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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Codisposal Of Garbage And Sewage Sludge--A Promising Solution To Two Problems

The quantity of sewage sludge and garbage which must be disposed of is rapidly increasing. At the same time, some traditional disposal methods are being restricted or eliminated.

GAO believes that combined disposal, or codisposal, of sludge and garbage by thermal techniques is a logical approach. Although more data based on operating experience is needed, some forms of thermal codisposal appear environmentally safe and economically sound.

Many factors, including institutional and financing problems have tended to limit codisposal in the United States. The Environmental Protection Agency should act to expedite consideration and implementation of codisposal.

UNITED STATES GENERAL ACCOUNTING OFFICE

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COMPTROLLER GENERAL OF THE UNITED STATES
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To the President of the Senate and the
Speaker of the House of Representatives

This report examines the combined disposal, or codisposal, of sewage sludge and municipal garbage using thermal techniques.

Our review was made to determine (1) whether thermal codisposal represents a viable, environmentally safe alternative and (2) why codisposal's implementation has been limited despite rapidly increasing quantities of waste and restrictions on certain other sludge and garbage disposal methods.

We are sending copies of this report to the Director, Office of Management and Budget; the Administrator, Environmental Protection Agency; and the Secretary of Energy.

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

CODISPOSAL OF GARBAGE AND SEWAGE SLUDGE--A PROMISING SOLUTION TO TWO PROBLEMS

D I G E S T

The quantity of sewage sludge and garbage which must be disposed of is rapidly increasing while traditional ways of disposing of these wastes are being restricted or eliminated. The Environmental Protection Agency needs to emphasize the development of alternative disposal methods.

Recent legislation, such as the Resource Conservation and Recovery Act of 1976 and the Clean Water Act of 1977, encourages innovative wastewater techniques, including sludge management and integrated approaches to waste disposal.

GAO believes that combined disposal, or codisposal, of these two wastes is a potentially viable alternative which is both economically and technologically feasible. Codisposal is the integrated processing of garbage and sewage sludge through burning, in which (1) garbage is used as a fuel in sludge drying and (2) the volume of both wastes requiring ultimate disposal is greatly reduced.

Two basic codisposal approaches exist. One uses garbage incineration equipment, while the other uses the combustible portion of processed garbage as the auxiliary fuel source in sludge incinerators. (See p. 8.)

Co-incineration in garbage burning incinerators appears to be the most developed of the technologies. Using processed garbage as an auxiliary fuel source in sludge incinerators and copyrolysis (thermal decomposition in an oxygen starved or oxygen free environment), although demonstrated, have not yet become established methods. (See p.22.)

Potential air emission problems and surface and ground water contamination from landfills of residual materials appear to be the primary environmental concerns associated with codisposal. Additional data based on operating

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experience is needed to more completely assess environmental and health effects. Available information suggests, however, that with safeguards, codisposal can be environmentally sound and, under some conditions, superior to other disposal methods.

Although cost data is limited, numerous estimates show that codisposal is economical. In many cases it can be less expensive than the combined costs of separate garbage and sludge disposal. Savings in operating, maintenance, and energy costs generally account for this. More cost data based on actual experience, however, is needed.

CONSTRAINTS TO IMPLEMENTATION

Numerous factors have limited codisposal development, including early technological failures and the availability of less costly disposal methods. By the mid-1970s only a handful of facilities were operating. Other constraints, such as a restrictive Federal funding policy and institutional barriers, also hinder implementation.

Codisposal requires a major capital investment. The availability of Federal construction money can strongly influence whether or not codisposal will be implemented. A confusing funding policy under the Environmental Protection Agency's construction grants program, the primary Federal funding mechanism, has to some extent discouraged implementation. The policy can result in a higher level of Federal funding for sludge-only disposal than for codisposal. (See p. 30.)

Institutional barriers have also limited codisposal development. In many parts of the country, sludge and garbage are disposed of by different governmental departments and/or political subdivisions which may not coordinate their efforts. Lack of coordination also exists to some extent within the Environmental Protection Agency. (See p. 41.)

THE OUTLOOK IS PROMISING

Government and industry have a renewed interest in codisposal. Facilities are being built or planned in various parts of the country. The Environmental Protection Agency has sponsored research, development, and demonstration activities in an effort to improve existing technologies. The Department of Energy has also begun to play a role in this area. (See p. 17.)

At the time of GAO's review, the Environmental Protection Agency was considering revising its construction grants program funding policy. These revisions will provide more equitable and favorable Federal financing of codisposal projects. GAO believes the Environmental Protection Agency should encourage and facilitate more widespread consideration of codisposal.

RECOMMENDATIONS

The Administrator, Environmental Protection Agency, should:

--Undertake research to identify and analyze thermal codisposal's impact on health and the environment. Results of the research should be disseminated to Agency regional offices and to cognizant State and local officials.

--Require that planned Agency evaluations of codisposal projects provide for developing and disseminating actual operating cost data which cognizant officials can use in evaluating disposal options.

--Establish a construction grants funding policy which, to the extent allowed under existing legislative authority, would provide at least the same level of funding for deserving codisposal projects as for single-purpose sludge-only disposal options.

--Require that States and local communities consider codisposal technology as a possible alternative during the Federal Water Pollution Control Act areawide and facilities planning process and as part of the Resource Conservation and Recovery Act planning activities.

AGENCY COMMENTS

Oral comments were obtained from Environmental Protection Agency and Department of Energy officials and, where appropriate, their comments and suggested revisions were included. They agreed with the report's conclusions and recommendations.

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ABBREVIATIONS

BTU	British thermal units
EPA	Environmental Protection Agency
FWPCA	Federal Water Pollution Control Act, as amended
GAO	General Accounting Office
RCRA	Resource Conservation and Recovery Act of 1976
RDF	refuse-derived fuel

CHAPTER 1

INTRODUCTION

Disposing of the increasing quantities of garbage 1/ and municipal sewage sludge economically and in an environmentally safe manner has become a major problem in many parts of the country. These two types of solid waste have generally been disposed of separately through various techniques. This report examines the possibilities, benefits, and problems of combined disposal, or codisposal, of garbage and sludge.

SOLID WASTE COMPOSITION

The Environmental Protection Agency (EPA) estimated that in 1975 Americans generated 136 million tons of garbage, or about 3.4 pounds per person daily. The total will increase to about 225 million tons by 1990. These estimates include postconsumer residential and commercial wastes typically comprising the major portion of municipal collections.

Although the composition of garbage varies according to such factors as a community's size and location, the season, and the climate, EPA estimates that food and yard wastes (leaves, grass clippings, etc.) accounted for 49 million tons, or about 36 percent of the total. Of the the remaining amount, paper (44.1 million tons), glass (13.7 million tons), and metal (12.7 million tons) are the largest categories.

Sewage sludge is the residue containing the solid matter extracted from municipal wastewater during treatment. Before it is subjected to processing, sludge is from 95 to 98 percent water. The composition of sludge also varies, depending on the treatment process used and the type of wastewater treated. Although sludge is primarily organic and contains varying amounts of nutrients, it may contain disease-causing bacteria and toxic substances, such as pesticides and heavy metals. Currently, about 5 million dry tons of sludge are produced a year. This amount is expected to double by 1987 as the level of wastewater treatment is upgraded and more treatment plants become operative.

1/As used in this report the term "garbage" refers to municipal solid waste, refuse, or trash excluding agricultural, industrial, and construction wastes.

THE FEDERAL ROLE IN GARBAGE AND SLUDGE DISPOSAL

State and local governments have the primary responsibility for disposing of garbage and sludge; the private sector also plays an important role. Waste disposal problems have, however, become national in scope; consequently, the level of Federal involvement has increased.

A number of Federal laws concerning waste disposal have been enacted in recent years. The Resource Conservation and Recovery Act of 1976 (RCRA) (42 U.S.C. 6901), is a comprehensive statute intended to protect health and the environment and conserve materials and energy. Among other things, RCRA

--provides for technical and financial assistance to State and local governments for developing solid waste management plans and methods;

--prohibits open dumping of wastes on the land and requires closing or upgrading existing dumps;

--regulates treatment, transportation, storage, and disposal of hazardous wastes;

--requires promulgating guidelines for acceptable solid waste management;

--promotes a national solid waste disposal and resource recovery/conservation research and development program; and

--encourages the demonstration, construction, and application of more effective waste disposal, conservation, and recovery systems.

The 1977 Clean Water Act (Public Law 95-217), which amended the 1972 Federal Water Pollution Control Act (FWPCA) (33 U.S.C. 1251 et seq.), provides increased controls over sludge disposal. The act also authorizes additional funds for constructing wastewater treatment facilities. Implementing innovative and alternative wastewater technologies, including sludge management, is encouraged by the act through increased funding. (See pp. 38 and 39.)

Other Federal statutes affecting sludge and garbage disposal are the (1) Marine Protection, Research, and Sanctuaries Act as amended in 1977 (Public Law 95-153) (33 U.S.C. 1401), which prohibits ocean dumping of harmful sludge after December 31, 1981, (2) Department of Energy Act of 1978: Civilian Applications (Public Law 95-238), which mandates a waste to energy demonstration program, and (3) 1977 Clean Air Act (Public Law 95-95), which requires establishing air quality standards and regulating air pollution sources, including waste disposal facilities.

Various Federal agencies, including the Food and Drug Administration, the Department of Agriculture, the Department of Commerce, and the Department of Energy have responsibilities in the waste disposal area. EPA, however, has the primary role. As such, this report focuses on EPA's policies, programs, and activities concerning codisposal.

CODISPOSAL--A VIABLE DISPOSAL ALTERNATIVE

While amounts of sludge and garbage are expected to increase sharply, some of the current disposal options, as discussed in chapter 2, will be restricted or eliminated. Given this situation, the interest in recovering resources (including energy from waste) and the fact that RCRA and the Clean Water Act encourage integrated waste management, we examined codisposal's viability.

This report provides an overview of codisposal and examines such matters as the status of technology, barriers to implementation, and the extent and adequacy of Federal efforts to overcome these barriers.

Codisposal of sludge and garbage can be accomplished through various techniques, including thermal and biological processes. This report focuses on codisposal through thermal processes, such as co-incineration and copyrolysis, 1/ since these techniques can significantly reduce the volume of waste requiring final disposal while conserving or creating energy. Further, certain thermal technologies have been proven and are applicable in the United States, particularly considering restrictions on existing disposal options. For the purposes of our examination, codisposal is defined as the integrated processing of sewage sludge and garbage through burning, in which (1) garbage is used as a fuel in sludge drying and (2) the volume of both wastes requiring ultimate disposal is greatly reduced.

1/Copyrolysis is a process of waste decomposition through heating in an oxygen starved or oxygen free environment.

SCOPE OF REVIEW

We made our review at EPA headquarters in Washington, D.C.; the EPA Municipal Environmental Research Laboratory in Cincinnati, Ohio; EPA regional offices in Boston, Chicago, New York, and Philadelphia; and State environmental protection agencies in Connecticut, Maryland, Massachusetts, New Jersey, New York, and Pennsylvania. We also reviewed data provided by officials of other Federal agencies, including the Department of Commerce and the Department of Energy.

We examined pertinent legislation, regulations, reports, and other documents. We also interviewed officials of various public interest groups, professional societies, and environmental organizations and reviewed studies and other pertinent materials provided by these sources. Our review included discussions with representatives of several firms currently developing and/or marketing codisposal equipment and analysis of reports and other data they provided. We also obtained information from several consulting firms on various subjects, including specific codisposal projects.

AGENCY COMMENTS

We discussed the report with EPA and Department of Energy officials and, where appropriate, we included their comments and suggested revisions. The agencies agreed with our conclusions and recommendations.

CHAPTER 2

CODISPOSAL IS A TECHNOLOGICALLY VIABLE ALTERNATIVE TO CURRENT DISPOSAL METHODS

A continuing need exists for safe and efficient solutions to the sludge and garbage problems, particularly when the problems with current disposal options are considered. A number of important benefits have been attributed to codisposal; for example, that it is a logical and cost-effective disposal alternative which is environmentally sound and energy efficient. If the benefits from codisposal are to be realized, sound technology must exist. This chapter examines the status of codisposal technology.

PROBLEMS WITH CURRENT DISPOSAL AND RECOVERY OPTIONS

Some sludge and garbage disposal techniques have caused or contributed to major environmental and economic problems. Further, certain disposal alternatives will be restricted or eliminated as new Federal requirements are implemented.

Garbage disposal practices

Almost all the Nation's garbage is disposed of in landfills, open dumps, or incinerators or it is littered. Land disposal in the nearly 20,000 municipal sites is the most commonly used technique.

Land disposal has caused serious environmental problems. When water mixes with the waste it removes soluble components which can form a highly polluted liquid called leachate. Surface and ground water contamination due to leachate has been increasingly documented by EPA and others. Currently, only about 6,000 of the 20,000 municipal disposal sites are considered sanitary landfills. Our previous report 1/ discussed the seriousness of the contamination and recommended that EPA take certain steps to control the problem. It should be noted that, even if the environmental problems could be controlled, land disposal is no longer possible in certain areas since no available land remains. Other localities are rapidly running out of landfill space.

1/"Waste Disposal Practices--A Threat To Health and The Nation's Water Supply," CED-78-120, June 16, 1978.

Environmental difficulties, particularly air pollution control problems, also exist with garbage incineration. Many incinerators have shut down because operators were either unable or unwilling to invest the money needed to bring the facilities into compliance with emissions standards.

Current disposal practices also pose economic problems. Disposal is expensive, and EPA estimated that the average direct cost for collecting and disposing 1 ton of garbage in 1976 was $30, representing a total cost of about $4 billion. This figure is expected to increase sharply due to inflation, rising land values, and costs of complying with new land disposal requirements. A related economic problem is the failure to recover and use the material and energy in garbage.

<u>Waste reduction and resource recovery efforts have been disappointing</u>

Attempts are being made to address the garbage problem by reducing or preventing waste generation at its source by (1) using refillable beverage containers, (2) changing packaging design, and (3) shifting to more durable products. Although these efforts generally have not been successful, EPA estimates that the amount of garbage generated could be reduced by about 10 percent through waste reduction methods. The multiagency, Cabinet level Resource Conservation Committee mandated by RCRA is studying this approach.

Resource recovery, or productively using what would otherwise require disposal, is another approach to the garbage problem. Recovery includes (1) recycling--processing waste to recover the original material, (2) materials conversion--using waste in a different form (e.g., road paving material from old tires), and (3) energy recovery--capturing the heat value from waste by direct combustion or by conversion into an intermediate fuel product. Source separation (segregating specific items such as newspapers and bottles at the point of discard) and mixed waste processing of collected garbage at a centralized point are the two primary resource recovery extraction techniques.

Resource recovery has faced economic, technological, and institutional barriers which have limited its success. According to EPA, although about 25 percent of the Nation's garbage could be recycled through source separation alone, in recent years total materials recovery has never exceeded 7 percent. Further, although garbage has significant energy potential, EPA has found current energy recovery efforts to be limited.

Despite the problems, resource recovery will probably be an increasingly attractive alternative to land disposal. As mentioned, landfill space is not as abundant as it once was. If effectively enforced, RCRA provisions, including the ban on open dumping and the requirement that localities comply with Federal landfill criteria, should cause a shift away from land disposal in many areas or at least make it more expensive. Although RCRA's full impact is unknown, in an early 1978 draft environmental impact statement EPA estimated that it would cost about $1.65 billion a year to bring solid waste land disposal facilities into compliance with the proposed RCRA landfill criteria. Land disposal in many parts of the country will no longer be the attractive, relatively low-cost alternative it has been.

Sludge disposal methods

The most common sludge disposal methods are (1) ocean disposal, (2) landfilling, (3) land application, and (4) incineration. As is the case with garbage disposal methods, however, these practices can cause major environmental and/or economic problems, and some may be eliminated or restricted.

Ocean disposal is believed to have degraded the marine environment and endangered human health and welfare. EPA regulations and the 1977 amendments to the Marine Protection, Research, and Sanctuaries Act prohibit ocean dumping after December 31, 1981. However, there is some question as to whether this requirement will be realized. Our work in EPA region 2 (New York and New Jersey), where most ocean dumping occurs, showed that most localities with dumping permits were not fully complying with the phase-out schedule.

Landfilling sludge can create odors, and public health and leachate problems similar to those described for garbage, with sludge leachate containing greater heavy metals concentrations. Landfilling's future is in doubt because (1) land availability is diminishing and (2) various Federal regulations, including those to be issued under RCRA and the Clean Water Act, will restrict the practice. Problems with incineration, most notably air pollution control and the possibility that the ash and air pollution control residuals may cause ground water contamination when landfilled, also exist. Further, incineration is expensive and requires large amounts of auxiliary fossil fuel or electricity for drying and incinerating the sludge.

Land application to croplands, forests, and other sites allows for sludge's beneficial uses as a fertilizer and soil conditioner and in land reclamation. Despite its advantages, however, there are some environmental uncertainties associated with land application. Although current knowledge is limited, application to croplands could be a threat to human health since sludge may contain pathogens, toxic organics, and heavy metals such as cadmium.

THE FUNDAMENTALS OF THERMAL CODISPOSAL

There are two basic thermal codisposal approaches. Both attempt to use garbage as a fuel to facilitate sludge drying and/or burning. The first approach uses garbage incineration equipment; the second approach uses the combustible portion of garbage as a fuel in sludge incinerators.

The garbage incineration approach

EPA estimates that from 70 to 80 percent of municipal garbage is combustible. This portion of the waste is almost totally comprised of organic materials. While heating values of raw garbage vary widely, the average value is about 4,600 British thermal units (BTUs) per pound, or about 9 million BTUs per ton. 1/ This is between one-third and one-half the energy value of coal. One ton of garbage can provide about as much energy as 65 gallons of oil.

Codisposal can be accomplished by using various types of garbage burning equipment, such as waterwall combustion units. Waterwall equipment burns garbage in specially designed furnaces jacketed with water-filled tubes which can recover heat in the form of steam. Regardless of the equipment used, the objective is to use the heat released from the burning garbage to dry the sludge to its autogenous (self-burning) point, which is about 30 percent solids. The heat form used is either hot flue gas or steam. After it is dried, the sludge can be burned along with the garbage. The heat value of the dried sludge can be relatively high--as great as 10,000 BTUs per pound of dry weight solids on an ash-free basis. Excess or exportable energy for such purposes as powering wastewater treatment plants may be produced.

1/A BTU is the quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

Sludge incineration methods

About 35 percent of municipal sludge is incinerated. The two most common types of sludge incinerators are the multiple hearth furnace and the fluidized bed furnace; the former is the most widely used. According to a December 1977 study done for EPA by Gordian Associates, Inc., there are over 300 multiple hearth incinerators in the United States.

Both furnace types are vertical, cylinder shaped vessels. (See pp. 10 and 11.) The multiple hearth furnace is equipped with numerous hearths and a rotating central shaft to which a series of arms are attached. Dewatered sludge enters the top of the furnace and is burned as it is pushed or raked downward from hearth to hearth by the arms. In the fluidized bed incinerator, sludge burning takes place in a hot sand bed which is fluidized (i.e., sand particles are suspended by blowing high pressure air into the bed from below). The size and capacity of sludge incinerators varies widely. Multiple hearth furnaces, for example, can range from 4.5 feet to 25 feet in diameter.

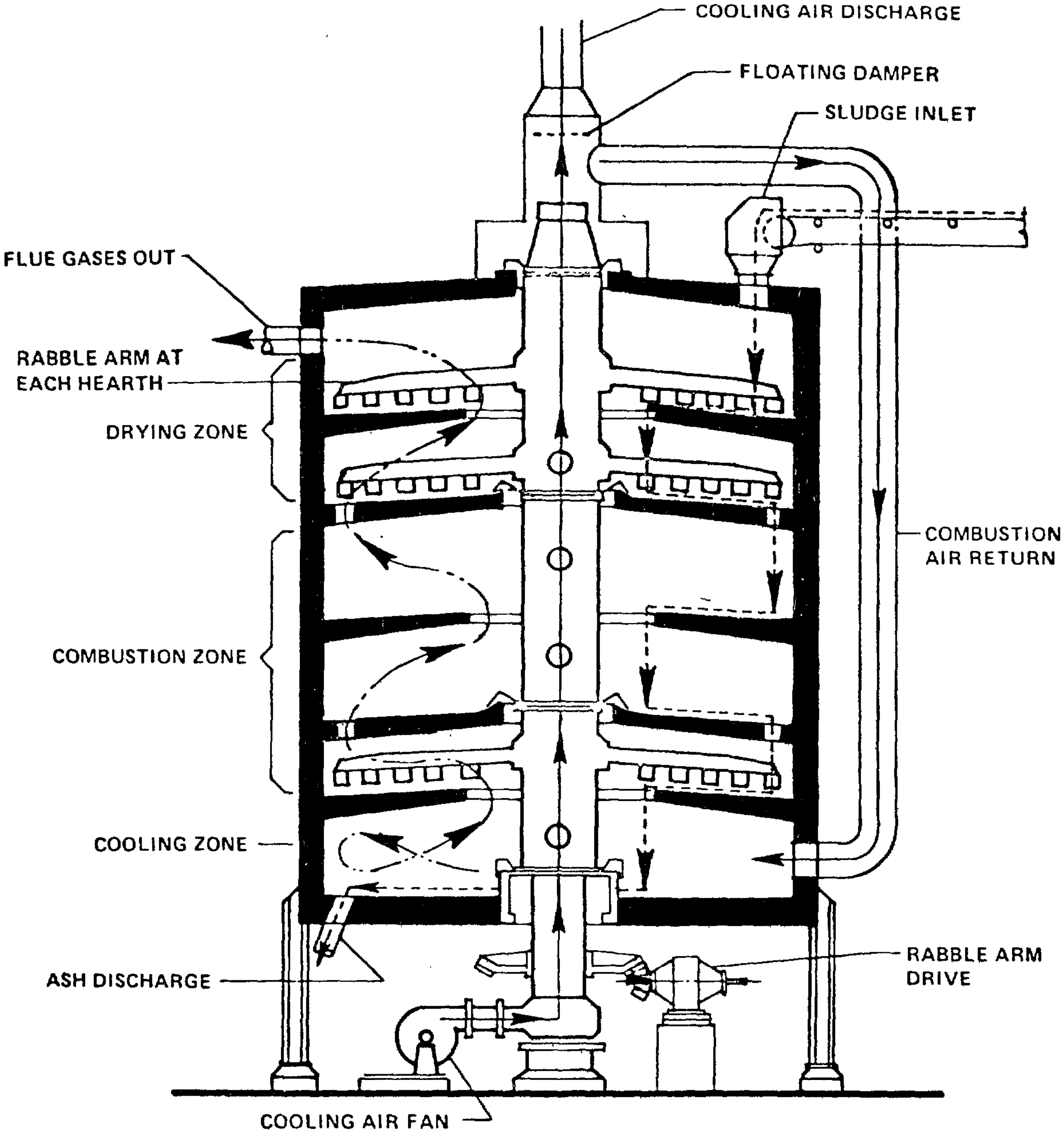
Due to the sludge's high water content, incineration often requires large amounts of auxiliary fuels, such as oil and natural gas. Auxiliary fuel and energy expenses currently represent a substantial portion of total incineration costs. EPA has estimated that the equivalent of almost 2 million barrels of fuel oil a year will be used in existing and planned sludge incinerators. The tremendous fuel cost increases during the 1970s have contributed to making incineration one of the most expensive, if not the most expensive, sludge disposal alternatives.

Consequently, finding cheaper alternative energy sources has been of interest. Using garbage as the auxiliary fuel in sludge incinerators is one answer. Although attempts have been made to use raw garbage, usually only the processed organic portion, commonly referred to as refuse-derived fuel (RDF), is used.

RDF typically is produced by shredding the garbage and then screening and/or air classifying it to remove the noncombustible or heavy portion. The remaining combustible light portion is generally referred to as fluff RDF. This material can be further processed into a higher BTU content form known as dust RDF. Attempts are being made to develop densified RDF forms such as pellets or briquettes. A wet RDF production process, which was first demonstrated at EPA's Franklin, Ohio, demonstration project, also exists. RDF has been used in sludge incinerators under both the co-incineration and copyrolysis modes.

FIGURE 1

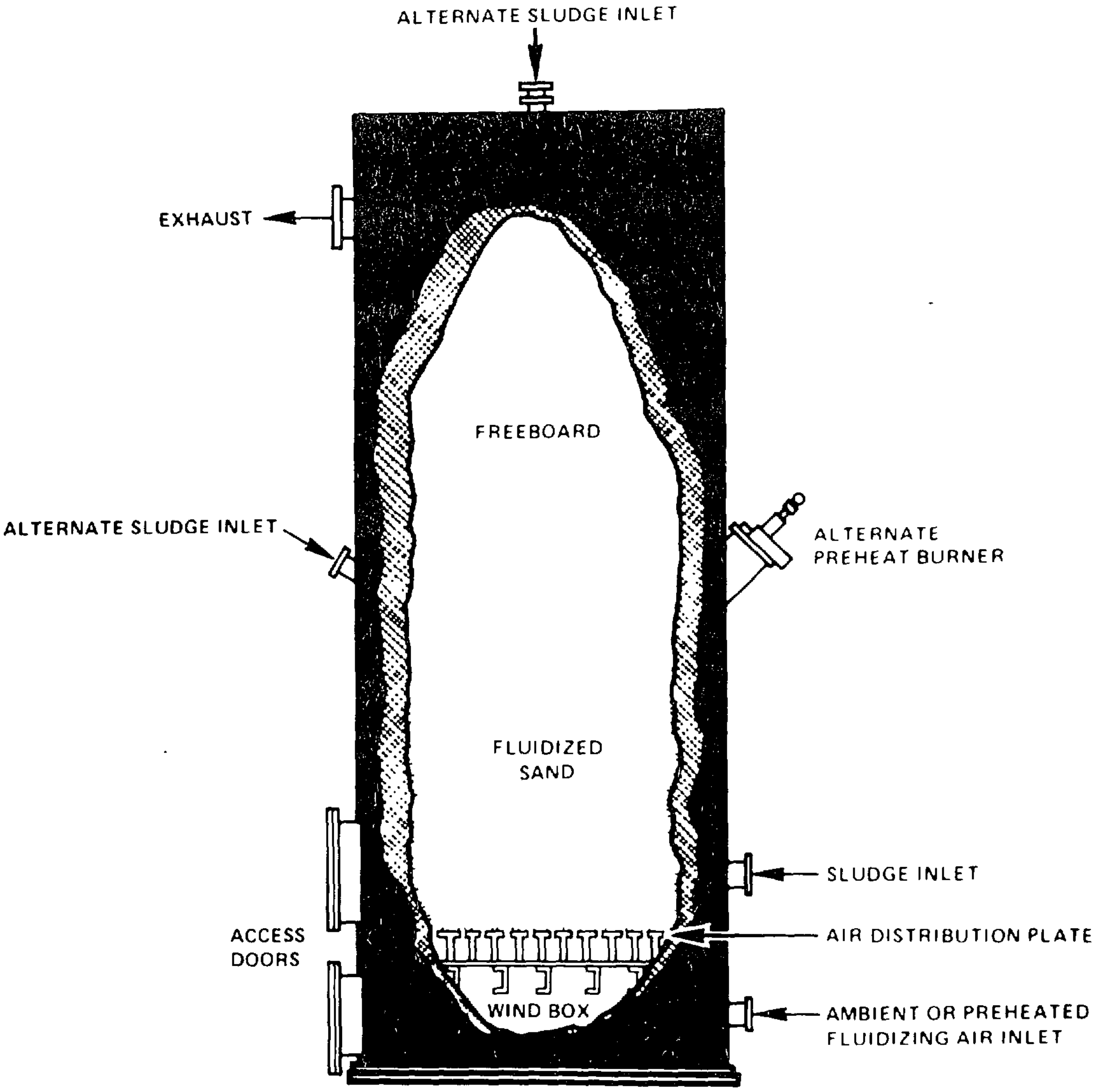
MULTIPLE HEARTH INCINERATOR



Source: Environmental Protection Agency

FIGURE 2

FLUID BED SLUDGE INCINERATOR



Source: Environmental Protection Agency

Several different foreign and United States technologies exist which employ the basic codisposal approaches. These technologies, which are in various stages of development, are discussed below.

EUROPEAN TECHNOLOGY IS PROVEN

Western European countries have been using technologies which recover energy from the combustion of garbage more extensively then has the United States. The lack of available landfill space along with high energy costs have encouraged the construction of waste to energy facilities in Europe. Several of these facilities are codisposal plants which have apparently been operating successfully for some time.

Operation of European plants

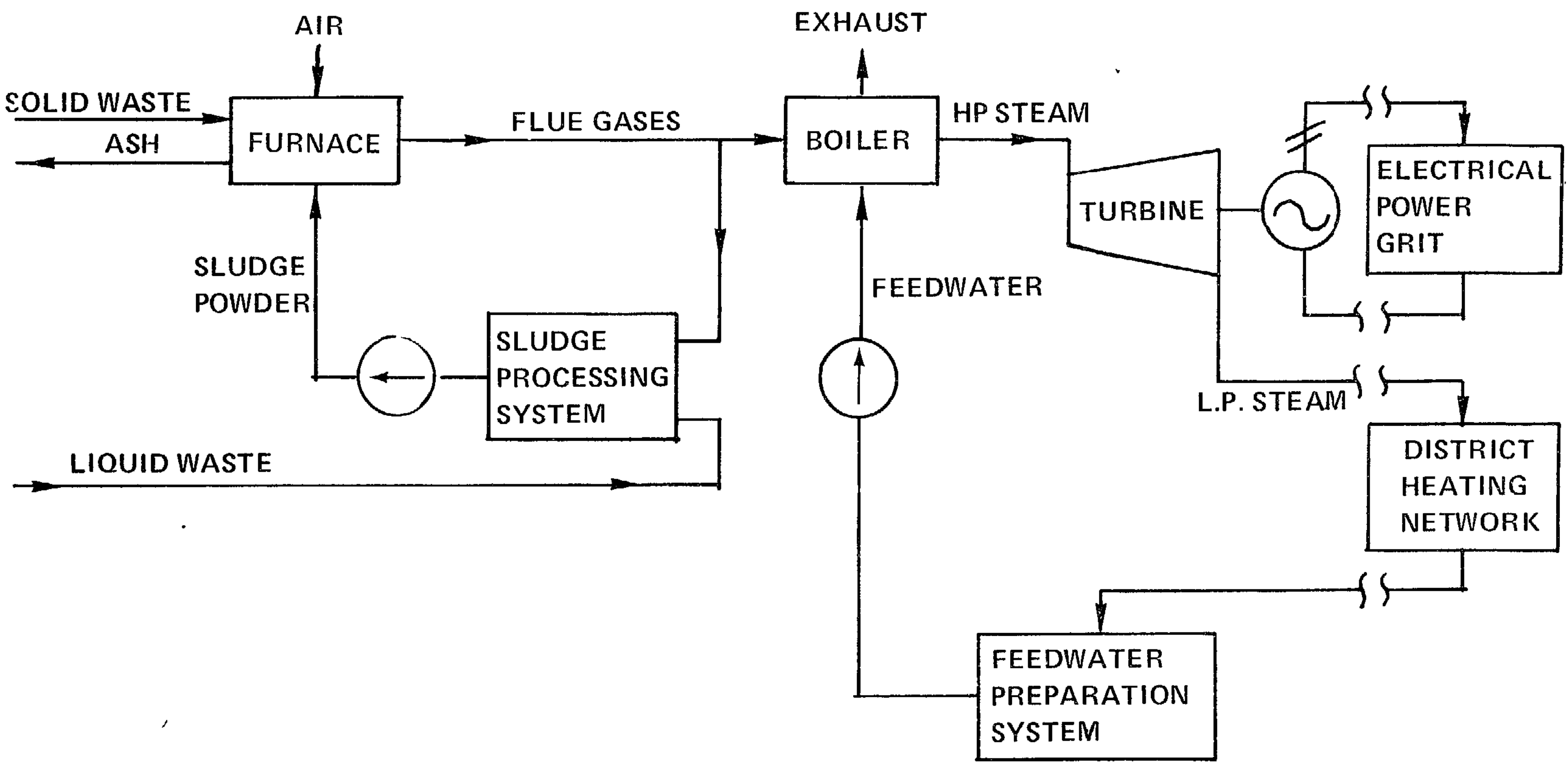
One of the largest integrated wastewater treatment/ codisposal facilities in Europe is the Krefeld, West Germany, plant. This facility began operating in 1975 and can serve a population equivalent to about 300,000 for garbage disposal and 600,000 for sludge disposal. 1/ The plant is equipped with two separate waterwall combustion units. Each unit is designed to process about 317 tons of garbage and 168 tons of dewatered sludge (25 percent solids) daily. The process used at the facility is shown on page 13. Sludge at about 5 percent solids is pumped from the adjoining wastewater treatment plant to the combustion unit where it is first dewatered to about 25 percent solids in centrifuges. This sludge is then dried in a chamber by hot flue gases from the burning garbage to about 90 percent solids. The sludge in a dry, powdered form and the gas are then blown back into the furnace where they are burned.

The facility produces exportable energy in the form of steam which is in turn used to produce electricity for the wastewater treatment plant as well as hot water and district heating for the community. Some offsite materials recovery from the ash also occurs. The plant, which has been operating successfully for a few years, uses codisposal technology developed by VKW, a West German company. Grumman Ecosystems Corporation has the exclusive marketing license in the United States for this technology.

1/The plant serves both residential and industrial sources. The population figures cited represent the estimated equivalent number of people it could serve if all waste came from residential sources.

FIGURE 3

SCHEMATIC OF THE KREFELD FACILITY



Source: Grumman Ecosystems Corp.

Another codisposal plant has recently become operational in Ingolstadt, West Germany. This facility, which uses technology developed by the Swiss firm of Widmer and Ernst, can process about 71,000 tons of garbage and 19,000 tons of sludge (25 percent solids) a year. Sludge mechanically dewatered to about 25 percent solids is conveyed to the incinerator plant where it is mixed with sludge previously dried by codisposal to create a mixture which is about 60 percent solids. The mixture is then dried by the hot flue gases from the burning garbage and milled into a dust. Some of the dust is retained for mixing with incoming sludge; the remainder is blown into the furnace and burned with the garbage.

Three codisposal plants operate in France. The facility at Dieppe serves a population of about 60,000. The facility began operating in 1971 and is the oldest European codisposal plant. The Brive plant began operating in 1975 and is the largest of the three; it serves about 160,000 people. The third plant at Deauville is the newest and the smallest; it serves about 50,000 people. The three plants, which are all integrated with wastewater treatment plants, were designed by Von Roll Ltd., whose American licensee is Wheelabrator-Frye, Inc.

Technologically, the plants are similar, using steam generated by the burning garbage to dry the sludge to its autogenous point and then burning it along with the garbage. Sludge (between 7 and 11.5 percent solids depending on the plant) is pumped from the treatment plant to the incinerator unit where it is metered into dryers. The sludge dried to about 55 percent solids is then mechanically removed from the dryers and conveyed to the furnace where it is burned. The three French plants have also been operating satisfactorily.

Although some operational problems have existed, the European systems have been proven. Despite this, widespread, large-scale implementation of the technology in the United States has not taken place. Although there are many reasons for this, one major factor may be the absence of detailed operating and technological data on the plants. EPA and the Department of Energy are trying to address this situation. Both agencies have contracted for studies which include evaluating selected European codisposal facilities, including the Dieppe, Deauville, Krefeld, and Brive plants.

PAST U.S. CODISPOSAL EFFORTS OFTEN UNSUCCESSFUL

Many attempts to implement codisposal in the United States have failed due to technological and related economic problems. Only a few plants have operated successfully in recent years. Generally, the previous attempts involved the co-incineration of sludge in garbage incinerators. Often the dewatered sludge was mixed with the garbage and merely dumped into the incinerator. Since the incinerators were not designed for codisposal, they were incapable of adjusting to this new feed material. Frequently, the fire was extinguished, or the material did not burn properly and was merely toasted.

Attempts to correct these technological problems, which in some cases also involved inadequate air emissions equipment, were generally expensive and ineffective. Further, there was not much incentive to pursue codisposal by investing in new equipment. Inexpensive land disposal alternatives for both types of waste were often available. Separate sludge incineration also remained an attractive alternative because the cost of auxiliary fuels was relatively low and because the sludge (unlike much of today's sludge generated through secondary wastewater treatment) was easier to dewater. As a result, codisposal was often abandoned. By 1975 there were only a few plants still operating, including EPA's Franklin, Ohio, demonstration project and three New England facilities, which have since closed.

The Franklin project, which began operating in 1971 and is still functioning, was the first U.S. facility to demonstrate codisposal in a fluidized bed sludge incinerator. The garbage rejected from the facility's resource recovery plant in the form of a heavily organic 20 percent solids slurry is mixed with 5 percent solids sludge. The mixture is then dewatered to 45 percent solids in a press and incinerated. The garbage provides the energy to burn the sludge, but there is no excess energy recovered. About 50 tons of garbage and 10 tons of dry sludge a day are processed.

All three New England plants used flue gas from the burning garbage to dewater sludge, but generated no excess energy. The Holyoke, Massachusetts, plant, which began operating in 1965, processed about 50 tons of garbage and about 3 tons of 28 percent solids sludge a day before it closed in 1976 due to air emissions control problems. The Ansonia, Connecticut, facility, which processed slightly more waste a day than the Holyoke plant, had been operating for several years. The dried sludge, however, was not incinerated, but used as fertilizer.

The third facility located in Stamford, Connecticut, was processing about 250 tons of garbage and 10 tons of dried sludge (about 25 percent solids) a day. A Stamford official said the plant functioned satisfactorily for about

16 months; but, in 1976, problems developed with the centrifuges after the facility began receiving a different kind of sludge from a new wastewater treatment plant. Because of these problems the facility could no longer function in the codisposal mode. The official told us that no problems existed with the co-incineration equipment and that the city plans to continue codisposal once the problem is corrected.

CODISPOSAL'S REEMERGENCE

Since the mid-1970s, Government and industry have had renewed interest in codisposal. The energy crisis, improvements in incinerator technology (including the European experience), and diminishing land disposal options in some areas have contributed to codisposal's reemergence. The renewed effort has been devoted to developing new technologies and to planning and constructing codisposal facilities. EPA and the Department of Energy have been involved in these efforts through such activities as sponsoring research, development, and demonstration projects.

EPA activities

Some EPA activities, such as the European technology study and the Franklin, Ohio, demonstration project, have already been mentioned. Other efforts include research conducted by Roy F. Weston, Inc., sponsored by EPA's Municipal Environmental Research Laboratory, which resulted in a comprehensive report published in December 1976, entitled "A Review of Techniques for Incineration of Sewage Sludge with Solid Wastes." The report examined the technological, environmental, and economic aspects of codisposal and made policy and technical recommendations to EPA. Among the report's primary findings was the fact that codisposal is technologically viable.

EPA's Office of Solid Waste is sponsoring research by Gordian Associates, Inc., which involves assessing various technological, institutional, and other matters associated with using RDF in sludge incinerators. The Gordian efforts confirm the technological feasibility of using RDF in retrofitted sludge incinerators.

One EPA effort in the demonstration area was its participation in testing the Union Carbide, Inc., "Purox," copyrolysis system. This process, originally designed for the pyrolysis of garbage only, was developed and tested on a small scale during the early 1970s. In 1974, the company completed construction of a commercial-scale test facility (200 tons per day) in South Charleston, West Virginia. Union Carbide and the city of South Charleston proposed that EPA help with large-scale testing of the Purox system in the codisposal mode. EPA agreed, and necessary modifications to the plant were completed in early 1977. Testing of copyrolysis using different sludge to garbage ratios and different moisture contents was conducted over a 2-month period in 1977. According to a January 1978 report prepared for EPA by Union Carbide, the tests proved the feasibility of codisposal using Purox. EPA spent about $332,000 on this project.

Another EPA-sponsored thermal codisposal demonstration project is being planned in Wilmington, Delaware. The project was first funded in October 1972 for $9 million and its original primary purpose was to produce humus from sludge and garbage. The project's purpose and concept have changed a few times. The most recent change, combustion of RDF and sludge to produce steam for sale and sludge drying, was required by EPA following the grantee's request to substitute an alternative energy market. The project will now process about 1,000 tons of garbage and about 50 dry tons of sludge per day. Its primary objective will be steam production, and we were told that if codisposal interferes with this, codisposal will be discontinued. At the time of our review, construction had just begun.

Department of Energy efforts

The Department of Energy, primarily through its Urban Waste Technology Branch, is also active in codisposal research and development. In July 1978, the branch requested proposals for research and/or design and development of new or modified technologies for energy recovery and conservation based primarily on solid and liquid waste treatment systems. The Department plans to fund four studies and spend about $450,000 on this effort. Among the studies to be funded are a review of the Krefeld facility and an analysis at the Harrisburg, Pennsylvania, codisposal plant to identify the optimun sludge and garbage mix.

Future codisposal projects

Various codisposal facilities, as shown in the following table, are either under construction or in the planning stage. Each facility is part of a larger wastewater treatment project for which EPA is providing some funding under the construction grants program.

Planned Codisposal Facilities

Location and description	Projected cost (millions)	Status
Contra Costa County, California. About 1,200 TPD (note a) of garbage will be processed into 600 TPD of RDF and burned with 96 TPD of sludge in multiple hearth incinerators in the pyrolysis mode.	$ 50.0	Facility plan completed.
Duluth, Minnesota. About 340 TPD of sludge will be burned in a fluidized bed sludge incinerator using 160 TPD of RDF as the auxiliary fuel source. Because the amount of RDF produced will exceed the amount required for sludge burning, other markets for the excess RDF are being sought. Ferrous metals will be recovered and steam will be used to run the processing facility.	21.7	Under construction.
Glen Cove, New York. About 175 TPD of garbage and 25 TPD of sludge (20 percent solids) will be coburned in a garbage incinerator. Waste heat from the incinerator will be used to produce power for the wastewater treatment plant. Ferrous metals will be recovered from the ash.	10.0	Construction delayed pending further EPA reviews.
Harrisburg, Pennsylvania. Some steam from an existing garbage burning waterwall incinerator will be used to dry sludge to 15 percent solids. The sludge will then be burned with the garbage. The incinerator can process 720 TPD of garbage and 49 TPD of sludge. Ferrous metals recovery is planned.	4.7	Under construction. Estimated completion date in October 1979.
Memphis, Tennessee. RDF production with ferrous metals recovery. RDF and sludge will be burned in multiple hearth incinerators in the pyrolysis mode. Steam will be sold to nearby industries. The plant capacity is 2,400 TPD of garbage and 1,225 TPD of sludge.	140.0	Facility plan under review by EPA.

a/Tons per day.

As is apparent from the table, the projects represent a mix of various codisposal approaches and technologies. All the projects will, at a minimum, use the energy from burning garbage to facilitate sludge drying and disposal. Some projects will use the excess energy created to power the wastewater treatment plants, while others will sell the excess energy. Some projects also plan to recover materials, particularly ferrous scrap, either through front-end separation or recovery from the ash. EPA plans to evaluate the performance of some of the new facilities.

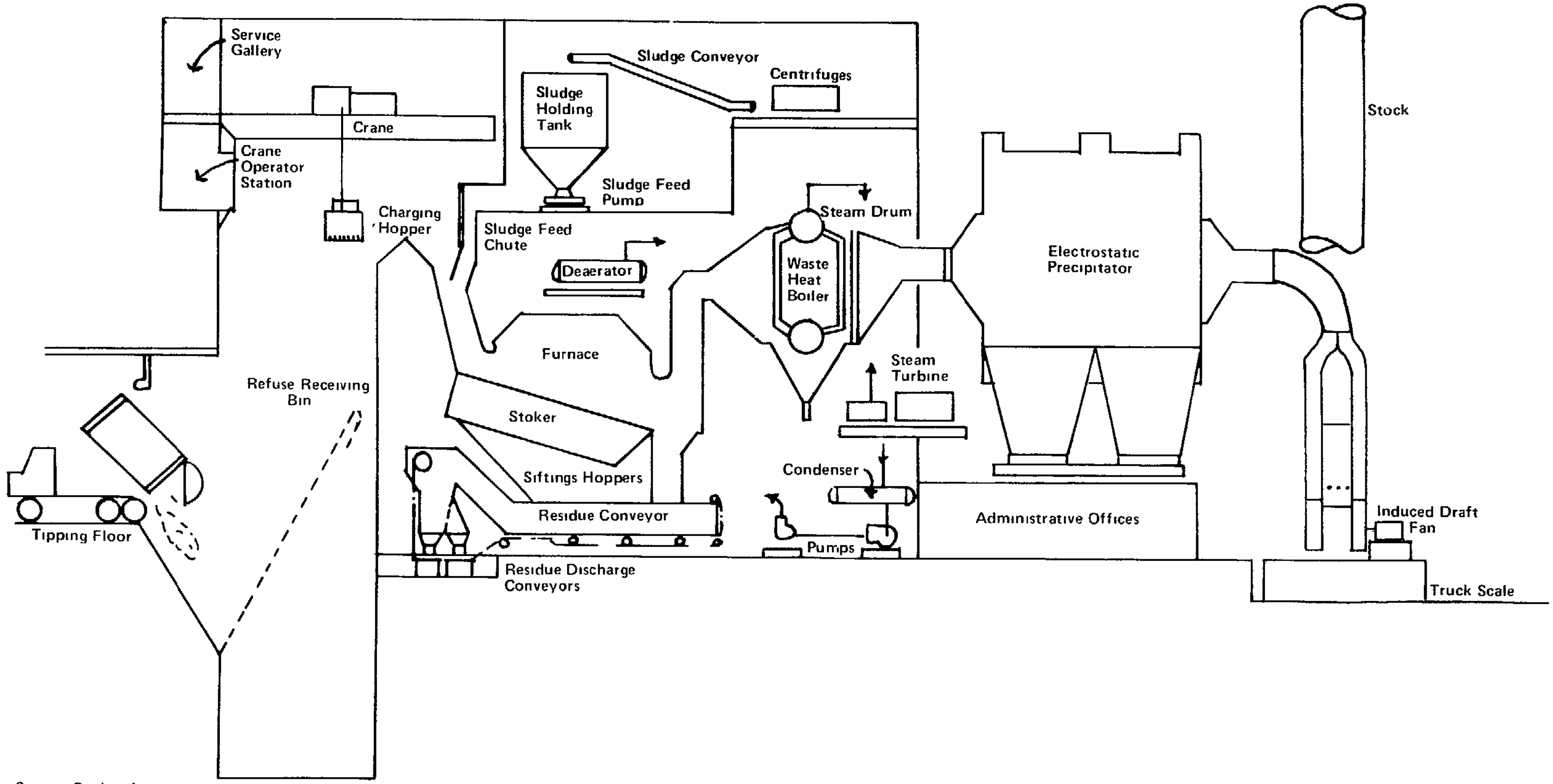
Two projects--Harrisburg and Glen Cove--will use garbage burning equipment. The Harrisburg project is interesting since it uses an existing waterwall incinerator, which has been in use for more than 6 years. According to the project consultant, the incinerator will be modified so that some of the steam it produces can be used to dry sludge, which is first placed in dryers and then burned with the refuse. Although steam will be sold to a utility, no energy will be generated for a wastewater plant.

The Glen Cove facility (see p. 20) will use a different codisposal approach. A thin layer of dewatered sludge will be applied directly on top of the burning garbage in a garbage-sludge ratio of 7:1. The sludge is dried and then burned along with the garbage. The heat will be recovered to produce steam which will be used to generate electricity for a wastewater treatment plant. The process was developed by the project's consulting engineers, using existing available equipment made by several manufacturers, and was demonstrated during tests at another facility. Construction on the Glen Cove codisposal project has been delayed pending EPA reviews of potential air emissions.

The Central Contra Costa project (see p. 21) represents the culmination of research and testing which demonstrated the technological feasibility of sludge and RDF co-incineration and copyrolysis in a multiple hearth furnace. Following small-scale testing of codisposal in November 1974, the consultants for the local sanitary district recommended a full-scale evaluation. EPA provided funds for the project under a planning grant. Testing was conducted for 31 days in a retrofitted incinerator. The consultants concluded that copyrolysis would be the preferred option for the district. They recommended a copyrolysis project, indicating that this approach would not only dispose of the waste but also provide energy for operating the new wastewater treatment plant.

FIGURE 4

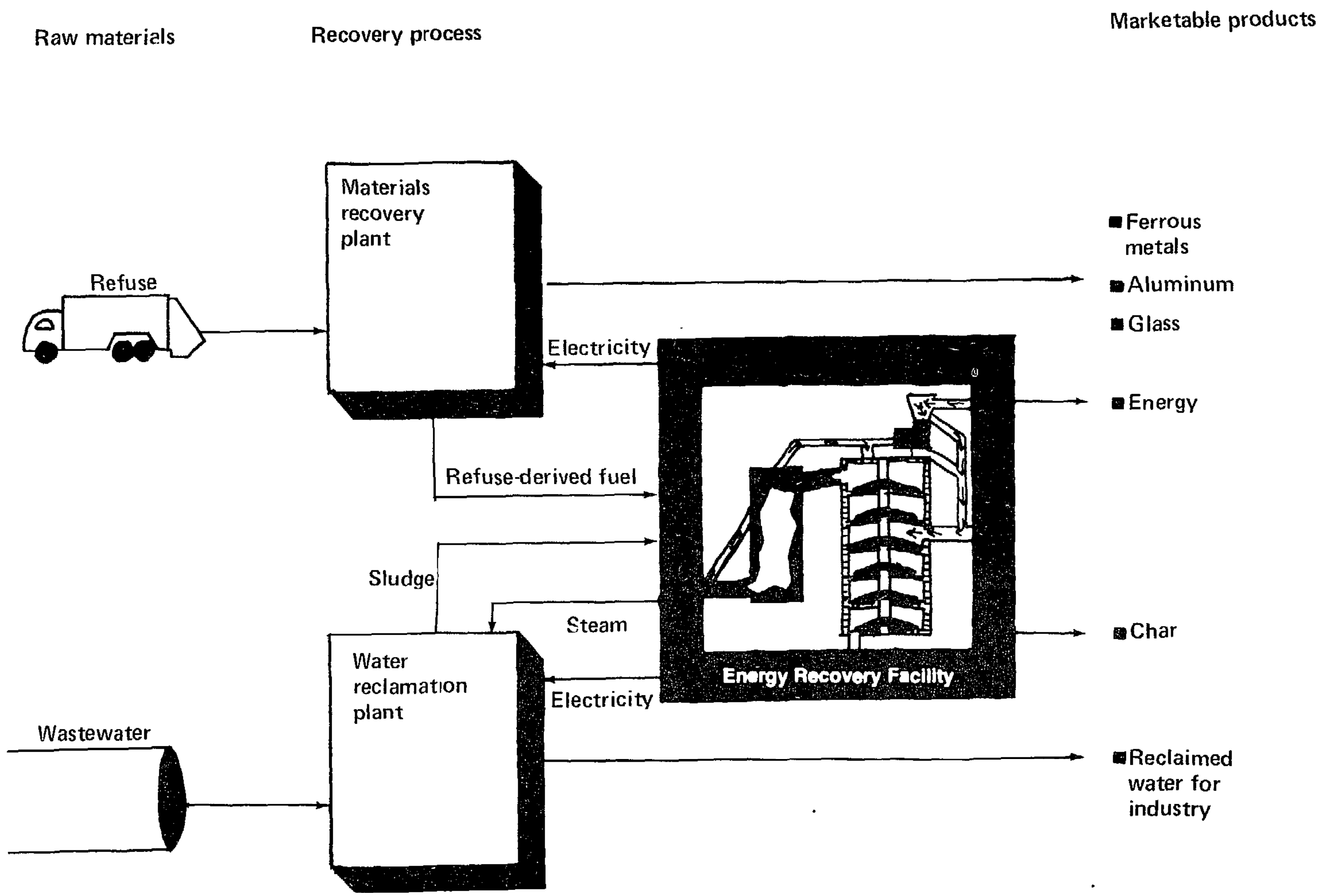
THE GLEN COVE SYSTEM



Source Gordian Associates

FIGURE 5

THE CONTRA COSTA SYSTEM



Source: Brown and Caldwell

Using RDF in a multiple hearth incinerator is also planned for a large-scale Memphis facility. This project, which will include the construction of RDF production plants, will also copyrolyze RDF and sludge. EPA is currently reviewing the latest detailed facilities plan for the project and it appears that construction will not soon begin. RDF will also be manufactured and used in Duluth, Minnesota, but unlike the other two projects, the RDF will be co-incinerated in fluidized bed sludge incinerators.

Although codisposal's reemergence in recent years is a step in the right direction, some crucial problems need to be resolved if State and local agencies are to consider co-disposal. We believe that EPA should accelerate its efforts to resolve the environmental, economic, and institutional issues and questions discussed in the following sections of this report.

CONCLUSIONS

Thermal codisposal, in either garbage or sludge burning equipment, has been demonstrated to be technologically feasible, as have co-incineration and copyrolysis, the two primary thermal techniques. Based on our review and considering the successful European experience, co-incineration in garbage burning incinerators is the most developed and proven codisposal technology. Using RDF in sludge incinerators and copyrolysis, although demonstrated, have not yet been proven on a commercial scale. However, confidence in these processes exists. Consultants and others, including local and EPA officials associated with certain planned codisposal projects, are prepared to invest large sums of money in these technologies. Further, implementation of such projects as the one in Duluth will allow for firsthand evaluation of actual operating conditions on a fairly large scale.

Although much codisposal activity has occurred in the past few years in which EPA has played an important role, codisposal has not been widely implemented in the United States. The early failures and the existence of numerous sludge and garbage disposal alternatives, including low-cost land disposal, have tended to limit implementation. However, things are changing; codisposal technology has improved and some other disposal options are being restricted or eliminated. As a result, thermal codisposal appears to be a technologically viable alternative on a site-specific basis.

Technological viability, though certainly important, is not the only factor which should be considered when assessing the possibility of implementing codisposal. Generalizing about disposal methods is difficult. Each method, including codisposal, has its advantages and disadvantages. Decisions to implement a particular method should be based on careful consideration of various site-specific environmental, economic, and institutional factors. Some considerations which might directly affect the choice of codisposal include:

--Are serious sludge and garbage disposal problems occurring simultaneously?

--What is the composition of the waste?

--What is the environmental situation in terms of air pollution and ground water conditions?

--Are relatively inexpensive alternatives such as landfill available?

--What size investment has been made in existing disposal/recovery approaches?

--Are there markets for recovered products and energy?

--What are the local political and institutional arrangements? Are there different political subdivisions or departments responsible for sludge and garbage disposal? Do these groups cooperate?

--To what extent is the private sector involved in waste management and disposal? How will the private sector be affected by or influence disposal decisions?

The following chapters examine some of the environmental, economic, and institutional factors affecting codisposal.

CHAPTER 3

MORE DATA NEEDED ON CODISPOSAL'S ENVIRONMENTAL IMPACTS

No completely safe way to dispose of wastes exists. All waste disposal options, including codisposal, involve some risk and potential damage to at least one of the three environmental media--air, land, and water. Potential air emissions problems are the primary environmental concern associated with codisposal. While there is a clear need for more specific data, the information available suggests that if proper precautions are taken, codisposal can be an environmentally safe disposal alternative.

THE AIR EMISSIONS ISSUE

Potential air quality degradation is a major problem associated with combustion systems, including codisposal. Despite the scarcity of hard data and site-specific variations, some overall observations regarding codisposal air emissions can be made. The major observation is that air emissions from codisposal, which should generally be no worse than emissions caused by separate sludge and garbage incineration, can be controlled.

Ability to control air emissions

Incinerating sludge and garbage separately, if not properly controlled, can cause certain criteria pollutants (e.g. particulates and lead) and other substances, such as heavy metals, to be emitted. Emissions problems have caused waste incinerators in the United States, including some of the early codisposal facilities, to close. Despite improved pollution control and incinerator technologies, fear of air quality deterioration has contributed to community opposition, making it increasingly difficult to plan new incinerators. This situation has affected thermal codisposal. For example, the Glen Cove project has faced opposition from a nearby community because of potential emissions problems. Further, some officials we interviewed were reluctant to implement thermal codisposal because of possible air quality degradation.

The available data suggests that the pollutants generated in codisposal facilities will generally be similar to those resulting from separate sludge and garbage incineration. According to data developed for EPA, the level of particulate emissions from co-incineration may be higher than in separate incineration. On the other hand, co-incineration may result in lower emissions of other pollutants, such as oxides of nitrogen. Overall, the air quality impacts of codisposal should generally be no worse than for separate incineration.

Although the data is limited, it appears that emissions from codisposal facilities can be controlled. Our review of available information and discussions with knowledgeable officials indicated that properly engineered and operated facilities which are equipped with the appropriate control devices, such as scrubbers and/or electrostatic precipitators, can effectively control air emissions. For example, the codisposal facilities in Western Europe have apparently not experienced serious air emissions problems. Specific emissions data on the Krefeld facility should soon be available from the Department of Energy's review. (See p. 17.) Facilities in West Germany are particularly significant since that nation's emission standards for certain pollutants are comparable to or stricter than U.S. standards. It must be recognized, however, that pollution control equipment is expensive and can add significantly to the costs of a facility.

Other ways exist to approach the air emissions problem. In any combustion process, "what eventually goes up the stack" to possibly become a pollutant is a function of several variables. These include the incineration and the pollution control equipment's efficiency, as well as the composition of the feed material. In the case of thermal codisposal, EPA officials told us that it may be possible to reduce potential air emissions problems by changing the garbage and sludge content. In the case of garbage, certain items can be source separated before incineration. EPA was considering this approach as a way of limiting potential lead emissions from the Glen Cove facility.

With respect to sludge, EPA requires States and local communities to establish pretreatment programs for industrial wastes designed to remove contaminants at the source before discharge into publicly owned sewers. Although opinions and data vary as to the exact effects pretreatment will have on municipal sludge, the amount of substances, such as heavy metals, which have contributed to air emissions and potential health problems should be reduced.

More emissions research and data needed

Although some information has been published, hard data dealing specifically with air emissions from codisposal facilities is lacking. The limited U.S. experience has contributed to this situation. Preparing a definitive, all-encompassing study of codisposal air emissions would be difficult due to differences in a locality's (1) sludge and garbage composition, (2) climatic and physical characteristics, and (3) codisposal and emissions control technologies employed. Nevertheless, we believe EPA needs to develop and disseminate specific data to permit a more complete assessment of codisposal's affect on air quality and health. In the absence of specific codisposal data, predictions on the air quality impact of codisposal plants are generally based on projections and estimates from separate sludge and garbage emissions information.

EPA officials and representatives of various environmental groups confirmed the absence of hard data on codisposal emissions. EPA region II officials told us that the lack of such data was one factor which complicated the environmental reviews of the Glen Cove project. The project consultant also found the data available to be quite limited. The EPA region II units which participated in the review and the project consultant developed much of the data. This information may be useful to others and could facilitate future air quality reviews of codisposal projects. Regional officials agreed that the data developed should be disseminated to EPA headquarters and other cognizant offices.

Air quality controls affecting codisposal

Codisposal facilities are subject to various air pollution standards and requirements set forth in the Clean Air Act, as amended in 1977. Some of these standards regulate particular sources, which may include codisposal plants. Others affect codisposal facilities through efforts to control ambient air quality in a particular area. Codisposal facilities in various parts of the country can be affected differently by these controls depending on such factors as the local air quality situation and the nature of State requirements. Individual States may impose stricter standards than those required by the Federal Government.

EPA is required to designate air pollutants which adversely affect public health and welfare. EPA must also issue criteria--known as National Ambient Air Quality Standards--for controlling these pollutants. To date, EPA has identified several criteria pollutants, including carbon monoxide, particulates, hydrocarbons, and sulfur dioxide. Ambient air quality regulation is intended to achieve and maintain the standards within the nation's 247 air quality control regions. To assure this is accomplished, States must submit implementation plans to EPA.

Air quality control regions which are attaining the standards are not to be polluted up to or above the allowable levels. Potential pollution sources, including codisposal facilities, which meet certain criteria under the act 1/ must generally be reviewed to prevent significant air quality deterioriation and receive a permit from EPA before construction.

In regions not meeting the standards, codisposal facilities would be subject to a new source review. State plans must include provisions for the review and for issuing preconstruction permits for all proposed facilities or major modifications to existing facilities. Permits may not be issued unless certain conditions are met. The applicant must, for example, demonstrate that the major new pollutants from the proposed source will be offset by emissions reductions from other sources in the air quality control region. EPA, however, issued regulations on January 16, 1979, exempting resource recovery facilities (including codisposal plants) from the emissions offset requirement if they use the best available control technology and if an effort is made to identify offsetting emissions reductions from existing sources.

Codisposal facilities are also subject to New Source Performance Standards, which are intended to ensure that certain emissions limitations, principally those relating to particulates, are not exceeded. Specific standards exist for sludge and garbage incinerators. Applying the standards to a codisposal plant is dictated by the total amount of waste burned and its percentage composition of sludge and garbage. There are no EPA preconstruction requirements under these standards, but we were told that EPA must be notified of construction and a post construction review may be performed.

Further, since codisposal involves sludge burning or drying, the facilities are subject to National Emission Standards for Hazardous Air Pollutants. Compliance with mercury emission standards is of primary concern, although EPA has identified other hazardous pollutants, such as beryllium.

1/An example of such criteria is that the source be one of 28 named source categories with potential emissions of 100 tons per year of any pollutant regulated under the act, or any other source with potential emissions of 250 tons a year of any such pollutant.

Federally funded codisposal projects are subject to an additional review process under the 1969 National Environmental Policy Act. Applicants for funds are required to prepare an environmental assessment which must include an analysis of how the proposed project will affect the environment, including air quality.

RESIDUE DISPOSAL: ANOTHER ENVIRONMENTAL CONCERN

Combustion processes substantially reduce the volume of waste which must ultimately be disposed. Sludge incineration, for example, results in a residue which is from 10 to 30 percent of the original volume. Even greater volume reduction is possible with garbage incineration. Volume reduction is advantageous since it lessens the burden on land disposal, the primary disposal method. Incinerator ash and materials collected in pollution control equipment, however, must also be disposed of. Often these substances are landfilled and leachate problems may result.

Specific data on the environmental effects of landfilling residues is limited. EPA officials told us that, while more research is needed in this area, landfilling the residues from codisposal facilities should be no more environmentally harmful than landfilling the residues from separate sludge and garbage incineration. Also, land disposal of incineration residues is preferred to landfilling raw garbage and sludge because (1) much less material by volume and weight is placed on the land and (2) the ash is probably less threatening in that certain substances, such as organics and pathogens, will have been destroyed during incineration. Land disposal of the residues is subject to regulations and criteria issued under RCRA, which are designed to ensure that disposal takes place in safe, sanitary landfills.

CONCLUSIONS

Thermal codisposal, like other waste disposal options, involves some environmental risk. Potential air emissions problems and, to a lesser extent, possible leachate contamination resulting from the landfilling of codisposal residual materials are the primary environmental concerns. Unfortunately, however, only limited specific data regarding these concerns exists. Additional hard data based on actual experience is needed to permit a more effective and complete assessment of codisposal's potential impact on the environment and health.

Numerous site-specific variables strongly influence how codisposal affects the environment. Our review, however, indicated that generally (1) environmental problems associated with codisposal should be no more serious than those resulting from separate sludge and garbage disposal, (2) the problems are controllable, (3) separating certain garbage items and pretreating industrial wastewater may reduce codisposal's environmental impacts, and (4) thermal codisposal can be environmentally superior to certain waste disposal options, particularly landfilling of raw sludge and garbage. We believe that existing standards, such as the various air emissions standards, if effectively implemented, should help assure that thermal codisposal does not harm the environment.

RECOMMENDATION

We recommend that the Administrator, EPA, undertake research designed to identify and analyze thermal codisposal's impact on health and the environment. Results of the research should be disseminated to Agency regional offices and to cognizant State and local officials.

CHAPTER 4

CODISPOSAL IS AN ECONOMICALLY VIABLE DISPOSAL METHOD

Technological viability and environmental safety are important prerequisites in choosing a waste disposal alternative. Economics is a third important consideration. Answers to economic questions often determine which of several options is selected. Although actual operating cost data is lacking at this time, codisposal seems an economically viable alternative. In some cases it may actually be less expensive than separate sludge and garbage disposal.

Codisposal does require a major capital investment, often well above the investment needed to implement other disposal options, such as landfilling. Available construction money, particularly Federal funding, will, therefore, strongly influence whether codisposal is implemented in a particular area. There has been some confusion as to how EPA's construction grants program, the primary Federal funding mechanism, applies to codisposal projects. On close examination, under current policies a community can receive more Federal funding for a sludge-only disposal approach than for a codisposal approach. Although changes are being made, these situations have tended to limit consideration and implementation of codisposal.

CODISPOSAL STUDIES SHOW IT AS AN ECONOMICALLY VIABLE ALTERNATIVE

Many studies, notably the 1976 report by Roy F. Weston, Inc., show that codisposal can be cost effective and less expensive than the combined costs of certain separate garbage and sludge disposal alternatives. Generally, the cost information available represents estimates and projections.

Some actual cost data on selected European plants has been published. Similar data on American codisposal facilities, however, is not available primarily due to the limited U.S. experience. Actual cost information would be useful in establishing a needed data base and in evaluating various disposal options. Cost information from a particular facility, however, would have to be used carefully since it would reflect various site-specific factors. Further, cost accounting systems vary, making it necessary to ensure that the data represents the facility's true cost.

The Weston Study

The Weston study is one of the most comprehensive reports on codisposal costs currently available. The report compares the projected total costs of separate garbage and sludge incineration with four codisposal alternatives, including co-incineration in garbage and sludge incinerators and copyrolysis.

The analysis developed detailed data in three primary cost categories--construction costs, total facility capital costs, and operating costs. A daily disposal requirement of 499 tons of garbage and 187 tons of sewage sludge (roughly a 2.67:1 ratio) was assumed. For purposes of the analysis, however, the equipment, on a design basis, had a higher capacity than the daily requirement (e.g., 600 tons per day for the garbage incinerator). The results of the analysis, based on mid-1975 dollars, is shown in appendix I.

The overall findings of the analysis include:

--Co-incineration is the preferred option in all three cost categories.

--While the capital cost savings attributable to co-incineration will vary as plant size changes, the percent differences should remain fairly constant.

--Co-incineration's lower operating costs are attributable mainly to savings in manpower and auxiliary fuel costs.

--All codisposal alternatives showed savings over separate incineration in total annual costs measured in total dollars or dollars per ton, the real economic indicators.

--Codisposal cost savings should be greater in 1985 since separate incineration is more susceptible to inflationary increases.

--Although the four codisposal techniques are less expensive than separate incineration, the improved economies will not bring the costs down to the level of land or ocean disposal.

Other sources also support codisposal's economic viability

The cost analysis done for the Glen Cove project included a comparison of the proposed codisposal option with four other approaches, each involving various separate sludge and garbage disposal techniques. The cost analysis showed that codisposal was actually the most expensive in terms of total annual costs, requiring a much higher capital investment than the other alternatives. However, the cost analysis allowed for offsets of about $870,000 a year for codisposal, including $420,000 in electricity cost savings (estimated power needs of the wastewater treatment plant). The remaining $450,000 represents anticipated revenues from ferrous metal recovery and "tipping fees" charged those bringing garbage to the facility. With these offsets the total annual costs of codisposal would be substantially less than those of the other alternatives evaluated.

The November 1974 Duluth project engineering study compared the costs of the codisposal system eventually implemented (co-incineration of RDF and sludge in a fluidized bed furnace) with four other codisposal approaches. Three of these involved pyrolysis; the fourth used co-incineration in a garbage-fired steam boiler. The costs of all the codisposal options were also compared with those of the original system. This sludge-only disposal system, which called for conventional sludge incineration in multiple hearth furnaces using fossil fuels, was to have been the system used at Duluth. After the oil embargo, however, it became apparent that fuels would not be available for the incinerator. As a result, the 1974 engineering study was undertaken to develop alternative waste disposal options.

The results of the cost comparison shown on the following page indicate that candidate system no. 3 was the approach eventually selected. According to the analysis, this codisposal approach was less expensive than the originally planned sludge-only disposal system.

Other studies have also found codisposal to be an economically attractive option. As a result of the sludge ocean dumping ban, several New York and New Jersey localities were forced to seek other sludge disposal alternatives. EPA funded studies in the various counties to facilitate this task. The Middlesex County, New Jersey, study, for example, compared codisposal with several other sludge disposal options and found it to be the least expensive in terms of cost per ton. The study also showed that codisposal offered annual energy savings equivalent to 13.8 million gallons of fuel oil. Despite these advantages, however, the consultants

Duluth Project Cost Comparison

	Original system	Candidate systems No.1	No.2	No.3	No.4	No.5
	- - - - - - - - - - -	(000 omitted)	- - - - - - - - - - -			
Total capital costs	$12,282	$20,166	$20,199	$17,433	$18,032	$30,528
Annual costs						
Amortization at 6-1/2 percent for 15 years	$ 1,307	$ 2,146	$ 2,149	$ 1,855	$ 1,919	$ 3,248
Total annual operaing maintenance costs	1,990	1,798	2,183	1,419	1,394	2,338
Gross annual costs	$ 3,297	$ 3,944	$ 4,332	$ 3,274	$ 3,313	$ 5,586
Less: Annual Credits						
Refuse tipping fees at $2.57 per ton	$ -	$ 469	$ 469	$ 469	$ 469	$ 469
Sale of ferrous metals at $10 per ton	-	-	69	69	69	-
Total annual credits	$ -	$ 469	$ 538	$ 538	$ 538	$ 469
Net annual cost	$ 3,297	$ 3,475	$ 3,794	$ 2,736	$ 2,775	$ 5,117

did not recommend codisposal. Several potential implementation problems, including institutional difficulties, apparently led to this decision. The consultants did, however, suggest that the recommended approach (multiple hearth starved air combustion of sludge) be designed to permit modifications for possible use of RDF.

Substantial differences can exist in cost effectiveness among various codisposal systems, even if they are similar in approach. The December 1977 Gordian Associates study projected the costs and benefits of building and operating an RDF production facility and using the RDF either as supplementary fuel in retrofitted multiple hearth incinerators or in fluidized bed sludge incinerators. The study compared the costs under three different financing arrangements, two of which involved Federal funding under FWPCA. The fluidized bed incineration system, which showed overall net savings under all funding arrangements, proved to be substantially more cost effective than the multiple hearth approach.

The analysis showed the production and use of RDF in sludge incinerators to be economically viable under certain conditions due primarily to energy and fuel credits. In addition, Gordian Associates concluded that numerous factors would help make this approach more cost effective. These include (1) obtaining RDF from an existing source, if possible and (2) securing Federal funds for the incinerator retrofit and construction of the RDF facility, particularly if the first condition cannot be met. Federal funding of codisposal facilities is discussed below.

A CLEAR, LESS RESTRICTIVE FEDERAL FUNDING POLICY IS NEEDED

The availability of Federal construction funds is a key factor affecting codisposal implementation. Billions of Federal dollars have been made available to construct wastewater treatment plants, including sludge disposal systems, under EPA's construction grants program; however, no similar Federal mechanism for financing the construction of garbage disposal facilities exists. Therefore, the Federal funding issue has centered largely on whether or not some FWPCA money can be used to fund all or part of a codisposal facility's garbage component.

Those opposed to using FWPCA money can argue that already scarce funds should not be further limited by funding activities not of primary concern under the act. However, compelling arguments in favor of using FWPCA money also exist. For example, section 201(e) of the act specifically directs the EPA Administrator to encourage waste treatment management which integrates sewage treatment with other waste disposal facilities, including those for municipal waste. Further, section 212(2)(B) supplements the definition of grant eligible treatment works to include any other method or system for disposing of municipal waste without specific reference to liquid wastes. RCRA also seems to encourage integrated waste management approaches. The act's definition of solid waste, for example, includes both sludge and garbage.

Although changes are being made as the 1977 Clean Water Act is implemented, we believe that EPA's construction grants funding policy has favored sludge-only disposal options over codisposal approaches. During our review EPA formed a working group to examine construction grants funding regulations which Agency officials thought may discriminate against codisposal.

EPA's funding policy confusing and restrictive

There has been some confusion as to exactly how EPA's construction grants funding policy applies to codisposal projects. Although the regulations and guidelines are relatively complex, much of the confusion seems to stem from the fact that EPA has funded codisposal projects differently throughout the country. Before December 1976 EPA had no formal written policy on the subject and, according to regional officials, headquarters guidance was limited.

In May 1976, EPA region V (Chicago) approved the construction grant for the Duluth, Minnesota, codisposal project. The amount approved was $17,294,550, or 75 percent of the total project cost, including the garbage component (a facility to process garbage and produce RDF) valued at about $5.3 million. We were told that the rationale for funding the garbage component was that it constituted an integral part of the project providing the necessary auxiliary fuel for sludge incineration.

During this period EPA region II received several inquiries as to how codisposal projects would be funded. Region II officials considered three primary funding options:

--Fund 75 percent of the entire project, viewing garbage as the fuel source.

--Provide the same amount of funding EPA would to fund the least costly single-purpose sludge incinerator.

--Prorate costs and fund only those specifically pertaining to sludge.

The region requested funding guidance from headquarters in June 1976. The request letter noted that the last option (which would probably result in the lowest amount of Federal funding) appeared to be inequitable since it would unfairly limit EPA participation in joint incineration processes. Despite this, headquarters directed the regional officials, who favored a more liberal approach, to use the prorated formula.

The Glen Cove, New York, project is being funded with the prorated formula. EPA calculated that 53.3 percent of total costs pertained specifically to sludge and was, therefore, fundable. EPA will fund 75 percent of this figure, or only about 40 percent of total project costs. The city would have received substantially more money if EPA had used the second option; that is, allow the same amount of funding for codisposal as would have been approved for constructing the least costly sludge incinerator. In our opinion this would have been a more equitable approach. Glen Cove stayed with the codisposal approach despite the relatively low level of Federal participation, primarily because the city was faced with major sludge and garbage disposal problems.

The prorated funding formula was eventually established as the EPA funding policy and was published in December 1976 in Construction Grants Program Requirements Memorandum No. PRM 77-4. Some confusion persists, however, in light of the different funding approaches used in Duluth and Glen Cove. A New York State official was still not exactly sure how EPA funds codisposal projects although he had requested and received funding data from a Duluth project official. The Duluth official told us that he received numerous inquiries as to why the project received 75 percent funding, which led him to believe that there was still some uncertainty about codisposal funding among State and local officials. Our discussions with other officials and the work done by Gordian Associates also showed this to be the case.

The prorated funding formula has, to some extent, acted as a disincentive to codisposal implementation. If implementing a sludge-only disposal option as opposed to codisposal results in a greater level of Federal construction funding, the former would probably be selected more often. The short term benefits of a greater Federal investment (and thus a lower immediate local funding requirement) can outweigh the fact that codisposal may be the most cost-effective long term approach.

Although determining the effect of prorating is difficult, it has, in some cases, influenced decisions not to implement codisposal. For example, as mentioned earlier, the Middlesex County, New Jersey, study found codisposal to be the least expensive option in terms of costs per ton. It appears, however, that codisposal will not be implemented. The lower level of Federal construction funding for codisposal, compared with that available for the sludge-only approach, was one factor in the decision.

In another instance, the Boston metropolitan area found codisposal to be a technologically and environmentally feasible integrated waste management system. Codisposal, however, was not implemented mainly because of the probability that less Federal construction grant funding would be available. The feasibility study for the area noted that EPA could encourage wider acceptance of codisposal if it made funds available for the construction of garbage facilities as it does for the construction of water pollution control projects.

Codisposal may receive more favorable treatment

The 1977 amendments to FWPCA encourage implementing innovative and alternative wastewater treatment processes and techniques, including codisposal. To induce implementation, the act provides for construction grants of 85 percent instead of the usual 75 percent and a 15 percent cost preference for those projects or portions of projects which use innovative or alternative technologies. At the time of our review, EPA had not fully resolved how codisposal projects would be funded under this provision. As discussed below, however, codisposal projects, or certain of their components, will probably receive more liberal funding.

According to EPA, the 1977 act and its legislative history make it clear that the provisions relating to innovative and alternative technologies are intended to encourage greater use of systems which reclaim and reuse water, productively recycle wastewater constituents, or otherwise eliminate pollutant discharges or conserve energy. Alternative technologies are those which have been proven and used in actual practice. Innovative technologies are developed methods which have not been fully proven for their contemplated use. EPA regulations define codisposal as an alternative technology for recovering energy. Codisposal is, however, only one of many different innovative or alternative processes and techniques identified in the regulations.

Under a proposed EPA funding policy, the grant eligible portion of a codisposal project which employs innovative or alternative technology, would be 115 percent of the ratio of the most cost-effective sludge option's present cost and the codisposal project's present cost. In some cases applying the formula may result in a grant eligible amount for codisposal which is less than the sludge-only option's capital cost. If this occurs, a minimum eligibility figure (115 percent of the least costly sludge disposal option's capital costs) would be used. Using this approach, the grant eligible amount for a codisposal project would be significantly higher than under the current prorated formula.

A draft EPA policy memorandum contains an example of how the grant eligible amount would be computed under the proposed formula. In the example, a municipality which landfills its sludge is being required to incinerate it. The single-purpose alternative is a standard sludge incinerator using coal as a supplementary fuel. The municipality, however, proposes a co-incineration project in which RDF would replace the coal, and waste heat would be used to generate steam for sale. The costs involved are as follows:

Capital cost of single-purpose incinerator for sludge	$35 million
Present cost of operation and maintenance cost for incinerator	20 million
Capital cost of co-incineration project	50 million
Present cost of operation and maintenance cost for co-incineration	45 million

In this example, about 67 percent of the codisposal's capital cost would be grant eligible. 1/ Therefore, the eligible amount is about $33.5 million (0.67 x $50 million). However, since this is less than 115 percent of the sludge-only capital cost, the actual grant eligible amount would be $40.25 million.

If a codisposal project, or one of its specific components, qualifies as innovative or alternative, it could be funded at 85 percent of the grant eligible amount. There is, however, some question as to whether funds will always be available to finance this increase in grant rates (from 75 to 85 percent). FWPCA requires States to set aside 2 percent of their construction grant allotments for fiscal years 1979 and 1980 and 3 percent during 1981 to fund the increase in grant rates. EPA has concluded that these figures represent the maximum which should be set aside. Enough money may not be available in some places to fund a codisposal project at 85 percent. Even if the projects are only funded at 75 percent, the proposed grant eligibility formula, if implemented, will allow for more equitable Federal funding of codisposal.

1/The 67-percent figure is computed as follows: $115\ [(35 + 20) \div (50 + 45)]$.

Other potential funding sources

Although this chapter has focused on EPA's construction grants program, codisposal projects could receive some construction funding (primarily as demonstration facilities) under other Federal statutes and programs. The Department of Energy Act of 1978: Civilian Applications (Public Law 95-238), for example, authorizes loan guarantees, grants, and other financial support to foster the construction of facilities which demonstrate the conversion of urban wastes and other materials into alternative fuels. The loan guarantee program, which authorizes $300 million, however, has not been funded. Section 8006(a) of RCRA authorizes the Administrator, EPA, to make grants for the demonstration of resource recovery systems or for the construction of new or improved solid waste disposal facilities. To date, only limited funding has been made available under this section.

CONCLUSIONS

Economics is a key consideration in evaluating and selecting waste disposal options. Unfortunately, actual hard cost data based on codisposal operating experience, which could be used in decisionmaking, is rather limited. The absence of hard data and potentially significant site-specific variations make it difficult to draw overall firm conclusions regarding the cost effectiveness of codisposal. Our review of numerous studies and cost projections, however, showed that thermal codisposal is economically viable and can actually be less expensive in terms of total costs per ton than certain forms of separate garbage and sludge disposal. Generally, this situation is attributable to significantly lower operating, maintenance, and energy costs for codisposal than for the separate techniques.

Thermal codisposal is, however, capital intensive. As a result, the availability of Federal construction funding can be a determining factor in whether codisposal will be considered seriously. A confusing and unfavorable funding policy under EPA's construction grants program, the primary Federal funding mechanism, has to some extent limited consideration and implementation of codisposal. Important changes, however, are being made. EPA is considering revisions to its funding policy which, if implemented, would provide for more favorable Federal financing of codisposal facilities construction.

RECOMMENDATIONS

We recommend that the Administrator, EPA, encourage and facilitate consideration of codisposal as an alternative waste disposal process by:

--Requiring that planned Agency evaluations of codisposal projects provide for developing and disseminating actual operating cost data which cognizant officials can use in evaluating disposal options.

--Establishing a construction grants funding policy which, to the extent allowed under existing legislative authority, would provide at least the same level of funding for deserving codisposal projects as for single-purpose sludge-only disposal options.

CHAPTER 5

INSTITUTIONAL BARRIERS CONSTRAIN CONSIDERATION AND IMPLEMENTATION OF CODISPOSAL

Certain technological, environmental, and economic problems, whether real or perceived, have tended to limit codisposal implementation in the United States. However, institutional problems, often jurisdictional and organizational in nature, have been an even more serious constraint. The absence of an integrated waste management approach appears to be both a major cause and effect of these institutional problems which exist at the local level and to some extent within EPA. If integrated waste disposal/ resource recovery approaches, including codisposal, are to receive more widespread and serious consideration, these barriers must be overcome. Although this will not be easy, there are some steps which can be taken.

THE NATURE OF INSTITUTIONAL BARRIERS

Institutional barriers encompass various issues and problems. With respect to codisposal, the most pertinent and serious of these relate to the structure of and interrelationships among (or lack of inter-relationships) the organizations responsible for sludge and garbage disposal.

In many areas of the country, sludge and garbage disposal are carried out separately by different governmental departments or different political jurisdictions. Although the situation varies, sludge disposal is typically the responsibility of fairly large public sewer authorities or commissions. Often these units are established regionally following political or hydrological basin boundaries. Garbage disposal, on the other hand, is generally the responsibility of smaller jurisdictions, which often follow different political boundaries.

Cooperation and coordination between these entities is essential for developing and implementing codisposal approaches. Frequently, however, these organizations do not coordinate disposal efforts, making it difficult for codisposal to be seriously considered. A number of factors contribute to this situation, including bureaucratic "turf" problems and legal and/or administrative requirements which mandate that sludge and garbage disposal be carried out separately. Many codisposal studies which we reviewed discussed this problem. Officials and experts we interviewed also identified lack of coordination as the most serious barrier to codisposal.

Unfavorable institutional arrangements and related organizational problems can block codisposal implementation even if it is considered a viable alternative. This was the case in the Boston area, for example, where the Metropolitan District Commission controls sludge disposal and the Department of Public Works handles garbage disposal. The institutional difficulties between the two organizations contributed to the decision not to implement codisposal. Conversely, conducive institutional arrangements greatly enhance the possibility of codisposal implementation. The planned codisposal projects mentioned earlier (see p. 18) are generally being carried out by organizations which are responsible for both sludge and garbage disposal. Further, we were told that more favorable institutional arrangements (i.e., coordinated authority and responsibility for garbage and sludge disposal as well as energy production) have facilitated codisposal implementation in Europe.

The split responsibilities for solid waste disposal do not only exist at the local level. Sludge and garbage programs are also often carried out by different organizations at the State and Federal levels. The Federal Government, including EPA, has tended to organize along separate lines instead of adopting an integrated waste management/disposal approach. Regional EPA officials told us that in some cases regional organization and the level of coordination between the different regional program offices were not conducive to establishing a unified, multimedia approach to solid waste disposal. Here too, as with other matters affecting codisposal, things are changing. With RCRA's enactment, for example, EPA's Office of Solid Waste, which was already responsible for carrying out garbage disposal/resource recovery programs, assumed a major role in sludge disposal activities.

Certain situations in the private sector can also constrain codisposal. In many parts of the country, private firms collect and dispose of garbage. The Weston study concluded that politically and economically powerful waste collection industries will exert pressure to stop or slow codisposal implementation if it appears that codisposal will significantly affect their operations. Such an industry, for example, would understandably oppose a requirement that garbage be hauled to a more distant codisposal facility without a commensurate increase in hauling rates. A main objection that garbage contractors in the Duluth area raised to the codisposal project was the increase in time and cost associated with hauling garbage to the new facility.

MECHANISMS FOR ENCOURAGING CONSIDERATION OF CODISPOSAL

EPA can act to foster increased consideration of integrated solid waste disposal approaches such as codisposal. Essentially, these actions involve (1) emphasizing and providing greater visibility for such approaches in certain planning processes and (2) disseminating additional information on such points as the proposed changes to the funding policy.

Section 208 of FWPCA established an areawide planning program for geographic areas with substantial water quality control problems. The planning process, which is funded by EPA, must address several matters, such as residuals waste management, including solid wastes. This process could trigger relatively early consideration of integrated solid waste management approaches. Officials of a consulting engineering firm agreed that codisposal should be considered during section 208 planning. They believe this is necessary, because the potentially complex institutional problems associated with codisposal should be examined as early as possible.

This may not be occurring, however, since the residuals waste management element of the planning process is apparently not receiving specific attention. EPA recently surveyed 43 areawide plans which covered the residuals management issue. The survey concluded that the area was handled in a very broad fashion and the implementation of specifics (e.g. selection of a sludge management alternative) was generally not dealt with. Our recent report 1/ also pointed out that residuals management often received only limited coverage in the section 208 planning process.

EPA also provides funds under section 201 of FWPCA for more specific wastewater facilities planning. These plans, which represent the first step in the construction grants process, must include an assessment of various sludge disposal options. EPA's recently issued regulations require that the cost effectiveness element of this assessment

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1/"Water Quality Management Planning Is Not Comprehensive And May Not Be Effective For Many Years," CED-78-167, Dec. 11, 1978.

include an analysis of innovative and alternative technologies. Although codisposal could be included in such an analysis by implication or reference, there seems to be no assurance that its potential applicability would in fact be examined by grantees and their consultants. We believe that the section 201 planning studies should assess the possibility of codisposal implementation.

EPA's recently implemented urban resource recovery grants program provides another mechanism for focusing attention on codisposal at the project level. The President's Urban Policy, issued on March 27, 1978, directed EPA to carry out a program of financial assistance to urban areas for solid waste resource recovery project planning and feasibility analysis. The program, which is authorized under RCRA, will provide grants up to $400,000 per project for comprehensive planning. Codisposal planning and development efforts are among the activities eligible for funding under the fiscal year 1979 program appropriation of $15 million. EPA has decided to fund project planning activities in 68 communities including 4 which are seriously considering codisposal approaches.

Opportunities for increasing consideration of codisposal also exist under the State solid waste management planning system mandated by section 4002(b) of RCRA. EPA's proposed guidelines clearly require coordination between this planning process and other planning efforts, such as those under sections 201 and 208 of FWPCA. However, there is no specific reference to codisposal in the guidelines.

EPA has disseminated information which might contribute to increased consideration of codisposal. Dissemination efforts include issuing major, technically oriented reports like the Weston study and publishing relatively brief articles in various journals and periodicals. Also, codisposal receives some coverage in EPA waste disposal and resource recovery seminars.

The information disseminated to date, however, does not reflect the changes in the construction grants program brought about by the 1977 FWPCA amendments. As discussed earlier, the proposed revisions to the construction grants funding policy should make codisposal more economically attractive. EPA could, therefore, encourage more widespread and serious consideration of codisposal by disseminating additional information about the new policy.

CONCLUSIONS

Institutional problems have been a serious constraint to the consideration and implementation of codisposal. Institutional barriers are complex and encompass various problems which restrict the development and adoption of integrated and coordinated garbage and sludge disposal approaches. The most serious problem is nonconducive organizational arrangements. In many areas of the Nation, sludge and garbage disposal are handled by different governmental or political entities. Coordination between these organizations, which is essential to serious consideration of codisposal, is frequently lacking. To expect immediate changes in these established patterns would be unrealistic, even though RCRA and FWPCA encourage a more unified approach. However, there are some steps which EPA can take to foster greater consideration of codisposal.

Our primary concern has been with ensuring that codisposal, which can offer certain advantages, such as significant cost savings, at least be considered during the waste disposal decisionmaking process. Decisions to implement a particular option, can only be made by the responsible local officials after careful consideration of all the appropriate alternatives.

RECOMMENDATION

We recommend that the Administrator, EPA, encourage and facilitiate consideration of codisposal as an alternative waste disposal process by:

--Requiring that States and local communities consider codisposal technology as a possible alternative during the FWPCA areawide and facilities planning processes and as part of the RCRA planning activities.

CO-INCINERATION COST ANALYSIS

(Basis:* Refuse 499 tpd; Sludge 187 tpd dry or wet)

Item	Separate Incineration: Refuse Incinerator	Separate Incineration: M.H. Sludge Incinerator	Total	Co-incineration: Rotary Drier	Co-incineration: Indirect Drier	Co-incineration: Multiple Hearth	Pyrolysis
Total Facility Cost	$19,100,000	$6,042,000	$25,142,000	$23,066,000	$24,204,000	$23,535,000	$24,160,000
Annual Capital Cost	1,803,000	570,000	2,373,000	2,177,000	2,285,000	2,221,000	2,280,000
Annualized Capital Cost Per Ton+	12.01	10.18	11.52	10.57	11.09	10.78	11.07
Percentage Savings, based on Separate Incineration Total				8.2%	3.7%	6.4%	3.9%
Operating Cost	1,564,900	1,102,700	2,667,600	1,935,100	1,971,300	2,591,100	2,253,600 (1,222,600)**
Operating Cost Per Ton+	10.43	19.68	12.95	9.39	9.57	12.58	10.92 (5.93)
Percentage Savings, based on Separate Incineration Total				27.4%	26.1%	2.9%	15.5% (54.2%)
Total Annual Cost	3,368,000	1,673,000	5,041,000	4,112,000	4,256,000	4,812,000	4,534,000 (3,503,000)
Total Annual Cost Per Ton+	22.45	29.86	24.47	19.96	20.66	23.36	21.99 (17.00)
Percentage Savings, based on Separate Incineration Total				18.4%	15.6%	4.5%	10.0% (30.0%)
Total Annual Cost Per Ton+ (Based on Solids)	31.18	149.37	42.29	34.50	35.70	40.37	38.04

* Throughput Basis.
** Parenthesis denote credit for steam sale.
\+ Divide by 0.907 for cost per metric ton.

Source: Weston, Inc.

APPENDIX I

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