

GAO

Report to the Chairman, Subcommittee  
on Investigations and Oversight,  
Committee on Science, Space, and  
Technology, House of Representatives

September 1994

## ENERGY SUPPLY

# Energy Potential of Municipal Solid Waste Is Limited



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Resources, Community, and  
Economic Development Division

B-257080

September 20, 1994

The Honorable James A. Hayes  
Chairman, Subcommittee on Investigations  
and Oversight  
Committee on Science, Space, and Technology  
House of Representatives

Dear Mr. Chairman:

Over 195 million tons of municipal solid waste—basically household and commercial garbage—were generated in the United States in 1990. However, only a small portion of solid waste is currently used for energy production, mainly through the use of electricity-generating facilities that burn municipal waste as a fuel (combustors) and engines fueled by waste gases from landfills. In addition, waste-recycling programs can save energy by reusing certain waste materials to make products rather than using virgin materials. Because of the magnitude of the amount of waste produced annually, you asked us to report on (1) the potential for using waste to produce energy; (2) the environmental impacts of producing energy from waste; (3) the Department of Energy's (DOE) research and development efforts to use waste as a viable energy source; and (4) the potential energy savings from and environmental impacts of recycling waste material.

## Results in Brief

Energy recovery from municipal solid waste has the potential for making only a limited contribution to the nation's overall energy production. Although the current contribution of waste-derived energy production is less than one-half of 1 percent of the nation's total energy supply, DOE has set a goal for energy from waste at 2 percent of the total supply by 2010. The industry's estimates show a smaller role for waste as an energy source in the future. The energy potential from waste is limited not only by the volume and energy content of the waste itself, but also by the factors affecting the use of waste disposal options, including public opposition and the availability of financing.

Energy production from waste combustors and from landfill gases generates pollutants, although these are reduced through current regulations that require the use of emissions control technology and define operational criteria for the facilities. Regulations to reduce harmful pollutants from both combustors and landfills have been adopted, and

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more stringent rules are being developed. In addition, several efforts are under way to decrease the impacts of landfill gases by encouraging the owners and operators of landfills to use these gases for energy production. Because most waste combustors and landfill-gas energy projects generate electricity, emissions from these sources may be offset when combustors or landfill-gas projects replace electricity sources that produce even more pollution, such as coal-fired utility plants.

DOE's research and development involving waste includes improving the operational performance of combustors and refining the techniques and technology for increasing energy production at waste landfills. Other research initiatives include increasing the use of waste materials as a resource for recycling and developing a clearinghouse for information related to waste-derived energy production.

Although DOE estimates that one-third of the energy available from waste is available in the form of energy savings through the recycling of materials, the Department's research in this area is ongoing. Energy savings from recycling some materials, such as aluminum, have been demonstrated; for other materials, such as certain grades of paper, more research is needed. Estimates on the environmental impacts of recycling programs vary and depend largely on the scope and assumptions of the analysis. DOE and the Environmental Protection Agency (EPA) have cofunded research activities designed to quantify the potential energy savings and environmental impacts associated with waste management options, including recycling programs.

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## Background

Municipal solid wastes are those generated at residences, commercial establishments such as retail stores and restaurants, and institutions such as hospitals and schools. These wastes are a mixture of paper, wood, yard waste, food waste, plastics, glass, rubber, and metals. According to EPA's estimates, the generation of solid waste is expected to increase from the more than 195 million tons generated in 1990 to 222 million tons by 2000. The predominant disposal methods include using landfills, combustion, and recycling/composting. Of the total waste generated in 1990, using landfills, the most common disposal method, accounted for roughly 66 percent, while combustion accounted for about 17 percent, recycling for about 15 percent, and composting for about 2 percent.

The largest source of energy production using waste as a fuel comes from electricity-generating combustion facilities—roughly 125 combustors are

currently in operation. The combustion of waste at most facilities occurs by feeding waste directly into a furnace, usually after sorting out noncombustible items and items to be recycled. In other cases, the waste is sorted, processed, and remanufactured into fuel pellets for later use. The majority of waste combustors combust waste to generate electricity, but they also generate steam for heating and other industrial purposes.

The remaining portion of waste-derived energy production stems largely from burning methane emissions at landfills.<sup>1</sup> Landfill emissions are formed through the decomposition of waste; the rate at which they are released into the environment varies over time. The emissions gradually increase as waste is added and may eventually increase to the point at which energy production equipment can be profitably used. Eventually the emissions decline, as do the benefits of reducing them, and controls are no longer necessary. Approximately 114 landfills with energy production systems are in operation; about 75 percent of these projects generate electricity, another 18 percent sell the gas for direct use (for example, as fuel for boilers), and the remaining projects sell the methane to natural gas pipeline companies for industrial uses.

Federal, state, and local laws govern the collection and disposal of solid waste. At the federal level, regulations developed by EPA under the authority of the Resource Conservation and Recovery Act of 1976, as amended, include criteria for the design, construction, and operation of municipal solid waste landfills. In addition, the Clean Air Act, as amended, requires the establishment of emissions standards for combustors, and emissions standards have been proposed for landfills that produce excessive emissions. State and local governments are responsible for planning and implementing solid waste programs.

## Energy Production Potential of Waste Is Limited

The potential of waste as a source of energy production is limited by the volume of the waste generated, the energy content of the waste stream, and the technology used to convert waste to usable forms of energy.<sup>2</sup> DOE estimates that the majority of waste-derived energy is likely to be produced through the combustion of (1) solid waste and (2) the methane that is generated at landfills. This energy is expected to contribute less

<sup>1</sup>The composition of landfill gas is typically 50 to 55 percent methane, 45 to 50 percent carbon dioxide, and about 1 percent nonmethane organic compounds.

<sup>2</sup>The energy content of a fuel refers to its potential for creating energy. A fuel with a high energy content, such as natural gas, is capable of producing a large quantity of energy per unit of gas. A fuel with a lower energy content, such as municipal solid waste, produces a smaller quantity of energy per unit of waste.

than 2 percent of the nation's overall energy production. The use of waste for energy production is also limited by the extent to which energy disposal options are available to solid waste managers. Many factors, including public opposition and a lack of financing, can limit the use of energy-producing disposal options.

### Energy Production From Combustors Will Increase Slowly

Although the increase in energy production from waste combustors is expected to continue, the future rate of growth in the number of these facilities is expected to be lower than in recent years. First introduced in the 1970s, electricity-producing waste combustors now have a total installed capacity of roughly 2,500 megawatts (MW).<sup>3</sup> The majority of the roughly 125 existing electricity-generating facilities were placed in service after 1980. However, according to one industry estimate, the number of planned combustors dropped by more than half between 1986 and 1993.<sup>4</sup> According to several analyses, the decrease in the growth of these facilities is the result of several factors, including general economic conditions, environmental concerns, and public opposition to siting combustors. An upcoming GAO report will discuss many of the issues affecting the use of waste disposal options.

The estimates of future energy production from electricity-generating combustors vary widely. The differences in the estimates are to some extent explained by the different assumptions used, such as the projected volume of waste generated and the energy content of the waste being considered for energy production. DOE's goal for electric power production from waste by 2010 ranges from 14,000 MW to 28,000 MW. These estimates, developed for use in DOE's 1991 National Energy Strategy, represent 1.9 percent and 3.8 percent, respectively, of the projected total electricity-generating capacity in 2010. The Energy Information Administration's (EIA) estimates show much slower growth in the use of waste as a fuel source: EIA estimates roughly 5,200 MW of production by 2010. EIA's annual estimates of the production of waste-derived electricity have decreased by more than half since 1992.

The significant decrease in EIA's estimates of waste-derived energy, according to EIA officials, is accounted for by several factors. These factors include increased recycling efforts, stricter environmental controls, and

<sup>3</sup>A megawatt is 1 million watts; a watt is the basic unit used to measure electrical power. In 1992, the nation's total electricity-generating capacity was roughly 690,000 MW.

<sup>4</sup>Eileen B. Berenyi and Robert N. Gould, *1993-94 Resource Recovery Yearbook: Directory and Guide*, Governmental Advisory Associates, Inc. (New York: 1993).

the uncertainty of future regulatory requirements. These officials explained that recycling efforts can remove some waste products with a high energy content, such as plastics and certain grades of paper, from the waste stream, thus reducing the potential energy available for energy production. Stricter environmental controls can increase the cost of some disposal options (such as combustors), which could lead to the selection of disposal options (such as landfills) with different energy production potentials. The uncertainty of future regulatory requirements could also lead to different disposal choices, some of which could result in reduced energy production.

### Efforts Under Way May Increase Energy Production at Landfills

Energy production from methane-burning landfills is constrained by many factors, although efforts under way may help increase the current level of production. The impact of these efforts on the production of energy from landfill gases is difficult to quantify; EPA's recent estimates range from 800 MW to 5,000 MW of additional electricity-generating capacity. These efforts include an EPA-proposed rule to capture and control landfill gases, expanded research and development programs to increase the efficiency and effectiveness of energy recovery projects at landfills, and an outreach program intended to remove or lessen barriers to using landfill gases for energy production. Other factors that may increase landfill energy production include new landfill regulations that would require monitoring of methane emissions and a recently established program that would pay owners and operators of qualified renewable energy facilities (including waste landfills) for the production and sale of electric energy.

EPA's proposed rule would require landfills with excessive emissions to capture and control methane emissions. Under the proposed rule, owners and operators of affected landfills must either burn (flare) their methane emissions or recover the gas for use in energy production. EPA has estimated that roughly 600 of the nation's approximately 6,000 active landfills would be required to capture and control their methane emissions. About 114 landfills already convert methane emissions to energy; the remaining landfills are faced with significant barriers to using methane as an energy source.<sup>5</sup> These barriers include the low price of competing fuels, limited and unstable markets, and regulatory and technological constraints. EPA estimates that the majority of these landfills will flare methane rather than recover it for energy production. However,

<sup>5</sup>The existing landfill-gas energy projects have a combined electricity-generating capacity of roughly 350 MW.

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as described below, several initiatives are under way that may increase the conversion of landfill methane to energy production.

The administration, in October 1993, announced the Climate Change Action Plan, which is a strategy to reduce the volume of gases suspected of contributing to a warming of the earth's atmosphere (the "greenhouse" effect).<sup>6</sup> The action plan includes an initiative to increase energy production at landfills. Methane is the second largest source of greenhouse gas, and landfills account for about one-third of the nation's methane emissions. The landfill initiative targets the completion of EPA's proposed rule requiring controlling and capturing landfill gases, supports an expansion of DOE's research program for technologies that recover landfill gases, and establishes an outreach program to remove or reduce barriers to using landfill gases for energy production.

The proposed expansion of DOE's research program is intended to facilitate the design of landfills to enhance the generation and recovery of methane as electricity, fuel, or pipeline gas. The initiative includes efforts to sponsor new joint demonstration projects with private companies. A joint state-federal coordination program is proposed to assist in siting and issuing permits to landfills that will use methane recovery technology. DOE has estimated that more than 100 MW in additional electricity-generating capacity may be installed as a result of this program.

The outreach program called for in the action plan would encourage landfill operators to overcome barriers to installing energy production technology at landfills. The outreach program is intended to capture methane emissions at those landfills not covered under EPA's proposed rules. The program includes a proposal for EPA to conduct state and regional workshops and to initiate site visits to discuss the opportunities for energy production at landfills. EPA estimates that as much as 120 MW of additional electricity-generating capacity may be installed as a result of these efforts.

Other ongoing efforts may also affect energy production from landfills, although the amount of increased energy production as a result of these efforts is uncertain. EPA's expanded regulations for landfills, which became effective October 9, 1993, require owners and operators of landfills to monitor methane emissions to ensure that the concentration of methane gas generated does not exceed a predetermined safety level. EPA expects

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<sup>6</sup>See also The Climate Change Action Plan: Technical Supplement, U.S. Department of Energy, Office of Policy, Planning, and Program Evaluation (DOE/PO-0011, Mar. 1994).



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that this monitoring requirement may create an additional incentive for owners and operators of landfills to install energy recovery technologies.

As part of the Energy Policy Act of 1992, DOE was directed to make payments to the owners and operators of publicly owned facilities that use renewable energy (including landfill-gas energy projects) for the production and sale of electric energy. However, the effectiveness of these payments may be limited. First, these payments are subject to the availability of appropriations, which could limit the number of potential participants. Second, under DOE's proposed rule for these payments, landfill-gas energy projects will receive funding only after all other payments are made to priority projects that include wind, solar, geothermal, and biomass energy technologies. DOE expects to issue a final rule for this program by the end of 1994.

In a report addressing the issue of methane emissions, sent to Congress in October 1993, EPA found that the profitability of landfill-gas energy projects is sensitive to the price at which the projects sell the electricity they generate.<sup>7</sup> EPA's analysis found that relatively modest increases in the price of electricity may result in large increases in the number of landfill-gas energy projects that could be expected to operate at a profit. EPA estimated that, depending on electricity prices, anywhere from 60 to 1,400 landfills could profitably recover methane and that the electricity-generating capacity added would range from 800 MW to 5,000 MW. However, the report noted the uncertainty in estimating the costs of collecting landfill gas and producing electricity. In addition, the report noted that the energy estimates did not consider the existing barriers preventing the implementation of projects to recover landfill energy.

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## Energy Production From Waste Has Environmental Impacts

Energy production from waste combustors and from landfill gases generates pollutants, although these are reduced through current regulations that require the use of emissions control technology and define operational criteria for the facilities. To further reduce emissions from these disposal options, EPA is in the process of issuing additional regulations to further reduce combustors' emissions and issuing regulations to limit landfills' emissions into the air.

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<sup>7</sup>Opportunities to Reduce Anthropogenic Methane Emissions in the United States (EPA 430-R-93-012, Oct. 1993).

## Emissions Standards for Combustors Have Been Expanded

A wide variety of materials is found in municipal waste streams, and the environmental impact of energy production at combustors depends in part on the composition of the materials being burned. The air emissions standards developed by EPA have been designed to limit the amounts of pollutants stemming from combustors. Currently, these standards are being revised to regulate additional pollutants. The ash residue remaining from the combustion process also contains pollutants, and the potential environmental impacts of this residue have been an ongoing source of concern for many years.

The air emissions from combustors consist of many pollutants, including organic material, acid gases, and metal compounds. Emissions of organic material include dioxins, some of which have been found to be highly toxic. EPA has categorized one form of dioxin as a probable human carcinogen. Acid gases include sulfur dioxide and hydrogen chloride, each of which presents concerns related to human health (respiratory problems) and the environment (acid rain). Metallic compounds include those which EPA considers possible human or animal carcinogens, such as arsenic, beryllium, cadmium, and chromium. Other metals include mercury and lead, which have been identified as threats to human health.

In 1991, EPA greatly expanded the emissions standards for both new and existing combustors. One component of these standards is technology-based, requiring facilities to rely on technology that will reduce emissions. These standards also include requirements for (1) operating practices that improve the combustion process and thereby minimize pollutants and (2) certification for combustor operators. Those facilities processing more than 250 tons of waste per day are required to comply with these standards.

The Clean Air Act Amendments of 1990 broadened the emissions standards for combustors to include emissions limits for several pollutants, including cadmium, lead, and mercury. The amendments also required that emissions standards be extended to include facilities that process less than 250 tons per day. According to EPA officials, emissions standards developed to comply with the amendments should be proposed by the end of 1994.

The ash residue remaining from the combustion process continues to pose environmental concerns. The issue of whether the ash generated by combustors should be regulated as a hazardous waste was the subject of a

recent U.S. Supreme Court opinion.<sup>8</sup> The court noted that the ash can be hazardous, even though the product from which it is generated is not, because the contaminants in the ash residue are more concentrated and more susceptible to leaching into groundwater. The court held that the Resource Conservation and Recovery Act does not exempt ash from regulation as a hazardous waste. As a result, the ash will need to be tested to determine whether it is a hazardous waste. To comply with the court's opinion, EPA has since announced a strategy for testing the toxicity of the ash. Because of the higher costs of hazardous waste disposal, the court's opinion could affect the future of waste-derived energy production.

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### Energy Production at Landfills Can Reduce Methane Emissions

Some landfills have adversely affected the environment, and some pose future risks. The environmental impacts of landfills include groundwater and surface water contamination and air pollution. Regulations to reduce future environmental impacts have been adopted recently, and regulations to reduce emissions of landfill gases are to be made effective by the end of 1994. Energy production from these facilities, however, because it uses waste methane gases from landfills as a fuel source, can mitigate some of the environmental effects.

Landfills are regulated to account for their many impacts on the environment and human health and safety. In proposing landfill regulations in 1988, EPA determined that many landfills have polluted the air and the groundwater and surface water and that landfills will continue to pose risks into the future. EPA also found that roughly 22 percent of the nation's abandoned hazardous waste sites on the National Priorities List are municipal waste landfills.<sup>9</sup> EPA also estimates that 70 percent of the existing landfills were operating before 1980 (the effective year of EPA's hazardous waste rules); these older landfills are of the most concern because they may have received large volumes of hazardous waste.

Regulations to reduce the threat posed to the environment and human health and safety were recently made effective, and additional regulations to limit air emissions are being developed. EPA's regulations on the design and operating criteria of landfills became effective for most large landfills on October 9, 1993. These regulations set forth minimum federal criteria for the location, design, operation, groundwater monitoring, closure, and postclosure care of landfills. EPA officials explained that although some

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<sup>8</sup>City of Chicago v. Environmental Defense Fund, 114 U.S. 1588 (1994).

<sup>9</sup>The priorities list specifies those hazardous waste sites posing the most serious threats to public health and the environment and requiring long-term cleanup activities.

older landfills may close as a result of these regulations, many will be replaced by new landfills that will operate under the new, more stringent standards.

Producing energy from landfills' methane emissions can reduce the environmental impacts of these sources. As discussed earlier, EPA is also in the process of developing regulations intended to reduce air emissions from landfills. According to EPA officials, these regulations are scheduled to become effective by the end of 1994. These regulations will require landfills with excessive gas emissions to install equipment to collect methane gas and other emissions. EPA estimates that under its proposed regulations, emissions of methane will decrease roughly 18 percent more than would otherwise occur. EPA also estimates that landfills' emissions from other organic compounds will be reduced by 44 percent.

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## DOE's Research and Development Efforts Encompass Broad Range of Activities

DOE's research and development programs involving municipal solid waste were funded at an average of roughly \$3.5 million in each of the last 3 fiscal years (1991-93). The research projects include increasing energy production and minimizing the environmental effects from combustors and landfills. Other research includes the information transfer initiatives designed to increase the quality of information available to officials responsible for managing solid waste issues. Many of DOE's research projects are cofunded with EPA, private businesses, and state and municipal governments.

DOE's research on combustors has focused on increasing energy production, reducing environmental impacts, and determining proper disposal techniques for ash from combustion. DOE recently completed a study that determined the feasibility of combusting waste with sewage sludge—two common municipal waste products—in a municipal waste combustor. Other recently completed projects presented the results of emissions control tests designed to reduce common pollutants found in waste combustors. The ongoing research includes identifying potential uses for ash from combustion, such as road construction material. Other ongoing research includes determining additional methods for reducing emissions at existing waste combustors.

DOE's research on landfill gases has concentrated on increasing methane production and energy recovery. DOE's ongoing research in this area includes accelerating the rate of methane gas production and reducing the cost of removing impurities from the gas. These efforts are aimed at

increasing energy production. Research projects are expected to be established on the basis of the government's sharing research costs with private industry. (App. I includes a list of DOE's recently completed, ongoing, and planned waste-related projects.)

As mentioned earlier, the administration's strategy to reduce "greenhouse" gases includes research involving landfills' emissions. The strategy proposes an outreach program to overcome barriers to profitable methane recovery projects and thereby reduce methane emissions. The strategy also proposes expanding DOE's ongoing research activities to include a joint federal-state coordination program to facilitate siting and issuing permits for landfill-gas energy projects. The program would examine the environmental performance standards and regulatory requirements identified as barriers to using methane as a source of energy production.

DOE's other research and development efforts include information transfer initiatives. DOE has found that information on waste management is not always available to the public officials responsible for making waste management decisions. As a result, DOE has funded research intended to increase the quality and scope of waste management information. The resulting reports have identified factors affecting the cancellation of combustor facilities and presented the status of available waste management alternatives.

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## Energy Savings and Environmental Effects of Recycling Programs Have Yet to Be Clearly Demonstrated

The energy savings available through the recycling and reuse of waste materials depend on a comparison between the energy costs of using reprocessed waste materials and the energy costs of harvesting/extracting and processing virgin materials. Similarly, determining the environmental effects of recycling waste materials necessitates a comparison of the environmental consequences of using reprocessed materials versus using virgin materials. DOE estimates that significant energy savings and reduced environmental effects are available through recycling programs. However, DOE plans additional research in conjunction with EPA to further quantify the energy and environmental impacts of waste management options, including recycling programs.

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## Energy Savings Depend on Type of Material Recycled

Estimates of the energy savings from recycling waste materials depend on the waste materials being considered for recycling. For some materials, such as aluminum, demonstrations have shown that making products with recycled materials requires less energy than making them with virgin

materials. For other materials, such as certain grades of paper, the energy savings through the use of recycled materials rather than virgin materials have not been clearly demonstrated. Many reports and studies on recycling issues are consistent in suggesting the need for further analysis of energy savings.

DOE has estimated that as much as one-third of the energy available from waste is available in the form of energy savings from recycling efforts.<sup>10</sup> DOE has reported that the amount of energy conserved through recycling differs by the type of waste material. According to DOE's estimates, recycling a pound of aluminum conserves 100,000 British thermal units (Btu), while recycling a pound of glass conserves only 1,500 Btu.<sup>11</sup> DOE has also reported that the conservation of energy in recycling a commodity may also differ depending on the product produced. For example, recycling old newsprint into new newsprint conserves roughly 5,000 Btu per pound, while recycling old newsprint into tissue may require more energy than using virgin materials.

In spite of previous estimates, DOE has continued to stress the need for the additional quantification of energy savings. A 1992 DOE report on the status of waste management alternatives identified as a primary research area the analysis of using recycled materials versus using virgin materials.<sup>12</sup> The report noted the wide variance between published estimates of the energy savings achieved by recycling paper products. The report also noted the need for additional research to assess and compare the net energy savings associated with recycling programs with the savings associated with other waste management methods.

The Office of Technology Assessment (OTA), in a 1989 report on municipal solid waste, found that the estimated energy savings from using recycled materials versus using virgin materials varied by the type of waste material.<sup>13</sup> OTA found that recycling several materials, such as aluminum, glass, and plastics, resulted in significant energy savings compared with

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<sup>10</sup>Summary Costs and Benefits: Conversion of Municipal Solid Waste to Energy (Draft), Department of Energy (Sept. 23, 1991).

<sup>11</sup>A British thermal unit is the standard unit for measuring heat energy, such as the heat content of fuel. One Btu is the amount of energy necessary to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

<sup>12</sup>RD&D Priorities for Energy Production and Resource Conservation From Municipal Solid Waste, National Renewable Energy Laboratory, Department of Energy (NREL/TP-431-4982, Aug. 1992).

<sup>13</sup>Facing America's Trash: What Next for Municipal Solid Waste?, Office of Technology Assessment (Oct. 1989).

using virgin materials. For example, the recovery of aluminum from scrap has been found to save 90 to 95 percent of the energy required to produce the same product from virgin materials. The energy savings occur largely because using recycled aluminum avoids the smelting process, which accounts for roughly 85 percent of the cost of producing new aluminum. In contrast, OTA found that for some materials, such as paper products, using recycled materials required more energy than using virgin materials. For example, using recycled materials for manufacturing box board required roughly 5,000 Btu per pound more than manufacturing the same item using virgin materials.

Recognizing the need for a greater understanding of the economics of waste management options, including recycling programs, DOE and EPA have agreed to cofund research to examine the energy and environmental impacts of the different disposal options. The study will, among other things, seek to quantify the tonnage of recyclables collected and recycled and the emissions associated with remanufacturing goods from recycled materials as compared with the tonnage and emissions associated with manufacturing goods from virgin materials. The findings of this research are expected to lead to a better understanding of the waste materials that should be recycled and those that should be disposed of through other options.

## Environmental Effects of Recycling Are Uncertain

Similar to the estimated energy savings from using recycled materials as compared with using virgin materials, the environmental effects of recycling efforts are also uncertain. DOE has noted that to the extent that raw material resources are saved, the environmental impacts associated with the exploration, extraction, and primary production of new materials are avoided. However, DOE has also noted that making products from some recycled waste materials (such as certain grades of paper) may produce greater quantities or more concentrated forms of pollution than making products from virgin materials.

A 1989 study by the New York State Energy Research and Development Authority of the environmental impacts of waste disposal options noted that information on the impacts of disposal options, including recycling, is based on information that is often incomplete, conflicting, and biased.<sup>14</sup> The report found that all waste disposal options have associated pollution problems that can adversely affect public health and the environment. The

<sup>14</sup>Joseph R. Visalli, The Similarity of Environmental Impacts From All Methods of Managing Solid Wastes, New York State Energy Research and Development Authority (Feb. 7, 1989).

report concluded that waste management decisions were being hindered by misperceptions of the risks and benefits of the various waste disposal options. The report recommended that more detailed information on the environmental impacts of disposal options be developed and that comparative risk assessments be conducted.

Similarly, a 1992 DOE report on the status of waste disposal options noted a lack of technical data on the environmental impacts of reformulating recycled materials into new products.<sup>15</sup> The report noted that studies of the environmental advantages of recycling individual waste materials appeared to have been based on limited data and analysis. The report also noted that many of the advantages claimed for recycling assumed high-effluent levels for virgin manufacture that no longer reflect current actual practice. The report identified as a primary research area the economic impacts of using waste materials in the production process as compared with using virgin materials. A 1992 report prepared by the National Academy of Engineering concluded that in many cases the combined economic and environmental benefits associated with recycling programs remain to be demonstrated.<sup>16</sup> The report noted that in a few instances, such as in recycling steel and aluminum, the environmental and economic advantages are clear. The report also noted that the scrap industry for these metals has been in existence for many years and is a major reason for the development of cost-effective recycling of these waste materials. However, the report further noted that the benefits of recycling larger volumes of paper and plastic are less obvious and depend on local factors, such as the existence of secondary markets for these waste materials.

## Agency Comments

We obtained written comments on a draft of this report from DOE and EPA. In its comments, DOE stated that our assessment that municipal solid waste is a limited resource and that its use is constrained by many factors is correct. DOE provided editorial comments that have been incorporated where appropriate. DOE's comments are included as appendix II in this report.

<sup>15</sup>Data Summary of Municipal Solid Waste Management Alternatives: Volume VII: Appendix E—Material Recovery/Material Recycling Technologies, National Renewable Energy Laboratory, Department of Energy (NREL/TP-431-4988G, Oct. 1992).

<sup>16</sup>Perspectives on the Municipal Solid Waste Problem, National Academy of Engineering, Technology and Environment Program (July 8, 1992).



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EPA commented that the report is generally well written and reasonably accurate in its description of EPA's activities. EPA also commented that meeting 2 percent of the nation's needs using municipal solid waste is significant. We agree, although as our report points out, the 2-percent estimate is a goal set by DOE for the year 2010. Our report notes that the current contribution of waste as an energy source to overall energy production is less than one-half of 1 percent.

EPA also commented that the report relies on estimates of energy production from waste, especially for landfills, that are conservative in light of efforts under way to promote this resource. We continue to believe that we have examined all relevant estimates of energy production from waste, including EPA reports, and that the report adequately reflects this evidence. We revised the report, on the basis of EPA's comments, to expand the description of efforts under way that could enhance waste-derived energy production. These efforts, we agree, could lead to increased energy production from waste, but the estimates based on these efforts are preliminary and must be judged in relation to the current constraints of using waste as a fuel for energy production. EPA's comments and our responses are included as appendix III in this report.

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## Scope and Methodology

To respond to your request, we interviewed and obtained documents from DOE and EPA officials responsible for municipal solid waste programs. We spoke to state and municipal officials located in states that have made waste management decisions involving many of the available waste disposal options. We discussed energy production issues with officials at federal energy research laboratories, including Argonne National Laboratory and Brookhaven National Laboratory. We also interviewed officials responsible for research and development on waste-related technology at DOE's National Renewable Energy Laboratory. We conducted our review between September 1992 and March 1994, in accordance with generally accepted government auditing standards.

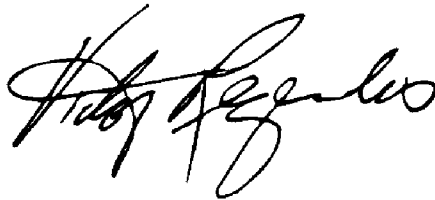
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Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies of this report to congressional energy committees and other interested parties. We will also make copies available to others on request.

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Should you or your staff have any questions or need additional information, please call me on (202) 512-3841. Major contributors to this report are listed in appendix IV.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Victor S. Rezendes". The signature is fluid and cursive, with the first name being the most prominent.

Victor S. Rezendes  
Director, Energy and  
Science Issues



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## Abbreviations

Btu	British thermal unit
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
MW	megawatt(s)
OTA	Office of Technology Assessment



# Summary of DOE's Municipal Waste Program as of April 1994

The goal of the Department of Energy's (DOE) Energy From Municipal Waste Resource Management Program is to increase the use of waste as a fuel or materials source and to ensure that environmentally and economically sound waste management options are available for decision makers. To achieve this goal, DOE has set several objectives, which include providing credible information for decision makers, improving waste combustion technology, increasing the production of gas emissions at landfills, and increasing the use of waste materials through recycling programs. The following is a list of completed, ongoing, and proposed DOE waste-related research efforts.

**Table I.1: DOE's Research—Completed Contracts**

<b>Contract number</b>	<b>Project title</b>	<b>Funding</b>
ZF-1-11115-1	Co-Combustion With Waste and Sewage Sludge	\$165,484
DA-2-11267-1	Development of Mathematical Model of Municipal Waste Combustion	100,000
HZ-2-11207-1	Technology Transfer Support	12,855
HZ-2-12034-1	Research/Analysis/Support of Waste Management Programs	24,900
AAZ-4-14087	Evaluation of Legislation, Regulations, and Rulemakings Related to Waste Management	288,356
HZ-2-11271-1	Waste-to-Energy Technical Publications	38,000
XF-1-11005-1	Assessment of Future Needs in Waste Utilization and Disposal	369,351
XD-1-11187-1	Guide to Energy Production and Conservation From Waste	315,395
YZ-2-11253-1	Evaluation of Waste Combustor Emissions Controls	258,348
ACA-3-12173-1	Recycling Versus Solid Waste Combustion	13,674
HM-1-11155-1	Planning/Coordination, New England Resource Recovery Conference	8,000
DA-1-11246-1	Assessment of Factors Contributing to Abandonment of Waste Combustors	198,299
XF-1-11003-1	Collection/Evaluation of Comparative Data for Waste Management	456,709
XF-1-11107-1	Waste Management Program Technical Assistance	24,998
YN-2-12316-1	Technical Assistance for Waste Management Program for Fiscal Year 1992	20,000
AS-2-12098-1	Mercury and Dioxin Studies	80,000
<b>Total</b>		<b>\$2,374,369</b>

**Appendix I  
Summary of DOE's Municipal Waste  
Program as of April 1994**

**Table I.2: DOE's Research—Active Contracts**

<b>Contract number</b>	<b>Project title</b>	<b>Funding</b>
AD-2-11143-1	Assessment of Metal Wastage in Waste Steam Generators	\$100,000
AAL-3-13050-1	Vitrification of Ash From Waste Combustion	7,000
XA-1-11146-1	Landfill Gas Research	762,000
DA-1-11156-1	Thermochemical Conversion Support	482,800
DA-1-11157-1	Effects of Recycling	150,000
AAE-4-13455-1	Municipal Solid Waste Study of Anaerobic Digestion Facility	41,185
CAK-4-13535-1	Review of Anaerobic Digestion Activities	5,984
HZ-2-12028-1	Research, Analysis, Support of Waste Management Programs	665,975
AAP-4-14143-01	Solid Waste Assessment Models	275,598
AAE-3-13287-1	Waste-to-Energy Technical Publications	41,000
XAR-3-13221-1	Utilization of Ash from Municipal Solid Waste Combustion	109,660
AR-2-12134-1	Education Program	162,954
AAE-4-14148-01	Education Program	85,788
AAE-3-13278-1	Utilization of Ash from Municipal Solid Waste Combustion	49,489
ACA-3-13349-1	Recycling versus Combustion of Waste (Tasks 2 and 3)	25,329
AAE-4-14116-01	Resource-Derived Fuel Commercialization Program and Technology Transfer	47,350
YAR-3-13184-1	Nitrogen Oxides Emission Control From Waste Combustion	45,392
YAE-3-13480-1	Energy Efficiency of Waste Water Treatment Facility	30,122
CAE-3-13276-1	Commercialization of Sludge/Waste Technology	26,840
AAV-3-12310-1	Assessment of Sludge/Waste Technology	65,411
AR-2-12242-1	Evaluation of Recycling Facilities	208,500
AAL-3-13185-1	Evaluation of Integrated Waste Management Systems	300,000
AAT-3-13445-1	Waste Information and Technical Assistance	59,820
AAE-4-14077-01	Assessment of Wood-Related Wastes	65,000
	Landfill Gas Workshop and Transcripts	15,000
XAE-3-13245-1	Utilization of Waste Incinerator Ash	100,079
TR-1-11293-1	Demonstration of Emissions Control Techniques for Waste Combustors	374,062
<b>Total</b>		<b>\$4,302,338</b>

**Table I.3: DOE's Research—Proposed Contracts**

<b>Project title</b>	<b>Funding</b>
Assessment of Landfill Mining and Combustion of Recovered Wastes	\$10,000
Utilization of Waste Incinerator Ash	50,000
<b>Total</b>	<b>\$60,000</b>

# Comments From the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



**Department of Energy**  
Washington, DC 20585

June 28, 1994

Mr. Victor S. Rezendes  
Director, Energy and Science Issues  
Resources, Community, and  
Economic Development Division  
U.S. General Accounting Office  
Washington, DC 20548

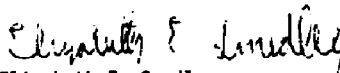
Dear Mr. Rezendes:

The Department of Energy appreciates the opportunity to review and comment on the General Accounting Office draft report titled "Energy Supply: Energy Potential of Municipal Solid Waste is Limited."

The general conclusion in the report is correct in that municipal solid waste is a limited resource and its use is also prevented by financial considerations and public opposition.

Minor editorial changes have been provided to the General Accounting Office under separate cover. The Department hopes that the comments in that letter will be helpful in the preparation of the final report.

Sincerely,

  
Elizabeth E. Snedley  
Acting Chief Financial Officer



See comment 1.



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**GAO Comments**

The following are GAO's comments on DOE's letter dated June 28, 1994.

1. DOE concurred with our general assessment that municipal solid waste is a limited resource and that its use is limited by financial considerations and public opposition. DOE also provided minor editorial comments that have been incorporated where appropriate.

# Comments From the Environmental Protection Agency

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

AUG 11 1994

OFFICE OF  
ADMINISTRATION  
AND RESOURCES  
MANAGEMENT

Mr. Victor S. Rezendes  
Director, Energy Issues  
Resource, Community, and Economic Development Division  
U.S. General Accounting Office  
Washington, D.C. 20548

Dear Mr. Rezendes:

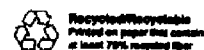
I am transmitting to you the Agency response to the General Accounting Office's (GAO) draft report entitled Energy Potential of Municipal Solid Waste is Limited (GAO/RCED-94-200).

The report is an assessment of municipal solid waste as a potential source of energy as it relates to the Department of Energy's (DOE) efforts to increase the Nation's overall energy production capabilities. The report is generally well written and reasonably accurate in its description of EPA's activities. Specific comments to the report are cited on Enclosure 1. Under separate cover, EPA staff provided GAO with editorial comments for consideration when preparing the final report.

General Comments

The report states that the energy potential from municipal solid waste landfills is limited. In fact, the ability to meet 2% of our energy needs with a renewable source is quite significant. Furthermore, EPA believes GAO's projections of the contribution of municipal solid waste to U.S. energy capacity, particularly landfill gas, is conservative and the report fails to recognize the many complementary efforts underway to tap this renewable source. Enclosure 2 describes the Federal government's activities underway to encourage the development of energy recovery projects.

Throughout the report, use of the term "combusters" is unclear. It should be made clear that combusting of wastes is different from combusting of landfill gas for the production of electricity, particularly from an environmental perspective. Combusting of wastes for energy recovery involves incineration of wastes in the current waste stream. On the other hand, combusting landfill gas for energy recovery involves using landfill gas generated by wastes in place, which will continue to be generated, whether it is recovered and converted to energy or allowed to dissipate into the atmosphere.



See comment 1.

See comment 2.

See comment 3.


Appendix III  
Comments From the Environmental  
Protection Agency

2

Municipal waste-to-energy combustors in the U. S. process presently about 16% of the total waste generated in the country. It has become an important option for those communities that do not have sufficient sites for landfills. Additional opportunities for recovering methane, escaping from landfills and reducing energy consumption through recycling, add to the value of municipal solid waste as a potential source of energy. Energy savings from recycling vary from material to material. For some materials, the energy savings can be significant. Aluminum cans for instance, have a 60% recycling rate and yield a 95% savings in energy consumption.

We appreciate the opportunity to review and comment on the draft report and look forward to receiving the final report.

Sincerely,

*for*   
Jonathan Z. Cannon  
Assistant Administrator  
and Chief Financial Officer

Enclosures

See comment 4.

## GAO Comments

The following are GAO's comments on EPA's letter dated August 11, 1994.

1. EPA holds the view that meeting 2 percent of the nation's energy needs through the production of energy from waste is significant. We agree. However, as our report points out, the current contribution of waste as a fuel source to overall energy production is only one-half of 1 percent. The 2-percent estimate cited by EPA, and also by us in our report, is a goal set by DOE for the year 2010. We also point out that other industry estimates show an even smaller role for waste-derived energy production in the future.
2. EPA commented that we relied on "conservative" estimates of waste-derived energy production and stated that our draft report failed to recognize efforts under way to use waste as an energy source. We have subsequently incorporated information that EPA supplied to us which provides additional estimates of potential energy generation from landfill gases. However, because of the limitations as noted in these estimates, we continue to believe that waste-derived energy production will make only a limited contribution to meeting the nation's overall energy needs. We agree with EPA, as our report suggests, that efforts under way to increase the production of waste-derived energy could have a significant impact in future years. We have expanded our discussion of these efforts on the basis of EPA's comments.
3. EPA said that the manner in which we characterized municipal waste combustors as compared to landfill-gas energy projects was unclear. We agree with EPA that these two forms of energy production vary significantly in terms of energy and environmental impact. Waste combustors necessarily remove waste from the current waste stream to produce steam and electricity. This technology inherently generates pollutants, which must be reduced through both emissions control technology and facility operating standards. Energy production using landfill gases, on the other hand, presents a somewhat different analysis. As EPA has pointed out, energy production using landfill gases relies on emissions that would be generated regardless of energy recovery efforts. This characterization, we believe, is consistent with our report's assessment that energy production using landfill gases can help to reduce some harmful emissions that would otherwise occur. We have revised our report to accommodate these comments.
4. We agree with EPA's comments that waste combustors have become important waste disposal options in areas where landfill capacity is

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**Appendix III  
Comments From the Environmental  
Protection Agency**

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constrained and that energy benefits can accrue from landfill-gas energy projects and recycling programs. We also agree with EPA, as we noted in our report, that energy savings from recycling varies by the types of materials recycled and that in some cases, such as aluminum, these savings can be significant. We have made appropriate revisions to our report.

# Major Contributors to This Report

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Resources,  
Community, and  
Economic  
Development  
Division, Washington,  
D.C.

Jim Wells, Associate Director  
Gregg A. Fisher, Assistant Director  
Daniel J. Feehan, Evaluator-in-Charge  
Peg Reese, Senior Evaluator  
Michael Shumaker, Staff Evaluator

---

Office of General  
Counsel

Jackie A. Goff, Senior Attorney

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