BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Conversion Of Urban Waste To Energy: Developing And Introducing Alternate Fuels From Municipal Solid Waste

Urban waste-to-energy systems can provide a valuable supplement to the Nation's energy supply and help to resolve material resource and solid waste disposal problems. They could

--produce energy equivalent to 48 million barrels of oil annually,

--recover non-renewable materials such as iron and aluminum, and

--process urban waste in an economical and environmentally acceptable manner.

However, Federal efforts to convert waste to energy are fragmented, uncoordinated, misguided, uncertain in priorities, and lacking in detailed overall strategy.

The Administrator of the Environmental Protection Agency, in consultation with the Secretaries of Energy and Commerce, should develop and submit to the Congress a detailed 10-year plan describing the specific strategy for the Federal Urban Waste-to-Energy Program.

UNITED STATES GENERAL ACCOUNTING OFFICE

EMD-79-7
FEBRUARY 28, 1979

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

B-193381

CWO 00061

To the President of the Senate and the
Speaker of the House of Representatives

This report discusses what may be the least recognized alternative source of energy--municipal solid waste, the garbage generated daily in our cities. It is a promising, virtually inexhaustible domestic energy resource. The technologies which would facilitate its broad, near-term commercial use are available. We recommend that executive agencies develop an interagency plan aimed at encouraging greater use of commercially proven waste-to-energy systems.

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

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

CONVERSION OF URBAN WASTE TO ENERGY: DEVELOPING AND INTRODUCING ALTERNATE FUELS FROM MUNICIPAL SOLID WASTE

D I G E S T

One of the least recognized alternative sources of energy, municipal solid waste--daily garbage in the cities--is a promising, virtually inexhaustible domestic energy source.

Technologies to convert this waste to energy are available, and the recovery of energy through the combustion of municipal solid waste is a well-established technique for conserving energy in Western Europe.

However, such systems have not been used widely in the United States. In the past, abundant land, energy, and material resources made them uneconomic. Now the economics are changing. Conventional energy sources are in short supply and escalating in price. Traditional disposal methods are being restricted and becoming more costly. The Nation is beginning to respond to the new situation and opportunities.

Oil and gas are finite commodities and will run out some day. National attention is being directed to truly responsible concerns about how to achieve an orderly transition to an economy based upon alternative sources of energy. Today's policies must buy time and provide the conventional energy supplies needed while other energy sources are developed and put in operation to supplement or replace them. Traditionally, municipal solid waste has been disposed of by incineration, landfill, or ocean dumping. Environmental restrictions and landfill siting difficulties are making these options less viable. Public and private entities are evaluating the benefits of alternative waste disposal methods.

FINDINGS AND CONCLUSIONS

Urban waste is abundant and growing in volume. The Environmental Protection Agency estimates 201 million tons of municipal solid waste will be generated annually by 1985, with 112 million tons being technically feasible for conversion to energy sources. (See p. 3-2.)

Urban waste-to-energy systems can provide a valuable supplement to the Nation's energy supply and help to resolve material resource and solid waste disposal problems. They could:

--Produce energy from a new and available source equivalent to 48 million barrels of oil annually by 1985, and some 158 million barrels by 1995. (See p. 3-22.)

--Recover non-renewable materials such as iron and aluminum, while conserving much of the energy used to process virgin materials. (See p. 3-4.)

--Process urban waste in an economical and environmentally acceptable way. (See p. 3-11.)

GAO identified 131 municipal solid waste energy projects in the United States, 20 operational, 10 under construction, 30 in the planning phase, and 71 in preliminary study stages. State and local governments, working with private industry, provide the prime impetus. If these 131 projects were to become operational by 1985, they could process about 36 million tons--18 percent of urban waste produced--and the Nation could realize energy savings equivalent to over 100,000 barrels of oil daily. (See p. 3-3.)

However, if technologically and economically viable waste-to-energy systems are to be used on an accelerated schedule in the near- and mid-term, a more active role by the Federal Government is required. (See p. 6-2.)

The Federal role in the development and commercialization of waste-to-energy conversion systems is authorized by law. Responsibility for administration rests with the

Environmental Protection Agency and the Departments of Energy and Commerce. (See pp. 6-2 and IV-1.)

GAO reviewed program elements at each agency and found a Federal Urban Waste-to-Energy Program which appears fragmented, uncoordinated, inadequately funded, uncertain in its priorities, and lacking in detailed overall strategy. More specifically GAO found that:

--The Department of Energy and the Environmental Protection Agency plan their activities largely independent of each other in spite of their similar and overlapping authorities and a May 7, 1976, interagency agreement to coordinate their planning and facilitate information exchange. (See p. 5-7.)

--Commerce Department efforts to stimulate broader commercialization of proven resource recovery technologies, to develop specifications, and to identify markets for recovered materials have been stalled by lack of funds. (See p. 4-13.)

--The Environmental Protection Agency has given regulation of hazardous wastes its top priority in the field of solid waste management and has not committed the human and financial resources required to carry out the overall resource recovery provisions of its mandate. (See pp. 4-6 and 5-4.)

--Environmental Protection Agency and Commerce budget requests for meeting their responsibilities under the Resource Conservation and Recovery Act of 1976 have frequently been cut and in some cases disallowed by the Office of Management and Budget. (See pp. 4-14 and 5-4.)

--The Department of Energy funds its Urban Waste Technology Program at a level inconsistent with the high priority assigned this technology in its National Plan for Energy Research Development and Demonstration, and it lacks a specific strategy for the development and implementation of municipal solid waste conversion processes. (See p. 5-6.)

--Loan guarantee programs authorized by the Energy Conservation and Production Act of 1976 and the Department of Energy Act of 1978 have not been funded. At present, there are no Federal economic incentives designed specifically to encourage the use of municipal solid waste energy systems on a broad scale. (See pp. 4-9 and 4-10.)

RECOMMENDATIONS TO AGENCIES

To ensure that greater use of commercially proven municipal solid waste energy systems is encouraged and that developing urban waste-to-energy technologies are commercialized in a timely manner, GAO recommends that the Administrator of the Environmental Protection Agency, in consultation with the Secretaries of Energy and Commerce and in coordination with other Federal agencies, State and local governments, private industry, and public interest groups, develop and submit to the Congress by September 30, 1979, a detailed 10-year plan describing the specific strategy for the Federal Urban Waste-to-Energy Program. This plan should be updated and submitted annually. The interagency plan should:

--Specify goals and objectives with appropriate emphasis on commercialization and research, development, and demonstration activities which must take place by 1985 if the Nation is to realize the full potential of municipal solid waste energy systems in the 1985 to 2000 time frame.

--Define the specific roles and responsibilities of the Departments of Energy and Commerce, the Environmental Protection Agency, and any other Federal agencies involved in this effort, giving full consideration to the skills and expertise dispersed through these agencies and any organizational realignments or transfers of responsibilities which will minimize overlap of functions and lead to improved effectiveness of program operations.

--Provide for expeditious completion of all relevant interagency agreements consistent with the plan.

--Establish time frames and resource requirements for accomplishing the plan's purpose, and identify alternative financing options and the specific type and timing of Federal assistance by each agency needed to facilitate completion of projects in advance planning and preliminary study stages. Especially important would be identification of the roles loan guarantees should have in support of municipal solid waste projects, and the amount of financial risk which might require Federal guarantees.

--Provide for incentives which best foster the use of municipal solid waste energy systems and their products, including technical and limited financial assistance aimed specifically at encouraging the timely completion of all 131 municipal solid waste energy projects. Particular emphasis should be given to those projects employing commercially available technologies. These projects would then serve as examples for other projects yet to be developed and minimize or eliminate the need for substantive, long-term Federal involvement.

--Provide for an improved information and education program to furnish States and local governments with a maximum flow of information and practical assistance regarding such matters as system planning, acquisition, and implementation; Federal financial guarantees; sale and use of plant output; and needed compliance with relevant environmental standards.

--Include milestones for measuring progress in meeting the plan's goals and objectives.

--Include as appendixes the separate views of the Departments of Energy and Commerce. (See pp. 6-5 and 6-6.)

AGENCY COMMENTS

The Departments of Energy and Commerce agreed with the report's recommendations but believed that either Energy or Commerce, not the Environmental Protection Agency, should have the lead in developing GAO's recommended interagency plan. Specific comments from the Departments of Energy and Commerce are reprinted as appendixes V and VI. Informal comments were obtained from the Environmental Protection Agency. (See p. 6-8.)

The Congress has already given the Environmental Protection Agency responsibility for planning, developing, implementing, and coordinating Federal solid waste management programs and the recovery of resources, including energy, from wastes. GAO believes the leadership role properly belongs with that Agency. However, should the Agency not act responsibly in developing the recommended interagency plan, then a leadership change should be considered by the Congress.

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ABBREVIATIONS

Agr	Aggregate
Al	Aluminum
Btu	British thermal unit
DOE	Department of Energy
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
Fe	Ferrous metals
HEW	Department of Health, Education, and Welfare
kWh	Kilowatt-hour
MCF	Thousand cubic feet
MCU	Modular combustion unit
MMBBL	Million barrels
MMBBL/D	Million barrels per day
MMBOE	Million barrels of oil equivalent

MMBtu	Million British thermal units
MMCF/D	Million cubic feet per day
MSW	Municipal solid waste
NCRR	National Center for Resource Recovery
OMB	Office of Management and Budget
QUAD	Quadrillion British thermal units
RCRA	Resource Conservation and Recovery Act of 1976
RDF	Refuse-derived fuel
R&D	Research and development
RD&D	Research, development, and demonstration
RWI	Refractory wall incineration
TVA	Tennessee Valley Authority
TBD	To be determined
TPD	Tons per day
TPY	Tons per year
WWI	Waterwall incineration

CHAPTER 1

INTRODUCTION

For the next 25 to 50 years the United States will be shifting from a dependency on oil and natural gas to greater use of other forms of energy.

In 1976, oil and natural gas supplied almost 75 percent of the energy consumed in the United States, and 41 percent of the oil and 5 percent of the gas were imported. By 1985, as much as 60 percent of our oil and 10 percent of our natural gas may be imported. Our latest analysis of domestic oil production, coupled with our recent analysis of projected non-oil domestic shortfalls, 1/ points to 1985 oil imports in the range of 12 to 13 million barrels per day, at least double what the Administration said they would be, and 5 to 6 million barrels per day higher than 1976 imports.

Such increasing dependence would expose the Nation to international, political, and economic pressures--such as that exerted by the oil embargo--and limit our freedom in foreign and domestic policy making.

As President Carter noted in his energy message of April 20, 1977, gas and oil are only a small part of our domestic energy reserves and we cannot continue to consume them at our present rate. The potentials of new energy-producing technologies must be explored in terms of the economy, the environment, and other national priorities. This report discusses what may be one of the least recognized alternative sources of energy--municipal solid waste (MSW), the garbage generated daily in the cities of the United States. It is a promising new domestic energy resource because the technologies which would facilitate its broad, near-term commercial use are available and its use could provide both environmental and economic benefits.

1/"An Evaluation of the National Energy Plan," U.S. General Accounting Office, EMD-77-48, July 25, 1977; and follow-up letter report, EMD-78-5, Oct. 14, 1977.

Urban waste 1/ is abundant and growing in volume. The average person generates 3.5 pounds a day, and together we generate about 135 million tons a year. The Environmental Protection Agency (EPA) estimates that 175 million tons will be generated annually by 1980, 201 million by 1985, and 225 million by 1990. It is collected at central sites and much of it is combustible. Its conversion to fuel could reduce the waste bulk by as much as 95 percent and do much to eliminate environmental, social, and economic problems now associated with MSW disposal.

MSW is traditionally disposed of by incineration, landfill, or ocean dumping. The average cost of collecting and disposing of the waste is about $30 a ton, or over $4 billion a year. EPA estimates that by 1985 this cost will increase to around $50 a ton. The conversion of these wastes to energy is a viable alternative and has a sound scientific and practical basis.

--Typically about 75 percent of the waste is combustible matter (see table III, p. 3-1) which can be converted into gaseous, liquid and solid energy forms.

--It is a virtually inexhaustible resource and the volume generated is growing.

--It is in continuous supply and is concentrated in cities which require large amounts of energy.

--A ton of MSW contains about 9 million British thermal units (Btus) of heat energy and could provide as much energy as 65 gallons of fuel oil or about 9,000 cubic feet of natural gas.

--It can be fired as a supplemental or primary fuel in commercially available steam boilers.

1/For the purpose of this report, the terms "urban waste," "municipal solid waste" (MSW), "garbage," "refuse," and "trash" are used interchangeably and refer to the discarded leftovers of a consumer society, that is, food and yard wastes, paper, wood, glass, metals (ferrous and non-ferrous), leather, rubber, and plastic goods. Included are household and commercial waste, but not industrial, agricultural, construction and sewage waste.

--It is low in sulfur 1/ and can be burned so that it produces less sulfur dioxide than pulverized coal.

Waste-to-energy conversion offers many auxiliary advantages:

--Saleable materials such as ferrous metals, aluminum, and glass are recovered 2/ and by-products such as carbon, char, ash, and glassy aggregate, which can used in the manufacture of cement and paving materials or for fertilizer, are produced.

--Landfill requirements can be reduced by as much as 95 percent (if materials are recovered) at a time when suitable landfill area is scarce and this method of disposal is being restricted or prohibited. 3/

--Energy recovery can be more economical and more environmentally preferable than conventional incineration systems which have no heat recovery capabilities.

Even though cost-effective waste-to-energy conversion processes are commercially available and are used extensively in Europe where some units have been in service for over 30 years, 4/ their use is not widespread in the United States. EPA estimates that less than 1 percent of the MSW produced--about 1 million tons a year--will be converted to energy in the United States before 1979. The National Center for Resource Recovery, Inc. (NCRR), 5/ says that only about

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1/Sulfur content of MSW is 0.1 to 0.2 percent by weight compared to 1.0 to 3.0 percent for most coals and residual oils now in use.

2/Recycling itself conserves energy. In most instances it takes less energy to recycle than to process virgin materials. (See p. 3-6.)

3/Resource Conservation and Recovery Act of 1976, P.L. 94-580, Oct. 21, 1976, requires that open dumps be phased out or improved by 1983. EPA estimates that only 5 percent of all disposal sites meet generally accepted environmental standards.

4/See app. I, p. I-1.

5/News Release (NR-1977-5) from the National Center for Resource Recovery, Inc., Washington, D.C., Dec. 16, 1977, p. 1.

10 million tons annually will be used for energy by the early 1980s. This is less than 6 percent of estimated MSW production.

This report describes various conversion processes, the efforts of private and public agencies to implement them, and the benefits which they could provide in the near- and mid-term. It also discusses the institutional, economic, technological, and environmental barriers to their use and the actions needed to overcome them.

SCOPE OF REVIEW

To determine the extent and effectiveness of Federal efforts, we reviewed urban waste-to-energy programs at the Department of Energy (DOE), EPA, and the Department of Commerce; analyzed actual energy production and material recovery projects; talked with officials in 20 municipalities, personnel at 33 diversified energy research organizations, and utility company managers in 8 metropolitan areas. We examined reports from public and private researchers, equipment manufacturers, industry associations, and congressional committees, and we reviewed relevant legislation enacted or proposed by the Congress.

CHAPTER 2

URBAN WASTE-TO-ENERGY SYSTEMS--

STATUS OF DEVELOPMENT

CONVERSION PROCESSES

There are several processes which burn solid waste directly or convert it into solid, liquid, or gaseous fuels:

--Incineration with heat recovery (mass burning of raw, unprocessed waste to generate steam).

--Refuse-derived fuel (RDF) process (firing of processed waste as a primary or supplemental fuel in conventional boilers).

--Pyrolysis (thermal decomposition of waste to produce oil or gas).

--Bio-conversion (biological decomposition of waste through anaerobic digestion, and acid and enzymatic hydrolysis to produce a variety of solid, liquid, and gaseous energy forms).

--Hydrogenation (high pressure thermal and chemical decomposition of waste to produce oil).

The stages at which these processes are now developed range from bench and pilot-scale testing to full-scale commercial applications. This report designates the processes as either commercially available or developmental. We have emphasized combustion, pyrolysis, and anaerobic digestion (i.e., bio-conversion) because these have the greatest potential for implementation in the near- (present to 1985) and mid-term (1985 to 2000). Table I shows the variety of energy forms producible with these waste-to-energy systems. Table II shows their development status.

The other processes, acid and enzymatic hydrolysis and hydrogenation, 1/ now have only limited abilities to handle non-homogeneous MSW due to the complexity and sensitivity

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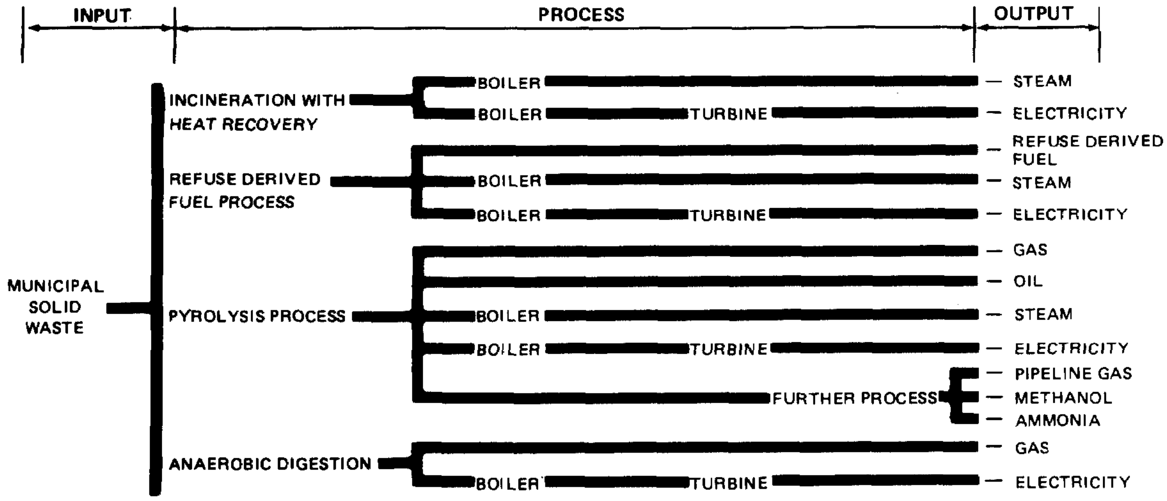
1/Much research on these technologies is centered on the conversion of agricultural and forest residues to energy forms and other useful by-products (e.g., feedstocks, fertilizers).

TABLE 1

ENERGY FORMS PRODUCIBLE WITH MSW ENERGY SYSTEMS



of the reactions involved. Also, their economics either limit them to large operations, as in the case of hydrogenation, or are still uncertain. These systems, therefore, will not be discussed further.

Table II

Energy Recovery Systems Status Summary

Process type	Output	Status
Incineration with heat recovery	Steam for district heating, cooling, or industrial use. Also steam to drive turbine for electricity generation.	Commercially available and proven. Practiced in Europe in various forms.
Refuse-derived fuel	Solid fuel for co-firing in existing facilties or as 100 percent in specially designed RDF combustors.	Commercially available. Has gained some acceptance by both private and public sector operators.
Anaerobic digestion: Methane recovery	Burnable medium-Btu gas 1/ for use in existing facilities or can be brought up to pipeline quality by scrubbing	Commercially available. Landfill gas being commercially recovered in Palos Verdes, Calif., and being demonstrated in Mountain View, Calif., with Federal EPA sponsorship.
Mechanical digester	Burnable medium Btu gas 1/ can be burned in existing facilities or brought up to pipeline quality.	Developmental (demonstration stage). 50-100-ton-per-day demonstration plant built in Pompano Beach, Fla., with Federal DOE sponsorship.
Pyrolysis: MSW to gas	Burnable low Btu gas 1/for on-site or nearby combustion/utilization.	Developmental (demonstration stage). Pilot and some full-scale prototype plants being developed privately and under Federal EPA sponsorship.
MSW to oil	Burnable oil (75 percent Btu of No. 6 fuel oil) for firing in existing facilities.	Developmental (demonstration stage). 200-ton-per-day plant constructed in San Diego County, Calif., with Federal EPA sponsorship.

1/The Institute of Gas Technology defines gas yielding 100 to 450 Btus per cubic foot (cu. ft.) as low; 450 to 800 Btus per cu. ft. as medium; and 800 Btus per cu. ft. or above as having high calorific value. Btu = British thermal unit.

COMMERCIALLY AVAILABLE SYSTEMS

Incineration systems

These systems, which generate steam by burning unprocessed solid waste, have been successfully utilized in commercial facilities. There are two basic processes,

--refractory wall incineration 1/ in which heated gases are channeled from a refractory-lined 2/ combustion chamber to a boiler and

--waterwall incineration in which the burning takes place in a combustion chamber lined with water-filled tubes.

The steam produced is piped away and used in electric power generation, industrial processes, or for the heating and cooling of buildings.

Over 180 of these waste-to-energy systems are in operation in Western Europe 3/ where the process has been employed for over 30 years. For example,

--Germany has over 20 installations, with the city of Frankfurt producing about 7 percent of its electricity by this process; and

--Amsterdam burns waste to obtain 6 percent of its electrical output.

The United States has several commercial applications of this technology. (See app. II, p. II-9.) One, a 720-ton-per-day municipally run plant 4/ in Nashville, Tennessee, produces steam and chilled water for a downtown complex of 30 buildings.

1/Small-scale (100 tons a day or less) versions of the refractory wall incineration process are called modular combustion units.

2/Refractory material is difficult to fuse or corrode and capable of enduring high temperature.

3/See app. I, p. I-1.

4/Owned and operated by Nashville Thermal Transfer Corporation (a non-profit Tennessee corporation).

The plant was initially completed in July 1974 at a cost of $18.5 million but required modification to overcome air pollution and combustion problems. The modifications, which include the addition of two electrostatic precipitators, cost about another $8 million.

Researchers feel the initial problems experienced in Nashville were caused in large part by a design structured to meet the city's low-bid requirement. Particulate emissions and other problems could have been avoided using available state-of-the-art technology. Later ventures have avoided many of Nashville's problems by entering into full service contracts which require that qualified suppliers share the associated risks. The risk-sharing lessens the chance that a marginal design will be presented for consideration.

Results from the modified plant have been encouraging and chances for further success appear promising:

--The plant processed an average of 400 tons a day (55 percent of capacity) in 1977.

--Energy equivalent to in excess of 500,000 barrels of oil has been recovered.

--Landfill requirements for the processed waste have been reduced by 90 percent.

--Air quality has been improved.

Project officials expect to be processing 500 tons a day by early 1979 and be up to full capacity in 3 years.

Refuse-derived fuel systems

RDF systems involve the preparation of waste for combustion in utility and industrial boilers. Solid waste is shredded and the combustible paper, food, and other organic material are separated from noncombustibles such as glass and metals. The organic material is then fired as a supplemental or primary fuel in commercially available boilers. The steam produced can be used for industrial processes, the generation of electricity, or for heating and cooling. This system has been demonstrated and applied successfully in the United States and new applications are scheduled in the near future. (See app. II, p. II-11.)

The shredded waste fuel system demonstrated by EPA, Union Electric Company, and the city of St. Louis is perhaps the best known example. This $4 million demonstration plant, which operated intermittently from April 1972 to November 1976, shredded, sorted, and converted 300 tons of mixed municipal refuse to solid fuel each day. The fuel was used as a coal supplement in two slightly modified 1/ Union Electric boilers originally designed to fire pulverized coal.

The system provided 10 percent of the heat requirement of the two boilers, and saved the equivalent of about 135 tons of coal a day. It also cut the bulk of the processed waste by 95 percent.

Union Electric planned to follow up the demonstration by building a $70 million coal-fired plant which would utilize all the solid waste collected in the St. Louis metropolitan area (some 8,000 tons a day, or 2.5 million to 3 million tons a year). It would use the RDF as a supplement to generate about 6 percent of its electrical power.

The plan, though technologically feasible, was cancelled in April 1977. The reasons were

--passage of a State law preventing electric utilities from including current carrying costs of investments in new facilities under construction in their rates, and

--the enforcement of a zoning ordinance which prevented use of a key site for a transfer station.

Many researchers believe the St. Louis demonstration proved the value of converted municipal refuse as a supplemental fuel in large pulverized coal or oil-fired boilers, 2/ and commercial versions of the St. Louis system have been constructed.

In Chicago, a city-owned supplementary fuel-processing plant modeled after the St. Louis system is in shakedown and will be used to convert 1,000 tons of refuse a day (260,000 tons a year) to low-sulfur fuel. Commonwealth Edison Company will pay about $700,000 a year for the fuel and use it as a supplement to coal in the production of electricity for 45,000 homes. The fuel should provide the annual equivalent of 120,000 tons of low-sulfur coal, 360,000 barrels of

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1/The only modification required was the addition of solid waste firing ports.

2/Oil-fired boilers which have been designed to also fire pulverized coal.

fuel oil, or 2.2 billion cubic feet of natural gas. The city expects to realize annual savings of about $600,000 in operating expenses compared to conventional incineration and receive about $200,000 annually from the sale of ferrous metals recovered during conversion.

Methane recovery systems

Methane recovery systems extract gases produced by the natural decomposition (i.e., anaerobic digestion) of wastes deposited at landfills. The fuel extracted is about half methane and half carbon dioxide. Two successful demonstrations, one a commercial application, have taken place in the Los Angeles area.

The Los Angeles Department of Water and Power extracted gas on a test basis from a 100-foot well at the Sheldon-Arleta landfill in Sun Valley. From April 1974 to February 1975, this medium-Btu gas 1/ was used to fuel a 300-horsepower internal combustion engine which drove a generator to produce 200 kilowatts of electrical power for about 350 homes. The department is now extending its tapping activities in Sun Valley and in other landfills in the area.

At a 208-acre Palos Verdes landfill in Los Angeles County, Reserve Synthetic Fuels, Inc., 2/ is operating the world's first commercial methane recovery facility. Methane, extracted from a series of wells, is cleansed through a molecular sieve system. The gas, which is clean enough for direct insertion into a natural gas pipeline, is sold to a local utility. 3/ In addition, the city of Mountain View, California, the Pacific Gas and Electric Company, and EPA are trying to define some of the parameters involved in gas extraction and identify marketing possibilities. Their demonstration plant began operation in early January 1979. 4/

1/Approximately 500 Btus per cu. ft. compared to 1,000 Btus per cu. ft. for natural gas.

2/Formerly NRG NuFuel, Co.

3/A more detailed description of the Palos Verdes system is contained on p. 3-15.

4/Pacific Gas has contracted with Mountain View for the gas extracted.

Researchers view methane extraction from a sanitary landfill as a viable means of helping to solve two serious problems. It eliminates a potential hazard of fire or explosion from uncontrolled gas migration and it uses an otherwise wasted energy resource.

The energy potential of metropolitan area landfills satisfying key commercial criteria of volume, depth, age, and refuse composition appears significant. According to an EPA official, the amount of methane potentially recoverable from landfills serving our 20 largest Standard Metropolitan Statistical Areas may be over 38 billion cubic feet annually. An EPA market analysis, based on interviews with large U.S. gas producers, concluded that major metropolitan areas

--have sufficient quantities of wastes in place to justify gas recovery,

--will continue to put into landfills sufficient quantities of new wastes to generate economically recoverable quantities of methane gas for at least the balance of this century, and

--are located in or near major markets for the gas so that transmission costs will not be excessive.

The analysis further concluded that methane recovery requires a relatively low capital investment compared to other MSW energy recovery systems.

DEVELOPMENTAL SYSTEMS

Many power engineers believe the direct combustion of raw or prepared municipal refuse and the extraction of methane from landfills are the most effective waste-to-energy systems now available, but other systems are being developed and demonstrated (pyrolysis and anaerobic digestion) which may be proven for commercial use by 1985 or thereafter.

Pyrolysis

This process, the basis for petroleum refining, involves the thermal decomposition of materials in the absence or near absence of oxygen. It produces oil and gaseous fuels when raw or prepared refuse is fed into a reactor vessel and heated. The fuel is captured and separated and the remaining ash or char removed. A ton of solid waste yields the energy equivalent of one or two barrels of oil.

Several waste-to-energy pyrolysis systems are currently being demonstrated. (See. app. II, p. II-14.) A few, although unproven on a full scale, are available from several manufacturers. 1/

Pyrolysis of MSW to gas

The first commercial-scale waste-to-energy pyrolysis system began operation in the city of Balitmore in spring 1975. The $25 million plant was built near a Baltimore Gas and Electric Company district heating facility which purchases the process steam for use in heating and cooling large buildings in the downtown area.

The plant uses the "Landgard" pyrolysis system developed by Monsanto Enviro-Chem Systems, Inc. It was designed to convert 1,000 tons a day, or about one half of the city's municipal solid waste to a low-Btu gaseous fuel, 2/ for combustion on-site to produce steam.

The system was designed to produce daily about

--4.8 million pounds of steam, which would save Baltimore Gas and Electric the equivalent of 357,000 barrels of oil annually;

--80 tons of carbon, char, and ash (reduced to 6 percent of original volume);

--70 tons of saleable ferrous metals; and

--170 tons of glassy aggregate which can be used for concrete manufacturing and street paving.

Results have been disappointing. High particulate emissions and a variety of mechanical problems 3/ have limited

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1/Monsanto Enviro-Chem Systems, Inc. (Landgard system); Occidental Petroleum Corporation (Pyro-Fuel system); Carborundum Co. (Torrax process); and Union Carbide Corp. (Purox system).

2/From 75 to 100 Btus per cu. ft.

3/Scrubbers were unable to keep stack emissions within Federal and State standards, the refractory in the rotary kiln failed prematurely, and other mechanical problems developed (e.g., jamming of the garbage feeders).

the operation. Researchers feel the primary difficulty has been a too-ambitious attempt to scale up a successful 35-ton-a-day pilot demonstration into the 1,000-ton-a-day version.

Many of the problems were solved, but Monsanto felt that mechanical reliability had not been demonstrated and it withdrew from the project in February 1977. It recommended the city convert its system to conventional incineration with heat recovery at an estimated cost of $11.4 million.

Baltimore felt it could not shut down the project or wait a year to get voter approval needed for the change to incineration, and it rejected the recommendation. It is continuing the modifications begun in 1976. 1/ They are scheduled for completion in January 1979, and will cost an estimated $4.6 million. Officials estimate that at the current use level, Baltimore's landfill capacity will be exhausted by the spring of 1979.

During 1977, the plant processed 85,000 tons of waste averaging approximately 270 tons for each day operated. It supplied Baltimore Gas and Electric with over 275 million pounds of steam worth about $822,000. This is the energy equivalent of about 96,000 barrels of oil, but less than 30 percent of what the system was designed to supply. A city official told us the rated capacity of the unit has been lowered to 600 tons a day. The plant is expected to be operating at this capacity in early 1979.

Union Carbide has a "Purox" pyrolysis-to-gas process available, but it is yet unproven on a commercial scale. It produces a gas of low heating value 2/ and the technology has been successfully demonstrated at a 200-ton-a-day company owned and operated pilot plant at South Charleston, West Virginia. It has been in operation since June 1974. The economic viability of a scaled up, commercial version,

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1/Modifications include the addition of an induction fan and 220-foot stack ($0.68 million), an electrostatic precipitator ($1.2 million), and construction changes to accommodate the new equipment or correct design deficiencies ($2.7 million).

2/The Purox system produces about 21,000 cu. ft. of gas with a heating value of 350 Btus per cu. ft. (compared with about 1,000 Btus per cu. ft. for natural gas) from each ton of MSW processed.

however, is still uncertain. Evaluations of the system by the cities of Lowell, Massachusetts, and Seattle, Washington, illustrate this uncertainty.

Both cities, after extensive initial investigation, concluded the process was technologically and economically viable for their specific applications:

--Lowell planned to use the process to produce methane at a cost of $2.72 per thousand cubic feet, which compared favorably with the $4 to $6 per thousand cubic feet paid for supplemental supplies of imported liquified natural gas and propane.

--Seattle planned to synthesize the gas to produce anhydrous ammonia fertilizer to sell at $133 a ton, which compared favorably with wholesale or dealer prices ranging from $150 to $250 a ton in the Pacific Northwest.

Recent evaluations, however, show that refinements to the system coupled with inflation have changed the economics and the system is no longer cost-effective in these applications. Lowell has abandoned its plans for the system and Seattle has withdrawn from its contract negotiations with Union Carbide.

Another difficulty in the pyrolysis process is the quality of the produced gas. It cannot be used as a gas turbine fuel without further processing to remove impurities, and its low heat content requires that it be used close to the source of production. Pyrolysis Systems, Inc., a subsidiary of Pyro Sol, Inc., has developed a process which produces a higher heat-value gas (408 Btus per cu. ft. compared to Langard's 100 Btus per cu. ft. and Purox's 350 Btus per cu. ft.) and a demonstration project began shakedown operation in August 1978 in Redwood City, California. It will cost an estimated $1 million and process about 100 tons of refuse a day. 1/

Pyrolysis of MSW to oil

Other pyrolysis systems will produce oil. The most advanced is the "flash pyrolysis" system developed by Garrett Research and Development Company, a subsidiary of Occidental Petroleum Corporation. A $14.5 million, 200-ton-a-day demonstration plant has been built with EPA sponsorship in El

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1/It uses two 50-ton-a-day modules which can be added to to increase the system's capacity.

Cajon (San Diego County), California, but is experiencing difficulties. Shakedown operations begun in December 1977 revealed mechanical and thermal problems which require numerous modifications, and the project's future is uncertain. EPA has withdrawn from the demonstration and Occidental is studying the feasibility of its continuing with the process.

The system is designed to produce about 36 gallons of a pyrolysis oil called "Pyro-Fuel" 1/ from each ton of waste. Preliminary tests by Combustion Engineering, Inc., a manufacturer of utility and industrial boilers, indicate that pyrolysis oil, or blends of the oil with No. 6 fuel oil, can be burned successfully in a standard utility boiler with relatively minor changes. The San Diego Gas and Electric Company has agreed to test it in its generating stations.

Compared to systems that burn raw and processed wastes, pyrolysis processes appear to have potential advantages. Some will produce storable oil and others a gas that can be used as a fuel or chemical feedstock. It should be recognized, however, that pyrolysis processes are complex and the technology and the economics are not yet commercially applicable. Given the current state of the art, it may be 5 to 8 years before their commercial viability is known.

It also should be noted that pyrolysis processes are energy users 2/ as well as producers. The systems consume about one-fourth the energy produced and have energy recovery efficiencies ranging from 37 to 62 percent compared to direct combustion processes which range from 62 to 71 percent.

Bio-conversion

A bio-conversion waste-to-energy process called anaerobic digestion involves the biological reduction of organic materials to simple, more stable forms such as methane, the main component of natural gas.

1/Previously called the Garrett process under the trade name "Garboil." It has a heat content of 114,900 Btus per gal. compared to a residual fuel oil value of 148,800 Btus per gal.

2/Each of the systems heats the feedstock as part of the conversion process.

This process, which converts organic solid wastes to a gas containing methane naturally (see p. 2-7), can be sped up by circulating the organic fraction of MSW within a mechanical digester.

The waste is sorted, shredded, and mixed with sewage sludge in a sealed tank under oxygen deficient conditions, and this feedstock is heated and circulated through a digester for about a week. During this time micro-organisms decompose the organic material, yielding a gaseous fuel which is half methane and half carbon dioxide. 1/ The gas can be used as a supplemental fuel on-site or upgraded to pipeline quality through a scrubbing (cleansing) process 2/ which removes carbon dioxide, water moisture, or other contaminants. Cleansed gas can be as much as 99-percent pure.

Recovery systems utilizing a mechanical digester, however, appear to be further from commercialization than pyrolysis. They are still developmental and just entering the demonstration stage. The Energy Department is sponsoring a $3.6 million, 100-ton-a-day demonstration plant constructed by Waste Management, Inc., at Pompano Beach, Florida. The plant began operation in May 1978 and should provide information on the feasibility of the process. It will convert a mixture of 95 percent solid waste and 5 percent sludge and is expected to produce a methane gas with a heating value of 550 to 750 Btus per cubic foot. The gas will be used initially for process energy, with the excess flared.

While it is too early to draw any conclusions as to the economic and technical viability of the anaerobic digestion process, it should be recognized that research to date indicates that disposal of uncoverted material (sludge and water) could be a major envionmental and economic problem. The process also uses energy to heat the feedstock during conversion and has an energy recovery efficiency of only about 25 percent compared with 62 to 71 percent for direct combustion systems.

1/Each ton of MSW yields about 3,000 cu. ft. of methane gas with a heating value ranging from 550 to 750 BTUS per cu. ft.

2/Several cleaning methods are commercially available for the upgrading of gas quality (e.g., molecular sieve system described on p. 3-15).

CHAPTER 3

URBAN WASTE-TO-ENERGY SYSTEMS

PROVIDE SIGNIFICANT BENEFITS

The commercially available waste-to-energy systems described in the previous chapter can reduce our Nation's disposal load, provide new energy sources, and recover iron and aluminum and other saleable materials. When used for these combined purposes, MSW energy systems can be cost-effective.

ENERGY POTENTIAL

About 75 percent of urban waste is combustible material (see table III) which when exposed to high temperatures breaks down into gaseous, liquid, and solid fuels of varying heat-producing qualities. Typically, a ton of urban waste contains from 9 to 9.4 million Btus of heat energy, the equivalent of about 65 gallons (1.5 barrels) of oil, about 9,000 cubic feet of natural gas, or more than a third of a ton of coal.

Table III

Composition of Municipal Solid Waste

Components	Approximate percent by weight
Corrugated paper boxes	75% combustible
Newspaper	
Magazine paper	
Brown paper	
Mail	
Paper food cartons	
Tissue paper	
Wax cartons	
Plastic coated paper	
Vegetable food wastes	
Citric rinds and seeds	
Meat scraps, cooked	
Fried fats	
Wood	
Ripe tree leaves	
Flower garden plants	
Lawn grass, green	
Evergreens	
Plastics	
Rags	
Leather goods	
Rubber composition	
Paint and oils	
Vacuum cleaner catch	
Dirt	25% non-combustible
Metals	
Glass, ceramics, ash	
Adjusted moisture	

112 million tons, or about 56 percent of the Nation's estimated 201 million annual tons of urban waste. 1/ Our Nation could realize important energy, economic, and environmental benefits, however, if MSW energy systems being implemented or planned in the United States were to begin processing this recoverable portion in the near- and mid-term.

Our review has shown there are 131 urban waste-to-energy projects in various stages of planning or implementation in the United States. 2/ If fully implemented by 1985, these projects could process over 36 million tons of MSW--18 percent of urban waste produced--and provide our national energy system with the equivalent of over 100,000 barrels of oil per day or about 37 million barrels annually, currently valued at some $534 million. Methane extraction from existing landfills could provide the equivalent of another 3 million barrels annually with a current value of about $44 million. The significance of the development and expansion of these alternate energy sources will be discussed in detail. (See p. 3-18.)

RECOVERABLE MATERIALS

Approximately 25 percent of urban waste is non-combustible (see table III, p. 3-1) and, typically, this portion includes recoverable ferrous and non-ferrous metals and glass. These materials can provide a source of revenue to help offset the cost of MSW energy conversion. Processes for recovering some of these materials are commercially available, and others are being developed. (See table V.)

Revenues from recovered materials are affected by the characteristics and condition of the materials, and the proximity of markets. Color-sorted glass, for example, brings three times more revenue than mixed glass, and materials recovered before conversion (front end systems) appear more marketable than those recovered after conversion (back end systems).

This table from EPA's "Fourth Report to Congress" showed the state of materials recovery technology:

1/"Fourth Report to Congress, Resource, Recovery and Waste Reduction," Environmental Protection Agency (SW-600), Aug. 1, 1977, p. 8.

2/See app. II, p. II-1.

The volume of municipal solid waste produced in the United States is growing and provides a new fuel source with equivalent heat energy potentials projected below.

Table IV

Energy Potentially Recoverable From MSW

Year	Tons of MSW (note a)	Energy potential (note b)	Oil equivalent (note c)	
	(millions)	(QUADs)	(MMBBL)	(MMBBL/D)
1975	136	1.22	211	.58
1980	175	1.58	272	.75
1985	201	1.81	312	.85
1990	225	2.03	350	.96

a/As stated in EPA's "Fourth Report to Congress" (SW600), Aug. 1, 1977.

b/Based on 9 million Btus (MMBtus) per ton of MSW, the generally accepted energy value of "as received," unprocessed waste. One QUAD equals a quadrillion Btus.

c/Based on 5.8 MMBtus per barrel of oil, and 365 days per year. MMBBL = million barrels; MMBBL/D = million barrels per day.

This means that the equivalent of .85 million barrels of oil a day, or some 7 percent of projected imports ranging from 12 to 13 million barrels of oil a day 1/ would be the full energy potential of the MSW produced by 1985. By 1990 the potential energy equivalent would be almost a million barrels of oil a day.

It is not likely that the maximum (i.e., all the urban waste generated in the United States annually) will ever be converted to energy. Since the economics of most energy recovery systems require large quantities of waste, they are generally thought to be restricted by logistics and economies of scale to the metropolitan or urbanized areas of the country. According to EPA, the maximum amount of MSW technically feasible for recovery in 1985 will be about

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1/GAO estimate based on our evaluation of the National Energy Plan (see letter report EMD-78-5, Oct. 14, 1977).

Table VI

Quantity and Value of Materials From Recoverable Portion of MSW Projected to be Produced in 1985

	Recoverable materials			
	Glass	Ferrous metals	Aluminum	Total
Quantity of material per ton of MSW (lbs.) (note a)	190	170	10	-
Quantity of material recoverable (millions of tons) (note b)	10.6	9.5	0.6	20.7
Market value of materials ($ per ton) (note a)	$22	$50	$200	-
Gross revenue potential ($, millions)	$233	$475	$120	$828

a/EPA estimates in published proceedings, "A Conference on Capturing the Sun through Bioconversion," Washington Center for Metropolitan Studies, Mar. 10-12, 1976, p. 106.

b/No adjustment made to allow for processing efficiencies because no prejudgment can be made as to recovery method used.

Recovery of these materials from MSW can help meet our Nation's materials requirements and improve our international balance of trade. The United States, with about 7 percent of the world's population, consumes almost half of the world's industrial materials. The U.S. trade deficit for such materials is growing significantly and by the year 2000 could be more than 10 times what it was at the beginning of this decade.

Materials recovery also benefits our Nation's energy supply problem. The recycling of recovered materials uses less energy than if virgin materials are used in manufacturing operations. This is exemplified by data supplied to

Table V

Materials Recovery Technology Status Summary

Material	Status or recovery technology
Glass	Mechanical processes are available to separate construction-grade aggregate.
	Recovery of mixed-color container quality glass by froth flotation has been demonstrated (pilot plant).
	Recovery of color-sorted glass cullet is in a developmental stage (pilot plant).
Ferrous metal	Electromagnetic separation has been commercially demonstrated and is available.
Aluminum	Heavy-media process is used commercially in auto scrap recovery.
	Electrostatic and electromagnetic methods are in advanced stages of development.
Other non-ferrous metals	Developmental stages (pilot plant).

Although processes for recovering color-sorted glass or non-ferrous metals other than aluminum are still in a developmental stage, a full use of available technologies could produce valuable economic and energy-related benefits in the near term (i.e., by 1985).

Materials recovery provides a source of revenue and conserves energy

If commercially available technologies were to be fully used, about 21 million tons of glass, ferrous metals, and aluminum with market value of abut $828 million could be recovered from the 112 million recoverable tons of MSW projected to be produced in 1985.

Table VII

1985 Energy Savings--
Recycling vs. Use of Virgin Material

	Recovered materials		
	Ferrous metals	Aluminum	Total
Tons recoverable annually for recycling (millions)	9.5	0.6	10.1
Energy required to manufacture a ton of new product using virgin material (kWhs per ton) (note a)	4,270	51,379	55,649
Energy required to manufacture a ton of new product using recycled material (kWhs per ton)	1,666	2,000	3,666
Energy saving per ton as the result of recycling (kWhs per ton)	2,604	49,379	51,983
Annual energy savings (million kWhs)	24,738	29,627	54,365
Annual energy savings (billion Btus) (note b)	84,431	101,117	185,548
Equivalent barrels of oil (thousands) (note c)	14,557	17,434	31,991
Estimated value ($, millions) (note d)	$211.7	$253.5	$465.2

a/KWh = Kilowatt-hour.

b/Based on standard conversion of 3,413 Btus per kWh.

c/Based on 5.8 million Btus per barrel of crude oil.

d/Based on $14.54 price per barrel of imported crude reported in "Monthly Energy Review," U.S. Department of Energy, Energy Information Administration, (NTISUB/D/127-010) Oct. 1978.

the Congress by the National Association of Recycling Industries, Inc. 1/ The data synthesized results from studies by various Federal agencies and showed that in 1976, recycling of materials by U.S. manufacturers saved the energy equivalent of over 151 million barrels of crude oil.

The recoverable recyclables in our urban waste represent the potential for substantial additional energy in the near term. Using conversion factors from the above studies, we estimate about 54 trillion kilowatt-hours of electricity, the annual equivalent of almost 32 million barrels of oil, currently valued at about $465 million, could be potentially saved in 1985 by recycling the ferrous metals and aluminum in the 112 million tons of recoverable MSW. 2/ (See table VII.)

The 131 urban waste-to-energy projects now in various stages of implementation or planning could process about 32 percent of the recoverable MSW and provide an estimated recovery of materials valued at some $235 million annually by 1985. (See table IX, p. 3-21.) Recycling of the metals recovered by these projects could save the energy equivalent of about 8 million barrels of oil annually, currently valued at about $121 million (see app. II, p. II-19).

1/Statement before the Subcommittee on Transportation and Commerce, House Committee on Interstate and Foreign Commerce, on "The Implementation of the Resource Conservation and Recovery Act of 1976," Apr. 26, May 18 and 19, 1977 (serial no. 95-38), pp. 185-188.

2/Does not reflect energy it takes to segregate the metals and transport them to point of use because of the site specific nature of such energy use.

with development of urban waste conversion processes. Other problems, economic in nature, will be resolved as markets are developed for the energy produced and materials recovered. The results of a number of actual operations show that urban waste-to-energy systems can be a practical and cost-effective means of municipal solid waste disposal.

Resource recovery economics are site-specific and tied to multiple benefits derived

To be economical, MSW conversion systems usually must produce saleable energy forms and by-products, recover valuable materials, dispose of garbage advantageously, and have long-term, stable markets. A comparison of MSW energy system net disposal costs (capital and operating costs less revenues from the sale of energy and materials) with the increasing cost of conventional disposal (excluding collection cost 1/) gives some indication of the economic viability of these systems.

Little hard economic data on waste-to-energy systems is yet available because of their limited application in the United States. However, detailed studies 2/ of the economics of these processes show that projected net disposal costs for each ton of MSW processed by selected projects in operation range from $1.53 to $9.90 a ton for refuse-derived fuel processes and from $5.89 to $13.00 a ton for incineration with heat recovery.

The range of net disposal costs noted above compares favorably with the $7 a ton average cost of conventional

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1/Waste collection is a necessary activity regardless of the disposal option being considered, and its cost is excluded from the comparison.

2/"Resource Recovery Technology for Urban Decision Makers," by Urban Technology Center, Columbia University, for the National Science Foundation, Jan. 1976. "Overcoming Institutional Barriers to Solid Waste Utilization as an Energy Source," by Gordian Associates, Inc., for the Department of Energy (contract number FEA-CO-04-50172-00), May 1977; and "Final Report: Engineering and Economic Analysis of Waste to Energy Systems," by Ralph M. Parson Company, for the Environmental Protection Agency (contract number 68-02-2101), June 1977.

COST-EFFECTIVENESS OF MSW ENERGY SYSTEMS

Factors such as high population densities, the resultant shortage of land for solid waste disposal, and high energy costs which have made MSW energy recovery an economically viable waste disposal option in Western Europe since before World War II are now working to that end in the United States. In the past, abundant land, energy and material resources, and the availability of low-cost waste disposal options made use of these systems in the United States uneconomic. The economics are now changing.

Conventional methods of waste disposal--landfilling, incineration, or ocean dumping--are being severely curtailed or limited and becoming more costly partly due to pollution control restrictions. Landfilling, the most widely used method, is becoming less viable because of the depletion of existing landfills, the urbanization of much of the land in and around metropolitan areas, and citizen objections to the siting of landfills in their locale. Also, previously abundant domestic fossil fuels are in short supply and the prices of these fuels are escalating rapidly. As a result, the economics of alternative MSW energy systems are becoming more favorable and the Nation is beginning to respond to the new situation and opportunities.

Researchers, equipment manufacturers, Government agencies, public interest groups, and prospective users have evaluated the advantages and disadvantages of resource recovery, but conclusions vary. Some evaluators consider that the barriers to the full-scale use of these systems (discussed in the next chapter) are formidable and have taken "wait and see" positions. Others believe the demonstrated and potential benefits justify immediate implementation.

Many technological and environmental problems experienced by pioneers were due to misapplication of the technologies involved and have been or can be resolved. A DOE draft strategy for the commercialization of urban waste technologies 1/ notes that environmental requirements have been identified and the requisite research and development can be conducted in a time frame consistent

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1/Draft of "Urban Waste Commercialization Strategy, Phases I, II, and III," Urban Waste Technology Task Force, U.S. Department of Energy, July 19, 1978.

of operating these land disposal facilities are much lower than the costs of replacing them with landfills modified or designed to meet environmental standards. Many municipalities have employed cost accounting techniques which ignore landfill acquisition costs, depreciation expenses, and administrative and overhead costs. These practices have tended to make local solid waste services appear less costly than they really are. To properly evaluate the comparative cost of resource recovery, municipalities must examine their current and future cost of solid waste disposal objectively, making certain all costs are considered and that they are realistic.

Prospective users must consider the economics of these processes in terms of their own particular situations. A number of municipalities have found them cost-effective and others are examining the benefits.

In the following pages we describe instances in which commercially available waste-to-energy systems applied by municipalities working with private firms have proved to be economically and technologically viable and environmentally acceptable waste disposal options.

Successful application of waste-to-energy techniques

Each successful use of a waste-to-energy conversion system is based on the adaptation of a particular technology to a specific situation. The following examples illustrate the successful application of commercially available technologies (the use of refuse-derived fuel, and the use of methane recovered from a landfill) to resolve waste disposal problems common to many U.S. cities.

Milwaukee, Wisconsin--refuse-derived fuel in a conventional utility boiler

The city of Milwaukee felt the impact of tightened air pollution regulations in early 1970. It had to spend $20 million to control emissions or close down its incineration system and rely exclusively on a privately operated landfill refuse disposal system. 1/ The decision to discontinue incineration coupled with rising disposal costs and an increased citizen interest in recycling then provided the impetus for evaluating the resource recovery option.

1/A system of city-owned transfer stations and landfill sites operated by a private company.

disposal (excluding collection cost) 1/ and its higher cost in major urban areas. In certain areas of the country, especially our larger cities, it now costs from $10 to $20 a ton to dispose and cover a ton of garbage, exclusive of collection.

As environmental regulatory programs are enforced, the comparative cost advantages of using waste-to-energy systems are likely to increase.

--EPA estimates the cost of conventional, environmentally acceptable methods of collecting and disposing of municipal waste will increase from a present average of $30 a ton to $50 a ton by 1985. Proportionately, the average cost of processing each ton exclusive of collection cost could increase from $7 to $12.

--Transportation and land acquisition savings should result from converting the waste to a compact, sterile residue and can logically be offset against the costs of MSW energy conversion. The original volume of waste processed is reduced by as much as 95 percent and thereby lessens transportation and landfill requirements.

In addition, waste-to-energy fuels should become increasingly competitive as the replacement costs of conventional fossil fuels rise.

Some words of caution are appropriate. Cost and revenue estimates are site-specific and include a range of variables--quantities and characteristics of waste, transportation costs, facility costs, construction costs, the cost accounting methods employed, and the value of energy forms and materials. Also, cost projections for processes still in developmental stages are not yet considered highly reliable.

It must also be recognized in comparing present and projected costs that much of the Nation's solid waste is now disposed of in dumps that do not meet the minimum requirements for sanitary landfills. 2/ The direct costs

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1/EPA estimates the average cost of conventional disposal at almost $30 a ton--approximately $23 to collect each ton and $7 to process it.

pays a surcharge 1/ on each ton of MSW delivered up to a maximum of 300,000 tons a year. Both fees are adjusted annually by the percentage change in the Consumer Price Index.

Wisconsin Electric has agreed to pay Americology the same Btu price for RDF that it paid for the coal replaced. It adjusts this price by deducting any differences between costs and savings resulting from the use of RDF. 2/ It is estimated that the price of the fuel will range from $6 to $7.80 per ton of RDF. 3/ This means then that fuel revenues should range from $2.76 to $3.59 per input ton of MSW.

The 1,600-ton-a-day, $18 million Americology plant began operation on May 18, 1977. As of January 1978, it was running at about 56 percent capacity and processing approximately 900 tons a day of refuse.

A detailed analysis of the estimated cost-effectiveness of the system by the National Center for Resource Recovery, Inc., shows the following results based on available 1977 data: 4/

1/Surcharge serves as a form of reimbursement to Americology for the property taxes which would not otherwise be payable if the plant were publicly owned, and to compensate the operator for the expense of privately financing the project. The $2 per ton charged in 1977 was reduced to $1.50 for 1978.

2/The contract between Wisconsin Electric and Americology requires the typical characteristics of the RDF at time of delivery be 15 to 25 percent moisture, 10 to 20 percent ash, less than 0.3 percent sulfur and chlorides, and 5,000 to 6,000 Btus per lb.

3/Based on the recovery of 46 percent RDF from each ton of incoming waste, a value of $0.90 per million Btus and a discount of $3 per ton of RDF to reflect the cost of Wisconsin Electric's capital investment.

4/Since the plant was in operation less than a year at the time of NCRR's fall 1977 analysis, operating costs were not yet available.

In 1971, the city and Wisconsin Electric Power Company began an exhaustive study of the feasibility of using solid waste to produce energy. In January 1975, the Americology Division of American Can Company agreed to finance, design, construct, own, and operate a waste-to-energy system under a contract with the city. It would

--process up to 400,000 tons a year of mixed municipal solid waste;

--produce up to 184,000 tons a year of RDF to be sold under a 15-year contract to Wisconsin Electric Power Company for use as a supplemental fuel in two pulverized-coal-fired boilers;

--recover paper, ferrous metals, glass, and aluminum and market these materials; and

--transport the refuse from city-owned transfer stations to the plant and the residue of unrecoverable wastes to landfill sites.

Americology underwrote all financial and marketing risks and took responsibility for

--operating the transfer stations and landfill sites;

--installing RDF receiving and storage facilities costing $4 million at the Wisconsin Electric generating plant (subsequently purchased by the utility); and

--delivering the fuel to the utility.

Under terms of the agreement, the city leases transfer stations and recovery plant sites to the operator for $1 per year; collects the refuse and guarantees delivery of a minimum of 250,000 tons a year to Americology; pays Americology a tipping fee set at $10 per ton for 1977; 1/ and

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1/Fee compares favorably with the cost of optimal direct delivery to landfill which was projected to increase from $8.20 per ton (1975 dollars) to over $10 per ton in 1977 due to the need to transport the wastes considerable distances.

On the basis of recent economic analyses of other resource recovery plants, the Center believes that $10.35 per ton should be more than sufficient to offset Americology's operating costs.

The RDF used by Wisconsin Electric at a feed rate of 10 to 15 tons per hour supplies about 5 to 8 percent of the heat input to one of its boilers and is converted into enough electricity to service the needs of about 30,000 homes. Also, the volume of the incoming waste is reduced by 90 percent, requiring less landfill area for disposal.

<u>Palos Verdes, California--recovery of methane from a sanitary landfill</u>

In 1972, the Los Angeles County Sanitation District proposed that Reserve Synthetic Fuels, Inc. (then NRG NuFuel Company), extract and sell methane gas escaping from one of the county's six landfill sites. Extensive tests were made to determine the production potential, the best tap locations, and the best markets for gas. Recovery operations began at the Palos Verdes landfill site in June 1975.

The 208-acre site receives about 3,000 to 4,000 tons of refuse per day. Natural decomposition (i.e., anaerobic digestion) of the wastes produces daily an estimated 9 to 12 million cubic feet of gas containing about 50 to 55 percent methane. The remaining 45 to 50 percent is mostly carbon dioxide with some contaminants (water moisture and other liquids). The project recovers each day about 2 million cubic feet of the gas produced.

The gas is extracted through eight wells which range from 100 to 125 feet deep. The heat value at the well head is about 540 to 550 Btus per cubic foot 1/ (compared to 1,000 Btus per cu. ft. for pipeline quality natural gas). After recovery the gas is passed through a purification process consisting of a series of towers or tanks filled with a molecular sieve. The resulting pipeline quality methane, which is 99 percent pure when it flows from these towers, is then further processed to remove any remaining contaminants.

1/Suitable for use as a fuel on-site or for industrial application in systems which can be adjusted to accommodate the medium Btu levels of the gas (e.g., Los Angeles Department of Water and Power system noted on p. 2-7).

City's net disposal cost		$ per ton delivered
Payments to Americology:		
Tipping fee	$10.00 per ton	
Surcharge	2.00	$12.00
Less credits/offsets		
Fuel credit (note a)	$ 0.35 per ton	
Property tax (note b)	0.70	1.05
Net disposal cost		$10.95

Americology's 1977 operating result		
Revenues (note c):		
Tipping fee and surcharge	$12.00 per ton	
Fuel (RDF)	2.76	
Ferrous metal	2.40	
Paper	1.80	
Aluminum	1.50	
Glassy aggregate	0.14	$20.60
Costs:		
Capital cost amortized (note d)	7.90 per ton	
Property taxes	2.00	
Fuel rebate	0.35	
Operating costs	-	10.25
Operating result prior to deducting operating costs		$10.35

a/The city receives 10 percent of the revenues from sale of the RDF to partially offset the tipping fee (amount paid to deposit waste at the recovery plant).

b/The city receives about one-third of the property taxes paid by Americology.

c/Revenues from sale of materials based on: Ferrous (6 percent recovery, $40 per ton); paper (6 percent recovery, $30 per ton); aluminum (0.5 percent recovery, $300 per ton); glassy aggregate (7 percent recovery, $2 per ton).

d/Amortization based on $18 million, at 10 percent interest over 15 years, operating at 75 percent capacity or 300,000 tons a year.

--the likelihood of localized land and water pollution by removing a polluting element;

--the localized air pollution that is inherent in conventional non-heat-recovering incineration; and

--broad area pollution by substituting low sulfur refuse-derived fuels for fossil fuels.

Other cities with refuse disposal problems can profit by the experiences of these two. Some are examining the benefits.

We found 131 waste-to-energy conversion projects operational or underway in the United States at the beginning of 1978, with most in a planning or feasibility study stage. 1/ A distribution of these projects by process type and status of development follows:

Project status	Process type: Incineration (note a)	RDF	Pyrolysis	Anaerobic digestion (note b)	Total
Operational	11	6	2	1	20
Under construction	1	7	1	1	10
Advanced planning (note c)	12	15	2	1	30
Subtotal	24	28	5	3	60
Projects in feasibility study stage					71
Total U.S. projects					131

a/Incineration includes waterwall incineration, refractory wall incineration with heat recovery, and modular combustion units.

b/Projects recovering methane gas from sanitary landfills.

c/Request for proposal issued, design study underway, or construction funds made available.

1/See app. II, p. II-1, for specifics as to the projects and their locations.

About 13 to 14 million cubic feet of the purified methane (about 995 Btus per cu. ft.) is sold to Southern California Gas Company each month. It is bled from the Palos Verdes site directly into the utility's pipeline system. It is estimated the site could sustain this production level for 15 to 20 years.

The selling price of the gas to the utility has not been made public. It can be estimated, however, based on the royalty paid to the Sanitation District, which is 12.5 percent of the selling price. The royalty for the representative period September through November 1977 was $8,626, or a monthly average of about $2,875. Thus, the monthly sales of gas averaged about $23,000 ($2,875 ÷ .125), with the selling price averaging about $1.70 per thousand cubic feet (MCF).

This price is very competitive when compared with the prices paid by utilities for "peak shaving" gas which is used to meet surges in gas demand. Imported liquefied natural gas (LNG) or propane is commonly used for this purpose and prices range from $3 to $5 per MCF.

Also, methane at $1.70 per MCF will become increasingly more competitive as current long-term contracts expire for domestic supplies of natural gas at prices below the current market. The price of replacement intrastate gas in new contracts ranges from $1.50 to $2.00 per MCF.

Recovery of methane at Palos Verdes

--provides revenue to the county;

--eliminates the potential hazard of fire or explosion from gas migration; and

--makes economical use of an energy source which would otherwise be wasted.

Other communities are finding informed judgment can lead to viable solutions

The experiences of Milwaukee and Palos Verdes show the value of pre-implementation assessments of resource recovery systems to determine which is best suited to the specific needs of a community. These cities are now better able to control the cost of solid waste disposal and recover energy and materials from a resource which would have been otherwise discarded. They have also reduced by 1985, we estimate about 18.1 million tons of MSW will be converted. (See table VIII.) This figure falls within the range projected by EPA and is approximately 9 percent of the 201 million tons of MSW produced and about 16 percent of the 112 million tons EPA considers recoverable.

Conversion of this waste would produce some 106.1 trillion Btus of heat energy (see table VIII), the annual energy equivalent of 18.3 million barrels of oil, which have a current market value of about $266 million. Also, the systems could recover about 2 million tons of ferrous and non-ferrous metals and glass the value of which would be over $91 million. (See table IX.)

In terms of our national energy requirements, we can under the present program expect that by 1985 only about 16 percent of the heat energy out of a potential 0.67 quadrillion Btus 1/ will be recovered from MSW sources. Also, we can expect to recover only a little over 11 percent of the $828 million in materials potentially recoverable from MSW sources by 1985. (See p. 3-5.)

However, as a Nation we have an opportunity to improve upon these projections. If adequate assistance and incentives were provided to encourage use of commercially available urban waste-to-energy systems by those already in study stages and to accelerate their implementation, this might produce an additional 107 trillion Btus of energy by 1985 and recover materials worth an additional $143.1 million. 2/

1/Estimated as follows: 112 million tons of MSW x 9 MMBtus per ton x 66 percent energy recovery efficiency of commercially available systems = 0.67 QUADS of heat energy.

2/For calculations forming the basis for these additional energy and materials recovery estimates, see app. II, p. II-17.

Though these projects represent a substantial beginning, few cities are yet using solid-waste-to-energy conversion to their full economic advantages. Projections show only small amounts of the abundant and growing volume of municipal solid waste will be converted to energy.

Barriers must be overcome if near- and mid-term potentials are to be realized

EPA estimates that at the current level of implementation only about 1 million tons of MSW (less than 1 percent of the MSW produced) will be processed for energy recovery by 1979. NCRR 1/ says that only about 10 million tons will be used for this purpose by the early 1980s. This is less than 6 percent of estimated MSW production. By 1985, based on present trends and policies, EPA estimates only 10 to 20 million of the 112 million tons of waste it considers available for energy conversion will be processed for energy and material recovery. To improve these projections, we as a Nation will have to overcome the barriers which block wide-scale uses.

SIGNIFICANCE OF BRINGING PLANNED PROJECTS ON LINE BY 1985

The uncertainties associated with developing technologies and EPA's 1985 projection noted above appear to indicate that only those projects now under construction or in an advanced stage of planning are likely to become operational by 1985.

--Experience shows that it can take 5 to 7 years after feasibility studies are completed and technologies decided on for a commercially proven system to be implemented.

--Projects now underway and in a feasibility study stage will be evaluating processes which are not commercially proven (e.g., pyrolysis and (mechanical) anaerobic digestion options) and present a set of uncertainties common to developing technologies which will take time to resolve.

If the 40 systems under construction or in advanced planning join those now operating and all become fully operational

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1/"News Release," National Center for Resource Recovery, Inc. (NR-1977-5), Washington, D.C., Dec. 16, 1977, p. 1.

The total amount of energy and materials potentially recoverable from the 131 projects now at some stage of development is shown below:

Table IX

Energy and Materials Potential of U.S. MSW Conversion projects

Source	MSW Millions of TPY (note a)	Energy MMBOE (note b)	Energy Value (millions)	Materials TPY (thousands)	Materials Value (millions)
60 projects which are operational, under construction, or in advanced planning (note c)	18.1	18.3	$265.9	1,986	$ 91.4
71 projects in the feasibility study stage (note d)	18.0	18.5	268.3	3,370	143.1
Totals	36.1	36.8	$534.2	5,356	$234.5

a/TPY = Tons per year.

b/MMBOE = Million barrels of oil equivalent.

c/See pp. 3-18 to 3-20.

d/See app. II, pp. II-16 and II-17.

Recycling of recoverable ferrous metals and aluminum could provide additional savings equivalent to some 8.3 million barrels of oil annually, valued at about $121 million. 1/

Also, a study by EPA 2/ shows that about 38.8 billion cubic feet of low-Btu 3/ methane gas, which can be brought up

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1/See app. II, p. II-19.

2/"Methane Gas Recovery in Mountain View (California) Moves into Second Phase," Solid Wastes Management, May 1976, p. 90.

3/Approximately 450 Btus per cu. ft. compared to 1,000 Btus per cu. ft. for pipeline quality gas.

Table VIII

Summary of Planned Performance Data Projections For Individual Projects Identified (note a)

Status/process	No. of units	TPY capacity (note b)	Energy producible Btus per year (billions)	Materials recoverable (TPY) Ferrous metals	Non-ferrous metals (note c)	Glass
Operational		(000 omitted)				
Incineration:						
Waterwall incineration	6	1,261	7,606	78,122	212	-
Refractory wall incineration (note d)	5	117	703	5,406	-	-
Refuse-derived fuel	6	1,407	8,104	109,595	4,120	30,210
Pyrolysis	2	318	1,345	27,030	265	5,035
Anaerobic digestion (note e)	1	(f)	185	-	-	-
Subtotal	20	3,103	17,944	220,153	4,597	35,245
Under construction						
Incineration:						
Waterwall incineration	-	-	-	-	-	-
Refractory wall incineration	1	13	80	1,126	-	-
Refuse-derived fuel	7	2,486	14,319	211,310	7,145	146,015
Pyrolysis	1	27	112	2,253	-	-
Anaerobic digestion	1	(f)	168	-	-	-
Subtotal	10	2,526	14,679	214,689	7,145	146,015
Advanced planning						
Incineration:						
Waterwall incineration	11	5,353	32,279	455,005	10,600	75,525
Refractory wall incineration	1	11	64	-	-	-
Refuse-derived fuel	15	6,877	39,610	584,520	18,683	193,848
Pyrolysis	2	238	1,009	20,272	-	-
Anaerobic digestion	1	(f)	487	-	-	-
Subtotal	30	12,479	73,449	1,059,801	29,283	269,373
Total	60	18,108	106,072	1,494,643	41,025	450,633

a/In cases where information was lacking estimates of annualized capacity and energy and materials recovery were made. See app. III, p. III-1.

b/TPY = Tons per year.

c/Contains 4,230 tons of non-ferrous metals other than aluminum.

d/Includes modular combustion units.

e/Methane recovery from sanitary landfills.

f/Not applicable to methane recovery from sanitary landfills.

CHAPTER 4

BARRIERS TO THE

USE OF URBAN WASTE-TO-ENERGY SYSTEMS

In this chapter we focus on problems which hamper the widespread use of commercially available waste-to-energy systems in the near- and mid-term future.

These problems have technological, administrative, and economic aspects but are primarily institutional in character. We have not had a systematic, coordinated program fostering the use of waste-to-energy systems and to a great degree this reflects a failure by Federal Government agencies to meet their responsibilities.

MAJOR BARRIERS

Federal agencies charged with encouraging the use of waste-to-energy systems have not provided

--adequate dissemination of information and assistance to State and local governments and to the general public;

--sufficient assistance in financing the evaluation or acquisition of currently available waste conversion systems, many of which are capital-intensive;

--incentives to encourage investment in MSW energy systems and participation in associated markets;

--adequate assistance in identifying and developing markets for both recovered materials and non-energy by-products; and

--an effective testing program aimed at resolving technological questions which inhibit potential investors and users.

INFORMATION AND ASSISTANCE PROBLEMS

Many State and local governments do not have the resources, expertise, or experience to plan, evaluate, develop, finance, and implement a successful resource recovery project. They lack information on the availability, costs, economics, energy efficiencies, and environmental benefits.

to pipeline quality using commercially available technology, could be recovered annually from existing landfills serving the 20 largest Standard Metropolitan Statistical Areas in the United States. (See p. 2-8.). This is the equivalent of 3 million barrels of oil valued at $43.6 million.

If the energy potential of methane recovery and recycling of ferrous metals and aluminum is added to that of the projects in the table above, we could, by 1985, be provided with energy from MSW sources equivalent to over 48 million barrels of oil annually, or about 132,000 barrels of oil per day, with a current value of almost $700 million. By 1995, this amount could increase to the equivalent of some 158 million barrels of oil annually, or about 433,000 barrels of oil per day, 1/ currently valued at approximately $2.3 billion.

1/Based on EPA's estimate that 56 percent of urban waste can be feasibly converted, the energy potential of MSW by 1995 can be calculated as follows: 225 million tons of MSW x .56 = 126 million tons x 9 MMBtus per ton = 1.13 quadrillion Btus x 66 percent conversion efficiency = 0.75 quadrillion Btus divided by 5.8 MMBtus per barrel of oil = 129 million barrels of oil equivalent annually. Recycling of recoverable materials could produce an additional energy savings equivalent to almost 29 million barrels annually.

2 years ago. Several communities have since used that project as a model. A more timely analysis might have provided valuable information to them and to other communities considering waste-to-energy conversion.

Program lacks funds and manpower

EPA's Resource Recovery Technical Assistance Program also provides consultation directed towards helping State and local governments determine if resource recovery is feasible, and whether a system should be implemented in a specific area. 1/ EPA provides this technical assistance, upon request and without cost to the community, using Resource Conservation and Recovery Panels (formerly called teams) with expertise in engineering, operations research, finance, and management. EPA's ability to provide consultation, however, by its own admission 2/ has been and continues to be severely limited because of funding and manpower constraints. An EPA official reported that from January to June 1977, the Agency received 41 formal requests for resource recovery technical assistance, a figure he feels was lower than it might have been since the Agency has purposely not actively advertised the program. EPA was able to respond to less than half of the requests.

Panels program budget

Since the enactment of the Resource Conservation and Recovery Act (RCRA) in October of 1976, EPA has been required to use 20 percent of its Office of Solid Waste budget to furnish technical assistance to State and local governments using resource conservation and recovery panels. The panels

--are selected and managed by EPA's regional offices which have the responsibility for evaluating community requests and determining the extent and type of technical assistance to be provided; and

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1/Limited to communities familiar with resource recovery that had demonstrated political commitment to implementation (i.e., request had to be signed by elected official).

2/"Using Solid Waste to Conserve Resources and to Create Energy," U.S. General Accounting Office (RED-75-326), Feb. 27,1975, p. 53; "EPA Activities Under the Resource Conservation and Recovery Act of 1976" (SW633), U.S. Environmental Protection Agency, Feb. 1, 1978, p. 51.

Communities need assistance in project management and planning, public education, evaluation of different technologies, marketing of products, project financing, management of risks, and drafting of appropriate procurement documents and contracts.

EPA's Information and Assistance Program needs improvements

The Congress has given EPA responsibility for gathering and disseminating urban waste-to-energy information and for providing resource recovery technical assistance upon request to State and local governments. 1/

EPA's Resource Recovery Technical Assistance Program, in its Office of Solid Waste, provides general information through publications, demonstrations and analysis, and direct assistance through consulting teams and panels.

The program offers published information on planning, financing, procurement, technologies, and markets, but much of it is dated. For example, EPA's latest national survey of resource recovery activities 2/ and its Fourth Report to Congress, 3/ dated August 1, 1977, give the status of planned and actual, energy and non-energy related commercial and experimental projects, and the agency's research and development efforts as of mid-1976 and September 30, 1976, respectively. Information on many of the energy recovery projects mentioned (including the ones sponsored by EPA) is substantially out of date in terms of scope, costs, and time frames. An EPA Resource Recovery Program official told us the need to update information is hampering the agency's ability to provide outreach services. EPA did not publish until September and December 1977 the final results from tests completed in fall 1975 of a successful RDF technology demonstration it sponsored in St. Louis (see p. 2-5) which ended over

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1/Soild Waste Disposal Act of 1965 (P.L. 89-272), as amended by the Resource Recovery Act of 1970 (P.L. 91-512) and the Resource Conservation and Recovery Act of 1976 (RCRA, P.L. 94-580). See app. IV, p. IV-1.

2/McEwen, L. B., Jr., "Waste Reduction and Resource Recovery Activities; A Nationwide Survey," Environmental Protection Publication SW-142, 1977.

3/"Fourth Report to Congress, Resource Recovery and Waste Reduction," Environmental Protection Agency (SW-600).

EPA region	Population (thousands)	Number of States and territories (note a)	Amount	Percent
I	11,848	6	$ 84,200	8.42
II	28,187	3.5	100,700	10.07
III	23,425	6	112,300	11.23
IV	31,826	8	151,300	15.13
V	44,027	6	162,400	16.24
VI	20,340	5	95,600	9.56
VII	11,237	4	64,300	6.43
VIII	5,579	6	69,100	6.91
IX	23,208	5.5	107,200	10.72
X	6,521	4	52,900	5.29
Total	206,281	54.0	$1,000,000	100.00

a/Includes Guam, Puerto Rico, the Virgin Islands, and the District of Columbia.

Panel funds termed insufficient

EPA feels these funds are not sufficient to meet the goals of the panels program because in addition to providing technical assistance in resource conservation and recovery, the program is intended to

--help States develop plans to manage hazardous solid wastes;

--help counties, cities, towns, and regional authorities replace environmentally unacceptable disposal facilities with acceptable ones (includes upgrading of sanitary landfills in addition to the resource recovery option); and

--help local governments implement more efficient solid waste collection, storage, and transfer, and management information systems.

--use a "peer matching" concept which permits the use of State and local officials as volunteer panel members 1/ to supplement EPA staff and consultants under contract to the agency.

The panels' program budget for fiscal year 1978 is:

	Amount (millions)
EPA personnel (headquarters and regional)	$1.47
Consultant contracts and grants	1.64
Total	$3.11

A distribution of the amount budgeted for contracts and grants is shown below:

	Amount
Regional consultant contracts	$1,000,000
Peer matching grants	150,000
Panels administration and technical support	490,000
Total	$1,640,000

Based on a formula which takes into consideration the number of States in each of EPA's 10 regions and its population, the amounts allocated for regional consultant contracts are:

1/State and local government officials who provide expertise and assistance to a panel's client on a voluntary basis and whose travel and expenses (but not salary) are paid for through grants to designated public assistance groups (e.g., National League of Cities).

institutions would not be generally willing to invest in resource recovery systems unless the principal risks 1/ were assumed by a responsible party and a rate of return consistent with the risks was assured.

It appears that the burden of providing funds for resource recovery projects will continue to be on the public sector until these concerns are satisfied. According to DOE, however, public financing of these facilities may be a problem, particularly for local government units, because of high initial costs and the risks associated with using a new technology.

Financing options

The prospective economic return on investments in resource recovery plants has been too low to attract equity capital. The focus in plant financing has been on the bond market. According to EPA's August 1977 report to the Congress, 2/ the majority of U.S. resource recovery facilities in excess of 300 tons per day capacity, either built or contracted for since 1967, have been financed by tax-exempt, long-term debt obligations. But no single pattern or model has been established. Options have varied to meet the specific objectives and constraints of a given locality. Factors such as the financial status of a city, voter attitudes, legal constraints, and the magnitude and risks of the project have determined which of the options will be used.

There is disagreement as to the need for Federal financial guarantees to improve the marketability of these obligations. Representatives of State and local governments, private industry, and the private financial community have recommended that the Federal Government guarantee State, municipal, and private bonds. Others, however, believe the risks involved should be borne by the principals, and the current Federal program appears to support this view.

1/Principal risks include a guaranteed waste stream, system reliability, technological and mechanical obsolescence, economic viability, and product marketability.

2/"Fourth Report to Congress, Resource Recovery and Waste Reduction," Environmental Protection Agency (SW-600).

EPA's draft of a strategy for the implementation of RCRA 1/ says that the Agency probably will not be able to provide sufficient technical assistance in all areas of solid waste management because of its limited funds and manpower and the program's broad scope. As a result, the Agency has adopted a system of priorities, placing hazardous wastes management and the development of State solid waste management plans at the top.

EPA officials feel that in view of the Agency's priorities, it seems probable that EPA will provide only minimum assistance in evaluating, procuring, and implementing resource recovery systems at the State and local level and that this situation will continue through fiscal year 1979. The fiscal year 1979 panels program budget is expected to be about $4.8 million.

FINANCING PROBLEMS

The difficulty of financing the capital costs of commercial plant construction is a major barrier to the swift implementation of waste-to-energy systems. Plant costs are highly site-specific and difficult to estimate. Depending on their scale and the technology employed, they can cost $50 million or more.

Some firms which build power plants and chemical plants consider the development and construction of waste-to-energy plants a logical extension of their businesses, and some have participated in federally sponsored demonstration projects. However, information developed by EPA indicates that nearly all such firms lack the financial resources to assume liability for more than one or two resource recovery systems. EPA concludes, therefore, that the role of the private sector in financing recovery plants may be severely limited.

Members of the investment community have expressed concern as to the technological and economic uncertainties of such ventures. Representatives of prominent investment firms told a House Subcommittee 2/ that in their opinion financial

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1/"Draft Strategy for the Implementation of the Resource Conservation and Recovery Act of 1976," Environmental Protection Agency, Dec. 5, 1977, pp. 3-6 and 17-34.

2/"Solid Waste-Materials and Energy Recovery," House Rep. No. 94-1319, Committee on Government Operations, June 30, 1976, p. 22.

The number of awards, 17, was only 8 percent of the 201 applications, and the amount funded, $790,000, was only 7 percent of the $11.7 million requested. An EPA official said no fiscal year 1975 program funds had been appropriated for these grants and the Agency was able to divert only a limited amount of money from another program.

RCRA, enacted in October 1976, made implementation grants to State and local governments conditional to the existence of State solid waste plans which meet the minimum requirements stipulated in the act and are approved by EPA. EPA officials reported that fiscal year 1978 and fiscal year 1979 grant funds have been authorized, but it is not likely that any implementation grants will be awarded before fiscal year 1980 because of the time needed to develop State plans and have them approved.

Loan guarantees

The Energy Conservation and Production Act of 1976 (P.L. 94-385) authorizes loan guarantees to encourage implementation of renewable resource energy measures. The authorization expires at the end of fiscal year 1979. DOE has promulgated rules 1/ listing eligible energy measures. These include urban-waste-fired boilers partially or entirely fueled by refuse-derived fuel, and urban waste pyrolysis systems. However, while loan guarantees up to $2 billion have been authorized, an appropriation to provide funds for possible default payments under the loan guarantees has not been requested. A DOE official said the appropriation was not requested to avoid conflict with similar provisions and amendments proposed for inclusion in the National Energy Act. The act passed by the Congress on November 9, 1978, however, does not provide loan guarantees for urban waste-to-energy systems.

The Department of Energy Act of 1978--Civilian Applications (P.L. 95-238) also authorizes loan guarantees to foster a demonstration program which includes the production of alternative fuels from MSW. The House and Senate, however, differ on whether to appropriate funds that might be necessary in connection with a loan guarantee program and the fiscal year 1979 appropriation (P.L. 95-465) passed by the Congress on October 17, 1978, does not include such funds.

1/Federal Register, (Vol. 42, No. 142), July 25, 1977, p. 37795. These rules were actually proposed by the Federal Energy Administration before DOE was established. After the establishment of DOE, these rules fell within DOE's authority.

Federal financial assistance limited and conditional

The Congress has authorized the use of Federal grants and loan guarantees to encourage implementation of resource recovery systems. 1/ Seventeen implementation grants were awarded in 1975, but there have been none since. Loan guarantees were authorized in 1976 and 1978 legislation but funds to support the guarantees have not been appropriated.

Implementation grants

In 1975, EPA instituted an implementation grants program for State, regional and local governmental agencies. The grants were intended to demonstrate proper planning practices and to stimulate implementation of resource recovery systems. To be eligible applicants were required to

--submit detailed work plans leading directly to implementation, and

--demonstrate their commitment by providing cash or in-kind services for at least 25 percent of pre-design and pre-construction costs.

A comparison of the grants awarded with the applications received shows the following results.

	Mar. 1975 (note a)	Oct. 1975 (note b)	Total
Applications received	102	99	201
Amount requested	$7.2 million	$4.5 million	$11.7 million
Average request	$70,588	$45,455	$58,209
Grants awarded	8	9	17
Amounts awarded	$440,000	$350,000	$790,000
Average award	$55,000	$38,889	$46,471

a/Only energy recovery projects were eligible.

b/Energy recovery, materials recovery, source separation, and waste reduction projects eligible; four of the nine grants awarded were for source separation projects.

1/See app. IV, p. IV-1.

Financial assistance

--Low-cost Federal loans and/or loan guarantees.

--Price guarantees for the various energy forms produced and materials recovered.

Regulatory changes

--Assurance that inclusion of MSW energy investment costs will be allowed in a utility rate base.

--Resolution of environmental uncertainties, particularly air quality control requirements.

--Adjustment of discriminatory freight rates in the shipping of recycled materials.

--Deregulation of the price of domestic fuels now price controlled.

The Resource Conservation Committee

RCRA established the interagency Resource Conservation Committee 1/ to conduct a complete investigation into the economic, social, and environmental consequences of resource conservation including determination of which incentives and disincentives are appropriate to foster use of MSW energy systems.

The Committee's work will cost an estimated $2 million, and it is required by law to report its findings to the President and the Congress with specific recommendations including needed legislation.

Two reports have been issued to date, but neither discusses incentives needed to foster use of MSW systems. 2/

1/The Committee is chaired by the Administrator of EPA and includes the Secretaries of Commerce, Labor, Treasury, and Interior, the Chairman of the Council on Environmental Quality, and representatives from the Office of Management and Budget and Council of Economic Advisors.

2/Reports entitled "Implementation Plan for the Resource Conservation Committee," and "Committee Findings and Staff Papers on National Beverage Container Deposits," issued by the Committee on June 9, 1977, and Jan. 23, 1978, respectively.

INCENTIVES LACKING

There are no incentives available aimed specifically at stimulating the widespread commercial application of waste-to-energy systems. This requires extensive interaction and cooperation between municipalities, firms that manufacture, construct, or utilize waste-to-energy systems, and the utilities which are the primary consumers of the fuels or the steam or electricity produced. The actual conversion facilities could be owned or operated by any one of the three.

Many industrial firms, utilities, and financial institutions are reluctant to participate in urban waste-to-energy projects without provision of incentives at the Federal and State level. The primary reasons are the high capital cost of commercial plant construction and uncertainties as to marketability of the energy forms produced and the materials recovered during conversion.

Utilities are for the most part able to pass along to their customers the high costs of conventional fuels and see little reason to invest in waste-to-energy systems or to use fuels produced by these systems. In addition to technological considerations discussed later in this chapter (see p. 4-15), utilities are concerned about uncertainties in pollution control laws and State variations in their enforcement, and the likelihood that MSW energy investment costs will not be allowed in their rate base.

The reluctance of utility companies to support the widespread use of MSW conversion systems is considered a major barrier since the utilities would be the basic customers for the refuse-derived fuel produced.

According to government studies, system suppliers, industry and utility representatives, and members of the investment community, desirable incentives would include:

Tax policy changes

--Tax exempt status for corporate bonds used for investing in urban waste-to-energy projects.

--Tax incentives such as property tax exemptions, accelerated depreciation, or investment tax credits.

--Higher import taxes on fuels.

The Committee's priorities may also prove detrimental. The question of economic incentives and disincentives, such as subisidies for resource recovery and discriminatory freight regulations which are of immediate importance in the development of materials markets, are near the bottom of the Committe's scheduled activities and run the risk of not receiving adequate attention. We believe it is important that the Committee allocate adequate time, staff, and money to give them the detailed attention they require.

MARKETING PROBLEMS

The marketability of the energy produced and the materials recovered must be demonstrated if the private financial community is to finance large-scale conversion systems. Markets have to be identified and developed. The Department of Commerce has responsibility for furnishing Federal assistance in this effort.

Department of Commerce unable to meet its responsibility

RCRA directs the Secretary of Commerce to stimulate broader commercialization of proven resource recovery technologies and encourage the development of markets for recovered materials.

Commerce instituted two projects, both of which have been hampered by a lack of funds. One being done in-house involves the identification and development of markets for recovered materials. The other by Commerce's National Bureau of Standards involves the analysis and sampling of RDF and of recovered materials to determine their characteristics and uses.

Project to identify and develop markets

This project, undertaken by the Commerce Department's Industry and Trade Administration, 1/ was to have been done in two phases:

--Phase 1, completed in early 1978, identified the geographic location of potential markets for various non-energy products. This information was to be used in accomplishing the project's second phase.

1/Formerly the Bureau of Domestic and International Business Administration.

The first described the Committee's implementation plan. The second reported on the national beverage container deposit issue. The Committee's future work includes consideration of the solid waste product charge issue (i.e., levies on materials which reflect the cost of their ultimate disposal). The Committee will also review a full range of alternative, potential, and existing policy issues, including subsidies for resource recovery, depletion allowances, capital gains, tax incentives, and freight regulations.

Committee's performance and program give cause for concern

The Committee has gotten off to a slow start and its implementation plan drew considerable criticism from industry associations and public interest groups.

The questions of staffing levels and resource commitments by contributing agencies were not resolved for 8 months, one-third of the time allotted for the investigation, and much of the Committee's work has fallen on an EPA staff which is finding it difficult to meet its own Agency's responsibilities under RCRA. Also, it was not until late 1977 that DOE was officially represented 1/ on the Committee.

In addition, several industry associations and public interest groups have criticized the Committee's implementation plan. Some said it did not provide the essential detailed information needed for policy making. They are concerned that the Committee

--lacks funds for the development of data bases and analytical techniques for the quantification and concrete comparison of alternative policies;

--relies too much on existing studies and appears willing to accept "rough estimates" of the relative impacts of alternative solid waste management policies, which will result in a study more superficial than the Congress intended; and

--lacks a formal mechanism to assure continued, frank communication between the Committee and the private sector.

1/Prior to establishment of DOE in October 1977, neither ERDA nor the Federal Energy Administration was officially represented on the Committee although both agencies had a mandated involvement in the development and implementation of urban waste conversion technologies.

expeditiously accomplish virtually identical tasks assigned these agencies under RCRA in October 1976. Their interagency agreement in this regard was not completed until May 30, 1978.

TECHNOLOGICAL UNCERTAINTIES

Technological uncertainties also hamper the near- and mid-term use of MSW energy conversion systems. A study for DOE completed in May 1977 1/ identified technological factors that inhibited the participation of investor-owned utilities in energy recovery projects. It found that utilities are afraid that the burning of refuse as a supplemental fuel will clog equipment, accelerate corrosion, or create other technical or environmental problems. It recommended that Federal agencies provide additional research, development, and demonstration (RD&D) programs and that they evaluate the possibility of using applied European technology. The Federal Government has done little to resolve such important near-term problems. Two recent examples demonstrate the inadequacies of its efforts.

A Tennessee Valley Authority (TVA) study completed in July 1976 2/ examined the feasibility of adapting TVA steam plants to burn refuse as a supplementary fuel. It also examined the economic feasibility of using methane or methanol derived from waste as a peaking turbine fuel. It concluded that solid, gaseous, or liquid fuels could be derived from solid waste, but that further tests would be needed to determine the effects of burning such fuels in the TVA system. These tests have not been made.

EPA has sponsored one demonstration of the use of RDF in a conventional utility boiler. The St. Louis project (see p. 2-5), which was completed in the fall of 1976, demonstrated in the opinion of many reseachers that RDF can be burned successfully in large pulverized-coal-fired boilers. Further testing of this technology appears warranted and TVA has

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1/"Overcoming Institutional Barriers to Solid Waste Utilization as an Energy Source," done by Gordian Associates, Inc., for the Department of Energy (then the Federal Energy Administration's Office of Synfuels, Solar and Geothermal Energy, contract no. FEA-CO-04-50172-00), May 1977.

2/"Study of the Feasibility of a Regional Solid Waste Derived Fuel System in the Tennessee Valley Authority Service Area," TVA publication PRS-8, sponsored by EPA, DOE, and TVA, July 1976.

--Phase 2 was to determine the most favorable market locations for resource recovery systems, using a site selection model developed by Mitre Corporation. This part of the project was abandoned when the Office of Management and Budget (OMB) cut the $418,000 required from the Department's budget. A Commerce official told us that attempts to have these funds reinstated have been unsuccessful.

Project to characterize materials and fuels

The second project, in its National Bureau of Standards, was intended to characterize samplings of RDF and materials recovered from urban waste-to-energy systems.

With respect to fuels, the project would:

--Sample raw refuse to determine heat values and moisture content.

--Evaluate corrosion properties of RDF (an important consideration with respect to their being used by utilities).

--Develop standards for RDF and determine the storability qualities of these fuels.

--Determine the effects of seasonal variations in the waste stream on fuel qualities.

With respect to material recovered, the project would:

--Develop specifications for various materials recovered from MSW to help determine their suitability for use in particular products and processes.

--Determine uses for incinerated ferrous metals.

The Bureau says the project has also been stalled by the lack of requisite funding.

OMB rejected Commerce's request for a $1 million supplemental appropriation for this purpose in fiscal year 1978. OMB took the position that money for this purpose must be gotten from the "lead agency"--in this case EPA.

A Bureau official told us he is not optimistic the funds will be provided since EPA has but limited funds available for resource recovery and conservation efforts. (See pp. 4-6 and 5-4.) Also, there is a need for Commerce and EPA to

CHAPTER 5

FEDERAL URBAN WASTE TECHNOLOGY

PROGRAM NEEDS IMPROVEMENT

Some energy researchers feel pyrolysis and anaerobic digestion systems, though not yet commercially proven, could be economical and effective means of MSW resource recovery in 5 to 10 years. Many technological and economic uncertainties must first be resolved, however. By Congressional direction, Federal research programs have been initiated in these areas, but they are fragmented, underequipped, and need to be improved.

The Congress has given EPA and DOE responsibility for developing and participating in programs for the research, development, and demonstration of new and emerging urban waste-to-energy technologies. 1/ Their programs, however, lack a specific strategy and the necessary financial and manpower support.

EPA's RD&D PROGRAM

In 1967, EPA began to participate in the RD&D of new and improved methods for processing and recovering both materials and energy from solid wastes. Administration of this resource recovery program is shared by the Office of Research and Development and the Office of Solid Waste. The principal objectives of EPA's program are

--the attainment of a more cost-effective system of solid waste management through resource recovery and

--reduction and control of undesirable environmental impacts resulting from waste utilization in various fuel technology operations.

The waste-to-energy research program has four major areas of emphasis,

--municipal waste co-firing with coal, oil, or industrial waste;

1/See app. IV, p. IV-1.

suggested that components of its system be used for this purpose, but neither EPA nor DOE has plans for tests at TVA in their RD&D programs. DOE said its future work on boiler corrosion problems is expected to be minor. EPA's next demonstration of an RDF technology will not take place until fiscal year 1981.

Demonstration projects

EPA's August report also shows they have supported seven demonstration resource recovery technology projects. Four of the ongoing projects demonstrate waste-to-energy processes and three of these involve technologies not yet commercially proven (i.e., pyrolysis and aerobic digestion).

Project location	Purpose/time period	Total cost (thousands)	EPA share (thousands) (note a)	%
Energy projects:				
St. Louis, Mo.	Burn processed solid waste (RDF) with coal at a steam power plant, and recover ferrous metals (July 1970 to Nov. 1976)	$ 3,889	$ 2,580	66
Mountain View, Calif.	Recovery of methane from a sanitary landfill (July 1974 to May 1978)	677	260	38
Baltimore, Md.	Pyrolyze solid waste to gas to generate steam and char, and recover ferrous metals and glass (Jan. 1973 to Apr. 1978)	b/31,250	7,200	23
San Diego County, El Cajon, Calif.	Pyrolyze solid waste to fuel oil and char, and recover ferrous metals, aluminum, and glass (Dec. 1974 to May 1978)	c/14,500	4,263	29
Wilmington, Del.	Burn processed solid waste (RDF) with sewage sludge in waterwall steam generator. Aerobic digestion of sludge to produce humus. Recover ferrous metals, aluminum, and glass (Oct. 1977 to July 1982)	c/32,000	9,000	28
Materials projects:				
Franklin, Ohio	Recovery of paper fibers, magnetic metals, aluminum, and color-sorted glass (Mar. 1969 to Mar. 1976)	3,105	2,154	69
Sommerville and Marblehead, Mass.	Source separation and combined separate collection of paper, metals, and glass (July 1975 to June 1979)	252	81	32
Total		$85,673	$25,538	30

a/EPA share of costs represents demonstration grants from Office of Solid Waste.

b/Updated to reflect additional $4.6 million for modifications to the plant--electrostatic precipitator, fan, and stack.

c/Updated to reflect later information provided by NCRR.

--municipal waste co-combustion with sewage sludges;

--pyrolysis and bio-conversion processes; and

--assessment RD&D (environmental, technical, and economic).

From fiscal year 1967 to fiscal year 1976, EPA's Office of Research and Development spent about $23.4 million on resource recovery RD&D, with major concentration on waste-to-energy technologies. During this same period, EPA's Office of Solid Waste spent more than $25.5 million for demonstrations of resource recovery processes.

Research projects and analytical studies

EPA's August 1977 report to the Congress 1/ showed the Agency supporting 53 research and development projects and studies in the area of resource recovery and waste reduction. As shown in the following table, 28 of these projects involved recovery of energy from MSW and received $6.3 million of the $8.25 million total expended.

Table X

Summary of R&D Projects and Studies

Resource recovery category	Office of Solid Waste No.	Office of Solid Waste Amount (thousands)	Office of Solid Waste %	Office of R&D (note a) No.	Office of R&D (note a) Amount (thousands)	Office of R&D (note a) %	Totals No.	Totals Amount (thousands)	Totals %
Materials (note b)	12	$ 607	30	6	$ 478	8	18	$1,085	13
Energy:									
MSW	4	1,050	53	24	5,248	84	28	6,298	76
Biomass (note c)	-	-	-	5	535	8	5	535	7
Energy Subtotal	4	1,050	53	29	5,783	92	33	6,833	83
Technical support (note d)	2	331	17	-	-	-	2	331	4
Totals	18	$1,988	100	35	$6,261	100	53	$8,249	100

a/R&D = research and development.

b/Projects or studies dealing with recovery of materials and no energy component identified.

c/Projects or studies having primary emphasis on use of agricultural and forestry wastes as fuels or feedstocks for energy conversion processes (e.g., pyrolysis, acid and enzymatic hydrolysis).

d/Provision of technical support to branches within EPA, e.g., support in evaluating specific technical issues and in aiding local, State, and Federal programs on implementation of resource recovery facilities.

1/"Fourth Report to Congress-Resource Recovery and Waste Reduction" (SW-600), prepared by Office of Solid Waste, U.S. Environmental Protection Agency, Aug. 1, 1977.

of fuels from organic materials. About $3.2 million was spent in 1976 for urban waste projects and about $10 million in obligations was outstanding in fiscal year 1977. ERDA's research and development projects and studies in this area during fiscal year 1977 included:

Category	No.	Amount (thousands)	Percent
Materials recovery	3	$ 705	7
Energy recovery:			
MSW	13	8,075	85
Industrial wastes	2	304	3
Subtotal	15	8,379	88
Air/water pollution from MSW energy systems	4	425	5
Total	22	$9,509	100

Seven energy recovery projects involved thermochemical 1/ processes and eight emphasize biochemical 2/ methods. The thermochemical projects were divided about equally between pyrolysis and direct conversion technologies. Seven out of eight biochemical projects were on anaerobic digestion, the biochemical process nearest to commercialization. The eighth was on enzymatic hydrolysis development. 3/

Program emphasis is expected to continue along the present lines. Additional work in combustion systems is expected to be minor and will relate to boiler corrosion problems and boiler design. The agency's urban waste technology expenditures are expected to be about $11 million in fiscal year 1978. In fiscal year 1979 it is estimated they will drop to around $8.5 million.

1/Thermochemcial processes utilize heat or chemicals to rearrange the molecular structure of biomass energy sources.

2/Biochemical processes utilize micro-organisms to decompose organic matter into simpler compounds.

3/See p. 2-1 for an explanation of the developmental status of this technology relative to MSW energy conversion.

Urban waste-to-energy
RD&D given low priority

Discussion with EPA officials and our review show that relatively low priority has been given resource recovery RD&D. The Agency's first solid waste management priority is the regulation of hazardous wastes. Resource recovery with an emphasis on energy production is secondary.

An EPA official said that RD&D budget cuts by OMB usually affect resource recovery programs (both energy and non-energy related). During the decade 1967-1976, EPA expenditures in this area have totaled about $50 million, an average of about $5 million per year. 1/ In fiscal years 1975, 1976, and 1977, OMB cuts amounted to $1.5 million, $3.4 million, and $6.5 million, respectively. The Agency's expenditures on waste-to-energy technologies in fiscal year 1977 were about $4.9 million, and for fiscal year 1978 are expected to drop to about $4.4 million.

DOE'S RD&D PROGRAM

EPA is not the only agency mandated to research, develop, and demonstrate waste-to-energy technologies. A former Energy Research and Development Administration (ERDA) MSW-to-energy program, now at DOE, is similar in purpose to EPA's program.

This program, now housed in DOE's Office of Conservation and Solar Applications, considers economic, institutional, environmental, and technical problems of urban waste processing. It involves research and investigation of direct combustion, pyrolysis, biological/biochemical conversion, and hydrolysis, and it includes the development and testing of equipment and large-scale experiments. DOE's national plan for energy RD&D gives waste-to-energy technologies a high priority in the near- and mid-term. 2/

DOE's urban waste technology program began in December 1975, with an appropriation of $1 million to ERDA for research and development of urban waste recycling and the development

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1/Represents funds provided by EPA's Office of Research and Development and Office of Solid Waste.

2/"A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future," ERDA 76-1, Energy Research and Development Administration, Apr. 15, 1976, pp. 28, 30.

In its April 12, 1977, response to the Senate Appropriations Committee, the agency reported that the above study indicated that "* * * the most effective operational mode was to maintain ERDA's waste and residual programs as they are presently organized since they reflect the institutional alignments inherent in waste and residual activities." The agency's response did not accurately reflect the study's conclusion that ERDA's program was deficient and needed improvement.

A DOE official told us the urban waste technology program has not been changed substantially since its transfer from ERDA. It still does not have a clear-cut overall strategy to provide for its coordination with other Federal agencies such as EPA or Commerce, and continues to be funded at a level which does not reflect the priority assigned to this technology in the agency's RD&D plan. DOE's $8.5 million program budget request for fiscal year 1979 is, in fact, more than $2 million lower that its fiscal year 1978 funding level.

LACK OF COORDINATION A SERIOUS PROBLEM

In many cases the EPA and DOE programs for the development of waste-to-energy conversion systems focus on the same technologies; both support RD&D projects in anaerobic digestion, on pyrolysis, and on combustion. The two agencies agreed in May 1976 to coordinate planning and exchange information, but little effort has yet been made to accomplish these goals. Officials in both agencies told us

--they rarely receive each other's progress reports and other sources of information;

--they are in infrequent contact, as seldom as once every 3 or 4 months;

--they are rarely informed of contracts awarded by each other;

--their research projects are not reviewed for possible duplication prior to being awarded; and

--their program plans are still usually developed independently.

Waste-to-energy RD&D falls short of meeting the stated goals and objectives of the agencies' programs and does not reflect the emphasis called for in the legislative mandates.

DOE's most ambitious current MSW project is a demonstration of anaerobic digestion at a privately owned and operated landfill in Pompano Beach, Florida. (See p. 2-13.) It is financed by a $3.6 million grant from DOE.

DOE's waste-to-energy program priority not reflected in agency's RD&D efforts

DOE's national plan for energy RD&D gives near- and mid-term waste-to-energy technologies high priority as a means of helping to meet the demand for alternative sources of energy. The agency's commitment to its urban waste technology program, however, has not been consistent with the ambition and has been criticized as insufficient by the Congress.

The Senate Committee on Appropriations, the House Committee on Goverment Operations and the congressional Office of Technology Assessment 1/ have expressed concern that ERDA had not given enough attention to the development of waste-to-energy technologies. In response to this criticism the agency commissioned a study 2/ of its activities in this area. The findings showed

--ERDA's mandate and strategy in energy from waste RD&D had not been made sufficiently clear;

--the high priority accorded waste-to-energy technologies in the national plan was not reflected in the funding of the agency's urban waste technology program; and

--the agency's urban waste-to-energy projects were dispersed in three divisions causing a detrimental separation of research activities.

The agency's fiscal year 1977 budget for its waste-to-energy program was less than $5 million, about half that of its fuels from biomass program, which received $9.7 million and had a long-term low priority.

1/Senate Rept. 94-991, House Rept. 94-1319, and the Office of Technology Assessment's Comparative Analysis of the ERDA-76 Plan and Program.

2/"Organization of Waste Materials RD&D at ERDA," Dec. 31, 1976.

CHAPTER 6

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

CONCLUSIONS

Municipal solid waste is a promising new inexhaustible domestic energy source. Its conversion to energy can be a practical and economic means of helping to alleviate our Nation's energy, material resource, and solid waste disposal problems. Technologies for converting this resource to energy and recovering valuable materials are available, have been commercially proven, and are used extensively for energy conservation in Western Europe. In spite of the benefits, use of MSW energy systems in the United States is not widespread due largely to barriers which are institutional or economic in nature. Federal assistance is necessary to overcome these barriers and accelerate the use of urban waste-to-energy systems in the near- and mid-term.

Existing legislation provides the basis for furnishing that assistance, but the current Federal waste-to-energy program suffers from low priorities, inadequate funding levels, and fragmentation within several agencies with similar and overlapping authorities. The current program is not effectively coordinated and lacks a specific strategy. It can be improved by development of a detailed, comprehensive inter-agency plan which is supported with adequate resources including the technical and financial assistance needed to assure near-term completion of U.S. urban waste-to-energy projects in advanced planning or preliminary study stages. These projects will serve as examples for others and provide a base for expansion of the benefits they can provide.

The recovery of energy through the combustion of MSW is a well-established technique for conserving energy in Europe, but its use is not widespread in the United States. Western Europe has 181 operational plants converting waste to energy. The United States has 20 such plants operating. These systems are not used widely in the United States because in the past abundant land, material, and energy resources made them uneconomic. The economics are now changing. Conventional methods of waste disposal--incineration, landfill, or ocean dumping--are being disallowed or becoming more costly due partly to strict enforcement of environmental regulations and the lack of suitable landfill space near urban areas. Also, the rising cost of conventional fossil fuels has improved the competitiveness of alternate fuels. The Nation is beginning to respond to the new situation and opportunities, but the rate of response can be improved.

MSW is abundant and growing in volume, but projections show only small amounts will be converted to energy. EPA estimates that about 1 million tons of MSW per year, less than 1 percent of the MSW produced, will be processed for energy by 1979. NCRR says that about 10 million tons per year, less than 6 percent of the MSW produced, will be converted to energy by the early 1980s. By 1985, EPA estimates 201 million tons of MSW will be generated annually and that 112 million tons will be available for conversion to energy. Agency projections indicate, however, that based on present trends and policies, only 10 to 20 million tons of these wastes could be processed for energy and material recovery. We feel a very real potential exists for increasing substantially the amount of MSW converted by 1985.

We identified 131 MSW energy projects in the United States, 20 operational, 10 under construction, 30 in the planning phase, and 71 in preliminary study stages. If these 131 projects were all fully operational by 1985, they could process about 36 million tons of MSW--18 percent of urban waste produced. The energy recoverable by these projects, including the recycling of recovered metals, and the extraction of methane from existing landfills could provide the Nation with annual energy savings equivalent to about 48 million barrels of oil now worth almost $700 million. An expansion of these projects could realistically be expected to provide by 1995 annual energy savings equivalent to some 158 million barrels of oil with a current value of about $2.3 billion. These projects could help reduce our growing waste disposal load in an economical and environmentally acceptable way.

Increased use by 1985 is possible if the Federal program for providing needed assistance is improved

An active role by the Federal Government is necessary if technologically and economically viable waste-to-energy systems are to be used on an accelerated schedule in the near- and mid-term, and the Federal program for providing needed assistance must be improved. State and local governments, working with private industry, provide the prime impetus for the 131 MSW energy projects in the United States. Many of these governments and other organizations look to the Federal Government for technical or financial assistance, advice, and encouragement. Existing legislation provides the basis for the Federal role in the development and commercialization of MSW energy systems, and responsibility for administering the legislation has been assigned to EPA, DOE, and Commerce. We have reviewed program elements at each of these agencies and have found a Federal Urban Waste-to-Energy Program which appears fragmented, uncoordinated, inadequately funded, uncertain in its priorities, and lacking in detailed overall strategy. More specifically, we found that:

--Both DOE and EPA plan their activities largely independently of each other in spite of their similar and overlapping authorities and a May 7, 1976, interagency agreement to coordinate their planning and facilitate information exchange.

--Commerce Department efforts to stimulate broader commercialization of proven resource recovery technologies, develop specifications, and identify markets for recovered materials have been stalled by lack of funds. Also, an interagency agreement with EPA to resolve nearly identical responsibilities between these agencies has not yet been implemented.

--EPA has given regulation of hazardous wastes its top solid waste management priority and has not committed the human and financial resources required to carry out the overall resource recovery provisions of its mandate.

--EPA and Commerce budget requests for meeting their responsibilities under the Resource Conservation and Recovery Act of 1976 have frequently been cut and in some cases disallowed by OMB.

--DOE funds its urban waste technology program at a level inconsistent with the high priority assigned this technology in its national plan for energy RD&D, and it lacks a specific strategy for the development and implementation of MSW conversion processes.

--Loan guarantee programs authorized by the Energy Conservation and Production Act of 1976 and the Department of Energy Act of 1978 have not been funded. At present, there are no Federal economic incentives designed specifically to encourage the use of MSW energy systems on a broad scale.

If the Federal Urban Waste-to-Energy Program is improved to provide needed information, assistance, and incentives, it is possible that many MSW energy systems now in a planning or study phase could accelerate their efforts and be implemented and become operational by 1985. These projects can provide the foundation for what can be a valuable new source of alternate fuels for our national energy system, and potential annual energy savings equivalent to 48 million barrels of oil by 1985 and 158 million barrels by 1995 could be realized.

We believe needed program improvements include:

--A cohesive and specific overall strategy for all involved agencies which takes into account the skills and expertise dispersed through these agencies, any organizational realignments or transfers of responsibilities which will facilitate the program, adequacy of funding levels, and the timely completion of agreements needed to keep overlap to a minimum.

--A more useful flow of information and an expansion of practical outreach service to State and local governments and to public and private researchers. This will provide a forum for the exchange and dissemination of technical and economic data and help identify and resolve institutional problems and concerns.

--An expansion of studies and research on the development and application of new and improved methods of processing and recovering materials and energy, the development of specifications and identification of markets for recyclable materials, and the development of new uses for these materials. This will help resolve technical, economic, and environmental uncertainties regarding the conversion processes, the energy forms produced, and materials recovered.

--Provision of adequate technical and financial assistance to communities evaluating or acquiring MSW energy systems, with appropriate emphasis on encouraging timely implementation of technologies which have been proven in commercial applications.

--Provision of incentives to ensure the marketability of energy forms produced and materials recovered, and to encourage investment in MSW energy systems. This will require the timely determination of which subsidies and economic incentives best foster the use of MSW energy systems and require advising the Congress as to which are needed for encouraging the use of these systems in the near- and mid-term.

Most commercially available MSW energy systems are capital-intensive and involve the economic uncertainties common to new technologies. We believe that provisions of technical and some limited financial assistance and incentives by the Federal Government to encourage investment in them are essential if all near-term benefits attainable by 1985 are to be realized.

In our August 1976 report on emerging technologies 1/ we concluded that commercially available municipal waste-to-energy technologies were cost-effective and that proper Federal financial assistance could hasten and maximize their use. We further concluded that Federal loan guarantees appeared to be a preferred mechanism for accelerating their use by utilities and municipalities. Funds for this purpose have been authorized by the Congress, and we feel they should be made an integral part of the incentives package developed as part of the urban waste-to-energy plan and program improvements we are recommending.

RECOMMENDATIONS TO AGENCIES

To ensure that greater use of commercially proven MSW energy systems is encouraged and that developing urban waste-to-energy technologies are commercialized in a timely manner, we recommend that the Administrator of EPA, in consultation with the Secretaries of Energy and Commerce and in coordination with other Federal agencies, State and local governments, private industry, and public interest groups, develop and submit to the Congress by September 30, 1979, a detailed 10-year plan describing the specific strategy for the Federal Urban Waste-to-Energy Program. This plan should be updated and submitted annually. The interagency plan should:

--Specify goals and objectives with appropriate emphasis on commercialization and research, development, and demonstration activities which must take place by 1985 if the Nation is to realize the full potential of MSW energy systems in the 1985 to 2000 time frame.

--Define the specific roles and responsibilities of DOE, EPA, Commerce, and any other Federal agencies involved in this effort, giving full consideration to the skills and expertise dispersed through these agencies and any organizational realignments or transfers of responsibilities which will minimize overlap of functions and lead to improved effectiveness of program operations.

1/"An Evaluation of Proposed Federal Assistance for Financing Commercialization of Emerging Energy Technologies," EMD-76-10, Aug. 24, 1976, pp. 47 and 54.

--Provide for the expeditious finalization of all relevant interagency agreements consistent with the plan.

--Establish time frames and resource requirements for accomplishing the plan's purpose, and identify alternative financing options and the specific type and timing of Federal assistance by each agency needed to facilitate completion of projects in advance planning and preliminary study stages. Especially important would be identification of the roles loan guarantees should have in support of MSW projects, and the amount of financial risk which might require Federal guarantees.

--Provide for incentives which best foster the use of MSW energy systems and their products, including technical and limited financial assistance aimed specifically at encouraging the timely completion of all 131 MSW energy projects. Particular emphasis should be given to those projects employing commercially available technologies. These projects would then serve as examples for other projects yet to be developed and minimize or eliminate the need for substantive, long-term Federal involvement.

--Provide for an improved information and education program to furnish States and local governments with a maximum flow of information and practical assistance regarding such matters as system planning, acquisition, and implementation; Federal financial guarantees; sale and use of plant output; and needed compliance with relevant environmental standards.

--Include milestones for measuring progress in meeting the plan's goals and objectives.

--Include as appendixes the separate views of the Departments of Energy and Commerce.

AGENCY COMMENTS

Comments on a draft of this report were solicited from EPA and the Departments of Energy and Commerce. Written comments were received from the latter two agencies. (See apps. V and VI.) This report was discussed with EPA officials.

DOE and Commerce agreed with the recommendations but believed that DOE or Commerce, not EPA, should have the lead in developing the recommended interagency plan. The Congress, through the Resource Conservation and Recovery Act, has already given EPA responsibility for planning, developing, implementing, and coordinating Federal solid waste management programs and the recovery of resources, including energy, from wastes. Our recommendations are consistent with the act's intent and we believe that the leadership role properly belongs with EPA. However, should EPA not act responsibly in developing and implementing the recommended interagency plan, we would then agree that a leadership change should be considered by the Congress.

Commerce stated that many of the report's numerical values were overstated and should be checked for accuracy and reasonableness. We have checked the report's numerical values for accuracy and reasonableness, and in our report we have accurately presented EPA's projection that in 1985, recovery of resources from 112 of the 201 million tons of MSW produced will be technically feasible.

Commerce also objected to the report's numerical values being stated in millions of barrels of oil equivalency rather than in Btus. Commerce stated that in most cases, municipal solid waste substitutes for coal. We recognize that some of the MSW technologies such as firing RDF in utility boilers do provide for substituting waste for coal. (See p. 2-5.) However, there also exist other commercial and developmental MSW technologies (see p. 2-8) which produce energy forms that provide oil and gas substitutes or make possible retirement of boilers which now burn oil or gas. The report points out that MSW is a promising new inexhaustible and alternative source for a variety of solid, liquid, and gaseous fuels. Expressing potential energy savings from these fuels in terms of millions of barrels of oil equivalents is consistent with energy reports prepared by governmental agencies as well as private industry.

Commerce also stated that GAO believes loan guarantees are extremely important. We disagree with this statement. Our report clearly recommends that the interagency plan to be developed should provide for incentives which best foster the use of MSW energy systems and their products, including technical and limited financial assistance aimed specifically at encouraging the timely completion of the 131 MSW energy projects. Particular emphasis should be given to those projects employing commercially available technologies. These projects would then serve as examples for other projects yet to be developed and minimize or eliminate the need for substantive, long-term Federal involvement. We believe the specific role that loan guarantees should have in support of MSW projects and the amount of financial risk that might require Federal guarantees should be determined as part of the interagency planning effort.

DOE and Commerce also had a number of specific comments regarding information included in the report. We considered each comment carefully in preparing our final report and made revisions as appropriate.

At the request of EPA officials, we discussed the draft report in detail with them and informally obtained their comments. EPA took no exception to the report's conclusions or recommendations. EPA had numerous suggestions for improvements to technical language included in the draft report. We considered all its suggested changes and made appropriate clarifications in the final report.

EUROPEAN WASTE-TO-ENERGY SYSTEMS 1/

The recovery of energy through the combustion of municipal solid waste is a well established technique for conserving energy. Combustion units can produce electricity; hot water for domestic use; and steam for district heating, industrial processes, or the drying of sewage sludge.

There are fewer than 20 such waste-to-energy systems in the United States. In Western Europe, however, 243 combustion units are currently recovering energy from municipal solid waste. The oldest of these facilities went into service before World War II.

Waste-to-Energy Systems in Western Europe

Country	Number of units (note a)	Number of plants (note b)
Austria	2	2
Belgium	3	3
Denmark	45	31
Finland	2	2
France	29	20
Italy	16	14
Luxembourg	1	1
Netherlands	7	6
Norway	13	8
Spain	3	2
Sweden	22	16
Switzerland	33	29
United Kingdom	9	9
West Germany	58	38
Total	243	181

a/A unit is a facility built at one time in a single location.

b/A plant is the building in which one or more waste-to-energy units is installed.

The number of waste-to-energy systems now in service in Western Europe is an indicator of the soundness of this technology.

1/Excerpted from "European Waste-to-Energy Systems, An Overview," Resource Planning Associates, Inc., Washington, D.C., June 1977, prepared for ERDA under contract no. EC-77-C-01-2103.

Luxembourg, Denmark, Switzerland, the Netherlands, Sweden, and West Germany make the most use of combustion with energy recovery. These countries have more than 20 tons of hourly capacity per million inhabitants, or enough to recover energy from the waste produced by 40 percent of the population.

Several factors seem to have encouraged the use of this technology in these countries. They all have concentrated population, their cities are reasonably wealthy, and they have strong manufacturing industries (in particular, the major firms licensing grate design are headquartered in these countries).

Furthermore, they benefit from favorable conditions for the sale of energy. They all have cold weather, which makes district heating attractive, and local electricity producers (unlike the state monopolies of France or Italy), which makes the sale of electricity easier. Costs of alternative means of disposal, such as landfills, are high.

The combustion units are usually located in large cities which often have more than one (e.g., Berlin, Munich, Paris, Stockholm, Oslo). There are two exceptions to this pattern, Denmark and Switzerland. In Denmark, several small towns have incineration units. In Switzerland incinerators are centrally located and serve rural areas. The unit at Monthey, Switzerland, for example, generates electricity with energy recovered from the solid waste of 57 villages.

In Denmark and Norway, small incinerators predominate. Some burn as little as a quarter of a metric ton per hour. In Germany, France, and the Netherlands, large units are most common. The largest European plant, located in Rotterdam, the Netherlands, has 6 units of 20 metric tons per hour capacity each. The largest single furnace is located in Paris, France (Ivry II), and has a capacity of 50 metric tons per hour.

Although 15 percent of the units in Western Europe have a capacity over 25 metric tons per hour and account for 47 percent of total capacity, energy recovery is not limited to large cities.

Units under 15 metric tons per hour account for 26 percent of the total European capacity and 64 percent of the units. These figures show that, although the very large units handle the bulk of the waste from which energy is recovered, the systems for smaller towns (150,000 inhabitants) exist in large number.

SYSTEM CONFIGURATIONS

Waste-to-energy systems generally consist of a furnace, heat recovery equipment (usually a boiler), and some system for making use of the energy recovered (e.g., a steam pipe network or a turbo-generator). Most systems have some form of air pollution control. A few have shredders to process the municipal solid waste before it enters the furnaces. In nearly all the combustion units, energy is recovered through the medium of steam.

The main uses of the recovered energy are to generate electricity; to heat water for domestic use; and to produce steam for district heating, an industrial process, or the drying of sewage sludge. A number of other uses (e.g., heating swimming pools and greenhouses) have been tried or suggested.

Electricity can be produced with a condensing turbo-generator (e.g., the Cheneviers unit at Geneva, Switzerland) which uses all of the steam available. It can also be co-generated along with low pressure steam, using a back-pressure turbo-generator (e.g., as in Munich, West Germany). However, in Europe, the production of electricity is sometimes a state monopoly and, in any case, is subject to many regulations. Institutional barriers are therefore a serious concern in the production of electricity from solid waste.

The use of steam for domestic water heating or district heating generally works best in a new town built in conjunction with the waste-to-energy system. The steam pipe (or hot water pipe) network can then be laid down during initial construction and the community planners can incorporate the heating system into their design.

When sewage sludge is dried, either directly by the combustion gases or indirectly in steam jacketed driers, the dried sludge can be incinerated along with the solid waste. Such a system requires that the combustion unit be built in conjunction with a waste-water treatment facility.

Whatever the end use of the recovered energy, there may well be conflict between its production and the other purpose of the plant--reduction of the volume of municipal solid waste. If the operators see this latter as their overriding purpose, they may choose operating trade offs which maximize availability rather than the efficient production of energy.

POLLUTION CONTROL

Since most Western European waste-to-energy systems are located in urban areas, pollution control is important and becoming more so. Regulations vary from country to country, which means that different pollution control equipment is required.

West Germany has the strictest laws in Western Europe. Stack gases may have no more than 100 mg of particulates per cubic meter. 1/ There are limits on emissions of carbon monoxide, chlorine compounds, and flourine compounds. Since 1974, when these regulations went into effect, new combustion units in West Germany have required electrostatic precipitators followed by at least partial scrubbing.

In other countries, only particulate emissions are regulated, and scrubbers are not needed. In France, for example, the limits for particulate emissions are 600 mg per cubic meter for furnaces with a capacity between 1 and 4 metric tons/hour; 250 mg per cubic meter for furnaces with a capacity between 4 and 7 metric tons/hour and 150 mg per cubic meter for furnaces with a capacity above 7 metric tons/hour. Finally, in some countries, such as Denmark, the regulations are lax enough that most incinerators currently need only multicyclones. It is clear, however, that the trend in all Western European countries is toward stricter regulations of particulate emissions. This means that electrostatic precipitators will be required in nearly all cases. These devices will mean higher capital costs, but no basic technological changes in the waste-to-energy systems.

The use of scrubbers is not widespread. Although the equipment exists, it is very expensive and needs frequent maintenance. It is not certain that, at the moment, any plant operates with continuous scrubbing. For this reason, most countries are hesitant to impose strict legislation until improved scrubbers appear.

TECHNOLOGY

The techniques commonly used to recover energy from municipal solid waste in Western Europe are mature and stable. Most combustion units have good operating records. Most improvements have been in response to changes in the

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1/In the U.S., the national standard for incinerator emissions permits a maximum of 180 mg per cubic meter of particulates. Some States and cities have stricter limits. (GAO note: mg = milligram.)

characteristics of the waste (e.g., more plastics) and stricter pollution control requirements.

Boiler corrosion has been the single most pervasive problem necessitating design changes in the combustion process and the incorporation of a system for cleaning the tubes by physically knocking the tube bundles to shake off soot. Newer units based on the improved design have met with extraordinary success and major corrosion problems have been reduced. 1/ One such unit operated for over 28,000 hours without having to be shut down for cleaning the tubes.

ECONOMICS

The chief alternative to combustion for municipal solid waste is landfilling. Western Europe has historically had high population densities and, as a result, a shortage of land for disposal of solid waste. Thus, the costs of the chief alternative to combustion have been higher there than in the United States.

As the U.S. population density increases, this difference will narrow. If landfill sites can only be found at greater distances from the generators of waste, growing transportation costs will further narrow this difference. The trend to require accounting for environmental costs may well close the gap entirely. As a result, more and more American communities will choose combustion for the disposal of their solid waste.

In this case, the question will arise, is it worthwhile to recover the energy produced in the combustion? The answer depends upon the availability of an appropriate end use for that energy.

Direct use of heat energy avoids the inevitable efficiency losses in the generation of electricity. If the heat can be used for domestic hot water, district heating, or an industrial process near to the combustion plant, the economics may be more favorable. 2/ The recovery of energy from waste can be most cost-effective if the end use is well integrated with the combustion unit (and even the waste collection system). Increasing fuel costs can only reinforce this trend.

1/A waterwall unit based on this improved design is now operating successfully in Saugus, Mass.

2/GAO note: Table on p. I-7 summarizes the economics of several units examined in Resource Planning Associates' case studies.

For example, the solid waste of a Western European town of 150,000 inhabitants can provide district heating for 10,000 housing units. If those housing units and the combustion unit were part of a well integrated plan, the economics might be quite favorable.

The recovery of materials from the residues of combustion may slightly enhance the cost-effectiveness of waste to energy systems. Many plants recover ferrous metals for sale as scrap.

In France, the Bureau des Recherches Geologiques et Minieres (B.R.G.M.), the equivalent of the U.S. Bureau of Mines, has built a pilot plant to recover glass, ferrous metals, aluminum, and other non-ferrous metals from the residues of incineration. This plant has operated satisfactorily since 1974 and a large scale system is contemplated for Paris (Ivry).

If the use of this technique is to spread in this country (and the needs to conserve energy and protect the environment suggest that it should) the lessons of Western European systems can be valuable to those planning for similar systems in the U.S.

Cost Summary of Selected European Waste-to-Energy Systems
(1975 unless otherwise noted)

City and population	Number and size of units	Tonnage of waste incinerated annually	End use of recovered energy	Capital cost	Direct operating cost	Total cost
Toulouse, France 400,000	3 x 8.15 metric tons/hr. (3 x 9 short tons/hr.)	100,000 metric tons (110,000 short tons)	District heating, domestic hot water, electricity for use in plant	FFr 34/metric ton (note a) ($6.80/short ton)	FFr 7/metric ton ($1.40 short ton)	FFr 41/metric ton (note a) ($8.20/short ton)
Brive, France 160,000--area	2 x 3.5 metric tons/hr. (2 x 3.9 short tons/hr.)	30,000 metric tons (33,000 short tons)	Drying of sewage sludge	FFr 27.50/metric ton ($5.83/short ton)	FFr 32/metric ton ($6.77/short ton)	FFr 59.50/metric ton ($12.60/short ton)
Geneva, Switzerland 340,000--canton	2 x 8.3 metric tons/hr. (2 x 9.15 short tons/hr.)	115,000 metric tons (126,000 short tons)	Electricity for sale	SF 22.61/metric ton ($6.87/short ton)	SF 41.64/metric ton ($12.70/short ton)	SF 64.25/metric ton ($19.57/short ton)
Korsor, Denmark 20,000	1 x 2 metric tons/hr. (1 x 2.2 short tons/hr.)	6,500 metric tons (7,150 short tons)	District heating	Kr 82/metric ton ($12.30/short ton)	Kr 38/metric ton ($5.70/short ton)	Kr 120/metric ton ($18/short ton)
Munich, West Germany 1,315,000	2 x 25 metric tons/hr. 3 x 40 metric tons/hr. (2 x 27.5 short tons/hr. 3 x 44 short tons/hr.)	450,000 metric tons (496,000 short tons)	Electricity for sale, district heating	DM 35/metric ton ($11.75/short ton)	DM 12/metric ton (note b) ($4.25/short ton)	DM 47/metric ton (note b) ($16/short ton)

a/Only two furnaces were in operation in 1975.

b/Average of direct operating costs at North and South plants.

APPENDIX I

SUMMARY OF URBAN WASTE-TO-ENERGY PROJECTS--

UNITED STATES (DEC. 1977) 1/

Contents

1/Information sources: Resource Recovery Briefs, National Center for Resource Recovery, Inc., Washington, D.C., Oct. 1977; Solid Waste Facts, Institute for Solid Wastes, Washington, D.C., Sept. 1977; EPRI Journal, Electric Power Research Institute, Palo Alto, Calif., Nov. 1977; Solid Waste Processing Facilities, American Iron and Steel Institute, Washington, D.C., May 23, 1977; McEwen, L.B., Jr., Waste Reduction and Resource Recovery Activities; A Nationwide Survey, Environmental Protection Agency Publication (SW-142), Washington, D.C., 1977; updated through Dec. 1977 by phone survey of sponsoring organizations and individual projects.

Systems in operation (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Groveton, N.H.	MCU	30	Steam	None	10/75	Diamond International Paper Co.	$ 0.3
Harrisburg, Pa.	WWI	720	Steam	Fe	10/72	Pennsylvania Power & light	2.8
Lane County, Ore. (Eugene)	RDF	500	RDF	Fe	12/77	Eugene Water & Electric and Univ. of Oregon	3.5
Milwaukee, Wis. (p. 3-11)	RDF	1,600	RDF	Paper, Fe, Al, glass agr.	5/77	Wisconsin Electric Power Co.	18.0
Nashville, Tenn. (p. 2-4)	WWI	720	Steam	None	7/74	Building complex	26.5
Norfolk, Va.	WWI	360	Steam	None	6/67	U.S. Navy Base	4.3
North Little Rock, Ark.	MCU	100	Steam	None	9/77	Koppers Co.	1.5
Palos Verdes, Calif. (p. 3-15)	Methane recovery	1.1 MMCF/D	Methane gas	None	6/75	So. Calif. Gas Co.	1.5
Portsmouth, Va.	WWI	160	Steam	Fe, Al	8/77	U.S. Navy Base	4.5
Saugus, Mass.	WWI	1,200	Steam	Fe	10/75	General Electric Co.	38.3

APPENDIX II

SUMMARY OF URBAN WASTE-TO-ENERGY PROJECTS--UNITED STATES (DEC. 1977)

Systems in operation (20)

Project location	Process type	Capacity (TPD) (note a)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Ames, Ia.	RDF	400	RDF	Paper, Fe, & Al (note b)	9/75	Ames Municipal Power Plant	$ 6.3
Baltimore, Md. (p.2-9)	Pyrolysis	1,000	Gas to steam	Fe, glass agr. (note c)	6/75	Baltimore Gas & Electric Co.	25.0
Baltimore County, Md.	RDF (note d)	400 to 1,200	RDF	Fe, Al, glass	4/76	TBD (note e)	10.0
Blytheville, Ark.	MCU (note f)	50	Steam	None	11/75	Metal plating industry	0.8
Braintree, Mass.	RWI/WWI (note g)	240	Steam	Fe	9/70	Weymouth Art & Leather Co., and Sigma Industries	3.0
Chicago, Ill. (NW)	WWI	1,600	Steam	Fe	Spring 1972	Industrial park	30.0
East Bridgewater, Mass.	RDF	1,200	RDF	Fe	8/76	Utility plant	14.0
El Cajon, Calif. (San Diego County) (p. 2-11)	Pyrolysis	200	Oil	Fe, Al, glass	12/77	San Diego Gas & Electric Co.	14.5

a/Tons per day.
b/Fe = ferrous metals; Al = aluminum.
c/Glass agr. = glass aggregate.
d/Refuse-derived fuel.
e/To be determined.
f/Modular combustion unit.
g/RWI = refractory wall incineration;
WWI = waterwall incineration.

APPENDIX II

Systems under construction (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Redwood City, Calif. (p. 2-11)	Pyrolysis	100	Gas to steam	Fe	5/78	Pacific Gas & Electric	$ 1.0
Western Lake Superior Sanitary District (N.E. Minn.)	RDF	400	RDF	Fe	12/78	Negotiating with Duluth Transit Co.	60.0

Systems in advanced planning (30)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Beverly, Salem, and Lynn, Mass.	WWI	500	Steam	Fe	1979-1980	United Shoe Machinery and Mass. Electric	30.0
Central Contra Costa County Sanitation District, Calif.	RDF	1,200	RDF	Fe, Al, glass	1979	Central Sanitary District	32.0
Chemung County, N.Y. (Elmira)	Pyrolysis	200	Gas to steam	Fe	1980	A&P Food Processing	5.4
Columbus, Ohio	RDF	2,000	Steam	Fe	Mid-1981	Columbus Municipal Electric	118.0

APPENDIX II

APPENDIX II

Systems in operation (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Siloam Springs, Ark.	MCU	20	Steam	None	9/75	Canning plant	$ 0.4
Tacoma, Wash.	RDF	500	Steam	Fe	12/77	TBD	3.0
Systems under construction (10)							
Akron, Ohio	RDF	1,000	Steam	Fe, non-Fe	12/79	B.F. Goodrich Co., Univ. of Akron	46.0
Albany, N.Y.	RDF	1,200	RDF	Fe	5/79	N.Y. State Office of General Services	11.0
Bridgeport, Conn.	RDF	1,800	Powdered RDF	Fe, Al, glass	3/78	United Illuminating	53.0
Chicago, Ill. (Crawford) (p. 2-6)	RDF	1,000	RDF	Fe, non-Fe	3/78	Commonwealth Edison	19.0
Hempstead, N.Y.	RDF	2,000	Steam	Fe, Al, color-sorted glass	5/78	Long Island Lighting Co.	81.0
Jackson-ville, Fla.	MCU	50	Steam	Fe	3/79	U.S. Navy Base	2.0
Monroe County, N.Y.	RDF	2,000	RDF	Fe, non-Fe, mixed glass	Late 1978	Rochester Gas & Electric Co.	50.4
Mountain View, Calif. (p. 2-7)	Methane recovery	1 MMCF/D	Methane gas	Fe, paper, glass	7/78	Pacific Gas & Electric	0.7

Systems in advanced planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Memphis, Tenn.	RDF	2,000	Steam	Fe, Al, glass	1981	Memphis Light, Gas and Water and TVA	$ 70.0
Minneapolis-St. Paul, Minn.	WWI	1,500	Steam	Fe	1980	Paper mill	73.0
Montgomery County, Ohio (Dayton)	WWI	2,000	Steam	Fe	12/81	Cargill Corp.	67.3
Newark, N.J.	RDF	3,000	RDF	Fe, Al	12/79	Public Service Electric & Gas Co.	70.0
New Haven, Conn.	WWI	1,800	Steam	Fe, Al	1982	United Illuminating	50.0
Niagara Falls, N.Y. (Buffalo)	RDF/WWI	3,500	Steam	Fe	1/80	Hooker Chemicals & Plastic Corp.	70.0
North Andover, Mass.	WWI	3,000	Steam	Fe, non-Fe	12/81	Mass. Electric	108.0
Onondaga County, N.Y. (Syracuse)	WWI	1,000	Steam	Fe	1981	Syracuse Univ., City and County bldgs.	64.8
Pinellas County, Fla.	WWI	2,000	Steam	Fe, Al	Early 1980	Florida Power Co.	70.0
Portland, Ore.	RDF	1,400	RDF	Fe	Mid-1981	Publishers Paper Co.	35.0

APPENDIX II

Systems in advanced planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Dade County, Fla.	WWI/RDF	3,000	Steam	Fe, Al, glass	Spring 1981	Florida Power & Light Co.	$ 82.0
Detroit, Mich.	WWI/RDF	3,000	Steam	Fe	Mid-1981	Public Lighting Comm. or Detroit Edison	100.0
Dutchess County, N.Y. (Poughkeepsie)	Pyrolysis	700	Fuel gas	Fe	7/81	Central Hudson Power & Light	30.0
Guilford County, N.C. (Greensboro)	RDF	1,000	RDF	Fe	1978	Duke Power Co.	1.4
Honolulu, Hawaii	RDF	1,750	Steam	Fe	Early 1983	Hawaii Electric and Hawaii Western Steel	88.0
Long Beach, Calif.	WWI	1,000	Steam	Fe	1982	U.S. Navy Base and Oil Co.	80.0
Los Angeles, Calif. (Wilmington)	RDF	2,000	Steam	Fe, Al, glass, paper	Mid-1981	Atlantic Richfield and Shell	54.0
Mayport, Fla.	MCU	40	Steam	None	10/78	U.S. Navy Base	4.3

APPENDIX II

INCINERATION SYSTEMS

Systems in operation (11)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Blytheville, Ark.	MCU	50	Steam	None	11/75	Metal plating industry	$ 0.8
Braintree, Mass.	RWI/WWI	240	Steam	Fe	9/70	Weymouth Art & Leather Co. and Sigma Industries	3.0
Chicago, Ill. (NW)	WWI	1,600	Steam	Fe	Spring 1972	Industrial park	30.0
Groveton, N.H.	MCU	30	Steam	None	10/75	Paper mill	0.3
Harrisburg, Pa.	WWI	720	Steam	Fe	10/72	Pennsylvania Power & Light	2.8
Nashville, Tenn.	WWI	720	Steam	None	7/74	Building complex	26.5
Norfolk, Va.	WWI	360	Steam	None	6/67	U.S. Navy Base	4.3
North Little Rock, Ark.	MCU	100	Steam	None	9/77	Koppers Co.	1.5
Portsmouth, Va.	WWI	160	Steam	Fe, Al	8/77	U.S. Navy Base	4.5
Saugus, Mass.	WWI	1,200	Steam	Fe	10/75	General Electric Co.	38.3
Siloam Springs, Ark.	MCU	20	Steam	None	9/75	Canning plant	0.4

APPENDIX II

Systems in advanced planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
San Diego, Calif.	RDF	1,400	Steam	Fe	Early 1983	San Diego Gas & Electric	$ 75.0
Seattle, Wash.	RDF	1,500	RDF	Fe, Al, glass	Mid-1980	Boeing, Monsanto, Jorganson Steel	40.0
Sheldon-Arleta, Calif. (p. 2-7)	Methane recovery	2.9 MMCF/D	Methane gas	None	Mid-1979	L.A. Dept. of Water & Power	1.8
S.E. Virginia Regional Solid Waste Processing System, Va. (Portsmouth)	RDF	2,000	Steam	Fe, Al	Mid-1981	U.S. Navy Base	100.0
Tulsa, Okla.	RDF	1,000	RDF	Fe, Al, non-Fe	Early 1981	Public Service Co., Oklahoma	23.0
Westchester County, N.Y.	(a) WWI	1,400	Steam	Fe	9/81	Con. Ed. and County bldgs.	75.0
	(b) RDF	1,200	RDF	Fe	Late 1985	TBD	60.5
Wilmington, Del.	RDF	1,000	Steam	Fe, Al, glass, humus	Mid-1981	Delmarva Power & Light Co.	55.0

APPENDIX II

Systems in Advanced Planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
North Andover, Mass.	WWI	3,000	Steam	Fe, non-Fe	12/81	Massachusetts Electric	$108.0
Onondaga County, N.Y. (Syracuse)	WWI	1,000	Steam	Fe	1981	Syracuse Univ., City and County bldgs.	64.8
Pinellas County, Fla.	WWI	2,000	Steam	Fe, Al	Early 1980	Florida Power Co.	70.0
Westchester County, N.Y. 1/	WWI	1,400	Steam	Fe	9/81	Consolidated Edison, and County bldgs.	75.0

REFUSE-DERIVED FUEL SYSTEMS

Systems in Operation (6)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Ames, Ia.	RDF	400	RDF	Fe, Al, paper	9/75	Ames Municipal Power Plant	6.3
Baltimore County, Md.	RDF	400 to 1,200	RDF	Fe, Al, glass	4/76	TBD	10.0
East Bridgewater, Mass.	RDF	1,200	RDF	Fe	8/76	Utility plant	14.0
Lane County, (Eugene) Ore.	RDF	500	RDF	Fe	12/77	Eugene Water & Electric and Univ. of Oregon	3.5
Milwaukee, Wis.	RDF	1,600	RDF	Fe, Al, paper, glass agr.	5/77	Wisconsin Electric Power Co.	18.0
Tacoma, Wash.	RDF	500	Steam	Fe	12/77	TBD	3.0

1/Two units, WWI and RDF planned; see p. II-14 also.

APPENDIX II

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Systems under construction (1)							
Jacksonville, Fla.	MCU	50	Steam	Fe	3/79	U.S. Navy Base	$ 2.0
Systems in advanced planning (12)							
Beverly, Salem and Lynn, Mass.	WWI	500	Steam	Fe	1979-1980	United Shoe Machinery and Mass. Electric	30.0
Dade County, Fla.	WWI/RDF	3,000	Steam	Fe, Al, glass	Spring 1981	Florida Power & Light Co.	82.0
Detroit, Mich.	WWI/RDF	3,000	Steam	Fe	Mid-1981	Public Lighting Comm. or Detroit Edison	100.0
Long Beach, Calif.	WWI	1,000	Steam	Fe	1982	U.S. Navy Base and Oil Co.	80.0
Mayport, Fla.	MCU	40	Steam	None	10/78	U.S. Navy Base	4.3
Minneapolis-St. Paul, Minn.	WWI	1,500	Steam	Fe	1980	Paper mill	73.0
Montgomery County, Ohio (Dayton)	WWI	2,000	Steam	Fe	12/81	Cargill Corp.	67.3
New Haven, Conn.	WWI	1,800	Steam	Fe, Al	1982	United Illuminating	50.0

APPENDIX II

Systems in Advanced Planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Guilford County, N.C. (Greensboro)	RDF	1,000	RDF	Fe	1978	Duke Power Co.	$ 1.4
Honolulu, Hawaii	RDF	1,750	Steam	Fe	Early 1983	Hawaii Electric, Hawaii Western Steel	88.0
Los Angeles, Calif. (Wilmington)	RDF	2,000	Steam	Fe, Al, glass, paper	Mid-1981	Atlantic Richfield and Shell	54.0
Tulsa, Okla.	RDF	1,000	RDF	Fe, Al, non-Fe	Early 1981	Public Service Co., Okla.	23.0
Memphis, Tenn.	RDF	2,000	Steam	Fe, Al, glass	1981	Memphis Light, Gas & Water and TVA	70.0
Newark, N.J.	RDF	3,000	RDF	Fe, Al	12/79	Public Service Electric & Gas Co.	70.0
Niagara Falls, N.Y. (Buffalo)	RDF/WWI	3,500	Steam	Fe	1/80	Hooker Chemicals & Plastics Corp.	70.0
Portland, Ore.	RDF	1,400	RDF	Fe	Mid-1981	Publishers Paper Co.	35.0
San Diego, Calif.	RDF	1,400	Steam	Fe	Early 1983	San Diego Gas & Electric	75.0
Seattle, Wash.	RDF	1,500	RDF	Fe, Al, glass	Mid-1980	Boeing, Monsanto, Jorganson Steel	40.0

APPENDIX II

Systems Under Construction (7)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Akron, Ohio	RDF	1,000	Steam	Fe, non-Fe	12/79	B.F. Goodrich Co. and Univ. of Akron	$46.0
Albany, N.Y.	RDF	1,200	RDF	Fe	5/79	N.Y. State Office of General Services	11.0
Bridgeport, Conn.	RDF	1,800	Powdered RDF	Fe, Al, glass	3/78	United Illuminating	53.0
Chicago, Ill. (Crawford)	RDF	1,600	RDF	Fe, non-Fe	3/78	Commonwealth Edison	19.0
Hempstead, N.Y.	RDF	2,000	Steam	Fe, Al, color-sorted glass	5/78	Long Island Lighting Co.	81.0
Monroe County, N.Y.	RDF	2,000	RDF	Fe, non-Fe, mixed glass	Late 1978	Rochester Gas & Electric Co.	50.4
Western Lake Superior Sanitary District (N.E. Minn.)	RDF	400	RDF	Fe	12/78	Negotiating with Duluth Transit Co.	60.0

Systems in Advanced Planning (15)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Central Contra Costa County, Sanitation Dist., Calif.	RDF	1,200	RDF	Fe, Al, glass	1979	Central Sanitary Dist.	32.0
Columbus, Ohio	RDF	2,000	Steam	Fe	Mid-1981	Columbus Municipal Electric	118.0

APPENDIX II

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Systems in Advanced Planning (2)							
Chemung County, N.Y. (Elmira)	Pyrolysis	200	Gas	Fe	1980	A&P Food Processing	$ 5.4
Dutchess County, N.Y. (Poughkeepsie)	Pyrolysis	700	Fuel gas	Fe	7/81	Central Hudson Power & Light	30.0
METHANE RECOVERY SYSTEMS							
Systems in Operation (1)							
Palos Verdes, Calif.	Methane recovery	1.1 MMCF/D (note a)	Methane gas	None	6/75	So. California Gas Co.	1.5
Systems Under Construction (1)							
Mountain View Calif.	Methane recovery	1 MMCF/D	Methane gas	None	7/78	Pacific Gas and Electric Co.	0.7
Systems in Advanced Planning (1)							
Sheldon-Arleta, Calif.	Methane recovery	2.9 MMCF/D	Methane gas	None	Mid-1979	L.A. Dept. of Water & Power	1.8

a/Million cu. ft. per day.

APPENDIX II

Systems in Advanced Planning (cont.)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
S.E. Virginia Regional Solid Waste Processing System, Va. (Portsmouth)	RDF	2,000	Steam	Fe, Al	Mid-1981	U.S. Navy Base	$100.0
Westchester County, N.Y. (note a)	RDF	1,200	RDF	Fe	Late 1985	TBD	60.5
Wilmington, Del.	RDF	1,000	Steam	Fe, Al, glass, humus	Mid-1981	Delmarva Power & Light Company	55.0

PYROLYSIS SYSTEMS

Systems in Operation (2)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Baltimore, Md.	Pyrolysis	1,000	Gas to steam	Fe, glass agr.	6/75	Baltimore Gas & Electric Co.	25.0
El Cajon, Calif. (San Diego County)	Pyrolysis	200	Oil	Fe, Al, glass	12/77	San Diego Gas & Electric Co.	14.5

Systems Under Construction (1)

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Redwood City, Calif.	Pyrolysis	100	Gas to steam	Fe	5/78	Pacific Gas & Electric Co.	1.0

a/Two units, WWI and RDF planned; see p. II-11 also.

APPENDIX II

Estimate of Energy and Materials Recovery Potential--
Projects in Feasibility Study Stage
(Based on 18,020,000 tons (68,000 TPD x 265 days)
of MSW processed annually 1/)

Energy

18,020,000 tons per year (TPY) x 9 MMBtus per ton x 66 percent energy recovery efficiency of commercial systems = 107 trillion Btus of heat energy equivalent to about 18.5 million barrels of oil valued at $14.54 per barrel for a total value of about $268.3 million.

Materials	Millions
1,531,700 TPY Fe x $50 per ton =	$ 76.6
90,100 TPY Al x $200 per ton =	18.0
36,000 TPY other non-Fe x $300 per ton =	10.8
1,711,900 TPY glass x $22 per ton =	37.7
3,369,700 tons of materials per year valued at	$143.1

1/See app. III, p. III-1, for parameters established for making the above calculations.

URBAN WASTE-TO-ENERGY PROJECTS IN FEASIBILITY STUDY STAGE--U.S.

Location	TPD capacity (note a)	Location	TPD capacity
Allegheny County, Pa.	2,000	Lincoln County, Ore.	b/100
Anchorage, Alaska	500	Madison, Wis.	200
Auburn, Me.	200	Marquette, Mich.	b/100
Auburn, N.Y.	200	Miami County, Ohio	b/300
Babylon, Hunting and Islip, N.Y.	3,000	Middlesex County., N.J.	b/2,000
Brevard County, Fla.	200	Montgomery County, Md.	1,200
Burlington, Vt.	200	Morristown, N.J.	b/75
Cedar Falls, Ia.	300	Mt. Vernon, N.Y.	400
Charlottesville, Va.	b/140	New York, N.Y. (Arthur Kill)	1,500
Chautauqua County, N.Y.	400	New York, N.Y. (State Pwr. Auth.)	3,000
Cincinnati, Ohio	1,700	Niagara County, N.Y.	760
Cleveland, Ohio	2,000	Oakland County, Mich.	b/3,200
Colton-Riverside, Calif.	750	Orange County, Calif.	1,000
Cortland County, N.Y.	140	Pasadena, Calif.	200
Cowlitz County, Wash.	100	Peabody, Mass.	2,000
Cuyahoga County, Ohio	1,200	Philadelphia, Pa.	1,600
Danbury, Conn.	1,000	Phoenix, Ariz.	2,000
DeKalb County, Ga.	1,000	Pittsburgh, Pa.	1,500
Denver, Colo.	1,200	Richmond, Va.	1,300
District of Columbia (metro area Council of Governments)	750	Riverview, Mich.	b/50
		Rochester, Minn.	b/200
Dubuque, Ia.	500	St. Cloud, Minn.	b/140
Erie, Pa.	450	Salt Lake County, Utah	750
Erie County, N.Y.	2,000	Santa Clara County, Calif.	3,000
Fairmont, Minn.	150	Scranton, Pa.	400
Greenville County, S.C.	1,700	Springfield, Ill.	b/250
Hamilton, Ohio	175	Springfield, Mo.	1,000
Hamilton County, Ohio	1,500	Suffolk County, N.Y.	3,000
Hampton, Va. (Peninsula Planning District)	1,500	Tallahassee, Fla.	b/250
		Tampa, Fla.	750
Hempstead Sanitary Dist. #1 (Hempstead, N.Y.)	300	Toledo, Ohio	1,200
		TVA	2,000
Hennepin County, Minn.	2,000	Wabash, Ind.	800
Humboldt County, Calif.	350	Western Berks County, Pa.	250
Lawrence, Kan.	200	Wichita, Kan.	850
Lawrence, N.Y.	500	Winnebago County, Ill.	b/850
Lincoln, Neb.	b/520	Wyandotte, Mich.	1,000
		Cumulative total	68,000

a/TPD = tons per day.

b/Estimate based on population data from 1970 U.S. Census, assuming 5 pounds of MSW per person per day and the conversion system being available 265 days a year.

POTENTIAL ENERGY SAVINGS--U.S. URBAN WASTE-TO-ENERGY PROJECTS--RECYCLING OF RECOVERABLE METALS VS. USE OF VIRGIN MATERIALS (note a)

	Recoverable metals		
	Ferrous metals	Aluminum	Total
	(tons recoverable annually)		
Projects which are operational, under construction, or in advanced planning (note b)	1,494,643	36,795	1,531,438
Projects now in the feasibility study stage (note c)	1,531,700	90,100	1,621,800
Total	3,026,343	126,895	3,153,238
Energy savings per ton as the result of recycling (kWhs per ton)	2,604	49,379	51,983
Annual energy savings (million kWhs)	7,881	6,266	14,147
Annual energy savings (billion Btus) (note d)	26,898	21,386	48,284
Equivalent barrels of oil (thousands) (note e)	4,638	3,687	8,325
Estimated value ($, millions) (note f)	$67.4	$53.6	$121.0

a/See p. 3-6 for basis of energy conservation calculations. Calculations do not reflect energy it takes to segregate the metals and transport them to point of use because of the site-specific nature of such energy use.

b/See pp. II-2 through II-8; and p. 3-20.

c/See p. II-17.

d/Based on standard conversion of 3,413 Btus per kWh.

e/Based on 5.8 million Btus per barrel of crude oil.

f/Based on $14.54 price per barrel of imported crude, "Monthly Energy Review," Energy Information Administration (NTISUB/D/127-010), Oct. 1978.

EXPERIMENTAL SYSTEMS

Project location	Process type	Capacity (TPD)	Energy form produced	Other resources recovered	Start date	Market for energy form	Capital cost ($, millions)
Houston, Texas	RDF (note b)	65	RDF	Fe	1971	Cement plant	$ 2.0
Los Gatos, Calif.	RDF	100	RDF	Fe	1970	None	1.4
Pompano Beach, Fla.	Anaerobic digestion	50-100	Methane gas	None	1978	Used on site, excess flared	3.1
Santa Barbara, Calif.	Pyrolysis	0.5+	Gas	Fe	1962	Used on site	1.4
St. Louis, Mo.	RDF	300	RDF	Fe	1972	Union Electric	4.0
South Charleston, W. Va.	Pyrolysis	200	Gas	Fe	6/74	None (flared)	13.0

a/TPD = tons per day.

b/RDF = refuse-derived fuel.

APPENDIX II

BASIS FOR ESTIMATING THE QUANTITY AND VALUE OF ENERGY AND MATERIALS RECOVERABLE FROM MSW ENERGY SYSTEMS

Capacity--Tons per year (TPY). The amount of urban waste to be processed annually was estimated by multiplying the individual system's design capacity by 265, an assumed number of days of availability per year. 1/

Energy Conversion--millions of Btus (MMBtus). The amount of heat energy produced by a particular system was estimated by multiplying its annual capacity (TPY) by a typical heating value of 9 million Btus per ton of MSW. This result was then multiplied by the percentage energy recovery efficiency for the system 2/ (i.e., Energy Recovered (MMBtus) = Capacity (TPY) x 9 MMBtus per ton x Percent Energy Recovery Efficiency). The conversion to million barrels of oil equivalent (MMBOE) was based on a factor of 5.8 MMBtus per barrel of oil.

Materials recovered--tons per year (TPY). The amount of ferrous and non-ferrous metals and glass to be recovered annually by a particular system was estimated by multiplying its annual capacity (TPY of MSW) times the quantity of each material (pounds) estimated by EPA (see p. 3-5) to be contained in a ton of MSW. 3/ This result was then converted to tons.

Value of energy and material recovered--millions of dollars per year. The dollar value of energy recovered was estimated by multiplying the annual million barrels of oil equivalent (MMBOE) by the $14.54 market price per barrel of

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1/Availability factor is conservative and is based on the results from a study entitled "Resource Recovery as an Alternative Energy Source," prepared for the United States Brewers Association, Inc. by R. S. Weinberg and Associates, St. Louis, Mo., Oct. 1977.

2/Energy recovery efficiency based on a National Science Foundation study entitled "Resource Recovery Technology for Urban Decision Makers," Jan. 1976. Percent efficiencies used are: Waterwall incineration, 67 percent; RDF in a conventional boiler, 64 percent; pyrolysis, 47 percent; and anaerobic digestion, 25 percent.

3/No adjustment made to allow for materials recovery processing efficiencies because no prejudgment can be made as to recovery method used.

imported crude oil. 1/ The value of materials recovered was determined by multiplying the quantity (TPY) recovered by the appropriate dollar value per ton as estimated by EPA. (See p. 3-5.)

1/"Monthly Energy Review," U.S. Department of Energy, Energy Information Administration (NTISUB/D/127-010), Oct. 1978, p. 58.

LEGISLATION PROVIDING BASIS FOR THE FEDERAL URBAN WASTE-TO-ENERGY PROGRAM

The legislation described below provides the basis for the Federal Government's involvement in the research, development, demonstration, and commercialization of methods for recovering materials and energy from municipal solid wastes and the timely development and implementation of these systems.

LEGISLATIVE MANDATES

The Solid Waste Disposal Act (42 U.S.C. 3251) of 1965, as amended by the Resource Recovery Act of 1970 (42 U.S.C. 3251), initiated the Federal Government's major efforts in the field of solid waste management. Major provisions of the legislation 1/

--directed the Secretary of Health, Education, and Welfare (HEW) to perform research and demonstrations to develop and apply new and improved methods for processing and recovering both materials and energy from solid wastes;

--authorized grants to State, interstate, municipal, and intermunicipal agencies and organizations for planning purposes;

--authorized grants to public agencies to demonstrate resource recovery systems or to construct new or improved disposal facilities;

--directed HEW 1/ to publish guidelines on the collection, separation, recovery, and disposal of solid wastes consistent with public health and welfare and the environment.

1/The legislation cited was revised by the President's Reorganization Plan No. 3 of 1970 (transmittal document no. 91-364, dated July 9, 1970) and the Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901, dated Oct. 21, 1976). The functions described above were given to the Administrator of EPA.

--required HEW 1/ to recommend model codes, ordinances, and statutes to States and municipalities to implement the guidelines and purposes of the legislation and to issue technical and cost information on feasible processes and methods of dealing with solid wastes; and

--authorized grants for training personnel (including instructors and supervisory personnel) working in solid wastes or resource recovery and directed HEW 1/ to carry out extensive study on manpower availability and requirements.

Additional legislation

Several additional laws have since been enacted to provide for (1) an accelerated, centralized, coordinated resource recovery RD&D program; (2) the dissemination of information as to the technical and economic feasibility of the various waste-to-energy systems; and (3) the timely implementation of those systems shown to be commercially viable. The specific pieces of legislation are:

--The Federal Energy Administration Act of 1974 (15 U.S.C. 761). This law created the Federal Energy Administration and a national energy information locator system. The act also called for the preparation of a comprehensive energy plan (Project Independence), and provision of technical assistance to States in dealing with energy problems and shortages.

--The Energy Conservation and Production Act (15 U.S.C. 761) of 1976. This act extended the Federal Energy Administration; established the Office of Energy Information and Analysis to coordinate all Federal energy data collection and analysis activities; and authorized use of loan guarantees to encourage implementation of renewable resource energy measures, including urban waste-fired boilers partially or entirely fueled by refuse or a refuse-derived fuel and urban waste pyrolysis systems.

--The Energy Reorganization Act of 1974 (42 U.S.C. 5801). This law created ERDA and moved to centralize Federal energy R&D activities by transferring to ERDA responsibility for energy programs at several Federal agencies (including some from Interior and EPA). The

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1/See footnote 1, p. IV-1.

legislation assigned to the Administrator of ERDA responsibility for (1) planning, coordinating, supporting, managing, and encouraging R&D programs respecting all energy sources including demonstration of commercial feasibility and practical applications of clean and renewable energy sources; (2) participating in cooperative R&D projects taking into account the existence, progress, and results of other public and private R&D activities; and (3) developing, collecting, and making available for distribution relevant scientific and technical information on all energy conservation technologies and energy sources as they become available for general use.

--The Federal Nonnuclear Energy Research and Development Act of 1974 (42 U.S.C. 5901). This act established broad policy guidelines for carrying out nonnuclear R&D. It directed the ERDA Administrator to formulate and carry out a comprehensive Federal nonnuclear energy research, development and demonstration program which will expeditiously advance policies established by the act and other relevant legislation establishing programs in specific energy technologies. The law requires that heavy emphasis be given to those technologies which utilize renewable or essentially inexhaustible energy sources and that Federal involvement in a particular R&D undertaking consider urgency of public need, national or widespread extent of the problem, presence of Federal disincentives to private involvement, high risk, poor profit outlook, or magnitude of required investment. The act also authorized the use of price supports to encourage demonstration and implementation of alternate sources of energy including municipal solid waste projects. 1/

--The Resource Conservation and Recovery Act of 1976 (42 U.S.C. 6901) established several major new programs to provide technical and financial assistance

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1/The act provides explicit authority for price supports subject to certain conditions including congressional authorization of each price support program. Limited at present to the production of ammonia from municipal solid waste. See statement by Chairman of the Subcommittee on Energy Research, Development, and Demonstration, House Committee on Science and Technology, "A Conference on Capturing the Sun Through Bioconversion," Washington Center for Metropolitan Studies, Mar. 10-12, 1976, p. 92.

for the development of management plans and facilities for the recovery of energy and other resources from discarded materials. The act authorizes grants for developing and implementing solid waste management plans; provides for training of supervisory personnel, and an accelerated, well-coordinated resource recovery RD&D program; calls for the phasing out of open dumps by 1983; provides special financial assistance to rural communities; and directs EPA to undertake extensive study of the technological, economic, and environmental aspects of the solid waste management problem and to serve as a central clearing house for information dealing with these concerns. In addition, the act directs the Secretary of Commerce to stimulate broader commercialization of proven resource recovery technologies, and encourage the development of markets for recovered materials. The act also authorizes the Secretary to evaluate the commercial feasibility for resource recovery facilities.

--The Department of Energy Organization Act (42 U.S.C. 7101) established the Department of Energy on Oct. 1, 1977. The act brings together under one department the many fragmented energy programs and offices created over the years within the Federal Government. The act transferred to DOE all functions of the Federal Energy Administration and ERDA, including the responsibilities noted in the above mandates. The Federal Energy Administration's energy conservation and energy resource development programs, and ERDA's fuels from municipal solid waste program are now the responsibility of DOE's Office of Conservation and Solar Applications.

--The Department of Energy Act of 1978--Civilian Applications (P.L. 95-238) authorized appropriations to DOE for energy research, development, and demonstration, and related programs. The act's provisions include establishment of a program to (1) demonstrate municipal waste reprocessing for the production of fuel and energy-intensive products and (2) gather information about the technological, economic, environmental, and social costs, benefits, and other impacts of such demonstration facilities. The act also provides loan guarantees for costs related to the construction and start-up of such facilities.

Department of Energy
Washington, D.C. 20545

November 13, 1978

Mr. J. Dexter Peach, Director
Energy and Minerals Division
U. S. General Accounting Office
Washington, D. C. 20548

Dear Mr. Peach:

We appreciate the opportunity to review and comment on the GAO draft report entitled "Federal Efforts To Develop And Introduce Alternative Fuels From Municipal Solid Waste."

The draft report correctly points out the need for increased inter-agency cooperation and coordination on RD&D projects in the area of energy recovery from municipal solid waste (MSW). DOE has also identified this need in dealing with municipal waste as a component of fuels from biomass.

Although the draft report does contain useful material, we believe that changes in wording and qualifications of statements should be considered before issuance of the final report so as to eliminate misunderstandings or misleading statements. Our views with respect to the text of the report and recommendations contained therein are discussed below.

The introductory section does not address the real technological barriers and environmental problems of waste-to-energy processes. The technological barriers include corrosion, inhomogeneity, and transportation and storage of raw urban waste. Environmental concerns such as small particulate emissions, fate of trace elements and siting problems have not been addressed anywhere in the report. These omissions result in a somewhat unbalanced emphasis on the benefits of waste-to-energy process development.

Disposal costs are incorrectly stated in Chapter 1. The $30 per ton mentioned represents collection <u>and</u> disposal, with collection cost of $23 being the major cost. This cannot and should not be used as offset to energy system economics. Also, in order to reduce the bulk of urban waste by 95 percent, the ferrous metals, aluminum and glass should be removed and recycled to exclude them from landfill volume.

The discussion in Chapter 2 of the St. Louis Refuse-Derived Fuel (RDF) Plant is misleading and implies that the St. Louis plant has proven the technology; however, the plant has never operated at its small maximum capacity for more than a week.

Energy savings -- The potential BTUs available in waste should not be used as the energy savings estimates because it requires energy to obtain that energy. A check with EPA on energy balances of their demonstration plants will indicate that the energy out will be 50-60 percent of the potential.

Material recycling -- The product must be reasonably segregated to be sold. The energy savings from recycling must take into account the energy it takes to segregate the product and transport it to where it can be used.

The report indicates on page 4-14 that several industry associations criticized the lack of a formal mechanism to assure continued, frank communication between the Resource Conservation Committee and the private sector. According to the DOE representative on the Resource Conservation Committee, this criticism came from industry on the beverage container issue rather than on its deliberation relative to munici-0 pal solid waste energy systems. OMB was, and continues to be, an official member of this committee. CEA and DOE were unofficial members from the start of committee efforts but are now official members.

The report cites DOE's National Plan for Energy Research Development and Demonstration as giving waste-to-energy technologies a "high priority". It appears that the report is referring to ERDA-48, 76-1, or 77-1. None of these plans for Energy Research, Development and Demonstration contain such a priority ranking. ERDA's policy was to keep as many energy options open as possible and to create energy options for the future rather than to quickly limit or foreclose on research, development and demonstration efforts.

The report also cites FY 77 funding for waste-to-energy programs on page 5-9 as being $5 million and comments that this $5 million is "about half that of another of its Research, Development and Demonstration programs which received $9.7 million and has a long term low priority." For comparison purposes we believe that the "other" program should be specified. The claims on page 6-3 relative to potential energy savings attributable to MSW energy projects for 1985 and 1995 are supported only by general statements such as "if certain projects

GAO note: Page references in apps. V and VI refer to the draft report and may not correspond to this final report.

were fully operational" and "an expansion of these projects could realistically be expected to provide." The assumptions leading to these claims should be spelled out for review and verification by the various concerned agencies. With regards to the recommendation for development of a 10 year plan, we agree that such a concept is desirable. However, if the plan deals primarily with waste-to-energy system technologies and implementation, we believe the wording of the recommendation should be modified to recommend that a joint EPA, DOE, and Department of Commerce (DOC) plan be developed in consultation with other interested agencies. The report discusses energy production and energy conservation which is a DOE function. However, these activities take place in context with EPA's responsibilities for environmental control and concommitant solid waste management functions and with DOE's expertise in market development, particularly for recycled materials.

We appreciate your consideration of these comments in the preparation of the final report and will be pleased to provide any additional comments you may require.

Sincerely yours,

Don C. Gestiehr

Donald C. Gestiehr
Acting Director
GAO Liaison

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Policy
Washington, D.C. 20230

November 15, 1978

Mr. Henry Eschwege
Director
Community and Economic Development Division
United States General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

This letter is in reply to your letter of October 16, 1978 requesting review and comment on your proposed report to the Congress entitled "Federal Efforts to Develop and Introduce Alternative Fuels from Municipal Solid Waste." (MSW)

We agree with the objective of to report: to marshal Federal efforts to promote the utilization of municipal solid waste as an alternative energy source. The report has a number of conclusions. The most important is that the Federal effort with respect to converting energy from waste is fragmented, duplicative, misguided and incomplete. This assessment is accurate.

Many of the numerical values given in the report, however, are over-stated to such an extent that the report loses some of its credibility. For instance, the very first finding and conclusion on page ii of the Digest of the report states "The EPA estimates 201 million tons of municipal solid waste will be generated by 1985, with 112 million tons being readily available for conversion to energy sources." The conclusion continues on to imply that this is equivalent to 51 million barrels of oil annually by 1985. It is not economically feasible to process 56% of the municipal waste produced in 1985 into energy, 1985 is only six years away.

It is recommended that every numerical value in the report be checked for accuracy and reasonableness and that the report's numerical values be restated in BTU instead of barrels of oil. As noted again below the reader is led to believe that "barrels of oil equivalent energy" is really barrels of oil, as stated in the report, and can be directly subtracted from oil imports. In reality, municipal waste in most cases substitutes for coal. Its use will have little impact on imports of oil. In order to comply with the National Energy Act of 1978, most stationary users of oil will be shifting to coal or nuclear power. Exceptions to this are users of oil for feedstock, users of residual fuel, and certain users of oil in the industrial processes not amenable to conversion. Municipal waste will, thus, be used in place of coal or nuclear energy.

GAO recommends that the Administrator of EPA, in consultation with the Secretaries of Energy and Commerce, develop a ten year plan describing specific strategies for federally funded waste energy programs. GAO further recommends that this ten year plan define specific roles and responsibilities of DOE, DOC and EPA, layout time frames, and required resources for accomplishing the plan (GAO believes that loan guarantees and support of MSW projects are extremely important). However, we do not recommend EPA take the lead. Leadership in this area should rest with DOE or DOC. One possible mechanism for doing this would be to shift the Chairmanship of the Resource Conservation Committee from EPA to either DOE or DOC; the Resource Conservation Committee could then take the lead in planning for federal roles in solid waste management - as originally intended by the Resource Conservation and Recovery Act.

Specific Comments

- The report appears to present an accurate assessment of the several Federal Government programs in the area of resource recovery. The Commerce Department's role is prescribed under Subtitle E of the Resource Conservation and Recovery Act of 1976. The Department's responsibilities include the development of specifications for recovered materials, the development of markets for recovered materials, and the promotion of proven technology.
- The report's assessment of the Department's program on pages iv, 4-15, 16, 17, and 6-4 is generally correct. However, the reference on these pages to the interagency agreement between the Department and EPA concerning the implementation of the Resource Conservation and Recovery Act is no longer correct. The agreement was completed and signed by both agencies on May 30, 1978.

- o As noted above GAO persists in using barrel of oil equivalents when referring to energy recovered from waste. While such a conversion is technically possible, it is misleading. Energy-from-waste will not reduce oil imports or even oil usage but rather supplements solid fuels such as coal. The advantages of obtaining energy-from-waste are that co-firing of coal with refuse derived fuels may reduce air pollution and provides an acceptable way to dispose of the refuse. The GAO use of oil equivalents leads to difficulty in evaluating the economic impacts from waste because, as shown in Appendix C of the draft report, the oil barrel price is utilized to determine the cost conversions for energy-from-waste. This is not the best way to determine such costs. Rather, whatever the market will bear in dollars-per-million BTUs should be used to determine cost equivalence for energy-from-waste.

- Page 3-10. To be economical, MSW conversion systems must have stable long-term markets.

- Page 3-11. The GAO evaluation of net disposal costs is incomplete and is probably far too low; for example, in Eastern Massachusetts, disposal is about twenty dollars per ton.

- Page 3-12. GAO is correct in stating that in order to properly evaluate the comparative cost of resource recovery, municipalities must fully account for projected and future costs of solid waste disposal, making certain that all costs are considered in a realistic fashion. This is the most crucial economic issue in the entire solid waste management field.

- Page 3-20. GAO should consider the institutional problems arising if refuse derived fuel adversely affects Wisconsin Electric Power Company operations, e.g., if the boiler corrodes, who is liable?

- Page 3-23. In considering methane recovery at Palos Verdes, Los Angeles, GAO should ask the question - how does one calculate life cycle costs of the gas purification plant?

- Page 4-1. The barriers identified by GAO appear to be the most important barriers to the adoption of methods to obtain energy from waste. The NBS role in energy from waste is discussed on pages 4-16 and 4-17.

- Page 6-5. GAO points out the need for information exchange dealing with institutional problems and concerns, however, if Subtitle B of the Resource Conservation and Recovery Act were fully implemented, this consideration would be fully dealt with. Perhaps GAO should consider the impacts of full implementation of Subtitle B. The GAO recommendation for expanded research is correct.

- Page 6-8. GAO recommends provision for financial incentives to best foster the use of MSW Energy Systems. GAO should consider the question as to which agency or agencies would have the responsibility for providing such incentives. The GAO figure of nine million BTU per ton of MSW seems to be quite optimistic; seven million BTU per ton is a more realistic figure.

We hope the above comments will help you in achieving the objectives of the report.

Sincerely,

James W. Curlin
Deputy Assistant Secretary for Policy

cc: J.F. Gustaferro, OORSPC
V.H. Ketterling,OBP/ITA
Harvey Yakowitz, ORM/NML/NBS
Guy Chamberlin, Jr.
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