' markets (glass and tin cans) are affected by national trends but often have local markets. And, some materials' markets (compost and waste oil) are, for all practical purposes, strictly local.

Commodity Markets

This commodity analysis is based on industries located throughout the State of Indiana and the Great Lakes Region. Overall, the recyclable commodity markets in this area have been good. The area has numerous mills and end-users of recyclable commodities, in addition to the potential for expanded exports to Canada. In particular, the market for some grades of wastepaper will expand, based on current expansion plans of specific mills. This expansion will be important to all communities in the State of Indiana developing aggressive recycling programs. Markets for recyclable commodities, like other commodity markets, are not perfect. Marketing products when an oversupply of the products exists is often difficult. While expansion in commodity capacity is occurring, it is likely that some oversupply problems will occur over the long-term.

Wastepaper

Of the existing waste commodity markets, the wastepaper market is the most volatile. However, in this region, the market for wastepaper has been relatively good, except during 1989 and 1990 when the market for lower paper grades (newspaper and mixed) has been weak. A review of the prevalent wastepaper grades follows:

Newspaper - Waste newspaper is the most frequently recycled material from the residential waste stream. The waste newspaper recycled in the State of Indiana is generated mostly in homes and as a by-product of the local newspaper publishers. Waste newspaper is typically collected and processed by wastepaper brokers and local governments or their vendors engaged in provision of community recycling services. After the material is baled, it is transported and solid primarily to paper mills that produce paper products. One of the primary products manufactured from waste newspaper is new newspaper.

The Consultant interviewed the major consumers of waste newspaper in the region. The FSC mill in Alsip, Illinois is the major consumer of waste newspaper in the region. The FSC mill has a very unique arrangement with suppliers of wastepaper and publishers in communities that supply paper; this program is referred to as the "ton-for-ton" program and is such that if a local newspaper publisher is purchasing rolls of newsprint from the FSC mill, the FSC Corporation agrees to purchase back an equal volume of wastepaper from the recycling firms in the community. This provides the wastepaper suppliers in communities where newspaper publishers use FSC recycled newspaper a competitive edge and a guaranteed market for their waste newspaper.

There has been an oversupply of waste newspaper throughout the nation, especially in the Northeast, during 1989 and 1990. Numerous mills have announced expansion plans which will create new capacity for waste newspaper. Currently, no major expansions are planned for mills in the north central region of the nation. However, mill expansion and new construction in the Northeast, Canada, and Tennessee is expected to increase waste newspaper demand in the north central part of the nation. Minimum recycled content legislation and voluntary recycled content agreements in other states are causing mills to expand capacity.

Relative to other areas of the nation, the State of Indiana has a good potential for long-term marketing of waste newspaper due to the following conditions:

- A good, historic working relationship exists between recycling firms and mills;
- Large mills are located in the region;
- Expansion of mill capacity in Canada and Tennessee is planned; and
- The potential for development of "ton-for-ton" programs exists.

The price paid in the region for waste newspaper seems to fluctuate between zero and $50 per ton based on market conditions. This is for baled newsprint - freight on board (FOB). The industry quality control standard for waste newspaper, "New De-Ink Quality", consists of baled, sorted, fresh, dry newspapers; not sunburned; free of magazines, white blank, press room overissues, and containing not more than the normal percentage of rotogravure (semi-glossy) and colored sections. Prohibitive materials are not permitted, and total outthrows (all papers that are manufactured, treated, or are in such a form as to be unsuitable for consumption as the specific grade) may not exceed 1/4 of 1%. Quality standards for regular newsprint consists of baled newspapers containing less than 5% of other paper types. Prohibitive materials may not exceed 1/2 of 1%. Total outthrows may not exceed 2%.

In mid-1990, Stone Container Company announced plans to produce a recycled content grocery sack using waste newspaper. This product, referred to as the "good news" bag, will consume over 100,000 tons per year of waste newspaper. Stone has agreed to share the technology with all of its competitors and estimates that if all manufacturers use the product, a total capacity of 500,000 tons of newspaper will be required. Non-paper related demand could include refuse-derived fuel (RDF). While RDF is a lower priority of the State of Indiana, it could offer help market stability. Use of waste newspaper for animal bedding also offers market potential.

In summary, the prospect for future recycling of waste newspaper generated in the State of Indiana is good for existing volumes and increased volumes potentially generated by new recovery activities. However, the long-term supply and demand of waste newspaper is unpredictable. Market recessions like the ones experienced in the early 1980's and in 1989 and 1990 are possible, especially as significant new volumes of material are recovered. "Ton-for-ton" agreements between the paper mill industry and communities can be developed to protect both from recessions. The State recycled paper task force and IDEM could assist with the development of such agreements, as well as assist paper mills with their expansion planning. The State could also explore both minimum recycled content requirements and new opportunities for use of waste newspaper within and outside of the paper industry. The State may be required to work with the mill industry, local communities, and surrounding states to assure market capacity.

<u>Corrugated Cardboard</u> - Corrugated cardboard is the largest volume material recycled from the commercial sector. Numerous large business generators and supermarkets have developed effective corrugated cardboard recovery programs to reduce waste disposal costs and to generate revenue. Corrugated cardboard must be baled for transport to mills. Cardboard can be used to manufacture a variety of products, including new cardboard.

There are approximately ten mills utilizing waste cardboard within the State of Indiana, providing significant capacity in the region for utilization of waste cardboard. As with other wastepaper grades, the marketability and price of waste cardboard are dependent upon supply and demand. In recent years, prices for baled waste cardboard have fluctuated between $15 and $65 per ton.

The industry quality control standard for waste corrugated cardboard consists of baled corrugated containers having liners of either test liner, jute, or kraft. Prohibitive materials may not exceed 1%. Total outthrows may not exceed 5%.

The market for waste corrugated cardboard has been depressed during 1989 and 1990. Due to increased demand nationally, the prospect for future recycling is good. However, as states and cities in the region continue to increase recovery of cardboard, the potential exists for oversupply which would lower prices.

<u>Mixed Paper</u> - Mixed paper is a low grade of wastepaper usually consisting of types of paper that are not saleable as a specific individual grade. A significant portion of the mixed paper marketed by wastepaper brokers is actually a by-product of their wastepaper sorting and grading operations and provides little, if any, financial profit. Therefore, most wastepaper brokers do not purposely solicit large volumes of mixed paper. Collection of mixed paper from residents in cities with active recycling programs is very rare. Residential collection of mixed paper is not provided in the majority of communities that provide recycling collections because the value of the material is so low and markets for the material are decreasing nationwide. The few cities that provide collection service of mixed paper are able to financially justify collections due to high tipping fees. The mixed paper generated in homes includes most packaging products.

The price for mixed paper in the region has fluctuated between zero and $20 per ton. The market for mixed paper is weak, and while some expansion is under consideration, it is the Consultant's opinion, based on the market analysis, that the market will not improve dramatically.

The industry quality control standard for mixed paper consists of a mixture of various qualities of paper not limited as to type of packing or fiber content. Prohibitive materials may not exceed 2%. Total outthrows may not exceed 10%.

The prospect for future recycling of mixed paper generated in Indiana for increased volumes is not very good. The prices paid for mixed paper limit its recovery.

Office Paper - Office paper primarily includes white and colored ledger grades and computer paper and is generated by corporations, government, and the public. Waste office paper can be manufactured into a variety of new products, including office papers and tissue products.

Currently, Great Lakes area regional mills have ample capacity to consume additional quantities of waste office paper. Unlike the supply of some wastepaper grades, regional mills experience supply-side problems with certain office paper grades.

The industry quality control standards for colored ledger paper consist of printed or unprinted sheets, shavings, and cuttings of colored or white sulfite or sulphate ledger, or bond, writing and other papers which have a similar fiber and filler content. This grade must be free of treated, coated, padded, or heavily printed stock. Prohibitive materials are not permitted and total outthrows may not exceed 2%. The standard for sorted white ledger consists of printed or unprinted sheets, shavings, guillotined books and cuttings of white sulfite or sulphate ledger, bond, writing papers, and all other papers which have similar fiber and filler content. Prohibitive materials are not permitted and total outthrows may not exceed 2%.

The average price ranges for waste office papers for the region are as follows:

Computer printout	\$170 to \$325/ton
White ledger	\$140 to \$225/ton
Colored ledger	\$90 to \$160/ton

As previously noted, quality control standards for office paper are strict; therefore, a significant labor investment is necessary to meet stringent standards. The waste office paper market situation is a supply-side problem unlike the market for the paper grades. Therefore, these materials should be marketable to existing mills within the region for the long-term.

Glass

Container glass can be recycled and is most often remanufactured into new container glass. Unlike wastepaper commodities, prices paid for waste glass, referred to as "cullet," are relatively stable. However, prices are relatively low because cullet competes with inexpensive raw materials such as sand, limestone, and soda ash. Glass is collected nationwide by many community-supported residential recycling programs. Most glass end-users require glass to be color separated. Cullet is expensive to transport long distances because of its weight and special equipment requirements.

There are five primary cullet users in Indiana and eight glass facilities in surrounding states. Collectively, these facilities have the capacity to consume all of the waste glass generated in the State, with the possible exception of green glass. The current average price paid for glass in the area is as follows:

Clear cullet	$30 to $70/ton
Green cullet	$10 to $50/ton
Amber cullet	$10 to $55/ton

Cullet purchasing standards vary depending on specific markets. However, glass quality control standards are usually high, requiring removal of contamination. The quality standards for the Indiana glass facilities are strict because none of the facilities have what is referred to as benefication (cleaning) equipment. If glass does not meet quality control standards, the purchasers will reject the material. Foreign matter such as pyrex or ceramics can cause glass facilities serious problems if mixed in with cullet .

Metals

Metals can be broadly classified into two groups: ferrous and non-ferrous. Ferrous metals are those in which iron is a major component. Ferrous metals are attracted to magnets, a characteristic that allows easy separation. Non-ferrous metals include aluminum, copper, brass, gold, and silver. Valuable metals and large volumes of lower grade scrap metals have historically been recycled by private sector scrap dealers.

Although the market for metals has been cyclical, the highs and lows have not been as drastic or as abrupt as those of wastepaper. One difference in the scrap metal industry is that different metal commodities experience market shifts at different times. The majority of the industrial scrap metal is generated in large volumes and automobile scrap is already recycled because it is economically attractive for the generator to do so. Aluminum cans generated as post-consumer waste are also recycled to a significant degree due to the of the high value of this scrap. However, this is not the case with appliances and steel cans which are generated at the residential level. The following reviews each of these materials.

<u>Steel Cans</u> - Often referred to as tin cans, steel cans deliver a variety of products to the consumer including coffee, vegetables, and juices. The de-tinning industry recycles tin cans by separating and recovering the steel and the tin. At de-tinning facilities, the containers are treated with a hot caustic

solution to strip tin from the container. The tin is then removed from the caustic solution by electrolysis. High-grade tin is recovered and the steel is sold for reprocessing.

The Consultant interviewed the two largest consumers of steel can scrap in the nation; one business has a facility in Gary. Both businesses expressed an interest in purchasing all of the cans that could be recovered in Indiana. Each offers long-term contracts for material (e.g., 10 years), with floor prices. The price paid for scrap steel cans in the region during the past few years has been $45 to $80 per delivered ton.

Industry quality control standards depend on the specific market; however, they generally call for tin-coated or tin-free cans. The cans may include aluminum tops, but must be free of aluminum cans, non-ferrous scrap, and non-metallics of any kind. Cans must be free of food, and have labels removed.

The market for scrap steel cans within the State of Indiana is good, with strong prices relative to other regions of the county. The primary potential problem will be transportation costs to move cans collected in rural areas to consumers.

Aluminum - Aluminum recycling has become a significant industry because the aluminum industry has aggressively implemented and supported recycling programs. Aluminum is much less a factor in the waste stream now than before the aluminum industry's aggressive programs, which began in the early 1970's. Since aluminum has a higher economic value than most recyclables, recovery rates for both aluminum cans and scrap are higher than for other recyclable materials.

The Indianapolis market, as well as the Chicago market, provides numerous opportunities for marketing aluminum beverage can scrap and aluminum scrap. Prices for aluminum cans fluctuate between approximately $800-$1,500 per ton. The aluminum industry has the capability to consume all of the aluminum scrap that can be generated in the State of Indiana.

The industry standards for aluminum beverage can scrap have a minimum density of 14 pounds per cubic foot, and a maximum density of 17 pounds per cubic foot for unflattened UBC and 22 pounds per cubic foot for flattened UBC. The standards require a minimum volume of 30 cubic feet, with bale range dimensions of 24 inches to 40 inches by 30 inches to 52 inches by 40 inches to 84 inches. The only acceptable tieing method is four to six 5/8 inch by 0.20-inch steel bands or six to ten No. 13 gauge steel wire (aluminum bands or wires are acceptable in equivalent strength and number). Use of skids and/or support sheets of any material is not acceptable. UBC moisture content is not to exceed 2%.

White Goods - The recycling and disposal of appliances, also referred to as white goods, from the State of Indiana occurs at scrap metal facilities in Indianapolis and Chicago that prepare the recovered materials for transport to the mills.

Currently, the shredding and landfilling of appliances involves a serious potential risk. Appliance recycling throughout the nation has decreased in the past two years due to a concern about the presence of polychlorinated biphenyls (PCBs). PCBs are regulated by the United States Toxic Substance Control Agency which sets standards for their handling and disposal. Currently, the disposal options for PBCs are determined by the PCB concentration. Generally when PCBs occur in material at concentrations below 50 parts per million (ppm), they are not regulated. Above that level, special standards for handling and disposal apply. Therefore, the concentration levels of PCBs are a critical issue for appliance recyclers.

In the normal recycling process, white goods are shredded and the metal is then magnetically separated from the remaining material which includes plastic, rubber, wire, dirt, etc. -- a residue known in the industry as "fluff." Normally, the fluff is disposed in a landfill and the separated metal is sent on to a steel mill for reprocessing. Recently, fluff has been tested by local environmental authorities and, in some instances, alleged to have more than 50 ppm PCBs.[1]

At issue are appliances manufactured before 1979 which contain small capacitors that may have PCBs inside them. PCB is a oily liquid substance used as a dielectric fluid in capacitors; capacitors are small devices attached to electric motors used to regulate the electrical flow. Capacitors can vary in size from a few inches long to almost a foot in length. Some are easy to remove from the appliances, while others are much more difficult to locate and remove. By agreement of appliance manufacturers, appliances made since 1979 do not contain capacitors containing PCBs.

The possible presence of PCBs presents a major problem for companies interested in recycling appliances. The recycling of appliances is a financially marginal enterprise The recycling company must collect appliances, shred them, load them for transport to a mill, and pay for disposal of the fluff. The potential problems of generating material with high concentrations of PCBs, in terms of both disposal costs and liability exposure, create an uneconomical situation This is why most scrap dealers in the Northeast have stopped accepting appliances. One approach to solving this problem would be for the scrap dealer to remove capacitors from units, at significant labor expense, and properly pack the capacitors for transport to an approved disposal site. Landfilling appliances with capacitors containing PCBs also carries a serious risk of liability exposure.

[1] Institute of Scrap Recycling, Inc., Background Information: Handling Old Appliances, 1987 and 1988.

The Institute of Scrap Recycling Industries (ISRI), the trade association for scrap dealers, is currently working with the United States Environmental Protection Agency (EPA) to determine if PCBs do, in fact, occur in fluff in concentrations greater than 50 ppm. Seven sites around the country are now being used in a pilot program. Samples of shredded scrap from each of the sites are being tested for PCB concentrations. The EPA report on this pilot project is due to be released by the end of 1990. The report may conclude that fluff does not contain PCBs at concentrations greater than 50 ppm, which should stimulate the recycling of appliances. Or, the report may conclude that further testing is required to make a final determination. In the meantime, ISRI is advising its members to recycle only those appliances which are certain not to contain capacitors with PBCs. Detroit area scrap brokers report that they are testing their own fluff and are within current EPA standards.

The capacity for the industry to consume appliances is good given the concentration of steel mills in the region. However, the toxicity issue is one that must be reviewed by all parties handling waste appliances.

General Scrap Metal - General scrap metal includes a variety of scrap metals from industrial and residential sources. The materials currently being processed are transported to Detroit for preliminary processing and are then shipped to steel mills. The material is categorized as No. 2 steel. The price range in Detroit historically has been $20 to $40 per ton. The Detroit market reports that it can consume all of the No. 2 scrap that can be generated by Indiana. Quality control standards are specific to each purchaser.

Plastics

Based on current estimates of total municipal solid waste landfilled in the United States, approximately 13% of all landfilled material consists of plastics. Although the actual annual volume of plastics disposed each year has increased significantly since 1970, the total weight of these disposed materials has remained relatively constant due to the lighter, more durable plastic packaging currently used. This increase in volume without a commensurate increase in weight increases the difficulty of economically recycling plastics. Plastic packaging is now displacing a number of other alternative materials used in the past for packaging, including glass, tin cans, aluminum, and paper. Most plastics (i.e., thermoplastics) can be recycled without significant technical difficulty, mainly by reheating the material and reforming the resin into a new product. A large portion of the plastic industrial scrap generated in the United States is already being recycled, either in-plant or through recyclers who clean, granulate, and pelletize the scrap material for sale to end-users.

The primary difficulty in recycling plastics arises due to the numerous types of plastics and the difficulty in differentiating between and separating the different plastic materials. In the past, plastic recycling has been hindered as a result of two major problems: (1) contamination due to an inability to separate plastics by resin type and (2) the need to process the plastic into a transportable densified material.

Based on discussions with a number of recyclers, brokers, and major end-users in the central United States (including Indiana, Wisconsin, Illinois, and Ohio), a number of firms are currently willing and able to purchase post-consumer plastics collected in Indiana. However, market barriers exist for certain types of plastics. The main barriers for styrene, LDPE and other non-PET/HDPE plastics will be: (1) generating sufficient quantities of each resin type for economical processing; (2) educating the general public as to which products are made of these materials; and (3) properly separating these materials once collected. The following is a brief description of the five major groups of recyclable plastics, along with a discussion of major recyclers/end users, quality standards, transportation requirements, and current material pricing.

Polyethylene Terephthalate (PET) - Based on information provided by the Plastic Bottling Institute, PET accounts for approximately 20 to 30% of all plastic containers used nationally. New or "virgin" PET plastic is primarily used in soft drink containers, while recycled PET plastic is used in a number of manufacturing products, including polyester strapping, fiberfill, tennis ball coverings, and polyester fabric.

Historically, the market for PET has been relatively stable. Currently, prices paid for post-consumer PET beverage containers range from $60 to $200 per ton. Transportation costs for shipment of PET varies directly with the distance traveled to the processor's facility. Transportation costs usually range between $20 to $60 per ton. Granulating PET bottles generally increases the price offered by processors by up to $80 per ton. However, the actual cost of granulating PET bottles usually ranges between $80 and $100 per ton.

High Density Polyethylene (HDPE) - The Plastic Bottling Institute estimates that HDPE accounts for approximately 50 to 60% of all plastic containers consumed nationally. HDPE is used in a variety of plastic containers and products. Most individuals associate HDPE with the clear, colorless, or otherwise referred to as "natural" color plastic milk, juice, and water containers. In addition, HDPE is used to produce containers for various other liquid products such as motor oil, cooking oil, laundry detergent, and shampoo.

Post-consumer HDPE is currently used in a number of manufacturing applications, including plastic lumber, roofing products, highway construction barrels, flower pots, drainage pipe, and mud flaps. The material, like PET, is generally granulated, cleaned, and pelletized by plastic recyclers for sale to end-product manufacturers. Post-consumer HDPE accounts for approximately 60 to 65% of all post-consumer plastic currently recovered.

The market for HDPE has been under extreme pricing pressure during late 1989 and the first half of 1990. HDPE processors contacted cited a significant weakening in offshore demand for post-consumer HDPE and competition for virgin HDPE material as the primary reasons for the sharp decline in prices paid for post-consumer HDPE. As recently as 1988, processors had been paying up to $360 to $400 per ton of post-consumer HDPE. Current quotes for post-consumer HDPE range from $80 to $350 a ton. Most processors feel the market price for post-consumer HDPE will at least stabilize at current levels, if not increase, primarily as a result of an explosion at the Phillips Petroleum virgin HDPE production facility in Texas. The explosion at the plant has reduced national production of HDPE by approximately 20% or 1.2 billion pounds per year. In addition, processors contacted have indicated that the Phillips facility will not be on-line for at least one to two years. Therefore, it is likely that demand for post-consumer HDPE will stabilize, if not increase, over the short to intermediate term.

Prices paid for post-consumer HDPE also vary greatly, depending upon the degree of color separation performed prior to shipment. Mixed loads of HDPE (which may include milk and water containers, shampoo and detergent bottles, and motor oil containers) are generally of lesser value to plastic processors than pure loads of colorless HDPE (milk and water containers). Mixed post-consumer HDPE prices quoted by processors ranged from $80 to $160 per ton, while pure colorless loads of HDPE commanded significantly higher prices, generally ranging from $180 to $350 per ton. Processors of HDPE value colorless HDPE more highly since the colorless variety of HDPE can be used in a number of manufacturing applications, particularly for products that require specific coloring. HDPE, like PET, must be densified prior to shipment in order to make it cost effective.

Low Density Polyethylene (LDPE) - LDPE and other flexible or film plastics are used in a number of packaging applications such as garbage bags, ice bags, stretch wrap, and other plastic packaging that does not return to its original shape after applying pressure. Post-consumer LDPE is used in a number of manufacturing processes such as garbage bags, pipe, and geotextiles. Markets available for processing LDPE are very limited at this time, with the majority of LDPE recycling occurring in the industrial community.

Expanded Polystyrene (Styrofoam) - Styrofoam is used in a number of applications, most notably for food handling (cups, plates) and by fast food restaurants in fold-over sandwich containers, otherwise referred to as "clam shells." Currently, styrofoam is being recycled to a limited degree by individual processors. Until recently, no large scale recycling effort had been performed due to the limited supply of styrofoam. McDonald's has recently begun to collect styrofoam packaging at a number of its New England restaurants, which is then processed for sale to local end product manufacturers. Cleveland Reclaim Industries/Turtle Plastics is currently manufacturing license plate holders from McDonald's styrofoam containers in the Cleveland, Ohio area. In addition, other processors are producing pelletized recycled material to be sold back to their industrial plastic supplying customers. However, these materials need to be baled and relatively free of contamination.

A number of other procedures used to recycle styrofoam are in the development stages; until recently, styrofoam was not widely considered as recyclable material.

Other Plastics - Other plastics considered to be recyclable include thermal plastics used in foam pads, trash cans, trains, and automotive parts. Since these products are composed of a number of plastic resins, separation of these materials by resin type would most likely not be cost-effective. Some Southeast Asian countries are hand sorting these mixed plastics transported from the United States. In addition, certain extrusion technologies which use mixed plastics for manufacturing sign and fence posts and plastic lumber are also in the production stages. Post-consumer mixed plastics generally have a lower value relative to post-consumer PET and HDPE, with firms paying $10 to $20 a ton for mixed materials. For the most part, recycling systems for mixed plastics are still in the development stages and will be influenced by a number of factors, including acceptance of post-consumer mixed plastics by end-user manufacturers and the future price and availability of competing materials.

PVC is included in this category and is considered a recyclable specialty plastic with a high market value. However, the short supply of post-consumer PVC has limited its collection and reuse.

Major Plastics Recyclers and End-users

The current very firm market for post-consumer plastics is a result of: (1) increased processing capacity by a number of major plastic recycling and end-product manufacturing firms entering the plastics recycling industry, and (2) entrenched firms expanding their respective operations. Based on telephone interviews with several plastic recycling/processing and end-product manufacturing firms, a large market is available for the sale of post-consumer PET and HDPE plastics generated in the State of Indiana. Table V-2-2 provides a representative list of major PET and HDPE processors and end-users that are willing to purchase post-consumer plastics from Indiana, along with facility location and reported processing capacity.

Table V-2-2. Major PET and HDPE Processors/End-Users

COMPANY	LOCATION	ANNUAL CAPACITY IN TONS PER YEAR
United Resource Rec.	Findlay, Ohio	5,000
Eaglebrook Plastics	Chicago, Illinois	6,000
Mid-West Plastics	Stoughton, Wisconsin	10,000
Cleveland Reclaim Industries	Cleveland, Ohio	15,000
N.E.W. Plastics Corporation	Luxembourg, Wisconsin	2,250
Wellman	Allentown, Pennsylvania	550,000
Partech	Anderson, Indiana	10,000
Trojan Plastics	New Castle, Indiana	6,000
Plastics Recycling Alliance	Chicago, Illinois	10,000

This list contained in Table V-2-2 is not meant to be all-inclusive. Instead, it is meant to provide a representative sample of the major PET and HDPE recyclers and end-product manufacturers with the ability to handle post-consumer PET and HDPE plastic collected and handled within the State of Indiana. All firms were extremely interested in receiving larger amounts of PET and HDPE materials generated within the state.

Markets for LDPE, styrofoam, and other non-PET/HDPE plastics are much more limited due to the difficulty associated with: (1) the public's ability to recognize and separate these materials for recycling; (2) increased handling costs by plastic recyclers during separation from PET and HDPE; and (3) the overall limited supply of each of these separate plastic resins.

RECYCLING STRATEGIES

Development, implementation, and operation of a successful recycling program requires that four groups of strategies be considered. They are:

- Collection Strategies
- Processing Strategies
- Market Development Strategies
- Funding Strategies
- Education Strategies

A discussion of strategies embodied within each group follows.

COLLECTION STRATEGIES

Residential Curbside Collection Services

Numerous cities have implemented or are in the process of planning residential curbside recycling programs. The cities of New York, Philadelphia, and San Francisco are serving approximately one-third of their single-family and small-unit complexes. The cities of Seattle, San Jose, Charlotte, and Cincinnati are serving all of their single-family households. The cities of Miami, Los Angeles, and Phoenix are providing pilot collection programs and are planning to serve all households. The cities of Denver and Nashville are planning programs that will be implemented within the next year. Residential curbside programs provide citizens with a simple system for participating in recycling. The primary components of these programs include public participation, collection mechanisms, processing of materials, and marketing of materials. Some cities provide the curbside collection service in-house, by means of their own public works departments, while others contract for services. Usually, if a city provides waste collection services, it will consider providing recycling collection services.

The provision of residential recycling services is critical to encouraging citizens to participate in waste reduction. The successful recycling programs have provided weekly residential collections, household recycling containers, and collection service on the same day as trash collection. Since trash collection services may be provided in different ways, provision of collection service on the same day isn't always possible. The exact type of program differs across the county, based on who is providing the service. Some communities provide source-separated services, whereby materials are separated by material type by residents prior to collection. Others provide collection of co-mingled materials.

At the state level, there have been two primary strategies to delivering local residential curbside recycling service. One strategy for the state to mandate that citizens participate by keeping recyclables separate from waste items. The State of New Jersey was the first to implement mandatory recycling regulations, followed by Rhode Island and Connecticut. The second strategy, first implemented in Oregon, is for the state to mandate that local government must provide residential collection services to its citizens. In Oregon, all cities with populations of over 4,000 must provide residential recycling collection services. Given the aggressive waste reduction goal in Indiana, it is likely that one or both of these strategies will be required. Some communities that mandate citizen participation enforce the law, some do not. Enforcement is usually in the form of a fine similar to a parking ticket or a refusal to collect waste, or both.

Local governments need to decide whether to provide the collection service themselves or to contract for the provision of service. The local governmental role is entirely different depending on which strategy is developed. If the local government is delivering the service, it will need to employ staff, purchase equipment, and make arrangements to process materials. If the local government is contracting for service, it will be required to perform a competitive bid process. Most contracts are for a five-year period. Contracts usually require a monthly payment to the contractor versus up-front capitalization. Such contracts generally require the vendor to provided collection, processing, and marketing services.

Some states have mandated which recyclable materials must be collected; other states have left this decision to local governments. Typical materials collected include newspapers, glass, and metal cans. Some communities also collect plastic containers and other materials. A decision on what materials will be collected is critical to selecting appropriate collection and processing equipment. Serious consideration should be given to requiring collection of newspaper, phone books, corrugated cardboard, grocery sacks, magazines and catalogs, office paper, plastic containers, steel cans, aluminum cans, glass, and motor oil. If the If disposal bans for these and other materials are enacted, consideration could be given to aligning materials to be collected with materials banned from disposal;

this may not be possible for some materials such as appliances. Consideration could also be given to mandating the provision of waste collection service at the local level, such that every city with over specific population size would be required to provide waste collection service (e.g., over 5,000 persons). As for whether the state should mandate citizen participation, consideration could be given to a voluntary program for two years, with consideration of mandatory participation in cities not significantly reducing the waste stream. Mandatory participation may not be necessary to the success of a recycling program. However, if voluntary recycling goals are not reached within a specified period, enactment of mandatory programs may be necessary to achieve the goals.

Local governments providing residential recycling services should consider providing residents with household recycling containers. Most large city recycling collection programs have been successful in encouraging citizen participation by supplying containers for household use. Most communities provide collection service to single-family homes and apartments up to usually four or six units. Larger apartment or condominium units (up to 25 units) are generally provided with specialized service, which is more costly. Although large residential buildings are more costly to service, collection service should be offered, as should recycling containers. Consideration should be given to the frequency of collections; weekly collection is the suggested frequency.

The provision of residential recycling services is not a service that will pay for itself solely from the sale of recyclable materials. The earned income from the sale of materials will assist by means of offsetting the cost of provision of the service. There will also be financial savings based on avoided disposal costs and avoided operational costs based on normal waste hauling services. However, in most cases, a funding mechanism will be required. Provision of matching funds to local governments by the state would assist with recycling start-up phases. Over the long-term, local government may need fund the service.

Multi-family Recycling Services

Over 1,600 cities now provide residential recycling services to their residents. The majority of these services are provided to single-family living units, and unit sizes up to usually four- or six-plexes. Cities have found that multi-family living complexes are the most costly to service and resident participation is often lower, so many cities have not begun to service multi-family living units. However, the participation of all Indiana citizens in recycling activities, regardless of what form of housing they live, may be necessary if the State's aggressive waste reduction goals are to be realized. Therefore, the State could work with local governments to ensure the provision of recycling collection services to residents of multi-family living units in the same manner as those provided to single-family residences.

Owners of multi-family buildings with over 25 units could be required to produce a recycling plan that would be provided to the local government for review. The plan would outline what materials will be collected, how they will be stored, and how collection service will be managed. Consideration could be given to mandating the provision of multi-family recycling collections for all cities over a specified population size (e.g., over 5,000 persons).

One of the difficulties of providing recycling services for multi-family living units is the lack of space in apartments to store recyclable materials and the lack of space on-site to store collected recyclables for collection. Building codes could be altered to require provision of adequate space for storage of recyclable materials in any new multi-family complexes, or existing complexes when remodeled.

Rural Areas

Providing recycling services to rural residents is difficult because of the cost of collection of materials and the cost of transporting materials to processing facilities. Provision of recycling opportunities to rural residents may require assistance from the state. All landfill and transfer station operators should be required to provide recycling drop-off facilities. Consideration should be given to requiring waste haulers that provide service to residents in communities with populations of less than 5,000 to provide recycling services to their customers.

Commercial Sector

The commercial sector's participation in waste reduction will be critical to the success of meeting the State's goals. Most cities and states have not engaged in providing collection services for the business sector. States like Rhode Island and Maine have mandated corporate participation in recycling. Other states have, in effect, persuaded the business sector to participate by means of disposal bans. Most communities have determined that the cost of recycling for businesses should be borne by the businesses themselves, as a cost of doing business. However, some states provide technical assistance to businesses developing waste reduction and recycling programs. Employment of staff to provide technical assistance to businesses developing recycling and source reduction programs could be considered. Consideration could also be given to requiring commercial waste audits of all businesses employing more than 200 persons. Disposal bans will most probably be the primary mechanism for encouraging corporate participation if the State proceeds with development of a disposal ban program. A state could mandate corporate participation in recycling, although this could be held as a secondary option. For a disposal ban to be effective, a technical assistance program will be necessary, as will an enforcement program.

PROCESSING STRATEGIES

Once recyclable materials are collected from residents, they will need to be processed. Local and state governments are developing material recovery facilities (MRFs) for the purpose of processing recyclable materials. Material recovery facilities should be designed to process all of the materials that will be collected by means of residential collection programs. Also, consideration should be given to processing some commercially generated materials. Some states have developed a state network of MRFs to support local government's programs of marketing recyclable materials. The three primary ownership strategies are private sector ownership and operation, governmental ownership and private sector operation, and governmental ownership and operation. State ownership and private sector operation is working well for the State of Rhode Island.

Similar to fire houses that are strategically located to provide fire prevention services, MRFs need to be sited to maximize use by local governments. If the state were to assist with the development and financing of a statewide network of MRFs, the State and districts would need to work together on siting. Other states in the MRF business have contracted with the private sector for operation of the facilities on a five-year basis. The contractor is responsible for receiving all materials, processing materials, assuring quality control, and marketing materials. The State or local government would have to perform a competitive procurement process to select the vendors.

A second potential strategy for development of the MRFs is for the State or local governments to contract with the private sector to build, own and operate the facilities. This method allows for the private sector vendor to pass facility costs on to the State or local government in the per-ton processing costs over the course of five years. Management of the State's financial role is dependent on the State's interest in the long-term strategy of how to fund and who should fund facilities (as reviewed in the funding section of this paper).

If the State were to decide not to play a role in funding the MRFs, then local governments would have the financial burden. State financial support would permit smaller local governments to participate and permit the State to participate in the facility siting process. Also, the State's participation in the process could assure that adequate capacity is developed and that distribution of facilities throughout the state is completed in logical manner.

Consideration should be given to designing facilities that are as comprehensive as possible in relation to the recovery of materials. This might include processing commercial waste and materials like tires and wood waste, in addition to residential waste.

MARKET STRATEGIES

To complete the recycling and waste diversion cycle, the solid waste must be removed from the waste stream and returned to the stream of commerce. Therefore, the success of city-wide recycling programs is dependent upon viable markets that will consistently purchase recyclable commodities. For some materials, this is not expected to be problematical. The steel can recycling industry has reported that it can purchase all of the steel cans collected in the State. However, the market for waste newspaper has been weak for the past two years, due to an oversupply of waste newspaper at the mills. This oversupply is partially the result of hundreds of new residential curbside collection programs, collecting waste newspaper that was previously disposed. State governments have begun to play a role in market development, in an attempt to develop adequate capacity for recyclable commodities that will be diverted from the waste stream.

One of the primary market development strategies being implemented in other states is the concept of recycled content legislation, whereby the state mandate that newspaper publishers use specific percentages of recycled fiber in production of newsprint. The legislative approach to recycled fiber content is a new concept; therefore, it has not been completely tested. Historically, industry alone has not proceeded with the development of adequate markets for recyclable commodities. Therefore, if the State is going to play a role in inducing large volumes of waste recovery, the State's participation in market development will be very important.

The State can assist in the development of markets for recyclable materials in a number of ways. The possible forms of the assistance are as follows:

Institutional

Government Procurement Policy - One of the ways to increase demand for products manufactured with recycled materials is through an aggressive government procurement policy. Government's buying of recycled products helps create stable markets and establishes a model for other purchasing policies. The State, by means of HB1391, has given preferential treatment to procurement of products having at least a 50% recycled material content.

Establish a procurement policy for the broadest possible range of products containing recycled materials will encourage market development. The policy could incorporate the following provisions:

- A price preference mechanism for products that meet specified minimum recycled content standards.

- A price preference mechanism for products that are recyclable.

- Stipulations that allow and encourage all state agencies, local jurisdictions, and school districts to specify the use of recycled and recyclable products on all purchase requests.

- Minimum recycled content standards that meet or exceed EPA Guideline Standards.

- Requirements that all state agencies, local jurisdictions, and school districts increase the use of recycled and recyclable products.

- Requirements that contractors and consultants use recycled and recyclable products.

- Procedures for monitoring and enforcing the policy.

- Requirements that all state agencies, local jurisdictions and school districts use recycled paper for letterhead on all new orders after a designated date.

- Requirements that the words "Printed on Recycled Paper" and the recycling logo be printed on letterhead and the title page of all reports.

- Provisions for the establishment of a list of materials and products, content guide, and price preferences to be revised periodically. At a minimum, the list should include paper, tires, building insulation, lubricating oil, compost and compost products, and plastics.

- Designation of a state agency to perform such review, to participate in the development of national (ASTM) standards and to be responsible for monitoring and enforcing this policy.

- Requirements that all vendors who intend to supply products containing recycled materials estimate, in writing, the recycled content of such products. Successful bidders would provide certification of such content.

New procurement guidelines could be developed and implemented in a timely fashion. This process would be aided by assigning the primary responsibility to the Department of Environmental Management and by working with procurement officers and other state agencies so that their concerns can be addressed before rules are established.

Recycled Content Legislation - As noted in the Source Reduction Work Paper, recently enacted legislation in California and Connecticut has focused attention on the ability of states to assure markets for recycled newsprint by requiring that newsprint used in these states contain recycled fiber. To assure the success of recycling programs, stable markets must be encouraged through the expanded use of recyclable materials.

Content legislation need not focus solely on secondary fiber in newsprint. Other products can also be considered for content legislation. The following items should be considered when considering content legislation:

- Input from industry groups, including but not limited to publishers, mills, collectors, and citizen and environmental groups.
- Phased implementation.
- Consideration of pricing, quality, and availability of newsprint containing secondary fiber.
- Easy and reasonable documentation and reporting procedures.
- Recognition of the regional base of mills and the publishing industries. Any legislation should be consistent and compatible with other regional efforts aimed at increasing secondary fiber used in newsprint.
- Legislation should not attempt to control the origin of the secondary fiber used by mills.
- The production and procurement of the highest quality newsprint possible.

If content legislation is adopted for newsprint, IDEM could recommend that other products be evaluated as candidates for future content legislation.

Establish an Ombudsperson at the IDEM - An ombudsperson could be established at the IDEM to assist businesses in obtaining permits and meeting other requirements when constructing new capacity for use of recyclable materials. An ombudsperson would provide a single source of information about permit and environmental requirements, could provide assistance in obtaining permits, and could serve as a liaison between the IDEM, other regulatory agencies, and the project proponents. This type of assistance would speed up the permit process and make regulation less onerous for the recycling industry.

The ombudsperson could also serve as the source of information about markets for recyclable materials, providing up-to-date market data and information to both local governments and the recycling industry.

Economic

Consumption Tax Credits - To provide tax relief and, thereby, a financial incentive to those Indiana businesses using recyclable materials or products made from recycled materials, a consumption tax credit could be established for recycled materials. The State's Business Tax is the logical candidate for amendment. This incentive would offset federal subsidy of virgin materials and make recyclable materials economically more attractive.

This type of an incentive has not been tried in other states It is difficult, without a detailed analysis, to assess the actual long-term effect that a consumption tax credit would have on patterns of use. Similar legislation was introduced in California, but was not adopted into law.

The amount of the credit or the formula for calculation of the credit would have to be carefully derived to provide sufficient incentives for purchasing recyclable materials. The credit would probably vary from material to material, and from grade to grade within a material classification. The loss in state business revenues could be offset by a tax on the use of virgin materials.

Two methods for establishing credit could be based on:

- The price differential between virgin and recyclable materials to compensate for the price advantage of competitive raw materials over recycled materials; or
- A projection of disposal costs avoided by diverting these materials from disposal in landfills or incinerators.

Limiting the credit to recyclable materials collected in the state could also be considered. If this is not done, the State will experience a loss of revenues that will in effect subsidize the use of recyclable materials from other states. This requirement would create a need for supplemental record-keeping systems and certification processes to ensure that the credit is being applied only to those materials collected within Indiana.

Tax Credits, Exemptions or Deferrals - To encourage small manufacturing and processing businesses that use or process recyclable materials, a tax credit, exemption, or deferral could be allowed for purchase of necessary capital equipment. Small businesses tend to be more innovative in response to changing market conditions than larger corporations; yet, they are often more constrained by limited capital and cash flow. If limited to small businesses, a tax relief or other specific financial incentive is likely to have a great influence on recycling.

Incentives could include tax credits or deferrals of the State's Business and Occupation Tax for equipment purchases or exemptions from sales tax due on qualified purchases. Any type of capital equipment could qualify as long as its primary function was for the use or processing of recyclable materials. The definition of "small business" could be that used by the State and the federal government in their small business assistance programs. Oregon has a program, administered by that state's Department of Environmental Quality, that could be used as a model.

Tax credits, exemptions, or deferrals could also be offered to businesses forced to make capital expenditures for equipment required to meet environmental regulations. These tax incentives should be restricted to investments in equipment and capital programs undertaken to meet State and federal environmental regulations when adding capacity to process recyclable materials. The cost of this program could be offset by a tax on processing or manufacturing facilities that only use virgin materials or a statewide tax on the consumption of virgin materials.

Authorize Diversion Payments - To increase and stabilize markets over the long term, local jurisdictions could be authorized to provide diversion payments to recycling programs using revenue from the State of Indiana disposal surcharge. Diversion payments would provide a consistent source of funding to recycling programs that handle low valued materials. State legislation would be required and guidelines would have to be developed. Since many recycling services cross jurisdictional boundaries and the exact areas served are difficult to delineate, diversion payments could be allocated regionally, by means of the Solid Waste Management Fund.

An alternative would be to establish a statewide diversion payment fund to be used for specific types of recycling programs. This would allow the State to act on statewide priorities, set consistent criteria for diversion payments, and respond to cyclical changes in markets for recyclable materials. This would also circumvent problems with cross-jurisdictional recycling services.

Eliminate Sales Tax - The elimination of retail sales tax on products containing recycled materials would make those products more competitive with products made from virgin materials. State legislation would be required. A minimum percentage of recycled content would have to be established in order to determine eligibility for the sales tax exemption. These thresholds could be set at the same levels as those required to receive preferential price treatment under the recommended government procurement programs. Supplemental record-keeping would be required to segregate and account for taxable versus non-taxable purchases by retailers. A source of revenue, such as a tax on virgin materials, should be identified to compensate for the loss in State revenues.

Technical

Technical Assistance and Research Support - The State of Indiana could provide technical assistance and support research to identify and develop new uses for recyclable materials and increase the use of recyclable materials. The most effective way to provide technical assistance and support research and development in the Indiana, considering constitutional constraints, is to provide direct grants to universities and non-profit foundations or funnel grants through governmental or non-profit agencies. The products and technologies that result from technical assistance and research support will ultimately reduce the need to export or landfill surplus recyclable materials.

Grants should target two types of activities:

- Research to develop new applications and technologies; and
- Studies to market these new products.

Grants should be limited to projects targeting high-priority recyclable materials. Priority should be given to developing products that use large quantities of recyclable materials and have a long useful life. Efforts also could be made to leverage private resources.

Establish Standards for Recyclability - To improve the quality of recyclable materials and increase the recyclability of all products, legislation establishing standards for recyclability could be adopted. Standardization of product manufacturing would make the quality of recyclable materials more reliable and reduce contamination. Standards would identify materials that should not be used or should be used only in limited quantities. Products that combine materials that are otherwise recyclable should be targeted.

The Packaging Task Force could be charged with the task of developing these standards. The Task Force would be responsible for examining the volume, weight, and toxicity of packaging materials, with the goal of reducing waste and increasing the recyclability of packaging. Implementation should also be coordinated with any efforts to set standards for recycled content in consumer products.

Cultural

Support Public Education Programs - To encourage the purchase and use of products made from recycled materials, the State of Indiana could develop and support recycling public education programs. The consumer, as well as private and public purchasing agents, needs to be informed about:

- Which products are recyclable or made from recycled materials;
- The environmental benefits that result from using these products;
- The avoided costs of using recyclable products; and
- Where these products may be purchased.

State educational programs need to emphasize the recyclability of products and the use of products containing recycled materials. These programs could be developed for a statewide campaign and local government campaigns. Sector-specific educational programs also could be developed. The environmental benefits of using products made from recycled materials or products that are recyclable should always be highlighted. However, answers to technical and practical questions should be developed and readily available. A State education effort should dispel the perception that products containing recycled materials are inferior. IDEM could take the lead in developing and expanding educational programs, convening a task force of local government, recycling industry, and sector-specific representatives to assist in the effort.

Official Statewide Symbol Signifying Recycled Content - To inform consumers and influence their purchasing habits, the Indiana could develop an official State symbol or logogram for placement on products containing recycled materials. Labeling recycled products with a standard symbol would enable consumers to easily recognize those products containing recycled materials. If the products are generally comparable to other products in terms of cost and availability, consumer purchases of products made from recycled materials will likely increase.

Implementation of this recommendation on a state level may be difficult since many products are produced and marketed on a national level. A federal recycling logo would be preferable, and the State should encourage this. However, the State need not wait for federal action. The State can define standards for use of its own recycling logo and set up an approval process for logo use.

Consumers should also be educated about products with potential for becoming hazardous wastes. For example, if a potentially hazardous product comes in a package containing recycled content, the recycling logo may inadvertently create the impression that the product is environmentally safe.

FUNDING

Implementation of waste reduction services including material collection, drop-off facilities, processing facilities, staffing, and educational and instructional activities statewide will require a significant financial investment. The Solid Waste Management Fund will provide some of the necessary funding. Additional funds will be required and the State will need to determine the appropriate mechanisms for funding programs. Experience in other states has demonstrated that earmarked funds related to solid waste activities must be provided for effective results. One strategy that is being utilized in states like Florida and Rhode Island is state financial support to assist local government in the early years of development of solid waste recycling and composting. Some of the state programs include matching fund grants between the local governments and the state.

The most effective state programs have included state funding support to local government for planning and implementation of services. In Florida, grants are provided to local government based on a per capita basis; therefore, governmental entities do not compete for funds. Some states provide the required seed funding for capital support for the short-term, such as providing funding for collection equipment and processing facilities. The State of Rhode Island funded development and construction of the material recovery facilities, with subsequent private-sector operation of the facilities. By providing start-up capital, a state absorbs a significant portion of the start-up cost; thereby releasing local government from the financial burden of start-up and permitting local government to focus attention on delivering the services. For many local governments, the process of collecting and especially processing and marketing recycling materials is an activity with which they are not familiar. Therefore, the State of Indiana will need to examine the best mechanism, if any, for providing financial assistance. One option is to use the disposal surcharge funds collected at the state level, along with any other solid waste funding sources developed to provide financial assistance for recycling program start-up costs. A second option is for the State to permit the local surcharge funds to be allocated for funding the waste reduction programs. A third option may be to use State and locally generated disposal surcharge funds for funding waste reduction programs.

On average, the provision of residential recycling services to urban areas is currently costing between $12.00 and $24.00 per household per year. This number represents net costs after income is received from the sale of recyclable materials. Therefore, a community with a population of 100,000, and approximately 40,000 living units (most of which are single-family or small complexes) spending $20.00 per year in services, would require $800,000 for operation expenses. This annual cost assumes amortization of collection equipment over a five-year period. If the local government operates the recycling program, it is likely to purchase collection equipment. If the private sector operates the program under contract, then equipment costs are divided per year based on length of the contract. Additional funding would be required if the community had a high population of multi-family housing. Additional funding would also be required for if yard waste collection and material processing services were to be offered.

Funding mechanisms used in other states to fund waste reduction services have included: advanced disposal fees (product charge), property tax, general fund appropriations, tax on waste haulers, business taxes, and oil overcharge funding. Advanced disposal fees (ADF) are being used for general funding of solid waste trust funds for waste reduction. In some cases, the ADFs are used for recovery of specific problem wastes, such as a $1.00 ADF on tires dedicated to tire recovery programs. Disposal surcharges and ADFs are two of the most frequently utilized solid waste recovery funding mechanisms.

In other states, an important role for state government in recycling program start-up stages has been to provide significant funding assistance. Some states have accomplished this by providing full or partial funding for processing facilities and collection operations, such as funding construction of material recovery facilities, purchase of composting processing equipment, or purchase of recycling collection equipment. After providing significant start-up assistance, some states begin to phase out their support. This strategy is one whereby state government is assisting local government to begin the program, but at the same time making it the local government's responsibility to operate over the long-term. Start-up funds in some states have included operational assistance and in other states only capital support. State funding has been effectively used to support recycling coordinator salaries and educational/informational campaigns on the local level. Often, local governments have difficulty supporting educational/informational campaigns when capital is required for equipment. State involvement in the educational campaign allows an opportunity for presentation of a consistent message statewide.

PUBLIC AWARENESS AND EDUCATIONAL STRATEGIES

Public support and convenience for citizen participation are the two most important contributors to the success of waste reduction and recycling programs. To meet the aggressive waste reduction goals that have been set by HB1240, the State and local governments are going to have to change the solid waste management behavior of every citizen in the state. In order for citizens to participate, local government will need to deliver professional, reliable waste reduction services and will have to educate the public on the importance of participating. The public needs to:

- Know why individual participation is important;
- Know exactly how to participate (e.g. how, what and where to recycle);
- See successful waste reduction programs in action; and
- Have waste reduction and recycling problems anticipated and solved.

The primary role of delivering waste reduction educational services to the general public will be the responsibility of local government and the districts. The educational programs will have to be tailored to local programs (e.g. collection schedules, drop-off locations, etc.). However, State assistance, in the form of statewide educational campaigns and technical assistance for local programs will be necessary. Historically, most local governments have not had to educate their citizens about solid waste management practices.

The first educational activity the State might participate in is a process to educate local governmental officials, waste haulers, recycling firm representatives, and others who will have a role in the waste reduction developments of HB1240. One of the most effective methods would be a series of State-sponsored workshops held around Indiana. These events would focus on source reduction, recycling collection and processing strategies, the economics of waste reduction, and markets for recyclable materials. The workshops would provide local government representatives with an opportunity to have a hands-on mini-course on the components of services they will be responsible for delivering, including the educational, informational, and public awareness aspects. As local representatives become educated about the elements of waste reduction, they will become more effective at instructing the citizens of their communities.

The State can also develop a statewide toll free 800 recycling hotline for citizens. Citizens throughout the state would be able to call in and have specific questions answered and the State could then mail instructional literature to them.

The State can produce public service announcements on source reduction, recycling, and composting for the mass media. These productions can be developed to permit specific additional information to be added for local areas (e.g. local recycling phone number). In other states, television,radio stations, and newspapers have donated air time and newspaper space for these important messages. House Bill 1391 requires IDEM to provide technical assistance and education programs about alternatives to land disposal and incineration of solid waste. Programs similar to those described here could accomplish this task.

The State can also produce an instructional slide presentation on its entire solid waste program, focusing attention on the types of waste and volume of waste generated in the state. Also, with attention focused on solutions including source reduction, recycling, and composting, this production could be utilized by IDEM staff or targeted audiences. The State could also produce a similar video tape production that would not require a staff presentation.

Additionally, the State could consider producing specific "how-to "tapes." Examples include a "How to Start an Office Paper Recycling Program" and a "How to Start a Backyard Compost Pile." The State could also consider developing and publishing a guide to waste reduction activities in the state.

The State might require a theme and logo for its statewide involvement in waste reduction. Other states and cities have used a variety of slogans, themes, and logos to communicate the waste reduction message to their citizens. Connecticut uses "RAY CYCLE," a super-person character who appears in an educational cartoon book for children and performs at school assemblies. The State of New Jersey has a character named R. E. Cycle who is a magician; part of his act includes turning waste products into new materials. These campaigns are designed to help citizens identify and become involved of waste issues.

The State could develop an educational curriculum for school children grades K-12. Education programs about responsible solid waste management has short-term and long-term benefits. Students bringing home information about the local solid waste situation and about local opportunities to recycle can immediately affect adults' solid waste disposal habits. And, as students begin to make their own buying and disposal decisions, the information they received as students can lead them to continuing responsible behavior. Numerous other states have developed excellent waste reduction curriculum programs for school children. The State of Oregon has "Re: Thinking Recycling," Rhode

Island has "Oscar's Options," Ohio has "Super Saver Investigators," Washington has "A-Way with Waste," and Michigan has "WISE" (Waste Information Series for Education). All of these programs can be used as models. The Department of Education could work with IDEM to develop a curriculum, test it, and implement it. An effective program could include lesson plans, hands-on experiences (building a model landfill), field trips to solid waste facilities, video tape instruction, and computer games.

The State, in cooperation with local governments, could expect to maintain a high level of educational activity and public outreach for years to come, until old wasteful habits have been transformed and waste reduction, recycling, and composting have become second nature for citizens of Indiana. By means of HB1926, the State has developed the Indiana Institute on Recycling to develop concepts, methods, and procedures for assisting in efforts to recycle solid waste. The goals and objectives of this organization are as follows:

- Research barriers to recycling markets and make recommendations to the General Assembly to correct these barriers. This should include financial, institutional, regulatory, and public perception barriers.

- Research funding mechanisms for recycling and composting programs and facilities. Make recommendations to the General Assembly for making financing of these types of facilities easier for local government and the private sector.

- Investigate new methods for recycling and composting. Evaluate their impact on existing markets, programs, and need for regulation.

- Investigate recycling opportunities for rural communities and citizens. Make recommendations to increase participation in rural areas.

- Act as a referral center for elected officials, environmental groups, citizens, and other interested in recycling information.

- Monitor and evaluate recycling programs throughout the state.

- Work with other solid waste advisory groups formed in the state to develop consistent recycling recommendations.

- Recommend priorities for increasing the number of recycling programs throughout the state, focusing on including as many components of the residential, commercial, and industrial waste stream as possible.

The Indiana Recycling Coalition (IRC) is a not-for-profit corporation representing concerned citizens, local officials, business, industry, and environmental organizations. IRC works to expand waste reduction, reuse, and recycling efforts throughout the state. The IRC serves as an information clearing house and sponsors an annual recycling conference. Similar organizations in other states have been instrumental in assisting the development of effective recycling programs.

CASE STUDIES

WEST LAFAYETTE

The city-operated recycling program provides residential recycling collections to 3300 households which represents approximately 90% of the homes. The materials collected include aluminum, glass, newspaper, and steel cans. The City also collects appliances and scrap metal for recycling. Yard waste is also collected separately. The City expects to recover a total of between 1200 and 1300 tons of solid waste during 1990, representing approximately a 25% reduction of the waste stream reaching final disposal. The City processes the material and at this time has no plans for expansion.

LA PORTE

The city-operated recycling program provides residential recycling collections to the entire population. The City estimates citizen participation is between 60 and 70 percent. Materials collected include aluminum, glass, newspaper, and plastic PET and HDPE. The City provides recycling buckets to resident. The City processes the recyclable materials. The City also provides a commercial recycling service to businesses; and about 150 of the 400 businesses participate. There is one drop-off facility provided for recyclable materials. The City collects yard waste separately and long term, La Porte would like to develop a compost program.

NOBLE COUNTY

Noble County provides citizens with a mobile recycling center which collects newspaper, cardboard, mixed paper, aluminum cans, glass, steel cans, and plastic PET and HDPE. The mobile center is parked in one area of the county each day and returns on a weekly basis. The County collects 50 to 75 tons of recyclable materials per month. The County plans to develop a pilot curbside collection program. The County is also developing a composting program. The County also plans to develop a waste oil recovery program. The County processes the recyclable materials.

BARRIERS TO RECYCLING

Major barriers or obstacles to waste reduction and recycling exist at a variety of levels. State governments are working to reduce governmental barriers in the interest of increasing waste recovery. For instance, local governments can assist waste recovery by means of zoning regulations that support provision of space for recycling centers at multi-family complexes. States are attempting to assist wastepaper recovery by means of procuring recycled products. Some of the barriers to increasing waste recovery are reviewed herein.

TRANSPORTATION

Transport regulations in the State of Indiana require common carrier permits for the transportation of commodities and are taxed for transporting commodities. Therefore, trucking firms contracted to transport recyclable goods are taxed. However, waste haulers transporting waste are not taxed.

COMMERCIAL SOURCE-SEPARATED COLLECTION

The major barrier to implementing this method is the lack of efficient internal collection systems and space for businesses to store recyclable materials such as corrugated cardboard on-site. There is also a lack of financial incentives for haulers and building owners and managers to establish and operate these systems. As disposal costs increase and as rate structures are modified to encourage waste reduction and recycling, these barriers will begin to disappear. Franchises and contracts for haulers should be structured to provide an incentive to recycle materials, as well as make recycling worthwhile for building owners and managers.

LACK OF AWARENESS AND MOTIVATION

Without an awareness of the need to reduce waste and without some reason to reduce waste, few reduction efforts will occur. The population, both producers and consumers, must be educated regarding the desirability of waste reduction. Reduction efforts cannot be effective without a general awareness of both the waste problem and the need to reduce the amount of waste which is disposed. In addition, some means of providing a source of motivation, such as increased disposal costs or variable rates, is necessary.

THROWAWAY SOCIETY

Society has been taught and encouraged to use items and then throw them away. Often the approach is portrayed as being less expensive and easier. Citizens use disposable razors, cameras, eating ware, and a variety of other products without thinking about disposal consequences.

COST OF DISPOSAL NOT REFLECTED IN PRODUCT PRICES

The ever-increasing cost of waste disposal is not reflected in product prices. If it were, an "economic signal" or financial incentive would be provided to individuals and manufacturers to minimize their purchases of disposable products.

DIFFICULTY SITING FACILITIES

This barrier includes the difficulty, time, and expense associated with siting solid waste recycling facilities.

INHERENTLY VOLATILE AND CYCLICAL NATURE OF MARKETS

Price swings and the cyclical nature of the market are common characteristics of markets for recyclable materials.

UNQUANTIFIED "TRUE COST" OF GARBAGE DISPOSAL

The ever-increasing cost of waste disposal has not been fully quantified and is not reflected in disposal charges or product prices; the crucial economic role recycling plays in solid waste management is not currently recognized.

TECHNICAL PAPER ON COMPOSTING

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

BACKGROUND

INTRODUCTION

Composting is the biological decomposition and stabilization of organic matter. Composting occurs when organic wastes naturally decompose over time and produce a biologically stable end product. This is the same process that produces humus (organic topsoil) in forests.

When the compost process is properly controlled, the organic fraction is stabilized into a material that can be easily stored, handled, and used in an environmentally acceptable manner. Controlled composting is essentially a management program for natural processes, encouraging growth of organisms that consume organic materials. The product is a decomposed, disinfected, and stable organic material that is beneficial to plant growth.

Interest in composting began to develop in the United States in the 1950s when research was initiated by a number of universities and government agencies. As a result, the composting process is now well enough understood to be applied on a large scale.

GENERAL DESCRIPTION

Most commonly, controlled composting occurs under aerobic (oxygen-rich) conditions. Aerobic processing systems are designed to maintain moisture, oxygen, and temperature at adequate levels to sustain the microorganisms that consume the organic materials. Using air as a source of nitrogen and oxygen, the organisms break down the materials' carbon based constituents. Composting can also occur in anaerobic (oxygen-starved) environments. Anaerobic digestion in controlled composting systems is typically more difficult to control and decomposition takes longer.

Both aerobic and anaerobic processes produce heat and other byproducts. Aerobic processes produce carbon dioxide and water, while
anaerobic processes (digestion or fermentation) produce methane, carbon dioxide, and hydrogen sulfide. Both involve some level of odor. However, while aerobic processes produce an earthy odor, anaerobic processes produce the "rotten egg" smell associated with hydrogen sulfide gas. In either process, once

the organic fraction has been substantially consumed, organic materials stabilize into a biologically inactive state.

Vermiculture, another composting approach, uses worms and insects to digest organic materials. Bacteria in their digestive tracts help to reduce the organic materials. Because neither anaerobic decomposition nor vermiculture is commonly used to compost municipal solid waste (MSW), they will not be addressed further in this report.

In general, composting systems are designed to produce a stable end product quickly. The rate of decomposition is determined by the type of material, local climatic conditions, system configuration, and operating procedures. Depending on the method used, most aerobic composting operations can produce an end product in one to six months.

Most biodegradable organic material is suitable for composting; however, certain organic materials, such as meatscraps, may cause odor or attract vectors. Generally, simple and easily accessible organic materials produce a better compost product more quickly. In the United States, most composting programs use sewage or wastewater sludge, yard waste, or a combination of the two (co-composting). Other parts of the world, particularly Europe, have been successfully composting these materials with MSW for 30 years or more. MSW composting in the United States is a relatively new technology that is receiving increasing interest.

Yard waste consists of materials like leaves, brush, tree and shrub trimmings, grass clippings, garden waste, and tree stumps. Nationally, yard waste represents 15 to 20 percent of the municipal solid waste stream, depending on the local climate. Before 1976, most yard wastes were burned in private yards or at community disposal facilities. However, with the passage of the 1976 Clean Air Act, open burning was outlawed and most communities began to dispose of yard waste in landfills.

Yard waste is bulky for its weight, requiring a disproportionate amount of space in shrinking landfills. It is difficult to control, resisting compaction unless it is size-reduced with a grinder. In addition, natural decay of this dense, moist material contributes to landfill gas and leachate production. Understandably, many state and local governments have actively discouraged, if not prohibited, the landfilling of yard waste. As a result, municipal waste management officials have begun to take innovative approaches to managing this troublesome waste.

One solution is yard waste composting, either alone or in combination with sludge or MSW. Not only does composting dramatically reduce volume by as much as 80 percent, but composted yard wastes, alone or in combination with sludge, yield useful end products suited to a number of uses.

Yard waste is an ideal target for diverting material from landfill disposal. It is easy to identify and separate from other types of refuse generated by the home owner. In general, both individuals and municipal and commercial entities generate yard wastes as part of maintaining lawns, public parks, and landscaped businesses.

Because yard waste compost is derived from a relatively uncontaminated waste material, the resulting product is quite versatile. Yard waste compost is an economical substitute for purchased soil amendments, and can be used for private and public landscaping and road-cut stabilization. The compost can also be sold to local and regional buyers seeking affordable substitutes for their current soil amendment applications, such as commercial horticulture businesses or garden suppliers.

At-Home Composting

There are two primary approaches to yard waste composting: at-home composting and community composting. At-home composting occurs at the house or multi-family residential complex (on the same lot as the residence). At-home, composting offers a simple, low-cost approach to diverting yard wastes from the waste stream. Leaves, weeds, grass clippings, and waste garden material are typical yard wastes that can be composted. Homeowners can also add vegetable kitchen scraps to their compost piles. Because the yard waste does not leave its original site and thus does not enter the waste stream, the at-home composting program can be a cost-effective way to reduce the waste stream and reduce the burden on collection or disposal systems. Reduced material handling cuts cost, and participating residents can produce a valuable material to benefit their home landscaping needs.

At-home composting relies on individuals to compost on their properties using low-technology approaches. The homeowners use the small amounts of compost generated as a soil conditioner and mulch. Local government programs usually provide instruction in the purpose and methods of composting, either directly to interested citizens or through more organized programs such as the Master Composter program practiced by the City of Seattle. In this program, a number of volunteer "master composters" are trained in composting methods and compost use. These master composters then train others in their neighborhoods. In some programs, interested citizens are provided with free or low-cost backyard composting bins.

Yard waste production can be minimized by using landscaping and horticultural practices that produce less yard waste. For example, grass clippings can be reduced by planting perennial ground covers instead of lawns. Modifying mowing and fertilizing practices can also reduce lawn growth and reduce the materials collected for disposal. For instance, mulching mowers allow grass clippings to be left on the ground.

Education is crucial to a successful backyard composting program and is relatively inexpensive to implement. Education efforts include training interested citizens in methods of backyard composting, informing local horticulturists, landscapers, and others about the advantages of backyard composting, and establishing demonstration projects at parks, nature centers or other appropriate areas. For example, some county cooperative extension services provide pamphlets on yard waste recycling and reduction techniques. These pamphlets give information to homeowners on mowing, fertilizing, and maintaining lawns while reducing yard wastes. Such efforts can be coordinated with the county's overall composting education programs.

However, while making a contribution, at-home composting will not significantly reduce the total waste stream because:

- Not every yard is large enough to allow for at-home composting;
- Not everyone will be interested in composting;
- Only leaves and grass can be readily handled in back yard composting. Brush is not usually handled;
- Not everyone will want to use compost; and
- Both the aesthetic impact of a compost pile and the cost of an enclosed system may keep people from composting.

In addition, changing homeowners' attitudes, time constraints, and mobility may preclude consistent participation, even with ongoing educational efforts.

At-home composting programs typically have low participation, and are estimated to reduce the total waste stream by 2 to 3 percent. Consequently, backyard programs must be supplemented with an alternative for those who can't or don't want to compost on their properties.

Community Yard Waste Composting

Yard waste that is not composted at home can be collected and processed by a central operator. In a community composting program, yard waste is separated and prepared for collection by individual waste generators. A central operator collects the separated waste, transports it to a processing facility, processes it into compost, and markets or otherwise distributes the end product. This central facility can be publicly or privately owned.

Although community composting is more complicated and expensive than backyard composting, it is much more effective in diverting yard waste quantities from landfills and benefits more of the community. People are generally more willing to participate in community programs because it is more convenient. Around the country, community programs average 85 percent participation.

Community programs also generate local business opportunities, government revenues, and affordable sources of soil amendments for public projects. Programs operated by a local government can realize direct benefits, such as cost savings when the compost product is used as a substitute for purchased soil amendments in public landscaping or related projects and additional revenues collected by selling compost products to local and regional markets. If the program is privately operated, the waste diversion program becomes an opportunity to develop a new local business.

The major disadvantages of community composting are cost and complexity. Compared to backyard composting programs, community collection, processing, and distribution require more planning and management, as well as greater capital and operating costs. To ensure cost-effectiveness, a community program must be designed to balance the additional costs and complexity against potential revenues from the product.

Municipal Solid Waste Composting

Municipal solid waste, which is largely organic material (some studies suggest as much as 70 to 80 percent), also lends itself to composting. Many facilities in Europe and elsewhere compost the organic fraction of MSW. Some of these are co-composting facilities. Only a few MSW composting facilities are in operation in the United States, but interest is growing and several facilities are in the planning stages. The driving forces for development of MSW composting in the United States include the desire to find alternatives to incineration and landfilling as methods of waste volume reduction and final disposal. Before MSW composting will become an accepted solid waste alternative in the United States, composting facilities need to produce a high-quality finished product. Stable markets for MSW compost could be developed if quality control procedures are developed which assure end users of consistently high-quality products.

There are two strategies to the MSW compost market. One approach is to process the mixed MSW. The mixture is shredded and ground, blended with a nitrogen source, typically sewage sludge or urea and water, and mixed in a composting reactor. The compostable paper, food scraps, yard waste, and nitrogen source can comprise more than 70 percent of the solid waste stream. This material will process into a stable humus product. However, this product also contains the non-degradable fraction of the waste stream. This non-degradable portion is what limits the marketability of most MSW compost. In Florida, Minnesota, and Illinois, compost with a high percent of inorganic material will not meet state requirements for marketing. There are indications that compost having lower aesthetics will not be marketable in Indiana.

The second strategy for composting MSW is to remove non-degradable material from the waste stream before composting. Separation of organics from non-organics by the waste generator before collection generally permits production of a higher quality MSW compost than is produced by separation of the materials after collection and prior to composting.

Sludge Composting

Composting sewage sludge can be an ideal solution to a troublesome waste stream. Although many communities use sludge in beneficial land application programs, they may be limited by agricultural practices, available land, or climatic constraints. Sludge management alternatives such as composting can make a significant contribution to the success of sludge management programs.

Constituents found in sewage sludge make it a rich source of nitrogen, phosphorous, and other essential nutrients. When amended with a high carbon source, the result is a mixture that encourages microbiological activity and produces a finished compost material with excellent gardening qualities.

Most sewage sludge usually comes from an anaerobic digester or is undigested sludge from a treatment plant's primary settling basin. These sludges are normally dewatered to 15 - 25 percent solids. Before amendments are added, sludge usually has a consistency of tooth paste and is difficult to keep aerated unless it is mixed continually, exposing new surfaces for oxygen transfer. Adding drier organic amendments or bulking agents such as sawdust, wood chips, ground tree trimmings, or other yard waste in a high enough volume can significantly reduce the need for mechanical aeration. Amendments affectively dry sludge out and increase air voids. Amendments such as wood chips can also increase the available organics in the compost mixture. An ideal composting amendment should be dry, have a low bulk density, degrade easily, be readily available, and have a low cost. Some commonly used amendments include wood chips, sawdust, rice hulls, straw, agricultural waste, yard waste, and MSW. Addition of such amendments to sludge is considered to be a co-composting process. Although the quality of the finished compost may be affected by the amendment used, all amendments provide a way to increase aeration for the compost system.

Wood chips and sawdust are the most common amendments used in sewage sludge composting. This combination yields more desirable products than MSW composting; however, there is a significant demand for MSW compost in topsoil deficient areas.

Past industrial waste practices of dumping heavy metals such as cadmium, mercury, and lead into the wastewater stream have caused concern over the use of wastewater sludge for agricultural purposes. Pretreatment programs which began in the early 1980's have significantly reduced the concentrations of metals in many community wastewaters before they reach municipal treatment systems. The resulting sludge now produced from these systems can be used as a beneficial resource, and as sludge compost, it is an excellent soil conditioner. As a fertilizer, sludge compost releases organic nitrogen slowly, allowing plants to use more of the nutrients and minimizing nitrogen losses to groundwater.

Whether sludge is land-applied, incinerated, or co-composted with other materials, it is strictly regulated by the EPA to prevent contaminants from entering the food chain or from threatening human and animal health. Proposed new regulations are scheduled to be finalized in October 1991. These new regulations are expected to encourage the beneficial use of sludge and help promote other solid waste alternatives such as co-composting sludge with MSW and yard waste.

COMPOSTING STRATEGIES

Whether applied to yard waste or MSW, a typical composting program has four main components:

- Collection;
- Processing;
- Marketing; and
- Education.

Each of these components must be designed to complement the others. Additionally, composting program development may require review of environmental and cost considerations.

COLLECTION SYSTEM DESIGN

Equipping and operating a yard waste collection system can be expensive. Collection can account for 50 to 80 percent of the total capital and operating costs of a centralized composting program. There are two basic approaches to yard waste collection:

- Drop-off collection; and
- Curbside collection.

These two approaches are similar to those used to collect recyclable materials. Drop-off collection systems require yard waste generators to separate their waste and transport it to a central collection point. Curbside collection systems only require participants to place their separated yard waste at a designated pick-up point, usually a curb or alley near where the waste is generated.

Regular garbage collection services would not necessarily have to be altered when implementing a MSW composting program. The organic portion of MSW, separated from the MSW stream at the point of generation, can be collected and delivered to a composting facility instead of taking the organic portion to a landfill or other disposal facility. The same collection approaches utilized for yard waste apply to collection of the source separated organic portion of MSW. If the separated

MSW is placed in bags for collection, the bags would have to be emptied, either manually or mechanically, at the curbside or at the composting facility.

Drop-Off Programs

Drop-off collection systems can be applied anywhere and are often used to supplement curbside service. However, drop-off systems are most appropriate in rural, sparsely populated areas or areas where curbside collection services are not available.

Simpler to operate than curbside collection systems, drop-off systems are usually more affordable, requiring less equipment and fewer staff. However, because drop-off systems are less convenient (requiring people to take their waste to a central point), these systems have 5 to 10 percent participation rates compared to 85 percent with curbside systems. Thus, a drop-off system will generally recover considerably less total yard waste than a curbside program.

Drop-off sites can be difficult to maintain. Throughout the year, program operators must find ways to control blowing debris and prevent illegal dumping of other refuse at the sites. During peak yard waste seasons, drop- off sites require greater attention to control traffic, as well as debris.

In general, the drop-off site should be designed to promote cleanliness and minimize impacts on the local environment. Deposit points should be located within a buffer zone to contain odors, dust, and blowing debris. Further, the site must be graded to allow ample drainage and prevent ponding that could promote waste decay and carry unstable organic materials into nearby water supplies.

Depending on how the waste will be managed after deposit, yard waste is commonly deposited either in open or covered piles on the ground or in roll-off containers. Containers can fill up quickly and require frequent collection. Compacting yard waste should be considered when it will be transported long distances to be composted. This can be done by using a compactor or grinder before loading the yard waste into a transfer vehicle or by using a packer truck as the transfer vehicle. High noise levels may make grinding impractical if the drop-off sites are located in populated areas. Front-end loaders are commonly used to load piled yard waste into trucks or compaction equipment.

Some of the equipment used at drop-off sites can be used to deliver other types of municipal services and may only be needed part-time to adequately operate the drop-off system. When planning a cost-effective community composting program, alternative sources and equipment uses should be considered.

A drop-off site collection system will be most cost-effective if it is designed to minimize hauling distances and frequency to the central composting facility. Even packer trucks fill quickly with such dense and voluminous waste, requiring frequent dumping. Time and fuel-consuming hauls reduce productivity and increase operating costs. Transfer areas that consolidate collected yard waste for further transport can reduce transportation costs and can also serve as drop-off sites.

An example of a drop-off program for yard waste is operated in Austin, Texas. A Christmas tree recycling project collects over 200,000 trees each year through temporary drop-off centers. Volunteers unload trees at the sites, while local haulers provide containers and haul the trees to a central site where local tree trimmers chip the trees. The chips are then used by the city for landscaping. A drop-off operation in the Denver area receives yard waste throughout the year. The material is allowed to decompose and is then used as bedding for horticultural plants.

Curbside Programs

A curbside collection program for yard waste is most applicable in areas where refuse is already collected regularly from the curb or alley. Curbside collection systems are most effective if they are supplemented by drop-off sites to serve homeowners and others who generate yard waste but do not have refuse collection service or want to dispose of yard waste between scheduled collections.

Curbside collection systems usually recover greater quantities of yard waste than do drop-off systems. Depending on how the system is designed, curbside programs are generally more equipment- and labor-intensive than drop-off systems. Additionally, curbside programs require sustained promotional and educational efforts to maintain cost-effective participation levels.

In general, curbside collection programs can recover more materials than drop-off programs because they promote greater resident participation. People respond positively when asked to separate their yard waste and deliver it to the curb or alley where the refuse is collected, rather than separating and then transporting the waste to a drop-off site. The average participation rate for curbside yard waste collection approaches 85 percent as compared to 5 to 10 percent for drop-off systems.

When addressing the economic and logistical feasibility of curbside collection systems, planners must define three basic program factors:

- Requirements for how yard waste will be presented at the curb;
- Methods of collecting the yard waste from the curbside; and
- Systems to transport the collected waste to the processing facility.

Collection Methods - Yard waste can either be set out at the curb in loose piles or in disposable or permanent containers. Allowing waste to be piled loosely at the curb is more convenient to the homeowner and promotes greater participation, but it can cause problems. Uncontained debris can be carried about the area by wind or water, producing litter and clogging storm drains. Further, yard waste cannot be piled at curb zones posted for no parking, since the piles would obstruct traffic.

Although containers can make a curbside collection system more expensive and complex, they can also alleviate the problems associated with loose piles. In addition, when waste is packaged, collection system operators have more options for collecting it. But participation rates can drop when residents are required to cut their yard trimmings to fit a container. Containers also allow more contaminants to be "hidden" in the collected yard wastes. If containers are introduced into a collection system, they must be compatible with the existing collection and processing systems.

Containers can be disposable or reusable. Disposable containers, such as paper or plastic bags are less expensive and easier to handle than reusable containers; however, plastic bags add to the overall waste stream and can complicate waste collection and processing. For example, plastic fragments contaminate the compost product, so the bags must be removed before the yard waste is processed.

Several communities have addressed the problem of disposable bags by providing residents with biodegradable paper bags. The reported advantages include maximized convenience for the resident, minimized processing costs, and maximized potential uses for the finished product since the resulting product is supposedly uncontaminated.

Many composting operations around the country use biodegradable paper bags for collecting yard waste. The bags are made in 30 gallon sizes and are generally wet-strength treated. The paper bags are both degradable and compostable. As organic material, they become an integral part of the compost product, breaking down in the decomposition process. A disadvantage of the biodegradable paper bag is its unit cost, which is more than a plastic bag. However, this cost is offset by the labor costs required to separate pieces of plastic bags from the compost. Biodegradable paper bags are also subject to moisture degradation, even when wet-strength treated; they should be collected in a timely manner and should not remain standing in water for any length of time.

Biodegradable plastic bags are made with a starch-based additive that promotes bacterial attack on plastic waste. The microorganisms consume the additive, destroying the structural integrity of the bag. The microorganisms consume only the additive, not the plastic itself. The additive comprises only about 6 percent of the total bag material; the remainder of the bag degrades into "plastic dust."

Ordinary plastic can take anywhere from a few years to perhaps hundreds of years to decompose. Promoters of cornstarch-additive bags say that whole bags degrade within nine to 18 months, with proper compost pile aeration, shredded bags in less time. However, these claims have not been substantiated by actual field testing.

Even though plastic bags may deteriorate during the composting process, the plastic material remains and contributes to the contamination of the finished compost product. Additionally, "biodegradable plastic" bags actually contain approximately 30 percent more plastic than ordinary plastic bags. Because of their relatively unknown degradation characteristics, some composting facility operators consider yard waste in "biodegradable plastic" bags to be as contaminated as yard waste in ordinary plastic bags. There is also some concern that biodegradable bags may be weaker, that they may begin to break down before they are used, and that residual chemicals may be released during degradation. Also, all types of plastic bags tend to jam shredders unless the equipment is operated at reduced speed. Another disadvantage arises from the heavy metals used as stabilizers and pigments. These can and do leach into the compost as the plastic decomposes. Cadmium - a toxic metal used in pigment - was found in a municipal compost operation in Lincoln, Nebraska. It was traced to yellow dye in the degradable bags that held leaves and grass clippings.

Reusable containers can help to reduce compost contamination from disposables; however, they are more difficult to handle and are initially more expensive. Most of these containers are plastic or metal cans, with 32- to 90-gallon capacities. Larger containers can be shared by neighborhoods. Some cans are specifically designed to be used with mechanized collection vehicles, constraining options for equipping the collection fleet. More often, the cans are emptied by hand into a collection truck, allowing more flexibility in container design. Residents are most frequently asked to provide their own containers, with some programs specify which types of containers are acceptable. Other communities provide containers as a way to encourage participation.

The cost of reusable containers varies with material, capacity, and many other factors. Thirty to 32-gallon plastic trash cans range from $10 to $15 each. The price of wheeled containers ranges from $18 to $38 for 32- gallon units to $63 to $75 for 90-gallon units. Multi-family unit containers of 300 to 400 gallons cost from $160 to over $200 each.

<u>Curbside Collection Equipment</u> - In designing a system to collect waste from the curb, planners must consider how their options are tied to other program components, such as curbside

presentation of the yard wastes or the market specifications for the compost products. For example, if yard wastes are presented loose at the curb, the collection system should probably include a front-end loader or a vacuum system, as well as a crew to rake up the loose debris. If the yard waste is bagged, processors may empty the bags to prevent contamination of the final compost product.

Although some technologies have been specially adapted for yard waste collection - mobile vacuum units, for example - most collection systems use equipment commonly found in refuse collection fleets. Some of the most common curbside collection configurations include:

- Collection of loose yard wastes using dump trucks and a wheeled loader with multiple crews consisting of a loader operator, operators of a fleet of 8 to 12-yard dump trucks, and a team of two to six rakers;

- Collection of bagged residential yard waste using paper or plastic bags and compactor trucks. Crews consist of one or two collectors and a truck driver;

- Collection of yard wastes in a 90-gallon container using a semi- automated system and a packer truck. Crews consist of one to two collectors and one truck driver;

- Collection of loose yard wastes using an open dump truck and vacuum unit, either towed on a trailer or as a completely self-contained vacuum unit. Crews consist of a vacuum unit operator, truck driver and a team of rakers to control blowing debris; and

- Collection of loose yard wastes using packer trucks and an automated loading system, having an articulated "arm and claw". Crews consist of a loader operator, truck driver and a team of rakers.

Open trucks and trailers hauling loose yard waste are simple to operate, but they fill quickly and need to be unloaded often. In addition, truck/trailer combinations are less maneuverable, further reducing productivity.

Vacuum units used to collect loose yard waste are reportedly effective. However, they are relatively expensive and require careful operation. Also, vacuum units are limited in the type of yard waste they can effectively recover. Sticks and wet leaves can clog the mechanism or be difficult to pick up. Finally, such units are usually operated with open trucks, producing the same problems as described above. Vacuum units come in two types: (1) self-contained units that include both the vacuum machine and a self dumping collection unit and (2) units with only the vacuum machine. Self-contained units can be either trailer- or chassis-mounted and cost between $15,000 and $40,000 for the body or body and trailer. Units consisting of only the vacuum machine are usually trailer-mounted and designed to load into enclosed containers that are built onto dump trucks. These vacuum machines range in cost from $6,000 to $25,000, with most in the $10,000 to $15,000 range.

Articulating arm and claw systems, more versatile than vacuum units, are able to pick up 5' x 5' x 5' piles of trimmings, grass clippings, and leaves. Claws can easily load packer trucks. However, these units are expensive and must be operated by trained personnel. The capacity of articulating claws ranges from 0.25 to 2 cubic yards and cost between $4,000 and $11,000.

Packer trucks are usually used to collect yard wastes. The trucks permit compaction of the voluminous wastes, increasing a crew's productivity and decreasing operating costs for each collection route. Packer trucks are also versatile fleet additions, useful for hauling other types of waste. Retail price for a 25 cubic-yard rear-loading packer truck ranges between $60,000 and $100,000. Reconditioned, used equipment can be purchased at a 20 to 50 percent savings.

Some of the described equipment is commonly used to deliver other types of municipal services. Commercial operators might develop a more cost-effective composting program if they can identify alternative sources and uses for their equipment.

Other Collection Considerations

Seasonal Variations - Collecting yard waste can be a problem because of the tremendous variations in volume that can occur throughout the year. In temperate climates, the collection season may last all year. However, a variation in the amount of yard waste generated at different times of the year will probably still be noticeable. In some of the northern states, yard waste collection is offered only at certain times of the year. Many communities have developed curbside yard waste collection programs as part of larger solid waste collection contracts or in conjunction with curbside recyclable collection programs.

Another important planning consideration is the type of materials that will be collected. Some estimates suggest that as much as 75 percent of yard waste is grass, with leaves comprising 20 to 25 percent and brush 5 to 10 percent. However, these ratios are highly dependent on local conditions and seasons.

Most curbside yard waste collection programs collect materials weekly, at least during periods of high generation. Participation may be increased by collecting yard waste on the same day as garbage. However, some studies have indicated that this may not always be true, possibly because yard waste is generally collected at a single time during a specific week or month, not regularly throughout the period.

A recent survey of yard waste curbside collection programs indicated that the total route size of the programs varied widely. For loose collection, the route sizes varied from 1,000 to 2,500 households per route. Containerized collection routes ranged from 700 to 3,500 households. The survey indicated the costs of curbside collection programs. Costs were reported on to range between $1.00 and $4.00 per household per month.

Yard Waste Transport - The most cost-effective transport systems are designed to minimize hauling distances and frequency. As with drop-off systems, transfer areas can help address this concern. Further, system efficiency can be greatly improved by using a mobile grinder to reduce wastes or a compactor to condense materials before they are hauled in trucks or transfer trailers to the central processing center.

Yard wastes can be composted at transfer facilities, creating a network of smaller compost operations around the service area. This approach eliminates secondary hauling costs and makes composted products more conveniently available to the residents who generate the waste. However, a decentralized composting system requires greater coordination and additional permits, and costs more. Some of the costs associated multiple composting sites could be controlled by transporting processing equipment, like mobile grinders or front-end loaders, from site to site. The multiple-site approach is generally more feasible if the sites are located away from densely populated areas.

Commercial Collection - The commercial sector generates significant quantities of yard waste. Most of this waste is generated by landscape contractors that service single family residences, multi-family dwellings, and commercial establishments. These contractors collect and transport the wastes to disposal facilities, in effect providing a separate yard waste collection system. Incentives to contractors and businesses disposing of commercial yard waste may be necessary to encourage either delivery of the waste to a centralized composting facility rather than the landfill or composting of their waste. Residents who use landscape contractors can encourage landscape crews to leave the waste at residences where curbside yard waste collection is provided.

COMPOST PROCESSING

In selecting a compost processing system, specifications for the final product must be carefully considered. Most composting systems involve at least three stages:

- Preprocessing - preparation of the material through screening, size reduction and contaminant removal;
- Composting - controlled biological decomposition; and
- Postprocessing.

Preprocessing

Preprocessing is designed to prepare materials for maximized decomposition rate and biological activity.

Yard Waste Preprocessing - In general, yard waste is considered a clean material and does not usually require much preprocessing. Thus, at operations dedicated to yard waste, preprocessing primarily consists of size reduction to reduce woody materials. Reducing the size of yard waste material before starting the compost process greatly reduces the time necessary to achieve a stable finished product. Equipment typically used for this type of processing includes commercial/ industrial tub grinders, hammermill shredders, and chippers. Before the waste is ground, impurities, such as plastic bags, wire, or rope should be removed. The amount of preprocessing actually required will depend on the level of source separation and contaminant removal before or at the point of collection. Preprocessing may occur on-site at a composting facility or at satellite stations (transfer or drop-off points) before the waste is transferred to the facility.

Tub grinders are the most widely used yard waste size reduction equipment. Some tub grinder units can process materials up to 12 inches in diameter. Tub grinders using external power sources cost between $15,000 and $35,000, while self-powered units cost from $36,000 to $131,000.

Shredders are being used more frequently at yard waste composting sites. Shredders can generally process materials faster than tub grinders, but they cost more - typically from $75,000 to $400,000.

Programs collecting woody materials can use a chipper to reduce volume. Most chippers can accept materials with diameters of 6 to 12 inches. The chip size is often adjustable depending on the product desired. Chippers cost from $10,000 to $50,000.

Reducing the size of brush and tree trimmings facilitates handling of the compostable material. Blending easily digested grass and stems with more resistant woody materials speeds the composting process; the harder, more uniform wood chips also help aerate the piles, enhancing decomposition. The composting process can be further enhanced if leaves are also pre-shredded to speed digestion.

MSW Preprocessing - Preprocessing of MSW generally involves:

- Materials classification;
- Size reduction; and
- Mixing (adding moisture).

Large non-compostable and bulky items such as white goods and tires must be removed from the MSW. Glass, metals, and other abrasives should be removed to protect the machinery, improve the quality of the final product, and provide for salvage and recycling. However, removal increases the facility's operating cost. Most of the sorting can be accomplished by manual separation or screening techniques, while ferrous metals are removed in the preprocessing or postprocessing stages by magnetic separators. Other non-compostable compounds not removed in the preprocessing stage are removed during post processing.

Grinding or shredding the remaining material reduces the particle size to facilitate handling and digestion. Grinding also permits easier removal of certain impurities, increases the quantity of compostable material, and mixes the material. Not all processes use grinding before digestion; some processes allow the non-biodegradable glass, metals, and other materials to grind with the waste as it tumbles in the digester. Screening, before or after grinding, will remove large fragments.

Thoroughly mixing the composting materials before they begin decomposing is a critical part of any composting operation. The more homogeneous the mixture, the less likely it will be to develop anaerobic pockets that can cause temperature differences, reduced product quality, or odor problems. Inadequate mixing is generally only a problem when co-composting sewage sludge or MSW. However, yard waste composting can be significantly improved when the waste materials are thoroughly mixed.

Composting

The numerous aerobic composting technologies can be classified into three basic methods: windrow systems, aerated static pile, and in-vessel systems. In comparison to in-vessel, windrow and aerated static pile systems are considerably simpler and less expensive to develop and operate.

Windrow Systems - In the windrow approach, preprocessed waste is composted in long piles (windrows), on a flat site that may be open to the air or covered. Windrows are aerated mechanically by turning the material periodically with front end loaders or special windrow turning equipment. The turning frequency is dependent on the composting materials, moisture, texture, stability, alternative aeration methods (blowers), and operational goals such as odor control, composting speed, and pest control.

Although windrow systems can be less capital intensive and complex, they must be operated effectively to properly manage the compost process. If piles are not turned frequently enough, the center of the pile may not receive adequate oxygen, permitting development of anaerobic conditions that may produce strong, unpleasant odors. This is particularly a problem if grass clippings comprise a large fraction of the waste. Because the clippings are very dense and moist, it is difficult to ensure adequate oxygen levels. One approach mixes the clippings with dirt or mature compost. This keeps the organic materials mixed and separated to encourage air flow. Once the digestion process is complete, the finer material can be removed by screening.

Pile construction can be as critical as pile management for effective windrow composting. Piles must be constructed to accommodate local climatic conditions. Pile dimensions help ensure that the center of the piles will not overheat in the hot summer season and that they are sufficiently dry during periods of rain and high humidity.

Mechanical compost turners can be self-contained units that straddle the windrow or push the composting material to one side as they operate. Other units are propelled by a tractor. These units move the material to the rear of the machine. Depending on the design, windrow turners can extend up to 7 feet high and 18 feet wide, with rates up to 3,000 tons per hour. The self contained units cost from $100,000 to $200,000. Systems which require a tractor or loader for propulsion range in price from $35,000 to $70,000.

Static Pile Systems - In a static pile system, air is introduced into the pile through air duct systems usually installed beneath the base of the pile. Aerated static pile operations avoid anaerobic conditions by introducing a consistent and controllable measure of air to each pile. This air can be positive, blowing up through the pile, or negative, drawing air down through the pile. Positive aeration will use less energy; however, negative aeration permits the process air to be exhausted through odor scrubber systems when necessary. In general, aerated static pile systems have higher capital costs, but lower overall operating costs than turned-pile systems.

Both static and windrow systems must be managed to control moisture levels. In many cases, this includes periodic infusions of water. One method of moisture control employs soaker hoses placed along concave troughs at the top of windrow piles. Vehicles equipped to spray road construction sites have also been used effectively to water windrow piles. In more elaborate systems, sprinklers are installed above or beside each row or pile. All systems must include means to control runoff from the piles. Often, runoff can be simply reintroduced to the composting materials.

In-Vessel - Containment systems are designed to promote rapid digestion rates by continuously aerating and mixing the material in an enclosed structure. Although these systems can produce an end product more quickly, they are more complex to construct, operate, and maintain. Moisture and temperature levels must be closely monitored.

Designs for in-vessel systems vary widely. One system, shown in Figure V-3-1, combines the windrow and containment approaches in a two-step process that accelerates early digestion processes, using a rotating drum system. As the mass begins to stabilize, it is deposited into windrows to finish decomposition and cure into an end product. Facilities are commonly designed to use a system of fixed augers or agitated beds to promote mixing, such as the agitated bed system shown in Figure V-3-2. Most in-vessel systems feature forced aeration, as well as a graduated system of vessels, allowing new material to be introduced as more mature masses cure.

Other Considerations - Temperature control is an element in managing either windrow piles, static piles, or contained compost masses. In order to meet USEPA requirements, temperatures must be sustained at a level high enough to destroy pathogenic organisms, weed seeds, and other undesirable components. Although the composting process can produce high temperatures of over 140° F (60° C), it is critical to sustain temperature exceeding 130° F (55° C) for a minimum of 100 hours.

Moisture, usually water, is added to the yard waste or MSW to ensure adequate decomposition. Sludge or septage is added in co-composting programs to provide adequate moisture. The components are then blended mechanically to produce a homogeneous feed material for the composting process.

Odor control can also be a problem. Although proper aeration can generally prevent undue odor, in-vessel systems can produce a large amount of gas that may need treatment before being released.

Postprocessing (Finishing)

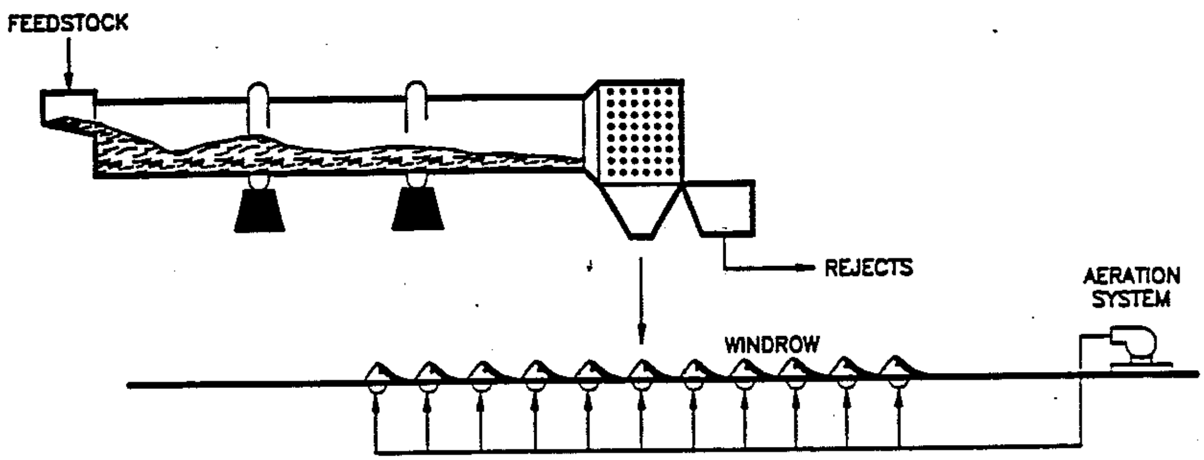
Postprocessing includes curing, preparation for market, storage, and packaging. The method will, in large part, be dictated by market standards.

Generally, curing is considered to be a final step of the decomposition process and is used to stabilize compost that is not entirely digested. The freshly processed compost mass is deposited into windrows or piles for a cooling-off period and final digestion. Such piles are monitored for the carbon to nitrogen (C:N) ratio. A satisfactory C:N ratio will depend on how the material is to be used. If it is to be applied as a soil amendment, the C:N ratio should indicate low carbon so that ongoing digestion does not steal nitrogen from the host soil. Most market buyers will specify their C:N tolerance range.

Once digested materials have stabilized, they must be finished to market specifications. Preparation may include further size reduction through grinding and screening, as well as other cleaning processes to remove contaminants such as plastics, undigested wood chips, or metals. Screening operations are often accomplished by using disk screens or trommel screens. Grinding operations can be accomplished using equipment similar to that used in the preprocessing stage. Screening equipment for compost facilities can be purchased with a variety of throughput capacities. Trommel screens typically cost from $60,000 to $135,000. Costs for combined shredder/screens which provide an opportunity to reduce the particle size before screening, typically range from $25,000 to $180,000. Equipment such as roller grinders, disk-mill grinders, and ball mills are more appropriately designed for fine screen-size grinding. As requirements for consistency increase, screening processes become more complex. In some cases, finishing may also involve adding enhancements, such as nutrients, to produce a higher-grade product.

FIGURE V-3-1

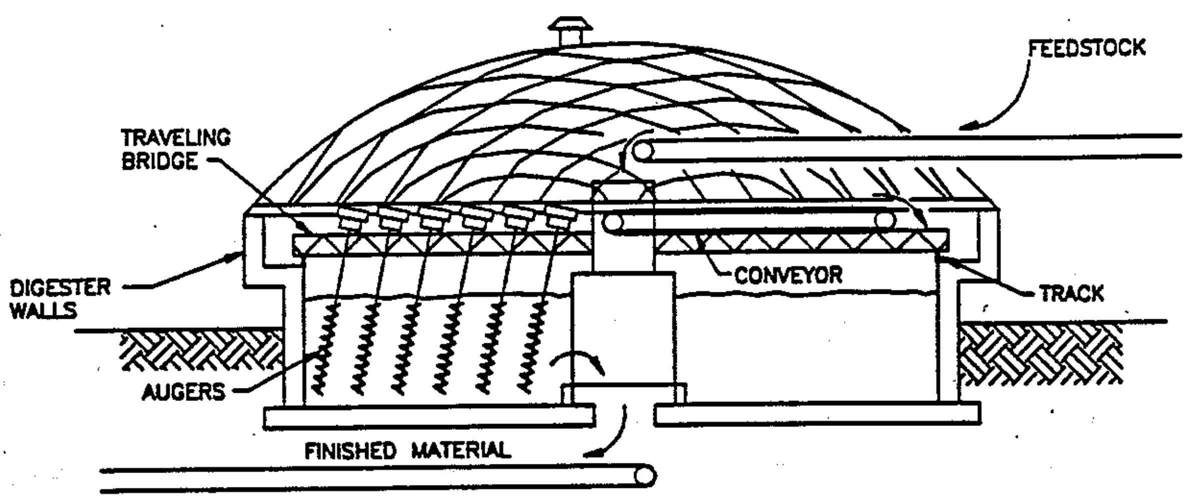
IN-VESSEL COMPOSTING SYSTEM



COMBINATION ROTATING DRUM & WINDROW SYSTEM

FIGURE V-3-2

IN-VESSEL COMPOSTING SYSTEM



CIRCULAR AGITATED BED SYSTEM

Commercially Available Systems - The growing interest in the United States in composting as a cost-effective and environmentally beneficial alternative to solid waste disposal has prompted a number of European companies to establish offices and organizations here to market, design, build and start-up integrated composting systems. These systems, having long operating histories in Europe and other parts of the world, incorporate the three elements of compost processing just described - preprocessing, composting and postprocessing. The systems are marketed as a complete package, tailored to the specific requirements of a municipality or community.

MARKETING

The potential uses for compost will depend on the type of material and the quality and characteristics of the compost. Compost is commonly used as an additive to improve soil physical properties and fertility when used in high enough ratio. Most of the readily decomposable organic matter is consumed during the composting process. The material remaining represents a stabilized organic material. Thus, when applied to soils, the effects of compost are apparent over long periods of time. Some soil improvements from compost additions are:

- Increased available nutrients;
- Decreased chemical fertilization requirements;
- Improved soil porosity;
- Improved soil aeration;
- Enhanced soil aggregation;
- Decreased soil crusting;
- Improved water infiltration;
- Improved water retention; and
- Increased cation exchange capacity.

Compost can be used to reclaim land or as soil amendment in the horticultural and agricultural industries. While compost produced from yard waste is generally entirely organic and contains few if any impurities, compost produced from MSW and/or sewage sludge may contain small quantities of contaminants such as trace metals and bits of plastic and glass. The quantity of impurities depends upon the original material composition and the processing it receives. Impurities may limit compost uses and affect its overall marketability in comparison with commercial compost brands.

Public sector uses for compost include parks development and maintenance, road and highway maintenance, and landfill cover material. Much of the MSW compost produced to date has been used for landfill cover.

Landscape contractors, nurseries, and residential users are frequent horticultural compost users. The luxury horticulture industry typically requires a high-quality, consistent product similar to peat moss and, therefore, would probably prefer yard waste composts to MSW compost products.

Although agriculture may be a potential large volume application for compost, it has not proved to be a good market. Agriculture does not typically demand a high quality compost since the material is used for erosion control and top soil stabilization. Agricultural applications, however, limit metals and organic compounds, and may also specifically limit glass, plastics, and other non-biodegradable components.

Sod farms are an ideal use of compost material. Although they require a well stabilized consistent product, the compost aesthetics are not as critical as for the nursery or residential markets. Sod farms also have a continual need to replace the top soil removed each time sod is harvested from an area.

Currently, land reclamation has the least demanding market specifications. Because most land reclamation is in remote locations where the existing soil lacks ingredients essential to promote vegetative growth or prevent erosion, certain impurities not tolerated by other markets could be contained in compost intended for this use. The Indiana Department of Natural Resources has over 1,000 acres, mined and abandoned prior to 1977, which would benefit from soil amendment treatments. Six to seven thousand acres are disturbed annually in Indiana and will require reclamation. These areas could potentially use more that three million cubic yards of compost material annually. The volume of reclamation, specification of needed materials, and transportation costs will determine the viability of this potential use.

EDUCATION

Whether composting MSW or only yard waste, educating residents and businesses about the ease and benefits of composting is generally required to achieve a significant reduction in the volume of organic material reaching final disposal. Effective composting education programs provide the public and private sectors with information on what materials can be composted, how the material can be composted, and where the material can be composted. As with recycling and source reduction education programs, involvement of the individual is key to the success of a composting program. Education programs help to get the public and private sector involved and help to keep them involved.

A major barrier to a successful composting program, as with recycling and source reduction programs, is a lack of public awareness of the problems associated with the disposal of organic waste and the disposal solutions available for relieving the problems. Education programs promote public awareness and encourage participation. The success of a composting education program does not rest with the complexity of the program. Even simple education programs, such as "how to" pamphlets can result in a significant percentage of residents participating in a composting program. Regardless of the complexity, an education program must explain the "what, where, and how" of particular composting program available to residents or businesses.

GENERAL SCHEDULES AND COSTS

Information about typical physical features, performance, personnel requirements, implementation schedules, and capital and operating costs for various sizes of composting facilities are shown in Tables V-3-1 and V-3-2. Table V-3-1 presents information about yard waste composting facilities, assuming the use of windrows. Information about MSW composting facilities is presented in Table V-3-2; this information assumes the use of in-vessel systems.

ENVIRONMENTAL CONSIDERATIONS

Like any other solid waste management facility, composting facilities must be sited and designed with consideration given to the operation's environmental and aesthetic impacts. The key issues in composting include odor, dust, litter/debris, surface water run-off or leachate, traffic, and noise. Many of these concerns can be addressed by establishing a buffer zone; using site grades and barriers to control noise, odor, debris, or surface water run-off; and proper facility design and operation.

The most significant positive effect composting can have on the environment is to reduce the total volume of waste sent to landfills or other disposal facilities. In addition, compost improves the physical properties of soil, increases nutrients in soil, and can control erosion and stabilize topsoil.

TABLE V-3-1

YARD WASTE COMPOSTING FACILITIES

Parameter(1)	Facility Sizes 10 TPD	50 TPD	100 TPD
Physical Characteristics			
Site Area, acres(2)	3-10	10-25	30-60
Operation and Performance Characteristics			
Yard Waste Processed per year, tons(3)	3,650	18,250	36,500
Volume Reduction (% of yard waste composted)	50-80%	50-80%	50-80%
Process Residue (% by weight of throughput)	1-10%	1-10%	1-10%
Personnel Requirements	1-3	2-5	3-10
Implementation Schedule			
Procurement (months)	6-12	6-12	6-12
Construction, Startup and Testing (months)	6-18	6-18	6-18
Costs			
Capital, (1990 $/ton of daily capacity)	15-40,000	10-30,000	10-20,000
Operating, (1990 $/ton of throughput)(4)	15-30	10-25	10-20
Revenues			
1990 $/ton of throughput	0-25	0-25	0-25

(1) Nominal capacity per day; tons per day (TPD).
(2) Does not include buffer area.
(3) Assumes 100% availability.
(4) Residual disposal costs not included.

TABLE V-3-2

MSW COMPOSTING FACILITIES

Parameter(1)	Facility Sizes 100 TPD	400 TPD	1000 TPD
<u>Physical Features</u>			
Facility Area (sq. ft.)	10-120,000	70-140,000	130,000
Site Area, acres(2)	4-8	6-10	8-14
<u>Operation and Performance Characteristics</u>			
MSW Processed per year, tons(3)	32,850	131,400	328,500
Volume Reduction (% of MSW composted)	15-45%	15-45%	15-45%
Process Residue (% by weight of throughput)	20-50%	20-50%	20-50%
<u>Personnel Requirements</u>(4)	3-10	10-25	30-55
<u>Implementation Schedule</u>			
Procurement (months)	6-18	6-18	6-18
Construction, Startup and Testing (months)	12-18	12-18	12-18
<u>Costs</u>			
Capital, (1990 $/ton of daily capacity)(5)	30-65,000	25-55,000	25-50,000
Operating, (1990 $/ton of throughput)	20-35	15-30	15-30
<u>Revenues</u>			
1990 $/ton of throughput	0-10	0-10	0-10

(1) Nominal capacity per day; tons per day (TPD).
(2) Does not include buffer area.
(3) Assumes 90% availability.
(4) Depends on degree of mechanization, number of shifts, amount of preprocessing etc.
(5) Costs are highly dependent on degree of preprocessing. If preprocessing includes production of RDF, costs could be significantly higher. Operating costs do not include residual disposal costs.

BARRIERS TO COMPOSTING

STATE REGULATIONS

329 1AC2. (3291AC 2-3-1.5) states that wastes (other than tires) that have been segregated from the general solid waste stream prior to arrival at the processing site, are not controlled under the solid waste regulations.

Solid waste processing of uncontaminated, untreated yard waste, including tree limbs, stumps, leaves, and grass clippings are not subject to the solid waste regulation. However, mixing other waste, such as wastewater treatment sludge, would make a composting program subject to these regulations. This is consistent with regulations in states other than Indiana and is not considered a barrier to composting in Indiana. However, it should be noted that additional cost may be incurred for the more complex siting and permitting procedures required when co-composting sewage sludge with yard waste.

FEDERAL REGULATIONS

Federal regulations (CFR40, section 503) controlling the beneficial use of wastewater sludge are scheduled to be finalized October 1991. These regulations could have a significant impact on marketing composted yard waste that have been combined with wastewater sludges. Evaluating the benefits of co-composting yard waste or MSW waste with sewage sludge should be deferred until these regulations are finalized.

CASE STUDIES

INDIANA COMPOSTING PROGRAMS

Several Indiana communities have taken the lead and initiated composting programs. Presented below are examples of composting programs in the state. These programs illustrate the trend towards composting within the State of Indiana and indicate the success of certain composting methods.

City of Terre Haute, Indiana

Terre Haute began a yard waste composting program in 1989 in response to a restrictive landfill dumping policy instituted by local landfill owners.
The area landfills eliminated the longstanding policy of permitting the county to dump leaf waste at no charge.

The Terre Haute Street Department, using two old vacuum trucks and two newly purchased 25-yard compaction trucks, began providing leaf and yard waste collection. Each area of the Terre Haute received yard waste collection service just twice during 1989. Even with the restricted waste collection frequency, the city was able to collect nearly 600,000 bags of yard waste in 1989, resulting in approximately 14,000 cubic yards of compost material. The volume of composted material produced by the facility is expected to double for 1990.

The composting facility is located on a level section of a closed landfill located three miles from the city. Yard waste received in bags is emptied, and the bags are sent to the local landfill for disposal. The compost material is then placed in windrows to permit the composting process to occur. The facility adds water to the windrows as needed to maintain moisture content for optimum microbial activity. Currently, the windrows are turned every two weeks using a front loader. The city intends to purchase a SCAT windrow turning machine to increase the quality of the resulting compost and to increase the facilities' operating efficiency.

City of Bloomington, Indiana

Bloomington's Blucher Poole wastewater treatment plant has been co-composting its sewage sludge with yard waste for several years. The facility produces a compost product that has more demand than the facility can produce.

The wastewater plant produces three dry tons of sludge daily. Yard waste material is delivered to the plant and is mixed with the dewatered sludge. The new compostable material is placed in windrows daily. Windrows are turned twice each week to promote aerobic decomposition.

Finished compost is screened and stockpiled for pickup by local residents. Blucher Poole's chief operator, estimates that the total sludge treatment cost including sludge dewatering is $60 per dry ton, including the cost for compost operations.

City of Kokomo, Indiana

The City of Kokomo wastewater treatment plant has used a high temperature/high pressure sludge treatment process. Historically, operation and maintenance costs for the system have been high. The Kokomo Public Works Department recently determined that continued operation of the existing sludge handling system would require approximately $2 million of rehabilitation work.

The department has tested static pile composting methods for treating the 20 dry tons per day sludge output of the wastewater plant. A determination has been made that co-composting of the sewage sludge is a better alternative than the current handling method. The city is to begin construction of a new $4 million composting facility designed to co-compost sewage sludge with either yard waste or with the organic portion of the MSW stream. The facility is expected to begin operation sometime in 1992.

REGIONAL COMPOSTING PROGRAMS

As in the State of Indiana, communities around the country have begun to realize the importance of composting in planning and maintaining the effective use of existing and future final disposal facilities. Compost programs can service small populations to very large populations, depending on the program structure and local needs. The Urbana, Illinois, Yard waste reclamation facility is an example of a compost operation servicing 125,000 people.

Haulers from the Champaign/Urbana area deliver bagged and bulk material to the city-operated facility. Brush less than eight inches in diameter is ground in a 500 h.p. W.H.O. tube grinder. A grapple loader is used for loading the brush material into the grinder. The grinding helps to speed the composting process and produces a more uniform compost material. Brush greater than eight inches in diameter is sold as firewood.

After grinding, composting material is placed in 500-foot long windrows. The windrows are turned monthly using a power take off driven Wildcat compost turning machine. The compost turner is pulled by a Case 7110 loader which is also used to move and load material when not pulling the turner.

The facility composts approximately 15,000 yards of material annually. Approximately half of the compost material is brush and half is leaves and grass. The staff has recently tested biodegradable and photo-degradable plastic bags with success.

The compost facility is located on 22-acre site and operates seven days per week using a 2.8 full time employee equivalent. The start-up cost for the facility was approximately $350,000. The current annual operating budget is approximately $220,000. Nearly 90 percent of the operating budget is covered by tip fees. The remaining 10 percent of the budget is covered by compost sales. Future plans include increasing the staff by at least one person and purchasing a screen to improve the compost product quality.

Table V-3-3 indicates the applicability different composting methods on a local, county and statewide basis. Further, information on other regional composting programs is presented in Table V-3-4.

TABLE V-3-3

AVAILABLE ALTERNATIVES

Local Alternative	Local Community	County Wide	State Wide
Backyard Composting	X	X	X
Yard Waste Collection and Composting			
Drop-off	X	X	
Curbside	X		
MSW Collection and Composting			
Curbside	X	X	

TABLE V-3-4
YARD WASTE COMPOSTING FACILITIES

City or County	State	Contact Name	Company	Phone Number	Collection Method	Type Community (1)
Terre Haute	IN.	Bill Trout	Street Commissioner	(812) 232-8128	Vacuum Trucks	U/S
Bloomington	IN.	Dave Stremming	Blucher Poole WWTP	(812) 876-4875	Drop-off	R/S/U
Kokomo	IN.	Tom High	City Public Works	(317) 457-5509	City and Municipal	R/S
Urbana	IL.	Rad Fletcher	City Public Works	(217) 384-2381	Drop-off	R/S
East Tawas	MI.	Jacob Montgomery	City Government	(517) 362-6161	Plastic Bag Curbside Dropoff	R
Union	N.J.	Mr. Pat White	County P.W.	(201) 789-3660	City and Municipal	U/S
Montgomery	MD.	Al Free Rick Diemer	County P.W.	(301) 974-7254 (301) 974-7261	Vacuum Truck Dropoff	U/S/R
Summerset	N.J.	Mat Vastano	Middlebrush Compost Inc	(201) 560-0222	Tip Fee ($7.50)	U/S
Omaha	NE.	Dan Slattery	City of Omaha	(402) 734-6060	90 gallon	U/S
Wellesley	MA.	Pat Berdan	Wellesley D.P.W.	(617) 235-7600	$225 Vehicle Fee unltd loads	S/R

(1) U-urban, S-Suburban, R-Rural
(2) Includes only weekly collection, public information, and loader. Land was owned by the town.
(3) Includes three leaf vacuum, two leaf loaders, three trucks prorated with a five week leaf pick-up per year.
(4) Total cost for sludge processing, includes dewatering process.

(dj/350)

Population City/County	Total Yard Waste (tons/y)	Yard Waste as % of MSW	Total TPY Yard Waste Composted	Type Operation	Volume Reduction	Start-up Cost	Market/Uses
60,000	Yard waste is independent of other MSW. Total yardwaste collected is expected to double in 1990.		6,000	Windrow	80%	150,000 (3)	Self use/ city parks
25,000	Waste water plant produces 2-3 dry tons sewage sludge/co-compost with yard waste (3/1, yardwaste/sludge, volume/ volume ratio)			Windrow	80%	60.00/ton (4)	Home use
50,000	Waste water plant produces 20 dry tons sewage sludge. Has been conducting test. Expecting to go full scale co-composting 1992 using yard waste and MSW.			Aerated Stack Pile	---	4 million Includes belt filter presses.	Self use
125,000	13,000		4,000	Windrow	70%	$340,000	Home gardens/ Landscaping
2,500	1,500	10	138	Windrow	65%	<15,000/ (2)	City use/ Home gardens
Several composting facilities in the area receive yard waste.			80,000	Windrow	80%		
600,000	110,000	19	15,600	Windrow	85%	4 million	Whole sale $7.50/yard
They receive yardwaste from many areas.				Windrow	80%	>2 million	Whole sale topsoil Greenhouses
The City had a pilot program composting 1% of the yardwaste. They are now contracting privately to go city wide with composting.				Windrow	60%	$48/ton	Self use Land fill cover
30,000	6,500	The town uses two sites. Leaves are composted in the D.P.W. Yardwaste go 1.5 acre facility. Material is turned w/loader & dozer.		Windrow	60%	low cost	Self use Landscaping

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TECHNICAL PAPER ON LANDFILL TECHNOLOGIES

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

LANDFILL TECHNOLOGIES

INTRODUCTION

The state of Indiana has traditionally disposed of most of its municipal solid waste in landfills. In recent years, the number of permitted landfills in the state has been steadily decreasing, which poses a disposal capacity problem as the population - and thus the volume of solid waste - continues to increase.

In 1980, the state of Indiana had 150 permitted landfills. In 1990, that number dropped to 79, not including those located on military installations and those designated as ash scrubber, or solid fills. Of the remaining 79 landfills, many are expected to close in the near future, either because they will reach final capacity or due to an inability to meet federal and state landfill regulations.

Although landfills have been shown to cause environmental problems and are difficult to site, they remain an integral part of any solid waste management system. Even if the preferred solid waste management strategies outlined in Indiana's House Bill 1240 (HB 1240) are followed to the letter, some solid waste will always need to be landfilled. Even if the waste stream is reduced significantly by waste reduction and recycling efforts and the remaining waste is incinerated, there will still be incinerator ash and other bypass materials requiring final disposal.

LANDFILL CHARACTERISTICS

A modern sanitary landfill can take a number of forms, depending on the topography of its site. Flat surfaces, excavated trenches, and even canyons and abandoned mine pits or quarries have been used as landfill sites.

The "cell" is the landfill's basic building block. It is basically an engineered container for solid waste. The cell's configuration and construction is driven by site geology, type of wastes to be landfilled, need to contain fluids and gases, and economics. Impermeable clay liners are frequently used for the base, often augmented by sophisticated artificial liners made of flexible, reinforced geomembrane fabric. Elaborate collection systems must be installed as part of the liner to collect and divert accumulating fluids (leachate) throughout the life of the landfill and post-closure period. Methane gas control must also be provided, with venting systems to prevent buildup and migration of this highly explosive compound. Each cell is so expensive to construct that economics dictate that a cell be large enough to contain only two to three years' waste accumulation.

At the end of each day's operation, the waste is compacted and six-inch layer of earth or other acceptable material - sand, clay, foam-type spray, or even shredded tires - is spread over the working area. This daily cover is intended to minimize insect and rodent infestation and control odors and windblown debris. As each cell is filled, a permanent earth cover or cap is constructed - often including acres of geomembrane welded together into a giant sealed "package" - and the site can be converted into parks or playgrounds. Residential or business development is generally not an option because of pressure on the underlying material and the need for foundations and underground utilities and because the potential for methane gas migration remains.

There is some question whether or not material buried in landfills ever completely decomposes, biodegradable or not. A recent sampling of a 1950s-era landfill yielded readable newspapers and intact pork chops. However, that very lack of decomposition may be a blessing in disguise: if materials like plastics and newspaper don't break down, they can't release toxic chemicals that may possibly leach into groundwater.

A landfill operation is typically a long-term proposition. Most landfill sites are designed to accommodate 20 years' accumulation, but in practice, capacity has often been reached within 10 to 15 years because of growing waste volumes.

The siting and development process alone is lengthy. Most estimates range from five to seven years, partly for technical reasons and partly because of the highly emotional nature of landfill siting.

STATE LANDFILL REGULATIONS

Landfilling in Indiana is governed by several state regulations. Article 329 of the Indiana Administrative Code (IAC) includes provisions for solid waste management in the state and includes siting and design standards for sanitary landfills. These rules for the regulation of solid wastes, 329 IAC 2, became fully effective on February 11, 1989 and revised the previous requirements under 330 IAC 4.

The Indiana regulatory program can be divided into three major categories: permitting, compliance monitoring, and enforcement. Under permitting, the owner of every landfill is required to obtain an operating permit from the IDEM in order to maintain the facility. Permits are valid for up to five years and must be renewed prior to the expiration date of the permit. Without an approved permit, the state has the legal authority to close down a landfill.

Compliance monitoring is performed through regular inspections of landfill sites by IDEM personnel. The evaluation of each landfill for permit renewal is based in part on the quality of the facility operation as reported in these regular state inspections. In addition to the permitting and compliance monitoring authority, IDEM has the legal authority to enforce the solid waste regulations and to investigate any violations of the state regulations.

The siting requirements established in 329 IAC 2 list criteria that must be met in siting a new landfill. These regulations prohibit siting a landfill in: wetlands, habitats of endangered species, certain floodplain areas, within 600 feet of a potable water well or any dwelling, within 100 feet of any lake or reservoir, and within 1,200 feet of any public water supply well.

Article 329 also requires specific landfill design standards that require a complete facility permit application with engineering design drawings and specifications. New landfills are required to have an impermeable soil liner, a leachate collection system, and groundwater monitoring wells.

In addition to 329 IAC 2, recent legislation will affect solid waste disposal in the state. Act 1472 includes as a "good character provision," an allowance for any solid waste permit to be denied based on an applicant's character or history of compliance with environmental laws. In addition, a Certificate of Need must be submitted to prove that there is substantial need for additional landfill capacity in that specific region. Pending legislation on the state level includes requirements for proof of financial responsibility by landfill operators, addition of landfill inspection staff at the state level, and additional programs to encourage recycling efforts in the state.

FEDERAL LANDFILL REGULATIONS

The United States Environmental Protection Agency (USEPA) has released draft revisions to Subtitle D which contain stringent new requirements for municipal solid waste landfills. Under the proposed revisions to Subtitle D, new municipal solid waste landfill units will have to be designed with liners, leachate systems, and final covers as necessary to ensure that they meet specific state-established design goals for protecting the groundwater beneath landfill sites. In establishing design goals, the state would be required to consider at least the following factors:

- Hydrogeologic characteristics of the site;
- Climatic conditions;
- Volume and characteristics of the leachate;
- Proximity of groundwater supply wells;
- Groundwater quality; and
- Gas migration potential.

The proposed regulations also contain locational restrictions to prevent improper landfill siting. Restricted areas would include flood plains, wetlands, earthquake zones, and other geologically unstable areas. In addition, there are restrictions on the proximity of a new landfill site to airport runways.

The design criteria for new and existing landfill units proposed in Subtitle D are based on a risk-based performance standard. Instead of a federally mandated landfill design, this standard gives each state flexibility in determining the allowable risk levels within federally mandated guidelines.

All new municipal solid waste landfills will be required to have liners, leachate collection systems, and final covers that meet a state- established design goal within certain carcinogenic risk levels. These levels, as specified by the EPA, would be for a minimum excess lifetime cancer risk level within the 1×10^{-4} to 1×10^{-7} range (one cancer incidence in 10,000 exposures to one incidence in 10,000,000 exposures). This system will allow each state some flexibility in the specific liner design requirements as long as the groundwater quality is kept within these projected cancer risk ranges.

The proposed groundwater monitoring and gas monitoring requirements appear to be more rigorous than the current programs required in most states. The groundwater monitoring requirements are approaching those currently enforced for hazardous waste disposal facilities. In addition, the EPA is also developing air emission standards under the Clean Air Act. The air quality standards are likely to require the monitoring and control of methane gas, volatile organic compounds such as benzene and vinyl chlorides, and other air contaminants commonly emitted by landfills.

Other items which will be required by the new Subtitle D regulations are specific closure and post-closure requirements for landfills. In addition to developing formal closure plans, owners and operators will be required to conduct two phases of post-closure care. The first phase would be for a minimum of 30 years and the second phase would be for a length of time determined by the state.

Landfill owners and operators will be required to demonstrate their financial ability to pay for closure, post-closure care, and correction of known contamination.

These proposed Subtitle D regulations are expected to be finalized in mid-1990 and should be effective within 18 months of issuance. Many states will need to update their current solid waste regulations to include the Subtitle D requirements. Because the Indiana regulations were issued within the last few years and were written in accordance with the draft versions of the Subtitle D regulations, extensive revisions will probably not be necessary to bring 329 IAC 2 into compliance.

LANDFILL CLOSURES

Indiana's Refuse Disposal Act of 1965 prohibited open dumping after January 1, 1971. That Act spurred the development and use of sanitary landfills, which were the primary means for disposal of solid wastes in the state. An Open Dump Inventory Program conducted in the state in 1980 identified approximately 2,500 open dumps in the state. Since that inventory was taken, the majority of those sites have been inspected and brought into compliance.

Approximately 79 sanitary municipal solid waste landfills are currently operating in Indiana. The USEPA estimates that one-half of all of the existing landfills in the country will be forced to close because they will not be able to comply with the stringent requirements of Subtitle D when it is finalized. As with other areas of the country, many of Indiana's landfills could be forced to close in the next few years. As reported in Workpaper No. 2, it is estimated that approximately 53 percent of the state's landfills will reach maximum capacity within ten years.

Closure and post-closure plans are required for every permitted landfill in the state under Rule 15 of 329 IAC 2. Preparation of these plans must follow specific requirements and include estimates for both landfill closure costs and post-closure care costs. The regulations require that these cost estimates be prepared by a third party. These closure and post-closure plans were required to be submitted to the IDEM by September 1, 1989. As of June 1990, 38 landfills had not submitted closure and post-closure plans.

LANDFILL COSTS

Until recently, landfilling was the disposal method of choice throughout the United States because of its relatively low cost compared to other options. When land was plentiful and purchase prices were low, landfills could charge artificially low disposal fees because of low acquisition and operating costs and low-tech maintenance procedures. Today, the average tipping fee in the United States is approaching $30 per ton, up from just under $11 per ton in the early 1980s.

The development of new landfill technology to meet tougher design and operating criteria has made landfilling an expensive proposition. In addition to land acquisition costs, landfill capital costs include site development, cell construction, leachate collection system installation, and surface water management system costs. Operating costs include equipment, leachate treatment, groundwater monitoring, and closure, as well as day-to-day administrative and personnel costs.

Typical capital costs for developing a state-of-the-art landfill are on the order of $300,000 per acre. In addition to the development costs, the annual operation and maintenance costs are expected to be in the range of $500,000 to $1,000,000 per year, depending on the size of the landfill site.

Those expenses may rise even higher when the costs of meeting the new Subtitle D regulations are added to the existing costs. Because the post-closure care period is proposed to be at least 30 years after closure of a landfill, and the new regulations require financial assurance for these costs, landfill costs will probably continue to rise as landfill owners struggle to conform to the new regulations. State and local governments will bear the costs for publicly operated landfills.

The EPA has estimated that compliance with the Subtitle D regulations for the nation's 6,000 landfills would cost $262 million per year, an average of $43,600 per landfill. A generic model was developed to illustrate the estimated development costs of a state-of-the-art landfill as compared to landfill size and corresponding municipality population served. This model assumes a typical landfill design of a single composite liner (both synthetic liner and soil liner) with a leachate collection system. Typical national design standards were used, including an average refuse depth of 50 feet. It should be noted that final landfill cost estimates could vary considerably. Table V-4-1 shows the estimated costs of this generic landfill model:

Table V-4-1

Population of Municipality	Landfill Size (fill acreage)	Capital Costs	Annual Operating Costs
< 10,000	Less than 5 acres		
10 - 50,000	5 - 20 acres	$300,000/acre	$ 300,000/yr.
50 - 125,000	20 - 50 acres	$275,000/acre	$ 500,000/yr.
125 - 200,000	50 - 100 acres	$250,000/acre	$1,000,000/yr.
> 200,000	Over 100 acres	$225,000/acre	$2,000,000/yr.

PRIVATE VERSUS PUBLIC OWNERSHIP

The majority of the landfills in Indiana are privately owned. As of October 1989, there were 79 operating municipal solid waste sanitary landfills were operating in the state, of which 42 were privately owned and 37 were publicly owned. The majority of the landfill operations in the state are contracted to private firms by the counties. Supervisory authority is usually vested in either the Board of County Commissioners, or in metropolitan areas, the Board of Public Works.

TECHNICAL PAPER ON INCINERATION/WASTE-TO-ENERGY SYSTEMS

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

WASTE-TO-ENERGY SYSTEMS

INTRODUCTION

The incineration of municipal solid waste ("MSW") for the purposes of reducing the volume of material requiring landfilling and recovering energy products for resale or internal use has received considerable attention in many areas of the country as a potentially viable part of an integrated solid waste management plan. There are numerous waste-to-energy ("WTE") technologies currently in existence and in commercial operation, both in the United States and abroad. The objective of this work paper is to provide a basic understanding of the types of WTE technologies available, a classification of the technologies as either commercially proven, emerging or under development, and descriptive information of the costs, market considerations, siting issues, emissions, benefits, and risks associated with proven technologies.

Until the early 1970's, incineration technology was confined largely to Europe and Japan, due primarily to the short supply and high cost of available land for land disposal systems in those countries. Waste-to-energy systems, which incorporate some form of energy recovery from the heat of combustion, have been fairly widespread in Europe and Japan for over 35 years. In the United States, WTE systems have historically not been considered to be economically viable as long as landfills could be acquired and operated inexpensively, could be located within reasonable trucking distance of cities and towns, and as long as energy costs were relatively low.

During the late sixties and early seventies, an awareness of the need for better management of MSW disposal was developed in the United States in light of the increasing volume of waste requiring disposal and the environmental concerns associated with landfilling. This awareness, when coupled with the steep rise in energy prices after the energy crisis in 1973, created the impetus for the accelerated development of WTE systems. Early waste incineration methods, used mainly for the purpose of volume reduction, were expanded and developed into facilities which used the heat from incineration to generate steam for heating and industrial purposes, and for the generation of electricity.

As is often the case with developing technologies, difficulties were initially encountered and mistakes were made in the design and implementation of the new technologies. These were often coupled with attendant capital and operating cost overruns. To date, however, a considerable amount of experience has been accumulated in the construction and operation of various types of WTE facilities in the United States, to a degree that allows the assessment of the technological and economic feasibility of a variety of technologies.

The main WTE technologies that have been developed and proven to date include mass-burning, refuse-derived fuel ("RDF") combustion in conventional combustion units, and to a lesser extent, fluidized bed combustion. Mass burn and refuse-derived fuel systems are considered to be suitable for consideration for immediate application in Indiana, based on actual operating and performance characteristics and a proven and satisfactory track record during several years of operation at numerous locations. Fluidized bed systems are still considered in the developmental stages, although they are discussed herein. Incinerator-boilers of various size ranges are commercially available with various furnace designs, modes of combustion, types of grate systems, types of boiler construction, and MSW receiving, storage and handling configurations.

Relatively recent developments in technology, changes in energy sales prices, increased concerns over environmental impacts from WTE facilities, and mounting problems associated with the landfilling of solid waste have generated a great deal of interest and controversy in this industry. Strong public opposition to new waste incinerators is common, making public information and education programs as vital as sound engineering and environmental analysis.

MASS-BURNING SYSTEMS

Mass-burning WTE systems are commercially available in various designs. As the name implies, mass-burning facilities receive and incinerate MSW in an "as-received" condition. No mechanized sorting or preprocessing of the incoming waste is required before incineration, except for the removal of visible noncombustible and bulky or non-processible items such as tree stumps and large appliances. Some mass-burning WTE facilities recover materials from the waste stream prior to incineration; material recovery is normally limited to recovery of metals and aggregate from post-combustion residue, however. The Indianapolis Resource Recovery Facility is such a system.

The feeding of waste into mass-burning incinerators is normally accomplished through large charging hoppers which feed fuel by gravity to hydraulic rams, which then push a charge of fuel into the furnace. The rams typically provide a regulated and uniform stream of waste to the furnace. The feed hoppers are kept full to form an air seal in order to allow regulation of the air flow to the furnace. The feed hoppers are charged either by grapple cranes which supply fuel from a large storage pit, or by front-end loaders which supply the fuel directly from a tipping and storage floor. In the pit and crane system, delivery vehicles dump incoming MSW into a large pit, which is typically sized to hold sufficient MSW to provide several days of fuel at the facility's full capability to accommodate variations in waste delivery, the operation over weekends and holidays, and to allow waste receipt during short unit shutdowns for maintenance and repair. Overhead cranes are used to mix and stack the MSW in order to maximize waste storage, provide a more uniform fuel mixture, remove visible non-combustible and bulky items, to keep waste from compacting over time, and to fuel the boilers. Capital costs are usually higher, and previewing or sorting incoming waste is more difficult with this method than with the tipping floor method. Also, proper mixing is often more difficult, since the most recently deposited waste tends to be removed from the storage pit before waste located deeper in the pit.

In the tipping floor method, delivery vehicles dump incoming MSW directly on a floor where it can be sorted and objectionable items can be removed. Front-end loaders push the waste into floor-level hoppers or conveyors which lead to the furnace of the combustion unit. The advantages of this method include easier previewing and sorting of the waste, and lower building height, foundation, excavation and total capital costs. Disadvantages include wear on the loaders and tipping floor, and larger area requirements for long-term waste storage.

Virtually all larger units (greater than 400 tons per day of capacity) use storage pits and overhead cranes to supply MSW to the boilers, while most smaller units use a tipping floor and front-end loaders.

The combustion of the as-received MSW is accomplished in the furnace section of an incinerator. In some designs, partial, or incomplete combustion takes place in an initial chamber at relatively low temperature ("starved air combustion"). The combustion of the partially unburned gases is completed in a second chamber ("afterburner") at a much higher temperature. The purpose of this design is to minimize the carryover of ash particles to the exhaust stack, to minimize damage to the furnace refractory, and to help control emissions of certain combustion byproducts. Other designs accomplish the combustion process in a single chamber, which may be completely lined with refractory, or heat resistant brick ("dry incineration"), or with water-filled tubes to reduce furnace temperatures and contribute to the overall steam generating efficiency of the unit ("waterwall incinerators"). The waterwall design provides a higher thermal efficiency than the refractory-lined design. Due to the heat removal capabilities in the furnace section, and the smaller amount of refractory material used, the waterwall design also usually requires less maintenance of the refractory material.

The constant motion or tumbling of the burning fuel is necessary inside the furnace to ensure complete combustion of the moist and inert-laden MSW. In simpler mass-burn designs, this is achieved by a series of rams at the bottom of the furnace which push and tumble the burning waste through two or three combustion stages, advancing it toward the ash pit located at the end of the furnace. The floor of the furnace in designs of this type is constructed of high temperature refractory. In more complex designs, the furnace floor consists of reciprocating grates constructed of high chromium alloys which tumble and advance the waste toward the ash pit. Other designs have rotary or oscillating drum furnaces in an inclined position which slowly tumble the burning waste forward toward the ash pit. The drums are lined throughout with either refractory or water-filled tubes in which steam is then generated.

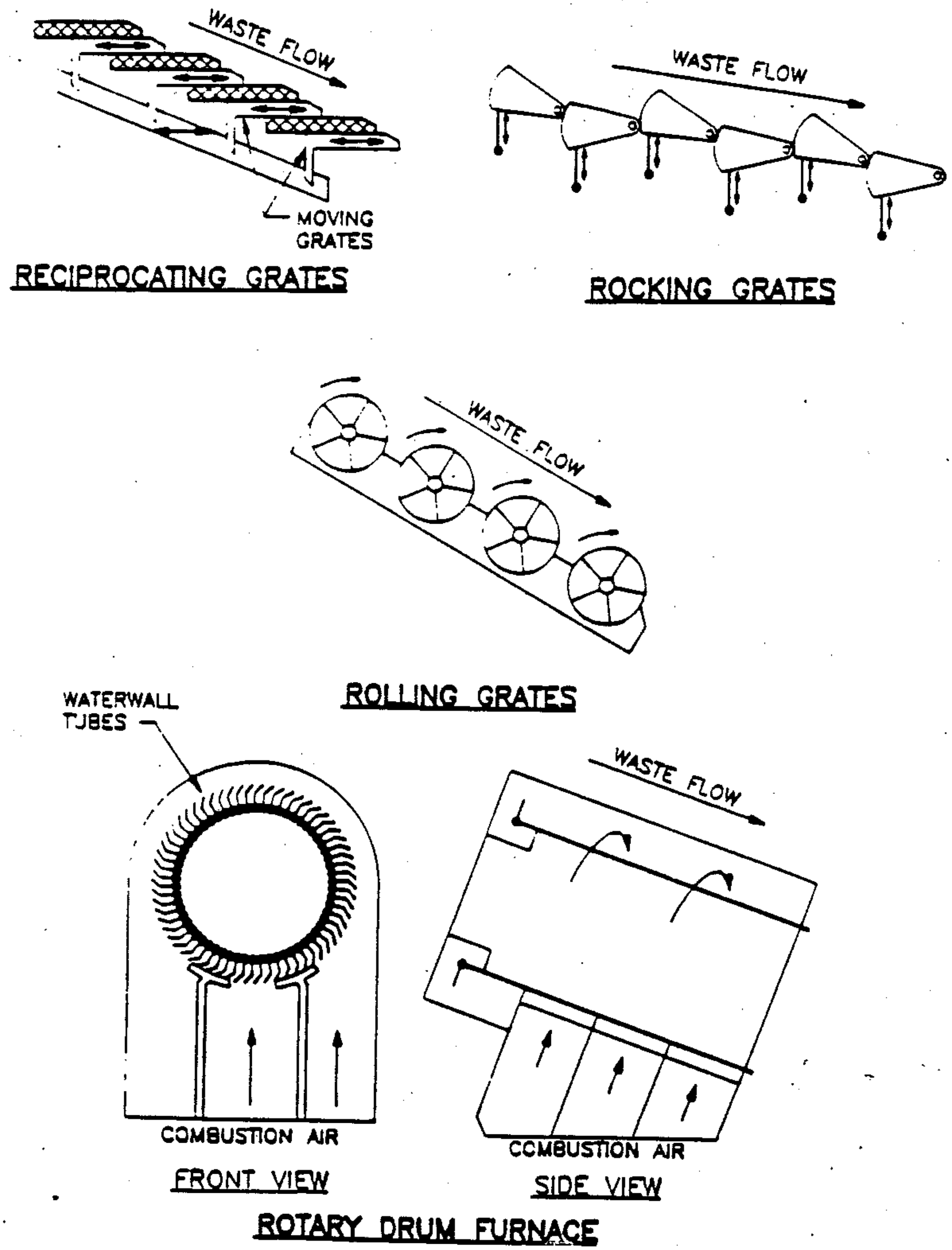
Figure V-5-1 illustrates the various combustion grate technologies considered commercially available in today's market. There are over twelve major grate technologies currently offered in the United States for mass-burning systems by a corresponding number of vendors.

The air required for combustion is usually supplied through small openings in the furnace floor ("underfire air") and through openings in the furnace walls ("overfire air") by means of fans and blowers. The underfire air also serves to cool the furnace floor or grates. In designs with afterburners, air is also supplied directly to the secondary combustion chamber to ensure complete combustion.

Residue ash from the furnace bottom ("bottom ash") is normally removed through a water-sprayed or water-quenched conveyor system and discharged into transport trailers either directly or through intermediate storage facilities. Fly ash is also collected in either an electrostatic precipitator or a baghouse and is normally mixed with the bottom ash prior to final disposal.

Steam is generated in boilers which are either an integral part of the furnace or a separate unit attached to the furnace. In the case where the boiler is an integral part of the furnace, the furnace walls are lined with water-filled tubes in which water is heated by radiation from the furnace. The hot combustion gases then travel through the remainder of the boiler convection section, giving up additional heat for steam generation. In the case where the boiler is a separate unit from the furnace, the furnace is lined with refractory and steam is generated by the hot combustion gases leaving the furnace in an attached heat recovery boiler. The boilers supplied with incinerators of this design may be of a different manufacture, quality and type than the incinerator itself.

EXAMPLES OF GRATE TECHNOLOGIES



The United States now has over 100 operational mass-burn WTE facilities, and worldwide, there are over 500 such facilities in operation. This technology has been successfully employed in WTE facilities of all sizes.

REFUSE-DERIVED FUEL SYSTEMS

The general principles of energy recovery from MSW burned in RDF combustion systems are basically similar to those of mass-burning systems. The major differences lie in the fuel preparation prior to combustion and in the types of furnaces and boilers used for steam generation. Whereas mass-burning facilities basically burn incoming waste as received, except for the removal of oversized items, RDF combustion plants process the incoming solid waste in various degrees prior to combustion. Consequently, different and generally lower cost furnace and boiler systems of different design are often used for the combustion and steam generation process.

The term RDF covers a wide range of fuels, both with respect to physical characteristics and composition. RDF processing systems have been developed in an attempt to produce a more homogeneous and easier to handle material, which can be used as a more efficient fuel. In addition, RDF systems allow for the recovery of a variety of materials for resale.

The size and composition of the RDF is dependant on the type and degree of processing. The type of combustion system used will dictate the level of processing required to meet the fuel specifications of the firing equipment or final market. After RDF has been produced, it may be burned on-site, transported to another site for final combustion, or sold as a fuel to others. However, there are limited examples in the United States of RDF being successfully produced as a fuel for sale to others.

In RDF facilities, raw MSW is usually received on a tipping floor or in a shallow conveyor pit where non-processible, harmful or objectionable wastes are removed. Front-end loaders are used to feed the waste to conveyors where it is transported to the processing equipment. Special attention must be given to RDF handling systems in order to remove items such as gasoline and paint cans or other explosives prior to their introduction into processing equipment. An adequately designed RDF facility provides for satisfactory methods of minimizing explosions in the processing equipment and the ensuing damage that could result.

RDF processing systems are generally classified as either wet processing or dry processing systems. In a wet processing system, a hydropulping technique is used to produce RDF. Wet processing has been used at two large-scale RDF facilities in the past, both of which have since been abandoned. This system is no longer being used for new facilities.

Dry RDF processing facilities have been operated in the United States for over ten years. The solid waste processing portion of dry processing RDF facilities usually shred the fuel into fairly small and uniform pieces, with additional screening and/or "classification" of the shredded fuel in either trommels, disc screens or other separation equipment (either before or after shredding, or sometimes both), and magnetic materials recovery. The purposes of the processing equipment are: 1) size control for the separation of small non-combustible items as well as large or bulky items which may require additional shredding; 2) the reduction of inert materials such as glass and grit in order to reduce abrasion and equipment wear downstream, 3) the development of a more homogeneous and consistent fuel; and 4) the recovery of marketable materials such as aluminum, glass and ferrous metals. Further degrees of RDF refinement are also achievable depending on the range and complexity of the processing systems incorporated in the facility design. A schematic diagram of a typical dry RDF processing facility is shown in Figure V-5-2.

In general, RDF produced by dry processing systems is classified as undensified or "fluff" RDF, which is a loose, uncompacted fuel. RDF may also be compressed and mechanically extruded into pellets, cubes or briquettes in an attempt to provide a fuel which can be more easily stored and handled. This densified RDF is referred to as "pelletized" fuel, or sometimes "d-RDF." Plants producing densified RDF have been operating in Europe for a number of years. A small number of facilities reportedly have the capability to produce d-RDF in the United States.

A variety of storage systems have been used in RDF facilities. Storage allows the RDF processing system to operate on a different schedule that the combustion system, which accommodates variations in MSW delivery and maintenance outage requirements. Commercially available bins, warehouses and storage pits have all been used for RDF storage.

The furnaces and boilers used for the combustion of RDF are usually of the spreader stoker travelling grate type in which the processed fuel is burned in semi-suspension, in a fluidized bed combustion mode, or co-combusted with other fuels in different boiler types. The conventional spreader stoker/suspension firing system is the primary method of combustion. A schematic diagram of such a system is shown in Figure V-5-3. Over 15 facilities in the United States currently incinerate fluff RDF in conventional firing systems. Fluidized bed incineration is still considered developmental for RDF combustion.

While mass-burning technology has been successfully used in WTE facilities of all sizes, RDF technology has generally been employed in larger facilities due to economic and other considerations. Generally, the types and designs of prospective technology offerings for a given application will vary, and there will probably be an ultimate tradeoff of higher capital costs and higher quality equipment in order to achieve lower annual operating costs.

All types of RDF can also be burned in existing conventional boilers designed to burn coal, wood, or other types of solid fuels, which is generally more cost effective than purchasing new and dedicated combustion systems. Such use could require extensive modifications to existing equipment to accommodate RDF receiving, handling and storage areas, impacts on boiler efficiency and maintenance problems, increased ash generation, and other operational problems that may arise, which must be examined on a case-by-case basis.

RDF has been burned in combination with coal in pulverized coal electric utility boilers. Based on experience, the ratio of RDF to coal input is limited to no more than 15 to 20 percent of the total heat input to avoid slagging and corrosion problems. Such boilers are generally fitted with pneumatic feed systems to inject RDF along with coal. RDF specifications for these types of combustion units generally require a fairly small particle size and the removal of as much grit, glass and metals as possible to avoid slagging and sever wear and erosion in feed systems and boilers.

RDF has been used or is being used in electric utility boilers by utilities in Missouri, Maryland, Wisconsin and Florida. Certain electric utilities in Indiana are also reportedly considering RDF combustion in existing boilers. While this concept is commercially proven and technologically feasible, most electric utilities have not shown much interest in participating in such projects due to the rather limited opportunity for economic benefit to them, as well as the potential for interference with their principal mission, which is the generation of electricity. Both RDF and d-RDF can also be burned in certain types of industrial spreader-stoker boilers. The viability of burning RDF in industrial boilers rests with the existence of an industry with solid fuel boilers with the proper type of firing systems, the proper furnace geometry and other design features. As a practical matter, there are a limited number of opportunities for this approach in Indiana. Further, combustion of RDF at an industrial facility requires a fairly sophisticated operating staff as undensified RDF is a relatively difficult fuel to handle and burn, as is the resulting ash, from an operations standpoint.

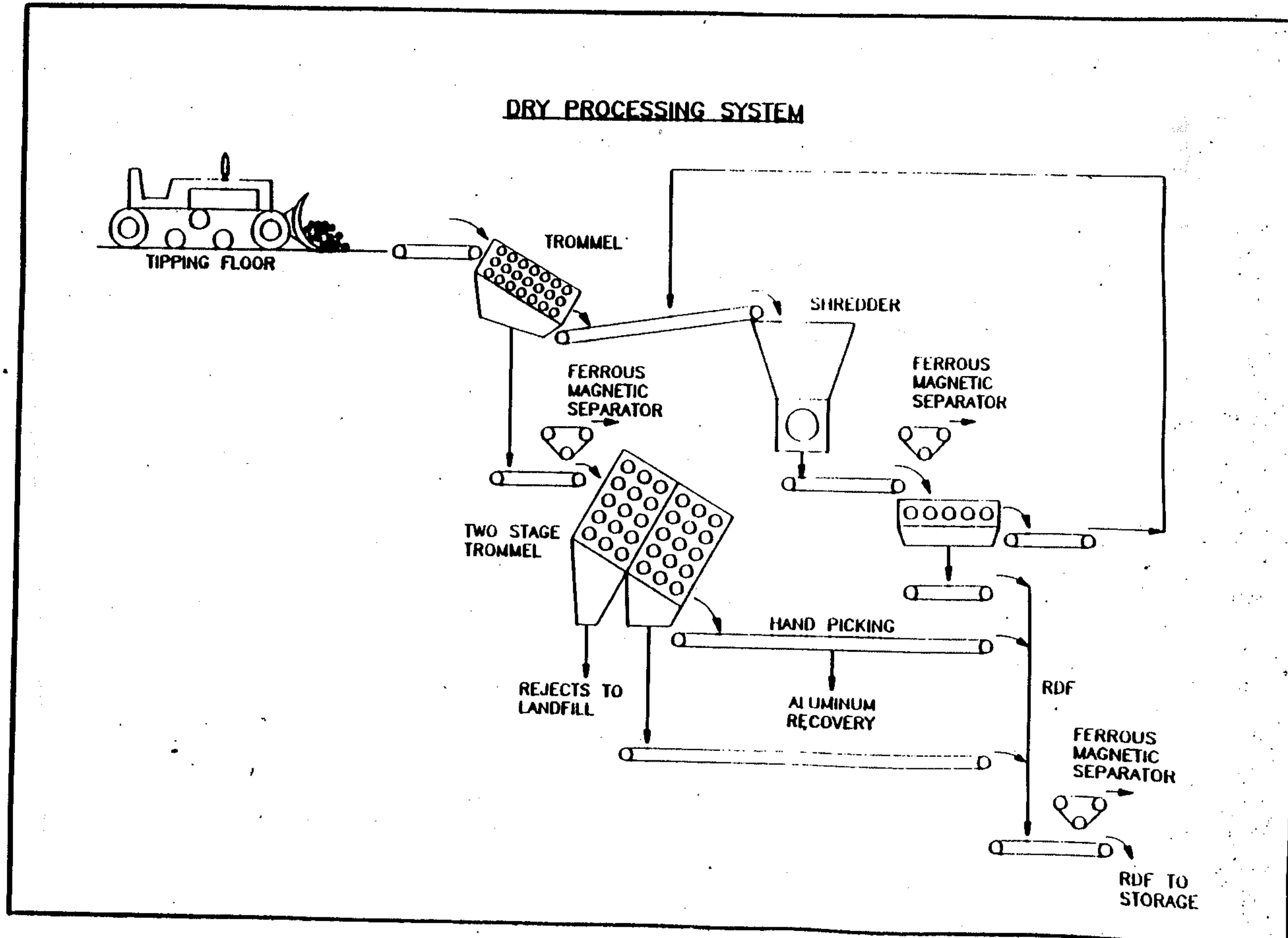
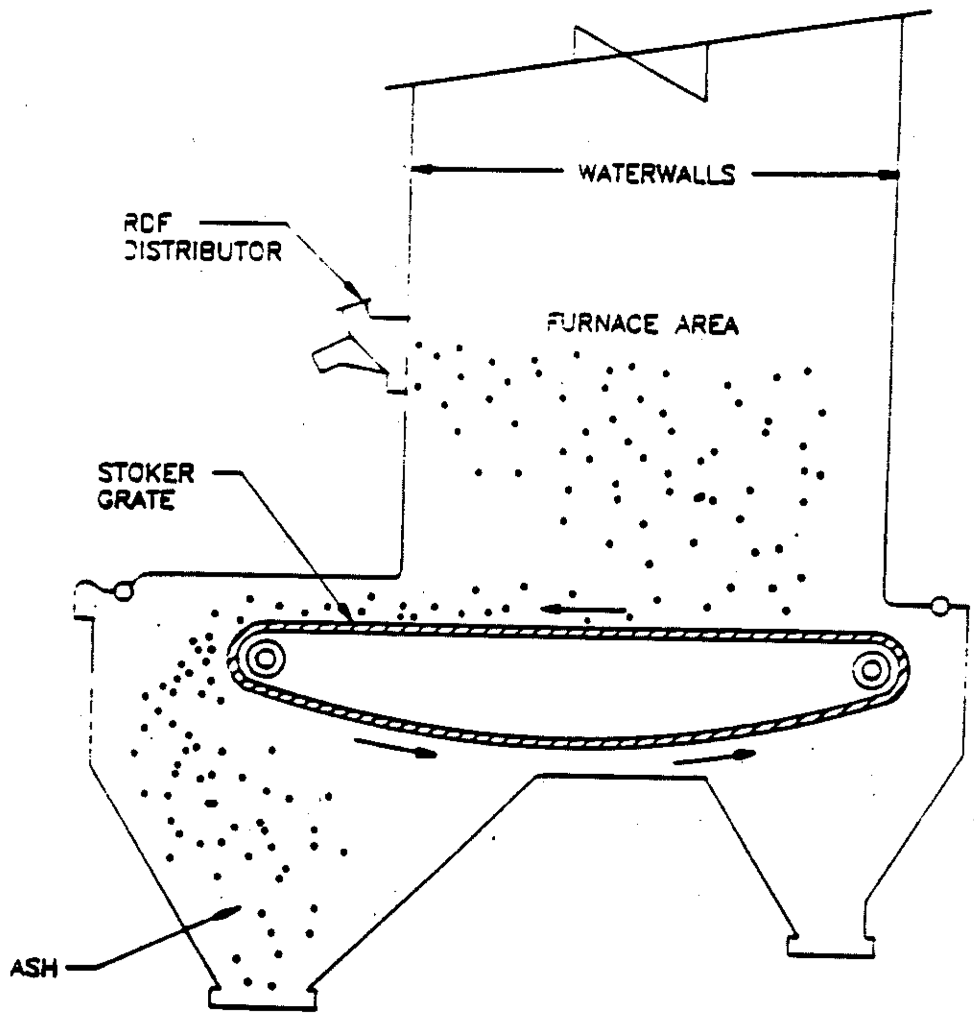

DRY PROCESSING SYSTEM
TIPPING FLOOR
TROMMEL
SHREDDER
FERROUS
MAGNETIC
SEPARATOR
FERROUS
MAGNETIC
SEPARATOR
TWO STAGE
TROMMEL
HAND PICKING
REJECTS TO
LANDFILL
ALUMINUM
RECOVERY
RDF
FERROUS
MAGNETIC
SEPARATOR
RDF TO
STORAGE

FIGURE V-5-2

FIGURE V-5-3

TYPICAL SPREADER-STOKER FIRING SYSTEM



Densified RDF is easier to burn in existing solid-fuel boilers and easier to transport and store than an undensified product; however, densification of RDF adds complexity and cost to processing systems and modifications are sometimes required to fuel feed and ash systems. Operating data indicate that d-RDF fuel behaves very much like coal, and has been burned at a few industrial installations by itself and in combination with coal. The only United States facilities reportedly burning d-RDF at this time on a commercial basis are a hospital in Minnesota (on an intermittent basis) and a facility in North Dakota.

WTE FACILITY DESIGN CONCEPTS

Depending on the size of a WTE project and the type of equipment selected, incinerator-boiler units may be delivered to the project site in pre-assembled modules ("modular incinerators") or they may be delivered in individual parts and assembled at the project site ("filed-erected incinerators"). Modular units are currently commercially available and demonstrated in various sizes up to a maximum of approximately 80 to 100 tons per day ("tpd") per module of capacity. They are generally used for smaller scale WTE facilities. Field-erected units generally range in size from 100 to 1,000 tpd of capacity. Both types of mass-burning technologies have been operating in the United States for more than 15 years (in Europe for over 35 years), and are considered to be commercially proven and the lowest risk mass-burn technology.

Modular Combustion Systems

Modular mass-burn units are relatively small incinerator and heat recovery systems. They are generally simpler to construct and install, and are relatively easy to operate. Because of their limited available sizes, however, they are usually inappropriate for larger facilities. They are typically installed in multiple unit configurations, which have historically been limited to a maximum of four modules per facility. This represents a total available processing capability of approximately 320 to 400 tons per day from modular WTE facilities.

Although some larger modular facilities are being designed with a storage pit and overhead crane, most such facilities are equipped with a tipping floor and a small front-end loader for waste storage, handling and feeding. The front-end loader sorts and mixes incoming waste, and pushes fuel into incinerator feed hoppers where it is typically fed through the furnace section by a series of rams and steps located in the refractory floor. The number and length of steps are selected to allow for sufficient retention time for proper waste burnout. Other modular designs include furnaces with various versions of rocking and reciprocating grate systems, circular grates, fixed beds and rotary drums.

Modular systems with either excess or starved air combustion are available. In most cases, the furnace sections in modular units are refractory-lined. Figure V-5-4 shows a schematic of a typical small modular combustion system.

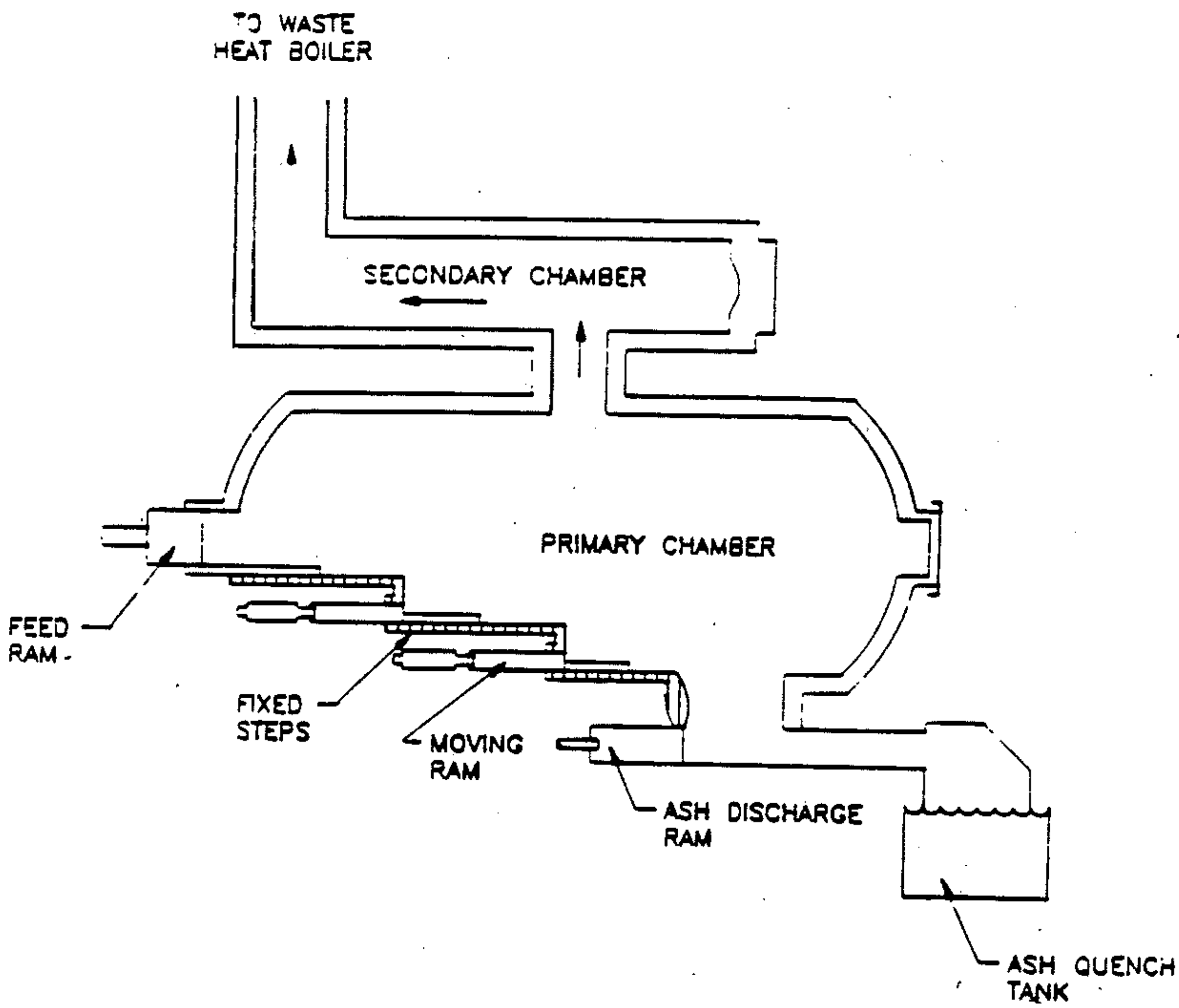
Early operating experience with modular units was somewhat "checkered". However, the units being designed and constructed today more closely reflect "utility grade" equipment and may be expected to provide more acceptable service. Early applications attempted to comply with air quality standards by simply controlling combustion air in multiple chambers. Present applications use supplemental, state-of-the-art air pollution control devices.

Field-Erected Systems

Construction of field-erected units consists of the delivery of the boiler and furnace components in individual parts, and the assemble of the completed units at the project site. Due to the increased amount of construction required and the non-uniformity of boiler criteria between projects, field-erected units are usually more expensive to construct than their modular counterparts. This cost difference, however, usually occurs with smaller facilities of less than 400 tpd, during which the modular design is often more cost effective. A schematic of a typical field-erected facility is shown in Figure V-5-5.

Because field-erected units are derived from standard utility boiler design, they are more thermally efficient than modular units. Field-erected units can be designed to accommodate a wider range of sizes, and are also installed in multiple unit configurations for larger facilities. In addition, they are considered to have a longer service life. If properly operated and maintained, a large field-erected facility constructed of utility-grade equipment should have an operating life of over 30 years. Many larger European facilities have been in operation in excess of 30 to 40 years. Smaller facilities, if properly operated and maintained, should have an operating life in excess of 20 years, and several such units have been in operation in the United States for more than 15 years. Field-erected units are considered commercially proven, and the "lowest risk" mass-burn technology.

TYPICAL MODULAR MASS–BURN SYSTEM



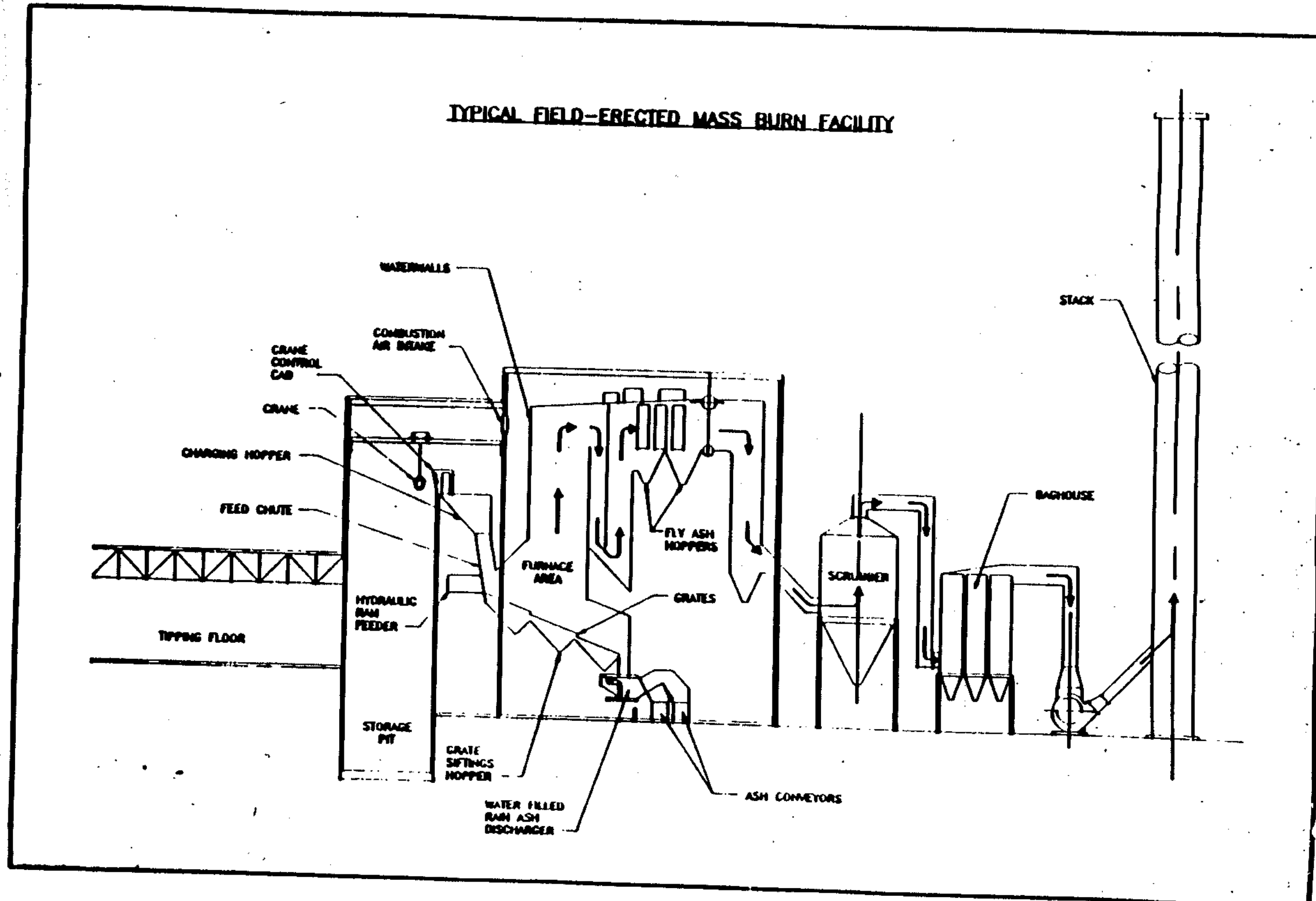

TYPICAL FIELD-ERECTED MASS BURN FACILITY
WATERWALLS
COMBUSTION AIR INTAKE
CRANE CONTROL CAB
CRANE
CHARGING HOPPER
FEED CHUTE
HYDRAULIC RAM FEEDER
TIPPING FLOOR
STORAGE PIT
GRATE SIFTINGS HOPPER
WATER FILLED RAM ASH DISCHARGER
FURNACE AREA
FLY ASH HOPPERS
GRATES
ASH CONVEYORS
SCRUBBER
BAGHOUSE
STACK

FIGURE V-5-5

RDF Combustion in Fluidized Bed Systems

The application of fluidized bed combustion to the WTE marketplace has been evolving since the 1960's. With this technology, processed refuse is burned in a turbulent bed of inert particles that are kept in a state of suspension and agitation by a flow of high velocity combustion air introduced into the bottom of the furnace. The bed media may be sand, dolomite or limestone. A schematic of a fluidized bed combustion system is shown in Figure V-5-6.

Fluidized bed systems are classified into two categories: pressurized and atmospheric. Pressurized systems operate at elevate pressures within the furnace and boiler, while atmospheric systems operate at or near atmospheric pressure. The operation of fluidized beds at elevated pressures has been found to increase efficiency, but has also led to significant technical difficulties. Therefore, a broader research effort has concentrated on atmospheric systems. The following discussion pertains mainly to atmospheric fluidized bed combustion systems.

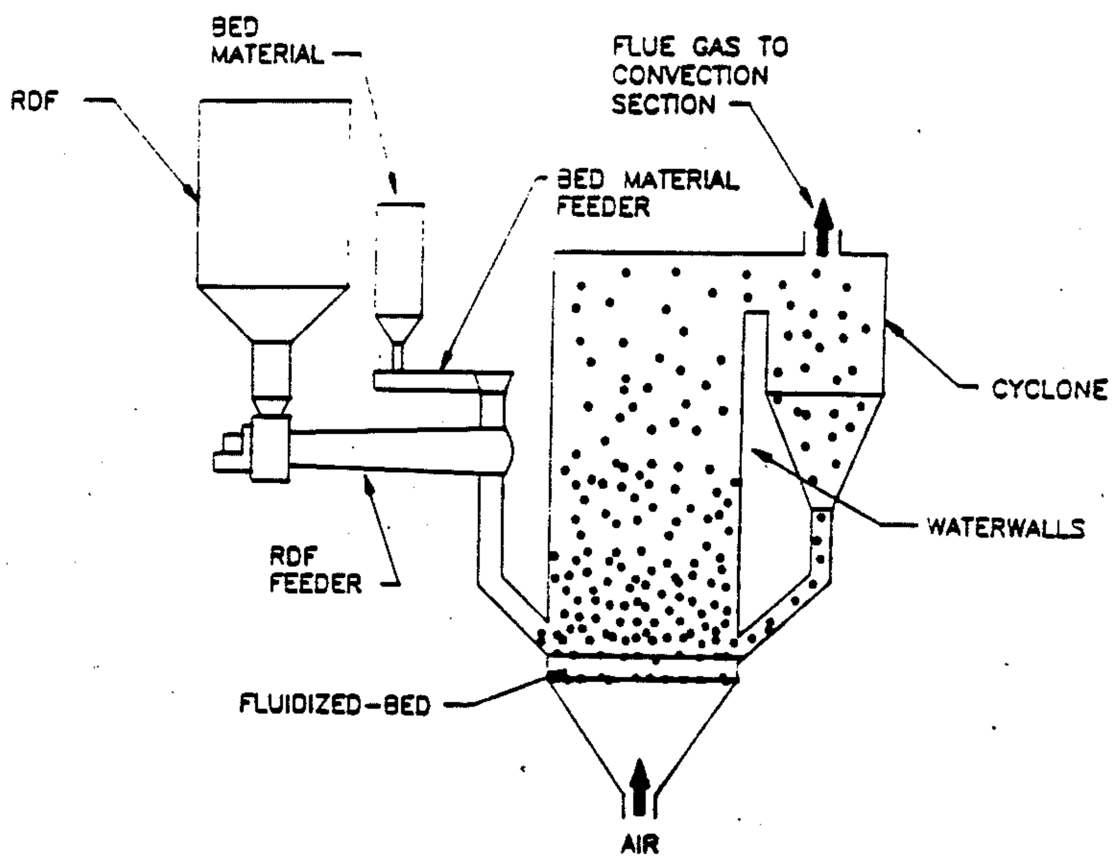
Fluidized bed combustion units are currently offered for solid waste in the 150 to 300 tpd size range. Very few large-scale units for RDF have been built, and hence, cost and performance information with large-scale facilities is limited.

Fluidized bed systems usually require a high quality RDF product with nearly all ferrous materials, glass and aluminum removed. Requirements vary with different manufacturers, however. Several units are operating successfully in Europe with loose and pelletized RDF, as well as other solid fuels.

RDF is fed either into or on top of the bed itself. Due to the turbulence of the fluidized bed, the combustion can take place at a lower temperature than in a conventional combustion system without significantly affecting combustion efficiency. Steam is generated either in in-bed tubes, internal heat exchanger tubes, waterwall tubes and/or in an external heat exchanger, waste heat boiler or conventional boiler.

One sizeable advantage of fluidized bed systems is that downstream acid gas controls may not be required because sulfur dioxide and nitrous oxides emissions from such units are generally less than from other systems. The use of a sulfur sorbent bed material, such as limestone, reduces sulfur dioxide emissions as the sorbent materials chemically react with the sulfur in the fuel within the bed. In addition, lower combustion temperatures result in lower nitrous oxide emissions. Removal of hydrogen chloride, however, is difficult, and a separate scrubber may be required.

TYPICAL FLUIDIZED-BED COMBUSTION SYSTEM



Another advantage of fluidized bed combustion is its ability to burn a variety of solid fuels, such as coal, wood waste and a variety of other waste products. Facilities using fluidized bed combustion are generally more expensive than facilities with conventional combustion units, and early experience with RDF combustion is limited.

Only a limited number of small fluidized bed systems burning RDF have been in operation in the United States. A few others facilities are retrofitting such combustion systems on conventional boiler units, and other facilities are in the planning and developmental stages. Hence, fluidized bed combustion is still considered an emerging, or developmental technology.

Energy Production

WTE facilities usually generate steam from the incineration of MSW either for sale directly to one or more steam (or heated water) customers, or for the generation of electrical energy, or for the cogeneration of both steam and electrical energy. Normally, WTE facilities that generate only steam sell it to either an existing central steam heating system with multiple steam customers or to one or more large industrial customers whose steam loads are sufficient to accept the entire output of the facility on a continuous basis. Any steam condensate available is usually returned to the facility via a separate water line.

Electricity can be generated by WTE facilities either in a cogeneration or strictly electrical generation mode. Cogeneration is defined as the simultaneous production of both electrical energy and a useful form of thermal energy, which is most often steam. If only electricity is produced, the steam generated in the boilers would be sent to a condensing turbine, which is used to reduce the pressure of the generated steam from that of the boiler down to that of the condenser, which is usually maintain at a vacuum. The steam is then condensed to water and recycled to the boilers for conversion back to steam to complete the steam generation loop. A condensing turbine generates the maximum amount of electrical energy possible with given steam conditions, but cannot provide for simultaneous steam sales to industrial customers.

Steam used to drive turbines is normally superheated in a dedicated section of the boiler. Due to corrosion problems that may result in the superheater tubes of WTE boilers, steam temperatures and pressures must be limited. Current practice is to limit superheated steam temperatures to a range of 700 F to 750 F, although superheater tubes constructed of special steel alloys have been used in some designs, allowing higher steam temperatures.

In cogeneration facilities, either an automatic extraction turbine or a combination of a backpressure and condensing turbine is utilized. With an automatic extraction turbine, partial quantities of steam are extracted from one or more of the steam turbine stages at appropriate pressures required to match customer needs. All steam generated by such a facility in excess of that amount required by steam customers is sent through the later turbine stages to the condenser. Both steam paths contribute to the overall electrical generation, and cogeneration typically results in increased thermal efficiency and energy revenues.

If two turbines are installed, a backpressure turbine would be used to exhaust steam to customers at the required pressure while simultaneously generating electricity in the pressure reduction process. If the customers have periods of reduced steam requirements, the excess steam will be passed through a condensing turbine for additional electrical generation.

Using two separate turbines in a cogeneration mode usually maximizes energy revenues, but generally increases initial cost. The choice of cogeneration system design will be dictated by economics and the requirements of the steam customers.

Incineration By-Products

After combustion gases leave the furnace, they are directed to an air pollution control system consisting of either an electrostatic precipitator or baghouse, or a combination of these systems, and a scrubber. The combustion gases are then discharged to the atmosphere through a stack. The by-products of the combustion process consist of either wet or dry residue ash, which is collected from the furnace exits and grate discharges, dry ash from precipitator or baghouse discharges, and residue from the scrubber system.

ENERGY MARKET ANALYSIS

The economics of a WTE facility will be directly impacted by the energy customer or customers it will serve. As such, a detailed review of potential energy markets must be conducted before the decision to proceed with a WTE facility is made. Generally, three distinct energy markets are available for generated products from WTE facilities - electrical energy, steam and RDF fuel.

Electrical Energy Markets in Indiana

The sale of electricity to electric utilities in Indiana is a long-term and viable option for WTE facilities. Under Section 210 of the Public Utility Regulatory Policy Act ("PURPA"), enacted in 1978, electric utilities (both investor-owned and municipal) are required to purchase the electrical output from any facility using MSW or RDF as a fuel at their "avoided costs." Avoided costs are basically defined as the equivalent costs or expenses that a utility would avoid having to spend for the operation of its own generating equipment because of energy produced from a qualifying WTE facility. Utilities are also required to provide back-up or standby power and energy to a WTE facility at reasonable and non-discriminatory rates. PURPA legislation was designed to encourage the use of energy generated by small power producers and alternative energy facilities.

Avoided cost tariffs, and hence the methodology used in their development, are dictated by individual state regulatory commissions, and as such, differ from state to state, due to regional fuel prices, capacity reserve margins, and other factors. Some states include both avoided energy and capacity-related expenses in setting avoided cost tariffs. In certain east-coast states, avoided costs have recently been in excess of 7 to 8 cents per kWh, due primarily to high fuel costs associated the predominant use of gas and oil as utility fuel. The situation in Indiana is quite different at the present time, given the abundant use of local and relatively inexpensive coal resources. Current avoided cost tariffs are based predominantly on avoided fuel costs only, and range from between 1.5 to 2.0 cents per kWh in southern and central Indiana to around 2.5 to 3.0 cents per kWh in the northern part of the State.

Historically, the level of avoided cost payments available in Indiana have not been sufficient to economically justify the construction of electricity-only WTE facilities. Although technically feasible, such facilities would require very high tipping fees due to low electric revenues. In certain neighboring states (Michigan and Illinois, for example), avoided costs have, or have been proposed to include either a capital (investment) component in their derivation, or to be based on the utility's actual cost of supplying retail service to the WTE facility sponsor. Such legislation has resulted in avoided cost tariffs in the range of 4 to 7 cents per kWh, which has significantly increased interest, and the resulting feasibility of WTE facilities designed to generate electricity. It is projected that similar legislation would be required in Indiana to produce higher interest in such projects.

With the recent enactment of acid rain legislation by Congress, it is probable that higher avoided electric costs could result due to sulfur dioxide and nitrous oxide emissions limits that will be imposed on all Indiana utilities. Such development could spur renewed interest and development of the use of alternative fuels for the generation of electricity, in which WTE facilities could play a major role.

Steam Customer Selection Criteria

A WTE facility's primary objective is to reduce the amount of solid waste to the greatest extent possible in an environmentally sound manner. In order to be an effective supplier of energy, it must generate steam at all hours of the day and night at a level that is as consistent with peak production levels as is technically and practically possible. In addition, since WTE facilities are very capital intensive, a constant and guaranteed revenue stream is required from the sale of generated products to provide for repayment of the principle and interest required to finance them. If steam is being sold, either alone, or in conjunction with electricity, the steam customer(s) should meet several criteria to satisfy these inherent requirements.

An ideal steam customer for a WTE facility will be one that has large industrial process steam loads that are as steady as possible throughout the day and year, thereby allowing for continuous steam sales. Industries who require steam for heating only are generally not desirable for several reasons. Often, heating loads are very small in relation to the amount of steam that can be produced by a WTE facility. For example, a 100,000 square foot office building usually requires between 2 and 4 million pounds of steam per year in this region, depending on the building's age and condition. A 100 tpd WTE facility, on the other hand, can generate in excess of 180 million pounds of steam per year for resale.

Secondly, steam sold for heating purposes is highly seasonal in nature, which assures steam revenues for only a few months out of the year. Third, heating loads occur during winter months only, while peak waste deliveries generally occur during summer months. This is an inherent and undesirable mismatch of fuel and market. Finally, the revenues that would be derived from heating steam sales are often negligible in comparison to the costs associated with building steam lines and interconnection facilities to steam customers.

In searching for potential steam customers, emphasis is usually placed on large industries, preferably with existing coal, oil or gas boilers whose output could be partially or totally displaced with WTE-produced steam. Generally, such steam is priced at a percentage (80 to 90 percent) of the cost the industry would incur through self-generation so that all parties share in benefits and savings from steam sales. There are limited numbers of such industries in many regions of Indiana, although potential steam customers do exist in the heavily populated regions of the State.

If a steam customer is located, several other considerations must be addressed, both by the industry and the facility sponsor. First, the steam customer must be willing to enter into a long-term contract for the purchase of steam from the facility at defined levels, conditions and pricing. Twenty years would be preferable, although shorter contracts may be acceptable for financing if other markets are available (i.e. cogeneration). Secondly, the steam customer must demonstrate creditworthiness and financial stability to the bond community. Finally, the facility should be located within one mile of the steam customer to minimize interconnection and steam line expenses and reduce delivery losses.

RDF Production and Sale

The markets for RDF production and resale, for combustion by the final purchaser, are very similar to steam and electric sales markets. Either undensified or d-RDF can be used in existing utility and industrial boilers designed to burn solid fuels, although significant plant modifications may be required to accommodate the new fuel source. In examining potential markets for RDF sales, emphasis is usually placed on existing coal-fueled utilities and solid-fuel burning industries with large annual fuel requirements.

Certain electric utilities in Indiana are reportedly considering RDF combustion in existing boilers. This concept is commercially proven and technologically feasible. To date, most electric utilities have not shown much interest in participating in such projects due to the rather limited opportunity for economic benefit to them.

As with the electric markets, the current likelihood of federal acid rain legislation could create new markets for RDF combustion systems. Such development could spur renewed interest and development of the use of alternative fuels for the generation of electricity, in which RDF may play a major role.

WASTE-TO-ENERGY FACILITY SIZING

Two opposing objectives often result when sizing a WTE facility. One objective is to size the facility large enough to process all of the community's non-recoverable waste and, therefore, minimize the amount of material for disposal. The second objective is to size it small enough so the facility can be operated at or near design capacity to provide the most efficient operation with the lowest net cost on a per-ton basis. Facility sizing also involves consideration and evaluation of the amount of processible waste available in the waste stream, seasonal variations in waste generation, and possible reductions or increases in the amount of processible waste which will be available in the future due to population growth, increased waste reduction and recycling efforts or changing social and economic patterns.

If a WTE facility were designed to meet the first objective, it would be sized to accommodate the largest anticipated daily and seasonal variations in waste quantities, as well as any anticipated growth in the waste stream during the life of the facility. By sizing the facility in this manner, the amount of waste which would bypass the facility would be small and the greatest conservation of landfill space would result. If a facility were sized based on anticipated growth in the waste stream, however, it would have excess capacity in the early years. In addition, if the growth were not realized, the facility would always have excess capacity. If the facility were sized for peak seasonal variations, it would have excess capacity during other than peak periods of the year. Operation of a WTE facility at less than full capacity generally results in significantly higher net costs per ton of waste disposed due to the additional cost of the larger facility, the lower efficiency of operation and the lower amount of energy revenues realized.

If a facility were designed to meet the second objective, it would be sized to operate at full capacity during the anticipated lowest period of waste generation during the life of the facility. In this way, the facility would not have unused capacity at any time, the efficiency of operations would be the highest and it would return the maximum possible energy revenue stream for its size during its entire operating life. Therefore, a lower net cost per ton of waste disposed would result. However, waste would bypass the facility during many periods of waste generation, resulting in less conservation of landfill space.

Typically, facilities are sized somewhere between the two extreme cases illustrated above to optimize the objectives of lowest cost and largest amount of waste reduction. MSW and RDF storage are generally provided to accommodate daily and some seasonal variations in waste generation, and scheduled maintenance and inspections are generally performed during low periods of waste generation.

Sizing a WTE facility requires a detailed evaluation of each community's individual requirements, goals and objectives. However, the general relationship between the population required to support a WTE facility and the resulting facility size is shown on Figure V-5-7.

TYPICAL POPULATION SERVED BY A WASTE-TO-ENERGY PLANT

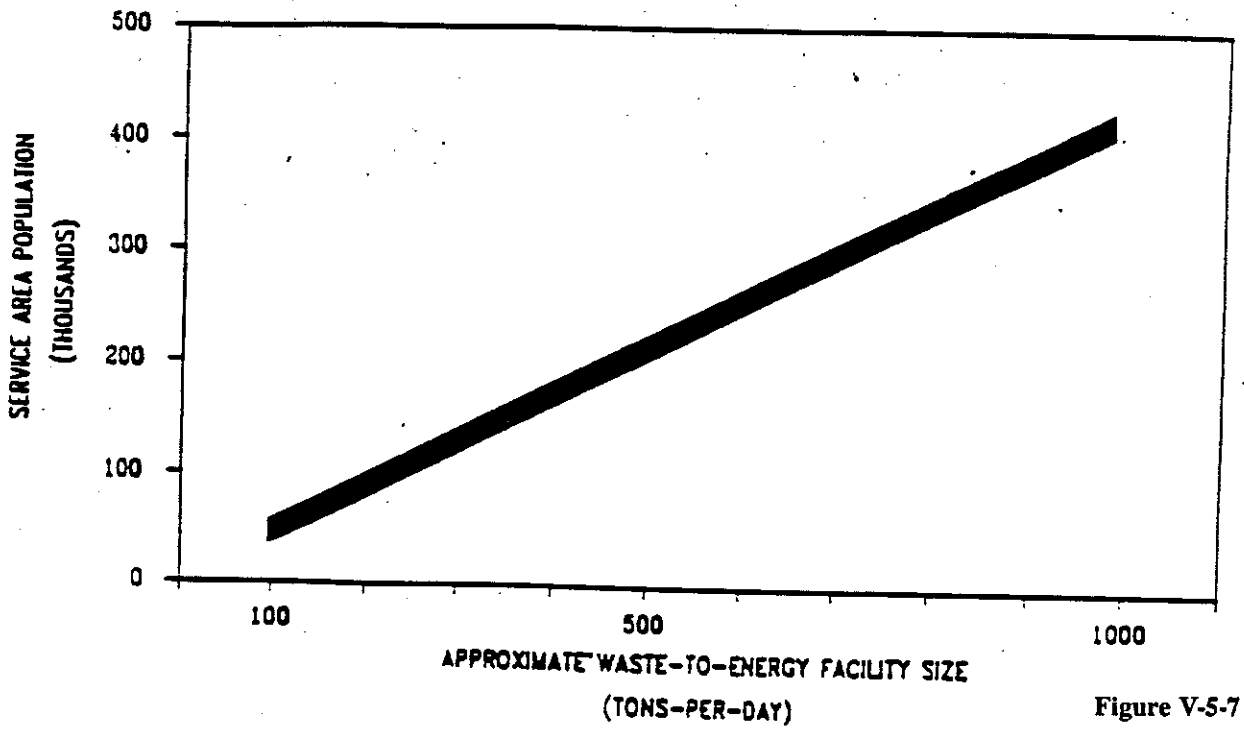


Figure V-5-7

WTE FACILITY OPERATION AND PERFORMANCE

The physical, operational and performance characteristics of WTE facilities vary greatly and depend on the specific design criteria involved. Generally, certain basic performance and operational criteria can be developed for generic WTE facilities, recognizing that specific site and regional differences will cause variance between facilities.

A modern WTE facility is expected, and is often guaranteed by the vendor and/or operator, to operate at full capability the equivalent of approximately 85 percent of the year. Approximately 15 percent of its processing capability is expected to be lost each year due to scheduled maintenance requirements and equipment outage periods. Certain of the solid waste generated by a community is non-processible (normally 10 to 20 percent); however, the volume reduction achievable by the incineration of processible waste in a WTE facility should be between 80 and 90 percent from a properly designed and operated WTE facility. Volume reduction is also often guaranteed to a certain degree by a WTE facility vendor.

ELECTRICAL ENERGY PRODUCTION

Larger WTE facilities that sell only electric energy typically produce from 450 to 550 net kilowatt-hours per ton of solid waste processed. Many smaller modular mass-burning facilities (100 tpd and less), however, have much lower energy production efficiencies. Figure V-5-8 shows the general relationship between WTE facility size and the net available electric output of the facility. Of the electric energy produced by a facility, 10 percent to 20 percent is normally consumed internally, depending on the designed capacity of the facility, and the balance is available for sale to the energy customer.

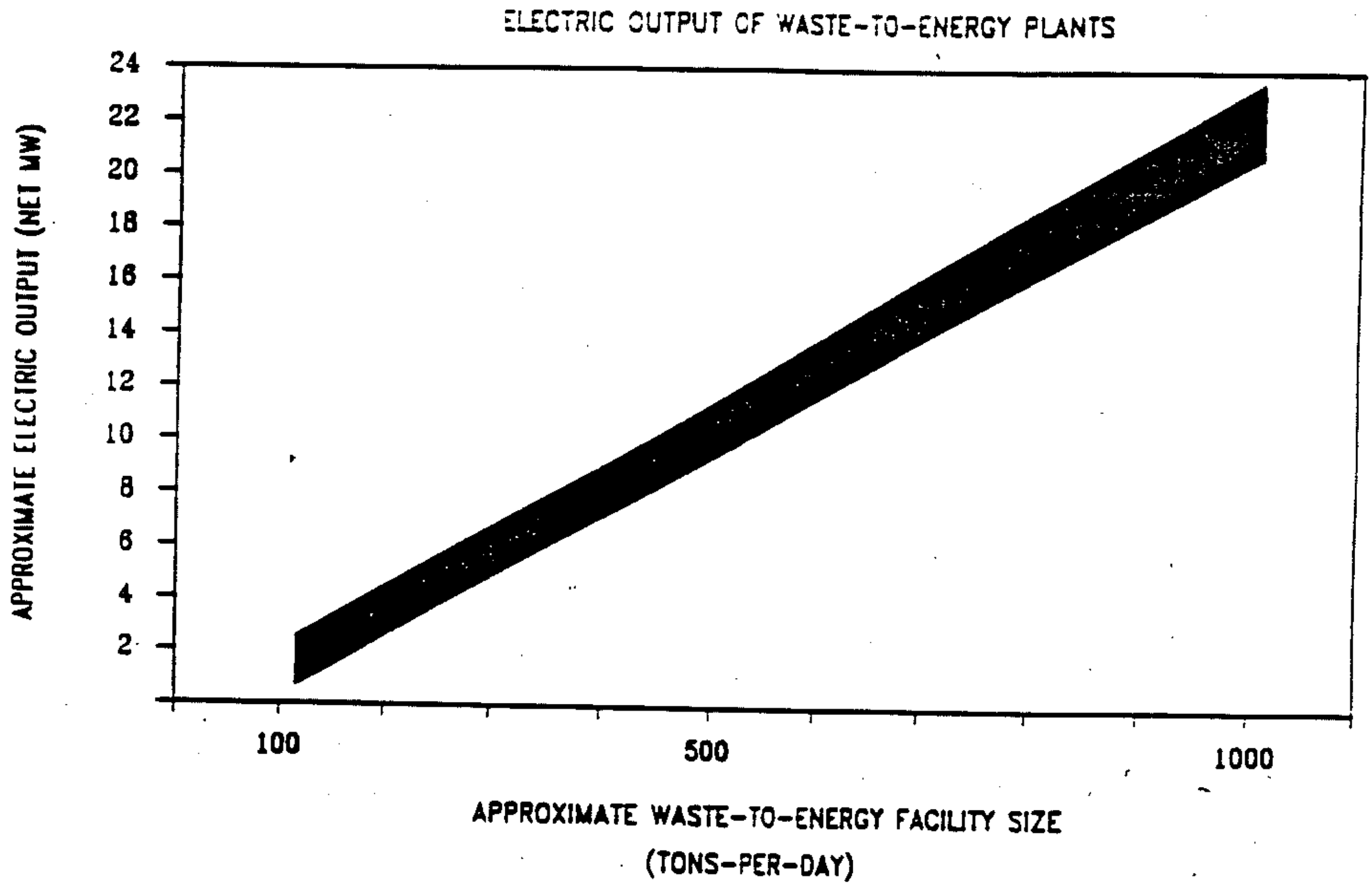


Figure V-5-8

WTE FACILITY CAPITAL COSTS

Construction and capital costs for the various WTE technologies implemented in the United States vary greatly, in part because of the large number of project-specific variables that impact such costs. The major factors influencing construction costs are site-specific factors and design requirements, the type of air pollution control equipment used, energy market requirements and the types of delivery systems used, the amount of taxes imposed, architectural and landscaping features, labor and material markets, construction details, degree of redundancy, types of materials recovered, and methods of procurement, financing, and implementation.

Figure V-5-9 provides a generic summary of the range of capital costs for the three major types of WTE facilities. Although the relative capital costs of the different technologies differ in each specific situation, the general trends are:

- Mass-burn facilities are normally the lowest capital cost option, especially for applications with installed capacity of less than 600 tpd.

- Small modular mass-burn facilities (320 tpd and less) generally have lower initial costs as compared to similar sized field-erected facilities.

- Conventional RDF facilities are usually more expensive than mass-burn facilities for projects that are less than 500 to 600 TPD.

- Very little experience exists with RDF fluidized bed systems. However, this type of unit would be expected to have the highest capital cost of available options and would be applicable for facilities larger than 500 tpd.

Smaller-scale RDF facilities are typically more expensive to construct and operate than comparably-sized mass-burn facilities; however, the cost difference is usually less for larger-scale facilities. Because of the potential cost differences, the benefits of an RDF facility are generally weighed carefully against any additional costs for an RDF facility. Selecting a technology for a specific application involves consideration of numerous factors in addition to capital costs. The "best" and most "cost effective" technology is not always the lowest capital cost option.

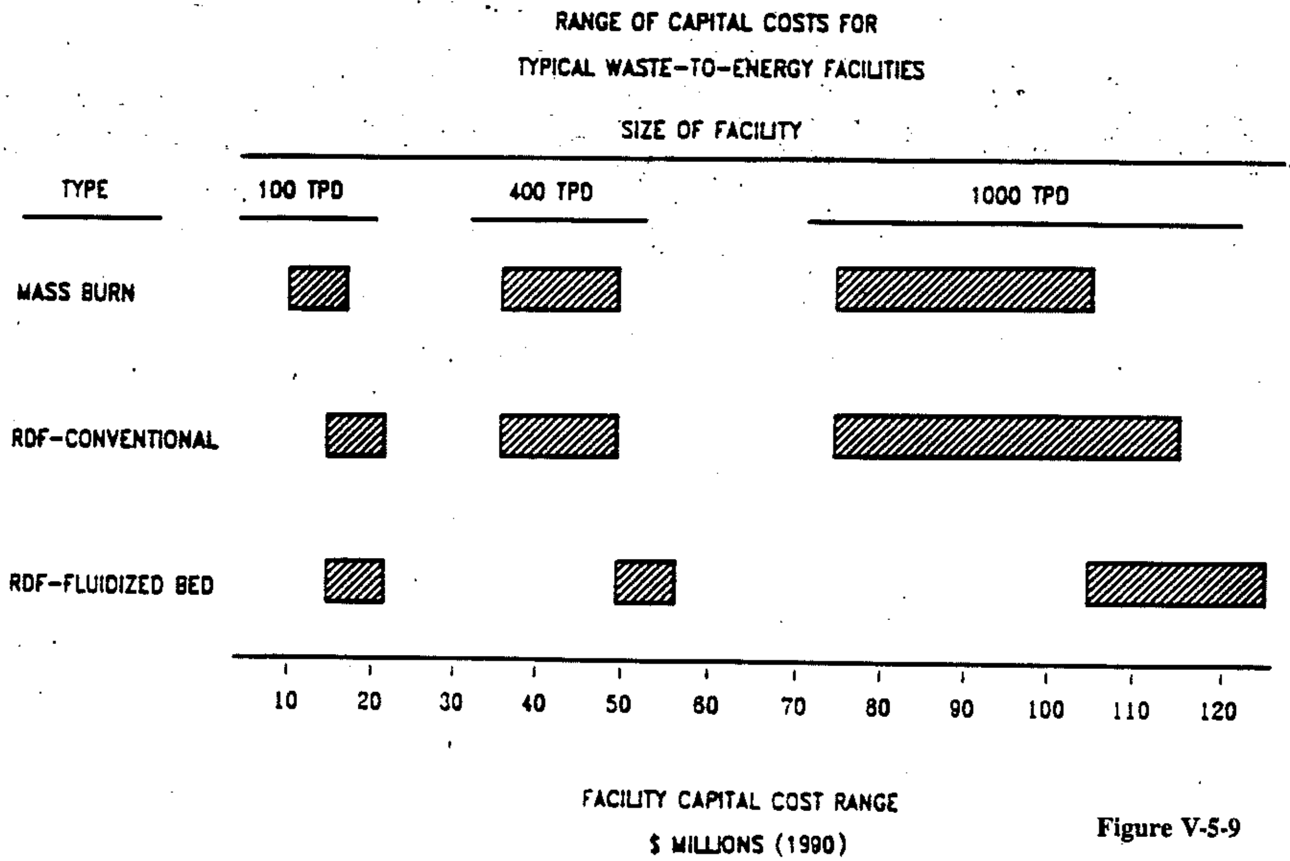


Figure V-5-9

The capital cost ranges shown on Figure V-5-9 are based on facilities that have the redundancy and equipment quality necessary to insure long-term reliable operation. Facilities using lower grade equipment and less redundancy can be constructed at a significantly lower cost; however, resulting operational and other problems make reduced cost systems unreliable and expensive to operate.

WASTE TO ENERGY FACILITY OPERATING COSTS

Costs for the operation of various WTE facilities are also highly variable. These costs are significantly influenced by community needs, current landfill operations, location of landfills, the type of operation (public or private), contractual arrangements for operation, labor and materials markets, and facility technology and design. Several additional factors influence operating costs, particularly when operating services are provided by a private contractor. Examples of these factors include energy revenue sharing provisions; whether operation of ancillary facilities, such as the scale house, is public or private; which costs are considered pass-through costs (e.g, taxes, insurance, construction of steam and/or electric interconnections, disposal of residue, and utilities); the tipping fee calculation methodology; and performance guarantees. Figure V-5-10 shows typical average operating costs for mass-burn facilities of various sizes.

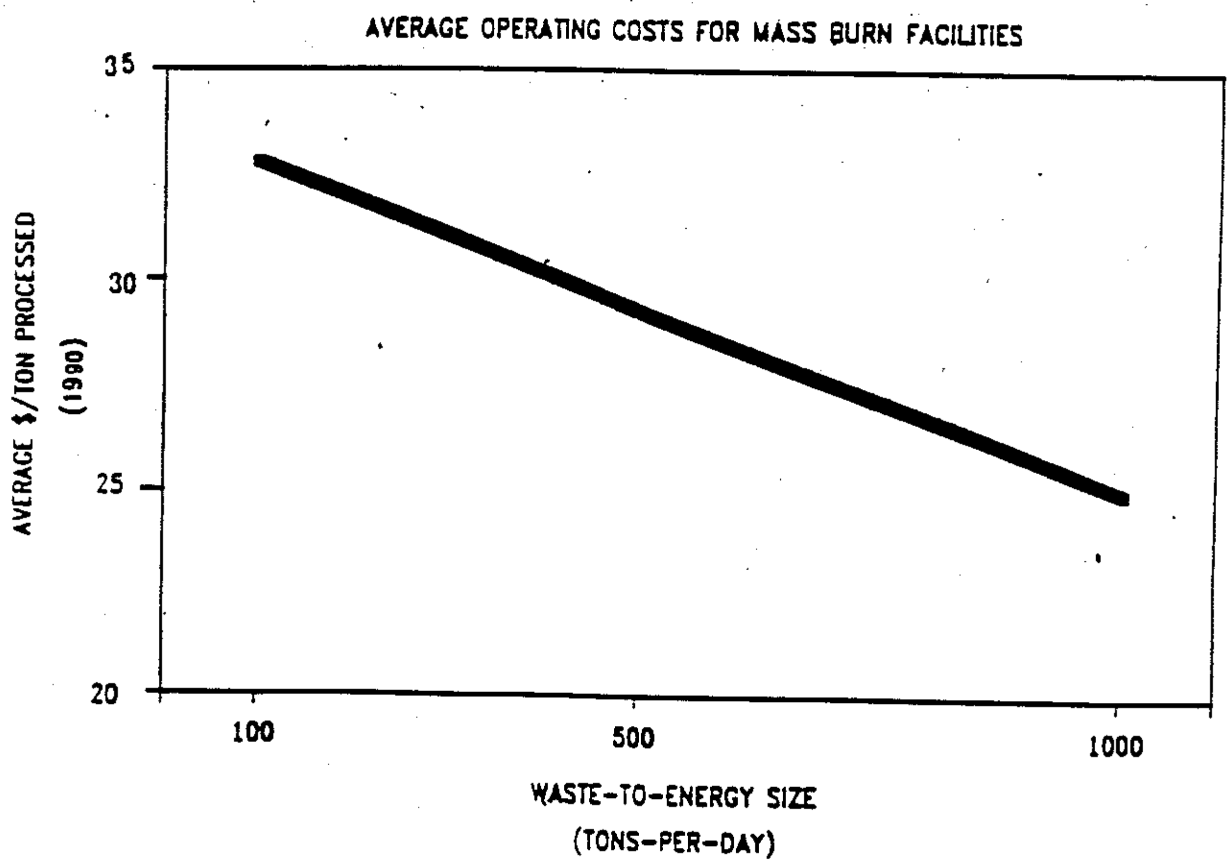


Figure V-5-10

WASTE TO ENERGY FACILITY CHARACTERISTICS

Tables V-5-1 through V-5-5 provide a summary of selected physical, operational, performance, cost and schedule characteristics of the WTE and RDF facilities reviewed. The information represents typical ranges of data for the indicated facility sizes. Typical operating schedules have been assumed in developing the information. Incineration equipment is assumed to operate on a continuous 24-hour-per-day, 7 day per week basis, with planned and forced outages curtailing operation 15 percent of the time. RDF processing equipment is assumed to operate on a 16-hour-per-day schedule six days per week.

The figures shown on Tables V-5-1 through V-5-3 for the 100 TPD facilities include estimated costs for site preparation; buildings, structures and foundations; combustion and ancillary equipment; electric generating equipment; a scrubber and baghouse system for air pollution control; engineering; permitting; construction management; start-up and testing; and miscellaneous costs. The characteristics in Table V-5-1 for the 100 TPD facility were developed assuming the use of a modular combustion system. The capital costs for the 100 TPD modular facility include all the above-listed costs, except it is assumed that an electrostatic precipitator is included in lieu of a baghouse, and that only steam is produced and sold. The operating costs for all facilities include labor, maintenance, materials, administration and miscellaneous costs. Residue disposal costs are not included.

The capital costs in Tables V-5-4 and V-5-5 include costs for site preparation; buildings, structures and foundations; waste processing equipment; engineering; permits; construction management; start-up and testing; and miscellaneous costs. The operating costs for the RDF facilities include labor, maintenance, materials, administration and miscellaneous costs. Residue disposal costs are not included. Costs associated with facility financing are not included in any of the tables.

The capital cost of building several small facilities is typically greater than the cost for building one large facility with an equivalent capacity. This can be explained by considering that, for each facility, it is necessary to provide certain duplicate facility requirements such as weigh scales, administration buildings, overhead cranes, stacks, waste storage, entrance roads, and land. In addition, planning, permitting, financing, and interest costs are generally much higher for multiple sites as compared to a single site.

TABLE V-5-1

CAPITAL COSTS AND CHARACTERISTICS OF MASS-BURN FACILITIES

Parameter	Facility Sizes 100 TPD [2]	400 TPD [2]	1000 TPD [2]	2000 TPD [2]
Physical				
Plant Area, square feet	60-90,000	70-100,000	100-120,000	200-250,000
Height, feet	200-250	200-250	250-400	250-400
Site Area, acres [1]	3-5	4-6	6-8	8-10
Plant Performance				
MSW Processed per Year, tons [3]	31,000	124,000	310,000	620,000
Energy Generated, Net kWh/ton MSW Processed	300-450	450-500	500-550	500-550
Ash/Residue Percent of Throughput, Dry	25-40	25-30	25-30	25-30
Liquid Discharges, gpm [4]	0-20	0-30	0-70	0-150
Utilities:				
Supplemental Fuel [5]	Yes	Yes	Yes	Yes
Water (Average gpm)	250	300	700	1,300
Electricity, Percent Gross	10-15	10-15	10-15	10-15
Lime, tons per year	800	1,000	2,600	5,100
Personnel Requirements				
Number of Personnel	25-35	30-40	40-60	60-70
Implementation Schedule				
Schedule, Months:				
Procurement	12-18	12-18	12-18	12-18
Construction and Startup	12-24	24-30	30-36	30-36
Costs				
Capital Cost, $1000/ton [6]	70-120	90-140	80-120	80-100
Operating Cost, $/ton [6]	30-50	30-45	20-30	20-30

[1] Without buffer zones around site.
[2] Nominal capacity per day.
[3] Assumes 85% availability factor.
[4] Liquid discharges primarily from boiler blowdown and cooling tower.
[5] Supplemental fuel usage is highly variable on a case-by-case basis and depends on the number of startup and shutdown occurrences, waste moisture content and variability of the minimum furnace temperature requirements. Normally natural gas, No. 2 fuel oil or propane is used as a supplemental fuel.
[6] Based on estimated 1990 costs.

TABLE V-5-2

CAPITAL COSTS AND CHARACTERISTICS OF CONVENTIONAL RDF FACILITIES

Parameter	Facility Sizes 100 TPD [2]	400 TPD [2]	1000 TPD [2]	2000 TPD [2]
Physical				
Plant Area, square feet	110-160,000	120-170,000	150-200,000	200-350,000
Height, feet	200-250	200-250	250-400	250-400
Site Area, acres [1]	4-6	5-7	8-10	14-20
Plant Performance				
MSW Processed per Year, tons [3]	31,000	124,000	310,000	620,000
Energy Generated, Net kWh/ton MSW Processed	300-450	450-500	500-550	500-550
Ash/Residue Percent of Throughput, Dry	10-25	10-25	10-25	10-25
Ferrous Recovery Percent of Throughput	3-5	3-5	3-5	3-5
Liquid Discharges, gpm [4]	0-20	0-30	0-70	0-150
Utilities:				
Supplemental Fuel [5]	Yes	Yes	Yes	Yes
Water (Average gpm)	250	300	700	1,300
Electricity, Percent Gross	10-15	10-15	10-15	10-15
Lime, tons per year	800	1,000	2,600	5,100
Personnel Requirements				
Number of Personnel	45-60	45-70	60-85	90-140
Implementation Schedule				
Schedule, Months:				
Procurement	12-18	12-18	12-18	12-18
Construction and Startup	20-28	24-30	30-36	30-36
Costs				
Capital Cost, $1000/ton [6]	100-150	90-130	80-120	80-120
Operating Cost, $/ton [6]	30-50	25-40	25-40	25-40

[1] Without buffer zones around site.
[2] Nominal capacity per day.
[3] Assumes 85% availability factor.
[4] Liquid discharges primarily from boiler blowdown and cooling tower.
[5] Supplemental fuel usage is highly variable on a case-by-case basis and depends on the number of startup and shutdown occurrences, waste moisture content and variability of the minimum furnace temperature requirements. Normally natural gas, No. 2 fuel oil or propane is used as a supplemental fuel.
[6] Based on estimated 1990 costs.

TABLE V-5-3

CAPITAL COSTS AND CHARACTERISTICS OF FLUIDIZED BED RDF FACILITIES

Parameter	Facility Sizes			
	100 TPD [2]	400 TPD [2]	1000 TPD [2]	2000 TPD [2]
<u>Physical</u>				
Plant Area, square feet	110-160,000	120-170,000	150-200,000	200-350,000
Height, feet	200-250	200-250	250-400	250-400
Site Area, acres [1]	4-6	5-7	8-10	14-20
<u>Plant Performance</u>				
MSW Processed per Year, tons [3]	31,000	124,000	310,000	620,000
Energy Generated, Net kWh/ton MSW Processed	300-450	450-500	500-550	500-550
Ash/Residue Percent of Throughput, Dry	5-10	5-10	5-10	5-10
Ferrous Recovery Percent of Throughput	3-5	3-5	3-5	3-5
Process Residue Percent of Throughput	15-30	15-30	15-30	15-30
Liquid Discharges, gpm [4]	0-30	0-30	0-70	0-150
Utilities:				
Supplemental Fuel [5]	Yes	Yes	Yes	Yes
Water (Average gpm)	250	300	700	1,300
Electricity, Percent Gross	15-20	15-20	15-20	15-20
Lime, tons per year	800	1,000	2,600	5,100
<u>Personnel Requirements</u>				
Number of Personnel	35-45	40-50	60-70	90-140
<u>Implementation Schedule</u>				
Schedule, Months:				
Procurement	12-18	12-18	12-18	12-18
Construction and Startup	20-28	24-30	30-36	30-36
<u>Costs</u>				
Capital Cost, $1000/ton [6]	120-150	120-140	110-130	110-130
Operating Cost, $/ton [6]	25-40	25-35	20-30	20-30

[1] Without buffer zones around site.
[2] Nominal capacity per day.
[3] Assumes 85% availability factor.
[4] Liquid discharges primarily from boiler blowdown and cooling tower.
[5] Supplemental fuel usage is highly variable on a case-by-case basis and depends on the number of startup and shutdown occurrences, waste moisture content and variability of the minimum furnace temperature requirements. Normally natural gas, No. 2 fuel oil or propane is used as a supplemental fuel.
[6] Based on estimated 1990 costs.

TABLE V-5-4

CAPITAL COSTS AND CHARACTERISTICS OF FLUFF RDF PRODUCTION FACILITIES

Parameter	Facility Sizes 100 TPD [2]	400 TPD [2]	1000 TPD [2]	2000 TPD [2]
Physical				
Plant Area, square feet	60-90,000	70-100,000	110-140,000	200-300,000
Height, feet	40-60	40-60	40-60	40-60
Site Area, acres [1]	3-5	3-5	6-8	10-14
Plant Performance				
MSW Processed per Year, tons [3]	31,000	124,000	310,000	620,000
RDF Generated, Percent of Throughput	65-85	65-85	65-85	65-85
Ash/Residue Percent of Throughput, Dry [4]	None	None	None	None
Ferrous Recovery Percent of Throughput	3-5	3-5	3-5	3-5
Process Residue Percent of Throughput	10-20	10-20	10-20	10-20
Liquid Discharges, gpm	Minimal	Minimal	Minimal	Minimal
Utilities:				
Water	Minimal	Minimal	Minimal	Minimal
Electricity, kWh/ton MSW Received	25-35	25-35	20-30	20-30
Personnel Requirements				
Number of Personnel	20-40	25-45	40-60	50-70
Implementation Schedule				
Schedule, Months:				
Procurement	12-18	12-18	12-18	12-18
Construction and Startup	12-18	12-18	12-18	12-18
Costs				
Capital Cost, $1000/ton [5]	50-70	45-65	40-60	35-55
Operating Cost, $/ton [5]	15-30	15-30	15-25	15-25

[1] Without buffer zones around site. Does not include area for MSW composting although such an operation could be added.
[2] Nominal capacity per day.
[3] Assumes 85% availability factor.
[4] Assumes ash disposal is the responsibility of the owner of the combustion units that burn the RDF produced.
[5] Based on estimated 1990 costs.

TABLE V-5-5

CAPITAL COSTS AND CHARACTERISTICS OF DENSIFIED RDF PRODUCTION FACILITIES

Parameter	Facility Sizes 100 TPD [2]	400 TPD [2]	1000 TPD [2]	2000 TPD [2]
<u>Physical</u>				
Plant Area, square feet	60-90,000	70-100,000	130-160,000	250-350,000
Height, feet	40-60	40-60	40-60	40-60
Site Area, acres [1]	5-10	6-10	8-14	12-18
<u>Plant Performance</u>				
MSW Processed per Year, tons [3]	31,000	124,000	310,000	620,000
RDF Generated, Percent of Throughput	30-65	30-65	30-65	30-65
Ash/Residue Percent of Throughput, Dry [4]	None	None	None	None
Ferrous Recovery Percent of Throughput	3-5	3-5	3-5	3-5
Process Residue Percent of Throughput	15-30	15-30	15-30	15-30
Liquid Discharges, gpm	Minimal	Minimal	Minimal	Minimal
Utilities:				
Water	Minimal	Minimal	Minimal	Minimal
Electricity, kWh/ton MSW Received	35-65	35-65	35-65	35-65
<u>Personnel Requirements</u>				
Number of Personnel	25-45	30-50	45-65	55-75
<u>Implementation Schedule</u>				
Schedule, Months:				
Procurement	12-18	12-18	12-18	12-18
Construction and Startup	12-18	12-18	12-18	12-18
<u>Costs</u>				
Capital Cost, $1000/ton [5]	60-80	55-70	45-65	45-65
Operating Cost, $/ton [5]	17-35	17-35	17-30	17-30

[1] Without buffer zones around site. Does not include area for MSW composting although such an operation could be added.
[2] Nominal capacity per day.
[3] Assumes 85% availability factor.
[4] Assumes ash disposal is the responsibility of the owner of the combustion units that burn the RDF produced.
[5] Based on estimated 1990 costs.

WASTE TO ENERGY FACILITY RISK CONSIDERATIONS

The development of a WTE facility, like any major project, carries certain inherent risks. The allocation of risk between the public and private sectors is accomplished through the procurement and operating contracts and arrangements developed for the project. Generally speaking, as more risk is assumed by the private sector (the vendors), the costs of construction and operation to the public sector increase. In addition, there are certain risks that will always be borne by the public sector, even if attempts are made to assign them to the private sector through contracts. The major items of risk associated with a WTE facility fall into the following broad categories:

- Solid waste supply problems
- Technical problems
- Environmental problems
- Economic problems

The general principle that is applied to the allocation of risk is that the party that has the most control over a given event will assume that particular item of risk. For many items of risk, it is clear which party should be responsible. However, there are some items which are beyond any party's control. These may include a future change in environmental law or a change in the price of energy. Customarily, such items of risk fall to the public sector to assume, although there are limited examples of vendors which have assumed certain items of risk beyond their control.

Solid Waste Supply

In nearly all cases, the public sector is directly responsible for obtaining and delivering an adequate supply of solid waste to a WTE facility, and all risks associated with failure to deliver, including sizeable economic penalties, are borne by the public sector. As such, it is usually imperative that a public entity (city, county or district) be able to enact and maintain control over the flow of waste within its jurisdiction for the expected financial life of a WTE facility. This requirement is also critical to obtaining requisite facility financing.

The public is also usually expected to assume all risks and corresponding economic penalties associated with unforeseen changes in the composition or heating value of the solid waste on which the WTE facility was originally designed. Both of these potential risks can be mitigated by a proper and careful analysis of the waste stream, the integration of the WTE facility with other solid waste management facilities, and the proper design of the final project.

Technical Reliability

Energy recovery from solid waste is a relatively young industry, and the technology is still in a period of innovation. In recent years, several governments and private companies have suffered severe consequences when plants either under-performed or had to be shut down completely. However, proven systems are now available from reliable companies and risk can be minimized by carefully seeking out a proven technology.

The accepted method of protecting the proponent from the risks associated with failure of a particular technology is through a vendor procurement process which carefully evaluates proven technology performance and through contract provisions which require the vendor to guarantee project performance and protects the project proponent through liquidated damages for shortfalls in performance.

Regional Applicability

Provided that the contractual and political issues can be resolved among the jurisdictions participating in a regional solid waste management system, a WTE facility can be implemented on a regional basis. Certain economies of scale may provide financial advantages to such an approach; however, the difficulties associated with the importation of solid waste across county lines are often underestimated. Numerous regional projects, which appeared to be economically and technically feasible, have failed due to an inability to overcome concerns over shared liabilities and political and community opposition.

Adaptability to Changing Conditions

WTE facilities are very capital-intensive and require a reliable waste stream for economic viability. Uncertainties regarding waste quantity generation or the inability or undesirability of guaranteeing waste flow through solid waste control legislation pose a risk to the project proponent.

Unforeseen changes in environmental law also pose a risk to the project proponent because performance guarantees and other protection provided by WTE facility vendors will not cover this situation. Past experience indicates that WTE facilities can be modified, if required, to meet new standards; however, this would result in additional cost that could be sizeable. Also, adequate land should be provided in the facility design to accommodate such potential equipment changes or additions.

Relative Risk

Risks in WTE facility development can be divided into two basic categories: those risks within the control of the party performing a specific project function, and those risks beyond the control of any party associated with the project. Examples of the former category are faulty technology and construction cost overruns; property casualties and strikes are examples of the latter category. These risks are handled differently, depending on the nature of ownership in the project. If the project is publicly owned, then most of the risks must be borne by the public. If the project is privately owned, many of the risks are borne by the owner.

Summary Risk Matrix

Table V-5-6 provides a summary of the likelihood of various risks associated with the development and operation of a WTE facility and the party which normally assumes the risk. The chance of a risk occurring as presented on the table is based on previous experience with projects that involve nationally-known, reputable vendors and consultants, and proven WTE technologies. Tables V-5-7 and V-5-8 provide a summary of typical risk-sharing during the construction and operating periods of a WTE facility under public and private ownership and operation, respectively.

TABLE V-5-6

TYPICAL RISK PROBABILITY AND ALLOCATION

WASTE-TO-ENERGY FACILITIES

Item of Risk	Chance of Occurring	Party Generally Responsible
Technical Items		
(1) Faulty technology - impossibility of performance at any price	Minimal	Vendor
(2) Energy production guarantees are not met	Possible	Vendor
(3) Performance shortfalls - project performs acceptably but below guarantee levels	Possible	Vendor
(4) Unsuitability of site for the project	Minimal	Vendor
(5) Project inability to comply with existing environmental laws	Minimal	Vendor
(6) Uncontrollable circumstances - change in environmental or other law	Possible	Public
Economic Items		
(1) Uncreditworthiness or bankruptcy of vendor - inability to build or operate the project at contract price or to pay damages for failure of performance	Possible	Vendor
(2) Uncreditworthiness or bankruptcy of municipalities - inability to pay disposal charge or increases due to uncontrollable circumstances	Minimal	Public
(3) Uncreditworthiness or bankruptcy of energy customer - inability to pay for delivered energy	Minimal	Shared
(4) Hyperinflation/Deflation	Minimal	Public
(5) Unavailability of insurance	Minimal	Vendor
(5) Project inability to comply with existing environmental laws	Possible	Public
(6) Increased cost of landfill for residue disposal and bypass	Likely	Shared

TABLE V-5-6

TYPICAL RISK PROBABILITY AND ALLOCATION

WASTE-TO-ENERGY FACILITIES
(Continued)

Item of Risk	Chance of Occurring	Party Generally Responsible
Economic Items (continued)		
(7) Change in law or similar factor addressing equity contribution and resultant tax benefits	Possible	Vendor
(8) Delation of market price of energy	Minimal	Public
Construction Items		
(1) Actual construction cost exceeds construction contract price	Possible	Vendor
(2) Delay - failure of project to meet scheduled acceptance date	Possible	Vendor
(3) General project mismanagement by Vendor	Minimal	Vendor
(4) Uncontrollable circumstances - strikes or other labor matters not site or project related	Possible	Public
(5) Strikes or other labor matters site or project related	Possible	Vendor
(6) Uncontrollable circumstances - acts of God and other casualties	Possible	Shared
(7) "Walkaway" - refusal or practical inability by any party to perform its contract obligations	Minimal	Party Refusing Performance

TABLE V-5-6

TYPICAL RISK PROBABILITY AND ALLOCATION

WASTE-TO-ENERGY FACILITIES
(Continued)

Item of Risk	Chance of Occurring	Party Generally Responsible
Operational Items		
(1) Actual operation cost exceeds operation contract price	Possible	Vendor
(2) Durability - ordinary course of business repairs and replacements exceed allowance in operation contract	Possible	Vendor
(3) Unavailability of backup landfill for residue or bypass waste	Minimal	Public
(4) Unavailability of waste tonnage committed by public sector due to mis-estimates or failure of flow control	Possible	Public
(5) Energy content of waste is less than that assumed in designing the facility	Minimal	Public
(6) Energy content of waste declines over time	Possible	Shared
(7) Uncontrollable circumstances - strikes or other labor matters not site or project related	Possible	Public
(8) Strikes or other labor matters site or project related	Possible	Vendor
(9) Uncontrollable circumstances - acts of God or other casualties	Possible	Shared
(10) "Walkaway" - refusal or practical inability by any party to perform its contract obligations	Minimal	Party Refusing Performance

TABLE V-5-7

TYPICAL COMPARISON OF RISK-SHARING DURING CONSTRUCTION

WASTE-TO-ENERGY FACILITIES

Construction Period Risks	Publicly-Owned Facility (1)	Privately-Owned Facility (2)
1. Technology Problems	Vendor bears this risk.	Vendor bears this risk. Public Sponsor may loose for facility use in excess of guarantees
2. Cost Overruns	Vendor bears this risk.	Vendor bears this risk.
3. Failure to Pass Tests By Certain Date	Vendor bears cost consequences to extent of negotiated liability. Should be at least equal to debt service.	Vendor bears cost consequences to extent of negotiated liability. Should be at least equal to debt service.
4. Failure to Meet Performance Guarantees	Vendor liable for damages.	Vendor liable for damages.
a. Above Minimum Standard	Buy-down occurs to make Sponsor whole in terms of cost per ton. Sponsor faces need to dispose of waste in another manner.	Buy-down occurs to make Sponsor whole in terms of cost per ton. Sponsor faces need to dispose of waste in another manner.
b. Below Minimum Standard	Vendor repays debt plus other damages. Sponsor needs another disposal solution.	Vendor repays debt plus other damages. Sponsor needs another disposal solution.
5. Force Majeure Event/ Changes in Law	Costs and consequences borne by Sponsor.	Vendor is relieved of certain cost and completion guarantees as negotiated. Sponsor bears cost increases due to delay or compliance with new laws and certain negotiated events.

(1) Publicly Operated
(2) Privately Operated

TABLE V-5-8

TYPICAL COMPARISON OF RISK-SHARING DURING OPERATION

WASTE-TO-ENERGY FACILITIES

Operating Period Risks	Publicly-Owned Facility (1)	Privately-Owned Facility (2)
1. Cost Overruns	Sponsor Liable for full operation and maintenance costs.	Vendor is liable for actual increases above inflation index except for pass-through costs.
2. Facility Non-Performance	Borne by the public.	Vendor guarantees to produce a minimum net energy output and generate a maximum residue and is liable for penalties equivalent to revenue lost or cost increase for performance below guarantees.
3. Force Majeure/ Changes in Law	Borne by the public.	Public assumes consequences of non-insurable events through adjustments to vendor's operating fee and performance guarantees.
4. Energy Price	Borne by the public.	May be shared with vendor.
5. Waste Shortfall	Borne by the public.	Borne by the public.
6. Changes in Waste Composition	Sponsor is responsible.	Subject to vendor/ Sponsor negotiation.
7. Residue Landfill Availability and Cost	Sponsor has responsibility for providing residue landfill and accepts costs as pass-through for residue landfill costs up to vendor's guarantee.	Sponsor has responsibility for providing residue landfill and accepts costs as pass-through for residue landfill costs up to vendor's guarantee.

(1) Publicly Operated
(2) Privately Operated

ENVIRONMENTAL CONSIDERATIONS

The principal environmental concerns and issues which are typically associated with operation of solid waste energy recovery facilities include: (1) dioxin, furan, and other hazardous air pollutants (e.g. trace metals, acid gas, etc.) and their associated public health risks; (2) disposal of residue ash: (3) tráffic impacts; (4) visual impacts; and (4) potential noise and odor. The following discussions are based on general information from typical WTE facilities. Specific analyses will be needed to include site-specific and technology-specific aspects for various topics for each district application.

Dioxin and Furan Emissions

The term "dioxin" generally refers to a group of structurally related polychlorinated dibenzo-p-dioxins ("PCDD"). The specific compounds in this group consist of two benzene rings bonded at two locations by oxygen atoms with two to eight chlorine atoms bonded to various carbon atoms in each ring forming a total of 73 isomers. The structurally and functionally similar polychlorinated dibenzofurans ("PCDF") or "furans" are a group of compounds which differ only in that the two benzene rings are joined by a single oxygen atom and a carbon-carbon bond. Although the remainder of this discussion generally will address dioxins, similar statements typically would apply to furans.

Dioxins are generally stable and are not absorbed by human tissue as easily as some other toxic materials.

There are numerous theories regarding the generation of dioxins from incineration of MSW. The most logical theories include the following:

- Burning of wastes which contain trace levels of dioxins will necessarily produce dioxins in the stack emissions to the extent they survive passage through the furnace.

- The presence of two or more chlorinated organics may act as precursors in the formation of dioxins. By a chemical process termed dimerization, these compounds (such as chlorinated phenols) may combine, under appropriate conditions of temperature and oxygen availability, to form dioxins.

- Dioxins may be formed by partial oxidation of single-molecule precursor compounds, such as the partial oxidation of polychlorinated biphenols ("PCB").

- The presence of chlorine and subsequent chlorination of basic aromatic hydrocarbon structures associated with lining, which is present in wood, vegetable residues, etc., may encourage dioxin formation. For instance, the attack of partially pyrolyzed char particles by HCl or other chlorine sources present in the flue gas stream due to the incineration of chlorinated plastics or reactions from inorganic chloride salts may produce dioxin emissions.

The data regarding dioxin emissions from WTE facilities is highly variable. The variations probably result both from analytical variances and from actual emission fluctuations. Differences in emission estimates result from the techniques used, the capabilities of the analysts, and the statistical variations associated with analyses at such low concentrations. Much of the variation in dioxin emissions probably can be related to the combustion technology and practices involved. In fact, there is strong evidence from multiple analyses of the same unit and from laboratory testing that fuel composition and furnace conditions significantly affect dioxin formation.

Public Health Risk Assessment

The United States Environmental Protection Agency has recently established standards (good operating practices and emission limits) for dioxins and furans for large municipal solid waste incinerators subject to the Federal New Source Performance Standards. Limits for smaller MSW incinerators will be proposed later this year. These standards are aimed at minimizing health risk from dioxin and furan emissions. Risk assessments are useful tools for evaluating the potential risk from dioxin emissions and should be performed for each proposed MSW incinerator.

Ash Disposal Issues

A WTE facility significantly reduces the volume of solid waste material to be disposed of in a landfill. For a typical facility, the landfill volume requirement using a WTE facility would be about 30 percent the landfill requirement for solid waste without a WTE facility. With no resource recovery operation, all solid waste is landfilled at a compacted density of about 1,000 pounds per cubic yard, resulting in a landfill requirement (without cover material) of 2.0 cubic yards per ton of solid waste. With a WTE facility, approximately 10 to 15 percent of the solid waste goes to the landfill directly when the facility is unavailable due to scheduled or unscheduled maintenance. In addition, non-processible waste and residue ash from the WTE operation require landfill disposal. The total landfill volume requirement (bypassed waste, non-processible waste, and ash) with a WTE facility would be approximately 0.6 cubic yards per ton of solid waste.

Although less material requires landfill disposal, the characteristics of that waste are different from the characteristics of compacted solid waste. Solid waste, when landfilled, produces methane gas and leachate with significant biological oxygen demand ("BOD"), chemical oxygen demand ("COD"), ammonia, and organic constituents. The combustion process generally reduces BOD, COD, and ammonia in resulting leachate but makes salts and metal ions more available to leaching from residue and ash when landfilled. Such components are especially available from the fly ash portion of the residue.

At a minimum, the State of Indiana requires landfilling of ash residue in a lined facility with leachate collection and treatment. The most conservative ash disposal alternative currently in use involves the use of an ash only landfill ("monofill") that is equipped with double composite lining, leachate collection systems, leak detection systems and groundwater monitoring. New federal regulations are expected to require more stringent requirements on the disposal of ash, and it is recommended that all future WTE facilities plan on acquiring the use of such a modern monofill for disposal of its residue ash.

Wastewater Discharge

The major sources of wastewater discharges from WTE facilities are stormwater runoff, sanitary wastewater and process wastewater. The amount of wastewater discharged from facilities can vary significantly, depending on specific site and project criteria. Many facilities have been designed and operated as "zero" discharge facilities, in which all wastewater is re-utilized internally in the facility.

Storm runoff is mainly a function of the site design and weather conditions. Contamination of stormwater runoff can be prevented by enclosing all equipment, work areas and ash handling and waste processing areas which could potentially contaminate stormwater, and carefully designing site drainage patterns.

The amount of sanitary sewer waste generated at a WTE facility is mainly a function of the number of employees at the facility. The total quantities of sanitary waste generated WTE facilities are typically quite small.

The amount of process wastewater produced is a function of the size and type of facility, the type of cooling system used, the portion of wastewater recycled for use in facility operations, and the type of wastewater treatment selected. Process wastewater may include cooling tower and boiler blowdown, wastewater from the boiler feedwater system, and wastewater collected in floor drains. The use of cooling equipment, such as air-cooled condensers instead of cooling towers can reduce the amount of wastewater generated. Wastewater from floor drains and areas where potential oil spills can occur should be independently collected and passed through an oil/water separator before being discharged. Process wastewater is normally reused as make-up water in ash quench systems and as dilution water for the acid gas control systems in WTE facilities. Local conditions and the type of wastewater generated will dictate the type of wastewater treatment used.

Other Emissions and Discharges

In addition to air and ash emissions from the combustion of MSW, WTE facilities may also emit water vapor and mist from cooling towers, depending on the type of cooling system used. Provisions should be incorporated in the design of the cooling towers to reduce these emissions, or alternative types of cooling systems incorporating systems such as wet/dry cooling towers or air-cooled condensers should be considered. In Indiana, the siting must also consider cooling tower drift and potential icing of nearby roads, bridges and buildings during the winter months.

Dust may also be emitted into the air from storing, handling or processing solid waste or RDF. Dust emissions can be mitigated by designing facilities so all work functions, ash handling systems and processing areas are completely covered and well ventilated. In addition, conveyors must be covered and conveyor transfer points should be hooded. Dust collection equipment may also be incorporated in the design of WTE facilities.

Traffic

Traffic is frequently an issue when considering WTE facility development. Incoming traffic is necessary to deliver MSW to the facility, and additional trips will be required to remove non-processible waste and residue ash to an appropriate disposal area.

In effect, the traffic issue involves the local areas around the facility and the landfill. Without the facility, waste would be directed to the landfill and traffic impacts on routes to the landfill would be expected to occur. With development of the facility, the solid waste would be hauled to the facility 90 percent of the time and the bypassed wastes would be directed to the landfill the remaining 10 percent of the time. In addition, non-processible wastes and residue ash would be transported by truck from the facility to the landfill. This would increase traffic at the facility and reduce traffic around the landfill. The net increase in traffic volume is relatively small; however, there are significant changes in traffic volume on affected routes depending on the relative locations of the landfill and the facility and the magnitude of the waste stream handled by each facility.

Proper planning is the most important element in reducing traffic impacts due to WTE facilities. The facility site must be chosen so that roads and highways leading to the facility can adequately handle any increased traffic flows. The facility site layout should also be designed to prevent, to as great an extent as possible, any queuing of delivery vehicles during peak waste delivery periods.

Noise and Odor Concerns

The primary sources of noise at a WTE facility would be due to truck traffic at the site and fans associated with the boiler facility (especially induced draft fans). Noise impacts would be a function of the noise created and how that noise would be perceived by the public. Numerous factors affect those parameters. The amount of noise created at the facility would be related to the size of the facility, the equipment selected, and the amount of acoustic baffling incorporated in the equipment design. The size of the site and attenuating structures, vegetation, and topography all influence how much noise carries to the boundaries of the site. Off-site characteristics, such as ambient noise level and the existing land use, also are important. Additional noise in an active industrial area is not as great an issue as the same increment of impact in a quiet, residential setting.

Noise issues can be avoided, to a great extent, by appropriate siting of the facility. Location of a suitably large site in an industrial or other non-residential area can significantly reduce the potential for noise impacts. Mitigation options also are available to attenuate the noise associated with operation. These include limiting the queuing of trucks, including earth berms and mature trees and shrubs in the landscaping design, using electrically powered equipment rather than pneumatic, avoiding prolonged idling of pumps and compressors, locating equipment to take optimum advantage of site attenuation, applying acoustic materials to stationary equipment and installing noise control equipment such as mufflers.

Public concern with the potential for objectionable odors associated with waste handling at a WTE facility can be expected. However, all refuse handling, including truck unloading and storage, could occur inside the facility. Such areas are normally maintained at negative pressure to limit the emission of odors to the atmosphere. Negative pressure is achieved and maintained by drawing combustion air for the furnace from the tipping floor and storage pit area. Odor causing compounds would be effectively eliminated in the combustion process by oxidation. Another method of reducing odors is to limit the time raw waste is stored, designing the facility so all work areas, ash handling systems and processing areas are completely covered and well ventilated, and ensuring complete waste combustion.

Public Acceptance

Public acceptance and support of WTE facilities can be achieved provided that the public perceives that a real solid waste disposal problem exists and that WTE is a realistic part of the overall solution to the problem. Even with widespread public support, any proposal to construct and operate a WTE project at a specific location may be expected to be challenged and opposed very strongly by local citizens and groups concerned about the impacts such a facility would have on the environment.

Aesthetics

The aesthetic impacts of a WTE facility come from the actual facility itself and increased truck traffic, noise, odor, and litter which may result from operation of the facility. The general appearance of most facilities is that of an industrial-type building with an exhaust stack of 80 to 120 feet in height. Noise from truck traffic is unavoidable; however, it can be controlled through proper equipment maintenance. Odors are controlled through appropriate ventilation systems and operating procedures.

Architectural treatment and landscaping can be used to mitigate the visual impact of WTE facilities. Depending on the type of architectural treatment and landscaping selected, the appearance of WTE facilities can vary from crude "power plant" type appearances to modern visually pleasing facilities which are difficult to distinguish from large office buildings. Landscaping features, such as earthen berms and rows of trees and shrubs, can be used to screen buildings and equipment from view.

PERMITTING REQUIREMENTS

The implementation of a WTE facility in Indiana must satisfy applicable environmental and other requirements. The responsibility for the regulation and permitting of WTE facilities falls with both the State and the Federal Government. The exact permits and approvals required will depend upon the characteristics and design of the WTE facility, and on the characteristics of the particular site where the facility is located.

There are usually only limited possibilities for involvement of federal agencies in the environmental permitting of WTE facilities. The IDEM has assumed the responsibility for major federally mandated requirements associated with air emissions, wastewater discharges and solid waste disposal. However, depending on a project's design, energy customer and site location, involvement from the Federal Aviation Administration ("FAA"), the Federal Energy Regulatory Commission ("FERC") and the U.S. Army Corps of Engineers ("COE") could result.

The FAA would likely review a WTE facility's exhaust stack location and height to determine if it would pose a hazard to aviation. FAA approval would normally contain requirements for appropriate markings and warning lights, and might impose height restrictions if the facility is located near an airport. Stack height limitations in turn can affect a other environmental impacts defined in other permitting practices.

The FERC would likely review a WTE facility's applicability under PURPA legislation and certify that such facilities meet the criteria specified, if electricity is being sold to electric utilities. Sales of electricity to regulated utilities in Indiana require such certification by the FERC.

The COE could become involved if a WTE site is near a navigable waterway. The COE is charged with permitting dredge and fill activities on all navigable waterways of the United States, and the selection of a site away from such waterways can help avoid delays associated with COE actions. Not only can a COE permit be time-consuming, but such regulatory activity could be determined to be a major federal action requiring the preparation of an Environmental Assessment and perhaps an Environmental Impact Statement, which is even more costly and time-consuming.

The State has authority for the control of air, water and hazardous waste pollutants as mandated by the Clean Air Act, Clean Water Act and the Resource Conservation and Recovery Act. Therefore, the State, through IDEM, would have the responsibility for issuing the permits needed to construct and operate a WTE facility in Indiana. State permits that would be required include a Air Pollution Construction Permit and Operating Permit, Solid Waste Permit, and a Prevention of Significant Deterioration ("PSD") permit for all facilities larger than 250 tons per day with the potential to emit over 100 tons annually of any criteria pollutant, which include sulfur dioxide, nitrous oxides, hydrocarbons, carbon monoxide, and hydrogen chloride. Additional State permits relating to water discharge, hazardous waste or residue ash disposal could also be required, depending on the WTE facility design and waste stream characteristics.

In addition to the federal and State permits and approvals, there are several permits and approvals that could be required at the local level. Local regulations may require permits and approvals for zoning and local land-use planning, sanitary sewer connections, city water connections, building permits and fire inspections, among others. The requirements for obtaining local permits and approvals are usually less extensive than those associated with State and federal requirements, and will depend on the particular site selected and the characteristics of the WTE facility.

EXISTING FACILITIES IN INDIANA

At present, there is only one operating WTE facility in Indiana, located in Indianapolis. The Indianapolis Resource Recovery Facility is a three unit, 2,670 ton per day mass-burn facility that generates steam that is sold to Indianapolis Power and Light Company for resale in their existing downtown steam heating system. The Indianapolis Facility has a dry scrubber and baghouse system for emissions control. Certain post-combustion products are recovered from the residue ash generated through the combustion process, including ferrous metals, aluminum, other non-ferrous metals and sized aggregate. The facility has been operational since 1988.

The only other large-scale municipal incineration facility in Indiana is located in East Chicago. It has a design capacity for two 250 ton per day mass-burn units, and does not recover any products for resale after incineration. The facility is reportedly operating under reduced capacity due to excessive environmental emissions, which are under an order from IDEM to correct the problems. In it also reported that the refurbished facility will be designed to recover some energy from the combustion process.

In addition, there are several small scale incinerators currently permitted in Indiana, the majority of which are located in hospitals, and commercial and industrial locations, which presumably incinerate internally generated waste only.

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TECHNICAL PAPER ON OTHER APPROACHES TO SOLID WASTE MANAGEMENT

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

NON-TRADITIONAL APPROACHES TO SOLID WASTE MANAGEMENT

INTRODUCTION

Pyrolysis and anaerobic digestion have been used successfully in managing waste products such as agricultural waste and sewage sludge, but these processes have only recently been applied to municipal solid waste (MSW). In general, these developing technologies have faced technical and financial difficulties and have only progressed to the demonstration plant phase. This work paper describes the technologies and the plants that have been built and operated in the United States and discusses the potential costs to develop facilities.

PYROLYSIS/GASIFICATION

Description of Technology

Solid fuel pyrolysis and gasification techniques use heat in an oxygen-deficient environment to transform solid organic material to other forms, principally a gas, an oil, and a char. Gasification is primarily intended to produce gas for energy; production of oils and char is intentionally minimized. Pyrolysis is intended to produce oil and/or char in addition to gas, which are intended to be sold for their energy value or chemical properties. Proponents of pyrolysis claim that the inherent worth of the additional products, over and above their energy value, is a positive economic addition to the process.

Several pyrolysis/gasification systems have been designed, including both fixed and fluidized bed reactor systems. Technically successful pyrolysis and gasification projects have been developed to a commercial level with relatively uniform fuels such as wood and agricultural waste. However, the transfer of this technology to a complex fuel such as MSW, which contains a significant percentage of noncombustible materials, may be problematic because of the physical differences between MSW and wood or agricultural wastes.

Most pyrolysis systems require preprocessing the MSW to reduce particle size and/or to remove inorganic material and develop a more homogeneous feedstock. Size reduction (shredders) and classification equipment (trommels) and magnetic separators can process MSW into a refuse-derived fuel (RDF). The preprocessing removes much - but not all - of the metal, glass, sand, and other inert materials that do not contribute to the energy value of the product recovered through pyrolysis.

Inert materials remaining in the RDF may melt during pyrolysis, forming slag that can contaminate char products or cause operational problems in fluidized bed or other non-slagging systems. An exception is the Union Carbide slagging reactor, which included a slag removal system at the bottom to handle the slag formed by the high temperature reaction of the MSW feedstock.

Despite preprocessing, there will still be differences between RDF and more uniform feedstocks such as wood or agricultural waste. RDF has a lower density and contains higher levels of chlorine and sulfur, as well as materials with low melting points, such as glass. These physical differences usually require modifying:

- the feed mechanism;
- materials used for construction;
- method of char and/or oil removal to reduce the potential for bed agglomeration and slagging.

In addition, the potential marketability of the gas, oil, and char products may be adversely affected by the presence of some of the materials commonly found in RDF.

U.S. Operational Experience

Gasification and pyrolysis systems have been operated at pilot plants, but none has yet achieved continuous commercial operation. In the 1970s, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy sponsored a project developed by Occidental Petroleum in El Cajon, California, and a project developed by Monsanto (the "Langard process") in Baltimore, Maryland. The EPA considered both of these projects unsuccessful, and they were shut down in 1985 and 1981, respectively. A privately financed pilot plant was developed in South Charleston, West Virginia in the mid-1970s. That plant, using approximately 200 tons per day of unprocessed MSW, was developed by Union Carbide, and was based on the company's "Purox" process. Union Carbide considered the technology successful because the system operated well; however, an oxygen plant had to be operated in conjunction with it, and the economics of the system were too high to be commercially viable. That plant was shut down in 1978.

Another company, Andco-Torrax, developed a facility in Lake Buena Vista, Florida, near Orlando. The plant was designed to process 100 tons of MSW per day, but the maximum capacity it attained was only about 80 tons per day. In addition, the natural gas required to sustain pyrolysis and the energy costs to operate the plant were much higher than anticipated, causing the overall economics of the plant to be unacceptable. The plant was closed in 1983.

More recently, Power Recovery Systems developed an RDF gasification process that was used in a pilot plant in Cambridge, Massachusetts. This plant, using a fluidized bed gasification system, was capable of processing six tons per day of a highly refined RDF produced at the Cockeysville, Maryland RDF production facility. While the plant was considered a technological success, the developer's financial difficulties shut the plant down in 1987.

European and Japanese experience has been similar. Several small- scale demonstration plants yielded mixed results. Four facilities were built in Europe; three have been shut down or dismantled. Several pilot plants were developed in Japan; today, all but two have been shut down.

Economics

Developing an MSW pyrolysis facility entails considerable technological and financial risk. Consequently, risk allocation should be clearly defined before proceeding with project development. In our judgment, additional research and development is required before the gasification/pyrolysis process can be considered technologically sound.

As MSW gasification and pyrolysis are still in their infancy, there is little reliable data on capital and operating costs. However, from the experience of the demonstration plants, capital costs for a pyrolysis plant are estimated to be approximately $100,000 per ton of daily capacity in current dollars.

ANAEROBIC DIGESTION

Description of Technology

Anaerobic digestion is the biological decomposition in the absence of oxygen of organic material such as sewage sludge or MSW. The process can be used to convert organic waste into methane and carbon dioxide and a solid residue. Traces of hydrogen sulfide and nitrogen gases are also produced.

Historically, anaerobic digestion has been used primarily to stabilize and reduce the quantity of sludges in sewage treatment plants. Uncontrolled anaerobic digestion takes place in landfills, producing methane and carbon dioxide. Landfill gas is recovered, processed, and marketed at some landfills in the United States. However, the use of controlled anaerobic digestion for the treatment of MSW is a relatively new technology, with demonstration plants coming on line only in the late 1970s.

Since only the organic components of MSW can be digested, the first step is to remove inorganic materials such as sand, glass, plastics, and metals, although technically only size reduction is required. Processing also includes shredding to reduce the size of the organic material, making the MSW more readily digestible by exposing additional surface area. Gas production will be improved by removing non-digestible materials and reducing organics to a uniform size.

The processed feedstock is then fed in to a mixing tank, where sewage sludge and/or nutrients may be added. Anaerobic digestion begins after the feedstock and additives are fed to the digester, where the mixture is heated and mixed. The operating temperature ranges from 80° F to 130° F, depending on the type of bacteria used. The time required for digestion depends on such factors as the incoming feedstock and the type of digester used and can range from five to 90 days. Because of the changing mixture of MSW and RDF, it is difficult to predict the digestion time required.

The output from the digester is a gas and a sludge residue. The gas is a mixture of methane and carbon dioxide, which can be burned on-site or processed into a synthetic natural gas. The remaining sludge residue is dewatered, and the solid is disposed of by landfilling, composting, or incineration. The liquid effluent can be recycled into the digester.

Typically, only 50 percent of the organic feedstock will be digested; the conversion process is incomplete. Additional research is needed to determine how to convert more of the RDF to a fuel product. The high level of residue that must be managed has hindered the development of anaerobic digestion as a feasible means of solid waste management.

The interest in applying anaerobic digestion to MSW was initially inspired by the potential to recover methane as a fuel source. However, the high energy prices of the 1970s have declined, reducing the incentive to develop this type of alternative source of energy. Today, the major goal is to reduce the volume of wastes to conserve landfill capacity; energy recovery is a secondary goal, but important in providing potential revenues which could help to offset the costs of waste disposal.

U.S. Operating Experience

Demonstration plants in Florida, France, and Belgium have shown that the anaerobic digestion process works well on a small scale. Waste Management, Inc. built and operated a demonstration plant in Pompano Beach, Florida under the sponsorship of the U.S. Energy Research and Development Administration (ERDA). The facility, known as RefCOM (Refuse Conversion to Methane), was operated from 1978 to 1985. The nameplate design capacity of the plant was 100 tons per day, but it could operate successfully only at 50 tons per day because of mechanical problems and lower process rates than initially projected. The plant was closed for economic reasons. No other anaerobic digestion facilities are currently operating in the U.S.

Because of its lack of development, anaerobic digestion has a high level of technological risk. Problems such as determining the required digestion time for an RDF feedstock and converting more organic material to an energy product have hindered the progress of anaerobic digestion development. While various demonstration plants have proved that the technology can convert solid waste to gaseous products, no full-scale plants are currently in operation.

Economics

The costs to develop an anaerobic digestion facility are difficult to estimate because of the lack of operating histories. In addition, the costs are highly dependent on the incoming feedstock and degree of processing required, type of digester used, and desired quality of the gas product. However, a paper published in 1982 estimated that costs could be $198,000 per ton of daily capacity, assuming optimistic process variables.

The financial risks involved with the development of this system are high, primarily because of the unproven technology. Other economic risks include the necessity of locating stable markets for the methane and compost produced by the system and of maintaining strict control of compost quality.

SUMMARY

Pyrolytic technologies have been successfully developed for uniform waste materials such as wood and agricultural wastes, and anaerobic digestion has been successfully used to process materials such as sewage sludge. However, the transfer of these technologies to MSW has been hampered by its inconsistent composition. While pilot plants have been technically successful on a small scale, many technical problems remain to be resolved, and the technologies have not advanced beyond the demonstration plant phase. Additional research and development must be conducted before these technologies can be considered technologically sound.

These technologies also carry financial risks. Long-term markets for the fuel products may be difficult to secure (if the fuel products are not converted to electricity), creating an additional risk to project developers. Costs to develop these technologies are estimated to exceed $100,000 per ton of daily capacity.

In addition, if volume reduction is the primary goal of a solid waste management program, anaerobic digestion may not fulfill that goal if the sludge residue must be landfilled. Alternatives such as composting or incinerating the residue could further reduce the volume of the sludge residue, although these processes would increase the cost of the total system.

TECHNICAL PAPER ON THE MANAGEMENT OF PROBLEM WASTES

INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

MANAGEMENT OF PROBLEM WASTES

INTRODUCTION

A number of materials found in the waste stream have been singled out for special consideration because they:

- Potentially threaten public health or the environment.
- Present a special handling problem.
- Present a special regulatory problem.
- Are recyclable but have low or no market value.
- Are perceived by the public as a problem waste requiring extraordinary management.

These materials are often referred to as problematic wastes or special wastes. The term "orphan wastes" has also been applied to these materials since they can slip through regulatory cracks and are not clearly claimed as either municipal wastes, hazardous wastes, or industrial wastes. The materials or waste categories included in this classification vary from community to community and from state to state. The specific materials for consideration in this task paper include:

- Waste (Used) Oil
- Tires
- Batteries
- Disposable Diapers
- Construction and Demolition Debris
- Household Hazardous Waste

A background discussion of each of these problem wastes explains why the material is considered a problem waste in the State of Indiana and how it is currently managed. Alternatives for managing each of the wastes are evaluated and barriers to effective management are identified. Case studies are provided as examples of successfully implemented programs.

USED (WASTE) OIL

BACKGROUND

The waste motor oil consists of lubricating oils from automotive crankcases (56%), industrial and aviation lubricating oils (36%), and oils from specialized industrial processes (8%). Generally, these oils pick up metals, water, acids, and other solid and dissolved contaminants as they circulate through the engine blocks and crankcases of gasoline or diesel engines. These contaminants can be removed through a re-refining or cleansing process, producing an oil useful as either a lubricant or as a fuel.

The deleterious impacts of waste oil's improper disposal account for its classification as a problem waste. The improper, but all too common, disposal method of pouring used motor oil onto the ground, into a storm drain, or into a stream threatens public health, damages the environment, and wastes a valuable resource. Even landfill disposal of waste oil can be a problem when the oil leaches into ground water aquifers. Waste oil disposed of in the trash with other refuse can cause problems when packer units crush the waste oil containers, allowing the oil to contaminate otherwise recoverable materials in the load and to possibly leak onto the roadway.

The principal culprits of improper waste oil disposal are the large number of "Do-It-Yourselfers" (DIYs) who change their oil at home or on vacant land, and dump the waste oil on the ground, down the sewer, or throw it out with refuse destined for a landfill. Isolated instances of "midnight dumping" by irresponsible business operators -- who have been paid to legally dispose of waste oil, but who then dump it or illegally resell it as "discount heating oil" -- have also been noted in some locations. In the past, waste oil has been applied to roads to control dust; however, this practice has been discontinued or restricted by regulations in most areas. Most waste oil generated by industries and commercial garages is currently managed appropriately through collection and processing networks.

The United States Environmental Protection Agency (EPA) estimates that, nationally, DIY oil changers generate in excess of 200 million gallons of waste oil per year, with less than 10% of the waste oil recovered for recycling. A national survey of DIYs found that only 14% attempted to properly dispose of the waste oil at a recycling collection point; most admitted to improper dumping or to putting it in the trash. Clearly, DIY oil changers are of great concern in managing waste oil. On the bright side, the increasing availability of convenient oil change services (some cities have seen an annual growth rate of over 300% in the last ten years), marks a trend towards fewer DIY oil changes.

Improper waste oil disposal can cause environmental and health problems. Improperly disposed waste oil can be carried by runoff following heavy rains, possibly making its way into the ground water or into sewers and on to sewage treatment plants not equipped to remove it. Oil deposited in water takes years to break down and can be transported and dispersed across vast areas. Waste oil, the single largest source of fresh water oil pollution, interferes with the re-oxidation process essential to healthy aquatic systems and is toxic to many types of fish and wildlife. Oil washed onto shores can destroy plant life and lead to shore erosion. Waste oil spread on the ground damages the productivity of soil.

Toxic elements such as lead, arsenic, and zinc are commonly found in waste oil and may originate in additives to either oils or gasolines. Human exposure to these carcinogenic substances may occur when people consume plants or animals in which the toxic substances have accumulated. In addition, skin contact with waste oil may cause cancer. Improperly disposed oil can degrade drinking water. The EPA has determined that one quart of oil will foul the taste of 250,000 gallons of water.

The contamination of otherwise recoverable waste oil by contaminants such as antifreeze, gasoline, solvents, and oils used in transformers is also a concern. For example, in 1981 a New Jersey waste disposal firm was caught pumping toxic waste containing PCB's into waste oil which was later sold as fuel oil to an apartment in New York City. These contaminants are difficult to remove and make it difficult or impossible to recycle the tainted oil. Concern about the presence of toxic substances in contaminated waste oil has lead to lengthy, and as yet incomplete, deliberation about whether or not waste oil should be regulated as a hazardous waste. In 1986, the EPA determined that waste oil was not a hazardous waste since classifying waste oil as such would discourage its recycling. However, a 1988 U.S. Court of Appeals decision requires that the EPA reconsider it's decision.

Improperly disposed oil is a wasted resource, since processed waste oil can be reused as a lubricant or burned as fuel oil. Proper disposal of oil through recycling protects public health and the environment and conserves petroleum. Re-refining oil is more energy-efficient than producing new refined oil from crude oil. A number of states have determined that collection and recycling of waste oil is the best management practice. Often, collection and recycling is the only acceptable and legal management practice for waste oil.

Re-refining is the best way to prepare waste oil for reuse. Less than 2% of 42-gallon barrel of crude oil is economically suitable for use in the manufacturing of lubricating oil. In comparison, over 50% of the volume of waste oil is recoverable as lubricating oil through the re-refining process. The highest quality virgin lubricating oils are obtained from limited and dwindling supplies of crude oil found in western Pennsylvania and west Texas. The production of new high-quality synthetic lubricants is not expected to keep pace with lubricating oil demand, currently 2.5 billion gallons per year nationally, once these high-quality sources are depleted. Recycling of waste oil can postpone the point of depletion of these crude oil supplies.

Through a thin-film distillation process, waste oil can be cleaned to the point where it is comparable to, and in some cases better than, virgin lubricating oil. The equipment used to refine waste oil, including the necessary environmental controls and wastewater treatment facilities, requires a significant capital investment. Thirty years ago, there were over 150 waste oil refiners in North America; today there are only a few. The remaining waste oil refiners only have capacity to handle about 10% to 20% of the available supply. Potential purchasers of re-refined oil are often wary of the quality and may prefer to go with a brand name virgin lubricating oil. However, the consolidation in the waste oil refining industry has improved the product's quality.

Over two-thirds of the waste oil collected is reprocessed for use as a fuel in industrial boilers or as bunker fuel for ships. Reprocessed waste oil is 20% to 30% cheaper than virgin burner fuel. Reprocessing waste oil to produce a fuel is less expensive than re-refining. The reprocessing may involve gravity separation, filtering, evaporation, and in some cases, chemical treatments. "Processing" of waste oil encompasses a range of treatments. Often waste oil is only blended (diluted) with other fuels before burning. Some large generators of waste oil maintain their own limited processing capability and consume their own waste oils. Some waste oil is used as a fuel without being processed at all. This may be acceptable for some hydraulic or other waste oils which burn cleanly.

The burning of unprocessed waste oil can potentially create operational and environmental problems. Under the 1980 Used Oil Recycling Act, EPA has developed guidelines for the combustion of waste oil which require testing and, most often, some form of processing before burning so that emissions and toxics in ash are held within acceptable levels. Boiler fouling, strainer clogging, accelerated nozzle wear, and reduced heat transfer efficiency are operational problems which may occur due to the burning unprocessed waste oil. Environmental and health problems may result from the burning of unprocessed waste oil due to toxic substances contained in the oil or to the increased fire risk resulting from inadequate burner and handling systems. In some areas, stringent air quality rules restrict the burning of most processed waste oils.

Probably less than 10% of the waste oil collected is currently used for road oiling or other purposes. Regulations vary on the type of reprocessing required for waste oil for these applications.

In the State of Indiana, it is against the law to use waste oil for road oiling or dust suppression. Environmentally sound dust suppression alternatives exist. The Times Beach, Missouri incident, in which the application of contaminated oil to roads and other areas killed livestock and forced evacuation of the town, illustrates the extreme risk of using waste oil for dust suppression.

Several businesses which collect and process used motor oil are located in the State of Indiana. Presently, the majority of gas stations, industrial accounts, and auto dealers have their waste oil collected by one of these companies. Although several communities have oil tanks available to the public for waste oil drop-off, the majority do not. Most waste oil collectors are charging $0.00 to $0.50 per gallon for pickup. Several collectors expressed an interest in collecting used motor oil from community collection centers if economically feasible collection routes can be developed. All collectors stressed that communities would have to be responsible for contamination. Waste oil collection programs in the State have thus far had no contamination problems.

A number of factors limit collection of waste oil in Indiana. It may take as long as two years to establish a profitable waste oil collection route. The liability from one incident of contamination could result in the loss of the entire business. In addition, low prices for crude oil and other energy sources limit the profitability of collecting waste oil or maintaining a drop-off site.

Waste oil processors serving Indiana reportedly have capacity sufficient to manage 100% of the volume which could be recovered through increased collection. Major waste oil processing facilities are located in Indianapolis, East Chicago, and South Bend.

MANAGEMENT OPTIONS

Nationally, the Energy Policy and Conservation Act (1975), the Resource Conservation and Recovery Act (1976 and 1984), and the Used Oil Recycling Act (1980) stipulate requirements for the proper disposal and recycling of waste oil from industrial, commercial, agricultural, and many other types of waste oil generators. Regulatory and recovery programs are well-established for this sector. For the most part, no new management structures are needed, although some fine tuning may be required to assure compliance. The principal concern with waste oil management today is the recycling of waste oil generated by DIY oil changers.

Regulatory requirements and DIY-generated waste oil recycling programs vary from state-to-state. Fourteen states have regulations stricter than those set by EPA; only seven states have no waste oil regulations at all. Seven states have regulated waste oil as a hazardous waste, independent of EPA policies. Twenty-four states have state waste oil recycling programs for DIYs and an additional 14 states have local DIY programs without state assistance. Of the 24 state level programs, only 12 are active. Similarly, of the states with DIY programs at the local level, only 20 are active. Only three states, California, Minnesota, and New Jersey, require residents to participate in DIY collection programs.

The established DIY recycling programs in the U.S. share common design characteristics and are basically variations of a few common themes. These programs include components common to all recycling programs, such as public education and program publicity. DIY waste oil recycling programs vary most dramatically in terms of the legislation governing them and in terms of collection system design.

Legislation

Waste oil recycling programs targeting DIYs are either mandated by state law or are voluntary. Both approaches have proven effective in the past. Often, states that mandate waste oil recycling have also designated waste oil as a hazardous waste and the resulting programs deal with the hazardous waste storage, treatment, transportation, and disposal requirements, as well as liability.

Some voluntary programs have been relatively successful, but often lack statistical proof of the program's success. Voluntary programs face increasing difficulty in dealing with the issue of liability, especially now that a federal court has ruled that the EPA must reevaluate its decision not to designate waste oil a hazardous waste. This recent court ruling is expected to have a chilling effect on oil recycling programs. Service stations and recycling centers accepting DIYs' waste oil are unlikely to assume liability if the EPA reverses its decision on waste oil classification.

Collection System Design

Four basic methods of DIY waste oil collection are used in state programs:

- Drop-off at service stations or other businesses which serve as collection centers.
- Drop-off at dedicated recycling or collection sites.
- Curbside collection.
- Designated drop-off days at specific locations.

Both voluntary and mandatory programs use these methods and DIY waste oil recycling programs often use more than one method.

The first method, collection at service stations or retail stores selling motor oil, is very common. Collection centers accept waste oil, usually in no more than five gallon amounts, and store it for removal by a waste oil collection service. Depending upon local markets and state laws, the collection center may charge for accepting waste oil from DIYs.

Drop-off at designated collection centers requires waste oil storage containers to be located at appropriate and convenient locations. These locations may be community recycling centers for other recyclable materials such as glass, aluminum, and paper, or may be municipal facilities such as transfer stations, landfills, Department of Public Works facilities, or fire stations. Often, municipal personnel monitor the clearly marked containers to prevent contamination of the collected oil. Specialized containers can be used for unattended waste oil collection, as is the case in several European countries.

Curbside collection is the third method of collecting waste oil. Containers, usually plastic jugs, used to store waste oil until collection may be provided to DIYs. Curbside collection of waste oil may be part of a broader recycling program or may be conducted independently. The frequency of collection varies from once a week, with the collection of other recyclables, to monthly or quarterly.

The vehicles used for curbside waste oil collection vary greatly among programs. Some recycling vehicles are specifically retrofitted for the collection of waste oil. Other types of vehicles can also be easily modified. Small tanks can be attached to vehicles, permitting waste oil to be poured into the tanks at curbside, or racks can be installed to carry waste oil in individual containers provided to residents. Oil from these containers is later transferred to a storage tank.

The fourth method of oil collection used in recycling programs is for waste oil to be dropped off on certain days at specified locations. Waste oil is often accepted during household hazardous waste round-up days. The frequency of these events vary, though many communities strive to offer them at least twice a year.

Education/Promotion

The major components of a waste oil education program are notification requirements, a hotline and information center, and brochures and promotional material. Extending education and promotion efforts to the local level can increase the effectiveness of a recycling program, particularly if collection opportunities are expanded as well. Public awareness and understanding of proper waste oil management and available services is key to the success of a waste oil recycling program. Frequent public service announcements, flyers, presentations, and other outreach activities provide the "what, where, how and why" of a waste oil program and can dramatically increase public awareness and participation in the recycling program.

Market Development

A number of actions could strengthen markets for waste oil. Waste oil generators, collectors, processors, and purchasers need a central source of clear and dependable information about current regulations and programs. In the past, regulations were reportedly interpreted inconsistently. Governmental efforts to assure that both products manufactured from waste oil and the businesses involved in their production meet the highest standards might serve to improve the image of this industry and to stabilize recovery systems.

While boiler fuel has been the primary end-use of waste oil from Indiana, the future should hold increasing opportunities to re-refine this resource into its highest and best use as a lubricant. A 1986 California law defining recycling of waste oil did not include the use of waste oil as a fuel as a recycling strategy. Until Waste oil refining capacity is more fully developed, a safely combustible fuel derived from waste oil is an end-use sufficient to encourage continued collection.

To encourage the development of waste oil refining capacity, State and local government agencies might consider procurement preferences or incentive and promotion programs encouraging their contractors and others to purchase refined waste oil. Federal procurement standards for waste oil have already been published (*Federal Register*, Vol. 53, June 30, 1988).

Other Options

A collection program for DIY waste oil must meet a state's goals and objectives and adapt to local conditions. Other options which a state may consider for managing waste oil include the following:

- Address Liability Issues. The thought of liability poses a major barrier to management of waste oil. Since the recent court decision requiring the EPA to reevaluate listing waste oil as a hazardous waste, liability has become a major concern in all states that have not already designated waste oil a hazardous waste.

In 1988, Florida adopted solid waste legislation which is revolutionary in its approach to the issue of liability for generation, transportation, and disposal of waste oil. The Florida law states that, "No person may recover from the owner or operator of a used oil collection center any costs of response action resulting from a release of either used oil or a hazardous substance or use the authority of (another section of the law) against the owner or operator of a used oil collection center." If other defined conditions are met (which basically assume sound operating collection methods), the collection center operator is not liable for the release or disposal of hazardous waste resulting from collecting waste oil from DIYs. Related legislation has been adopted in California, where small quantity handlers are exempt from provisions that regulate waste oil as a hazardous waste.

Currently, waste oil collectors are unable to obtain environmental liability insurance at a reasonable cost, or frequently, at any cost. The successful resolution of the liability issue may be key to the success of a waste oil recycling program. Approaches to accomplish this might include:

●● Government's assumption of liability or funding of a program to protect prudent operators.

●● Development of legislation which reasonably reduces the liability of qualified and conscientious waste oil collectors.

●● Development of safe-guard programs, such as operator training or certification and prescription of precautionary measures, to reduce the possibility of environmental and health contamination by waste oil.

These measures would assist collectors of DIY waste oil as well as handlers of commercial waste oil.

- Enhanced Drop-Off Opportunities. The successful resolution of the liability issue should encourage private enterprise to stabilize and expand waste oil drop-off opportunities. Drop-off waste oil collection programs could be made more convenient and effective by promoting their use, increasing the number of locations, standardizing operations, and reducing operating costs so that waste oil could continue to be collected without charge, or perhaps even provide some payment. Approaches to accomplish this include:

- Offering pooled environmental liability insurance to collectors as a credit or payment for their service of diverting waste oil from improper disposal.

- Financing, or providing storage tanks, collection containers, test equipment, and other supplies which enable collectors to operate profitably. This approach might also involve grants or diversion credits.

- Requiring distributors of new motor oil to establish and fund "no-charge" collection centers to provide adequate DIY waste oil collection in all areas where their products are distributed. Alternatively, as required in some states, this obligation could be assigned to retailers, although this alternative would be more difficult to administer.

- Providing incentives to private or non-profit developers of collection centers - e.g., operating sites, matching funds, low-cost loans, business development assistance, exclusive collection rights, etc.

- Providing incentives for citizens to use the waste oil collection system - e.g., discount coupons, prize drawings, promotional giveaways, etc. The Florida program uses such incentives. Although incentives can be useful in generating interest in new services, citizen participation should ultimately be based on appeals to environmentally responsible behavior: doing the right thing, protecting public health and the environment, etc.

- Funding collection program enhancement, including education and promotion, through a product charge on new oil, cooperative programs with retailers, user fees, or fines collected from those refusing to use the available system.

- Curbside Collection. Waste oil should be considered for pick up in those areas of a state where curbside collection of recyclables is underway or planned. Across the nation, concern about liability and uncertainty about handling requirements and market values have been a barrier in some communities where curbside collection of waste oil has been available. Nevertheless, this approach is one of the most convenient methods for collecting DIY waste oil.

- Regulation of Disposal. Some states, including Michigan, California, and Rhode Island have chosen to regulate waste oil as a hazardous waste. This requires special handling and disposal procedures which prohibit the disposal of waste oil in landfills and solid waste incinerators. Florida, though not designating waste oil as a hazardous waste, has prohibited its disposal in landfills. Minnesota has made it illegal to dispose of waste oil with other household waste in garbage cans. Such bans on disposal can reduce the volumes of waste oil disposed of improperly if alternatives for recycling are promoted and implemented.

- Regulation of Products and Activities. Additives in new lubricating oils or in gasolines make the production of high quality re-refined lubricant or burner fuel more difficult. Federal action to reduce gasoline's lead content has resulted in lower lead concentrations in waste oil. Regulating gasoline and oil additives could reduce the toxicity of used crankcase oil and of ash resulting from the combustion of processed waste oil, without diminishing the lubricating or performance qualities of these products. The oil and automotive industries should be involved in evaluating how to improve the recovery and management of waste oil.

  Product charges on new supplies of lubricating oil have been mentioned as one way to fund waste oil management. Taxes on automobile sales or licensing fees can provide an alternative source of funds. Self-imposed assessments by a particular industry could fund solutions to environmental problems caused by that industry's product. Reducing the number of people changing their own oil is another way to reduce the volume of unmanaged waste oil. With the rapid increase in the number of available quick oil change services in the last ten years, the percentage of DIY oil changes has been reduced. Short of prohibiting all DIY oil changes, local government or private business could provide low-cost facilities for DIYs to change their own oil.

CASE STUDIES

The following case studies serve as examples of programs which have been successfully implemented elsewhere:

Project ROSE

Organized in 1977, Project ROSE (Recycled Oil Saves Energy) serves to promote waste oil recycling for DIYs, as well as for industry. Funded through state grants and the Alabama

Department of Economics and Community affairs, Project ROSE has proved that extensive education coupled with voluntary efforts can make a significant difference in waste motor oil disposal methods.

Extensive education in the form of brochures, flyers, advertisements, and slide shows informs the public of the hazards of improper disposal of oil, as well as illustrates the convenient and environmentally sound disposal alternatives available to citizens.

The three collection options currently being utilized are drum placement, curbside collection programs, and collection centers. Since much of Alabama is rural, collection centers at service stations are the most widely used system. Over 240 collection centers are available within the state.

A large volunteer work force, along with three staff members, allows Project ROSE to keep a high profile with relatively low costs. While costs of implementation are not available, Project ROSE staff members stated that the majority of money spent is on production of educational materials.

Project Rose is recognized nationally as an extremely successful oil recycling program. It effectively removes over 6 million gallons of oil from the waste stream each year.

State of Virginia

The State of Virginia began voluntary used motor oil collection programs in 1982. Over 450 collection facilities are located throughout the state, the majority of which are existing service centers.

Retailers of motor oil are required to post signs stating if they accept used motor-oil. Oil retailers who do not accept used motor oil are required to post signs stating where the nearest collection centers are located. The state provides a toll-free number to answer questions regarding used motor oil recycling and has developed informational pamphlets regarding used motor oil recycling and collection.

Recent legislation effective July 1, 1990 makes the dumping of oil in sewers or on land illegal. It is estimated that 343,000 gallons were collected in 1989 and that 4.4 million gallons still go unrecovered within the state. The cost of the program to the state is unavailable.

City of Santa Monica, California

The City of Santa Monica has included used motor oil in its curbside collection programs since 1982. Waste oil is placed in a one gallon, non-breakable sealable container. The oil container is placed at the curb with other recyclables. Oil is placed in a separate section aboard the collection truck, then is transferred into a holding tank at the recycling center.

Public education was provided in the form of flyers and inserts in utility bills. Nearly 2,000 gallons of waste oil was picked up last year. Costs of the program have been incorporated into the total costs of the existing curbside collection program.

BARRIERS TO MANAGEMENT

The primary barriers to the management of waste oil in the State of Indiana include the following:

- The lack of public awareness about waste oil recycling and about the problems caused by the improper disposal of waste oil.

- The lack of an established, convenient, and effective collection network for the do-it-yourself oil changers and the lack of incentives or direction for a coordinated collection network to be developed.

- Limited demand for re-refined oil products and capacity to refine waste oil for use as a lubricant. This barrier is partly due to a perception that re-refined oil is not as good as virgin lubricating oils.

- Low crude oil prices affect the economics of burning and refining waste oil and reduce the incentive to collect it.

- The concern over the potential regulation of waste oil as a hazardous waste has hindered the development of collection networks and processing/re-refining capacity. Associated barriers include:

  - Concerns about the liability incurred by handling waste oil.

- •• The inability to obtain environmental liability insurance at a reasonable cost, or at any cost.

- •• The expense involved in testing waste oil for contamination and maintaining records.

- •• The unwillingness to make investments until the implications of regulations are known.

- Vertical integration in the oil industry gives major companies control over crude oil reserves, refineries and distribution networks. The market for oil lubricants is controlled by the major oil companies who have made major investments; this makes it difficult for smaller re-refiners or processors to become established.

- There is misinformation about appropriate waste oil disposal practices. For example, some oil changing kits sold in stores encourage do-it-yourselfers to dispose of waste oil with regular garbage.

TIRES

BACKGROUND

Tires pose a waste management problem and alternatives to disposal are sought for several reasons. Stockpiled tires can harbor disease-bearing insects and rodents, are unsightly, and can pose a serious fire threat illustrated by the Ontario, Canada fire of 1990. Tires create instability and vector problems in landfills if buried without costly shredding or splitting. In addition, alternatives to disposal are sought to conserve the energy available in the oil which composes two-thirds of a tire's weight.

Currently, there are few end-users of waste tires in Indiana. The retreading industry, which in the past has used as many as 20% of waste tires nationally, consumes between 5% and 10% of the waste tires generated. A pyrolysis plant in Brazil, Indiana is set to go on-line this year. At full capacity, the plant will be able to consume 200 tires an hour, equal to 35,000 tires a week. The facility owners estimate that the facility can consume every tire generated in the Central Indiana area. A facility in South Bend reports that it recycles 4.5 to 5 million tires a year. Several other businesses are currently shredding tires. Surveyed businesses are charging between $0.25-1.25 per tire that they accept at their facilities.

MANAGEMENT OPTIONS

Government Programs

Governments have approached waste tire management in these ways:

- Regulation of disposal
- Regulation of collection
- Consumer education
- Imposition of special fees to pay for tire management
- Model programs

Only a few state governments have tire management programs. Most are not comprehensive, and most are in the early stages of development.

- Regulation of Disposal. Several local and state governments have banned tires from waste disposal sites or have required that the tires be split or shredded before disposal. Tires may be stockpiled separately at landfills, with the landfill operator or local government contracting with a collector. The collector may haul the tires to a retreading firm or a shredding operation. Most used tires not being landfilled are being stockpiled. In a handful of cases, tires have been buried in separate areas of landfills so that they can be unearthed if a future use for them is found. The regulation of disposal encourages privately initiated development of recycling, processing, or energy recovery by assuring a continuous supply.

- Regulation of Collection. Collection and transportation of waste tires may be regulated so that only authorized individuals or firms may collect them. This allows a state to control the flow of waste tires, impose record-keeping requirements, and choose acceptable collection sites. Unlike other recyclables, most scrap tires are already source separated. Tire dealers usually keep customers' old tires when new tires are purchased. Tire "jockeys" service these retailers, sometimes without a contractual or other formal agreement. Some "jockeys" dispose of collected used tires illegally, creating litter and potential health problems. Imposition of licensing requirements on tire collectors would address the problem of illegal disposal.

- Consumer Education. Consumer education is aimed at reducing the tire waste stream. Proper tire maintenance can extend the life of a tire; purchase of better quality tires can result in longer wear. Consumers wary of retreads can be encouraged to purchase them from reputable companies.

- Waste Tire Fees. Several governments and private disposal operators have imposed special fees on waste tires delivered to waste disposal sites. Such fees offset the extra costs of tire disposal, while making disposal alternatives more attractive. To raise money for tire management, governments have also levied special advanced disposal fees (ADFs) on each tire sold or on vehicle transfer permits.

  This money may be used to pay for shredding or splitting before disposal, for government's administrative costs of managing tire disposal, and for award grants or subsidies to recycling operators. The states of Washington, Oregon, Oklahoma, and Maine currently collect a $1 per tire tax on new replacement tires. The State of Minnesota places a $4 tax on vehicle transfers.

- Model Programs. Some governments have set examples by implementing model programs to encourage tire recycling and reduce the generation of waste tires. Government agencies can use retreads on motor pool vehicles; keep tires properly inflated; and can use recycled tires in public projects such as road paving, artificial reefs, or school playgrounds as part of a model waste tire program.

  Draft federal procurement guidelines for rubber-asphalt and retread tires required by the Resource Conservation and Recovery Act were issued on May 2, 1988. The draft guidelines call for increased use of retread and recycled tire products by federal agencies and on projects that involve federal funds. Strong economic and safety objections to the use of retread tires have been raised by the General Services Administration, which buys over $4 million of tires each year. In response, the American Retreader's Association has requested an additional review of the performance and quality of retread tires.

End-Uses for Tires

Currently, the principal end-uses for waste tires are retreading, recycling for conversion into other products, and recovery of energy through incineration or fuel production. In the latter two cases the technology to consume large numbers of tires is very expensive and not well established.

- Retreading. The use of retreads has declined over the last few decades. The advent of steel-belted tires posed technical problems that took the industry time to surmount. In the meantime, the price difference between new and retreaded tires narrowed and became insufficient to motivate purchases by consumers wary of retread performance. While retreading is still a major use for recycled tires, the ability of this industry to expand is limited by the unsuitability of most tire casings for retreading. Improved tire designs, however, have increased the durability of tires which has resulted in waste reduction.

- Recycling. The reclaiming industry puts tires directly back into rubber-based products. A major shift has occurred in this market over the past 50 years. While old tires used to be the major component of new tires, changes in tire technology have eroded this market so that only a handful of reclaiming operations remain in the U.S.

Several technologies have been developed to incorporate used tires into other products. There are two major technological developments which have aided this transition:

- ●● Tires are shredded into "crumbs" of various sizes and used as an asphalt additive.

- ●● Tire crumbs are used to produce a material that can be substituted for rubber in certain applications.

The State of Arizona has successfully utilized rubber-asphalt for road construction and repair for the past 20 years. However, after over 20 years of on-and-off experimentation, rubber asphalt is still in the research and development phase. Road applications range from direct replacement of asphalt, to use only in the stress absorbing inner layer of a road surface, to repair of damaged pavement. Evaluation of the material for road application demands 10 to 15 years and testing of different ratios of tire chips to asphalt. Some studies find rubber asphalt superior to regular asphalt; others find it inferior. Questions are also raised about the ability of this application to consume large numbers of tires.

Recycled tires are also used by smaller firms to produce a variety of products such as park benches, flower pots, chocks, and bumpers.

- Energy Recovery. Pyrolysis is a new technology. Waste tires are heated in an oxygen-free environment, a process that breaks chemical bonds and produces crude oil, carbon black, combustible gases, and scrap steel. Though experts consider the technology sound, pyrolysis operations in Europe and the U.S. have had a shaky history. Plants are capital intensive and demand a steady supply of tires. Their ability to make money is affected by the price of waste disposal, energy, and oil. Just as some facilities began production, the price of oil dropped considerably, making them uneconomical. However, with the rising price of waste disposal, the inevitable increase in oil prices, and the increasing attention paid to the dangers posed by tire stockpiles, interest in pyrolysis is rising.

  General Electric has financed a pyrolysis plant designed by Oxford Energy Company located in Modesto, California near a stockpile containing over 35 million tires. The $38 million plant has capacity to produce an estimated 12.9 megawatts of electricity.

The major customer is a local electric utility. As of November, 1988, the plant was burning 600 tires per hour. The environmental impacts of Oxford-designed pyrolysis plants have not been established. The company hopes to site plants on the East Coast, but environmental concerns have thus far halted projects.

Tires may also be burned whole or in shreds to supplement other fuels. Shredded tires prepared for incineration are known as TDF, or tire-derived fuel. The proportion of tires to other fuel a facility burns is usually between 5% and 10% in order to meet air emissions requirements. For example, a refuse burning facility in Akron, Ohio uses about 150,000 tires per month to improve burning efficiency.

CASE STUDIES

The following studies serve as examples of legislation and programs which have been implemented:

State of Washington

About 4 million tires are generated each year in Washington. Washington is one of several states that has place a $1 per tire advanced disposal fee on the retail sale of new replacement tires. All funds are deposited in the Vehicle Tire Recycling Account. Account funds are used for, but not limited to: "(a) Making grants to local governments for pilot demonstration projects for on-site shredding and recycling of tires from unauthorized dump sites; (b) Grants to local government for enforcement programs; (c) Implementation of a public information and education program to include posters, signs, and informational materials to be distributed to retail tire sales and service outlets; and (d) Product marketing studies for recycled tires and alternatives to land disposal." The funds are being successfully used to educate the public and businesses of proper disposal methods for tires, as well as paying for the clean-up of the 22 million tires currently stored in piles throughout the State.

BARRIERS TO INDIANA WASTE TIRE MANAGEMENT

A comprehensive approach to waste tire management should be consistent with the State of Indiana's established priorities. The major barrier to proper management is economic. Eliminating, reducing, and regulating existing stockpiles; shredding or splitting tires before disposal, and the development of tire recycling or energy recovery capacity all require some form of State subsidy greater than current allocations. Other barriers are:

Reduction

- Consumers lack information about how to maintain tires to make them last.

- Consumers are wary of retreaded tires and do not distinguish high quality retreads from low quality retreads.

- Consumers may not consider tire life and life-cycle costs when pricing tires.

Recycling

- The State of Indiana lacks a reliable collection network that could efficiently supply users with waste tires.

- Shredding capacity in the state is underdeveloped.

- Investors are reluctant to sponsor tire recycling firms in the absence of a guaranteed supply.

- Tire-based products have difficulty competing in the marketplace when waste tire collection and processing costs are high.

- End-uses that consume large numbers of tires are capital-intensive; lack of an established track record makes them risky.

Energy Recovery

- The lack of a collection, transportation, and processing network and the expense involved in establishing and operating this system discourages recovering energy from waste tires.

- TDF lacks an established and diversified market. Its use may incur additional expenses such as pollution control or TDF storage facilities at boiler locations.

- The lack of a guaranteed supply of waste tires prevents major investment in capital-intensive energy recovery projects.

- New technologies for recovering energy from waste tires are unproven and expensive.

Disposal/Stockpiles

- Citizens lack awareness of waste tire disposal problems and potential solutions.
- Data on existing authorized and illegal stockpiles are limited.
- Fees collected for existing stockpiles are inadequate to properly manage them.
- Shredding capacity is limited and expensive.
- Tire landfilling practices vary in acceptability across the state.

BATTERIES

BACKGROUND

Twentieth century American society has become accustomed to the use of electrical devices for convenience, recreation, and an improved quality of life. Whether to operate an automobile, flashlight, hearing aid, or smoke alarm, a steady supply of batteries is required; a continuous supply of waste is created which must be managed in municipal facilities.

American consumers use and discard over 2.5 billion batteries each year. In relation to other wastes entering municipal disposal facilities, batteries seem insignificant. However, batteries contain high concentrations of toxic heavy metals and caustic chemicals which may pose a threat to human health and the environment.

Whereas the majority of auto batteries are recovered, waste household batteries are generally disposed, most commonly with other household wastes, causing concern about environmental contamination. Once in the waste stream, household batteries make their way to municipal incinerators and landfills. When incinerated, batteries create toxic emissions. In high concentrations, these toxic emissions may endanger life. If landfilled, any spillage or leaching from the batteries may contaminate ground water. Either of these circumstances could be deleterious to human health and the environment. The incidence of contamination through these pathways is not well documented.

Batteries consist of four main components: the anode (or negative electrode), an electrolyte solution, the cathode (or positive electrode), and the casing. Electricity is generated by passing electrons from the anode to the cathode, through the electrolyte solution. In certain cells, this process also generates highly toxic or hazardous by-product compounds.

There are several kinds of battery cells on the U.S. market and, hence, in the waste stream. Each type of battery has distinct applications and poses a particular waste management problem. Battery types include: automotive and marine batteries (wet cells), small alkaline batteries used in radios and flashlights (dry cells), rechargeable dry cells, and small button-shaped cells used in watches and hearing aids.

- Wet cell batteries constitute about 3% by number, or 90% by weight, of yearly battery production in the U.S. Wet cells are comprised of a plastic shell, sulfuric acid (about 1 gallon in each battery), and lead strips. "Maintenance-free" batteries contain sulfuric acid in a gel form.

- Dry cell batteries constitute approximately 95% (by number) of batteries sold in the U.S. Most popular is the long-lasting variety which is expected to control 75% of the battery market by 1990. These cells consist of a moist chemical paste, which is either an acid or caustic, mixed with manganese dioxide. A carbon rod runs through the middle of the paste. The casing is usually made of zinc; although, copper is sometimes a component. The fastest-growing segments of the primary (non-rechargeable) dry cell market are the alkaline-based batteries which incorporate mercury or other metals in low concentrations to increase useful life.

- Rechargeable dry cells constitute a small percentage of sales (about 10 million each year) in the U.S. due to their initial higher cost, although their life-cycle cost results in an ultimate savings. The electrolytic medium is most often constructed of a nickel-cadmium combination or, more rarely, of lithium. Rechargeable dry cell use is generally restricted to small household appliances or industrial-commercial applications. These batteries require a charging apparatus for recharging.

- Button cells account for the remaining 2% of yearly battery sales in the U.S. Button cells are also considered dry cells, but warrant a separate discussion because of the variety of their composition. Common components of these cells are mercury, silver, and lithium. Mercury cells are commonly used in cameras and consist of zinc, mercuric oxide, and potassium hydroxide. Silver oxide batteries are used in watches, and lithium cells are typically used in computers.

The health risks posed by most of the metals contained in batteries are well documented. However, conclusive information about the environmental effects of batteries placed in the waste stream is not yet available. Studies show that typical body burden concentrations of mercury, cadmium, and lead are higher than those in the pre-industrial era. It is also known that these metals accumulate in the environment and increase in concentration at successive levels of the food chain. Mercury, cadmium, and lead have no known beneficial health effects at any level; however, in trace amounts, manganese, zinc, and potassium do have a nutrient value.

The Occupational Health and Safety Code sets work place exposure limits for all of the metals used in batteries. The allowable concentration of lead and mercury in open air is limited by health standards set by the Clean Air Act. Concentrations of cadmium, lead, silver, and mercury in water are all regulated by the Safe Drinking Water Act.

These regulations are necessary to protect human health from the detrimental effects of ingesting or inhaling heavy metals. Mercury poisoning can cause kidney, central nervous system, and psychological disorders. Cadmium harms the liver, lungs, and prostate gland. Manganese causes respiratory disorders and also affects the kidneys, eyes, and nervous system.

There is no doubt that large doses of the metals contained in batteries are detrimental to health, but inconclusive research leaves unclear as to what concentrations define the safe limits and whether or not current landfilling and incineration practices release metals in concentrations surpassing the safe limits. In an effort to promote public and environmental safety, several states have issued regulations restricting the metal air emissions from incinerators.

Intact batteries pose no danger to the environment. Risks occur when a wet (lead-acid) or dry cell battery is broken through improper handling, incineration, or the corrosion of its protective casing.

If carelessly handled, lead-acid batteries pose particular problems due to the large volumes of acid they contain and the concentrations of lead dissolved in this acid. If this caustic is released, it can immediately harm people and the environment. When incinerated, the lead in emissions, if not controlled, can cause lead poisoning. A wet scrubber can reduce emissions to the point that only 2% of the lead burned is released to the environment. The remaining 98% is caught in incinerator ash and control equipment. The resulting ash material can still pose a threat when landfilled. When landfilled, lead is soluble in acetic and citric acids which are prevalent in household garbage, and can leach into the groundwater table if protective liners are inadequate. Thus, environmentally sound ash disposal is very important.

Dry cell batteries are much more difficult to break open than wet cells and, therefore, do not pose an immediate danger to the consumer or waste handler. However, when their casings are broken through corrosion or incineration, dry cell batteries can release mercury, cadmium, lithium, zinc, and copper. Tests in the United Kingdom have shown that dry cell battery casings can corrode in a relatively short-time when buried in a landfill, sometimes in as few as 100 days. Once casings are broken, a wide range of chemical and biological reactions can occur within the landfill environment that increase environmental hazards.

It has been estimated that household batteries are the principal source of mercury emissions in Canada. Similarly, 35% of the background levels of mercury in Sweden are linked to incineration of batteries. When mercury is incinerated in a facility equipped with only a wet scrubber, 96% is released to the environment. The behavior of this metal when landfilled is not well documented.

If not controlled, incineration also releases cadmium, which is not explicitly regulated by either federal or state air quality standards. Cadmium emissions can be reduced by approximately 50% through use of a wet scrubber. The remaining 50% is contained in scrubber ash and dusts which have to be landfilled.

When concentrated quantities of cadmium are landfilled, there may be danger of the metal making its way into a water source. Current research conducted in the United Kingdom shows that it is unlikely that landfilled cadmium contained in unbroken batteries will pose an environmental problem. The study hypothesizes that, in general, batteries are not landfilled in large, concentrated volumes, and any cadmium released will be diluted to minute and harmless concentrations before it reaches a water supply. However, with significant variations in landfill design and performance, long-term pollution of aquifers as a result of cadmium battery disposal should not be ruled out. Neither concentrations nor the flow of cadmium in landfilled incinerator ash has been evaluated; the metal could be more mobile in this form.

Little information is available on the environmental effects of lithium, zinc, silver, and copper from disposed batteries. Lithium reacts violently with water which could make disposal in a landfill a potential hazard although batteries containing lithium are relatively rare. The behavior of lithium in an incinerator is also not well documented. Similarly, more information is required on the behavior of zinc and copper, silver, and manganese dioxide during disposal. These elements are not thought to warrant the same concern as lead, mercury, and cadmium.

Not enough is known about how these heavy metals react to North American disposal practices to make a judgment on whether or not they pose a serious danger to public health or the environment. Mercury and cadmium emissions from incinerators are not adequately controlled by wet scrubbers, and it is not known how effective other emission control devices are. Lithium and lead are potentially harmful when landfilled, but their effect on water supplies is not clear. The effects of the rest of the eight heavy metals used in batteries remain undetermined. All releases of lead, mercury, and cadmium to the environment should be diminished wherever possible, especially in incinerator emissions. Eliminating polluting sources of the other metals does not appear to be as critical as for lead, mercury, and cadmium.

Current Management of Battery Waste

Currently, wet and dry cells are managed through a variety of measures which include research to reduce heavy metals in battery designs and collection of waste batteries for recycling or safe disposal. The success of these measures varies with the battery type.

- Wet Cells (Automotive and Marine Batteries). Battery retailers collect wet cells as trade-ins when new batteries are purchased; this is required in Indiana. These cells are then been shipped to secondary lead smelters for recycling. Lead can be reclaimed for sale to the paint and gasoline industries. The sulfuric acid can be reclaimed and either neutralized for disposal in the sanitary sewer or recycled for use in other industries Plastic can be sold to plastic recyclers.

  Recycling of lead acid cells has had an established collection and processing network among retailers, scrap dealers, and secondary lead smelters. However, the 1980's was a period of drastic reduction in demand for this recycled product, primarily due to increased concern about the hazards of lead paint in the home and lead emissions in the environment from gasoline. Lead smelters have been further affected by more stringent stack emission standards. The result for many U.S. battery recyclers has been loss of business and income, forcing many firms to close. U.S. lead battery reclamation efforts have decreased in recent years from 94% to 66% of available batteries.

  Recent financial liability and regulation have made collectors and processors increasingly reluctant to handle lead batteries destined for domestic recycling. For example, collecting and transporting lead-acid batteries for recycling is an activity fully exposed to Superfund liability provisions. In addition, concern is growing over the number of wet cell batteries which may be improperly disposed.

  Scrap dealers within the State of Indiana have recycling markets which are, at least for now, capable of absorbing all lead battery waste generated in Indiana. The limiting factor controlling the recycling of these batteries in Indiana is the current collection system.

- Dry Cells (Alkaline and Household Batteries). Nearly all household dry cell batteries, including rechargeable and button varieties, are currently disposed through incineration or landfilling with other domestic refuse. As a long-term strategy, this appears unacceptable.

To reduce the deleterious effects of these cells, the toxic materials they contain have been reduced and programs have been instituted to remove them from the waste stream. For instance, mercury content has been reduced in consumer batteries by an average of 71% since 1983.

Efforts to remove dry cells from the waste stream have been marginally successful in several countries such as Sweden, Switzerland, and Japan. In Japan, which has the most extensive program in the world, low recovery rates (27% by number) have been reported, even though button battery collection points are set up in all retail stores, and alkaline cells are collected by town governments.

Each of these countries has had problems dealing with dry cells. Facilities to recover metals from certain button batteries are limited. Low-value alkaline and zinc carbon batteries are currently not recycled at all. In Japan, battery programs cost around $525 per ton plus transportation costs. Most Japanese towns are solidifying currently unrecyclable batteries in concrete. Some cities like Toronto, Canada are collecting button cells through household hazardous waste programs, and then stockpiling them until a suitable market is found. Long-term stockpiling, however, presents the hazards of spillage, dangerous emissions, and possible explosions. Storage or disposal at certified hazardous waste disposal facilities is another option.

Several dry cell collection programs operate in the U.S. and most of them sell recovered batteries to a mercury refiner in Albany, New York. There appears to be some economic incentive for recycling these cells; however, the number of reclaimers in the U.S. is small and collection networks are undeveloped.

MANAGEMENT OPTIONS

One option for managing waste batteries is to continue current practices: landfilling and incineration of household batteries (dry cells), limited dry cell recycling and, successful widespread recycling (near 78%) of automobile (wet cell) batteries. However, current data indicates that incineration of wastes high in heavy metals should be reduced and that a significant portion of the heavy metals in incinerator ash originates in batteries. There is also evidence that certain of these metals are released in incinerator emissions. Few cases provide adequate information to conclude that heavy metal emissions are of sufficient volume to endanger health or the environment. Similarly, research suggests that landfilling batteries could create a hazard if cell casings erode and release their contents, but, again, there is no conclusive evidence.

Options for reducing environmental and health hazards associated with waste batteries are presented below:

Legislation

Legislative approaches to managing waste batteries have been used in several areas around the nation. These approaches provide enforceable methods for reducing the volume of waste batteries reaching final disposal and help to limit future environmental and health impacts associated with the improper disposal of waste batteries.

- <u>Battery Council International Suggested Legislation</u>. Minnesota was the first state to enact strict regulations regarding lead-acid batteries. This bill has been the model for the Battery Council Internationals (BCI) suggested legislation. It also has been adapted and passed by the following states: Pennsylvania, Wyoming, Florida, Iowa, and California. Similar legislation is pending in several other states. The State of Indiana has passed legislation which is patterned after the BCI legislation.

  The BCI legislation focuses on the battery recycling chain. Section 1(a) prohibits individuals from disposing of used lead-acid batteries except by delivery to a battery retailer or wholesaler, a secondary lead smelter, or state authorized collection facilities. Section 1(b) requires battery retailers to deliver used batteries to the agent of a battery wholesaler, a secondary lead smelter, or state authorized collection facilities. Section 1(c,d) state that each improperly disposed battery would constitute a separate violation, the fine for which is determined by the individual state.

  Section 2 requires battery *retailers* to accept at least as many used batteries (if offered) as new batteries sold. The retailer must also post a written notice at least 8-1/2" by 11" stating: (1) it is illegal to discard a motor vehicle battery or other lead-acid battery; (2) batteries should be recycled; and (3) state law requires all battery retailers to accept used motor vehicle batteries on a one-for-one basis in exchange for new batteries purchased.

Section 3 directs the appropriate state agency to distribute the notices required in Section 2 to all battery retailers, grants the authority to inspect any premise governed by Section 2, as well as issue warnings and fines for non-compliance.

Section 4 requires battery *wholesalers* to accept at least as many used batteries (if offered) as new batteries sold. A certain amount of storage time is also granted under this section.

- Refundable Deposit. A refundable deposit on new lead-acid batteries is another option that states have taken. Consumers may be charged a fee of $5.00 if he or she does not return a used core when purchasing a new battery. A grace period of up to 30 days is often allowed. Depending on the specific legislation, the state may become involved in the accounting process and receive a large portion of the deposit. In some cases, the retailer retains the deposit.

  The State of Rhode Island has the most comprehensive legislation along these lines. Effective July 1, 1989, a dealer who sells a battery to a consumer shall either: (a) collect a used or recyclable battery at the time sold, or (b) collect a deposit of $5.00. The long-term effects of this bill should be studied as more information is assembled.

Reduction

Prohibiting batteries containing certain heavy metals or reducing the toxic chemicals contained in batteries would eliminate some of the problems of managing waste batteries. Some metals replacement in battery design is already happening. For example, mercuric-oxide hearing aid batteries can be substituted with zinc-based batteries.

Banning batteries containing certain metals would only regulate known hazards. Bans would end markets for certain battery styles which fill a consumer need. Manufacturers would probably react by trying to meet these needs with new products not containing banned substances. However, the banned product may be replaced by a less acceptable substitute with unknown environmental and health effects.

Regulations limiting the concentrations of hazardous metals in household batteries could be developed. Such regulations would be more effective than an outright ban since it would not remove battery styles from the market or significantly alter the business of battery manufacturing. Instead, the regulations would simply reduce the volume of known hazards from entering the waste stream. Regulation of this type could be immediately applied to mercury, and be extended to other materials. This approach would require legislation and would best be implemented nationally or regionally, although state measures could be beneficial.

Manufacturers of wet cell or automobile batteries have taken steps to reduce the number of waste batteries by producing more durable and maintenance-free batteries. Improvements in automobile design have also contributed to the durability of these batteries. Policies discouraging the use of cheap, shorter-life auto or boat batteries could be initiated to significantly reduce the volume of wet cells in need of recycling or disposal.

Increased reuse of batteries would address the State of Indiana's reduction and recycling priorities since rechargeable batteries are also generally the most recyclable batteries. However, elements used in their construction may be more harmful when incinerated or landfilled than those in disposable types. Reuse is currently confined to the rechargeable variety of dry cells and to wet cells. Most nickel-cadmium batteries last four years since they can be repeatedly recharged. The volume of rechargeable batteries entering the waste stream is thus somewhat less than for non-rechargeables. Consumer use of rechargeables, especially the cylinder-shaped variety, could be promoted through household hazardous waste programs.

The U.S. military is already the largest consumer of nickel-cadmium batteries. Rechargeable batteries are also commonly used in commerce and industry. State and local government procurement policies could increase the use of rechargeables.

Source Separation

A key to environmentally sound management of batteries is to separate them from the waste stream before wastes are incinerated or landfilled. This is best done before waste collection since systems to recover household batteries from mixed waste are not generally available and handling and health problems can occur when auto batteries are mixed with municipal solid waste. Source-separating batteries does not necessarily mean that the segregated or collected batteries can be recycled. Recycling systems are well established for wet cells. However, alternative management approaches, such as stockpiling, may need to be developed for source-separated dry cells since end-users are not readily available.

Separation and recovery of batteries from the waste stream can be encouraged in several ways, including legislated incentives or bans, promotion and education, and the development of deposit-return or voluntary collection programs.

An obvious method of reducing wet cell battery waste is prohibiting disposal at all municipal solid waste landfills or incinerators not equipped to handle hazardous or chemical waste. Restricting wet cell batteries from trash collection containers is a logical extension of this approach. Bans on the disposal of household or dry cell batteries would be very difficult to enforce, although the possibility of being fined would no doubt cause some residents to separate batteries from household waste. Prior to any sort of ban, alternative management systems need to be available and promoted.

The reusability of nickel-cadmium batteries makes them attractive for general use. In homes, these cells are most commonly found in household appliances, such as rechargeable razors. Unfortunately, the nickel-cadmium batteries are often attached in such a way that removal for either recycling or safe disposal is difficult. Legislation restricting or taxing "hard wired" batteries could be adopted. Alternatively, a process to remove hard-wired batteries could be developed in coordination with appliance manufacturers.

A deposit-return system for household and automotive batteries could increase battery separation. Experience with beverage container deposit systems indicates that recovery through a deposit system can be 20% greater than through a voluntary return system. Experience in Japan shows that voluntary collection recovers a very small percentage of household battery waste. Widespread participation in curbside collection programs demonstrates that recovery is higher when recycling is made as convenient as possible. Therefore, a collection system combining incentives and convenience would result in the highest battery recovery rates.

One incentive could be a deposit applied to all household and automotive batteries. Such a deposit should affect all battery manufacturers equally and influence market shares as little as possible. In other words, all alkaline batteries would have the same deposit, as would all automotive batteries. The possible negative effects of implementing a combined voluntary/deposit program should not be overlooked. For example, scavenging for valuable batteries might result.

The ease of returning batteries for recovery is very important. Collection may be through household hazardous waste (HHW) programs. Permanent HHW collection facilities offer residents greater convenience and, thus, divert more hazardous materials from disposal than intermittent collections. HHW collection programs, whether permanent or not, are very expensive. Communities establishing these battery collections might require financial and technical assistance. An advanced disposal fee on the sale of new batteries could provide a steady source of funds for battery management programs.

Recovery of batteries can be enhanced by convenient collection points. Programs in Japan, New York, and Missouri collect button batteries where they are sold, such as at jewelers, hearing aid stores, and camera shops. Other points to be considered for dry cell collection are doctors' offices, electronics departments, and hardware stores. Wet cell batteries could be collected at automotive supply stores. When automobile batteries are sold through retail outlets such as grocery stores, alternative collection facilities may be required. If retailers are encouraged or required to establish return programs for the batteries they sell, as is the case in Indiana, the liability of storing potential hazardous materials needs to be evaluated.

Household batteries can also be collected by curbside collection programs. Much of Europe as taken this approach by using special lockable boxes distributed to residents for setting out household hazardous wastes, including batteries. Garbage collectors then unlock the boxes and remove the contents. Liability and risks to workers needs to be investigated. Curbside collection of automobile batteries is not likely to be as effective as point-of-sale collection.

Recycling

Recycling is the preferred practice for all batteries once they have been separated from the waste stream. For some battery types, such as wet cells, recycling is well-established and supported by a developed network of scrap collectors. Other batteries such as button cells have a less established market and network and only certain types of these cells are accepted by recyclers. Currently, alkaline cylinder batteries and nickel-cadmium rechargeables are not considered valuable for recycling. Battery recycling has thus far been dependent on the economics of recovery programs and industry support. The wet cell battery industry has encouraged the recycling of its lead-acid product, while manufacturers of household dry cells prefer to market their product as "disposable" following a single use. Until recycling is economically and technically feasible for a particular type of cell, those cells should ideally be stored for future recycling at licensed hazardous waste treatment facilities.

Markets for recycled dry cell batteries could be developed by providing an incentive to recycle. Imposing an environmental impact tax on batteries would encourage manufacturers to produce recyclable batteries. This impact tax could be structured in degrees; i.e., batteries would be taxed according to the degree of their environmental impact or lack of recyclability. For example, under this system, a reusable or recyclable product for which the industry had helped develop collection and end-uses would be taxed at a lower rate than a non-recyclable product. Tax monies could be used to educate the public, promote recycling, and fund research and development of recycling techniques. A portion of the monies could also be contributed to national and regional efforts to establish end-users for household and automobile batteries.

Although sorting the many different types of household batteries is very time consuming and costly, it is necessary for recycling. The costs of separating batteries according to their metal content could be significantly reduced by a coding system. Several methods of coding have been suggested, including color coding or printing a code for battery type on the cell. Printing the Mobius loop or the chasing arrows recycling insignia or "return for recycling" on all wet cell and dry cell batteries would increase recovery. Further study is necessary to determine the most suitable labeling method for batteries. Any effort in this direction should be nationally or regionally coordinated and should involve battery manufacturers.

Energy Recovery

Controlling toxic emissions from incinerators reduces the environmental impact of waste batteries. Emissions are reduced by improving pollution control equipment on incinerators. A study to determine practical methods for reducing heavy metals in emissions from municipal incinerators is needed. Such a study could evaluate existing systems, as well as research new emission control equipment.

Disposal

As with waste incineration, additional research would yield information about how to more safely manage household batteries in landfills. Evaluating mechanical systems to remove batteries from mixed municipal solid waste before incineration or landfilling would supplement the research on safe management methods.

Education

Once effective separation and collection systems are developed, promotion and education are needed to insure public support. Promotion and education are particularly important for household battery collection since most citizens are unaware of any need to separate dry cells from the rest of their waste. Awareness of appropriate methods for managing auto batteries is greater since many repair shops have taken old batteries when replaced by new. Several states, including Indiana, have enacted legislation to increase recycling of lead-acid batteries.

BARRIERS TO MANAGEMENT

The primary barriers to improved battery management in the waste stream are:

- Inconclusive information on the environmental and public health risks of battery disposal in landfills and incinerators.
- Lack of economic incentives for recycling of most types of dry cell batteries and of some type of wet cell batteries.
- Lack of established markets for most types of recycled dry cell batteries.
- Lack of recyclers, and collection networks for dry cell batteries.
- Lack of economical recycling technologies for dry cell batteries.
- Lack of unified support from the dry cell industry for recycling.
- The public's lack of understanding of the effects of improper battery disposal.
- Household hazardous waste collection programs accepting batteries are not offered in all areas or as frequently as desirable.

DISPOSABLE DIAPERS

BACKGROUND

"Disposable diapers" spark controversy. From a waste management perspective, the name "disposable diapers" seems self-contradictory. The product has come to symbolize a multitude of other products such as paper plates, razors, plastic utensils and fast food containers which are purposefully designed to be put out with the trash after only one or very few uses. Such products increasingly frustrate attempts to reduce the volume of solid waste.

From the perspective of many parents and those caring for infants or incontinent adults, "disposability" is a reason to buy disposable diapers. Perhaps people assume waste diapers are managed through sophisticated "disposal systems." However, with greater attention being paid to waste, many consumers are considering the disposal consequences of their purchasing decisions, including the consequences of buying disposable diapers.

The debate over disposable diapers centers on the extent to which disposable diapers:

- Contribute to the waste disposal crisis
- Pose a public health hazard
- Create problems in sewage systems
- Contribute in a particularly noxious way to litter
- Consume natural resources at an unacceptable rate.

The following discussion will address each issue. The issue underlying much of the controversy is the question of whether "disposable" is good or bad. Those involved in the debate over disposable diapers are consumers, environmental groups, the paper and diaper manufacturing industries, the diaper service industry.

- Presence in the Waste Stream. A national study estimates that 18 billion disposable diapers are purchased each year in the United States. The U.S. uses two-thirds of all disposable diapers, although they were originally developed and first used in Europe. When disposed, single-use diapers amount to 4 million tons of waste at a disposal cost of around $300,000,000 per year. Disposable diapers comprise 1% to

2% of the national waste stream, though lower estimates have been made on the basis of dry weight.

The use of disposable diapers in this country has increased steadily since their introduction in the early 1960's to account for over 80% of all diapering changes. In addition to their use for infants, a significant increase is being observed in their use for geriatric care.

Disposable diapers are composed primarily of fiber (paper or cloth) and plastic liners. Within the last few years, disposable diaper manufacturers have increased the use of super absorbent polymers (plastics) in place of some of the absorbent cellulose to reduce diaper bulk and dampness. After use, disposable diapers are bulky and usually wet.

No specific data is available on the volume of landfill space required for disposable diapers. On a density basis, the landfill space required is probably not much more than the mean volume required for most items (disposable diapers probably do not significantly alter compaction or settling efficiencies in landfills). Information on thermal content, combustion efficiency, and emissions produced by disposable diapers when burned in municipal incinerators is not available; however, they likely have minimal impact on ash generation and do not contribute to emissions to any greater extent than similar paper and plastic materials which are fairly abundant in municipal solid waste.

Disposable diapers have rarely been dealt with under any strategy other than collection and disposal. They have not been targeted for recycling or separation other than on a limited and experimental basis. No end-use or processing technology is currently available to recover the material from soiled disposable diapers. However, some experimental recycling efforts are underway.

- Health Risks. Concerns about the health risks posed by disposable diapers focus on three issues: health of diapered infants, health of waste handlers, and the fate of diaper viruses in solid waste landfills. Concerns about the adverse effects of disposable diapers on a child's health have included incidence of rashes, isolated incidents of children swallowing bits of plastic torn from the liner, the uncertainty about the presence of dioxins in paper products and the effects of long-term exposure to absorbent polymers. On the other hand, disposable diapers' contributions to health, such as protection from dampness, reduction in rashes, and avoidance of allergic reactions have been cited. Information on the health risks or benefits of disposables for infants is inconclusive. Ninety five percent of U.S. hospitals and nearly all day care centers rely on disposable diapers. It is not clear whether this preference is based on convenience or health.

Over 100 different viruses are known to be excreted in human feces and some of these are likely to be found in throw-away diapers left at the curb, including polio and hepatitis. Waste handlers and diaper changers may be exposed to these diseases, yet no studies have linked these occupations with any greater incidence of viral infection than other jobs.

Once disposable diapers are dumped in landfills, there is a risk that viruses will migrate off-site in leachate or be transmitted to humans by vectors. Though this is a valid concern, no studies have shown this to be the case. Studies by EPA and others indicate that the physical and biological environment of a landfill quickly destroys most viruses.

From a public health standpoint, the wastewater system is the preferred method of handling human wastes. Some jurisdictions may restrict human wastes from the solid waste stream, but this does not prevent people from placing soiled diapers in refuse.

Most disposable diaper packages instruct users to first rinse disposable diapers in the toilet before putting them in the garbage. Because of the inconvenience, very few people probably do this.

In summary, throw-away diapers pose health risks. Presently, this risk is not considered great enough to warrant special management or the classification of this item as an infectious waste. Household hazardous waste, designated infectious medical waste, and asbestos warrant greater concern than do disposable diapers. Additional objective research on the health risks of disposable diapers is needed.

- Sewage Systems. In the past, disposable diaper manufacturers recommended that users separate and then flush the paper section of waste diapers in toilets. Maintenance crews reported sewage system blockages tracing the cause to improper flushing of disposable diapers. These incidents were isolated; however, diaper manufacturers no longer recommend flushing parts of disposable diapers. It is also difficult to separate the plastic from the paper section of diapers. Changes in disposable diapers in the future, however, may once again result in reliance on the sewage system for disposal.

MANAGEMENT OPTIONS

No state or local government has instituted a waste management program directed specifically at disposable diapers. Environmental action groups have proposed disposable diaper measures which include:

- Bans on disposable diapers
- Product surcharges
- Requirements that disposable diapers be biodegradable
- Consumer education

It has also been suggested that diaper service companies be eligible for waste diversion credits. One firm in Seattle, Washington and another firm in Ontario, Canada are experimenting with recycling technology for disposable diapers. The following discusses possible management measures, none of which have yet been implemented.

Diaper Ban

Although legislative attempts have been made to ban disposable diapers, to date, none have been successful. Legislation has also addressed biodegradability of disposable diapers. As many jurisdictions are considering bans on various products or packaging material as a way to reduce waste, it is safe to assume that bans on disposable diapers will again be attempted.

Surcharge

A tax placed on disposable diapers to cover the costs of waste management would make alternatives such as diaper service or home laundering more economically attractive. However, it could also penalize users for whom alternatives are difficult or not available. Such users include low-income inner city residents who do not have access to diaper service or convenient laundering facilities. If the primary purpose of the surcharge were to discourage sales, it would need to be a significant amount. If the primary purpose of the surcharge were to fund recycling or waste reduction efforts, an analysis would be required to establish an appropriate amount.

Biodegradability

A number of companies have recently developed "biodegradable" disposable diapers that are designed to decompose within 2 to 15 years rather than the estimated 500 years required for normal plastic components (Cloth diapers degrade in about a year). Whether biodegradation will occur in landfills when oxygen is absent is in dispute. Also in dispute is whether a biodegradable product is preferable when the chemical effects of biodegradation are unknown and when attempts to stabilize landfills and recycle plastics may be thwarted by biodegradable plastics. Making diapers completely from paper fibers has also been suggested as a means of promoting decay in landfills.

Other options include requiring that all diapers be recyclable (i.e., have established collection, processing, and end-user infrastructures); that they be flushable; or that disposable diapers manufactured for sale have a minimum content (e.g., 50%) of post-consumer recycled material.

Consumer Education

Consumers should be educated about alternatives to disposable diapers, such as a diaper service. They should also be instructed about proper disposal of throw-aways. Education has thus far been undertaken almost exclusively by environmental action groups or by diaper services. Consumer education programs could use a variety of settings to reach parents or others who buy diapers. As with other waste management education programs, all economic and cultural groups must be addressed.

To reduce the potential for public health risks from disposable diapers, consideration could be given to requiring notification at the point of sale of proper and legal disposal methods. A program to educate waste haulers about requirements and precautions in handling residential waste containing disposable diapers and infectious and hazardous materials might also be considered.

Diversion Credits

Nationwide, the diaper service industry reports recent increases in use of its service, reversing a trend in effect since the 1960's when disposables were developed. However, many areas still do not have access to diaper service. Granting waste diversion credits or some other financial assistance to diaper service companies could induce firms to establish themselves in underserved areas. It could also make diaper service more economically attractive to consumers. The State of Wisconsin has created sales tax exemptions for cloth diapers and for diaper services.

CASE STUDY

The following example of a pilot program in the City of Seattle illustrates a possible alternative:

Seattle, Washington

Seattle was selected as a site to test the economic and technological feasibility of recycling disposable diapers. Procter and Gamble Co., in conjunction with a local waste management firm is operating the pilot program. Disposable diapers are being collected weekly in special recycled plastic bags for selected areas of the city. Over 1,000 babies are participating in the program.

The collected diapers are delivered to the diaper recycling center, a propriety process separates and sanitizes the reusable components of the diaper. The resulting material is plastic from the diaper backsheets and paper pulp from the diaper padding. Provided that markets are available, the reclaimed materials will be used to make plastic flower pots, corrugated boxes, and several other useful items. According to Procter and Gamble there is even an agricultural use for the absorbent gelling material contained in the higher-quality disposable diapers.

The economic efficiency of disposable diaper recycling has yet to be determined, but it appears that at the present time, it is not economically feasible as a full scale program. This program is also experimental in relation to technology.

While the effectiveness of these efforts is yet unknown, they do signal a private sector response to an environmental problem. The potential for innovation is great and sound public policy can provide guidance to industry.

BARRIERS TO MANAGEMENT

Barriers to proper management of waste diapers impede each management objective. Particular barriers to managing disposable diapers include the following:

Major barriers for reducing the volume of disposable diaper wastes in the waste stream are:

- Consumer preference for disposable diapers.

- The lack of a significant price difference between diaper service and disposables.

- The lack of consumer awareness of the potential problems caused by disposables.

- The lack of publicity for the diaper service option.

- The unavailability of diaper service or other alternatives to some potential users, due to economics, geographics, or age. The incontinent and geriatric diaper market is especially resistant to alternatives.

- The lack of a proven technology for recycling disposables.

For achieving proper disposal of throw-away diapers, major barriers are:

- The lack of definitive data on public health risks from disposable diapers in the solid waste stream.

- The lack of a published standard for proper disposal.

- The physical construction of disposable diapers - separating paper from plastic is difficult, as is shredding the paper section for safe flushing.

CONSTRUCTION AND DEMOLITION DEBRIS

BACKGROUND

Demolition waste is another material which can be significantly reduced through processing and recycling. It is bulky, difficult to compact and takes up valuable landfill space. More and more, the reuse or recycling of demolition waste is being developed as an alternative to landfilling.

The construction or demolition of buildings, roads and other structures produces demolition waste, which generally consists of concrete, brick, bituminous concrete, wood and masonry, composition roofing and roofing paper, steel, and minor amounts of metals such as copper.

Demolition waste contains a large volume of recyclable and recoverable materials. Removing materials such as wood, metals, and cardboard can reduce demolition-waste volume by up to 89 percent. Finding alternative uses and users for the recovered wood, cardboard, crushed rock, dirt and metals is a key element to the successful recycling and recovery of demolition waste. If all these materials are recovered, the potential savings in hauling and landfill disposal fees are significant.

As communities and states become aware of the potential for diverting large amounts of demolition waste from the landfills, demolition waste recycling operations are appearing. Much of the equipment for the process is European, where communities have been practicing demolition recovery since World War II.

Recycling concrete from large demolition projects has provided savings for contractors and government. Demolishing bridges, roads and highways creates large amounts of useful, contaminant-free material. The concrete, for example, can be crushed into aggregate for stabilizer and road base.

Although an estimated 100 million tons of asphalt is removed from America's highways each year, only 20 million tons is being recycled. Reclaimed asphalt (RAP) has been used in state projects for a number of years. Substantial savings in asphalt costs are the main economic incentive for recycling asphalt.

MANAGEMENT OPTIONS

Nearly all of the demolition waste generated in the State of Indiana is disposed by landfilling. Demolition waste, because it is basically inert though bulky and difficult to compact, usually has less stringent landfilling requirements than municipal solid waste.

Materials Recovery

Demolition waste contains a large volume of recyclable and recoverable materials. Effectively removing materials such as wood, metals and cardboard can reduce the volume of materials that will be ultimately disposed to one-ninth of the original volume. Reducing the volume will extend the useful life of existing landfills. Recovery of materials from demolition waste can be accomplished in two basic ways: private or publicly sponsored separation of materials or development of a salvaging system through a "waste exchange network."

Some recovery of demolition waste materials is already occurring in the State of Indiana. Encouraging expansion of these activities can produce benefits through the reduction of materials that are ultimately landfilled. In private enterprise, reclamation of materials from demolition waste will depend on both the cost-benefit ratio of salvaging versus material disposal and on the end-user market availability.

A key element to successful recycling and recovery of demolition waste is finding alternative uses and users for the recovered wood, cardboard, crushed rock, dirt, and metals. The potential savings in hauling fees and landfill disposal fees are great if all these materials are recovered. By methods of screening and sorting demolition waste, wood can be recovered and shredded into chips and solid as log fuel, ground cover, or to wood board manufacturers for filling material. Cardboard can be sorted out and sold to waste paper dealers. Metals can be sorted, cleaned and sold to scrap metal dealers. Remaining rock and dirt can be used for fill material or secondary paving.

A "waste exchange network" acts as a clearinghouse for information on the location, quantity, and condition of recyclable materials. A network could be operated by local governments or a private firm. Users of the network can either list the materials they have available or search through the current listings for materials needed. Cost savings is the driving force of this system. The owner saves on disposal costs, the material user saves on the costs of new materials, and landfill space is saved for disposal of non-recyclable material. Public promotion and a consistently high number of users are essential to the success of this type of exchange program. The program will work successfully with a high input and output of materials.

CASE STUDIES

The following case studies serve as examples of successful construction and demolition debris recycling:

Los Angeles, California

The Los Angeles City Bureau of Street Maintenance is using a propriety process which recycles 100% of the asphalt from its highways and streets. Microwave technology provides reclaimed asphalt which is comparable to virgin material. One hundred percent RAP now costs the City of Los Angeles $16.80 per ton in contrast to $24 per ton of virgin asphalt.

The City estimates that it diverts 50,000 to 60,000 tons of asphalt from landfills, providing a substantial savings in tipping fees and material costs. The material is used mostly on local streets and as a sub-base for busier ones. If positive results continue, the City plans to begin using it on its larger, busier streets.

Brooklyn, New York

The City of Brooklyn is presently processing 1,500 cubic yards a day of mixed construction and interior demolition waste, through the use of a propriety process. A modular approach includes a "sorting plant" where material is spread out and separated into basic categories by a vehicle with a grapple. A wood shredding system enables the processing of demolition waste into saleable wood chips. An air classification system separates wood, cardboard, and plastics from the rock fraction. The resulting clean rock material can be used as fill material in road paving or cement mixtures. Depending on the markets for rock and dirt, the last unit would be a rock crushing facility to enable processing of concrete pieces, small rock, etc., to generate a useable aggregate. The manufacturers of the system emphasize that any sorting plant for demolition waste has to be analyzed and custom-designed for specific local requirements and markets.

This type of system represents the opportunity for reclamation of demolition waste through effectively salvaging usable materials. The City is looking to expand the process in order to produce a more marketable final product.

BARRIERS TO MANAGEMENT

The primary barriers to management of construction and demolition debris include the following:

- The lack of public awareness about construction and demolition debris recycling.
- Facilities for recycling construction and demolition debris are underdeveloped in the State of Indiana.
- End-use markets are not developed to their full extent.
- The lack of a guaranteed supply of construction and demolition debris prevents major investment in recovery projects.
- Lack of economic incentives for recycling of most construction and demolition debris.
- Lack of recyclers and collection networks for construction and demolition debris.

HOUSEHOLD HAZARDOUS WASTE

BACKGROUND

Household hazardous products are substances made for use in the home and are ignitable, corrosive, reactive, or toxic. These products become household hazardous waste (HHW) when they are no longer wanted or used by the owner. Generally, HHW, when used or disposed of improperly, will cause harm to human health and the environment.

Each year, hundreds of thousands of tons of HHW are improperly disposed of in the environment through the solid waste stream, wastewater systems, surface water, and ground water through direct land disposal. HHW is thought to represent approximately 1% of the municipal solid waste stream. HHW in the solid waste stream can cause injuries to collection and disposal facility staff, damage equipment, and cause spontaneous combustion fires. In landfills, HHW can exacerbate leachate problems. In municipal garbage incinerators, HHW is linked to the production of dioxins and furans, along with contamination of the fly and bottom ash. HHWs in wastewater systems pose a threat to workers and may damage pipes and treatment equipment, as well as contaminate sludge and septic tanks or drain fields. A large amount of HHWs may be stored in homes. These wastes pose poisoning risk to children, may cause fires, or may threaten firefighters during a fire.

Household hazardous waste is any waste produced by a household which contains an ingredient listed in the Code of Federal Regulations (CFR) Chapter 40, [Part 261.33(e) or 261.33(f)] or exhibits characteristics of ignitability, corrosivity, reactivity, or toxicity. Table V-7-1 shows common household hazardous wastes. Containers retaining a residue of hazardous material are also classified as hazardous waste. Households often lack the incentive or opportunity to properly dispose of hazardous wastes.

The benefit of a HHW collection program is primarily two-fold: educating the public and reducing the amount of HHW that is improperly disposed. A HHW collection program should have a strong educational component. A large part of the problem of improper disposal is that individuals simply do not understand that certain household products should not be disposed of in the garbage, down the sink drain, the toilet, or the storm drain. An effective educational campaign will help the consumer to identify household products which are considered hazardous, define proper and improper disposal methods, inform about alternative products which are less hazardous or non-hazardous, and suggest purchasing hazardous products in only the quantities needed to get the job done. The result of this type of educational program is proper disposal of the existing hazardous wastes and a reduced generation of hazardous wastes through careful purchasing practices.

A HHW collection program not only provides a positive and proper disposal option, but also gives householders the opportunity to participate in a program that is good for the environment and good for their homes. Reducing the amount of HHW entering the environment through improper disposal diminishes risks to workers and systems in solid waste and wastewater treatment, contamination of other water bodies, and pollution by air emissions. Reducing improper HHW disposal also lessens the poisoning risks in and around the home and reduces the potential danger of fires related to HHW.

In the State of Indiana several communities and counties have HHW collection days, often known as "TOX-A-WAY Days". Successful programs have taken place in Indianapolis, Allen County, St. Joseph County, the City of Elkhart, and Bloomington. LaPorte, Marshall, Goshen, Nappanee and Elkhart Counties are also considering HHW collection programs.

Table V-7-1. Examples of Hazardous Household Substances

Repair and Remodeling

Adhesive, Glues, Cements
Roof Coatings, Sealants
Caulkings and Sealants
Epoxy Resins
Paints
Solvents and Thinners
Paint Removers and Strippers

Auto, Boat Equipment Maintenance

Vehicle Batteries
Waxes and Cleaners
Paints, Solvents and Thinners
Additives
Gasoline
Flushes
Auto Repair Materials
Motor Oil
Diesel Oil

Gardening

Insecticides
Fungicides
Rodenticides
Molluscides
Wood Preservatives
Moss Retardants
Herbicides
Fertilizers

Hobby and Recreation

Paints, Thinners and Solvents
Chemicals (including Photo and Pool)
Glues and Cements
Inks and Dyes
Glazes
Chemistry Sets
Bottled Gas
White Gas
Charcoal Fluid
Household Batteries

Cleaning Agents

Oven Cleaners
Degreasers and Spot Removers
Toilet, Drain and Septic Tank Cleaners
Polishes, Waxes and Strippers
Deck, Patio, Chimney Cleaners
Solvent Cleaning Fluid

Household hazardous wastes include any discarded items from the above hazardous household substances list.

Planning Guidelines for Local Hazardous Waste Plans. Washington State Department of Ecology, July 1987.

MANAGEMENT OPTIONS

The following methods are considered appropriate for the effective management of household hazardous waste:

Reduction

Waste reduction involves activities that are conducted at the point of generation to avoid generating HHW, for example, using nonhazardous materials instead of toxic chemicals for household applications. The primacy of waste reduction as a waste management method can be viewed from several perspectives:

- From a physical perspective, the generation of HHW represents a waste of resources.
- From an economic perspective, the generation of HHW represents an inefficiency, the performance of an activity at an unnecessarily high material cost. Conversely, waste management is a cost that does not necessarily contribute directly to the well-being of a household or the value of a product.
- From a health perspective, the use of household hazardous materials and the generation of HHWs represent an increased risk of exposure to householders, workers, and to the public, with the risk of acute and/or chronic health effects.
- From an environmental perspective, regardless of the degree of caution that is exercised, the greater the use of hazardous materials and the generation of HHWs, the greater the probability that more of these substances will find their way into the environment. Some of these substances remain hazardous or toxic indefinitely.

Physical laws dictate that some waste will always be associated with the use of hazardous materials in the production of goods and rendering of services, but this waste should be reduced to the lowest level possible. In general, greater use of HHW waste reduction techniques will result in smaller and less toxic quantities of wastes that must be managed off-site and lower probabilities of hazardous waste transportation spills and releases to the air, the soil and surface and ground waters. The lower risk of releases translates into a lower overall risk of exposure for the general public. These are some of the reasons why waste reduction is a usually considered the first management priority.

Recycling

Recycling of household hazardous wastes is second to waste reduction as a preferred waste management method. Recycling reduces the quantity of waste requiring treatment or destruction while conserving materials, energy, and often money. Unlike waste reduction, recycling does not reduce worker exposure to hazardous materials and often leaves residues that must be managed as hazardous wastes. Off-site recycling may entail risks to the general public during transportation and handling. Recycling must be carefully managed and regulated.

Treatment of HHW should be a preferred waste management method. Through treatment, toxic or hazardous properties are reduced or eliminated. However, the problem of disposal of the treatment residues remains and the treatment process may result in emission of pollutants to the air or water.

Incineration methods can destroy a broad range of organic wastes by exposing them to high temperatures in the presence of air. Thermal destruction mostly entails incineration, but also includes flameless methods such as wet air oxidation and pyrolitic destruction using infrared radiation. The major advantage of incineration is that it can be applied to a wide range of waste streams and, in theory, would only require the siting a limited number of off-site facilities. The major disadvantages of HHW incineration are the potential conversion of wastes into air and water pollutants, the consumption of resources, including potentially recyclable wastes, and the energy needed to the burn wastes.

The main concerns with landfill disposal of HHW are migration of hazardous substances into the environment (soil, water, air) and exposure of landfill workers to risks associated with HHWs, such as fire, explosion, poisonous gas, and chronic health effects from continual exposure. Many landfills in the country have become Superfund cleanup sites because of the presence of hazardous contaminants.

Collection Alternatives

Several alternatives exist for the collection of household hazardous waste. The following describes each alternative:

- <u>Household Hazardous Waste Collection Days</u>. A collection center is set up at one or more locations (e.g., school parking lots) for a short period of time, usually one or two days. Residents are encouraged to bring HHW to the center on the collection days. The center is staffed, often largely volunteer, by personnel who collect, sort and pack the household hazardous waste. Collected HHW wastes are then transported by a licensed hauler to a Treatment, Storage, or Disposal (TSD) facility for recycling, treatment, or disposal. Collection days are widely advertised in advance, offered as part of a general education/awareness alternative. Currently households in the State of Indiana, with few exceptions, have no alternative but to throw hazardous products in the community trash, pour them down the sewer, store them indefinitely, or use other unsafe disposal methods.

Household hazardous waste collection days give residents an opportunity to take these wastes to an appropriate facility. Once collected, many hazardous wastes can be recycled or treated, which is preferable to landfill disposal.

This alternative is less expensive to set up than a permanent facility because a permanent structure is not required and volunteer staff can be used for some aspects of the program. However, household collection programs are expensive. One-time alternatives can serve as pilot projects for permanent facilities. The collection days can be set up in different places at different times to encourage greater participation.

- Mobile Collection Center. A mobile collection center is a specially designed storage building, generally mounted on a semi-truck trailer or placed temporarily on a prepared concrete slab, that is used to collect moderate risk waste from one community for one or more days. It then goes on to another location in a manner analogous to bookmobiles. These structures are manufactured in several sites by a number of companies and can be outfitted with a range of options to improve safety and the range of wastes handled. The mobile collection center is staffed by trained personnel who screen, sort, and lab-pack wastes which are then stored in designated areas within the structure. These personnel can often be provided by the company that sells or leases the collection center.

  Advantages of the mobile collection center include the ability to move from community to community, making it more accessible to households. Costs can be shared by the communities involved. This collection technique is still relatively new and is not a widely proven and cost-effective program. It does show potential promise, especially for a regional rural application.

- Permanent Collection Facility. A permanent collection facility typically consists of a building designed for storage of hazardous materials, including separation of incompatible materials, safety equipment, and fire protection. These facilities are staffed on a part- to full-time basis by one or more workers trained to identify HHW waste types and properly lab-pack and store them for later collection by a licensed hauler. The City of San Francisco has such a facility.

One or more collection sites could be established, increasing the convenience of HHW disposal. Fire stations, solid waste management facilities, and other paved city, county, or state properties are examples of appropriate places to establish collection centers. Sites where hazardous materials are already being handled can be adapted to accept household hazardous wastes. Like other collection alternatives, a permanent facility could be operated by the state or counties, alone or in partnership with a private-sector entity. Pre-fabricated structures designed for small scale hazardous waste storage and collection are manufactured by several companies; some of these companies can also provide trained staff for the facility.

An advantage to permanent facilities is that they are available to use year-round, one or more days per week or month. People can dispose of their wastes at any time, rather than waiting for a collection day or mobile center. Facilities can also be of more sturdy construction and, therefore, be potentially safer than a mobile collection center. Permanent centers could have part-time trained staff who would be well prepared to deal with various types of hazardous wastes.

- Curbside Pickup of Hazardous Wastes. A curbside collection program would require householders to set out their HHW at curbside on specially designated days, one or more times per year. As an alternative, collection could occur in conjunction with garbage pick-up or a curbside recycling alternative. Specially equipped trucks staffed by trained workers would collect the HHW wastes. Wastes would then be classified according to compatibility and lab-packed as part of the collection process, then delivered to a treatment or recycling facility.

This alternative requires less effort by households since a collection truck comes to their houses. If the program allows only certain targeted wastes, less screening and sorting is needed, and storage and disposal are easier.

Potential public health threats and legal liabilities exist; children or pets may get into wastes left on the curb. Antifreeze, for example, tastes sweet and is highly toxic.

Safely transporting, sorting, screening, and lab-packing wastes may be difficult, given space and time limitations inherent in curbside collection.

Typically this is one of the most expensive program alternatives. A pilot door-to-door HHW collection program performed in Los Angeles resulted in very high costs per pound and was discontinued because of its perceived ineffectiveness. To be cost-effective, only limited waste types collected in existing or modified collection vehicles should be considered.

Education

Public education and outreach programs promote source reduction and thus, work hand-in-hand with collection alternatives. A comprehensive public outreach alternative involves use of a wide range of media to educate households about hazardous materials they may use in their homes, safer substitutes for these hazardous materials, and proper versus improper disposal methods. Media formats can include utility bill inserts, flyers distributed to households (particularly to advertise a collection alternative) or distributed at retail stores selling hazardous products, stickers applied to trash cans, newspaper articles, radio and television shows and/or public service announcements, a HHW "hotline," a HHW school curriculum, educational speakers at community groups, and public library materials. Comparisons to other common public risks should be used to give the public a realistic perspective on the risks associated with HHW.

Most households in the State of Indiana currently use disposal methods that pose risks to human health and the environment. Education promotes waste reduction because it leads to reduced generation of hazardous wastes through careful purchases and safe substitutes.

Successful educational alternatives have been carried out by many communities throughout the United States. The State of Indiana can take advantage of a wealth of education materials, flyers, and school curricula already prepared by other communities, industry and governmental agencies.

CASE STUDIES

The following use studies serve as examples of HHW collection centers currently in use:

Seattle, Washington

The City of Seattle operates a HHW collection facility at the South Transfer Station. This facility has been in operation over a year, and has collected over 30,000 gallons of hazardous material.

An 8-foot by 23-foot prefabricated hazardous materials storage container was purchased. It is divided into three containment bays and is capable of storing up to twenty-four 55-gallon drums. A 6-foot chain link fence provides a 15-foot buffer zone which must be kept free of all combustibles. A 4-inch sump for spill containment, a dry chemical fire fighting system, and eyewash and safety showers are some of the other features. The facility is staffed on a full-time basis by two members of the Seattle Solid Waste Utility. It is their responsibility to receive, sort, test, and pack all wastes collected.

Approximately 17,861 gallons of household hazardous waste were collected at the facility in 1989. Approximately 14,683 gallons of waste oil and 1,874 vehicle batteries were also collected. Participation levels have averaged between 9 to 14 users per day with the highest participation in the summer months. The facility was publicized through utility bill inserts as well as educational flyers. Stickers were also placed on residential garbage containers notifying residents not to dispose of HHW in regular trash. A phone number was provided to supply information and answers to questions regarding HHW.

The total budget for 1989 was $188,305; publicity totalled $7,440. Personnel made up over 40% of the budget while waste disposal costs made up roughly 46%. Future plans include expanding the facility as well as modifications to the site which will decrease the possibility of employee exposure.

King County, Washington

One of the options which King County is using for collection of HHW is a mobile collection center known as the Wastemobile. It has been operating since September 28, 1989.

The Wastemobile, operated by Chempro, includes an extensive array of materials. Some of its features are a waste processing area, a mini Haz Cat lab, an equipment van, a waste hauling trailer, and a staff trailer. The Wastemobile generally operates Thursday through Saturday.

Responsibility for daily operations, waste packing, transportation and disposal of all hazardous material collected is Chempro's. The County is responsible for overseeing all aspects of the program.

Data for the first 12 weeks of operation indicates that the Wastemobile collected over 98 tons of HHW. Paints made up 45% of the total waste collected. Service was provide to nearly 3,000 residents.

A publicity and educational program was developed for the Wastemobile. Flyer distribution, press releases, and a "Home Safe Home" program focusing on non-hazardous alternatives to HHW was developed.

Program costs for the 12-week period were: $155,312 for disposal; $49,440 for labor; $11,256 for equipment; and $13,287 for material development, site acquisition and publicity. The King County Solid Waste Division is currently evaluating future options for collection of HHW.

BARRIERS TO MANAGEMENT

A comprehensive approach to household hazardous waste management should be consistent with established waste management priorities. The major barrier to proper management is economic; the proper collection of HHW requires some form of funding greater than current allocations. Other barriers are:

- Consumers lack information on safe substitutes to household products containing HHW materials.
- Consumers are subject to constant advertising stating the advantages of certain hazardous products for the household, without information as to their accompanying environmental risks.
- Consumers may not consider substitutes to certain products because of perceived inconveniences and inefficiencies.
- The State of Indiana lacks a reliable HHW collection network.
- Collection alternatives may be sufficient to handle only a small portion of the household hazardous waste in the State.

- Collection alternatives face high costs.

- Potential liability for the HHW that is collected.