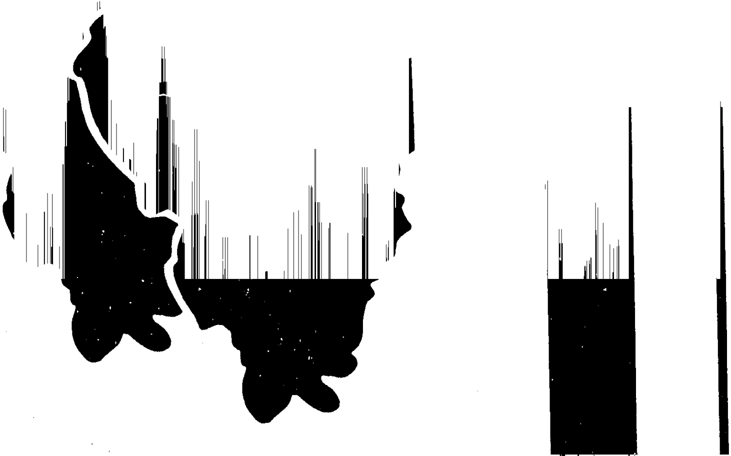

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ENERGY ASPECTS OF SOLID WASTE MANAGEMENT

PROCEEDINGS OF THE
EIGHTEENTH ANNUAL
ILLINOIS ENERGY CONFERENCE

CHICAGO, ILLINOIS
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CONTENTS

FOREWORD

The Eighteenth Annual Illinois Energy Conference entitled "Energy Aspects of Solid Waste Management" was held in Chicago, Illinois on October 29-30, 1990. It was organized by the Energy Resources Center, University of Illinois at Chicago with major support provided by the U.S. Environmental Protection Agency, the U.S. Department of Energy, the Illinois Commerce Commission, the Illinois Department of Energy and Natural Resources, the Illinois Environmental Protection Agency, the Citizens Council on Energy Resources, and the Chicago Association of Commerce and Industry.

The conference program was developed by a planning committee that drew upon Illinois energy and environmental specialists from the major sectors including energy industries, environmental organizations, research universities, utility companies, federal, state and local government agencies, and public interest groups. The planning committee was brought together for a full-day session where they were asked to assess the technical, economic and institutional issues surrounding the solid waste problem in Illinois and the Midwest. They also considered such related issues as MSW systems, landfills, and other new waste-to-energy technologies.

Within this framework, the committee identified a number of key topic areas surrounding solid waste management in Illinois which were the focus of the conference.

These issues included:

- Review of the main components of the solid waste cycle in the Midwest and what the relative impact of waste reduction, recycling, incineration and land disposal might be on Illinois' and the Midwest's solid waste management program.

- Investigation of special programs in the Midwest dealing with sewage sludge, combustion residuals and medical/infectious wastes.

- Review of the status of existing landfills in Illinois and the Midwest and an examination of the current plans for siting of new land disposal systems.

- Review of the status of incinerators and waste-to-energy systems in Illinois and the Midwest, as well as an update on activities to maximize methane production from landfills in the Midwest.

Subcommittees were then formed with the task of designing the four plenary sessions, keeping a focus on the state/regional impacts of each particular topic. The subcommittees also recommended several keynote speakers who would place the critical environmental issues into the national/international context. For these exceptional efforts, we express our thanks to the planning committee and subcommittee members who worked hard to suggest pertinent issue areas and speakers.

Appreciation also is extended to the outstanding speakers whose papers appear in this publication. The excellent quality of the program reflects considerable time and effort

on the part of the speakers in the preparation of the presentations. In addition, a word of thanks is given to the conference sponsors and the University of Illinois staff, David Balderas, Irma Jasso, and Douglas Sitzes who handled the detail work of the conference. Finally, I thank James Wiet, who managed the conference activities from beginning to end, and Smith-DuPage typing service for wordprocessing this manuscript.

I hope you find these conference proceedings useful in providing current policy information on energy and environmental aspects of the solid waste management problem in Illinois.

James P. Hartnett
Planning Committee Chairman

I. KEYNOTE PRESENATIONS

WASTE: THE POSSIBILITIES OF A NATIONAL RESOURCE

Alan J. Streb
Deputy Assistant Secretary
for Industrial Technologies
U.S. Department of Energy

Mike Davis wanted very much to be here, but due to previous commitments he found himself unable to participate. Because Mike's role is so central to the Department of Energy's (DOE) focus on solid waste management and related energy concerns, I would like to share with you a bit about him and the ways in which we are working to address the complicated problems facing our country today.

Less than a year after his appointment, in April of 1990, the DOE completed a reorganization of its Office of Conservation and Renewable Energy by creating five main sectors of energy resources from what had been only two. The sectors, and offices and divisions within them, are more closely allgned to end-use intent.

As a result of the reorganization, the Municipal Solid Waste (MSW) Program, the Solar Detoxification Program, and the Industrial Waste Program were combined to form what is now the Waste Material Management Division, headed by Donald K. Walter.

The Waste Material Management Division, which I represent, appropriately falls under the Office of Waste Reduction. It has a special mission to develop and maintain a balanced program of research and development as well as technology transfer, in order to establish a technology base from which industry can develop systems for waste treatment, detoxification, and beneficiation. The objective is to enable the possible reuse of waste materials, including hazardous materials, generated by industrial processes or municipal solid waste disposal programs.

I would like to go over some of what the Office will be doing in order to achieve the goals set in its mission. Our operations will include:

- Managing the development, implementation and evaluation of a national program to reduce the generation and increase the beneficial utilization of waste material. This program will largely consist of research and development of technologies to capture the energy value from industrial and municipal waste.

- Identifying and interpreting the legislative requirements and intent applicable to the program in order to implement and satisfy those needs.

- Maintaining close contact with the "decision-makers" of U.S. industry, state and local governments and the public to be sensitive to their accomplishments, capabilities, trends, and needs.

- Monitoring emerging technologies that may prove beneficial to the useful recovery, detoxification and/or destruction of industrial and municipal wastes, including hazardous chemical waste products, and the increased use of solar energy in industrial processes.

- Providing a waste material management technology base, including scientific, engineering, technical and programmatic data for analysis and support of planning and policy development. The data base will include a comprehensive profile of waste stream characteristics and volume flow.

- Collecting, organizing and maintaining economic and technical performance data on waste management systems and responding to all appropriate requests for such data and information.

- Interacting with DOE organizations and other agencies as appropriate to identify those requirements that may impact the waste material management research and development content of programs.

As an unrelated but complementary action, Deputy Secretary Henson Moore announced the launching of 11 initiatives which are geared to increase emphasis by the DOE on increased energy efficiency and the use of renewable energy sources--"seen as the cleanest, cheapest, safest means of meeting our nation's growing energy needs in the 1990's and beyond." The "initiatives" basically consist of new program starts or substantial enhancements of DOE program spending and activity. Deputy Secretary Moore promised that the initiatives will seek a reinvigorated partnership of federal government and private sector to promote greater energy efficiency and faster commercialization of promising energy efficiency and renewable energy technologies. Of the 11 initiatives, five are related to energy efficiency and six to renewables. Two in particular are of great interest to the Waste Management program. They are Energy from Municipal Waste and Solar Detoxification of Hazardous Waste.

SOLAR DETOXIFICATION OF HAZARDOUS WASTE INITIATIVE

The Solar Detoxification of Hazardous Waste initiative consists of the application of a novel, attractive new technology to the neutralization of hazardous wastes. Cleaning up hazardous wastes is increasingly receiving attention and public scrutiny. Potential cleanup costs of existing and future sites are estimated in the billions of dollars if existing energy intensive processes were to be used.

In 1988, the United States produced 280 million tons of hazardous wastes--more than one ton for each person in the country. Existing technology is not adequate to solve the nation's hazardous waste problems; new strategies are needed for waste cleanup. Eighty-five percent of hazardous waste is merely diluted with water and returned to the environment. Only five million tons are incinerated or recycled. Past poor disposal practices have contaminated or recycled more than one-fourth of all large U.S. drinking water systems with traces of toxic chemicals.

Recent breakthroughs in the laboratory have demonstrated that concentrated solar energy with a catalyst can destroy toxic chemicals such as dioxin and PCB's. Photons in sunlight convert organic chemicals into carbon dioxide, water and dilute acids, and harmless by-products. The technique is significantly more effective than incineration (with accompanying emissions), filtration through activated carbon (with disposal of the contaminated carbon), or the use of ultraviolet lamps (with high energy consumption).

Cooperative development programs are being explored with the Environmental Protection Agency (EPA), the Department of Defense, and other DOE programs. The first field test of the technology is to be the detoxification of ground water contaminated with low levels of trichloroethylene which originated a DOE site. Industrial participation will be encouraged in both the technology development and testing programs. Research activities currently on-going at DOE laboratories will be accelerated to improve process performance with a variety of chemical wastes.

ENERGY FROM MUNICIPAL WASTE INITIATIVE

Energy from Municipal Waste initiative deals with the growing national problem of which most of you are well aware. The initiative is directed at reducing barriers to increased use of municipal waste for energy production. It will enable early cooperative research programs with EPA, state and local governments, and industry to assist in the identification and resolution of environmental and various institutional impediments to the adoption of waste to energy alternatives.

What is Municipal Solid Waste? The majority of typical waste is comprised of paper and paperboard materials, plus yard food and plastic waste which are "combustible." Combustible, or burnable materials, comprise approximately 55 percent. The rest is 20 percent inorganic matter, i.e., glass, metals, and various other inorganic materials, and 25 percent water.

The problems we face are that we have an increasing amount of MSW: we do not have enough capacity in our current landfills to hold it; it is costing us more and more to dispose of it; and public concern and opposition is mounting. Also, our need for energy is increasing. Everyone wants their waste picked up from the curb in the morning, but no one wants it put in their backyard.

Let's look at the first issue. In 1960 it was estimated that each person in the United States generated approximately 2.7 pounds of trash every day. Today, this number has dramatically increased to 4.0 pounds for each person each day! This calculates to approximately 250 million tons a year--enough to spread 30 stories high over 1,000 football fields, or enough to fill a bumper-to-bumper convoy of garbage trucks halfway to the moon.

Americans discard almost twice as much garbage as the citizens of any other country; for example, the average Japanese throws away 2.5 pounds a day, the Norwegian only 1.7 pounds--less today than Americans did in 1960! It is regrettable to note that Europe has employed their technology far better than we have, and as a result uses three times as much MSW for energy as the United States.

Today we are burying approximately 79 percent of our waste in landfills, burning 11 percent and recycling only about 10 percent. Our goal should be to convert 50 percent of our waste to energy, recycle another quarter of it, and place only about 25 percent in landfills.

In 1988, EPA estimated that we had about 6,000 active landfills and that by 1993 we would have 2,000. If that occurs, we face a shortfall of 56 million tons per year of disposal capacity. According to a report sponsored by the Council for Solid Waste Solutions, many landfills have closed because they are filled to capacity, but many also closed because they fail to meet EPA standards. We have come to realize that older dumping techniques are potentially hazardous, causing soil and groundwater toxicity from decomposing garbage. In fact many superfund sites are old municipal landfills.

Because of the scarcity of landfill space, the cost of traditional landfill disposal in some places has reached astronomical rates in recent years--going from $10 per ton in 1978 to over $150 per ton today. It has also caused communities to haul their trash across state lines into rural areas, which can be costly (Long Island townships, for example, each spend about $23 million per year shipping out of state)--not to mention what it does to the ire of the "dumped upon" residents.

In fact, the shortage of landfills is directly related to the issue of public opposition. Citizens are speaking out and taking action to object to the placement of new landfills, but at the same time are opposing facilities for waste-to-energy or materials recovery; it makes progress difficult. Some of the newest acronyms to pepper our waste wars vocabulary are ones like NIMBY (Not In My Backyard), GOOMBY (Get Out of My Backyard), LULU (Locally Undesirable Land Use), NIMTOO (Not In My Term of Office), and one of the most ominous, NIMEY (Not In My Election Year).

One often-suggested answer to all of this is to recycle, but simple recycling is not such a simple issue. Refuse is heterogeneous, and even the quantities of any particular constituent vary widely from one location to another. This presents a formidable barrier to the effectiveness of unit operations in processing systems designed for more heterogenous materials.

About 20 percent of the materials can be separated out and recycled. Most of the rest can be converted to some form of energy.

Some of the problematic issues involved in recycling are economic, logistical, environmental and social--just about anything of which you can conceive. There are the issues of who will collect it, and who will pay for collecting it; who will sort it and how; who will do it; how we do it and recover it; what effect how we do it will have on the environment; and who will use the recycled product . . . and on and on.

Some recycling is driven hard by the economics. It is a shame to throw away an aluminum beverage container. Each can represents 4,000 Btu and a penny. However, even though actively sought by industry, only 60 percent of all aluminum beverage containers are recycled.

Thermal processes produce steam, electricity, or liquid and gaseous fuels from refuse-derived fuel (RDF). The oldest thermal technology for producing energy from waste is combustion; however, gasification and pyrolysis systems are now emerging. Pyrolysis and gasification systems produce liquid, gas, and solid fuel forms from MSW. These fuel forms can be cheaper, more convenient, used more efficiently and have large markets.

County); SWL/Envirotech (Grundy County), Perry County Landfill (Perry County); Daubs Sanitary Landfill No. 3 (Wayne County), and Rockford Speedway (Winnebago County). Rapatee Mine and Rockford Speedway landfills accept only coal ash and demolition debris, respectively--general refuse cannot be disposed of at these sites. Although two facilities located in the Counties of Macon and Rock Island received development permits, they failed to become operational, and subsequently their permits have expired. The balefill near Bartlett has received an Agency permit to develop but has not yet started development and awaits permits from other government agencies. Currently, Gallatin National in Fulton County has resubmitted a development permit application to IEPA

Biochemical conversion uses microorganisms or enzymes to convert MSW to liquid or gaseous fuels. Anaerobic digestion is the process in which microorganisms convert the natural organic matter in MSW to a mixture to methane and carbon dioxide. Certain enzymes selectively convert the cellulosic fraction of MSW to glucose, which may then be fermented to produce alcohol.

All of that said, what can we do? Well, actually, a lot. The goals of the MSW program are geared to tackle the issues head-on. In line with the Department of Energy's overall goals, we aim to have integrated waste management, including recycling, energy recovery, and environmentally sound disposal of residuals.

This goal could be achieved through increasing the number of waste-to-energy and resource recovery facilities and increasing the efficiency of facilities already in operation. The DOE program would contribute by increasing public information regarding the use of MSW as an energy source and making new conversion technologies available to industry for commercialization.

We have defined what our research tasks are, what the obstacles to commercialization are, what is needed to overcome them, and the potential for industry involvement where it exists. As we see it, the three areas having the highest priority are thermal and biological conversion, R&D and technical assistance.

In the near future, we will be developing an R&D plan with representatives from federal, state, and local governments and industry to help establish research needs, priorities, and resource requirements. Our plans include close cooperation with industry representatives so that commercialization of these technologies will be easier as they become available. We expect industry to be involved not only in the technology efforts themselves, but also in providing continuous input to the program's direction and priorities and in evaluating the program's progress. Although we will continue to address long-term high-risk research and development areas identified by industry, we will focus on near-term applications to facilitate implementation of the technologies.

All of these efforts will become part of the larger National Energy Strategy, which is being developed by DOE at the direct request of President Bush. DOE has opened a dialogue with the American people. There have been 15 public hearings across the country with more than 375 witnesses representing 43 states. Over 1,000 written submissions have been received from state and local governments, consumer organizations, business, industry and other recognized representatives.

The first phase in the development of the strategy--information gathering--has been completed and the "Interim Report on the Development of a National

Energy Strategy: A Compilation of Public Comments" has been released. The most important message contained in this document is that energy efficiency and renewable energy sources is seen as a way to reduce pollution, reduce dependence on oil imports, and reduce the cost of energy.

The first edition of the National Energy Strategy is expected to be submitted to the President in December of 1990.

CONCLUSION

Ultimately, even with all these governmental and industrial efforts, the success of these programs will rest with the American public. The motivation for cleaning up the planet may come from various sources, but the real willingness to comply with new measures, to find new ways of living and doing old things, must come from within the people. Americans must be convinced of their personal importance in taking part in the reclamation of our land and concomitant reduction in and conversion of its solid waste. The nation must be prepared to make trade-offs, and even to sacrifice--something many are often loathe to think about.

LIFE CYCLE ANALYSIS: UNIQUE PERSPECTIVES FOR PAPER

Richard E. Storat, Vice President
American Paper Institute

I will address a subject that seems to be gaining more and more interest in environmental discussions: Life Cycle Analysis. These types of analyses go by many names . . . PLA's (Product Life Cycle Assessments), REPA's (Resource and Environmental Profile Assessments), and cradle-to-grave analyses, among others. What many of these titles have in common is that they promise far more than the technique delivers.

First let me explain my perception of these analyses. Essentially, they provide an inventory or a summation of the energy consumed by, and the airborne, waterborne and solid wastes associated with, a product. One begins the inquiry by identifying the energy and emissions associated with obtaining the necessary raw materials, continues through the product's manufacture, distribution, use and reuse, and concludes with its final disposal.

Since the process begins with the gathering of raw materials and ends with final disposal, it is easy to see how the notion of cradle-to-grave has become popularized. And the results do offer such a profile of those parameters addressed in the study.

I would like sketch for you some paper industry profiles in areas often addressed by Life Cycle Analyses. This will be an industry overview . . . the view from 30,000 feet, so to speak. While far from providing the specific detail needed to undertake a Life Cycle Analysis for individual paper products, it will highlight some relevant issues of key interest to these proceedings. Then, with that background, I will offer a few additional comments regarding Life Cycle Analyses.

PAPER: MINIMIZING RELIANCE ON FOSSIL FUELS

The paper and allied products industry is energy intensive and accounts for nearly three percent of total U.S. energy consumption. At pulp, paper and paperboard mills, some 2.5 quads of energy were consumed in 1988. On average, it takes about 27 million BTU's to manufacture a ton of paper, but with wide variations for individual products. On average, the manufacture of recycled paper requires about 20 to 30 percent less energy. But that, too, depends upon the grade of paper considered, and to some extent, upon the recycling process.

The paper industry has made substantial gains in energy conservation and energy self-sufficiency. Between 1972 and 1989, it reduced oil consumption by nearly 60 percent, decreased natural gas consumption by 17 percent, and lowered purchased energy consumption by 15 percent. All this occurred while industry output increased by more than 57 percent, resulting in a reduction in fossil fuel and purchased energy use per ton by 47 percent.

Between 1972 and 1989, the industry's use of self-generated and residue sources of energy increased from 40.3 percent of total energy needs to 56.3 percent, a 40 percent gain in energy self-sufficiency. Today, U.S. paper mills derive over half of their energy from materials that would otherwise have to be disposed as industrial wastes in most cases.

Several studies show that the pulp and paper industry is one of the leading U.S. industries in the cogeneration and self-generation of electric power. Over the 1982-1989 period, the amount of electricity cogenerated by the paper industry has grown by 62 percent, and in 1989 represented 88 percent of total in-plant electric generation. All told, some 50 percent of the paper industry's own electricity demand is cogenerated.

Coupled with energy savings from cogeneration of electricity, the industry's reliance on energy derived from wood wastes displaces and conserves an equivalent of approximately 225 million barrels of oil each year. Placed in a current perspective, that is 15 percent of the amount of the oil exports cut off from Iraq and Kuwait. This heavy reliance on renewable energy is probably the most significant energy factor distinguishing the paper industry from other basic manufacturing industries. In the assessment of energy consumption in Life Cycle Analyses, it is crucially important to distinguish between energy from renewable and non-renewable sources, because the implications for both resource depletion and, indeed, our nation's economic security are markedly different.

PAPER: THE LEADER IN RECYCLING

Since these proceedings are focused on solid waste management, a description of the paper industry's recycling profile is expected. The industry's roots are in recycling. This year, the paper industry marks its 300th anniversary of the first paper mill operation in the U.S., recycling cotton rags into writing paper near Philadelphia. Today, paper and paperboard continue to be the leading recycled material, being recovered from the solid waste stream far in excess of its share of contribution to the municipal solid waste stream.

In 1989, over 27 million tons of waste paper were recovered for recycling at home and abroad, far more than in any other nation in the world. In fact, eight out of every ten tons of material recovered from the municipal solid waste stream is paper and paperboard.

Waste paper supplies over one-quarter of the domestic paper industry's requirement for fiber, 20.9 million tons in 1989. This figure has been growing at a rapid and accelerating rate since the mid-1980's. The use of waste paper is growing more than twice as fast as the rate of other fiber sources at U.S. mills.

Besides large volumes, two additional features characterize the recycling of waste paper: 1) a mature collection infrastructure, and 2) the varieties of waste paper collected and the products made from them. To give you an idea of the 1989 distribution, U.S. paper mills used 3.3 million tons of old newspapers of which 1.5 million tons went into recycled newsprint, 1.3 million tons to make recycled paperboard and 200,000 tons into recycled tissue products. Ten and a half million tons of old corrugated containers were used at U.S. mills, almost all of which went into the manufacture of recycled containerboard and boxboard grades. Also, 2.9 million tons of pulp substitutes and 1.9 million tons of high-grade de-inking grades were recycled into a wide range of products, mostly printing-writing papers and tissue products.

Mixed paper constituted the remaining 2.2 million tons used by the industry in 1989. It provided fiber for a range of products, mainly in the recycled boxboard and tissue grades.

Even though the paper industry's historical recycling record is impressive, there is more good news ahead on paper recycling. The U.S. paper industry has committed to be part of the country's solid waste solution and is publicly committed to maximizing recycling to the fullest extent economically and technologically feasible. In fact, the paper industry has taken the unprecedented step of establishing a national goal to recover 40 percent of all paper consumed in 1995. That is 40 million tons, 50 percent more than now being recovered. Significantly, we believe that 40 percent represents the maximum level of waste paper that can be collected in clean and useable condition by 1995.

To reach this 40 percent goal, the paper industry will need to recover more than one of every two newspapers printed, two of every three corrugated boxes, half of the high-grade printing-writing papers from printing plants, office buildings and other sources, virtually all the pulp substitutes from converting operations, and 40 percent more unsorted mixed papers than we recovered in 1988.

Expanding the existing infrastructure to collect 40 million tons of waste paper in 1995 will constitute a major national challenge. It will require a public/private partnership built on the efficient private infrastructure already in place. A few facts put this challenge in perspective:

- Nearly 90 percent of this growth must come from the post-consumer paper stream. This means that broad public involvement will be necessary.

- By 1995, more than three-quarters of all the paper collected will be post-consumer waste paper.

- And finally, between now and 1995 the U.S. recovery rate will move from below the worldwide average to above the world average.

In summary, the future for paper recycling is bright. U.S. producers are investing billions of dollars in recycling capacity as they move to meet their commitment to maximize recycling to the fullest extent possible.

Yet, the real challenge for expanding recycling, as we look to the mid-1990's and beyond, will be the country's ability to collect enough clean, sorted raw materials. Thus reaching our 40 percent goal will require the cooperation of government at all levels, as well as the participation of tens of millions of individual citizens.

A GROWING, RENEWING RESOURCE BASE

The reliance on an expanding resource base, one which is being renewed faster than it is being used, is another feature which distinguishes the paper industry from many other basic manufacturing industries. The nation's timber resource base is and has been expanding. A major contributing factor is the aggressive reforestation program of the forest products industry, including efforts of large companies and small tree farmers across the nation. Let me share a few facts regarding forest growth and renewal in the United States since 1952:

- Annual planting has increased by almost 600 percent from 523,000 acres per year to over three million acres per year.

- Annual forest growth has increased by 61 percent from 13.9 to 22.3 billion cubic feet per year.

- And, timber inventories have increased by 24 percent over this period.

It is significant to note that growth exceeds harvest in every region of the country. On a nationwide basis, growth exceeds harvest by more than 30 percent. The U.S. exceeds both Western Europe and Canada in both timber inventory and growth. So, the message is clear; the U.S. paper industry relies on a resource base which is both renewable and growing, as opposed to one which is being depleted.

INVESTING IN THE ENVIRONMENT

Clearly the paper industry's future is reliant on the healthy growth of trees, which can only happen in a healthy environment. In short, it is good business for our industry to not only invest its own money in protecting the environment but to encourage others to do so as well. We were environmentalists long before the term became fashionable.

The industry's capital investments for environmental controls have been substantial and speak directly to this point. Over the 1970 to 1989 time-frame, the industry has invested more than 8 billion dollars. That includes 3.3 billion for water, 3.9 billion for air and 0.9 billion for solid waste environmental controls. Over this period, levels of investment have ranged as high as 38 percent of the industry's annual capital investment.

Importantly, the rate of investment in each of these areas has escalated sharply over the past several years and is projected to increase substantially in the years ahead.

LIFE CYCLE ANALYSES: USES AND MISUSES

That completes a brief "tour de force" of some factors often addressed in Life Cycle Analyses which take on a unique perspective for the paper industry. With that as background, let me offer you some thoughts on Life Cycle Analyses themselves. I would like to offer a few highlights and caveats for your consideration from the perspective of a potential user of these studies.

First, what are they? Historically and currently, they are analytical tools to quantify the energy and raw material usage and waste generation during the stages of a product's life. These stages include raw materials sourcing, all stages of manufacturing, distribution, use/reuse/maintenance, and final disposal.

Second, why do them? The primary purpose of Life Cycle Analyses is to identify opportunities for reducing overall chemical loading to the environment and to identify opportunities to conserve natural resources. Properly scoped, they can serve as valuable input to product or process development and modification investigations.

But, like many useful tools, the potential for misuse also exists. Therefore, it is relevant to address what these studies do not accomplish, i.e., what are their limitations?

First, they are not risk assessments. They are inventories of energy and raw material consumption and emissions. They quantify the amount of a chemical generated, but do not evaluate its potential impact or harm in the environment. Overall conclusions about the comparative impacts of competing products cannot be drawn from these studies.

Second, they address only a subset of the total range of environmental effects associated with any product, those most easily quantified. Many other factors, litter, ozone depletion, global warming, to name just a few, are not addressed and may be much more difficult to quantify. Consequently, these studies cannot be used to determine a product's environmental friendliness or its total impact on the environment.

Third, these studies do not address any economic considerations, potential social or health benefits, or liabilities associated with use of a product. These analyses do study in depth some aspects of a product's use. But, as Paul Harvey would say they do not tell us, "the rest of the story."

And, fourth, the outcome of these studies can be very sensitive to the necessary simplifying assumptions and the often imperfect data available to the researcher undertaking the analysis. While straightforward in concept, these analyses are quite complex in actual practice. Assessing the accuracy and limitation of the results requires trained judgment and a thorough understanding of the analytical methods used. It is not enough to compare numbers directly and draw conclusions from them regarding a product's impact on the environment.

So, in summary, how useful these studies are depends upon their intended use. They can offer valuable assistance to one trying to gain a systematic understanding of the energy consumption and selected effluent loadings associated with a product or a manufacturing process. While perhaps a laudable goal for the future, to use these Life Cycle Analyses today as a basis for policy-making or to offer them as a tool to judge the overall environmental impact of products, would be misleading.

II. THE SOLID WASTE PROBLEM: CURRENT STATUS

SOLID WASTE HANDLING IN ILLINOIS

Michael F. Nechvatal
Manager, Solid Waste Management Section
Illinois Environmental Protection Agency

INTRODUCTION

Illinois, like most states, faces significant challenges in dealing with the waste products our modern lifestyle produces. Over the past five years, the state has addressed these problems with several pieces of legislation that have begun to influence the way we produce and handle our wastes. Additional laws are being considered to bring about even more changes in the years to come. This paper will focus on the current status of solid waste handling in Illinois and highlight some of the key state laws that direct the Agency and each Illinois resident to do certain things.

CURRENT HANDLING METHODS

In 1986, the General Assembly passed the Solid Waste Management Act to re-focus the state's attention back to solid waste concerns. This Act laid the foundation for state policy by adopting a hierarchy of solid waste handling preferences: 1) waste reduction; 2) recycling or re-use; 3) incineration for energy; 4) incineration for disposal; 5) landfill. While this hierarchy is widely accepted as a good goal, what the state faces now is a completely opposite situation with current waste handling conditions.

The U.S. Environmental Protection Agency estimates that solid waste production nationally will increase 11 percent from 1988 to 1995 due to increased population and increased per capita waste generation. There is no reason to expect that Illinois will be very far from this national trend. About five percent of the solid waste stream is currently being recycled. Since data collection for recycling is difficult, this figure may be somewhat higher, but it is still a relatively small percentage of the total waste stream. About two percent of the waste stream is incinerated for energy recovery in one facility owned and operated by the City of Chicago. This leaves 93 percent of the waste stream sent to Illinois landfills in 1990--13.2 million tons.

This increasing load of waste delivered to landfills has become a more difficult problem as there are fewer landfills in Illinois and other states. When the Illinois Environmental Protection Agency (IEPA) was created in 1970, the Agency estimates that there were about 1,200 "dumps" and landfills in the state. Now, there are 117 in Illinois, and many of those are predicted to close in the next two years as they reach capacity or fail to meet new, more stringent landfill rules. This trend to fewer landfills is not limited to Illinois; the National Solid Waste Management Association (NSWMA) predicted that eight states had less than five years of overall disposal capacity left in 1989, and 15 states had less than ten years left.

In Illinois, the disposal capacity is not evenly distributed through the state. Today, 29 of the 102 counties have no disposal capacity and must transport all their waste to other counties for disposal. If landfills close as predicted, in three years 39 counties will have no capacity. If all the solid waste in Illinois were evenly distributed to the existing landfills, a most unlikely situation, their current capacity would last from six to eight years. A more reasonable expectation is that some landfills will be filled very soon, and others will remain unfilled for many years.

FUTURE PLANNING

To deal with this impending disposal capacity shortfall, the state passed the Solid Waste Planning and Recycling Act in 1988 to require counties over 100,000 population and Chicago to prepare plans for their future solid waste handling needs by March 1, 1991, and implement a 25 percent recycling program. In 1989, this law was amended to extend these requirements to all other counties with a deadline of March 1, 1995. Most large counties are well on their way to meeting this time-frame, and a number of smaller counties have also begun their planning.

Despite Agency supported planning efforts, the best plans by local government can be circumvented in many cases by private companies who own and operate waste handling facilities. These operators use their own, private goals--not society's--when selling their waste handling services. Although over 90 percent of waste handled in Illinois is currently landfilled directly, the preponderance of Illinois landfill capacity is controlled by private owners. About 70 percent of

Illinois landfills with three-quarters of landfill capacity is now privately owned. Only about 3 percent of the current capacity is in privately owned and operated landfills.

In many cases the decisions of these private operators is to accept waste from generators located far away from the landfill, including many other states. While the total quantity of out-of-state waste is not a significant fraction of the total state waste stream yet, it is becoming so. The Agency estimates from surveys performed in August/September 1990 that *3.4 percent (1,500,000 cu. yd. per year) of all waste received at Illinois landfills was generated out of state.* In addition, out-of-state waste has become a major factor at some landfills. While data collection is incomplete due to a lack of statutory authority, Agency information indicates *out-of-state waste is accepted at a minimum of 23 landfills and accounts for over half of the volume received at five.* Thus, about 18 percent of the operating landfills are taking out-of-state waste.

FACILITY SITING

Regardless of who plans for a new facility, each site must receive local approval under state siting laws.

Forty-three requests for local siting approval on new landfills have been reviewed by units of local government. Of these requests, there have been 38 decisions: 22 approvals and 16 denials--a 58 percent approval rate.

These siting decisions were directed at 32 individual sites, since 11 of the 43 requests were duplicate proposals (i.e., resubmitted applications) on seven sites located in Alexander, Lake, McHenry, Wabash, and Wayne Counties. Subsequently, 18 sites received local siting approval, and 16 sites were denied (a 56 percent approval rate).

This category has the highest appeal rate with 68 percent of the local decisions being challenged. Presently, three local siting decisions in Bond, Fulton, and LaSalle Counties are being contested. Some areas of the state have a different local approval system than the "normal," local approval: Chicago and unincorporated Cook County.

Of the 19 sites receiving local approval (one through the local *zoning* process), 11 did not receive development permits from the Agency: two did not apply, five were denied, four were withdrawn.

To date, eight new landfills have received local siting approval and IEPA permits with only five new landfills becoming operational: Rapatee Mine (Fulton

County); SWL/Envirotech (Grundy County); Perry County Landfill (Perry County); Daubs Sanitary Landfill No. 3 (Wayne County); and Rockford Speedway (Winnebago County). Rapatee Mine and Rockford Speedway landfills accept only coal ash and demolition debris, respectively--general refuse cannot be disposed of at these sites. Although two facilities located in the Counties of Macon and Rock Island received development permits, they failed to become operational, and subsequently their permits have expired. The balefill near Bartlett has received an Agency permit to develop but has not yet started development and awaits permits from other government agencies. Currently, Gallatin National in Fulton County has resubmitted a development permit application to IEPA.

LANDFILL EXPANSIONS

Landfill expansions are the largest category of regional pollution control facilities reviewed by units of local government. To date, they have ruled on 60 applications: 41 approved, seven denied. There were two resubmitted applications on the same sites in Massac and Peoria Counties. Therefore, the approval rate of expansions on 58 sites is 69 percent. Of these local decisions, 38 percent have been challenged. To date, IEPA has issued permits to 31 sites, all for municipal waste disposal. Landfill expansion applications have been submitted to local governments in 38 counties; to date, approvals have been given in 28 counties.

FUTURE SITING AUTHORITY

There continues to be a public debate on who should have the initial authority to approve landfill siting and on what basis those decisions should be made. Several pieces of legislation were introduced in the Spring 1990 legislative session. Although none were acted on, there remains an interest (mostly business and local government) in the state to change the siting authority as exemplified by the Task Force which continues to consider this matter under a charter from the Speaker of the House.

Changes to the state siting process is possible in the Fall 1990 veto session or the Spring 1991 regular session. Exactly what those changes may look like cannot be predicted now since there are interests ranging from "no change" to wholesale changes in the siting laws. The next few years will most likely see the solid waste issues become even a greater public policy issue.

ILLINOIS COUNTIES WITHOUT DISPOSAL FACILITIES NOW AND IN THE THREE YEARS IF NO NEW FACILITIES ARE BUILT

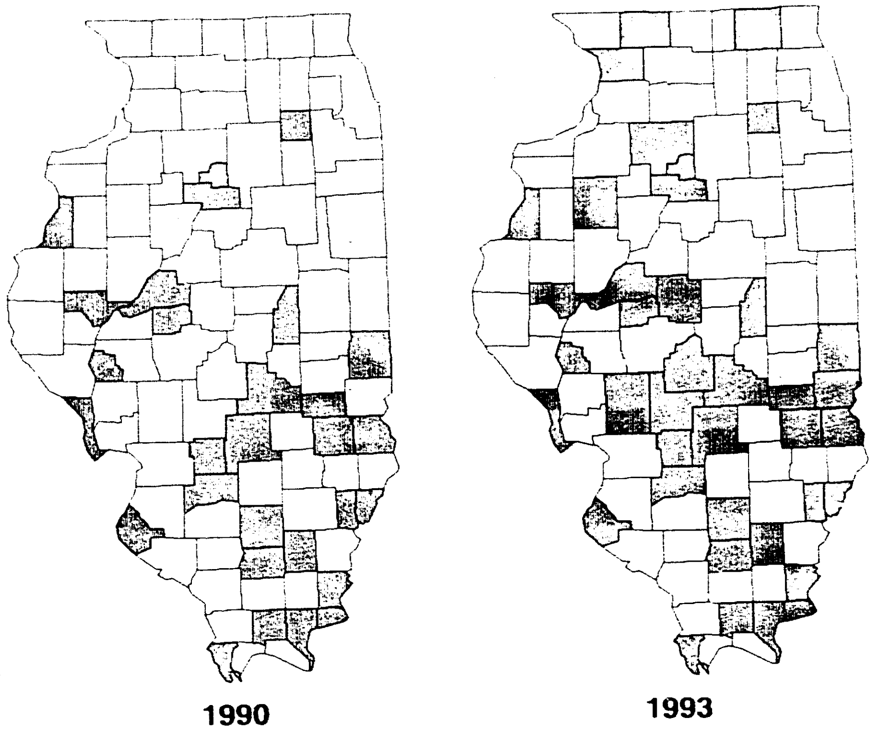
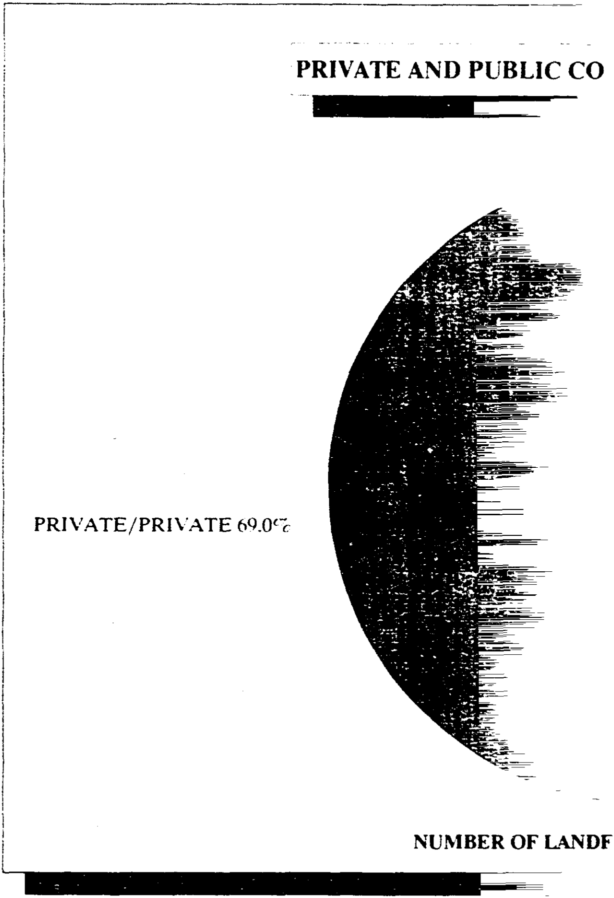


Figure 1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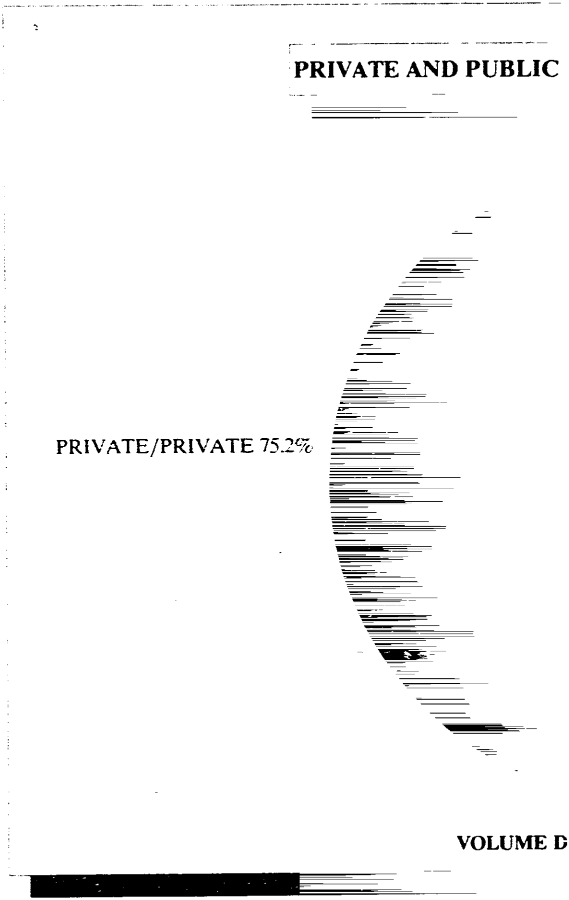
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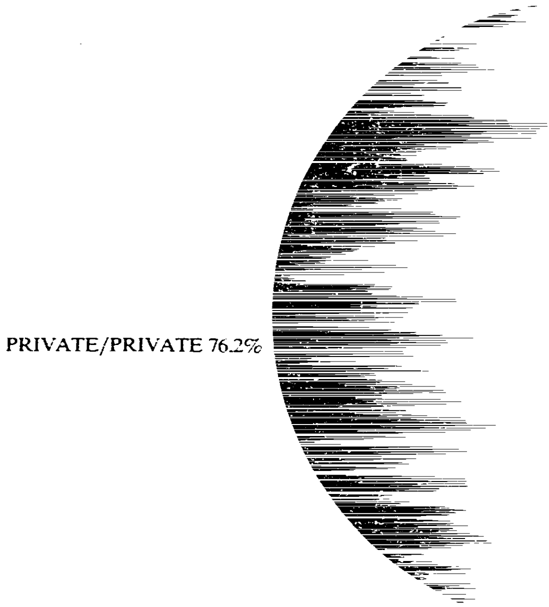


CAPACITY REMAI

LOCAL SITING APPLICATIONS FOR NEW LANDFILLS

(11/12/81 - 6/15/90)

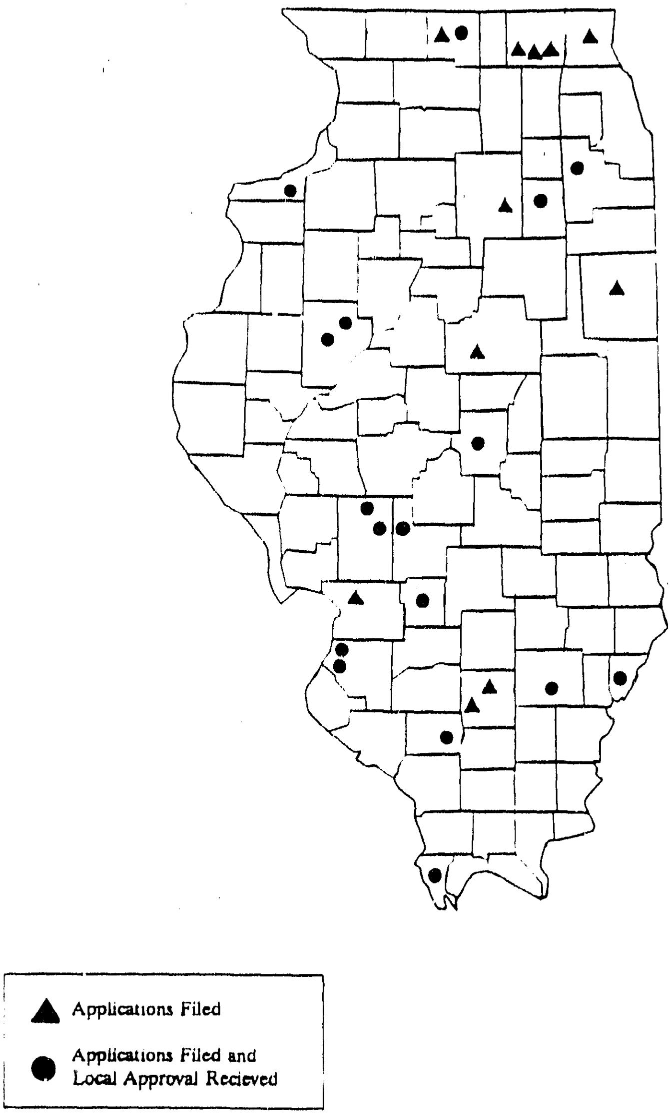
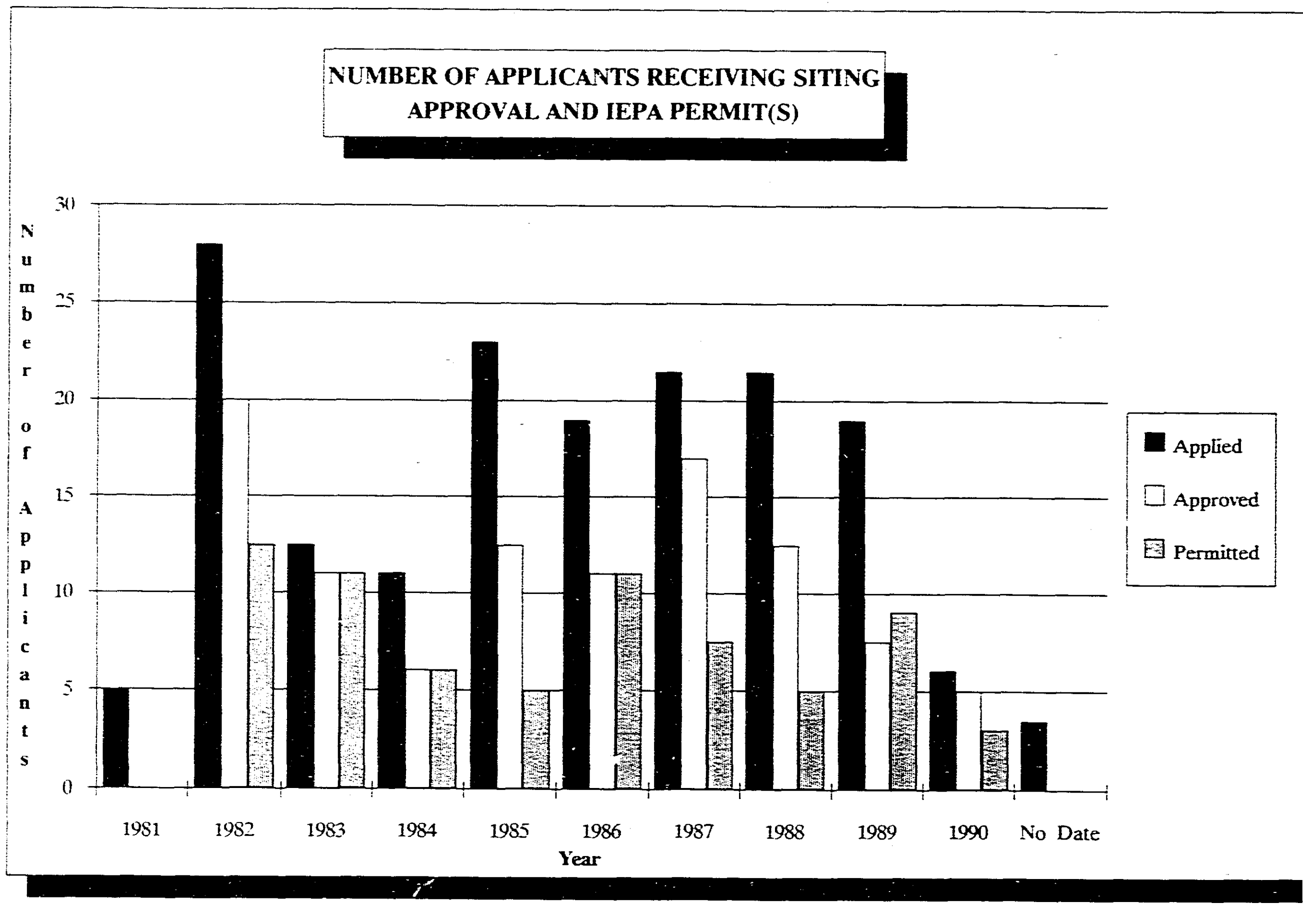


Figure 5


NUMBER OF APPLICANTS RECEIVING SITING APPROVAL AND IEPA PERMIT(S)
Number of Applicants
30
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20
15
10
5
0
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1982
1983
1984
1985
1986
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1988
1989
1990
No Date
Year
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Permitted

Figure 6

STATUS OF SITING CASES AT LOCAL LEVEL OF GOVERNMENT

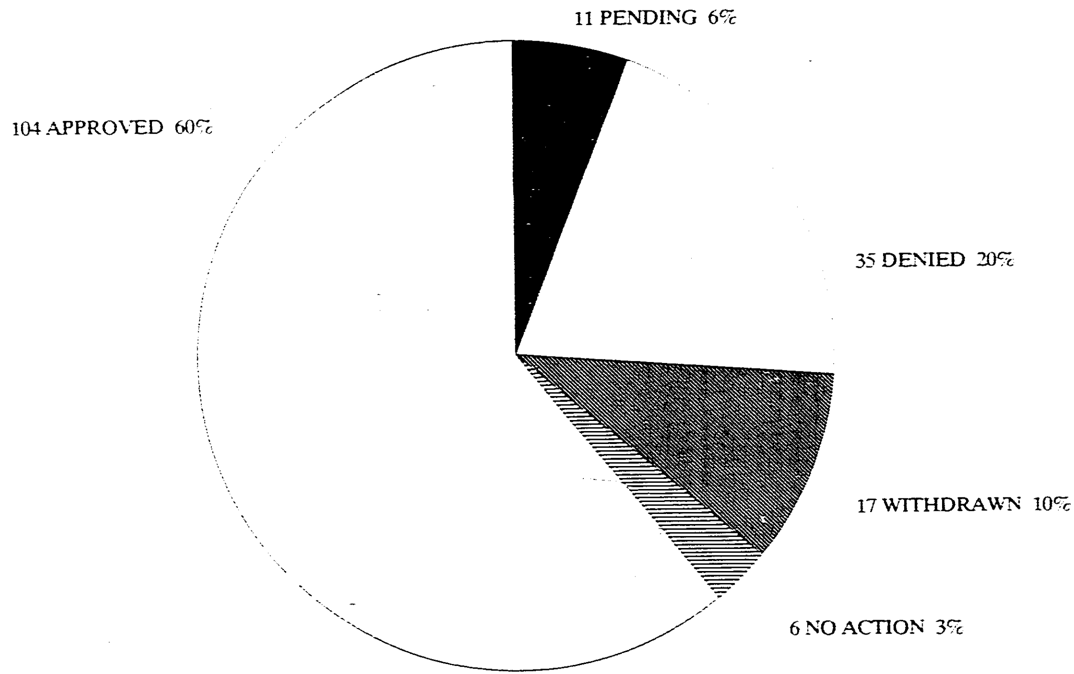

Figure 7

IEPA PERMITTING ACTION ON 104 APPROVED SITES

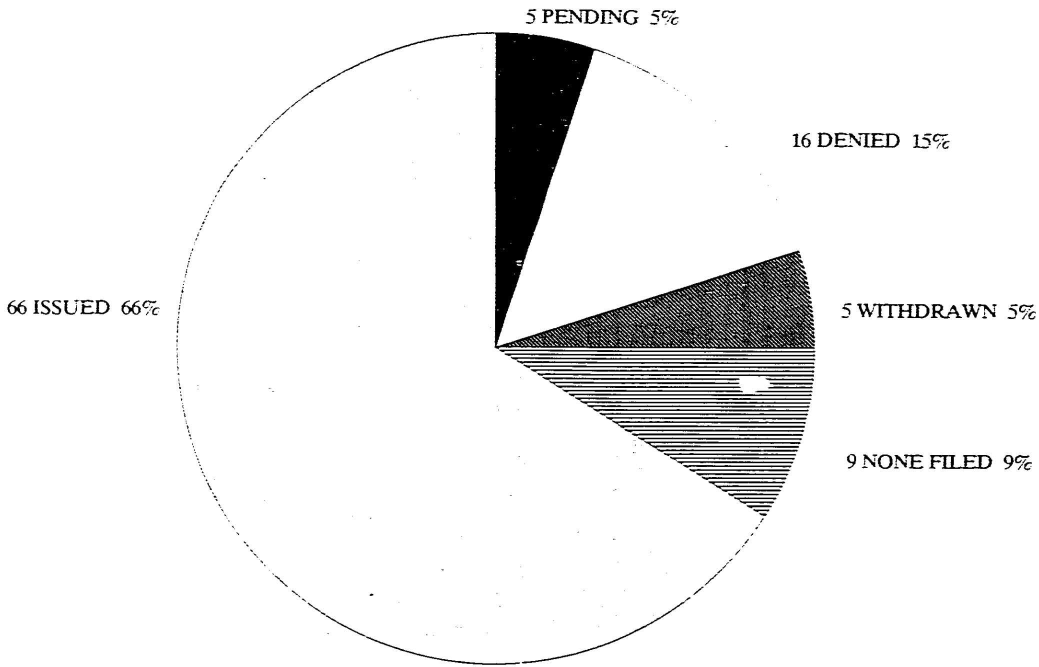

Figure 8

MANAGEMENT OF MUNICIPAL WASTES: THE FEDERAL REGULATORY PERSPECTIVE

William MacDowell, Manager
Region V, Solid Waste Program
U.S. Environmental Protection Agency

Between 1960 and 1988, America's garbage grew from 88 million tons per year to 180 million. While growth with population increase is expected, on a per capita basis we are generating 50 percent more waste today than 30 years ago. Now like densely populated European countries, our Northeast region is fast running out of places to put its trash. A solid waste crisis has arisen as the public has adopted a "not in my backyard" attitude toward siting new disposal facilities. The export of garbage to other states (or even countries) while legal, has stirred increasing opposition and resentment as those states see themselves becoming the dumping ground for someone else's trash. Mismanagement of solid waste disposal in the past has left the public nervous about the potential health and environmental impacts of disposal facilities. Nearly 20 percent of the toxic waste sites on the Superfund National Priorities List were at one-time municipal solid waste landfills. In addition, the public does not want to put up with the potential nuisances of truck traffic, dust, litter, and odors commonly associated with landfills. The result is that it is extremely difficult to site a landfill in any populated area. What is the federal government doing to solve this crisis of too much trash and too few places to put it?

Traditionally, solid waste management has been the responsibility of state and local governments. Congress enacted the Solid Waste Disposal Act of 1965 which established grant programs for the development of solid waste management plans by states and/or interstate agencies. Subsequent amendments to that act, i.e., the Resource Recovery Act of 1970, the Resource Conservation and Recovery Act of 1976 (RCRA) and the Hazardous and Solid Waste Amendments of 1984 (HSWA) have substantially increased the federal government's involvement in solid waste management. Despite this federal legislative activity, solid waste programs continue to be implemented principally by state and local governments.

The primary effect of RCRA was to set up under the U.S. Environmental Protection Agency (EPA), a cradle-to-grave system of managing hazardous waste. This is the Subtitle C program. However, RCRA has a Subtitle D which has as its objective to:

> "Assist in developing and encouraging methods for the disposal of solid waste which are environmentally sound and which maximize the utilization of valuable resources, including energy and materials, which are recoverable from solid waste and to encourage resource conservation."

To achieve these objectives, RCRA mandated that EPA develop criteria for the classification of solid waste disposal facilities and practices and established a framework for state solid waste management plans.

EPA promulgated the Criteria (40 CFR Part 257) in 1979. These Criteria establish standards for determining whether solid waste disposal facilities and practices may pose adverse effects on human health and the environment. Facilities that fail to meet the Criteria are "open dumps" and are prohibited under Section 4005 of RCRA. EPA was not given authority to directly enforce RCRA's ban on "open dumps," but citizens could seek enforcement in federal court through the citizen suit provision of RCRA, Section 7002.

EPA also promulgated guidelines for state solid waste management plans in 1979. EPA's role with respect to state development is limited to establishing the guidelines for their development, providing technical assistance, and approving plans that comply with these requirements. The responsibility for developing and implementing state plans lies with each state, and there is no federal sanction for a state failing to have and/or to implement an approved plan.

In the Hazardous and Solid Waste Amendments of 1984, Congress required EPA to revise the existing Subtitle D Criteria for solid waste "facilities that may receive hazardous household waste or hazardous waste from small quantity generators under Section 3001(d)." These sources of hazardous waste were exempted from the stringent hazardous waste treatment, storage, and disposal requirements of Subtitle C and could be disposed of in a non-hazardous solid waste facility.

Through information gathered for the report to Congress on solid waste management (also required by HSWA), EPA determined that these wastes are disposed of primarily in municipal solid waste landfills (MSWLFs). The Agency learned that approximately 160 million tons of municipal solid waste were generated in 1985, over 80 percent of which was landfilled in about 6,500 MSWLFs. Information on these landfills indicated that they vary widely in the use of environmental controls, such as clay or synthetic liners, liquid (leachate) collection systems, and ground-water monitoring, and that they may pose significant threats to ground and surface water resources. The report to Congress concluded that MSWLFs are adversely affecting the environment, and the current Subtitle D Criteria are not adequate to address these problems.

In 1988, EPA proposed revisions to the Subtitle D Criteria regulating MSWLFs under 40 CFR Part 258 instead of Part 257. The proposed rule, which is expected to be promulgated in late 1990, would significantly expand the current Criteria contained in 40 CFR Part 257 and would result in a more comprehensive and stringent set of requirements covering location, design, operation, closure, monitoring, and corrective action.

HSWA requires states to establish a permit program to ensure compliance with the Revised Criteria within 18 months of its promulgation. If, and only if, EPA determines that a state's permit program is not adequate for this purpose, the Agency can directly enforce the Revised Criteria. If EPA determines that a state's permit program is adequate to ensure compliance with the Revised Criteria, citizens will continue to be able to seek federal enforcement action through the courts, but EPA will have no direct enforcement authority.

Increasing attention at the federal, state and local levels is being directed at municipal solid waste management. Although primarily a local responsibility, the problems associated with municipal solid waste management are national in scope. Recognizing the need for a national response to the problem, EPA created a Municipal Solid Waste Task Force to develop a strategy for improving the nation's management of municipal wastes.

After a year-long effort, the task force produced its report, "The Solid Waste Dilemma: An Agenda for Action," in February 1989. The Agenda provides a number of proposals for actions by EPA, states, local governments, industry, and the public. It identifies an integrated waste management hierarchy--combining the complementary use of source reduction, recycling, combustion, and landfills--as the best approach for comprehensively managing municipal solid waste.

The task force surveyed current municipal solid waste management practices and identified goals for sound national policy. Recognizing the ever-widening gap between declining waste management capacity and rising levels of waste generation, the task force determined that the nation must find a "safe and permanent way to eliminate the gap between waste generation and available capacity in landfills, combustion, and in secondary materials markets." The task force concluded that source reduction and recycling are the preferred options for closing this gap and reducing the amount and toxicity of waste. As a result, EPA established a national goal to reduce or recycle at least 25 percent of the nation's solid waste by 1992. An equally important feature of the Agenda is strengthening the reliability and safety of all solid waste management options. The Revised Criteria for MSWLFs, as well as other EPA rulemaking under Section 111 of the Clean Air Act to reduce emissions from municipal waste combustors, are part of this effort (see proposed performance standards for municipal waste combustors in the Federal Register, December 20, 1989, Page 52209).

Finally, the task force identified objectives for national action to address the municipal solid waste dilemma. These objectives involve not only EPA efforts but the participation of state and local governments, industry, waste managers, and the public in implementing the concept of integrated waste management. These objectives include:

- Increasing the waste planning and management information (both technical and educational) available to states, local communities, waste handlers, citizens, and industry;
- Increasing data collection on waste generation for research and development;
- Increasing effective planning by waste handlers, local communities and states;
- Increasing source reduction and recycling by government and by individual and corporate citizens; and
- Reducing risks from municipal waste combustors and landfills in order to protect human health and the environment.

EPA has accomplished many of the specific items listed in its 1989 solid waste "Agenda." The Agency is now taking stock of its solid waste program and will soon be updating its Agenda based on a review of those accomplishments and on comments from inside and outside the Agency. This update is expected to be published in 1991.

Reauthorization of the Resource Conservation and Recovery Act is expected in the 102nd Session of Congress. In the 101st Session, about 70 bills were introduced to amend RCRA or otherwise address solid waste issues. Five bills that appeared most likely to be reauthorization vehicles were summarized and compared in a Report for Congress by the Congressional Research Service. That report is entitled, "Solid Waste Disposal Act: Comparison of Reauthorization Bills," dated January 23, 1990, and was prepared by David S. Loughran and James E. McCarthy. The report revealed that these five bills "deal overwhelmingly with non-hazardous solid waste issues," including recycling, source reduction, special wastes, solid waste export, and interstate shipment. It seems very likely that Congress will continue to be interested in these issues when the reauthorization process fully commences. Therefore, legislation mandating a more prominent federal role in solid waste management may well be in the future.

REFERENCES

Much of the information in this paper was taken from the RCRA Orientation Manual, 1990 Edition, published by EPA's Office of Solid Waste, EPA/530-SW-90-036

MATERIAL AND ENERGY RECOVERY FROM SOLID WASTE

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Office of Solid Waste and Renewable Resources
Illinois Department of Energy and Natural Resources

Solid waste management in Illinois and the Midwest consists of a number of handling methods including landfilling, recycling, composting, incineration, and importing and exporting. The Illinois Environmental Protection Agency (IEPA) estimates that of the 14.2 million tons of non-hazardous waste handled in Illinois in 1989, two percent was incinerated at the Chicago Northwest Waste-to-Energy Facility; at least six percent was recycled at 105 recycling facilities; and the remaining 92 percent was landfilled. Table 1 depicts the tonnages of material landfilled, recycled and incinerated in the seven geographical regions shown in Figure 1 in Illinois. (Figure 1 and all tables at end of paper)

The number of operating landfills in Illinois has dropped from over 500 in 1982 to 117 in 1990. It is estimated that only 90 landfills will be active by 1993. Currently, 29 counties in the state are without landfills, and it is projected that 39 counties will be without landfills by 1993. Increased local opposition to landfill siting and the closing of existing facilities due to capacity or environmental reasons have resulted in diminished landfill availability. As a result of fewer landfills, disposal costs continue to rise due to increased transportation costs and higher landfill tipping fees. Rising costs of disposal, as well as environmental concerns, have spurred the need for integrated solid waste management which includes waste reduction, recycling, composting, waste-to-energy and landfills.

RECYCLING IN ILLINOIS

State law currently requires all counties in Illinois to develop waste management plans with the goal to recycle 25 percent of all municipal solid waste generated within their boundaries. Table 2 lists the 1989 recycling rates by region. This table was developed by surveying 329 recycling facilities. Since only 32 percent of the facilities returned the survey, the recycling rate could be much higher. Only verifiable data was used in Table 2 with no attempt to extrapolate the recycling rate of all 329 facilities.

In 1987, one residential curbside program serviced 6,000 households in Illinois. In October of 1990, 120 curbside programs were serving 650,000 households in Illinois. The growth of recycling in Illinois has been impressive and facilitated in part by $5,983,300 in matching grant funds the Department of Energy and Natural Resources (ENR) has made available to local government, not-for-profit and private businesses to start or expand recycling programs.

Since 1987, seven recycling grant rounds resulting in 157 projects, including curbside, drop-off, buy-back, and composting programs, have been completed. Thirty-six of the 157 projects began in 1990. Another 25 are scheduled to be operational by the end of 1990. The majority of the yard waste composting programs also began in 1990. Currently, 106 composting permits have been issued by IEPA. Although tonnages of composted yard waste will not be counted in the figures provided by recycling centers, composting will reduce the tonnage of material landfilled and will count toward the overall recycling rate. Due to the establishment of new recycling and composting programs in 1990, the projected recycling rate for 1990 should no doubt increase from the six percent rate reported for 1989.

Commercial and institutional recycling is also becoming more pronounced. Private haulers are offering incentives to offices that store their paper separately from refuse. As a rule of thumb, each person in an office setting produces one half pound of waste paper each day. Simple but effective paper recycling programs can be put in place to drastically reduce the amount of paper disposed. Universities have begun recycling programs, mostly concentrating on high volume, high value writing and computer paper. For example, the University of Illinois in Champaign-Urbana initiated a campus recycling program and in the fiscal year ending June 30, 1990, had recycled 581 tons of paper and 334 tons of cardboard, aluminum, glass and plastic from 118 buildings. The Chicago Hyatt Hotel also started a recycling program which is recovering 65 tons of cardboard, glass, paper, plastic, and metal each month. In the 13 months this program has been in operation, the hotel has seen a net savings of $60,000 (Warren, 1990).

A number of state office buildings are engaged in a wastepaper recycling effort called the I-Cycle Program. In 1987, I-Cycle began as a pilot project at the Willard Ice Building in Springfield and State of Illinois Center in Chicago. Early success at those buildings has prompted expansion of office paper recycling to 68 state facilities, allowing 21,500 state employees to participate. Between July 1988 and July 1990, over 4,100 tons of paper were recycled which resulted in reduced disposal fees and revenue from paper sales. For example, $98,338 was realized in fiscal year 1990 from the sale of wastepaper (Haas, 1990).

Scrap dealers have been recycling for years and continue to make up the lion's share of recycling in the state. Table 2 shows that the majority of material recycled at the reporting recycling facilities was metal, which implies that many of those facilities are also engaged in the scrap metal business. Conversely, most of the tonnages from traditional recycling facilities consist of paper and cardboard, followed by glass, with metal comprising a smaller portion of the recycled quantities. It is estimated that of the six percent recycling rate shown in Tables 1 and 2, two-thirds is a result of the scrap dealers while one-third (or two percent of the total waste stream) is a result of residential and commercial recycling programs.

New types of recycling methods are also being tried. Mixed waste recycling, a process which separates recyclables from refuse at a central facility, is occurring at XL Disposal's transfer station in Crestwood, Illinois. The facility uses both manual sorters and mechanical separation to recover newsprint, cardboard, plastic, ferrous metal and aluminum from solid waste. From September 1, 1989, to September 1, 1990, a reported 9,597 tons of recycled materials were separated from 83,222 tons of refuse passing through the system (Brown, 1990).

ENERGY RECOVERY FROM SOLID WASTE COMBUSTION

While energy can be recovered from solid waste in a number of ways, the primary method used in the Midwest is combustion. Waste can be burned to generate steam. Steam can be sold directly to a steam customer or used to produce electricity. Table 3 lists municipal solid waste combustors operating in the seven Great Lake states. Although these waste-to-energy facilities produce energy from municipal solid waste, keep in mind that private industries also operate incinerators which may recover energy. Incinerators used primarily to burn industry waste are not listed in Table 3.

Illinois has one municipal solid waste combustor, the Chicago Northwest Waste-to-Energy Facility. In 1989, this facility consumed 289,413 tons of unprocessed municipal solid waste, or approximately two percent of the state's solid waste. The facility has operated since 1970 with a design capacity output of 300,000 pounds of steam per hour and sells the steam to a near-by industrial customer (Council of Great Lakes Governors, 1988).

The Indianapolis Resource Recovery Facility also burns unprocessed waste and produces up to 500,000 pounds of steam per hour for sale to Indianapolis Power and Light. The steam is used to heat buildings and provide power for turbines that produce electricity. The City of Indianapolis recently announced that as a result of the steam produced by this waste-to-energy facility, less coal was used by the utility company to produce steam, and sulfur dioxide emissions were reduced by 52 percent (Solid Waste Report, 1990).

Air pollution has been a major concern for those considering waste-to-energy projects. Solid waste is a heterogeneous fuel and the types and concentrations of contaminants that result from its combustion will depend upon the combustor design, operating conditions, amount of non-combustible material, and pollution precursor elements and compounds present in the refuse. Particulate matter, sulfur dioxide, nitrogen oxides, hydrogen chloride, hydrogen fluoride, metals, and products of incomplete combustion such as carbon monoxide, hydrocarbons and chlorinated organics are the commonly characterized emissions from waste-to-energy facilities. Although many of the 1960 era waste-to-energy facilities had poor pollution control technology and have been retired, modern facilities have the ability to extensively control pollutant formation and emissions. Electrostatic precipitators, baghouses, wet and dry scrubbers, combustion controls, and other pollution control technologies exist that can reduce the emissions to very low levels.

Some solid waste combustors burn processed refuse. Removal of non-combustibles, such as glass and metals, improves the heating value, reduces pollution precursors and reduces the ash content of solid waste. Processed refuse is termed refuse-derived fuel (RDF), and its characteristics will vary according to the extent of processing and the type of waste input. Minimally processed RDF may have heating values of approximately 5,500 Btu per pound, while extensively processed RDF can have values near 8,000 Btu per pound. Minimally processed RDF is typically shredded and sent through a magnetic separation device for ferrous removal. Extensive processing, however, may include a shredding device, manual picking lines to separate glass, aluminum, steel, batteries, plastic, high-grade paper, and mechanical systems to separate non-combustible materials such as steel, aluminum, dirt, stones, broken glass and other inorganics. Test results of three mass burn facilities utilizing unprocessed and processed refuse indicate that waste presorting can substantially reduce flue gas and bottom ash heavy metals, reduce emissions of carbon monoxide, hydrogen chloride, hydrogen fluoride and nitrogen oxide. Increased boiler efficiencies were also measured (Sommer, 1989). Table 4 shows typical fuel characteristics of RDF, refuse, coal and tire-derived fuel.

RDF can be co-fired with conventional fuels, such as coal, or fired totally independently. Most facilities burning shredded RDF (fluff) were designed specifically or modified to allow for the burning of fluff. On the other hand, RDF may be pelletized to facilitate transportation, storage and handling, and fuel feeding. Pelletized RDF has physical characteristics (density, mechanical strength, durability, size, dusting, percent fines, etc.) which result in fewer modifications to existing boiler systems. Pelletized RDF may be used in a number of existing facilities with little or no equipment modifications. However, special operating permits would be required. RDF burning facilities are located in several states throughout the country including Minnesota, Iowa, and Ohio (see Table 3).

Argonne National Laboratory has performed a study to determine the environmental effects of co-firing RDF with high sulfur (2.7 percent) coal. The study (Ohlsson, 1990) investigated the use of pelletized RDF made with (and without) calcium hydroxide binders. The results of the study indicate that the addition of a binder improved the storage and handling characteristics of RDF. The co-firing of the RDF (with and without the binder) resulted in lower nitrogen oxide and sulfur dioxide emissions. However, hydrogen chloride emissions were increased.

ENERGY RECOVERY FROM LANDFILLS

Much of the waste buried in landfills anaerobically decomposes and produces a number of gases including methane, carbon dioxide, nitrogen, oxygen, hydrocarbons, hydrogen sulfide and carbon monoxides. Table 6 shows a typical landfill gas composition. Theoretically, for every pound of dry solid waste buried in landfills, 3.3 cubic feet of methane can be generated (Van Nortwick). Often the gases are simply flared by atmospheric burners, and the energy value of the gases is lost. Some landfill operators collect and process the gases. Methane can be processed into a pipeline quality gas and sold to suppliers or directly to users. Landfill gas can also be used in gas-fired electric generators. Table 5 shows the gas-to-energy projects in the Great Lakes region (Waste Age, March 1989). Typically, about 0.1 cubic foot of gas can be collected per pound of refuse per year, with actual rates dependent upon moisture content, size of the landfill, and gas collection efficiency (Maxwell).

Landfill gas collection is important because energy can be collected from gases that are typically lost to the atmosphere. These gases are considered to be environmentally dangerous. Methane, if not collected or flared, can migrate underground into buildings and cause explosions resulting in the loss of life and property. Increased air pollution occurs when the gases are emitted to the atmosphere. Between two and 20 percent of the world's methane emissions are estimated to come from landfills (Municipal Solid Waste Management News, 1990).

MATERIAL AND ENERGY RECOVERY INITIATIVES

The need to expand integrated solid waste management opportunities in the state still exists, and ENR is committed to the task. The state's solid waste management hierarchy of source reduction, recycling, waste-to-energy and landfilling is the framework meant to be followed by Illinois communities. Although over 90 percent of the state's population has a means to handle yard waste, better composting methods are being investigated. Roughly 20 percent of the state's population is currently serviced by curbside recycling, but more curbsides need to be established. Commercial and institutional recycling programs need to be expanded, and the future grant rounds will respond to this need. An important component to recycling success is the ability to market the collected materials. Therefore, emphasis must be placed on market development of recycled materials and on procurement of products made from recycled materials in order to provide sufficient market outlets for the collected materials.

Projects that target large amounts of non-hazardous industrial wastes will gain more attention in the near future, such as factory wastes or demolition and construction debris. Better ways to handle the typically non-recyclable wastes are being investigated. For example, ENR is considering the solicitation of municipal solid waste composting projects which may or may not recover energy, but will produce non-threatening by-products. Funding for other environmentally sound methods of recycling and converting wastes to energy will be considered.

The scrap tire disposal problem has become a health issue due to the disease-carrying threat of the Asian Tiger Mosquito and other pests associated with tire piles. Tire piles also have become an environmental threat to land, air and water as a result of uncontrolled tire fires. In order to assist with the solution to this problem, ENR is currently involved in encouraging markets for used tire materials. In recent months, ENR has worked with a number of Illinois boiler facilities to test the fuel feeding, combustion, ash handling and air pollution control parameters associated with burning tire-derived fuel (TDF). Eastern Illinois University, Monsanto Company and Illinois Power Company have completed various phases of tests. Preliminary results of operational tests at the facilities have been very promising with extensive environmental stack and ash tests scheduled to continue.

Nearby states are also involved in TDF burn tests. Wisconsin facilities have been burning TDF for a few years, such as Fort Howard Paper Company in Green Bay. A number of utilities have recently investigated the use of TDF, such as Wisconsin Power and Light, Ohio Edison, Northern States Power, Northern Indiana Public Service, and others. Initial tests show that good combustion can occur with modest reductions in sulfur and nitrogen oxides when TDF is blended with high sulfur coal.

CONCLUSION

Yard waste composting and material recycling programs have blossomed in the state since 1986. The rising costs of disposal and growing environmental awareness have contributed to this growth, but more needs to be done. Emphasis must first be placed on source reduction and recycling. Today, over 650,000 Illinois households are involved in recycling household waste and composting yard waste, but there is much room to grow. Market development of recycled materials must accompany all recycling efforts. After appropriate recycling programs are in place, waste-to-energy options should be considered. Today, roughly 11,200 million Btu's and 451,200 kilowatt-hours will be generated in Illinois as a result of the conversion of solid waste to energy, but much more can be generated. The resulting effect of this material and energy recovery from municipal solid waste is that natural resources are being conserved and pollution is being reduced.

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TABLE 1

Regional Solid Waste Management Totals
(Amounts in Tons)

Region	Landfilled	%	Recycled	%	Incinerated	%	Total
1	736,874	96	31,683	4			768,557
2	8,500,508	94	290,110	3	289,413	3	9,080,031
3	1,050,684	83	208,722	17			1,260,406
4	1,110,094	94	64,706	6			1,174,800
5	449,005	96	16,600	4			465,605
6	1,065,385	82	237,854	18			1,308,239
7	215,868	99	2,534	< 1			218,492
State	13,128,418	92	852,209	6	289,413	2	14,276,040

Source: Available Disposal Capacity for Solid Waste in Illinois, Third Annual Report (IEPA).

TABLE 2

Regional Recycling Totals by Materials
(Amounts in Tons)

Region	Metals[1]	All Paper[2]	Aluminum	Glass	Oil	Others[3]	Totals	%
1	27,100	1,734	1,000	730	0	1,120	31,683	4
2	108,088	95,096	32,357	43,873	6,264	4,433	290,111	34
3	161,200	35,404	8,573	61	2,000	1,485	208,722	24
4	35,403	24,385	1,635	733	60	2,489	64,706	8
5	3,381	9,542	2,148	764	0	766	16,600	2
6	233,410	858	3,262	347	0	112	237,854	28
7	106	965	255	1,060	0	148	2,534	< 1
	568,688	167,984	49,230	47,568	8,264	10,553	852,210	
	67%	20%	6%	6%	< 1%	1%	100%	

1 "Metals" includes all metals other than aluminum.

2 "All Paper" includes the categories of newsprint, paper, corrugated, mixed paper, high grade and cardboard.

3 "Others" includes the categories of appliances, batteries, and plastic.

Source: Available Disposal Capacity ofr Solid Waste in Illinois Third Annual Report (IEPA)

TABLE 3

Energy Recovery from Solid Waste Combustion

Facility	Location	Type & Design Capacity (tons/day)	Generation Capacity (lb steam/hr or kw)
Chicago Northwest Waste-to-Energy	Chicago, Illinois	Mass burn 1,600	300,000 lb steam/hr
Indianapolis Resource Recovery Facility	Indianapolis, Indiana	Mass burn 2,362	500,000 lb steam/hr
Ames	Ames, Iowa	RDF[1] 200	100,000 kw (fired with coal)
Jackson County Resource Recovery Facility	Jackson, Michigan	Mass burn 200	49,200 lb steam/hr 3,750 kw
Fergus Falls	Fergus Falls, Minnesota	Mass burn 95	20,000 lb steam/hr
Northern States Power	Red Wing, Minnesota	RDF 720	21,500 kw
Northern States Power	Mankato, Minnesota	RDF 672	21,500 kw
Olmsted County Public Works	Rochester, Minnesota	Mass burn 200	48,000 lb steam/hr 3,500 kw
Polk County	Fosston, Minnesota	Mass burn 103	24,000 lb steam/hr
Pope-Douglas	Alexandria, Minnesota	Mass burn 80	14,000 lb steam/hr

TABLE 3 (Continued)

Energy Recovery from Solid Waste Combustion

Facility	Location	Type & Design Capacity (tons/day)	Generation Capacity (lb steam/hr or kw)
Quadrant Company	Perham, Minnesota	Mass burn 116	25,000 lb steam/hr
Red Wing Facility	Red Wing, Minnesota	Mass burn 72	15,000 lb steam/hr
Richards Asphalt	Savage, Minnesota	Mass burn 80	14,000 lb steam/hr
Western Lake Superior	Duluth, Minnesota	RDF 120	38,000 lb steam/hr
Winona County	Winona, Minnesota	Mass burn 150	22,435 lb steam/hr 2,000 kw
Akron Facility	Akron, Ohio	RDF 1,000	200,308 lb steam/hr
Columbus Facility	Columbus, Ohio	RDF 2,000	90,000 kw (fired with coal)
Montgomery County	Dayton, Ohio	Mass burn 525	6,000 kw
Waukesha City	Waukesha, Wisconsin	175	35,000 lb steam/hr
TOTAL		10,470	1,304,943 lb steam/hr 248,250 kw

Source: Biomass Energy Facilities, Great Lakes Biomass Energy Program

[1] Refuse-Derived Fuel

TABLE 4

As Received Examples
(Percent by Weight)

	Refuse	RDF	TDF	Coal
Volatile Matter	60.00	68.00	65.00	37.00
Carbon	28.00	36.00	78.00	77.00
Moisture	31.00	7.00	0.80	6.30
Ash	21.00	13.00	10.00	8.00
Sulfur	0.13	0.13	1.40	2.70
Chlorine	0.20	0.20	0.15	0.01
Nitrogen	0.20	0.80	0.20	1.50
Heating Value: Btu/lb	4,500	8,000	14,500	12,400

Note: RDF denotes refuse-derived fuel.

TDF denotes tire-derived fuel.

TABLE 5

Energy Recovery from Landfills

Location	Owner	Facilities Selling Gas (million cu.ft./day	Facilities Converting to Electricity Generating Capacity
Illinois			
Blue Island		4.0	
Calumet City	WMI[1]		6,600 kw
Geneva	Kane County		4,100 kw
Northbrook			6,400 kw
Peoria	WMI[1]		1,700 kw
Minnesota			
Anoka	WMM[2]	0.1	
Ohio			
Cincinnati	Rumpke	3.0	
Wisconsin			
Franklin	WMW[3]		6,400 kw
Menomonee Falls			9,600 kw

Source: Landfill Gas Survey Update, Waste Age, March 1989

[1] Waste Management of Illinois
[2] Waste Management of Minnesota
[3] Waste Management of Wisconsin

TABLE 6

Typical Landfill Gas Composition (13)
(VanNortwick)

Component	Percentage Dry Volume Basis
Methane	47.50
Carbon Dioxide	47.00
Nitrogen	3.70
Oxygen	0.80
Paraffin Hydrocarbons	0.10
Aromatic and Cyclic Hydrocarbons	0.20
Hydrogen	0.10
Hydrogen Sulfide	0.01
Carbon Monoxide	0.10
Trace Compounds*	0.50

* Trace compounds include: sulfide dioxide, benzene, toluene, methylene chloride, perchlorethylene and carbonyl sulfide, in concentrations up to 50 ppm.

SOLID WASTE REPORTING REGIONS

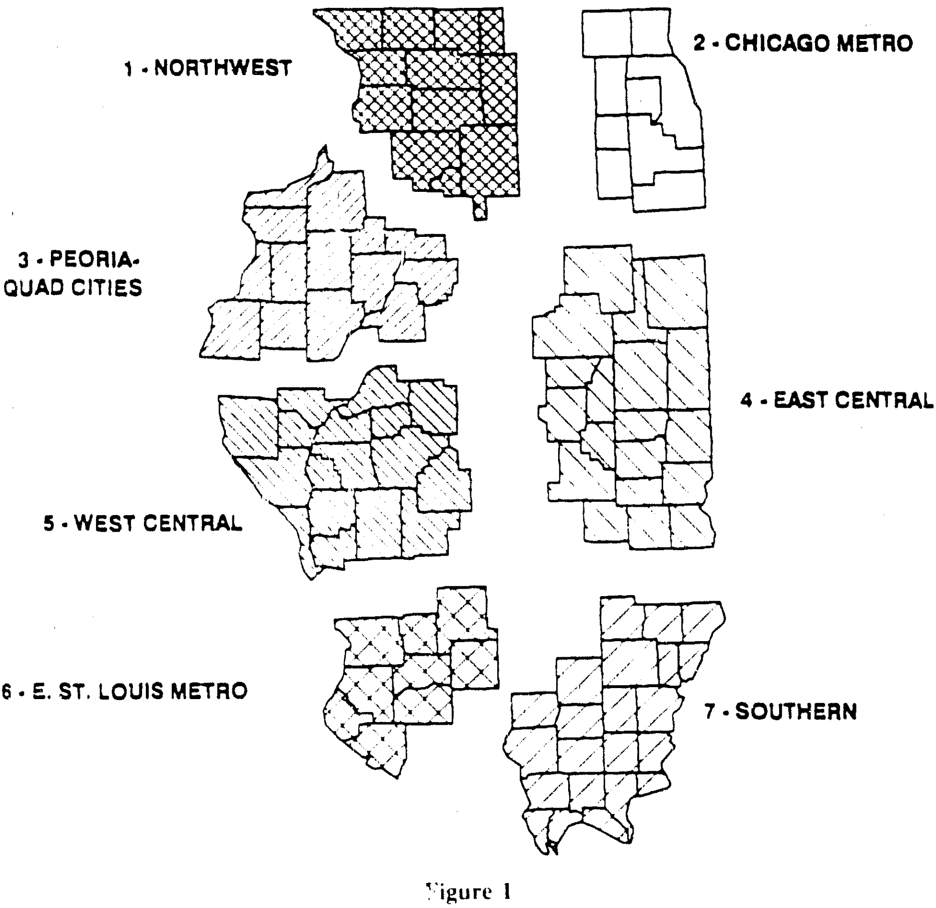

Figure 1

(Courtesy of the Illinois Environmental Protection Agency)

III. ENERGY OPPORTUNITIES IN SOLID WASTE MANAGEMENT

RECYCLING POLICY OPTIONS FOR ENERGY CONSERVATION

Phillip D. Schuller, Director
Renewable Energy
Pennsylvania State Energy Office

INTRODUCTION

Through the later part of the 1980's we as a nation, found ourselves confronted with the fact that space for solid waste disposal was quickly disappearing. Several forces precipitated this crisis including increases in the wastes per person generated, a growing awareness of the problems associated with past landfill practice and widespread local resistance to the siting of new landfills. In response to this, many states passed mandatory recycling laws and many communities began recycling programs voluntarily. In addition to reducing the demands for increasing landfill space, recycling offers considerable energy and resource conservation benefits. The following analysis attempts to quantify the current and future energy savings associated with recycling at the national level.

SUSTAINABILITY

By recycling a portion of the solid waste stream we are taking one small step along the long road toward becoming a sustainable society. "Sustainability" is a commonly used term with respect to the management of fisheries, forests and agriculture and is being more widely used with respect to economic development and environmental protection. Sustainability has two primary components--the usage of natural resources and the rate of pollution loading. In terms of natural resources a sustainable technology or policy would permit the use of natural resources only at a rate at which the resources could be replenished. In terms of waste, a sustainable technology or policy would permit the generation of wastes only at a rate at which the wastes could be cleansed from or metabolized into the natural environment.

Recycling contributes toward sustainability in both of these primary ways--it conserves natural resources and reduces pollution. Natural resources are conserved in two ways. A portion of the virgin feedstock materials (sometimes nearly 100 percent) is replaced with recycled materials, and recycling saves the energy resources that are necessary for the extraction of the raw materials (e.g., mining, drilling lumbering). There is very little material loss during the recycling of some materials such as aluminum, glass, steel and plastics, thus presenting the potential of significant benefits in terms of the longevity of natural resource supplies and reduced impacts on the natural environment. During the recycling of paper to newsprint, however, approximately 15 percent of the fiber is lost as waste during each cycle.

Recycling reduces pollution in several ways. Land pollution is reduced through the reduction of materials that must be landfilled. Air pollution is lessened through reduced incineration of wastes and through reduced emissions during product manufacture. Delineation of the pollution reduction benefits is beyond the scope of this paper. The pollution loading aspects, however, are of fundamental and widespread significance. The reader is referred to other sources. (Franklin, pp. 4-13, 1989; Pollock, p. 22, 1987; Purcell, 1980)

ENERGY PROFILES OF RECYCLING VARIOUS MATERIALS

Each material that is recycled into a new product has its own energy savings profile. Additionally, each recycled material can produce varying levels of energy savings depending on the product that is produced. For example, recycled plastic bottles can be used for the production of new bottles or as fiber-fill insulating material for garments. The higher value use is the production of new bottles. If the market is functioning properly, the recycled material will go to its highest value use, and this is usually the use with the greatest energy savings. This analysis assumes that the recycled materials will be used for their highest energy value uses. Figure 1 shows the energy savings values for the materials that are the subject of this study. (Figure 1 and all others at end of paper). The energy costs of operating a recycling program have been incorporated in all cases. A discussion of the energy savings of each material is given in the last section of this paper.

RECYCLING POLICY SCENARIOS

In this section, the Environmental Protection Agency (EPA) projections and current estimates for recycled materials are analyzed for energy savings, and the state recycling law of Pennsylvania is analyzed for its potential effect if it were adopted nationally (Figure 2). Because recycling programs mandated by state law are relatively new, data on the tonnages of materials collected are incomplete or non-existent. For example, it was impossible to model the future effects of the Illinois law for this reason.

CURRENT RECYCLING LEVELS

EPA's work in the area of recycling has included the tabulation of current recycling, the projection of future recycling, the establishment of national recycling and waste reduction goals, the promulgating of procurement guidelines for federal facilities and other efforts. In The Solid Waste Dilemma: An Agenda for Action (EPA 1989) a goal of 25 percent combined recycling and source reduction was set for the year 1992. In the 1990 "preliminary draft" of a similar document, EPA has established a source reduction goal of 10 percent by 2000 and a recycling goal of 40 percent by 1996. It is impossible to predict to what extent the goals will be met. Additionally, the EPA goals are not considered as driving forces in the projections that the study makes of recycling.

EPA's Characterization of Municipal Solid Waste in the United States: 1990 Update estimates current recycling and projects recycling for the year 1995. These projections are used below to estimate national energy savings due to recycling. The EPA study assumes that "local, state and federal agencies will continue to emphasize recycling and composting." (p. 68, EPA, 6-90) No attempt was made to quantify the particular effect of that emphasis. The estimates of future recycling rates are based on past experience and industry goals and projections. The study recognizes that future recycling rates are difficult to predict so all rates are estimated in ranges.

To estimate the national energy savings for various recycling levels the energy savings per ton for each material was multiplied by the tonnage recycled for each material.

Energy savings from current recycling are calculated at 345 trillion Btu's, and energy savings based on EPA's projected recycling are in the range of 480 to 610 trillion Btu's (See Figure 5).

PENNSYLVANIA

In a prior work it was projected that the State of Pennsylvania may save over 20 trillion Btu's of energy in the year 1995 (Schuller 1989) under the state recycling law. To arrive at this energy savings number, the total tonnages to be recycled were multiplied by the energy savings number for each material. The tonnages recycled were estimated by multiplying the tonnages available for recycling[1] by a recovery rate which is the percentage of material expected to be recovered from the waste stream by a curbside program. Most of these recovery rates were taken from the Pennsylvania Department of Environmental Resources (PADER) study on market development, and the reader is referred to the author's prior work (Schuller 1989) for a more complete discussion of recovery rates. A discussion of the main points of the law follows here since it is the basis for the national projection that follows.

Under the Pennsylvania law all communities with a population of more than 5,000 and a population density of more than 300 people per square mile must have a recycling program in operation by September 1991. Because of the accompanying regulations to the law, the recycling programs will almost always be the curb-side pickup type. Each recycling program must recycle at least three materials from a list of eight including clear glass, colored glass, plastic, newsprint, office paper, corrugated paper, aluminum and/or bi-metal cans (tin). Figure 3 shows the energy savings of curbside recycling programs for years prior to the mandatory recycling law and future years in Pennsylvania. It should be noted that an indeterminate additional tonnage of materials was recycled from 1983 to 1988 outside of the curbside system.

A QUASI-PENNSYLVANIA NATIONAL RECYCLING LAW

The measured effects of the Pennsylvania mandatory recycling law were projected to the national population with several additional considerations made (Figure 4). PADER has excellent data on all the curbside programs that are planned in the state. The data covers programs that serve over 5.4 million of the 7.5 million people who will eventually be served by curbside programs. Even though Act 101-88 requires local government to recycle only three materials, the data reveals that they are selecting an average of five materials. It is assumed here that people nationally would respond to a recycling law with equal vigor. The number of people affected by a national recycling law was adjusted for the difference in Pennsylvania and U.S. population distribution in communities with populations greater than 5,000.[2]

Two additional adjustments were made to the Pennsylvania example for projection to the U.S. as a whole. Since Pennsylvania does not have a bottle deposit law, an adjustment was made to account for the energy value of materials pulled out of the waste stream due to the deposit laws. A total of 45.5 million people live in states with bottle deposit laws. New York State's deposit reclamation rate (72 percent) was applied to the total tons of glass, plastic, and aluminum available. Existing bottle deposit laws contributed 76 trillion Btu's to the total energy saved. Care was taken to subtract the deposit return tonnages from the recycling law tonnages to avoid double counting.

Finally, recycling in non-mandatory communities (populations of less than 5,000) was accounted for. PADER data shows that 22.5 percent of the people living in non-mandatory communities are now covered by curbside recycling programs. It was assumed that by 1995 one-third of the people living in non-mandatory communities would be served by curbside programs and that these recycling programs would select materials in the same proportions that the current Pennsylvania non-mandatory programs are. These programs are recycling an average of four materials each. The non-mandatory communities contribute 50 trillion Btu's to the energy savings total.

The bulk of the energy savings comes from the direct effect of what would be a mandatory recycling law. The primary assumption here is that U.S. residents as a whole would respond to the law similarly to the response seen in Pennsylvania. A total potential energy savings of 560 trillion Btu's is calculated for the U.S. in the year 1995.

The 560 trillion Btu's number is a very large energy number although it is only a small percentage of total U.S. energy use. For example it is only 0.8 percent of total U.S. oil production and seven percent of total U.S. electric production. However, the same amount of energy is the equivalent of the output of 25, average 1,000 megawatt nuclear power plants or would power the Washington D.C. subway system for 500 years.

SELECTED ENERGY SAVINGS REFERENCES BY MATERIAL

The energy value of using a particular recycled material to replace a virgin material feedstock can vary considerably depending on the particular product being produced. The energy numbers below assume that recycled materials will be used in their highest value use. Some recycled content products do not use 100 percent recycled material so in some cases adjustments have been made based on the percent of recycled material commonly used. A straight line conversion has been employed.

GLASS

The energy savings for glass are the lowest of all the materials because the ground glass (cullet) needs to be heated to nearly the same temperature as the raw materials. There is, however, a considerable advantage to the manufacturer in using recycled materials in terms of furnace maintenance and repair which is not reflected in the numbers used here. Energy savings are the same for both clear and colored glass although the economic value is far different.

Although probably no glass container manufacturers use 100 percent cullet for product quality reasons, research is being conducted to develop the technical ability to do this (Hershkowitz, p. 44). For each ton of glass recycled, energy savings are on the order of 25 percent of the energy needs to produce glass from raw materials (Gaines, p. 14; Stauffer p. 3). Based on a virgin-materials energy demand of 17.4 MM Btu's per ton, an energy savings of 4.4 MM Btu's per ton of recycled material could be realized.

PLASTIC

The energy savings from recycling plastic are of importance since the raw materials for production of plastics are 70 percent natural gas and 30 percent oil (Stauffer, p. 3). There are 46 types of plastic, but this study assesses the energy implications of only the plastics which are the most likely to be collected by recycling programs. These are: PET (polyethylene terephthalate), the plastic used to produce soda bottles (excluding the base cap); and HDPE (high density polyethylene), the plastic used to produce the base caps, milk jugs, soap bottles and oil bottles.

After plastics are recovered they are shredded, cleaned and reformed into beads which are then used as a feedstock for the manufacture of products. Researchers at Argonne National Lab have estimated that the energy savings from producing a ton of PET from recycled PET versus virgin materials is 86 MM Btu's per ton (Gaines, p. 13). The use of recycled HDPE provides a savings of 76 MM Btu's (Milgrom, p. 17). Calculations based on a study conducted for the National Association of Plastic Container Recovery produce an energy saving number of 65.8 million Btu's per pound of finished bottle (Franklin, 1989). This number was used in the analysis because it was the most comprehensive number in terms of accounting all energy uses--even the delivery of the product to the retail store. And again, it is a more conservative number.

NEWSPRINT, OFFICE AND CORRUGATED PAPER

All studies that were reviewed in this category focused on the fossil fuel energy use of paper products manufacturers.

Energy from renewable resources such as waste wood and spent liquors accounted for 56.8 percent of the paper products industry energy supply. This study of Act 101 uses the total energy from both fossil fuel and renewable sources that is used for the production of paper from virgin materials since any part of this energy which is saved by using recycled materials could be put to an alternative use.

Tillman estimates that 13.1 MM Btu's per ton of recycled fiber are realized by producing newsprint from 100 percent recycled fiber (Tillman, p. 609). He also states that 5 MM Btu's per ton of pulp can be recovered from the production of newsprint from virgin materials. A study conducted for Garden State Paper indicates that as much as 20 million Btu's per ton of product are saved from the use of recycled fiber (Gersham, p. 46). However, to remain on the conservative side, an energy savings number of 13.1 MM Btu's per ton of recycled newsprint produced was used.

No analysis of energy savings from the use of recycled office paper could be located so the newsprint number was used. This should produce a conservative energy estimate since office paper would be of a higher quality than newsprint.

A value of 5.5 million Btu's per ton of product produced was used for corrugated paper. This is the mid-point of the range that Love offers of three to eight MM Btu's (Love, p. 66). This should be conservative since he considers only energy which is purchased by the mill, thus neglecting waste wood energy.

ALUMINUM

Aluminum is the energy and resource sweetheart of recycling. It is widely accepted that 95 percent of the energy needed to produce aluminum from virgin materials is saved by producing aluminum from recycled materials (Aluminum Association, p. 2). The energy values required to produce a ton of aluminum range from 197 MM Btu's (Environmental Task Force, 1986) to 296 Btu's (Purcell, p. 107). A compilation of energy savings from nine different sources reports an average reported savings of 219 MM Btu's (Powell, p. 52) which is used in this study.

STEEL

An industry source has indicated that for an "all-scrap" charge of a furnace 12.3 million Btu's of energy are saved (Bonfiglio). Other sources have reported that 47 percent to 74 percent of the energy used to produce steel from virgin feedstocks are saved by using scrap (Schwarz, p. 26). The Institute of Scrap Recycling Industries reports that 100 percent scrap recycling produces a 74 percent energy savings (ISRI). Based on an energy demand of 21.8 million Btu's per ton of scrap (Crawford), a 50 percent savings would be 10.9 million Btu's per ton. The 10.9 million Btu's number was used to be on the conservative side and to account for the fact that recycling with bi-metal cans (steel) will not produce the energy savings that all-steel scrap will.

CONCLUSION

Figure 5 compares the current energy savings and the future energy savings under the EPA projections and the hypothetical national recycling law described above. As can be seen from the estimates of energy savings, EPA's projections are fairly close to the estimates made under the relatively stringent national, Pennsylvania policy assumption. This may reflect an optimism in the industry targets for recycling in 1995 upon which the EPA estimates are built. However, it also could reflect an accurate projection that recycling in the U.S. will flourish to such an extent as to emulate the results which would be obtained with a national recycling law. In any case, it is clear that recycling will be making an ongoing and significant contribution to energy conservation and resource conservation and function in a fundamental way in support of our necessary journey towards becoming a sustainable society.

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[1] These tonnages represent 100 percent of each material available in the waste stream. The tonnage figures were taken from the EPA study which characterizes the waste stream (EPA 1990).

[2] In Pennsylvania the percentage of the population living in local governments with populations greater than 5,000 is 66.4 percent while in the U.S. the respective percentage is 63.5 percent.

ACKNOWLEDGEMENTS

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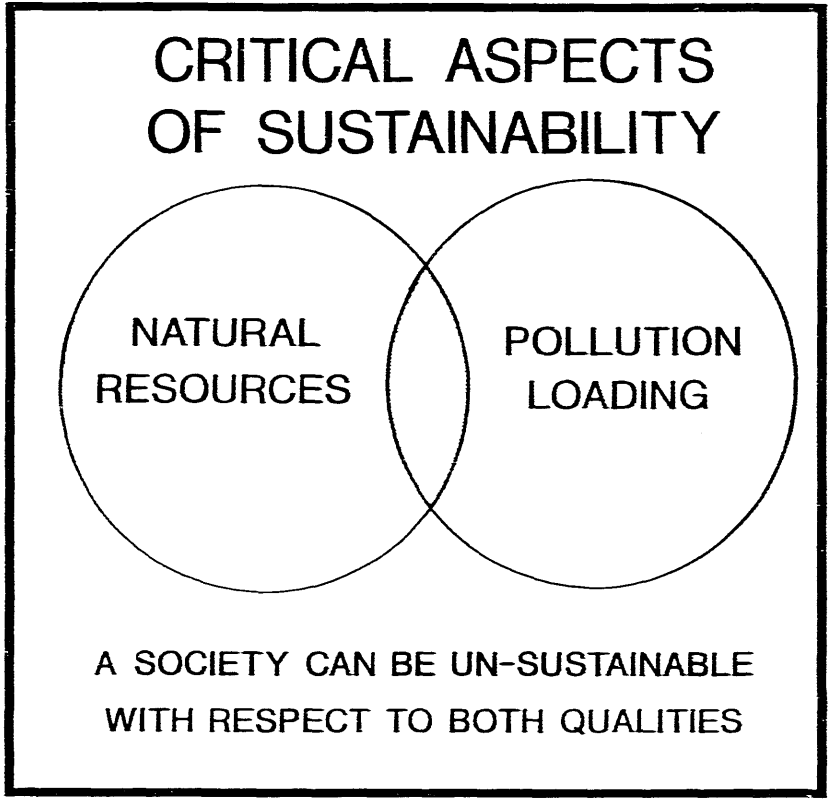
CRITICAL ASPECTS
OF SUSTAINABILITY
NATURAL
RESOURCES
POLLUTION
LOADING
A SOCIETY CAN BE UN-SUSTAINABLE
WITH RESPECT TO BOTH QUALITIES

Figure 1

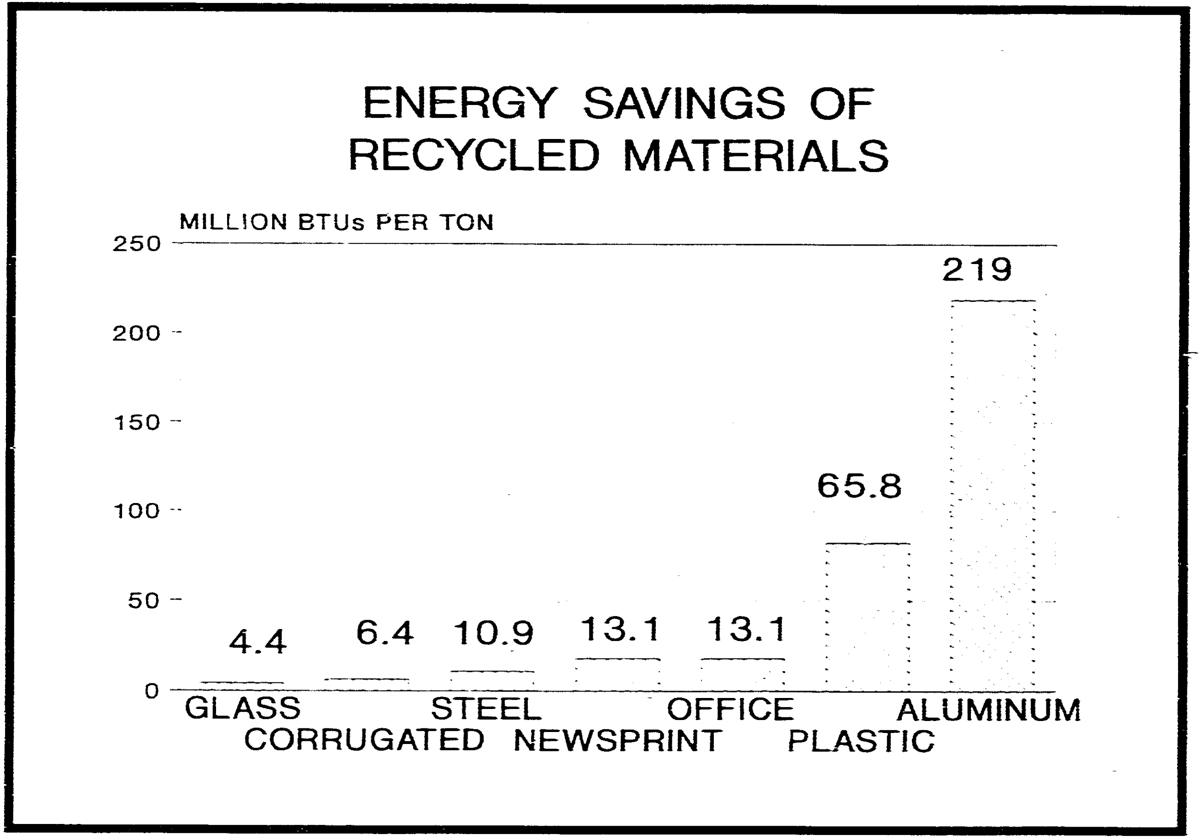
ENERGY SAVINGS OF
RECYCLED MATERIALS
MILLION BTUs PER TON
250
200
150
100
50
0
4.4
6.4
10.9
13.1
13.1
65.8
219
GLASS
CORRUGATED
STEEL
NEWSPRINT
OFFICE
PLASTIC
ALUMINUM

Figure 2

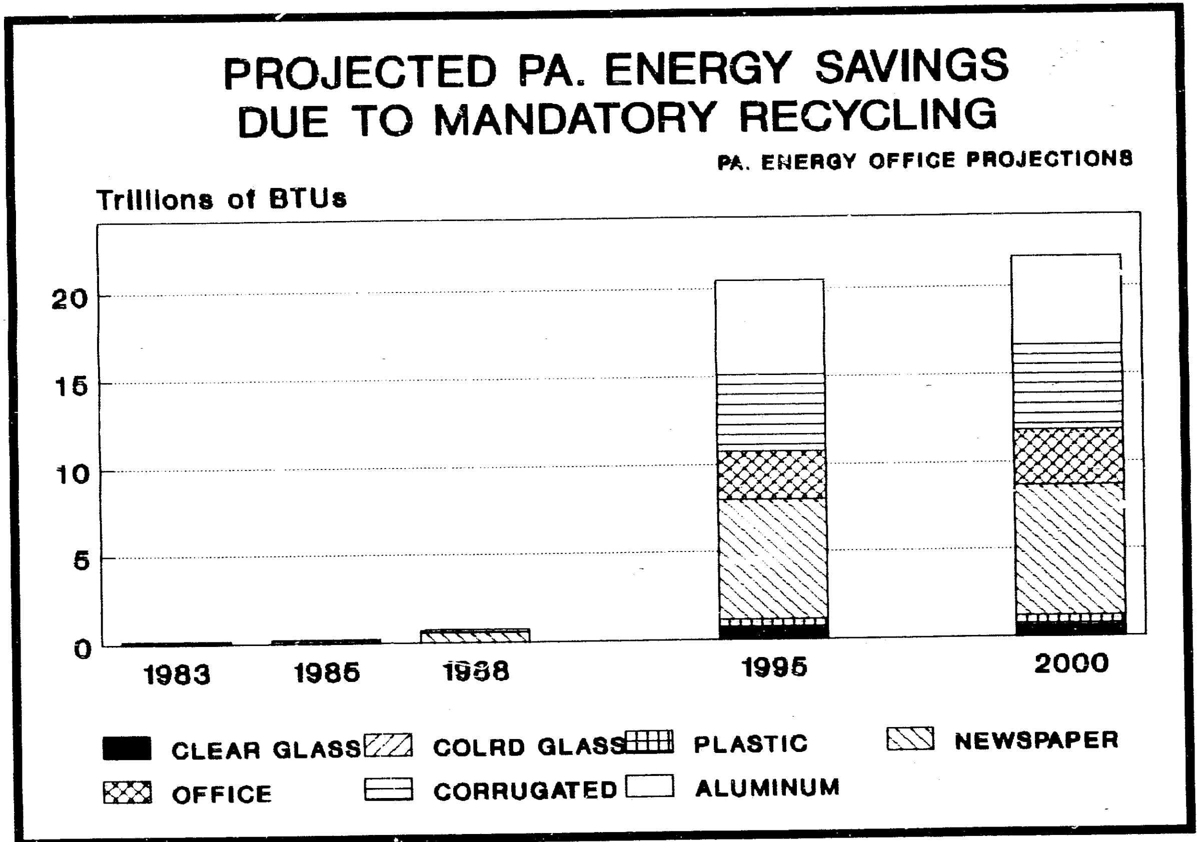
PROJECTED PA. ENERGY SAVINGS
DUE TO MANDATORY RECYCLING
PA. ENERGY OFFICE PROJECTIONS
Trillions of BTUs
20
15
10
5
0
1983
1985
1988
1995
2000
CLEAR GLASS
COLRD GLASS
PLASTIC
NEWSPAPER
OFFICE
CORRUGATED
ALUMINUM

Figure 3

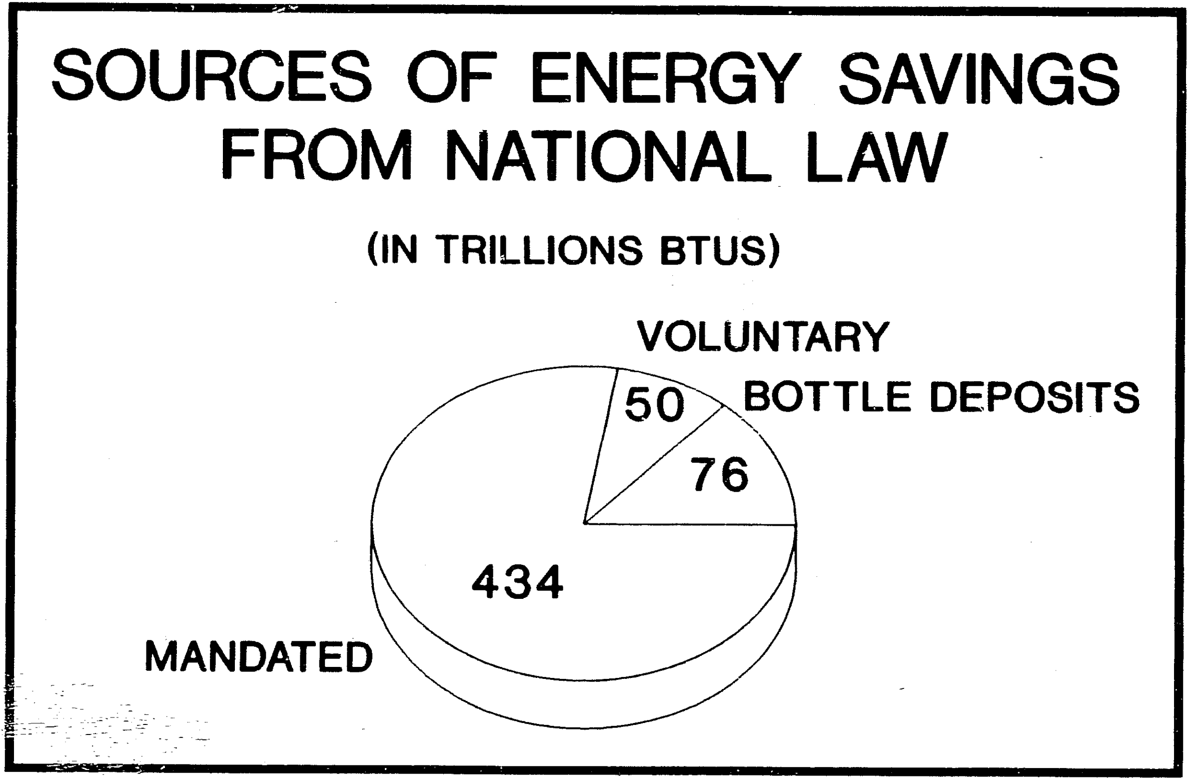
SOURCES OF ENERGY SAVINGS
FROM NATIONAL LAW
(IN TRILLIONS BTUS)
VOLUNTARY
BOTTLE DEPOSITS
50
76
434
MANDATED

Figure 4

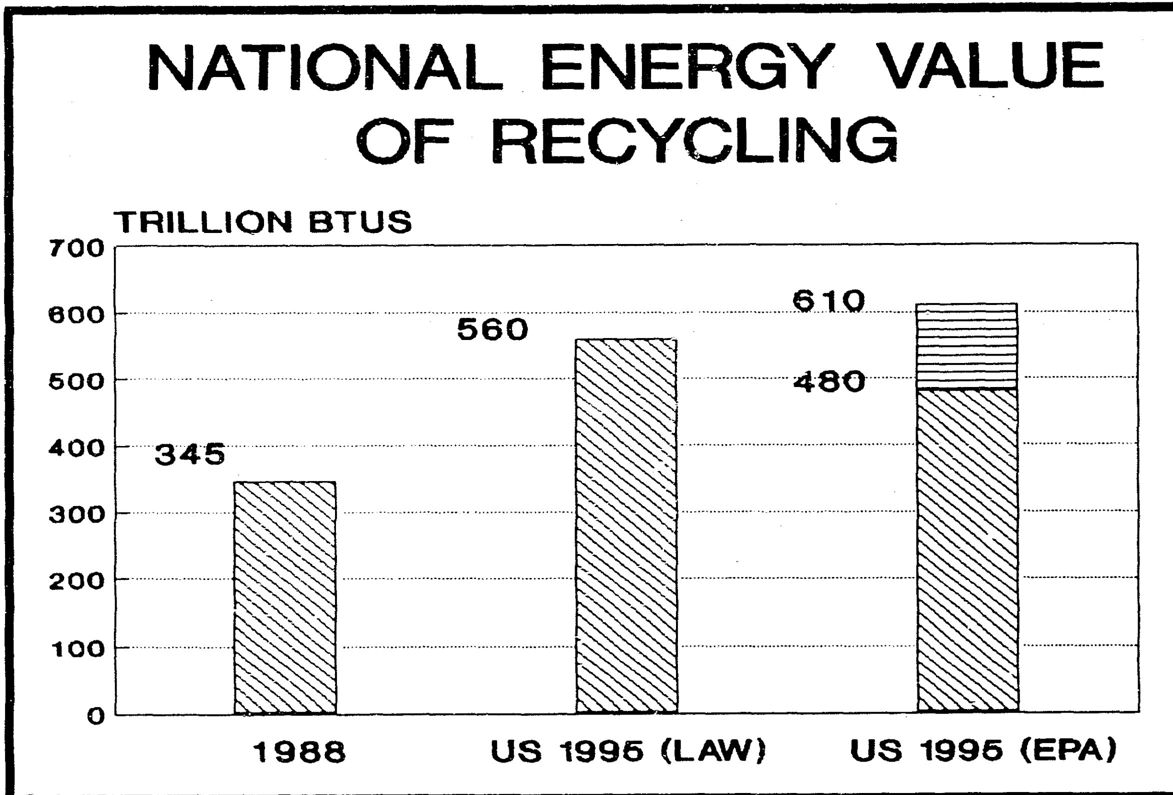
NATIONAL ENERGY VALUE
OF RECYCLING
TRILLION BTUS
700
600
500
400
300
200
100
0
345
560
610
480
1988
US 1995 (LAW)
US 1995 (EPA)

Figure 5

ENERGY POTENTIAL OF MODERN LANDFILLS

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ABSTRACT

Methane produced by refuse decomposition in a sanitary landfill can be recovered for commercial use. Landfill methane is currently under-utilized, with commercial recovery at only a small percentage of U.S. landfills. New federal regulations mandating control of landfill gas migration and atmospheric emissions are providing impetus to methane recovery schemes as a means of recovering costs for increased environmental control. The benefits of landfill methane recovery include utilization of an inexpensive renewable energy resource, removal of explosive gas mixtures from the subsurface, and mitigation of observed historic increases in atmospheric methane. Increased commercial interest in landfill methane recovery is dependent on the final form of Clean Air Act amendments pertaining to gaseous emissions from landfills; market shifts in natural gas prices; financial incentives for development of renewable energy resources; and support for applied research and development to develop techniques for increased control of the gas generation process in situ.

INTRODUCTION AND BACKGROUND

The organic components of refuse buried in a sanitary landfill decompose under anaerobic conditions with resulting production of landfill gas. Landfill gas is approximately half methane and half carbon dioxide with minor amounts of other gases. Because of its methane content, the gas has an energy value of about 500 Btu/SCF (19 MJ/SCM). Landfill gas can be recovered for commercial use by means of vertical wells drilled in a completed fill or horizontal collector systems placed concurrently with filling. At the present time, commercial recovery takes place at 242 sites in 20 countries, with a total energy output of approximately 5 x 10^{13} Btu/year; about 78 percent of this total is from more than 100 U.S. sites (Richards and Aitchison, 1990). These sites are a small percentage of the 6,000 or so existing landfills in the U.S. (Brown, Fallah, and Thompson, 1986), suggesting additional potential for commercial recovery.

Utilization options include: (1) direct use in gas-fired boilers, the least expensive alternative; (2) on-site generation of electricity; and (3) production of a substitute natural gas through carbon dioxide removal, the most expensive option. Since the economics of any given project are driven by the negotiated price of gas or electricity paid by the user, it is important to finalize user arrangements before installing a recovery system. A young industry, the first commercial landfill gas recovery project was in 1975 at Palos Verdes, California. Today the largest project is a 50 MW steam turbine power plant at the Puente Hills Landfill, Whittier, California.

Two new sets of federal landfilling regulations are also providing impetus to gas recovery projects as a means of recouping required costs for environmental control measures. First, new federal landfilling regulations under Subtitle D of RCRA require gas migration control. Second, soon-to-be-proposed amendments to the Clean Air Act will regulate atmospheric emissions from large landfills.

This paper will discuss the controls on methane generation in landfills. In addition, it will address how landfill regulations affect landfill design and site management practices which, in turn, influence decomposition rates. Finally, future trends in landfilling and their relationship to gas production will be examined.

CONTROLS ON LANDFILL METHANE GENERATION

Refuse decomposition in sanitary landfills occurs through a complex series of microbial decomposition reactions under predominantly anaerobic conditions (absence of air). All of the necessary microbes are present in refuse and soil materials at the landfill site. The terminal reaction is the production of methane by methanogenic bacteria, which are strict anaerobes and function best at near-neutral pH. In effect, the landfill functions like a high-solids, low moisture content anaerobic digester in the ground. Decomposition extends over decades since natural biodegradation rates are low.

Literature pertaining to laboratory decomposition studies of fresh refuse yields a wide range of gas production rates, with extremes from approximately 7.3 x 10^{-3}

to 3.2 m^3 (total gas) dry Kg-1 yr-1 (Rovers and Farquhar, 1973; Buivid, 1980; Halvadakis, Robertson, and Leckie, 1983). However, lack of standardized sampling methods, incubation techniques, and parallel controls makes comparison between studies difficult. Amendments that have been proposed for increased gas production and used in previous studies include moisture, sewage sludge (a source of microorganisms, nutrients, and moisture), nutrients, and buffers. In a recent study, Barlaz et. al. (1989), using a standardized shredded refuse, accomplished decomposition of approximately 70 percent of the cellulose and hemicellulose in 111 days with modest moisture addition, initial neutralization, and leachate recycle.

Laboratory studies which incubated actual landfill samples under anaerobic conditions indicated rates ranging from 10^{-3} to 10^{-1} m^3 (total gas) dry Kg-1 yr-1 (Jenkins and Pettus, 1985; Emberton, 1986; Bogner, 1990a). The wide range of rates reflects the wide range of refuse composition, nutrients, and moisture which may be present at different locations, even within a single landfill site. The results of Emberton (1986) suggested increased gas production rates from samples with increasing natural moisture content.

Field test cell projects can also yield useful rate information. A large field test cell project in Mountain View, California, realized rates of approximately 3.2 x 10^{-2} m^3 dry Kg-1 yr-1 in the control cell (Pacey and Dietz, 1986). A large field test cell project in progress at the Brogborough Landfill, England, showed initially higher rates of gas production from a sewage sludge-amended cell; however, cumulative gas production from each of the six cells with various treatments is now about equal after more than a year of monitoring--further moisture manipulations are planned (Campbell and Croft, 1990).

Practically, landfill gas developers will assume an ultimate gas potential of 6.2 x 10^{-2} to 1.1 x 10^{-1} m^3 dry Kg-1 (1.0-1.8 SCF dry lb^{-1}) and apply a first order decomposition reaction to model gas production over a 20-30 year lifetime (Pacey, 1990). It is important to note that the high figure is less than half the gas theoretically obtainable by complete anaerobic biodegradation, emphasizing the inefficiency of landfill anaerobic digestion. Field pumping tests are used to determine maximum sustainable pumping rates which are, in turn, equated to gas generation rates. These have suggested maximum rates of 7.5 x 10^{-3} m^3 dry Kg-1 yr-1 (EMCON, 1981). Typically, the results of decomposition modeling and field pumping tests are compared and merged when making long-term predictions for a particular site.

Controlled laboratory studies suggest the benefit of increased control of the landfill decomposition process. Table 1 (all tables and figures appear at end of paper) indicates gas generation rates from laboratory in-vitro studies of actual landfill samples due to moisture or moisture-plus-nutrient addition. Note that the addition of a comprehensive aqueous nutrient media for anaerobic digestion was of some benefit but did not produce substantially superior results over the addition of water alone. This was due to the fact that the majority of samples contained interbedded calcareous soils with high indigenous nutrients which contributed nutrients, neutralizing capacity, and microorganisms. Thus, it is important to consider the properties of the soils into which filling occurs with respect to the decomposition process. In addition, Table 1 indicates decreases in variability in landfill gas generation rates with addition of water or water-plus-nutrients. Thus, more control of the gas generation process is possible with manipulation of moisture and addition of nutrients. The samples indicated in Table 1 were amended to approximately 200 percent water content (based on percent dry weight), which is at the low end of moisture contents for conventional anaerobic digestion and is termed "high-solids" anaerobic digestion. The literature and recent operating experience suggest that good rates of biogas production can be realized in high-solids digestion (Jewell et. al., 1982; Wujcik, 1980; Six and DeBaere, 1990).

At any given location in a landfill site, the degree of decomposition may be negligible to highly advanced. Visual evidence indicates that both readable newspapers and green grass may coexist in a single site with dark gray sludges indicative of an advanced state of decomposition (low residual volatile solids). Thus, the observed gas production from a given well is a function of gas pumped from a cumulative volume of landfill containing variable gas production rates. It seems clear that the degree of variability within a given site may be at least as great as the variability between sites. For example, in the study cited in Table 1, the highest and lowest gas production rates among the controls were from samples taken at approximately the same depth at the same site; the rates varied by more than two orders of magnitude. Since complex relationships exist between the various groups of microorganisms and their substrates to accomplish landfill degradation of complex organic materials, greater process control is attainable only with increased homogeneity within the landfill. Some engineering measures to accomplish this will be discussed in greater detail later in this paper. Ideally, though, greater moisture contents combined with particle size reduction are key to bringing degradable substrates, bacteria, and nutrients together for more uniform decomposition rates.

ENGINEERING DESIGN, SITE MANAGEMENT PRACTICES, AND CLIMATIC FACTORS THAT INFLUENCE GAS GENERATION AND RECOVERY

Historically, landfills have not been designed for optimization of gas generation and recovery. Rather, they have been designed in accordance with the appropriate state regulations in force at the time the landfill was permitted. These regulations have evolved from more lenient regulations with regard to liquid and gas control in the 1960's-1970's to more stringent regulations in the 1980's and into the 1990's. Specifically, we now have the first federal landfilling regulations under Subtitle D of RCRA. States are free to set more stringent regulations; indeed, California regulations already exceed Subtitle D requirements. In addition, the U.S. Environmental Protection Agency plans to regulate gaseous emissions from landfills into the atmosphere (both methane and volatile organic compounds); these regulations will be formalized in proposed amendments to the Clean Air Act that will pertain to active, large landfills.

It is paradoxical to compare the design goals of older and newer landfill sites with respect to refuse decomposition and landfill gas generation. Older landfills, designed in the 1960's and early 1970's under less stringent cover and liner requirements, provided a more open system for infiltration of rainfall, surface water, and groundwater, thus encouraging increased decomposition rates. However, they often did not provide good containment for and control of the gaseous and liquid products of decomposition. Newer sites, on the other hand, are designed to provide a high degree of containment with low decomposition rates. Key features of modern landfills include covers that promote high rates of runoff with minimal infiltration, prohibition of liquid wastes, multiple barrier liners, and leachate collection and disposal systems. Landfill leachate typically contains high concentrations of intermediate decomposition products which are substrates for methanogenic bacteria; by removing leachate and sending it to sewage treatment or alternative disposal, substantial methane potential is lost from the landfill "digester."

It is useful also to examine general climatic factors with regard to landfill decomposition, particularly precipitation and temperature. Most landfills, regardless of climatic region or season, are mesophilic--with internal temperatures in the 30-35°C range. In a very few cases, landfill temperatures of 50-55°C indicative of thermophilic conditions with accelerated decomposition rates have been recorded. Precipitation is less of an influence at newer sites designed for a high degree of containment than it was at older, more open sites. Refuse contains entrained moisture and yields additional water during decomposition reactions. Thus, one can readily observe gas production at semiarid containment sites. However, at some such sites, yields to a commercial recovery system may be less than anticipated, with resulting mismatch of recovery hardware to gas production rates.

ENERGY POTENTIAL FROM CURRENT AND FUTURE LANDFILLS THREE SCENARIOS

In order to discuss the energy potential of modern landfills, one must distinguish between existing sites and some projections for landfilling practices at future sites. Three scenarios were developed to address the methane production potential of current and future landfills.

Scenario I: Existing Sites--Active and Completed

These operating and closed sites were constructed under a variety of state permit regulations and enforcement levels over three decades. (Note: Prior to the advent of controlled landfilling practices in the 1960's, most communities practiced open dumping and burning with negligible production of methane). The refuse contained therein is in various states of decomposition. The majority of sites do not have leachate and gas control measures. Nevertheless, where a potential gas user is available, particularly at larger sites, commercial gas recovery may be feasible. An individual site investigation is mandatory, including pumping tests, physical examination of refuse decomposition when test wells are drilled, laboratory testing of soils and refuse, and gas production modeling.

The only type of moisture manipulation permitted under Subtitle D is leachate recycle, provided the site is lined and provided with a leachate collection system. Not only does leachate recycle prevent loss of intermediate volatile fatty acids with methane potential, as discussed above, it also provides additional liquid circulation for contact between microorganisms, nutrients, and degradable substrates. Thus, where feasible, leachate recycle should promote increased gas generation rates. Unfortunately, it is not possible to accurately predict the magnitude of this increase for any given site. In the future, it may be possible to develop combined laboratory and field procedures that will provide meaningful rate information. At the present time, however, the increased benefit versus the increased cost of a leachate recycle system for a given gas recovery scheme cannot be accurately determined, only weighed against the cost of alternative leachate disposal measures.

Scenario II: New Sites--Geofills

Prohibitions against yard waste being placed in landfills and aggressive recycling practices for other biodegradables (particularly paper) remove a considerable portion of the methane potential from landfilled refuse. Table 2 indicates the methane potential of various organic fractions of a typical refuse. More than 90 percent of the methane potential is from cellulose and hemicellulose, major components of plant materials and paper products. Lignin is recalcitrant to anaerobic digestion. Table 3 presents a quick follow-on calculation for the overall decline in total methane potential resulting from removal of paper and plant materials from landfill disposal. Thus, with high recycle rates, the methane potential is drastically reduced.

The resulting landfills with low content of biodegradables plus various types of monofills (such as ash disposal sites) are poor candidates for gas recovery. They can be termed "geofills," since their purpose is to place the waste into geologic storage. Such sites will require stringent hydrogeologic controls and, if there is any potential for gas generation, control measures for gas migration. Such a site is portrayed in Figure 1. There is no commercial gas recovery potential at such sites, and thus, no potential for monetary return on cost of filling, other than user fees.

Scenario III: New Sites--Biofills

"Biofill" is a term coined by the U.K. Department of Energy (Richards and Aitchison, 1990) to describe a landfill that is designed and operated for optimum methane generation and recovery. This is a landfill that may achieve methane production approaching the values shown on Table 2 through manipulation of refuse placement in a tightly engineered subsurface system with supplemental moisture and other additives (nutrients, buffer, microorganisms). Currently the subject of basic and applied research in the U.K., including the field test cell project mentioned earlier (Campbell and Croft, 1990), the Biofill concept is being developed to extend high solids anaerobic digestion technology to the landfill environment.

For the U.S., Figure 2 suggests a conceptual design for a modified Biofill that would conform to Subtitle D regulations, which do not permit water or liquid waste to be added to landfills. Included are containment measures (multiple barrier liner and cover systems), leachate recycle, and internal permeable corridors for better moisture distribution through the decomposing refuse. Most new landfills will be designed with strictly engineered liners and covers; thus, the only major additions would be leachate recycle and altered internal design. Some size reduction of refuse and removal of selected nonbiodegradables would also be beneficial. Active gas collection must be concurrent with filling. Groundwater and gas monitoring systems must be extensive to assure containment. Preliminary laboratory testing of refuse and soils is recommended to assist with site design and optimum placement of materials for gas generation and recovery.

The benefits of biofilling include optimum methane generation and recovery, as well as faster stabilization of degradable organics. The latter is especially important at sites pressured by surrounding urban and suburban development to promote land uses more desirable than a long-term refuse repository. With current fills, anaerobic decomposition may extend over a half century or more, as evidenced by nondecomposed organics in fills 20-30 years old. It is perhaps worth repeating that lignin, which is recalcitrant to anaerobic digestion, will remain in landfill storage into geologic time. The geologic record suggests that future conversion of lignin to fossil fuel precursors is possible over very long time frames (Bogner, 1990b).

CONCLUSIONS

The production of methane from anaerobic decomposition of refuse in landfills is a complex process that has been largely uncontrolled in existing landfills. Nevertheless, commercial methane recovery has been achieved at a small percentage of U.S. landfills (over 100 sites). This alternative energy source is a relatively small but immediately attainable source of useful methane. As more stringent engineering measures are implemented under new federal regulations to achieve containment of decomposing refuse and control of its liquid and gaseous products, it is desirable also to promote increased control of the decomposition process within the tightly engineered landfill system. Some applied research and development will be needed to achieve that control within currently permitted landfill practices.

In addition to energy benefits, the utilization of landfill methane provides important environmental and safety benefits, including:

1) Capture of subsurface methane, which may form explosive methane/air mixtures in soil gas, at the ground surface, and in overlying structures.

2) Minimization of methane emissions to the atmosphere. Landfills are an important contributor to observed historic increases in atmospheric methane (Bingemer and Crutzen, 1987; Bogner, 1990b), a greenhouse gas implicated in global warming projections.

To a large extent, current regulations requiring increased landfill gas control are promoting a renewed interest in landfill gas recovery as a potential source of revenue to mitigate increased costs for environmental control. Shifts in natural gas prices and financial incentives for development of renewable energy resources can also stimulate increased commercial development of landfill methane.

In many parts of the U.S., landfilling will continue to be relied upon into the next century as the least expensive waste disposal alternative. To a large extent, refuse collection and landfill disposal are managed cooperatively between public- and private-sector interests. Thus, better control of the decomposition process, which is desirable for both commercial and environmental aims, should be the subject of applied research and development supported by cooperative public/private ventures.

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TABLE 1

Summary of cumulative biogas production after 200 days controlled anaerobic incubation at 35°C. Means of triplicate or quadruplicate biochemical methane potential assays of landfill samples from three sites. Water and aqueous nutrient media added to equalize water content at approximately 200 percent (based on percent dry weight) for comparison with unamended controls. See Bogner, 1990a, for detailed discussion of methods and results.

	Mean Total Gas (mL)	Mean Rate (m^3 dry Kg-1 yr-1)	Rate / Rate Control	N
Controls	273	3.31×10^{-2}		16
Water Added	677	7.16×10^{-2}	2.16	16
Aqueous Nutrient Media Added	852	9.16×10^{-2}	2.77	12

Ranges for Rates (m^3 dry Kg-1 yr-1):		
	controls	1.3×10^{-3} to 1.7×10^{-1}
	water	1.2×10^{-2} to 2.0×10^{-1}
	nutrient	3.5×10^{-2} to 1.8×10^{-1}

TABLE 2

Methane Potential from 1 Kg refuse, Madison, Wisconsin. Data from Barlaz, Ham, and Schaefer, 1989.

	% Dry Weight	Methane Potential L/dry Kg @ NTP Via Anaerobic Digestion
% Volatile Solids	78.60	
Including:		
Cellulose	51.20	191.0
Hemicellulose	11.90	44.4
Protein	4.20	21.7
Lignin	15.20	-
Soluble Sugars	0.35	1.3
		258.4, with > 90% from Cellulose & Hemicellulose

TABLE 3

Effect of Cellulose and Hemicellulose Removal on Refuse Methane Potential. Basis: Madison, Wisconsin refuse. See Table 2.

% Cellulose & Hemicellulose lost to Landfill Disposal	Decrease in Methane Potential (L/dry Kg @ NTP)	% Decline in Total Methane Potential Unit Mass Refuse
10	23.5	9
20	47.1	18
25	58.9	23
50	117.7	46

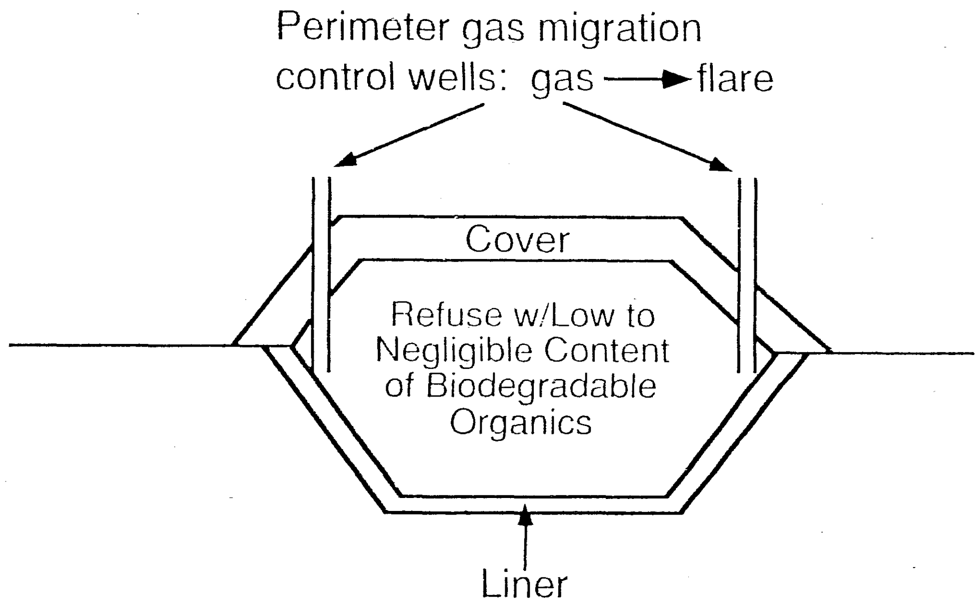

Figure 1

The Geofill Concept. Commercial Methane Production Potential Negligible. Gas Migration Control required where Methane Production Potential Exists. Not Shown are Leachate and Gas Monitoring Wells/Probes.

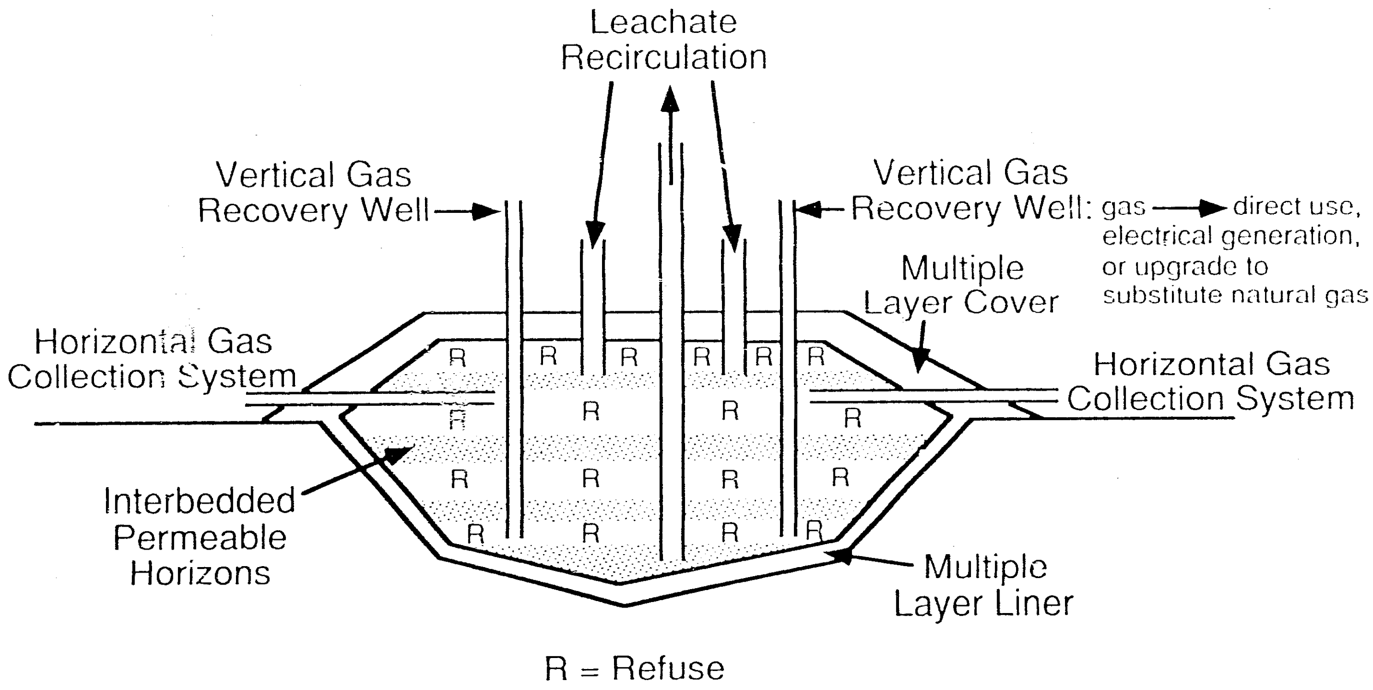

Figure 2

Conceptual Design for a Biofill that could be Permitted under Subtitle D Regulations. Optimum Methane Production and Recovery with faster Landfill Stabilization. Not Shown are Leachate and Gas Monitoring Wells/Probes.

ENERGY POTENTIAL FOR WASTE-TO-ENERGY FACILITIES

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This paper will focus on the 1990 to 2000 electric energy potential for waste-to-energy (WTE) facilities. It briefly examines identified WTE projects, market drivers and constraints for future WTE projects, and provides a forecast of future electric energy potential from WTE projects through the year 2000.

BACKGROUND

United States Power Needs 1990-2000

Between the years 1990 and 2000, as much as 110,000 megawatts (MW) of new generating capacity could be added in the United States (assuming 2.4 percent annual load growth). Of this, approximately 50 percent could be from traditional utility sources and the remaining 50 percent from non-utility generation. About 25,000 MW of non-utility generation will consist of cogeneration and small power production facilities (including waste-to-energy plants), and the balance will be made up of independent power production facilities.

Only about five to ten percent of the country's municipal solid wastes (MSW) is currently burned in WTE facilities with a net generation capacity of some 700 MW. At the current MSW generation rate of about 180 million tons per year, MSW projects could theoretically generate some 85 billion KWH or about 11,500 MW. That amount equals the output of about 20 large coal plants. The Environmental Protection Agency (EPA) has announced a goal of reducing the nation's waste stream by about 25 percent over the next several years through recycling and source reduction. However, this will still leave a substantial potential fuel source for waste-to-energy generation.

Waste History

The disposal of municipal waste dates back to 500 B.C. when the first dump opened in Athens. In 1885, the first incinerator was constructed in New York followed 13 years later by the first rubbish sorting plant. In 1978, passage of the Public Utility Regulatory Policy Act (PURPA) created a market for electric energy from cogeneration and small power production facilities including WTE facilities. During the '70s and early '80s, miscellaneous environmental acts were passed which regulated, among other things, landfills and air and solid waste emissions from WTE facilities. This year we have witnessed the development of significant curbside recycling. Finally, in the next ten to 20 years, we could witness the decline of significant landfill capacity in the U.S. raising the question, "What do we do with our waste now?"

Major Waste Disposal Options

The U.S. currently generates about 400,000 tons per day (TPD) of waste: municipal, industrial and biomass. Major waste disposal options currently available to address safe disposal of these wastes include landfilling, composting, recycling, source reduction and WTE facilities. It is the latter disposal option which is the focus of this paper.

Integrated Waste Management Systems

Figure 1 (this figure and all others appear at end of paper) illustrates the concept of an integrated waste management system. Waste is collected and brought to the WTE facility. Either at the facility or as part of the collection process, selected materials can be separated from the waste stream and recycled. Typically, recycled materials include glass, plastics, ferrous metals, newsprint, corrugated paperboard and aluminum. These recycled materials reduce both the amount of energy that must be consumed to produce new products and the amount of waste that must be currently disposed of. The WTE facility burns the remaining waste using the energy released to raise steam. The steam can either be sold directly to an industrial customer, used to turn an electric generator for power generation, or both.

On an economic basis, the integrated waste disposal system consists of revenues derived from the tipping fee, recycling sales, and power/steam sales. Balanced against these revenue streams are the costs to finance, operate and maintain the WTE facility as well as to dispose of the ash that is created.

IDENTIFIED WTE PROJECTS

Location

The 1988-1989 Resource Recovery Yearbook identifies WTE facilities across the United States. It classifies these facilities as existing (as of 1988-1989) in advanced planning (detailed design and/or construction is underway) and conceptual (preliminary design has begun). The top states for these identified WTE facilities are shown in Figure 2. A preponderance of the facilities are located in the northeast where there is the highest population density and the most significant shortage of landfill capacity. Additionally, WTE facilities have been sited in other population centers including California, Florida, Michigan and Wisconsin.

Energy Outputs

When the energy outputs (electricity and steam) from WTE facilities are examined, it is apparent that the mix of energy outputs is changing as shown in Figure 3. For example, existing WTE facilities primarily sell steam while WTE facilities in advanced and conceptual planning primarily sell electricity. This phenomenon may reflect the fact that electric energy capacity is also becoming constrained in the United States, creating attractive markets for the sale of electricity from WTE projects.

Electric Capacity

As a general rule, each ton of refuse burned in a WTE facility is capable of generating 475 to 500 KWH of electric power. As identified in the 1988-1989 Resource Recovery Yearbook, there are some 110 existing WTE facilities currently contributing about 700 MW net to the country's electric supply. The mean project net output is approximately 16 MW. This reflects the fact that there is a wide diversity in project size. Small modular combustion facilities have limited generation capacity while large combustion facilities can generate up to 80 MW (the limit for their ability to enjoy the benefits of PURPA, i.e., the market for selling their electric output to electric utilities). Advanced and conceptually planned facilities will be larger, contributing in total about an additional 3,200 MW through the year 1995.

FUTURE WTE PROJECTS

Market Drivers

The major market drivers for new WTE facilities include population density, landfill space, electric/steam sales opportunities, tipping fees and the political climate.

- Population centers create the most pressing need for waste disposal solutions by concentrating significant amounts of waste within a relatively small geographic area. States with major population centers (over 1,000,000) should be good candidates for the siting of WTE facilities. Additionally, population density can often lead to landfill capacity constraints which create the need for other waste disposal options.

  This shortage is being accelerated by current environmental regulations which are forcing existing landfills to close and significantly encumbering the ability of future landfills to be sited. Over the next 10 to 20 years, a significant portion of all existing landfills in the U.S. could potentially be closed. Recycling and WTE facilities provide two complementary alternatives to easing the pressure on existing landfill capacity because, in the one case, recycled material is kept out of the waste stream (at least for the present time) and WTE facilities can reduce the waste volume by about 90 percent. To the extent these two disposal techniques are employed, existing landfill capacity can be extended as shown in Figure 4.

- PURPA, which created the market for electric sales from WTE and other facilities, also drives the WTE market. In general, a WTE facility has three options with respect to marketing electric energy produced. First, electric energy generated can, in some states, be sold to an adjacent industrial customer. Second, in many states WTE facilities can negotiate under PURPA directly with electric utilities for the sale of power from their project to the utility. Finally, many utilities issue competitive requests for proposals to meet their capacity needs. In general all types of technologies are able to respond to these requests. To date, some 2,000 MW from WTE projects have been proposed to utilities across the country and some 500 megawatts of these projects have been selected for contract negotiation. More power will be required by U.S. utilities to meet load growth and replace retired and inefficient units.

  Several states such as Florida, Illinois, New Jersey and Michigan offer special power sales contract incentives to WTE facilities. For example, Florida will make available a standard offer contract for WTE facilities up to 75 MW, eliminating the need for the WTE facility to respond to a utility RFP. In

Illinois, WTE facilities can (in the near term) obtain the same rate that the utility charges the municipal customer for its power. In Michigan, special provisions have been set up to purchase up to 120 MW of power from WTE facilities.

In general, the utility buy-back rates for power generated by projects and purchased under PURPA depends on the type of generating facility the utility is avoiding need for, the type of fuel burned, and the projected in-service date. Various market projections have identified promising states for future development of non-utility generation. Figure 5 shows the 10 states that the Utility Data Institute has identified for the period 1989-1990.

Steam sales opportunities to local industries customers can also provide the impetus for siting a WTE facility; however, unlike electricity, there is no ready market available.

- Tipping fees are generally a function of landfill capacity. The more capacity available, the lower the tip fee. Generally, tip fees are highest in the Northeast. However, tipping fees can differ significantly between metropolitan areas. Looking at the ten largest metropolitan areas, New York City has the highest tip fees ($120-160/ton) while Dallas, Texas has some of the lowest ($5-10/ton).

- The local political climate can encourage the development of either local or regional WTE facilities as part of an integrated waste disposal system. In general, a positive climate is created when the various disposal options have been carefully balanced and a WTE facility is one of the integrated components along with waste reduction, recycling and landfilling.

Market Constraints

The major market constraints are political climate, environmental regulation and the relationship between tip fees and electric revenues.

- The political climate can also pose a constraint where a WTE facility is not an acceptable waste disposal option for a community; local residents simply say "not in my back yard" to the siting and development of a WTE facility; or, tipping fees are regulated.

- Environmental regulations concerning acid gas, trace metals, organics, particulates, waste toxicity and ash landfills can require the inclusion of state-of-the-art environmental control equipment and mitigation activities. However, it is the vocal concerns (real and perceived) of the local population that can block progress on WTE facilities.

- Projects which do not rely on tax incentives and special financing for their economic viability must look to tipping fees and electric energy/steam energy revenues for their economic viability. As shown in Figure 6, tipping fees and energy price are related. To the extent that a WTE facility can obtain high tipping fees, the energy price needed to make it economically viable is reduced. However, to the extent that there is volatility in the energy price, the economic viability of the project can be severely tested.

Market Forecast 1990-2000

The aggregate capacity of existing, advanced planning and conceptually designed facilities is approximately 3,500 MW. Using a target of 30 percent incineration of the U.S. waste stream in the year 2000, there will be a need to develop an additional 100 to 150 projects which will be capable of providing another 2,000 to 2,500 MW of capacity.

The major question is where these projects will be located. As demonstrated in the above analysis, these projects will generally be located where:

- The project is near a large, metropolitan area where it will be a regional facility serving a number of smaller metropolitan areas.

- Landfills in the general area have limited remaining capacity (with no prospect of either future capacity development or interstate disposal) resulting in relatively high tipping fees.

- The political climate is positive, or at least neutral, having recognized WTE facilities as a component of waste disposal management.

- Adequate ash landfilling is available within a reasonable distance.

- The electric utility serving the facility site (or one nearby) has near-term need for capacity that results in relatively high avoided costs for electric power purchases under PURPA.

As an industry, then, there is a bright future for WTE facilities if they are developed where they are needed as a key part of a local or regional integrated solid waste disposal program.

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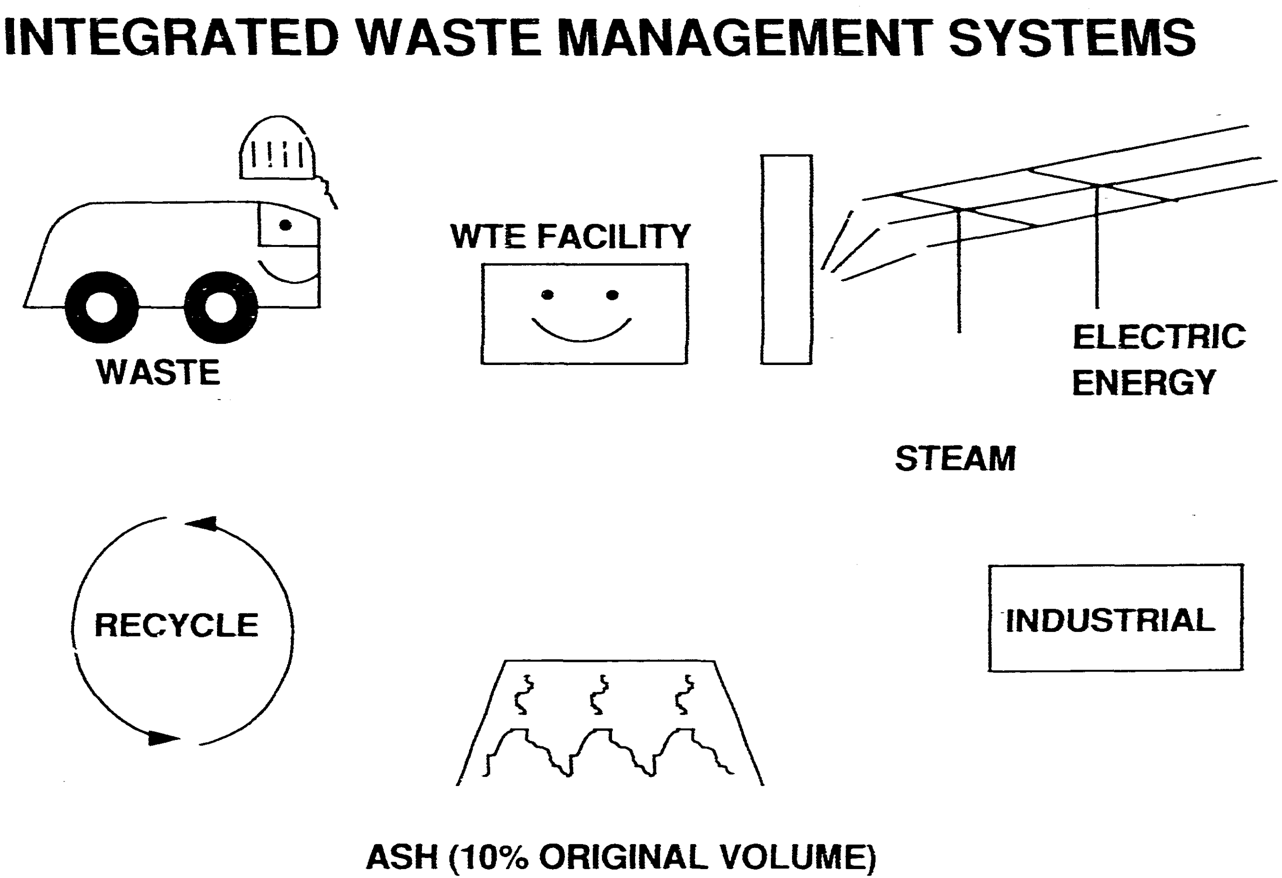
INTEGRATED WASTE MANAGEMENT SYSTEMS
WASTE
WTE FACILITY
ELECTRIC
ENERGY
STEAM
RECYCLE
INDUSTRIAL
ASH (10% ORIGINAL VOLUME)

Figure 1

TOP STATES
EXISTING AND PLANNED WTE FACILITIES
THROUGH 1995

Figure 2

WASTE TO ENERGY FACILITIES
ENERGY OUTPUTS

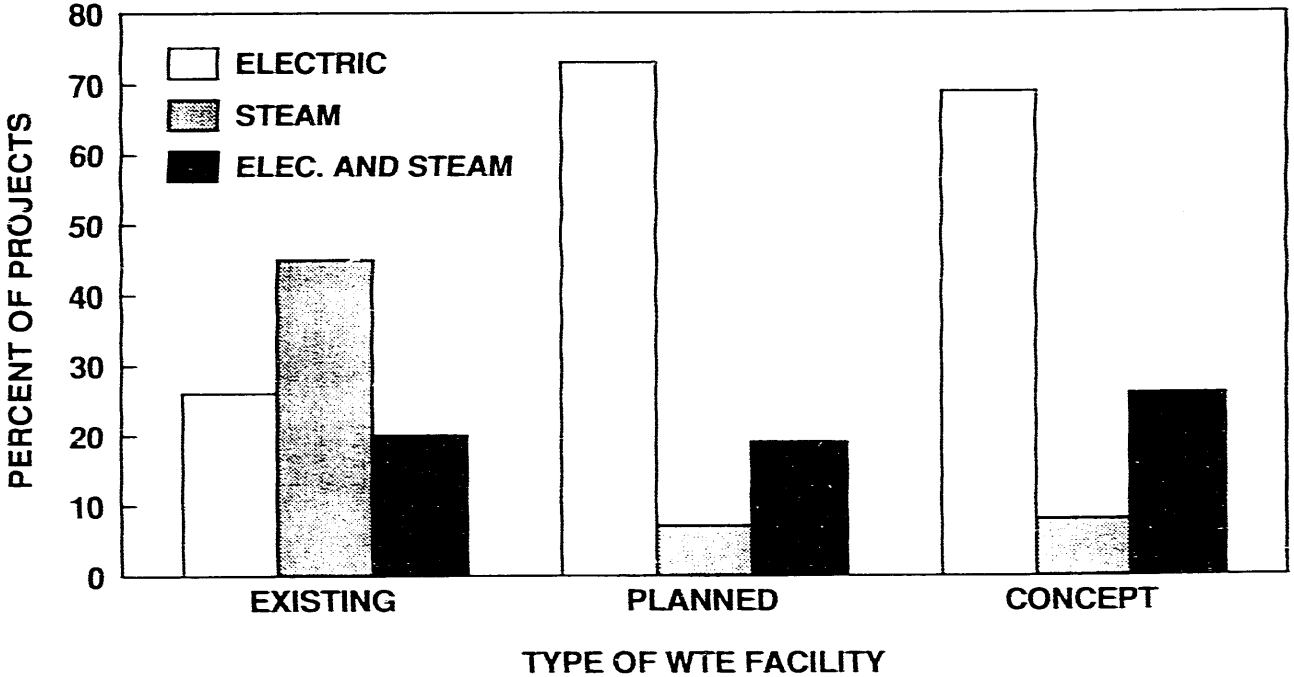

Figure 3

LANDFILL SPACE

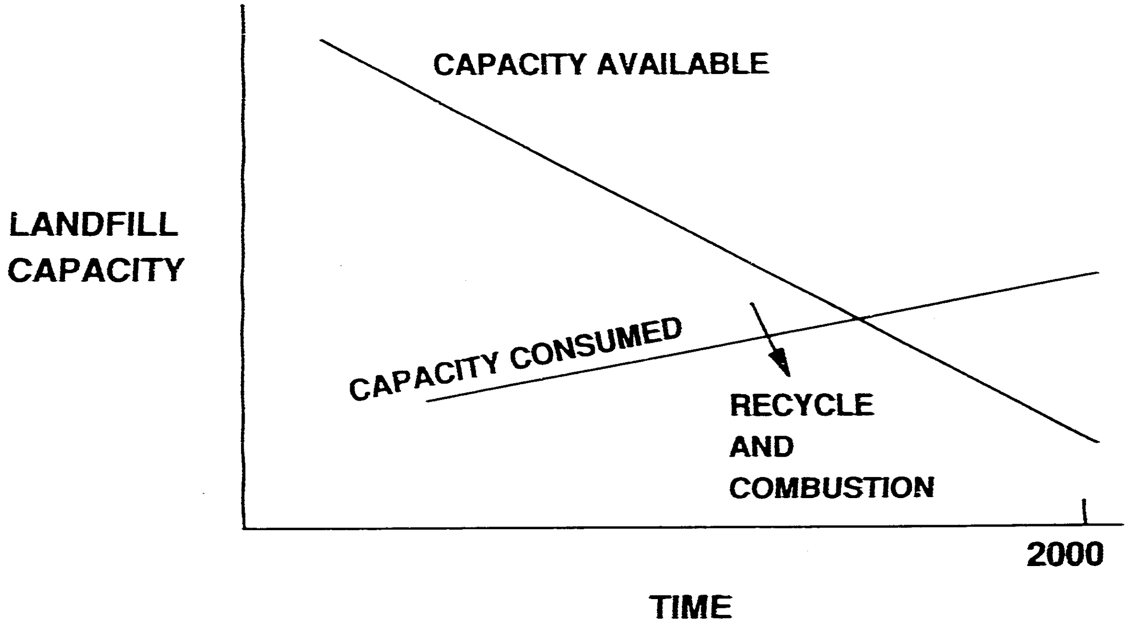

Figure 4

TOP TEN STATES FOR NEW NON-UTILITY GENERATION 1989-1999

Figure 5

TIP FEE AND ENERGY PRICE ARE RELATED!

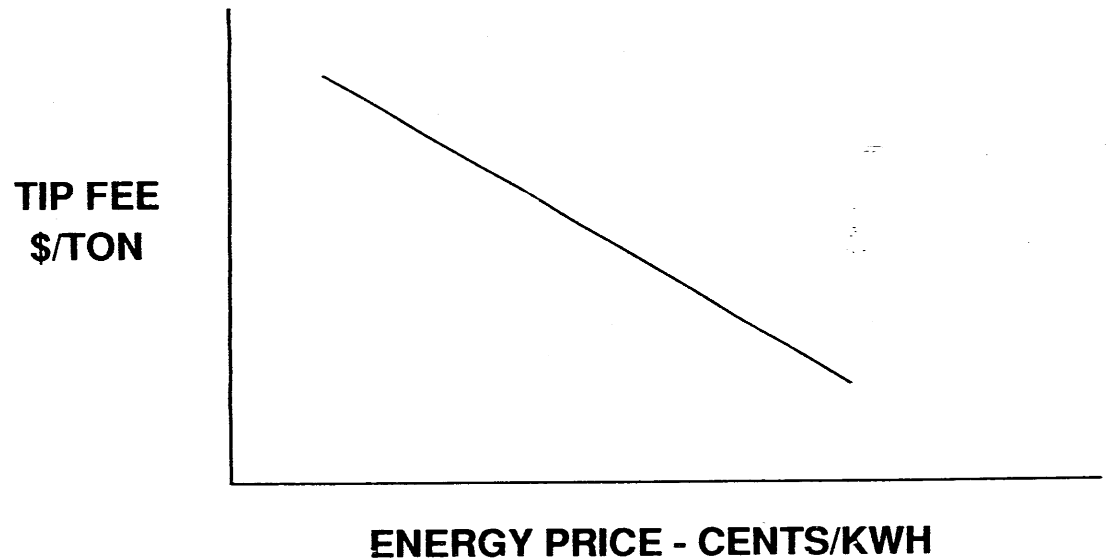

Figure 6

IV. NEW TECHNOLOGIES IN SOLID WASTE MANAGEMENT

NEW DEVELOPMENTS IN SORTING TECHNIQUES

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Council for Solid Waste Solutions

INTRODUCTION

The United States produces more than 500,00 tons of trash daily. This tonnage has been increasing steadily over the last decade. Nearly one-third of the 6,500 landfills in the country will close within five years. As a result, the cost of landfill disposal in some parts of the country has doubled, and in some instances, tripled. At the same time that communities are having difficulty approving new solid waste sites, cost of disposal on a nation-wide basis varies greatly.

The dilemma faced by the plastics industry and recyclers is how to operate in this economic setting. High disposal costs for solid waste may impact the recycling market. Some states think of legislating recycling fees to finance state-wide programs.

Farsighted entrepreneurs in the plastics industry see the need and are taking steps to develop recycling technology and collection systems. Consumers, assisted by non-profit groups, have voluntarily begun recycling programs. The Council for Solid Waste Solutions supports these efforts with a well developed research effort. Research is ongoing in the areas of collection, sorting and separation, reclamation and end-use markets.

THINK A BIT ABOUT CHANGE

Anyone reading this born before 1945 as I was? Consider the changes we have witnessed. We were born before television, before penicillin, before frozen food, plastic contact lenses, and the pill. We were born before radar, credit cards, split atoms, and ballpoint pens--before panty hose, dishwashers, electric blankets, and before man walked on the moon.

We got married first, and then lived together. How quaint can you be? In our time, closets were for clothes, not from coming out. In our day, cigarette smoking was fashionable; grass was mowed; coke was a cold drink; and pot was something you cooked in.

Through all these changes, the way solid waste has been handled has remained much the same--dump it in the ground.

LANDFILL

The technology for creating and maintaining the old dump has changed. It is now called a sanitary landfill; but the method of disposal is basically the same as it has been for centuries. It is time for a change.

I may be biased, but in many changes for the better, American industry has been at the helm, providing the resources and the expertise. It is time once again for industry to take the lead, to direct our nation toward solutions to our solid waste management crunch. Government officials have found a good way to spearhead change, and we have gotten the message: change or get banned.

PLASTICS UNDER FIRE

Initial legislation has focused on packing materials. Therefore, packaging recycling needs to be treated first. It is the Council's current focus; but the need to recycle durable goods is not far behind. The relationship between the need to recycle packaging and the need to recycle durables is similar to a patient with a broken arm and a heart attack. The heart attack needs to be treated first.

Plastic packaging bans are the heart attack--literally. Durable goods, including composites and thermostats, are the broken arm. We will not die from it, but it needs to be treated soon.

Let me start my overview along the lines of the Environmental Protection Agency (EPA) hierarchy for solid waste management. The Council strongly supports an integrated waste management approach. There is no single solution!

EPA HIERARCHY

What are the four steps?

1) Minimize future waste by reducing materials at the source.

2) Recycle what makes economic sense.

3) Convert to energy through incineration what can be in an environmentally sound way.

4) Landfill what is left.

This integrated approach allows each community to design a waste management program that reflects its own population and waste stream characteristics. It allows the best possible mix of waste management solutions tailored to the local situation.

I will discuss what the industry and the Council specifically are doing to make plastics part of the solid waste management solution in the four waste management areas: source reduction, recycling, incineration and landfill.

SOURCE REDUCTION

The industry has had success already in source reduction. Sometimes people in industry call this "cost reduction." The plastics industry has always had this on its agenda.

Light weighing plastics is a good example, PET soda bottles and HDPE milk containers and detergent bottles now weigh 30 to 50 percent less than they did in the 1970's. The double lamination process produces polystyrene foam food service products with up to 40 percent less foam by volume. P&G recently introduced thinner diapers with a new plastic wrap. The new packaging creates considerably less waste; and some companies are also removing potentially toxic heavy metals from their product formulations. All of this fits the EPA definition of source reduction, and progress is definitely being made.

RECYCLING

Recycling is the second step. It is the option where people are coming together--some passionately. Nearly everyone supports recycling.

The EPA's goal for the United States is to source reduce or recycle 25 percent of municipal solid waste by 1991. Some legislators are looking for even higher figures--talking about 50 or even 75 percent recycling rates. Technically, it can be done; but, as with all methods of solid waste management, there are costs. Time will tell whether the public is willing to pay the costs to reach those goals. Eighty percent of the resources in the Council's technical division are directed toward recycling.

Our approach is business-oriented. The Council has developed a national recycling framework--or blueprint--from a business perspective. We firmly believe that unless plastics recycling makes economic sense, it cannot be a long-term solution. The blueprint shows how the plastic industry can lead the way to develop systems that will make plastics recycling economical, convenient and profitable.

FOUR STEPS

There are four steps in plastics recycling:

- Collection
- Handling
- Reclamation
- Marketing End Products

In each step of the process, there will be challenges for our industry.

COLLECTION

In the collection step, we are defining the best ways to densify the plastics for economical transportation.

After aluminum, plastics are the second most valuable recyclable material; but, transporting plastics is akin to shipping popped popcorn. Systems to transport more densified loads will futher increase the value.

HANDLING

In the handling phase, manual labor is expensive. Automated sorting systems are being developed to avoid these costs. The Bezner designed material recovery facility (MRF) in Rhode Island can automatically separate glass, metal and plastics. This facility is one of the most advanced presently operational.

RECLAMATION

Reclamation technology is being improved to produce recycled products that meet high performance standards of a broad end-use market. New plants are springing up all over the country. Last October, Day Products opened a plant in Bridgeport, New Jersey to handle 30 m lbs/year of PET soda bottles.

Polysource, a division of ITC, opened its plant in Baltimore on the 20th of April. It is buying and processing all plastic household bottles.

Union Carbide is building a multi-plastics recycling plant in Piscataway, New Jersey that will handle 40 m lbs/year of both films and rigid containers.

DuPont/WMI; Sonoco Graham (Closed Loop); NPRC; and Phillips--Partec joint venture are all new reclaimers.

WASTE-TO-ENERGY INCINERATION

You have heard much on that subject in this seminar already.

The big money says that the United States is headed in the direction of incinerating an appreciable portion of its solid waste, following the lead of the developed nations of Asia and Europe.

Most of you know that NIMBY is not a Saturday morning cartoon character--it is the acronym for "Not In My Back Yard." In Washington, the related acronym is NIMTOO--"Not In My Term Of Office." The waste industry is learning to deal with NIMBY and to work with communities to address their concerns. This takes time. It is labor intensive; but the payoffs justify the effort.

The Council, together with other organizations, sponsored an incineration symposium coordinated by the U.S. conference of mayors. The Symposium convened an international blue ribbon panel of distinguished scientists and engineers who discussed technical issues related to incineration: risk assessment, monitoring air emission, ash management, facility operation and combustion behavior.

The findings indicate properly designed, operated and maintained municipal solid waste incineration facilities, equipped with modern pollution control devices, yield risks from all pathways that can be held below levels normally of regulatory concern in the U.S. for protection of human health. In plain english, today's incineration technology is safe; but we know that we cannot begin to discuss incineration in a NIMBY environment until the American people believe or are getting the most out of our materials through recycling.

MARKETS

In the fourth phase the most important challenge we face is to ensure markets for recycled materials.

Like millions of Americans, you probably picked up at least one newspaper this morning. In most places newspapers have been the number one recycled product. On the east coast, the market is oversaturated. There is a glut of newspapers to be recycled.

We want to avoid the situation facing paper today--a glut. We are working to ensure that plastics are worked into the nation's recycling infrastructure. The demand for generic PET and high-density polyethylene exceeds supply right now.

DEGRADABILITY

Lastly, degradability per se is not part of the EPA waste management hierarchy, but it does have some important implications, and it relates to the fourth method in the EPA solid waste hierarchy--landfilling. Degradable plastic bags that facilitate composting make sense. Degradability also makes sense when a material needs to disappear during a specific timeframe: like medical sutures or for products that are prone to be littered and can trap wildlife such as six-pack ring connectors; and in marine applications, products can be unintentionally lost at sea and have the potential to harm marine life, i.e., fishing nets.

The jury is still out on whether degradables are beneficial to operating and maintaining a sanitary landfill, but current data says no. A secondary concern with degradability in plastics products is with its potentially adverse impact on recycling; but sanitary landfills will probably always be with us for the disposal of materials that cannot be recycled or incinerated.

SORTING

I want to speak a bit about sorting or separating recyclables. After recycables are collected, they must be sorted or separated into individual waste streams.

CURBSIDE

The Council recommends community curbside collection systems where the homeowner is responsible for separating or sorting recyclables from non-recyclables. This may mean separate containers for glass, metal, plastics, and papers or perhaps one bin for commingled glass, metal and plastics with newsprint separate.

CAPTURE RATE

Studies show curbside collection can achieve a 70 to 90 percent capture rate, while buy-back centers reach 20 percent and drop offs only ten percent of the potential recyclables. Remember, this assumes the community has a recycling program and has properly identified what materials are to be recycled. Everything else goes to the landfill as trash. With collection solved you then utilize a local handler or MRF to handle the final sorting of materials.

HANDLERS--MRF'S

The Council has identified 577 handlers and 90 MRF's nationwide handling all recyclables and with several sorting systems. The Bezner designed MRF in Rhode Island can automatically separate steel cans, aluminum cans, glass, and plastics, but not separate the individual types of plastics. If you want more information about MRF's or handlers in your area call the Council on 1-800-2-HELP-90.

MULTI-MATERIALS

Let me touch a bit on the problems in the sorting of recyclables:

- Metals versus Aluminum
- Glass: Clear-Green-Amber
- Paper: Newsprint-Corrugated-Glossy
- Plastics: Six Polymers

The problem is large. Like other materials, plastics recycling is not just to separate plastics from other materials, but to separate the individual types of plastic from all others. Plastics are not unique! Their problems are just like others that require separation by type.

The Council is working to develop new plastics sorting/separation systems, and I would like to comment on several of the projects now underway. These are research and development projects at universities in several states nationwide. Also, work is being done by private engineering companies for the Council; but that is propriety information. Long-term, if our vision to recycle plastics is reached, it may no longer be practical to separate plastics piece-by-piece.

SOLVENT SEPARATION

For this reason, the Council is sponsoring research in such areas as solvent separation. By this method, a mixture of six types of ground plastics are dissolved and could be then separated as pure materials. The process is similar to the method you might use to get the salt back out of the pepper if you accidently mixed the two together. By pouring a glass of hot water over the mixture you dissolve the salt while leaving the pepper untouched. After filtering out the pepper and evaporating the water, you could recover the salt. At the price of salt, you would be wise to throw the mess out; but for plastics, it may be worthwhile.

SUPER CRITICAL POINT--DENSITY SEPARATION

A second separation project still in the laboratory stage involves separating thermoplastics by density using CO_2 at the super critical point. Density separation techniques are in use broadly today in separating light materials from heavy materials in many industries. The key objective in all of these sorting/separation projects is to improve the quality of the end product or material to be offered for sale. The better the quality, the closer the recycled material is to the virgin product--the higher the sales price.

DIELECTRIC ANALYSIS

A new study is underway using a system referred to as dielectric analysis where the conductivity of plastic may allow rapid sorting either in whole bottle or ground flake form. Work has been done using this system at the post office to identify mail containing bombs or drug shipments. The identification level was in excess of 90 percent with less than one percent false alarms. This research also was applied to detect contamination or spoiled powdered food, or for example, to separate flavors of jello on a high-speed packing line. One of the problems identified in this project was referred to as the airplane problem. In the mail room at high conveyor speed, the letters took off. A similar problem could result when handling empty plastic containers at high speeds.

FROTH FLOTATION

Separating minerals that are mined throughout the world involves technology referred to as Froth Flotation technology. A research project is underway to determine if that technique could be applied to the separation of plastics from the solid waste stream.

As you realize, many of these sorting systems for plastics operate down stream after the total recyclable pile has been separated into streams of metal, glass and plastics. This points out why it is important to have curbside collection of recyclables instead of trying to handle the garbage pile in total. The less contamination in the products being separated, the higher the quality of the output of the system. While saying that there are some people who think a "dirty" MRF receiving all solid waste (recyclables combined with garbage) might be more appropriate.

AUTOMATIC SORTING OF CONTAINERS

The final sorting/separation system I will mention is one the Council is excited about. It shows the most immediate promise. This is an automatic plastic container separation system capable of handling whole or deformed bottles at speeds of approximately 200 bottles per minute. This system uses light transmission detectors and is currently being evaluated at the CPRR at Rutgers University in New Jersey.

Using LEDS, we will be able to separate clear PET plastics bottles from green PET soda bottles, natural high density milk jugs and pigmented bottles, such as detergent and shampoo containers. This system will separate out PVC containers using low-level x-ray scatter detectors. This PVC technology is critical. A single PVC bottle mixed with 1,000 pounds of recycled PET can reduce the performance and value of the recycled PET.

1990 AND BEYOND

We are working to ensure that plastics are worked into the nation's recycling infra-structure.

Obviously, a lot is happening--momentum is building but certainly our work is not finished. I urge all of you to join with us in developing solutions. Industry must keep long-term environmental concerns in view. If we do not make the hard decisions, others will make the decisions for us. We must design products that are safe not only for their intended use, but for reuse or recycling. We must take the lead in our communities, working with public officials to incorporate the safest waste disposal methods available. We must continue to support the research and development of new technologies that can be used to ease the waste disposal crisis. We must become the most active environmentalists in this country. We have learned much, and now our knowledge which has a scientific base must be translated into action.

MODERN LANDFILL TECHNOLOGIES

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Delaware Solid Waste Authority

INTRODUCTION

Every organized society is faced with the problem of disposing solid and liquid waste generated by its residents. Liquid waste has been generally disposed through natural water systems. On the other hand, solid waste generated by society has no such easy means of conveyance, and therefore, has been disposed in man-made pits or depressions in the land. In fact, the word, "landfill," implies filling a cavity.

When the society was agrarian and the population was sparsely dispersed, the solid waste produced consisted of mostly vegetative matter, animal manure, and ashes from fire places and cooking stoves. The vegetative matter and the animal manure underwent normal, organic degradation in nearby dumps, and the only noticeable environmental impacts were odor, vermin, and occasional fires. Such dumps were tolerated because they were generally situated away from the residential areas. The Industrial Revolution resulted in rapid urbanization and a consequent increase in population density of towns. Nearby dumps, perceived as public health hazards, were moved to more distant locations. In many cases, swamp land was filled to create the more desirable firm land.

As industrial activity and productivity increased, the enormous output of manufactured goods and prepared foods required the development of new packaging materials. Glass, metal, paper, cardboard, cotton waste, and wood were the major materials used for packaging involved in the transport, storage, and marketing of materials. The introduction of hermetically sealed steel cans for food storage added to the discarded pile.

The post-war period brought on rapid developments in chemical and metal industries and resulted in the development of new plastics, aluminum, and composite packaging materials. Packaging helped mass production of goods which, in turn, raised the standard of living. The higher the standard of living, the greater is the discard rate. Table 1 (tables and figures are presented at the end of this paper) compares the discard rate of various cities around the world. Since the United States has achieved the highest common standard of living in the world, the per capita discard rate is also the highest. Many groups bemoan the high discard rate as a sign of a decadent, wasteful society. They confuse a highly organized, efficient society where time and convenience are important factors, with one that is wasteful. It is quite obvious because solid waste disposal is not a major problem in most of the poor third world nations, as compared to the richer, industrialized nations.

WASTE DISPOSAL METHODS

Burning the dumps was one common means of getting rid of waste material. However, the smoke from such burning dumps created serious public health hazards, and during the 1960's, burning open dumps was prohibited by state and federal air pollution control laws. Combustion of waste for energy production through well-designed incinerators is another means of reducing the amount of waste which required disposal. Composting of the waste is an alternative technology which undergoes periodic resurgence. Landfills, as always, continue to be the nations mainstay for solid waste disposal. The U.S. Environmental Protection Agency (EPA)[1] in its "Agenda for Action" released in February 1989 estimated the annual generation of muncipal solid waste (MSW) will increase from 160 million tons (1988) to 193 million tons by the year 2000. The U.S. EPA also set a national goal of 25 percent reduction through source reduction and recycling and another goal for combusting up to 20 percent of the remaining MSW. The target date for reaching that goal is 1992. Let us assume December 31, 1992, as the date, since EPA is not very specific in its' documentation. Table 2 depicts a simplified assessment of the nation's total landfill capacity needs, assuming that the national goal of "truly recycling" 25 percent of the discarded material and reduction of another 25 percent of the remaining waste through waste-to-energy plants is achieved by 2001. In the table, the order of magnitude of the values is important because there exists no real "measured" quantity of waste generated in the nation. Facing such a situation, one would expect the regulatory agencies, at both the state and federal levels, to pay substantial attention to the design and construction of landfills. Unfortunately, this is not the case. The regulatory agencies have ignored the need for landfills because politically, landfills are disliked.

In general, the more distant the landfill, the more environmentally acceptable it becomes. For example, New Jersey and New York political leaders feel that landfills (no matter what kind) in Indiana and Ohio are much more preferable and safer than new ones which they could build in their own states. They assume that they do not have the right conditions for landfills in their own backyards because public protests are encountered. Even on the west coast, the same attitude prevails. Both Seattle and Portland feel that the environment is best protected when the landfill is at least 200 miles away.

This general distrust of the landfill disposal method is surprising, because it is now, and will continue to be, the least-cost solution generated within the United States. The distrust is understandable to some extent, because of the prior history of the poorly constructed and operated landfills (more correctly, "uncontrolled dumps") which polluted both surface and groundwater.

REGULATORY TREND

The regulatory agencies, reacting to poor past practices in landfilling, are now adopting stringent regulations, requiring liners, leachate collection systems, and gas venting. A skeptical public and some special interest groups are pushing the regulatory agencies to raise the requirement for liner systems to mirror that of hazardous waste landfills. This is indeed strange, because there is a world of difference between the composition and nature of municipal solid wastes and the hazardous wastes which require landfilling.

The current trend is to require one or more flexible membrane liners (FML) interspersed with either clay or sand as shown in Figure 1. The acceptable thickness of FML varies between a low of 30 mils. to a high of 80 mils. The most popular liners are made from either polyvinylchloride (PVC) or high density polyethelene (HDPE). Sometimes liners with reinforcing nylon scrim are also used. As each state adopts or modifies its regulations, there is a leapfrogging effect in liner complexity. The more complex the liner, the safer it is supposed to be, although there is no technical evidence to support that view. The current trend is to have at least two composite liners, i.e., a compacted clay layer underlying each FML. The same regulatory climate also requires complex capping systems which often include compacted clay, FML, drainage layer, and topsoil. The capping system is designed to reduce infiltration to a maximum extent. The net result is a complex, plastic-wrapped cocoon from which the incipient moisture is withdrawn to retard the natural organic degradation. If the cocoon shows no sign of contaminating groundwater for a period of 30 years after closure, the site would be considered safe.

ROLE OF MOISTURE

Noble[2] has indicated that a dangerous situation may arise when cracks develop in the capping system, and moisture trickles into the cocoon. Organic degradation would be restarted and contamination could start and go unnoticed.

Pohland[3] has shown that organic degradation can be enhanced by selectively recycling leachate produced by the landfill. His concept is to encourage the natural degradation process until most of the easily degradable organics are stabilized and much of it converted to methane gas. The landfill would become relatively safe when it reaches the stable conditions. Stegmann and Spendlin,[4] working with municipal solid waste in Germany, have confirmed Pohland's thesis. They state:

> "Enhancement of methane production from MSW was found to occur when leachate was recycled with additions of buffer nutrients and microbial inoculum. In general, enhancement was found to have a positive effect on the rate of methane production and the quality of leachate produced."

Pacey,[5] experimenting on a larger scale at the mountain landfill in California, also concluded, "leachate recirculation may enhance methane production by providing a positive mechanism of moisture, nutrients, and bacteria transport."

It is possible to design new landfills utilizing leachate recirculation for moisture control, especially after capping. The key to such design is developing a technique for leachate recirculation. In actual practice, it is much more difficult as compared to laboratory lysimeter studies. Reintroduction of the leachate in a uniform manner within the landfill is a difficult process, because the landfill is made up of rather heterogeneous material, including large amounts of plastic materials. Most state regulations require six inches of soil cover at the end of each operating day. The soil cover can act as a moisture retardant. It also occupies space. In lieu of soil, many states such as Delaware allow the use of chemical foams. Two to three inches of foam (created by mixing proprietary chemicals, water, surfactants and air) often have the same benefits of soil cover. In contrast to soil cover, foams break down and do not occupy space or retard moisture movement. Plastic films, in particular, act as barriers to a uniform movement of leachate. Because of the substantial presence of cellulosic material, moisture will eventually find the path of least resistance and reach the bottom of the landfill's leachate collection system.

LANDFILL DESIGN

Over the last two decades, much attention has been focused on complex liner and capping systems and also on improved mechanical compaction of the waste within the landfill. Although attempts have been made to improve the design techniques of leachate collection systems, no radical improvement is obvious. Development of geotech fabrics and grids have added to the complexity of the leachate collection systems. Other than select work in university laboratories and some controlled, larger-sized experimentation, not much attention has been given to methods of enhancing the degradation of large-scale landfills. That is because under the current regulatory atmosphere, landfills are to remain as landfills forever!

Perhaps one should question the premise of leaving landfills forever wrapped in two or three layers of plastic. Instead, the solid waste management program should be holistically viewed and an attempt made to consolidate activities at one location. One concept is to develop a waste management center as shown in Figure 2. The Delaware Solid Waste Authority has initiated such a program by creating three waste management centers, one in each county. The core of the waste management center is obviously the "modern landfill." Once a landfill is constructed, it is much easier to add on other waste management activities around the landfill and use the landfill as the disposal site of last resort. In such a center it is possible to develop the concept of reusing the landfill space over and over. Pohland's concepts of leachate recirculation to enhance degradation become important in the development of such reusable landfill cells.

The Delaware Solid Waste Authority at it's Central Solid Waste Management Center has constructed two, one-acre size cells, each consisting of double liner systems and two identical leachate collection systems (See Figure 3). Approximately 9,800 tons of household solid waste has been disposed in these one-acre size cells. Test Cell I will be monitored with leachate recirculation to maintain optimum moisture conditions, while test Cell II will be allowed to dry out by gradual withdrawal of the moisture. A series of time capsules with known tagged materials have been inserted in both cells. The Authority intends to observe the degradation process between the two cells by excavating the time capsules after a sufficient period of time has elapsed.

LANDFILL RECYCLING

Figure 4 shows the concept of a reusable cell built out of concrete within a fly ash mound. A cell approximately 1,000 feet long, 100 feet wide, and 30 feet deep would allow the deposition of about 65,000 tons of waste. Mechanical means of compaction can be arranged through the use of cranes rolling over rails on either side of the cell. Leachate can be collected from the bottom of the cell and recirculated through an upper leachate spreading system. The decomposition gas can be withdrawn through a series of gas collection wells manifolded into the gas collection line. A movable roof over the cell will allow control of moisture while the landfilling is in progress. When the entire cell has been filled, a removable cap can be installed. The temperature, moisture conditions, and pH of the leachate can be monitored.

In order to assure a reasonably uniform distribution of moisture, it is better to prepare the material using a wet trommel, as shown in Figure 5. The incoming waste is sorted to remove bulky materials. The material entering the trommel (which has bag breaking spikes or bars) can be wetted down by either water or a portion of the leachate collected from a cell. The wet trommeling system allows removal of metals and plastic containers for recycling. By preparing the organic fraction with controlled moisture content, the bacterial action in the cell can start under near optimum conditions.

Figure 6 shows a series of eight cells within a waste management center serving a community of approximately 100,000 population. Assuming that it takes one full year to fill Cell I, new cells would be constructed in succeeding years and the degradation rate monitored. When Cell I shows a decrease in gas production (approximately six years from start), it is possible to excavate the material, screen out plastics, wood and any remaining metal, and reuse the same space over again with new material. The screen undersize material, after testing, can be further stabilized through static pile composting and used as a soil amendment material. Such a system would allow the community to reuse each cell and make maximum use of the available land. Yard waste, which would otherwise have to be composted and stored elsewhere, can also be introduced and converted to methane gas. The gas would have further use within the waste management center as a fuel.

While this concept may seem extraordinary, a controlled landfill for inorganic hazardous waste is being operated by AVR in Rotterdam, Netherlands. This landfill has been constructed on reclaimed land on the North Sea. It is expected to serve the Rotterdam area for a period of seven years, during which select, inorganic hazardous waste will be placed inside discrete sections of a concrete bunker and then capped. A movable roof allows a section to be used without introduction of precipitation. Obviously, a similar system can be used within the United States for municipal solid waste.

RESEARCH NEEDS

Neither the U.S. EPA nor the waste disposal industry project clear-cut research goals. Generally, very limited scope, short-term research is being undertaken to support ad hoc policy decisions instead of pursuing long-term goals. Industrial research support is generally targeted toward permit problems and liner systems. Assuming the nation currently disposes 131 million tons per year in landfills and further assuming that disposal fees average $20 per ton, the revenue for the disposal industry would be approximately 2.6 billion dollars. If 10¢ per ton were assessed as contribution toward long-term research, we would have a pool of 13.1 million dollars, a sum which is four to five times greater than the current U.S. EPA research funding for MSW. The research funding would be independent of congressional actions or inactions.

Since landfills will remain as the main stay for disposal, the national research agenda should include as a minimum the following:

a) Examination of anaerobic composting of yard waste;

b) Development of new biological organisms to enhance the breakdown of complex cellulosic material;

c) Development of biological organisms to anaerobically break down wax coated paper;

d) Improving the understanding of the role of fungi and enzymes in anaerobic decomposition in landfill cells;

e) Field testing and calibration of landfill models;

f) Improved understanding of the mechanism of clogging of leachate collection systems in order to retard or even prevent such clogging;

g) Assessment of the fate of halogenerated organics in the reducing environment of the landfill;

h) Potential for capturing heavy metals in the drainage layer at the bottom of the landfill utilizing natural or synthetic zeolites;

i) Development of standard methods to sample and measure gas emissions from landfills.

Without further research and development in landfill design, construction, and operations, the society is apt to repeat the mistakes of the previous decade.

Between 1991 and 2001, the nation is expected to generate 2,211 billion tons of MSW (See Table 2). Of that amount (assuming that the nation has achieved the stated U.S. EPA goals), about 1,503 billion tons of MSW will be landfilled, and another 95 million tons of ash will also be landfilled. These large numbers tell us now is the time to act to build modern landfills.

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3. Pohland, F. G. "Sanitary Landfill Stabilization with Leachate Recycle Treatment and Residual Treatment." EPA-600/2-75-043. October, 1975.

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5. Pacey. Ibid. p. 103.

TABLE 1

Solid Waste Generation*

	Country	Kilograms/Day	Pounds/Year
1.	U.S.A. (New York City)	1.80	1,445
2.	U.S.A. (New Castle County)**	1.49	1,200
3.	Japan (Tokyo)	1.38	1,108
4.	France (Paris)	1.10	883
5.	Singapore	0.87	699
6.	Pakistan (Lahore)	0.60	482
7.	Philippines (Manila)	0.50	402
8.	Nigeria (Kano)	0.46	369

* Data Extracted from "Mining Urban Wastes: The Potential for Recycling," Table 1, by Cynthia Pollock, World Watch Paper, No. 76.

** Delaware Solid Waste Authority

TABLE 2

Year	Population	Annual MSW Discards	Percent Remaining After Recycling	Remaining MSW	Remaining MSW Combusted	Remaining MSW to Landfill	Annual Ash to Landfill	Cumulative Ash & MSW to Landfill
	Millions	MM Tons	%	MM Tons	MM Tons	MM Tons	MM Tons	MM Tons
1991	251.25	179.64	90.00	161.68	16.17	145.51	4.85	150.36
1992	253.76	194.14	88.50	171.81	19.76	152.06	5.93	157.98
1993	256.30	196.08	87.00	170.59	22.18	148.41	6.65	155.07
1994	258.86	198.04	85.50	169.33	24.55	144.77	7.37	152.14
1995	261.45	200.02	84.00	168.02	26.88	141.14	8.06	149.20
1996	264.07	202.02	82.50	166.67	29.17	137.50	8.75	146.25
1997	266.71	204.04	81.00	165.28	31.40	133.87	9.42	143.29
1998	269.37	206.08	79.50	163.84	33.59	130.25	10.08	140.33
1999	272.07	208.15	78.00	162.35	35.72	126.64	10.72	137.35
2000	274.79	210.23	76.50	160.82	37.79	123.03	11.34	134.37
2001	277.54	212.33	75.00	159.25	39.81	119.44	11.94	131.38
		2,210.77		1,819.64	317.02	1,502.62	95.11	1,597.72

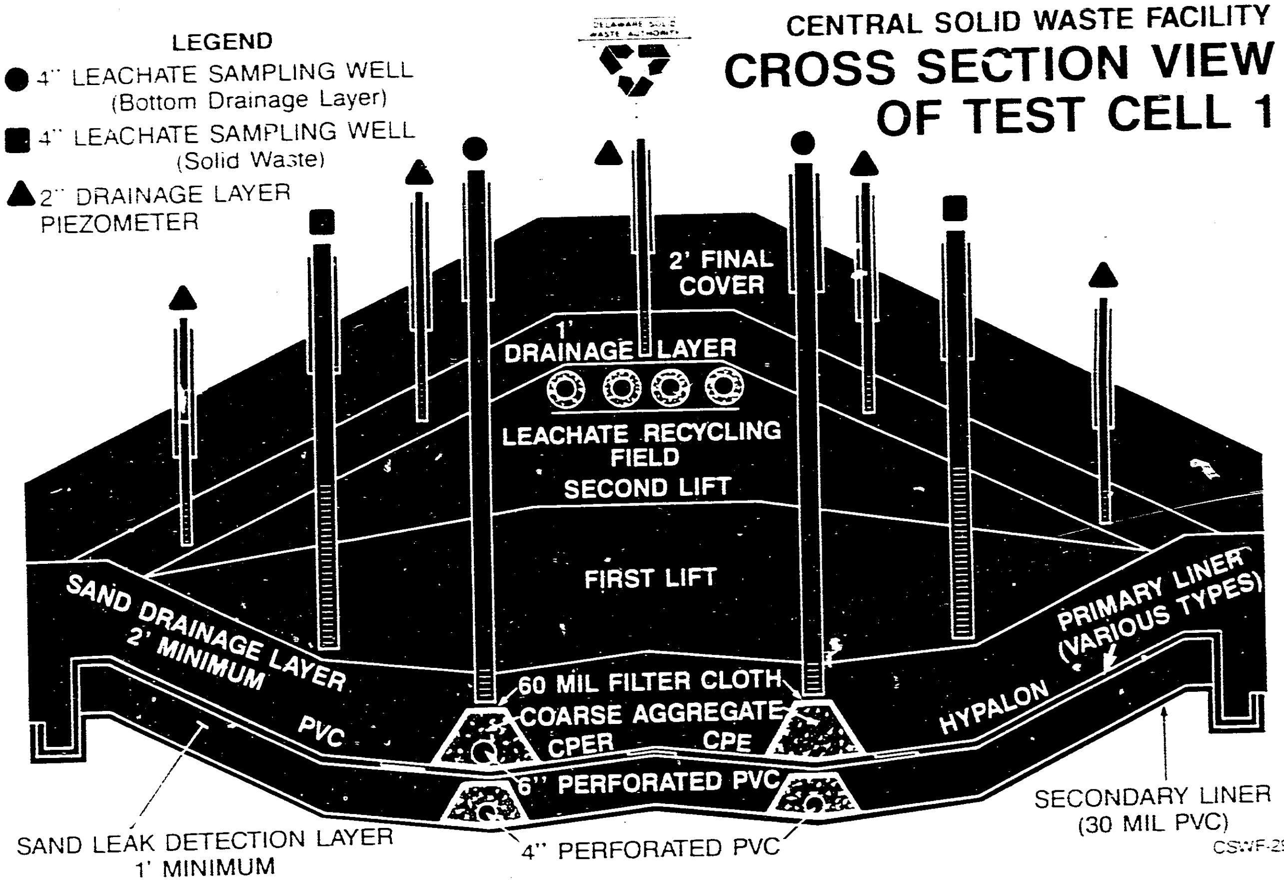
CENTRAL SOLID WASTE FACILITY
CROSS SECTION VIEW
OF TEST CELL 1
LEGEND
4" LEACHATE SAMPLING WELL (Bottom Drainage Layer)
4" LEACHATE SAMPLING WELL (Solid Waste)
2" DRAINAGE LAYER PIEZOMETER
2' FINAL COVER
1' DRAINAGE LAYER
LEACHATE RECYCLING FIELD
SECOND LIFT
FIRST LIFT
SAND DRAINAGE LAYER 2' MINIMUM
PVC
60 MIL FILTER CLOTH
COARSE AGGREGATE
CPER
CPE
HYPALON
PRIMARY LINER (VARIOUS TYPES)
6" PERFORATED PVC
4" PERFORATED PVC
SAND LEAK DETECTION LAYER 1' MINIMUM
SECONDARY LINER (30 MIL PVC)
CSWF-29

Figure 1

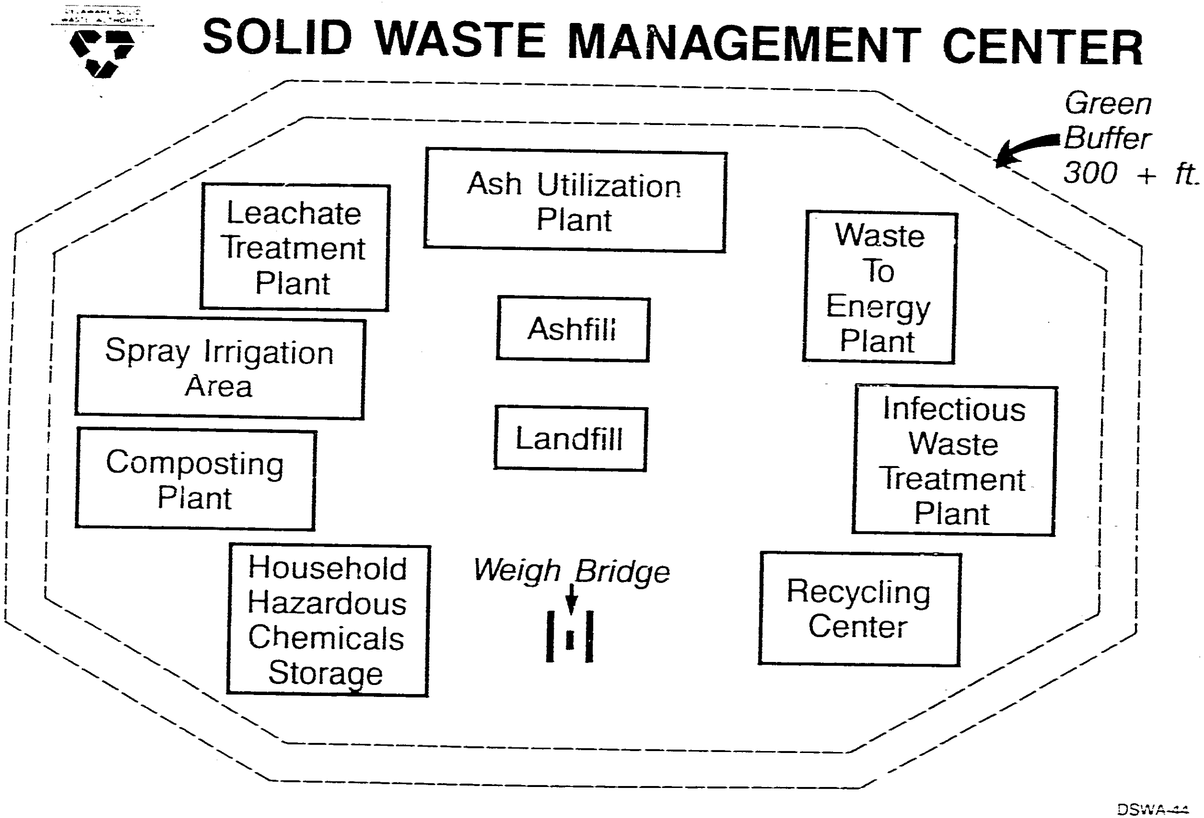
SOLID WASTE MANAGEMENT CENTER
Green Buffer 300 + ft.
Leachate Treatment Plant
Ash Utilization Plant
Waste To Energy Plant
Spray Irrigation Area
Ashfill
Landfill
Infectious Waste Treatment Plant
Composting Plant
Household Hazardous Chemicals Storage
Weigh Bridge
Recycling Center
DSWA-44

Figure 2

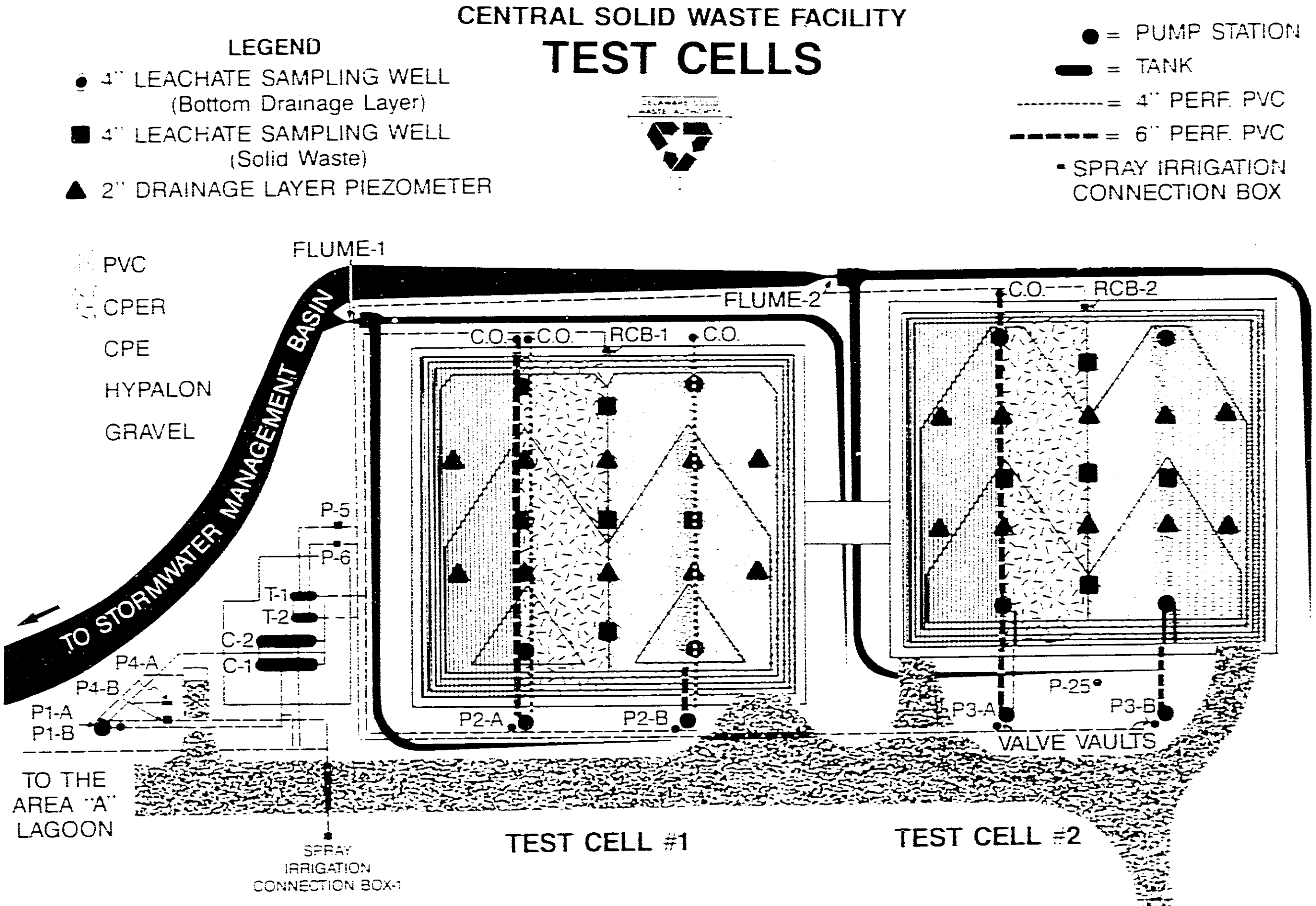
CENTRAL SOLID WASTE FACILITY
TEST CELLS
LEGEND
4" LEACHATE SAMPLING WELL (Bottom Drainage Layer)
4" LEACHATE SAMPLING WELL (Solid Waste)
2" DRAINAGE LAYER PIEZOMETER
PVC
CPER
CPE
HYPALON
GRAVEL
= PUMP STATION
= TANK
= 4" PERF. PVC
= 6" PERF. PVC
SPRAY IRRIGATION CONNECTION BOX
FLUME-1
FLUME-2
TO STORMWATER MANAGEMENT BASIN
C.O.
C.O.
RCB-1
C.O.
C.O.
RCB-2
P-5
P-6
T-1
T-2
C-2
C-1
P4-A
P4-B
P1-A
P1-B
P2-A
P2-B
P3-A
P3-B
P-25
VALVE VAULTS
TO THE AREA "A" LAGOON
SPRAY IRRIGATION CONNECTION BOX-1
TEST CELL #1
TEST CELL #2
CSWF-36

Figure 3

REUSABLE LANDFILL CELL

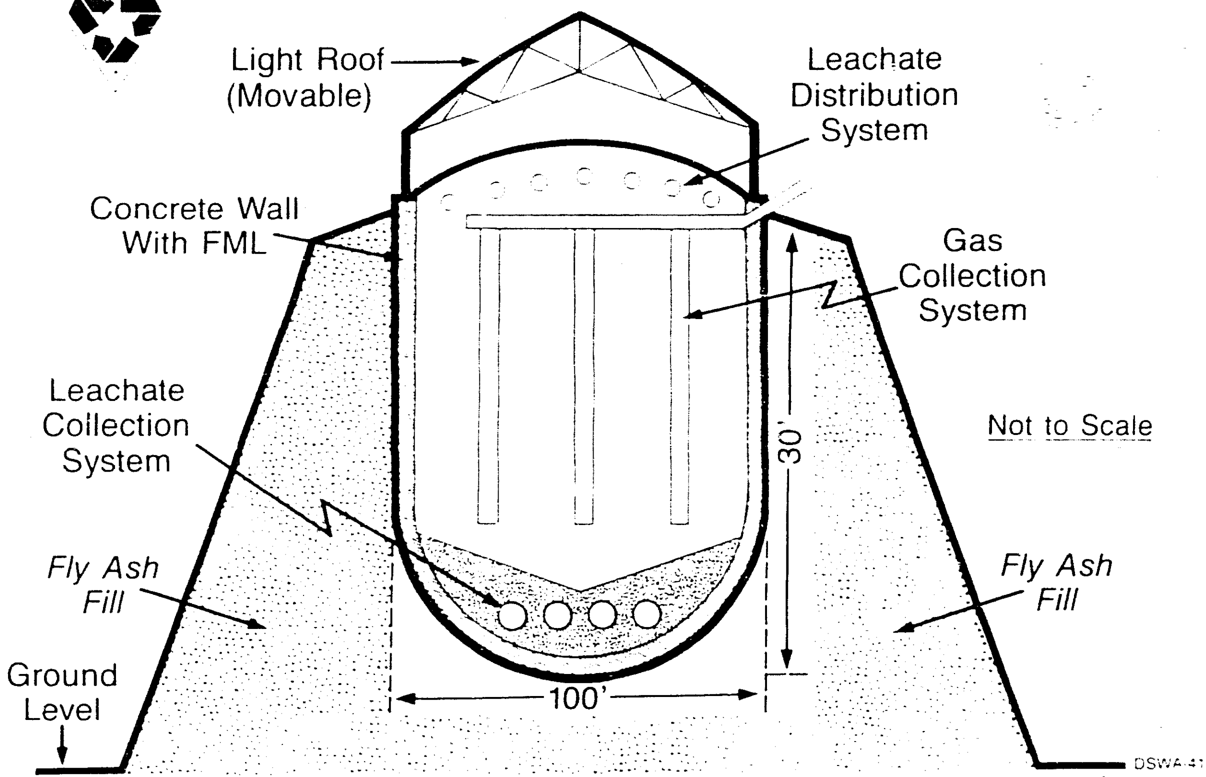

Figure 4

WASTE PREPARATION OPTION
WET TROMMEL

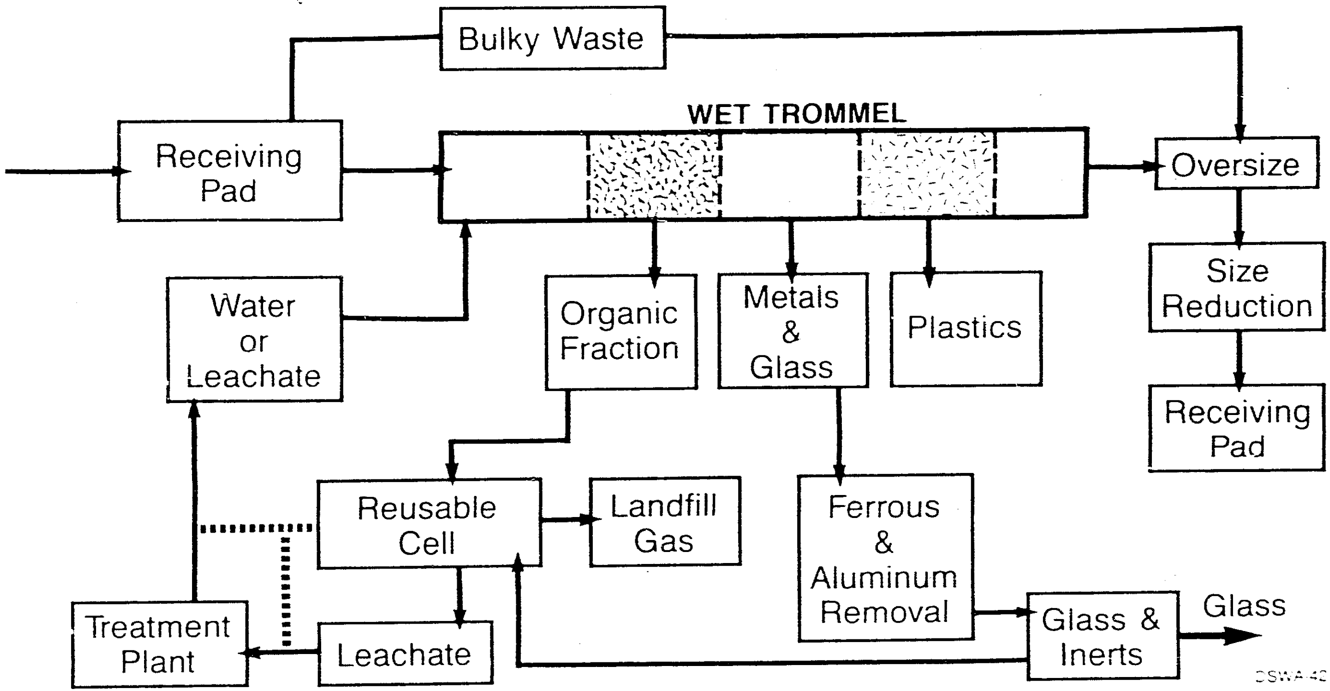

Figure 5

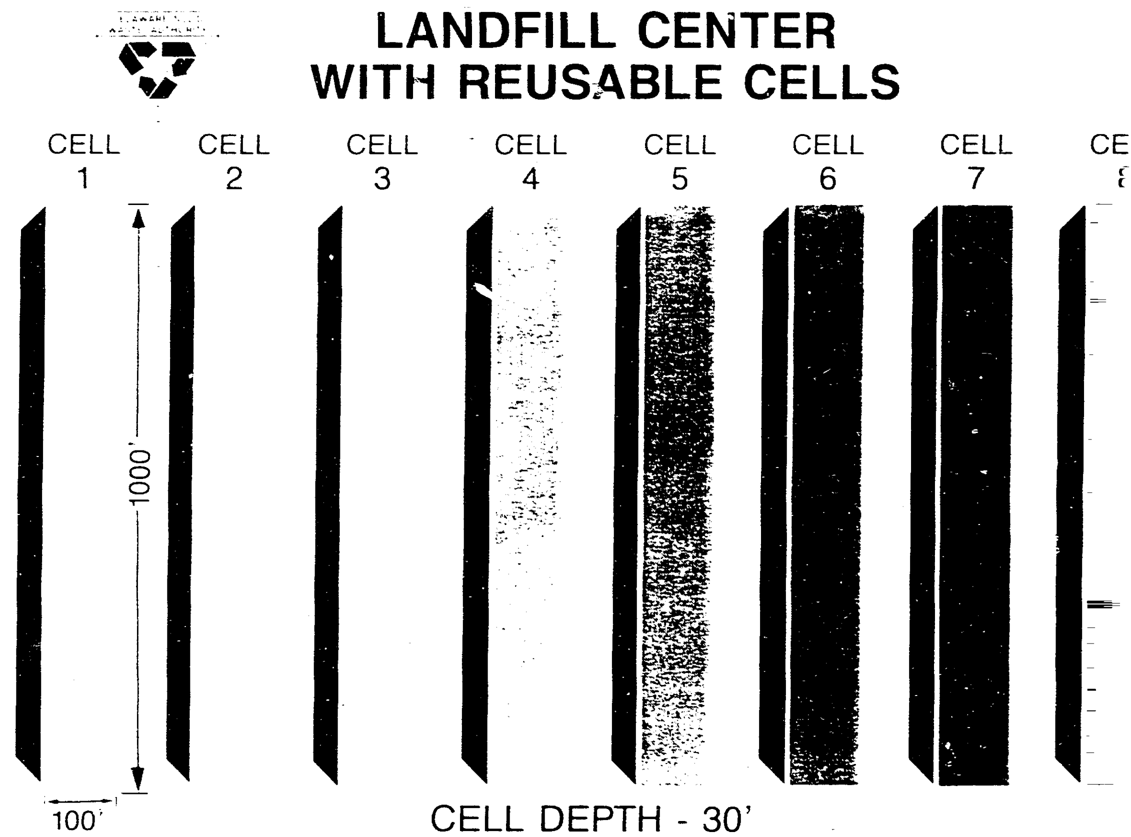
LANDFILL CENTER
WITH REUSABLE CELLS
CELL 1
CELL 2
CELL 3
CELL 4
CELL 5
CELL 6
CELL 7
1000'
100'
CELL DEPTH - 30'

Figure 6

WASTE-TO-ENERGY: STATE OF THE ART

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Rigo & Rigo Associates, Inc.

INTRODUCTION

The state-of-the-art is the latest and most sophisticated or advanced stage of a technology, art or science. Applying this definition to a technology that is made up of many sub-systems and components is not difficult as soon as it is realized that there is no such thing as a completely state-of-the-art facility. Rather, each sub-system has its own characteristics and applicable state-of-the-art.

Waste-to-energy plants are no exception to the above rule. Differences in design philosophy and capacity, regulatory requirements, and owner's risk posture result in the wide range of features currently installed at waste-to-energy facilities throughout the world. Some facilities have state-of-the-art air pollution control equipment and traditional waste receiving systems; others have leading-edge waste processing equipment. As a result, the leading edges of the technology, the state-of-the-art features, are found in different parts of various facilities.

When selecting which state-of-the-art features to apply in a given situation, it is important to recognize that the integrated facility must simultaneously comply with all regulatory requirements, public preferences, and be a prudent business deal. For example, in the early 1970's regulatory compliance consisted of controlling particulate air pollution emissions from large incinerators. As time marched on, additional legislation was passed; regulations were promulgated; and the public's interest in these facilities grew. Waste-to-energy plants began to be treated like any other industrial facility. This included the regulation of NO_X and SO_X emissions through application of the New Source Performance Standards for Industrial Steam Generators to what had traditionally been considered incinerators. Other federal and state regulations require the minimization of water, noise, and land pollution.

Requirements to practically minimize all environmental impacts through formal application of Prevention of Significant Deterioration and formal and informal application of Environmental Impact and Health Risk Assessment methodologies in the permitting process became applicable. Today, pending New Source Performance Standards for Incinerators extend the compliance constraints by requiring that 25 percent of the municipal solid waste generated in a waste-to-energy plant's service area be recycled and by establishing emissions control and monitoring requirements that match the performance of waste-to-energy plants equipped with state-of-the-art emissions control systems.

The balance of this paper reviews the various major systems found in waste-to-energy facilities and identifies what I believe to be state-of-the-art solid waste receiving and storage, processing, steam generation, energy conversion, and environmental protection systems. In some areas such as steam generation and air pollution control, there are several technologies which can be considered state-of-the-art; consequently, I will do my best to identify the alternatives and discuss their pros and cons.

RECEIVING

Solid waste is delivered to waste-to-energy facilities in collection and transfer vehicles. To minimize the potential for adverse environmental consequences due to blowing debris, fugitive dust, and odor emissions, state-of-the-art facilities provide enclosed receiving and unloading facilities. State-of-the-art receiving and unloading facilities are large enough for easy truck maneuvering and are designed with a minimal number of open doors to minimize the potential for fugitive emissions.

When the incinerators are not drawing combustion air from the receiving and processing areas, a back-up ventilation system complete with filters and provision for activated carbon odor control can be supplied to maintain a negative pressure on the receiving and unloading facilities so that fugitive dust and odor emissions are positively contained at all times. This back-up system may be addressing a perceived problem. My experience is that even with the incinerators off-line, it is rare to smell stored solid waste outside the receiving and storage hall, much less at the plant boundary. Nevertheless, a state-of-the-art receiving hall would, at a minimum, be designed to retrofit a negative pressure back-up system in the event that dust and odors prove to be a problem once the facility begins operation.

Another feature of state-of-the-art receiving halls is solid waste discharge onto a tipping floor rather than directly into a pit. This allows spreading the waste with front-end loaders and identification and separation, to the maximum practical extent, of household and inadvertently discharged commercial and industrial hazardous and biomedical waste in the material delivered to the plant. The floor is protected from front-end loader blade wear by an iron aggregate topping.

Floor, rather than direct pit discharge, increases the size of the receiving hall because space is needed to stage the waste before it is spread and placed into storage or taken to processing. The cost of waste handling is increased compared to facilities that use direct pit discharge because front-end loaders and operators are added to the plant staff.

The environmental benefits realized by this state-of-the-art feature have not yet been measured. My experience is that much of the lead acid batteries, oversized and bulky waste, and other materials that should not be processed or burned is separated with this receiving system configuration. The absolute efficiency of such separation is not yet known; therefore, every effort should be made to keep unacceptable and hazardous materials from being delivered to the plant. This way, tipping floor inspection and separation provides quality assurance rather a primary means of environmental protection.

Tipping floor separated hazardous materials are placed into a securely fenced, roofed, and dyked holding area until the material can be properly disposed. The holding area is purposely kept small (about 10 feet by 10 feet) so that separated hazardous waste time at the plant is minimized.

STORAGE

State-of-the-art facilities store solid waste in bunkers. If the bunker is deep, i.e., pit storage, it is equipped with at least two overhead bridge cranes and grapples. The bridge cranes are equipped with high cycle duty motors and brakes. They are designed for a dusty environment and will continue to operate when the building sprinkler system is activated so that burning material can be fed into boilers to effectively fight pit fires.

The crane controls are located in an air-conditioned pod that can be reached without personnel passing through dusty areas. The pod is reinforced and otherwise protected from grapple impacts. It is positioned to provide as unobstructed a view of the pit as possible. Closed-circuit television systems are usually provided so the operators can see the location of the grapples when feeding hoppers to ensure uniform feeding across the furnace or processing system.

If the bunker is shallow, i.e., tipping floor storage, waste is managed using air-conditioned front-end loaders in the reinforced, concrete-walled bunker. The walls extend one to two feet above the maximum stacking height that can be achieved by the selected front-end loaders--usually 12 to 14 feet. Like the tipping hall, the floor of the bunker is protected with iron aggregate topping. The walls may need to be protected by steel embedments or surface plates in some areas depending upon the operating practices employed.

State-of-the-art front-end loaders used in tipping halls and floor storage bunkers are hardened just as if they are to be used at a landfill. At a minimum, oversized swing-out washable radiators, solid rubber rock tires, and hardened hydraulics are provided.

PROCESSING

The ultimate purpose of front-end processing determines the type of system to be employed. There are several competing commercial systems, and identifying one as superior to the others is impossible.

One state-of-the-art approach that processes up to 100 tons per hour of solid waste opens bags and packages in a flail mill, separates tin cans with a magnet, and uses screens to separate "fine" material (predominantly wet organics, dirt, small batteries, etc.) from "middlings," waste that is already suitably sized to burn, from "overs," waste constituents that need further size reduction to meet furnace requirements. This type of processing system was developed to reliably produce refuse derived fuel (RDF) for use in spreader-stoker and other semi-suspension fired and fluidized bed boilers. The recovered cans are recyclable after secondary processing to separate loose paper. The fine material can be composted; but based on the characteristics of whole waste stream compost, the finished product will probably not be suitable for food chain applications. Glass is shattered in this process and not economically recoverable using available technology. Plastics and aluminum are recoverable if the screens are properly sized to create concentrates and hand picking or eddy-current (aluminum) separation occurs before the recoverables become too dirtied in the processing.

A second state-of-the-art approach that processes 25 to 30 tons per hour of solid waste introduces the mixed solid waste stream into a rotating drum where tumbling the waste onto blades causes the bags to open. Then, magnetics are removed by a series of flat magnets. Finally, the fines, including the glass which has been shattered, are separated by a bar screen. The stream leaving the rotating drum passes over an eddy-current, detection-based sorter which uses air pulses to blow an aluminum-rich concentrate out of the main stream. This concentrate is cleaned-up in a second eddy-current based aluminum concentrator and hand sorted into aluminum beverage can and foil streams to enhance market value. The remainder of the main stream passes by picking stations where cardboard, plastic containers, and film plastics are hand separated. The main stream residual is a clean incinerator fuel and only needs size reduction to become RDF. The separated fines are similar to the fines leaving the first process; the same market restrictions apply.

A third state-of-the-art processing approach (usually designed to handle ten to 25 tons per hour of solid waste, but can be designed to process up to 75 tons per hours) is frequently found in materials recovery facilities (MRF"s) designed to process curbside collected waste. Here, bags are opened in a low-energy bag breaker, and screens are used to create a middlings stream which concentrates the recyclable containers from the oversized material and the fines. The oversized material can be picked to recover corrugated, newsprint, plastic films, and large ferrous and non-ferrous items. The middlings are passed under a magnet to recover tin cans and then introduced into an air classifier that acts like the biblical winnowing device to separate "lites" from "heavies." The "lites" are hand picked to recover aluminum cans and plastic bottles from the contaminating small pieces of paper, yard waste, etc. which inherently follow the marketable containers. The "heavies" are hand picked to recover unbroken and large pieces of glass and heavy pieces of ferrous and non-ferrous metals from the contaminating garbage, yard waste, plastic toys, etc. The middlings and overs residuals can be combined and used in an incinerator or as RDF feed stock. The fines are generally similar to those generated by the first two alternatives, but they contain less shattered glass. End-use restrictions probably also apply to the compost made from this material.

The specific performance of a state-of-the-art processing system depends on the selected equipment arrangement and the composition of the waste. As a rough guide, practical systems recover 80 to 90 percent of the ferrous metals, 60 to 80 percent of the aluminum, 50 to 75 percent of the glass, and up to half of the recyclable paper and plastic in the feed stock. Higher recoveries are theoretically possible. However, the cost of increasingly expensive and less effective equipment, additional people (the concept of diminishing returns), and reduced marketability of the recovered products (due to increased contamination) need to be carefully considered before committing to higher recovery rates. Of course, if a MRF is processing only commingled recyclables, virtually complete recovery of marketable materials is possible.

Regardless of the approach selected, front-end processing is a state-of-the-art feature in a waste-to-energy plant. From a public policy perspective, such separation is worthwhile because recycling is encouraged; raw resources are conserved; and energy savings are realized (it usually takes less energy to make a new end product out of recycled feed stock than it does out of raw materials).

From an environmental perspective, front-end processing is intuitively good because it reduces heavy metal emissions by separating many metal bearing items prior to combustion. When a plant equipped with a medium efficiency electrostatic precipitator was tested using processed and unprocessed solid waste, there was a statistically significant reduction in the emission of trace heavy metals and some criteria pollutants. However, available data from plants equipped with state-of-the-art air pollution control equipment indicates that any changes in trace emissions achieved by processing are within the experimental error. That is, we cannot prove that a measurable reduction in emissions is really taking place even though such reductions appear to be intuitively obvious.

STEAM GENERATION

The heart of a waste-to-energy plant is the steam generator. Here the solid waste is incinerated with the liberated heat recovered in a working fluid-like steam. The recovered heat can then be used to generate electricity or provide heat to district heating systems and industrial processes.

The type of steam generator used is, to a large extent, a designer's decision and is constrained by plant economics, capacity, and regulatory and reliability requirements. It is economically feasible and prudent to do different things in large plants than it is in small. For example, 50 ton-per-day, shop assembled, refractory wall, modular incinerators are frequently the economic choice for a 200 ton-per-day installation, because four 50 ton-per-day, shop-assembled incinerators would provide a level of operating flexibility and reliability that could not be achieved by a single, field-erected incinerator. If a 2,000 ton-per-day installation is contemplated, however, using forty 50 ton-per-day incinerators is not state-of-the-art. A state-of-the-art, waste-to-energy plant uses two to four steam generators to provide an economic balance between construction, operating, and maintenance costs.

State-of-the-art steam generators may burn processed or raw solid waste on a grate, in semi-suspension or in a fluidized bed. The steam generator is designed with a gas-tight enclosure, has automatic controls for the rate and points of introduction for underfire and overfire air, and protects the portions of the furnace subjected to erosion and alternating furnace atmospheres with silicon carbide refractories and high chrome metals. The furnace shape is designed to ensure that the gases generated on the grate are thoroughly mixed with air and burned to practical completion as they pass through the throat. This usually means that the furnace is aerodynamically modeled and the overfire air system designed to ensure more than full-throat penetration of the mixing jets. The physical shape and combustion control features are designed to minimize incomplete combustion and the emission of carbon monoxide and trace organic contaminants.

Boiler outlet oxygen concentration signals are used to trim the amount of excess air to ensure that the furnace temperatures are as hot as possible and the flame is centered in the throat so it does not touch a wall and become quenched. By properly controlling the amount and location of air in the furnace, temperatures are maximized and trace organic formation discouraged by driving the combustion reactions practically close to equilibrium.

The furnace chamber and boiler convection passes are designed to minimize fouling and wastage, i.e., metal loss due to erosion and corrosion. Superheaters are used to elevate the steam temperature above the boiling point, and state-of-the-art superheaters are either made out of exotic metals or are shielded from direct radiant heat transfer from the fire. Economizer and boiler tube banks are used to first bring water close to the boiling point and then to actually boil the water to make a steam-water mixture which is separated; the steam going to the superheater and the water returned to the boiler. State-of-the-art economizer and boiler tubes are arranged in a wide-spaced, in-line pattern to minimize fouling and facilitate cleaning. Because of the ash characteristics, furnace walls and tubes are cleaned using rappers rather than the more conventional soot blowers.

State-of-the-art solid waste feeders provide positive control of waste introduction into the furnace and air infiltration. State-of-the-art ash handling systems are designed so that everything that can be fed into the furnace can leave. That is, the ash extraction system is designed to pass anything that can enter the incinerator through the feeder. Ram extractors which extrude the ash out of a water bath are state-of-the-art for unprocessed, waste-fired systems. There may be too little coarse material in RDF ash for a ram extractor to properly work so wet drag chain conveyors are state-of-the-art for this type of installation.

Individual state-of-the-art, waste-to-energy plant steam generators range in size from 25 to 50 tons-per-day modular units equipped with waste heat boilers, to 1,000+ tons-per-day wall furnaces with integral steam generators.

ENERGY CONVERSION

Waste-to-energy facilities are essentially steam-electric power plants, vintage 1950 to 1960. Waste-to-energy plant steam conditions are generally limited to 800 psig and 825°F by the nature of the combustion products and entrained ash. Higher steam conditions have been used when the market has demanded and should not be ruled out in special circumstances. Lower steam conditions should also be used when prudent or recommended by specific furnace manufacturers based on their experience.

The amount of electricity generated is determined by the steam cycle and is readily done using well-known engineering thermodynamics principles and procedures. Small waste-to-energy plants use simple steam cycles without extraction (taking some out of a turbine before the exhaust to use it to heat boiler feed water--if done properly, extractions increase the amount of electricity generated from the fuel burned). Larger waste-to-energy plants economically use three or four extractions and stages of feed water heating.

Determining how much electricity will remain to be sold after accounting for all in-plant uses is a function of what those in-plant uses are. State-of-the-art, waste-to-energy plants typically consume 80 to 100 kWh/ton of waste burned and sell more than 500 kWh/ton.

ENVIRONMENTAL PROTECTION

A state-of-the-art, waste-to-energy plant is designed to comply with all applicable laws and regulations. Today, this means that the steam generator is equipped with acid gas and fine particulate controls. In some locations, NO_x control is also applied. Process waste water emissions are minimized by using either high-cycle cooling towers or air-cooled condensers and recycling and reusing as much process water as possible, with the acid gas control system being the ultimate sink for process waste water, rather than the sewer. A state-of-the-art plant includes provision for the future beneficiation of ash and its conversion into a usable product.

AIR POLLUTION CONTROL

The state-of-the-art air pollution control equipment for small waste-to-energy plants is injection of a powdered acid gas control reagent followed by a bag house. For large waste-to-energy plants, the state-of-the-art in the United States is a spray drier (dry scrubber) where a dissolved acid gas control reagent is atomized and mixed with the flue gas followed by a bag house.

In state-of-the-art, waste-to-energy plants, the acid gas scrubbing reagent is introduced into the flue gas stream along with or following humidification to reduce the gas temperature to about 285°F. Acid gases are removed from the balance of the flue gas by absorption and adsorption followed by neutralization of the SO_x, HCl, and HF. In addition to control achieved during the initial contact, more removal is achieved in the bag house, as the acid gases in the flue gas contact the unreacted reagent present in the bag house filter cake. The filter cake provides a grace period of about a half hour, during which repairs can be made to the acid gas control system before emissions become essentially uncontrolled.

The acid gas reagent of preference for a spray drier equipped plant is usually on-site, slaked pebble lime. Dry injection facilities use either powdered hydrated lime or a naturally occurring sodium-based reagent like Trona or Nacolite. Typical acid gas removal design points are 80 to 90 percent SO_x and 90 to 95 percent HCl removal. Field experience indicates that better control is achievable.

Trace element control can be enhanced through the use of additives. For example, field trials indicate that sodium sulfide can be mixed with the water used in acid gas control systems to control 60 to 80 percent of the vapor phase mercury which would otherwise be emitted.

One of the acid gas control reaction products, calcium chloride, is very hydroscopic so that special care has to be exercised when sealing the bag house to prevent air leaks. Insulating and heat tracing to prevent sufficient wall heat loss to encourage water adsorption is necessary to avoid ash hardening.

There is an open question concerning the relative environmental performance of reverse air and pulse jet bag houses. While either are, in my opinion, state-of-the-art today, evidence is mounting that a significant portion of the trace hazardous emissions control is achieved by adsorption in the bag house. If this hypothesis proves to be the case, reverse air bag houses with their inherently thicker dust cake may be the future equipment of choice. Unfortunately, reverse air bag houses are designed with an air-to-cloth ratio less than two with one module off-line for cleaning and another off for repair. Pulse jet bag houses are typically designed with an air-to-cloth ratio less than ten. As a result, a reverse air bag house equipped system is about five times bigger than a pulse jet system, so pulse jets are more prevalent.

Limited data indicates that the removal efficiency for polar organic molecules like dioxins and furans are between 80 and 95 percent. Extensive testing at state-of-the-art, waste-to-energy plants indicates that most trace emissions are below detection limits unless sampling times are extended from the conventional two to three hours to more than eight hours.

In Europe, some large state-of-the-art, waste-to-energy plants are equipped with a low-efficiency, electrostatic precipitator; followed by the cooling side of a quartz tube, tubular heat exchanger; two stage, counter-current bubble cap or packed bed wet scrubber; wet electrostatic precipitator for mist elimination; and finally the reheat side of the tubular heat exchanger to control acid gases and particulates. While this equipment alignment is effective for acid gases and heavy metals which can be caused to condense, test data indicates that trace hazardous organics like dioxins and furans which have high octal-water partition coefficients are not controlled nearly as well as they are in dry scrubber/bag house equipped facilities. The scrubbing reagent can be doped, however, to control some otherwise emitted substances like vapor phase mercury, so the potential exists for this type of control system to be technically competitive with a dry scrubber/bag house after further development. Consequently, while a dry scrubber followed by a bag house represents the state-of-the-art in air pollution control for waste-to-energy facilities, the European approach may prove to be equally effective.

State-of-the-art in Oxides of Nitrogen (NO_x) control for waste-to-energy plants is specific non-catalytic reduction (SNCR). Competitive systems using either ammonia or urea alone or in combination with proprietary enhancers, "slip-killers," and hydrogen are commercially available.

The patented Exxon Termal deNO_x process is in commercial use at three Southern California waste-to-energy plants. While each of these facilities has a different NO_x emissions control design point, the most aggressively controlled is achieving emissions less that 125 PPM_{dv} @ 7 percent O_2, eight-hour average. This represents a nominal 50 to 75 percent reduction in NO_x emissions. There is a penalty associated with this level of NO_x control. Some of the ammonia does not react with the NO_x and is emitted in the flue gas as "ammonia slip." At the slip levels currently being achieved, sufficient ammonium chloride vapor can form by reactions between the slip and the 10 to 15 ppm HCl exiting a dry scrubber operated with high acid gas reagent stoichiometry that when the plum cools below 140°F (about four stack diameters down plume), the ammonium chloride vapor condenses as an aerosol fume and a visible, persistent, white-blue plume forms. Depending upon visibility and ambient air quality considerations, state-of-the-art air pollution control for waste-to-energy facilities may or may not include SNCR at a particular plant.

EMISSIONS MONITORING AND TESTING

A state-of-the-art, waste-to-energy plant has an extensive continuous emissions monitoring system installed in the stack. This system is used to demonstrate permit condition and regulatory compliance, control the acid gas and NO_x emissions control systems, and to help with troubleshooting. Continuous emissions monitors are available, and may be required to be applied by pending legislative action for NO_x, SO_x, CO, Opacity and HCl. Diluent monitors (O_2 and CO_2) are also needed to correct the emissions to standard conditions for comparison to standards.

The accuracy of extractive SO_x monitors may be compromised when SNCR systems are installed. Trace amounts of ammonium sulfate formed by ammonia slip combining with the small amount of SO_2 leaving the acid gas control equipment plates out in the sampling lines and adsorbs or desorbs SO_x as the concentration changes in the controlled gas stream. The result is that the federal CEMS relative accuracy and drift requirements cannot be reliably met. Final modifications to an extractive SO_X monitor to meet the federal monitor drift and relative accuracy requirements are under development.

Because of the public and regulatory interest in waste-to-energy plants, a state-of-the-art facility is designed to facilitate compliance and research testing. This means that there are more test ports and easier access than required by federal and state regulations. Permanent electrical, water, hoists, and platforms are provided.

The state-of-the-art facility is typically tested for permit compliance and trace emissions shortly after start-up and again a year later. Pending federal regulation indicates that testing will be done annually for the first three years and triennially thereafter if the continuous emissions monitors indicate that the facility has been operating within its permitted limits.

ASH MANAGEMENT

A state-of-the-art, waste-to-energy plant without front-end processing is designed to separate ferrous and large inert materials from the ash residue prior to disposal. The facility is designed for routine ash sampling so that compliance with RCRA hazardous waste trigger levels (lead and cadmium toxicity is of principal concern) can be routinely demonstrated.

Even though state-of-the-art, waste-to-energy plant ash tests non-hazardous, given pending federal legislation, a state-of-the-art, waste-to-energy plant sends its ash to a double or triple lined ash monofill equipped with leachate monitoring and collection systems. Alternatively, the state-of-the-art plant treats the ash by the addition of about 15 percent portland cement, and possibly, proprietary silicate reagents. Portland cement-treated ash has been shown to be non-hazardous using tests that are more aggressive than the federal Extraction Procedure Toxicity Test (EP-TOX; now replaced by the Toxic Concentration Leaching Procedure--TCLP). In addition, prototype vitrification of incinerator ash is underway so that the state-of-the-art in ash treatment may soon advance if the recovery of marketable metals, glassification of the balance, reliability materials of construction, and economics are proven.

WATER POLLUTION CONTROL

State-of-the-art, waste-to-energy plants generate waste water from sanitary facilities and industrial processes. Sanitary waste management is well known and usually accomplished by discharging to the sanitary sewer.

Industrial waste waters are generated as a result of treating boiler feed water, once-through bearing cooling, cooling tower blow-down, and plant housekeeping. In a state-of-the-art, waste-to-energy plant, these flows are minimized, and the remaining water recycled. Typically, high cycles of concentration cooling towers or air-cooled condensers are employed. Process waste water is accumulated on site, treated and reused to minimize the use of imported or potable water. Cooling tower blow-down and surplus process waste water is cold lime softened and used in the acid gas control system. Zero process waste water discharge characterizes a state-of-the-art, waste-to-energy plant; a sewer is only needed for sanitary waste management.

Storm water management at a waste-to-energy plant can be problematic. Despite best efforts, some ash may be tracked about the site and can be washed into the storm water system. A state-of-the-art, waste-to-energy plant design recognizes this potential problem and provides a holding basin for storm water so that any ash can be settled out. As a side benefit, the storm water holding basin supernatent is usually suitable cooling tower make-up. Thus, there can be operating cost savings associated with preventing any possibility of ash-laden water being discharged from the plant site; the value of this savings depends on the cost of water.

SUMMARY

A waste-to-energy plant that meets the state-of-the-art in all areas would receive waste in an enclosed area that is always kept under negative pressure to control fugitive emissions, provide for waste inspection prior to processing or storage, process the waste to remove recyclables and undesirables, have a modern steam generator equipped with at least a dry scrubber and bag house combination and possibly a SNCR NO_x reduction system, generate electricity using an economically optimal 800 psig/836°F steam cycle, recover metals, treat the ash to make it usable, collect and reuse storm water on site, and "zero discharge" the industrial waste water streams.

Of course, not all good, modern plants will match this interpretation of the state-of-the-art in some areas. If they did, the state-of-the-art would never advance, and there would be no further need for papers like this one!

V. CASE STUDIES IN SITING

INDUSTRIAL EXPERIENCE IN SITING

Mary Ryan, Director
Community Relations, Midwest Region
Waste Management of North America

INTRODUCTION

The date is in the future--January first of the year 2000. The place can be New York City, Los Angeles, Philadelphia, or Chicago. The situation is bleak. Residents in these cities have no place to dispose of their garbage--it *continues* to pile up at alleys, curbs, parklands, and vacant lots. Residents are *outraged*. No immediate solution is at hand. There is a tremendous amount of hand-wringing and finger pointing, but one fact is not refutable--the garbage in these locales is in search of a home. There is simply no place for it to go! Far-fetched, you say? Think again!

More than a third of the nation's landfills will be full within the next decade. New York will exhaust its capacity in eight years, Los Angeles in five, Philadelphia is out of capacity now, and Chicago will have filled its landfills to brimming by 1995. This does not paint a pretty picture, but it is, in fact, an all too real, accurate one!

The problem of solid waste or garbage disposal in the country today is not that the industry does not know how to solve it.

NOT IN MY BACKYARD

The essence of the problem with waste disposal today has to do with the American publics' perceptions, values, priorities and most significantly, their willingness to negotiate competing tradeoffs in life. We are afraid to confront ourselves in the mirror and admit, "Yes, I want garbage to be disposed of safely"; "Yes, I think recycling is a good idea"; "No, I don't want the landfill, the transfer station, or the incinerator in my community"; and "No, I can't be too personally inconvenienced by having to rinse bottles, or buy separate yard waste and recycling bags." "But," you might say, "most Americans are already doing their part." I was somewhat disheartened by the August 1990 Roper poll. Although it acknowledged that Americans generally are more environmentally conscious today than 20 years ago, only 22 percent of those surveyed said they were doing their part to improve the environment by, for example, recycling. We still have a long public education road to travel.

A 1988 survey conducted by the National Solid Wastes Management Association found that Americans are radically inconsistent when they talk about the country's garbage disposal problem. These inconsistencies, and the dread public officials face in speaking frankly to their constituents about the tough decisions that we must face relative to our garbage, are only too familiar across the country. We are doing ourselves a grave injustice by postponing these tough decisions.

Our company's daily activities find us facing one of the most important environmental challenges facing the country today, i. e., how do we safely dispose of the increasing volumes of garbage generated by Americans annually? Between 1960 and 1986 the amount of garbage Americans tossed away grew 80 percent from 87 million tons to 160 million tons. By the year 2000, this figure is expected to increase another 22 percent.

The problem our industry faces, very succinctly is this: Everyone wants their garbage picked up like clockwork, but they do not want it to cost too much. Most important of all, nobody wants the garbage put down anywhere near where he or she lives. This is the loathsome not-in-my-backyard syndrome or NIMBY.

The "not-in-my-backyard" attitude is unrealistic considering that each one of us produces an average of five to six pounds of garbage each and every day.

However, we are all abhorred by our own waste. Think about it. If you mistakenly throw something in your own garbage, you first want to convince yourself that you did not throw it away. Well, if you decide you did throw it away, you very gingerly begin to pick through your garbage can like a skilled surgeon trying to retrieve the hopefully not-too-soiled item. The point is, we cannot tolerate our own garbage.

Yet, the fact remains that it has to go somewhere. It has been argued that we can recycle waste and reduce waste at the source to such an extent that our need for disposal facilities will disappear. But this is simply untrue. The

Environmental Protection Agency estimates that by the year 2000, 55 percent of municipal wastes will still have to be landfilled. Down from 77.5 percent now, it still means finding a place for an estimated 107 million tons of waste. And keep in mind, ten years ago landfill disposal averaged $5 to $10 a ton. Today, fees of $50 a ton are common, and $150 a ton on the East Coast is not unknown.

Some suggest that it is in the interest of waste management companies not to recycle--the theory being the more garbage we have to handle, the more money we make.

I would respond that this argument is a smoke screen which tries to disguise the real truth. Americans will not be able to recycle everything. Even if we achieved a recycling goal of 50 percent nationwide, 50 percent of our garbage still has to go to those magical places called "AWAY"--transfer stations, incinerators, landfills, and compost facilities. This is a reality many people would rather not face. Can't garbage just disappear? It is time that we face the cruel, hard fact that the garbage we drop at the curbs or alleys each week is not picked up by Peter Pan and taken to Never, Never Land.

We produce it; we are equally responsible for finding solutions for its disposal.

I would ask you, how can people *not* assume responsibility for their own waste? Why do Americans resist siting new disposal facilities? Why have local, state, and federal officials not responded to the evolution of the NIMBY crisis situation?

A recent report on the NIMBY phenomena from the Robert Wood Johnson Foundation, a Harvard Medical School affiliate, revealed that more than one in ten people interviewed said that their neighborhood has opposed some type of facility (not restricted solely to disposal facilities) within the past five years. Half of those who said there was opposition indicated that the opposition was successful in stopping the proposed facility.

I believe the reason for this reaction to not site new disposal facilities is because it is harder to collectively arrive at solutions when all of us, as waste producers, share a little bit of the blame for causing or contributing to the problem. Each one of us believes that our "minimal contribution" could not possibly be materially significant in the big scheme of things. It is easy for the public to rally around tighter air pollution controls on those horrible "polluting factories." Ask those same Americans how anxious they are to have driving restrictions placed on them personally, so as to improve a region's air quality. Once again, it's a question of tradeoffs (as long as I am not too personally or directly inconvenienced).

ADDRESSING PUBLIC CONCERNS

How then do we attempt to first convince the public of the need for new disposal facilities, and second, to convince the public that they will be responsibly operated?

Today every facet of Waste Management's business is dependent upon good public, community and media relations skills. Our company's ability to site or expand new landfills, incinerators, transfer stations, recycling centers, etc. is directly dependent upon our ability to accurately assess community issues and concerns relative to our business and to our company--and to straightforwardly address them.

I can tell you that our industry is probably one of the most "loved to be hated" industries in the country. This fact, notwithstanding the success of companies like Waste Management, is dependent upon our ability to step back from the pursuit of our business plans, and to assess our plans from the community's point of view, thereby, "Putting Ourselves In Their Shoes."

Public opposition to the business pursuits of the waste industry occurs frequently. I am convinced that our industry is second probably only to the nuclear power industry in these four regards:

- The public scrutiny we face;
- The public outrage we face;
- The regulatory requirements with which we must comply; and
- The media and political interest in our business.

Like it or not, by the very nature of our business, Waste Management is a very high-profile company. The very nature of our business--dealing with garbage--bears a stigma.

For Waste Management, opposition comes with the territory. Everyone needs us; few want us when it comes to developing a disposal site.

Undoubtedly, though, the most critical issue facing local politicians over the next few years will be solid waste--or garbage--disposal. You will hear about the:

- Landfilling of garbage;
- Incinerating of garbage;

- Baling of garbage;
- Recycling of garbage;
- Reusing of garbage;
- Transporting of garbage; and
- Monitoring of garbage.

Fortunately, awareness of this issue is on the rise. In the recent Roper poll, the general population believed improving the environment (including solid waste disposal) ranks fourth on the list of national priorities, after solving the problem of crime and drugs, finding a cure for AIDS, and containing health care costs.

But despite increased concern and recognition of the problem, few Americans seem inclined to support additional disposal facilities.

- 65 percent of the general population is opposed to building new landfills in their community. This is uniform throughout the country.

Thus, effective siting efforts become essential if our nation is to have safe, reliable disposal facilities. Waste Management is no stranger to the siting arena. I was asked to address what works in the siting process and what does not. Before I do so, I would like to share with you some insights as to why we face opposition in the siting of new facilities.

Local communities resist new landfill facilities or the expansion of existing facilities for a number of reasons. The benefits of sound, proper waste disposal practices accrue to all of us as members of the general public. Neighbors surrounding a facility, however, feel that they alone bear the social costs associated with proximity to the facility. To the community involved, the generalized benefit of safely disposed waste does not balance or mitigate the social costs borne by them.

Public resistance to disposal sites exists for a variety of other reasons, as well, and I have heard all of these expressed at one time or another. Here is what I hear most frequently: lack of knowledge about waste facilities (what they are and what they do); distrust of government decisions; fear of increases in noise, truck traffic and odor; perceptions about aesthetics; potential effect on land value; and the belief that the facilities may do harm to human health and the environment. These fears may not be based upon the community's own experiences, but rather upon published accounts of past incidents in other locations. Suffice to say, it is now a rare community today that will welcome a waste facility of any kind.

It is within this context that Waste Management attempts to manage society's wastes in the most environmentally responsible manner. Sounds reasonable--sounds easy--not so.

We have to help the public understand that a waste facility, be it a landfill, a resource recovery plant, a transfer station or a recycling center, is a needed service, just like schools, hospitals, mental institutions, sewage treatment plants, airports, shelters for the homeless, etc. Our lifestyle in America makes it necessary for every community to have access to environmentally-sound waste disposal facilities.

I often ask people, do you ever wonder:

- What happened to those contaminated Tylenol capsules; or

- What happens to pharmaceuticals on which the shelf life has expired; or

- What happens to products which have a manufacturing defect; or

- What happens to medical wastes?

I will bet most of us do not even give it a thought. If we did, we would have to believe (for our own peace of mind) that these materials have been properly disposed in such fashion as to never pose a threat to an innocent person's health or safety. Without realizing it, we have deduced that these materials must have gone to a licensed disposal facility.

Waste disposal is not something to be taken lightly or to be handled by non-reputable, unsophisticated, technically non-progressive companies. People have the legitimate right to ask that a company such as ours inform them of the nature of our operations. It is our responsibility to take the time with community people such that they can come to develop a level of trust and comfort with us. However, unlike any other company, we are always in the position of defending our very right to do business. We must constantly remind people that we are not the generators of waste products, rather we are a service company disposing of their waste. We always seem to have a difficult time getting people to understand and accept this fact. Too many community people view the garbage going into our facilities as Waste Management's garbage.

I cannot stand here and tell you that I have the tried-and-true rules of the road for successful siting. I don't. You can have the best developed and honestly executed plan, and still not site a new facility or expand an existing facility. But, I can provide some insight as to what each siting effort should entail.

One reason we face hostile opposition is a perception by citizens that they have no control over many of the important decisions affecting their lives. And perception, especially in this business, *is* the only reality. People want to have some degree of control over their own destiny. So our goal is to strive to make sure that communities feel they have had input on permit decisions, expansion issues, etc., even if they are not pleased with what will be the end result.

Thus, I cannot overemphasize the importance of developing and implementing a good community relations or outreach program in siting waste facilities.

The basic objectives should be:

1) To increase credibility and foster understanding of the company in the communities in which you operate.

2) To increase company involvement in the communities around the new or existing facility.

3) To build credibility with the media and the regulatory community.

We know that it is in our best interest to have a proactive community relations program because community issues do have a profound effect on the way in which we will be allowed to continue to do business. Throughout the siting or expansion process, it is vital to:

1) Communicate with the public in an understandable way--not in a belittling way; not in an overly complex technical way--but in an understandable way. We strive not to talk about ppb; or TSD's; or RCRA; or Subtitle D; or leachate. We talk in terms that mean something to the audience. In our successful siting efforts, we have focused on the need for the facility and have stressed how the facility will enhance the environment.

2) Maintain an open-door policy. As axiomatic as this may sound, the most effective technique we can use in telling our story is, in fact, to invite people in to see the type of operations we run. We do not lose sight of the fact that people will "suspect" what they cannot see or what they suspect is being kept secret. We invite them in to see our place and to show them our future design plans. We try to take away the mystery that surrounds what we do.

3) Keep information flowing to the community. We make sure it is ongoing. We try to act instead of react. We seize every opportunity to get our story (new site expansion, price increases, new facility) to the community first. We do not give the community reason to say we were trying to sneak something in, that we refused to tell them about impending plans, that we had such little

regard for the community that they had to hear news about us from the media. We strive to be "disarmingly" available, open, and honest in good times and bad. We do not fool ourselves into thinking the community will never find out we are trying to expand. We count on the fact that they do know. We never underestimate the community.

4) Realize that siting is a tough, arduous process. It means continuous involvement and interaction between the company and the various community publics. It means being responsive to community fears. Through the process we need to continuously disseminate information about what we are doing. We have to be responsive to the inquiries and, yes, fears of the community.

   Average citizens cannot make effective decisions on complex public policy matters unless they are provided with accurate, understandable and meaningful information.

5) Strive to be credible on a consistent basis.

6) Be respectful to community people and to the media. Their support can be critical.

7) Work to garner the earned support of local elected officials.

8) Work to develop a network of allies in those communities in which you have a business presence.

9) And *always* tell the truth. In dealing with waste disposal facilities, the public has a thirst for 100 percent certainty that we will never make a mistake. People are absolute experts on what frightens and upsets them. Community people place waste operators in the same category as airline pilots, air traffic controllers, and doctors--no mistakes are allowed. Yet we have to be completely honest in saying that we strive to make sure that mistakes are not made, but can we give a 100 percent guarantee that we will never make mistakes--No. Be up-front about this fact.

Another important base to cover in the siting process, without doubt, is the media. According to a survey conducted for the Minnesota Waste Management Board a few years ago, a majority of print and broadcast reporters in Minnesota, in response to a survey, admitted they will feature conflict and confrontation in covering waste issues and problems, rather than causes and solutions. The fact is, a protest makes more "news" than does a quiet explanation. Opposition to the siting of an incinerator was the theme last year on one of the episodes of the television show,"Thirty Something," profiling siting opposition as a "yuppie" issue.

The press is a tremendously powerful force in today's communication society. If you doubt that bad press can seriously wound a company, consider what happened to Exxon following the Valdez oil spill last year.

Truly, media relations can become critical, especially when a given situation has potential for conflict, as often becomes the case during the siting process. You need to work closely with the media in exploring the need for disposal facilities, explaining the environmental safeguards in place, and disseminating your response to community concerns. You have to be up-front and honest with all the "publics" who could have a vested interest in your siting plans. But in all candor, you may nonetheless have to move forward in the face of some pretty rugged opposition. This is the scenario with which I am most familiar. My advice is to be available, be honest, be respectful, be empathetic, and if you are successful or not, be gracious. I consistently stress two points, be it relative to new facilities or expansions, the need for the facility and its positive environmental impact.

CASE STUDIES

There is no formula or cookie-cutter approach to siting--the dynamics of each community is very different. In recent years in Chicago, we have successfully secured our Part B (or final operating permit) for our CID Landfill, and last year we successfully secured a permit to add a stabilization plant at the site. Obviously, there was opposition to both, but I believe that we conducted ourselves professionally and ethically and were able to clearly demonstrate need and our ability to meet all permit conditions. I state, honestly, that about 100 people were nonetheless displeased with the decision.

A recent success that I would like to share with you is the siting and development of the Douglas County Landfill in Nebraska. In just seven months, a team of Waste Management people successfully sited and permitted a new landfill to serve the residents of the Omaha area. The existing landfill had less than one year of remaining capacity and so the need was imminent.

The project started in November 1988 when Douglas County officials announced that bids on a new landfill would be accepted. No sooner was Waste Management awarded the bid when a "Halt the Landfill" campaign was launched by the Area Coalition of Residents for Environmental Safety (ACRES).

Waste Management addressed each of the concerns raised by ACRES and worked to balance the various pieces of literature which surfaced from groups opposed to the landfill. The investment paid off as county officials held firm in their commitment to move ahead on the landfill's development and the local news media presented balanced stories. The negative publicity from the opposition resulted in minimal attention and coverage.

The opposition nonetheless persisted, and in March 1989, the group hired a lawyer to file a lawsuit to stop the development. Waste Management worked closely with the County and representatives of ACRES to settle the lawsuit. Again, our efforts paid off as the suit was settled with Waste Management agreeing to concessions requested by the community opponents. We agreed, among other things, to build a grass-covered, earthen berm to shield the landfill and to install a security fence.

With many issues resolved, Waste Management was able to break ground for the new facility on July 1, 1989--again, just seven months from our bid approval.

The key ingredients contributing to the success of this siting project included:

- We had selected a good environmentally/geologically sound location.
- We designed the site to be a state-of-the-art facility with complete environmental protection systems.
- We had a consistent message regarding the development of the landfill.
- We maintained the integrity of our "front-line" people so that their messages were never suspect.
- The "need" for a facility was readily acknowledged by the County Commissioners. The advertising we developed focused on "need."
- We devoted a full-time effort to the project. We met, talked with and answered questions of the Commissioners and residents. We attempted to allay fears and helped the people develop a level of comfort with the caliber of operation Waste Management would run.
- We developed an awareness and education program. Our themes became "a cost-effective solution to an urgent problem"; the role that a well-run, well-managed sanitary landfill would play in maintaining the quality of life in Douglas County; and Waste Management as the quality choice.

On September 1, 1989, the landfill to serve Omaha residents was opened. Since that time, our original opponents have actually publicly stated (upon completion of our first year) that they are extremely pleased with our operation. We are very proud of this facility.

In conclusion, I offer the following. It is a fact of life that people are increasingly looking for reasons to keep our type of activities as far away from their communities as possible. NIMBY's, many industry analysts say, have become a new force in American business life that could push the country toward unprecedented economic paralysis. In the abstract, most studies show Americans want growth. They just do not want it near them. Americans do not want the airports, sewage treatment plants, major recreational centers, prisons, hospitals, public housing, homeless shelters, etc. too close to them. These facilities universally belong "on the other side of town." Why? Because these locally unacceptable land uses or "lulus" force us to confront issues which, for most of us, fall outside of our traditional comfort zone. These issues are someone else's issues. Should we pile all of these undesirables in one backyard?

WHAT DO I SEE IN THE FUTURE?

1) It is my opinion the principal responsibility for the siting of future disposal facilities will be given to regional or state bodies. Politically, it is unrealistic to expect local officials to vote in favor of disposal facilities.

2) The American public will become more NIMBY'ish on a host of development issues.

3) Garbage costs will go up as supply diminishes, demand rises, and new facilities are severely restricted. It is dishonest to continue to approve moratoriums on the development of new facilities or the expansion of existing facilities. To do so is to say to the public, there is no need for disposal facilities. This ultimately and unnecessarily drives up costs, because as supply decreases, cost increases.

4) We will see a trend toward the regionalization of disposal facilities, as an individual community may not be able to singularly support its own facility, given the costs of developing environmentally sound facilities.

5) Border wars will intensify, with each state saying, "I may take care of my own garbage--but not someone else's."

6) An "arrogance of garbage" will emerge among the more affluent communities --wanting to "give their intrinsically better garbage" away--like a gift--to anxiously or not so anxiously, awaiting communities.

7) Community representatives will become full partners at the table in terms of working out "host community benefits" which will accompany new disposal facilities.

8) There is going to be a radical reordering within states and among states as to "garbage partnerships."

9) The waste industry will not develop that magic black box that makes garbage disappear into thin air.

Truly, garbage is an issue in need of cooperation--cooperation between local units of government in a state; cooperation between states; cooperation among local units of government, private industry and local residents.

Morally and ethically we all have a responsibility to leave the world a better place--and that includes doing our part to responsibly handle our garbage.

The garbage Waste Management handles is not Waste Management's garbage--it is garbage which belongs to all of us. I believe that our company demonstrates everyday that if it is good for the environment, it is good for business.

Clearly, as an industry our challenge is to demonstrate that solutions to address the disposal problem are available. We need to do a better job educating the public to this reality.

In my opinion if the NIMBY syndrome continues, it will result in a paralysis--effectively prohibiting or denying certain segments of the country with cost effective, environmentally responsible solid waste disposal. NIMBY effectively allows a handful of people to halt projects which would serve the many. We need to hear and address the concerns expressed, but at some point if there is no confluence of opinion, the needs of the many must be addressed. NIMBY threatens one of our most fundamental rights--the right to environmental democracy. We all are entitled to have access to cost-effective, environmentally responsible waste disposal. Public attention should not continue to focus on controversies over siting; attention should focus on how to best implement integrated solid waste management systems. Our survival as a society is dependent upon good solutions.

THE MICHIGAN SITING EXPERIENCE

William R. Allen, Manager
Waste-to-Energy Operations
Kent County Public Works
State of Michigan

INTRODUCTION

There are two key factors to keep in mind for anyone desiring to site a waste-to-energy (WTE) or other type of solid waste facility within the State of Michigan. These two factors are:

1) The Michigan Solid Waste Management Act, P.A. 641 of 1978.

2) Local "Site Specific" considerations.

Attempting to site a facility without equally taking into account both of these issues will doom any effort to sure failure.

The balance of this paper will discuss both of these factors within the context of a successful siting effort by Kent County for its Waste-to-Energy Facility.

PROJECT TIME-LINE/FACILITY DESCRIPTION

In 1982, the Resource Recovery Project for Kent and Ottawa Counties proposed the construction of a refuse-to-energy facility which would have the capability of burning up to 530 tons of solid waste per day. The project envisioned a plant located on a site near downtown Grand Rapids, generating steam only and serving an energy market consisting of the Consumers Power Company District

Heating and Cooling System. Initial studies of overall project economics looked promising, and a Site Selection Report was written in September 1982 which identified five potential sites for location of the facility near the downtown area.

Further work on selecting a site was deferred while staff concentrated on preparing the County's Act 641 Solid Waste Management Plan and refining the technical, economic, market, environmental and legal issues surrounding the facility. The proposed WTE Facility and the five sites identified in late 1982 were included as part of the 641 Plan. In August 1984, the facility description was updated to specify a cogeneration plant with an initial design capacity of 625 TPD (tons per day) capable of processing an average of 194,000 TPY (tons per year). The plant would also incorporate the ability to transfer waste since its initial sizing would be less than the available waste stream. The redefined project was presented to the Kent County Board of Commissioners for their review and approval. In October 1984, the Commissioners approved the concept of the WTE Facility and authorized the expenditure of $509,000 of local funds to enable a final determination to be made on whether or not to proceed with construction of the project. Included in this authorization was funding to identify preferred sites for the facility, conduct the associated environmental review and to secure the selected site by obtaining property purchase options. In February 1985, a Revised Site Report was issued that reviewed and updated the September 1982 Site Report in light of the project refinements. The 1985 Report identified the two most potentially suitable sites for further detailed analysis. In late 1985, a comparison of the two final sites was conducted and a final selection made. The county's site selection received the full support of the City of Grand Rapids and was not opposed by the adjacent residential neighborhood.

THE MICHIGAN SOLID WASTE MANAGEMENT ACT

The Kent County Board of Commissioners, in compliance with P.A. 641, 1978, the Michigan Solid Waste Management Act, Act 641, designated the Kent County Board of Public Works (KCBPW) to be the solid waste planning agency for the County. Acting through the Kent County Department of Public Works (KCDPW), the Board of Public Works entered into a contract with the Michigan Department of Natural Resources to prepare the County's Act 641 Solid Waste Management Plan.

Section 25 (1) of Act 641 states:

> "Each solid waste management plan shall include an enforceable program and process to assure that the non-hazardous solid waste generated or to be generated in the planning area for a 20-year period is collected and recovered, processed, or disposed of at

facilities which comply with state law and rules promulgated by the department (MDNR) governing location, design, and operation of the facilities."

And, Section 25 (2) of Act 641 states:

"The initial plan shall be prepared for a 20-year period and shall be reviewed and updated every five years."

In March 1985, the initial plan was approved, and in March 1990, the five-year update was completed. The Updated Plan replaced the county's currently approved plan on October 3, 1990, following the necessary state and local approvals and was deemed the Kent County Act 641 Solid Waste Management Plan. The planning period covered by the Updated Plan is January 1989 through December 2009.

Section 30 (4) of Act 641 states that following approval by the director of a county solid waste management plan and after July 1, 1981, an ordinance, law, rule, regulation, policy or practice of a municipality, county, or governmental authority created by statute, which prohibits or regulates the location or development of a solid waste disposal area, and which is not part of or not consistent with the approved solid waste management plan for the county, shall be in conflict with this act and shall not be enforceable.

The Act 641 Plan is intended by the state to be a solid waste regulatory and enforcement mechanism, providing each county with the authority to plan for and oversee solid waste management within its boundaries. As stated above, the Act required that the general plans for the WTE Facility and specific sites under consideration for its location had to be included in the initial and updated plan. Once a 641 Plan has received the necessary local and state approvals, it has the force of law and a local government cannot zone out or prohibit the construction of an "approved" solid waste facility located within its borders.

LOCAL CONSIDERATIONS

From the discussion above, it is obvious that the 641 planning process can be a very big club in the siting process. However, from a practical point of view, it is a club that you never really want to use. While it is theoretically possible to force an unwanted facility down an unwilling municipality's throat using Act 641, the project will live with the consequences for the next 20 years or more. A siting process that involves and, if possible, co-opts the host community is to be preferred. The balance of this paper will be spent in describing the process Kent County used in recognizing and responding to local concerns during the site selection process. In Michigan, it is enough that the perspective host community recognize that an approved Act 641 Plan may be invoked should siting efforts reach an impasse.

POTENTIAL CONCERNS

The process started with a formal request from Kent County to have key City of Grand Rapids staff assigned to work with project staff and consultants on the site selection process. Using guidelines and background information provided by U.S. Environmental Protection Agency (USEPA), a list of potential concerns that would have to be addressed was developed. The list included such "common sense" items as: traffic generation, access to area freeways and the capacity of local road networks; various environmental issues pertaining to air quality and the management of waste and ash on site; and negative preconceptions about the possibility of living, working, doing business or developing other projects near such a facility, the classic "Not In My Backyard" (NIMBY). It became clear that any discussion of siting a facility would also have to include commitments from the county on how these concerns would be recognized and addressed in the design of the plant, if necessary.

PRELIMINARY SCREENING

Using data provided by USEPA and consultants, a preliminary site search was conducted with city help using the following minimum requirements: a location within one and one-half miles of the downtown steam distribution system and a minimum site size of seven acres. A total of 11 possible locations were identified (Figure 1). Figures appear at end of paper.

PRIMARY CRITERIA

The 11 sites were next evaluated according to the following primary criteria developed by project consultants and staff and City of Grand Rapids staff:

1) Market Proximity

Based on delivering low quality (saturated) steam to the Grand Rapids District Heating/Cooling Loop, there is both a technical and economical consideration. Technically, the resource recovery facility could be as far away as one and one-half miles from the point of delivery. The energy loss associated with such a remote location would be approximately $296,000 per year for steam valued at $6.22 per 1,000 lbs. The annual energy loss for a plant located only 1,700 feet from the point of delivery would be approximately $48,000 with the same steam value. Capital costs for an underground steam distribution line in 1984 were on the order of $510 per lineal foot installed, or $4,039,200 for a one and one-half mile long system. The projected capital cost of 61.6 million dollars (1984 dollars) for the plant includes $1,345,000 for a steam distribution line of approximately one-half mile in length. Sites were rated as follows:

From 1.25 Miles to 1.5 Miles to Loop	3
From 1 Mile to 1.25 Miles to Loop	9
From .75 Mile to 1 Mile to Loop	15
From .5 Mile to .75 Mile to Loop	21
From .25 Mile to .5 Mile to Loop	27
Less than .25 Mile to Loop	33

2) Compatible with Adjacent Uses

Because of the function and character of the project, there can be a negative effect on the adjacent uses. The degree of that negative effect depends on several factors (proximity, density, existing buffering, etc.). Sites were rated as follows:

Very Incompatible	0
Incompatible	1
Compatible	5
Very Compatible	7

The rating system ranges from sites which are near or adjacent to residential areas with little or no buffering (very incompatible), to sites within heavy industrial areas (very compatible).

3) Traffic Impact on Residential

The project may result in considerable truck traffic on adjacent streets. Sites were rated as to possible traffic impact on residential areas as follows:

Very Likely	0
Likely	1
Unlikely	5
Very Unlikely	7

4) Compliance with the Master Plan

Compliance with City Master Plan recommendations for land use is an important means of avoiding future conflicts and problems. Sites were rated with respect to such compliance as follows:

Conflicts	0
Somewhat Conflicts	1
Neutral	3
Somewhat Conforms	5
Conforms	7

5) Site Development Costs

Sites were evaluated for potential demolition and site preparation required in the following manner:

Very Extensive	0
Extensive	1
Moderate	3
Minor	5
Very Little	7

6) Zoning

For ease of implementation, only sites with an "I-2 Heavy Industrial" Classification received a "5." Sites which are zoned to other classifications received a "0." The Zoning Code for this classification states the following as a permitted use in an "I-2" district:

> "Processing of junk, waste, discarded or salvaged materials, machinery or equipment, including automobile wrecking or dismantling, provided such use is conducted within a completely enclosed building or a solid fence or wall not less than six feet high, provided that nothing shall be piled higher than the fence or wall."

7) Relocation

Sites which are vacant, and therefore do not require relocation of residents other uses, received a "5." Lightly occupied sites received a "3." Heavily occupied sites received a "0."

8) Traffic Impact on Sensitive Non-Residential Areas

The project at any location could channel considerable traffic through sensitive non-residential areas. Such non-residential areas, due to density and/or character, could be harmed by that traffic. Sites which would have little or no effect on traffic in sensitive non-residential areas were given a "5" rating. Sites with the potential to have a small effect were rated "3" and sites with potential for moderate effect were rated "0."

9) Adequate Street System

Streets that serve the project and which can meet the need, in terms of present traffic load, ease of access and physical condition, received a "3" rating. Street improvements required, or more difficult access, yielded a rating of "0."

10) Availability of Utilities

Sites which appear to have adequate utility services received a "3" rating. Sites requiring some upgrading in utilities received a "0" rating.

11) Other Uses Planned for this Site

Sites for which there are no known development or redevelopment plans received a "5" rating. Sites which are under planning review for other potential uses received a "3" rating. Sites for which other uses have been designated were rated "0."

12) Possible Catalyst for Other Development

When this project on a given site might result in development or redevelopment of other areas, the site received a "5" rating, some potential was rated "3" and no potential "0."

13) Distance to Nearest Residential Housing Area

Since the preliminary siting report was issued in 1982, increasing concern developed that a buffer zone be established to physically isolate the most potentially objectionable portions of the facility from sensitive residential areas. The following ratings were given based on the probable situation of the facility's stack and tipping floor in relationship to the nearest housing area.

Probable Distance From Tipping Floor and Stack to Nearest Residential Area	Rating
Equal to or less than 300 feet	0
From 300 feet to 500 feet	4
From 500 feet to 600 feet	8
From 600 feet to 800 feet	12
From 800 feet to 900 feet	16
From 900 feet to 1,000 feet	20
Equal to or greater than 1,000 feet	24

SITE RANKING

Utilizing the 13 primary site evaluation criteria, the following matrix ranking of sites was prepared:

Site Comparison

Criteria Number	Rating by Site										
	P	Z	N	X	L	V	J	T	H	R	Y
1	21	15	33	21	15	21	9	27	9	9	3
2	1	1	1	1	1	5	0	0	7	1	7
3	5	5	7	5	1	5	0	5	7	1	7
4	1	0	3	1	5	5	3	0	7	3	7
5	7	1	0	0	5	0	3	0	1	0	3
6	0	0	0	0	5	0	5	0	5	0	5
7	5	0	0	3	3	0	5	0	5	0	3
8	3	3	0	3	3	3	5	0	5	3	5
9	3	0	3	3	0	0	3	0	0	3	0
10	3	3	3	3	3	3	3	3	3	3	3
11	0	5	5	3	5	5	5	5	3	5	5
12	3	0	5	3	5	0	3	0	5	0	5
13	12	12	24	12	12	12	24	0	12	4	24
Totals	64	45	84	58	63	59	68	40	69	32	77

PRELIMINARY RECOMMENDATIONS

Based upon the preceding analysis, sites "N" and "Y" were ranked highest as possible locations (Figure 2) for the refuse-to-energy facility. These two sites were rated at 84 and 77 points respectively. The next highest-ranked site, trailed sites "N" and "Y" by a considerable margin with a total of 68 points.

While sites "N" and "Y" present a contrast in some respects, they also share a common attribute of being able to position the facility stack and tipping floor so that they are isolated 1,000 feet or more from the nearest residential housing area (Criteria No. 13).

It was the recommendation of 1985 Siting Report that sites "N" and "Y" be ranked as the two best potential locations for the proposed mass burn refuse-to-energy facility.

This report received considerable media attention and public meetings were held by the project to present and explain the report's conclusions. Each site was next subjected to further detailed analysis. A generic air quality modeling analysis was conducted for each site to see if one site was more "permittable" than the other. A detailed traffic study was conducted by the City Traffic Engineer of the road network surrounding each site. Site specific acquisition, relocation and demolition costs were developed. Steam line construction and energy loss factors were quantified along with any other possible advantage or disadvantage associated with either site. Finally, a tour of operating facilities was organized by the project in May 1985 to document whether or not these plants can truly be good neighbors. Independent representatives from the media, the West Michigan Environmental Action Council, and representatives of the two neighborhood organizations adjacent to the sites took the tour in addition to the usual group of staff, consultants and politicians. This tour or "junket" as *The Grand Rapids Press* termed it, represented the single greatest risk the project development team took during the entire investigatory process. It turned out to be an unqualified success. Everyone seemed to be very impressed with the facilities we saw. The public saw that the site selection process was truly open to addressing their concerns and the project received strong editorial support from the area print and electronic media.

THE DECISION

A final recommendation in favor of Site "Y" covering 12.71 acres at the southwest corner of Market and Freeman Avenues was made by the county project team in September 1989. The Kent County Board of Public Works and Board of Commissioners approved the recommendation. The property was purchased on

November 12, 1985. There was no formal opposition to the site by any group. Ground was broken for construction on October 2, 1987, and the WTE Facility went into full commercial operation on January 31, 1990.

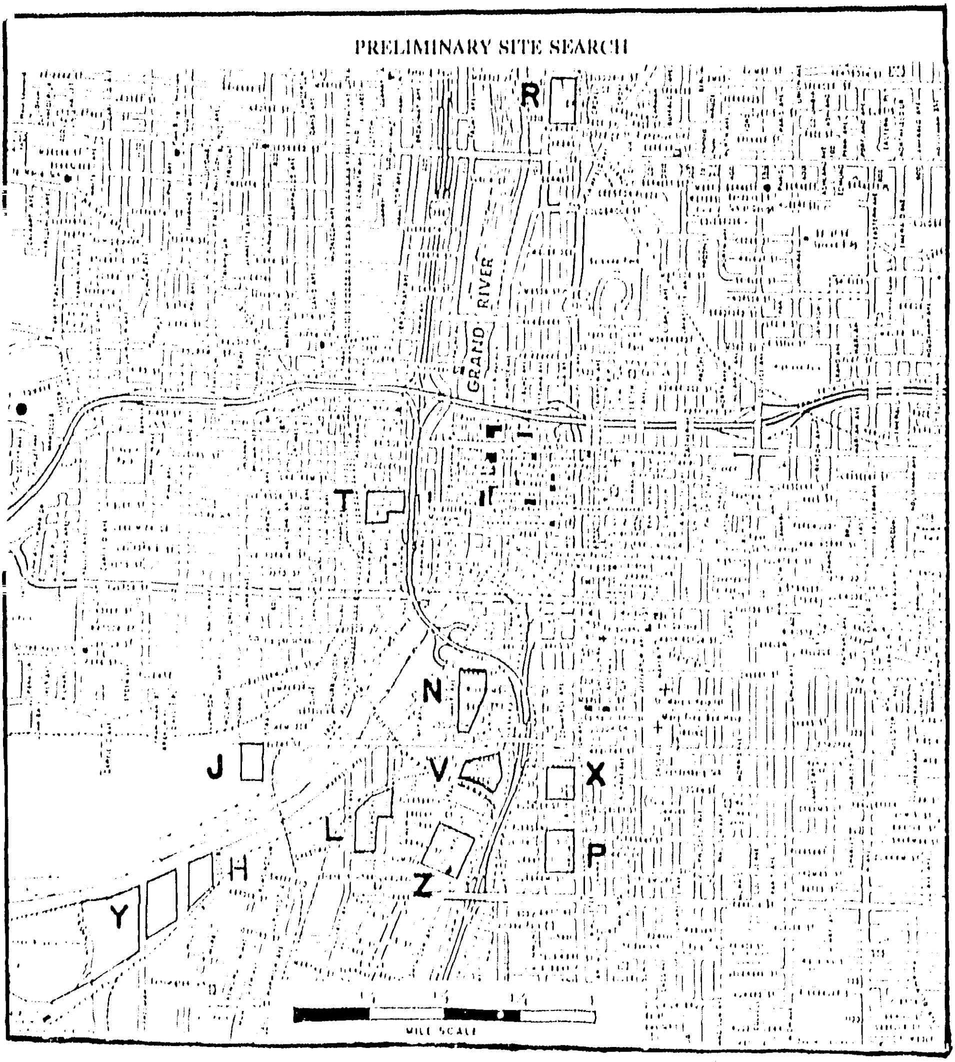

PRELIMINARY SITE SEARCH
R
GRAND RIVER
T
N
J
V
X
L
P
H
Y
Z
MILE SCALE

Figure 1

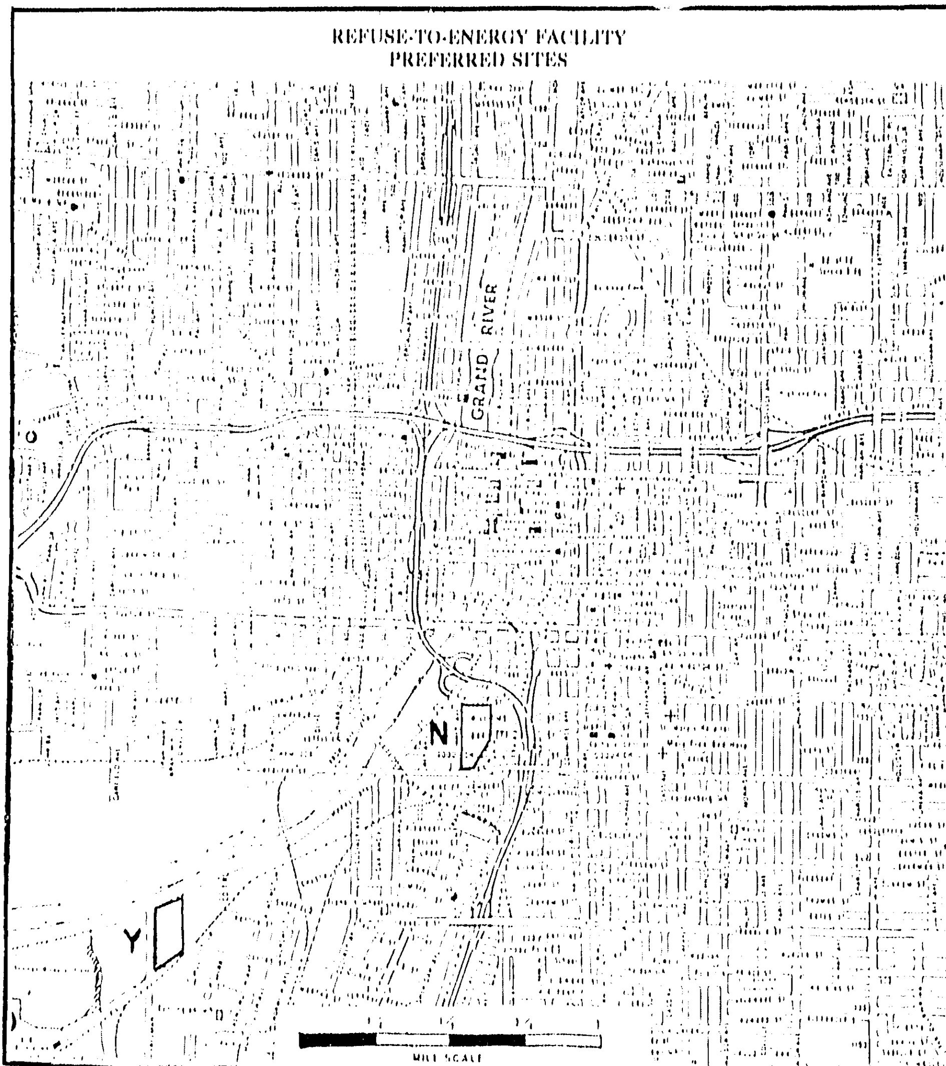

REFUSE-TO-ENERGY FACILITY
PREFERRED SITES
GRAND RIVER
N
Y
MILE SCALE

Figure 2

CHAMPAIGN ILLINOIS LANDFILL EXPERIENCE

James Pendowski, Manager
Intergovernmental Solid
Waste Disposal Association

INTRODUCTION

Champaign County is located in East Central Illinois, approximately 130 miles south of Chicago. The estimated 1985 county population of 168,800 is concentrated in the Cities of Champaign (population 60,357) and Urbana (population 34,205) and the Village of Rantoul (population 20,101). The county is the home of the University of Illinois and Chanute Air Force Base. Although agricultural land use dominates the 1,000 square mile area of the county, the economy is dominated by the government and service sectors with a small industrial component.

The Intergovernmental Solid Waste Disposal Association (ISWDA) was created by the "Agreement and General Plan for Development of Solid Waste Disposal Facilities and Programs and Creation of the Intergovernmental Solid Waste Disposal Association" in July of 1986. It is an intergovernmental agreement between the Cities of Champaign and Urbana and Campaign County. The Association is governed by a nine-member board made up of members of the city councils and the county board appointed by their respective governing bodies. The ISWDA Board elects its own officers, maintains an independent staff and offices, and prepares and executes its own operating budget with the concurrence of its member governments.

The ISWDA is organized as a "Municipal Joint Action Agency" and is delegated the powers enumerated in Chapter 127, Section 743.2 et seq., Illinois Revised Statutes. These powers include the power to sue and be sued, acquire property, incur debt and to contract with public and private entities. The Association is charged with developing and implementing a long-range solid waste management plan including a new regional landfill as well as solid waste processing facilities.

CURRENT SOLID WASTE MANAGEMENT SYSTEM

Currently, there is one permitted, functioning, municipal landfill in Champaign County operated by the Village of Rantoul. However, by ordinance it is allowed only to receive waste from the Village of Rantoul and immediately adjacent areas, including Chanute Air Force Base. The only regionally (county-wide) accessible facility, operated by the City of Urbana, closed on November 19, 1988. The majority of municipal waste formerly received at the Urbana landfill is now going to either Danville (H&L Landfill No. 3) located in Vermilion County or to Charleston (Environmental Reclamation Center Landfill) located in Coles County. These two facilities are located 35 miles and 50 miles respectively (one-way) from the center of generation in Champaign-Urbana. There are no permitted transfer facilities or construction/demolition disposal sites operating in the county.

Residential refuse collection for Champaign County is provided for by individual subscription with any of the approximately 20 companies engaged in the solid waste collection business. There is no municipal franchising of collection with the exception of the issuing of licenses. Refuse collection for commercial, institutional, and industrial accounts is provided in a similar fashion to residential collection services. The estimated generated volume of municipal solid waste (inclusive of industrial and construction/demolition wastes and treatment plant sludges in 1988 was approximately 197,000 tons).

Recycling programs in Champaign County are accomplished through the combined efforts of the public and private sector. Both the Cities of Champaign and Urbana, as well as Champaign County, have established nationally recognized curbside and drop-off programs. Urbana's curbside program, called U-Cycle, is a municipally provided recycling collection service, the first municipal program in Illinois. The City of Champaign's curbside program, called Receecycle, is provided for by a private hauler under contract to the city. Champaign County's drop-off recycling program, the Hometown Program, is provided for through a contract with the Community Recycling Center. In addition, both Urbana and the City of Champaign actively support yard waste diversion programs within their jurisdictions. The Community Recycling Center, a not-for-profit group, is also supported by operating and capital equipment subsidies from the cities and county.

Public and non-profit recycling efforts accounted for an estimated residential and commercial recycling tonnage (including yard waste diversion) of 14,300 tons in 1988. The private sector recycled an estimated 45,700 tons of residential, commercial, industrial, construction/demolition, and treatment sludge. The overall recycling rate for Champaign County is estimated at about 30 percent of the estimated generation rate.

SITING ACTIVITIES

The Association had planned to develop a 5,000,000 cubic yard landfill facility to dispose of the county's municipal and construction/demolition waste streams. The candidate site, called Site "B," was located approximately three miles northwest of the Urbana landfill. This facility was sized to handle the county's municipal and construction/demolition waste stream for a 20 year period, based on a 50 percent volume reduction capability for municipal solid waste available on the site five years after opening. This siting process started in April of 1986 with a projected April 1990 opening of the landfill facility.

On October 12, 1988, the Association rejected its candidate future landfill site, Site "B," after 18 months of investigatory work. Site "B" was abandoned because of concerns expressed by the ISWDA Board, as well as by community groups, regarding the site's location in relation to the regional aquifer. Implicit in this decision was that additional engineering safeguards should not be used to supplant proper site identification processes. At the same time, the Association passed Resolution 88-10-1, "A Resolution Concerning Future Plans for Solid Waste Disposal in Champaign County." This resolution directed Association staff to report to the Board within 60 days with, among other things, the cost and impact of the abandonment of Site "B" and the costs to re-establish a facility siting effort in Champaign County. During this period on November 19, 1988, the only regionally accessible landfill, the Urbana Municipal Landfill, permanently closed.

On December 15, 1988, the Association staff reported its findings. The impact of abandoning Site "B" was determined by the ISWDA staff to:

1) Have cost the ISWDA approximately $500,000 (10 to 15 percent of this cost had utility for subsequent siting efforts);

2) That the time for siting a new landfill facility would be approximately 45 to 61 months (this would move the April 1990 opening date back anywhere between 28 to 44 months);

3) Volume reduction facilities, of a non-combustion nature, would take 34 to 44 months to implement;

4) A landfill constructed based on the Site "B" design studies (5,000,000 cubic yards of air space, inclusive of daily cover) with volume reduction facilities built in advance of the landfill would provide a site life of 23 to 27 years (without any volume reduction, the site life would be approximately 15 years); and

5) Given the geology of Champaign County, it was likely that landfill sites would not be located at or near the center of generation of solid waste.

Among staff recommendations found in this report, the following course of action was suggested.

The Association should pursue the development of a volume reduction/material recovery facility which significantly reduces volumes and tonnages that must be ultimately disposed of out-of-county until a new in-county facility is available. The development of this facility should be pursued on the basis of least cost in terms of capital construction and time to implement in relation to:

- Reductions in volume and tonnage;

- Compatibility with existing and planned solid waste diversion programs as well as marketing programs already in place;

- Timely implementation of volume reduction prior to the operation of an in-county landfill and during the period of reliance on out-of-county landfills; and

- Promotes the best use of public and private sector capital and efficiencies.

The Association Board concurred with this recommendation and directed staff to develop a request for proposal (RFP) related to implementing a non-combustion facility. This RFP was to be directed towards a volume reduction/materials recovery facility and technology and should be performance based. Concurrently, staff was to complete solid waste management planning centered around a selected non-combustion volume reduction/material recovery technology. This technology should be oriented towards the phase implementation of a:

a) Transfer facility developing;

b) Volume reduction capabilities through material recovery and composting during the period of time when;

c) The landfill site search and development is underway;

d) Concurrent with this process, review current public sector diversion efforts in relation to potential diversion efficiencies in follow-on volume reduction technologies as they enter into the implementation process.

During its 1988-1989 fiscal year (May 1, 1988 through April 30, 1989), the ISWDA Board took a number of actions to move this strategy forward. These actions included:

1) Established the preference of public ownership/private operation for the material recovery/transfer facility (MR/TF) in January of 1989;

2) Interviewed and selected engineering and financial advisors to assist in the development of the MR/TF in May of 1989;

3) Executed a contract with the Illinois State Geological Survey to conduct county-wide landfill suitability mapping in February of 1989;

4) Requested and was delegated by the Champaign County Board solid waste management planning responsibilities as outlined in P.A. 85-1198, the Solid Waste Planning and Recycling Act, in April of 1989.

In FY 1989-1990 (May 1, 1989 through April 30, 1990), the Board initiated or completed the following:

1) Reviewed Statements of Qualifications submitted by firms interested in building and operating the MR/TF and pre-qualified 11 in September 1989;

2) Completed a Site Identification Study for the MR/TF (November 1989) and optioned two sites for inclusion in the RFP (January 1990);

3) Completed a RFP for a MR/TF and released it in February 1990;

4) Executed a contract with a landfill design firm to provide landfill site identification and development services in September 1989;

5) Completed Illinois State Geological Survey landfill site suitability mapping for the county in February 1990;

6) Established the Board Advisory Committee to assist in solid waste planning responsibilities delegated by the Champaign County Board pursuant to P.A. 85-1198, the Solid Waste Planning and Recycling Act, in May of 1989;

7) Completed the first three parts (Solid Waste Characteristics, Waste Reduction, and Recycling) of the Champaign County Solid Waste Plan in April 1990.

In FY 1990-1991 (May 1, 1990 through April 30, 1991), the Board has completed or initiated the following activities:

1) Identified a preferred vendor for the MR/TF in July 1990;

2) Completed a Site Identification Study for the Landfill Facility and released it in July 1990;

3) Completed the fourth and final part of the Solid Waste Management Plan (Facilities, Siting Criteria and System Costs) in October 1990.

MATERIAL RECOVERY/TRANSFER FACILITY

The ISWDA Board believes that a processing site adaptable to transfer, recycling and volume reduction functions will provide the greater flexibility in management options for Champaign County, particularly when coupled to landfill siting. The MR/TF being developed by the ISWDA incorporates some or all for the following operations:

- Commercial areas for municipal waste drop-off and processing
- Public (non-commercial) areas for municipal waste drop-off and processing
- Public drop-off and buy-back of recyclables
- Processing source separated recyclables (U-Cycle, Reeecycle, Hometown)
- Picking and sorting construction/demolition wastes
- Future expansion in municipal waste composting (enclosed, in-vessel)
- Compacting and transferring of non-processible residues
- Baling recyclables
- Storing and marketing recyclables

The ISWDA is requiring, through contract specifications and conditions and periodic inspection, that these operations will take place in enclosed buildings and be appropriately fenced and/or screened. The buildings and grounds are to be designed and landscaped to be aesthetically pleasing. The operator will collect all litter from the station and grounds at least daily, or more if necessary. All buildings, containers and equipment shall be cleaned at the end of each operating day. Compacted waste must be removed within 24 hours. The operator may not accept, store or transfer special wastes. There would be no disposal of material allowed on the site.

The criteria used to locate suitable parcels are listed in Figure 1 and Table 1. (Figures and Tables appear at end of paper).

Based on the criteria used, the ISWDA staff identified 40 potential MR/TF sites. This list was further evaluated by economic and locational criteria and reduced to ten preferred sites. The ISWDA staff recommended to the Board that it:

1) Have member government staff review all ten sites identified by the ISWDA in the Site Identification Study;

2) Add any sites to the list that member governments may have identified;

3) Approach the owners of the identified parcels with a detailed presentation of proposed facility characteristics. This should be done in conjunction with respective city or county staff;

4) Negotiate and secure options for purchase. Agree on a selected site with a possible alternate for inclusion in the RFP for a MR/TF.

5) If no option can be secured among the ten sites, request condemnation be exercised on behalf of the Association by the appropriate member government;

6) If a member government is not willing to sue condemnation on behalf of the Association among the ten sites, re-evaluate site evaluation criteria. If rail access requirements are removed, re-examine sites west and northwest of the City of Champaign.

The ISWDA Board directed staff to execute two options on sites from the preferred pool in January 1990.

LANDFILL FACILITY

Based on the state and federal location requirements and site identification criteria developed by the ISWDA and its Board Advisory Committee, a screening of Champaign County was conducted. Maps were developed for such screening criteria as lend themselves to cartographic illustration. This mapping was accomplished through a cooperative effort between the ISWDA of Champaign County, the Illinois State Geological Survey (ISGS), the Offices of Solid Waste and Renewable Resources (OSWRR) and the Office of Research and Planning (ORAP) of the Illinois Department of Energy and Natural Resources (ENR). The ISGS performed its work under contract with the ISWDA and has matched ISWDA funds with ISGS funds and in-kind contributions. The ORAP efforts were paid for by the Illinois Solid Waste Management Fund.

Utilizing screening criteria provided by the ISWDA, maps were produced of each criteria for the entire county (1,000 square miles). No area of Champaign County was eliminated a priori. The areas of the county remaining after geologic screening were considered suitable areas where present knowledge indicated a high likelihood that on-site investigation could verify a geologically acceptable landfill site.

The ISWDA, together with its landfill design engineering consultant, used this database to select sites for evaluation and on-site investigation. The ISGS, OSWRR, and ORAP provided support during ISWDA's development of the criteria, assisted in collection of data for evaluation of each criteria selected and produced maps showing the effect of the criteria selected.

At the meeting in which Site "B" was rejected, the ISWDA Board adopted Resolution 88-10-1 which requested, in part, "minimum technical or geographic standards for solid waste disposal site suitability, if any, from any interested parties who appeared before the Board." Requests were sent to parties identified in meeting minutes who appeared during the Site "B" process. Two parties submitted standards. These criteria were incorporated, where possible, into the site identification criteria. It was also determined during the Site "B" siting process, that sites located above the "regional aquifer" were unacceptable due to groundwater protection issues. Using the Geographic Information System (GIS), the ISGS produced thickness maps of sand and gravel deposits at the request of the ISWDA staff. Based on these ISGS mapped sand thicknesses, ISWDA staff (in conjunction with its consultant) interpreted the term, "regional aquifer," to be those major sand bodies contained in the Glasford and Banner Formations. These formations underlay a large portion of Champaign County. In order to distinguish "regional" from "other" sands and gravels in the Glasford and Banner formations, the mapped sand thickness category that was used to approximate the limits of the "regional" Glasford and Banner formation aquifers was the 25 to 100 foot category. Therefore, the extent of the composite sand thickness in the Glasford and Banner formations mapped as 25 to 100 feet or greater was considered a "regional aquifer." All other exclusionary criteria used in the site identification process followed from this definition.

The use of exclusionary and discretionary criteria in the site identification process was discussed at numerous ISWDA Board meetings and at meetings of the Board Advisory Committee. The Board Advisory Committee is a 16 member body of citizens appointed by the governing bodies of the County and the Cities of Champaign and Urbana representing a broad spectrum of views and interests. This body assisted in developing a set of criteria, listed in Table 2, used by the ISWDA staff in screening the county for suitable sites. The goal of this screening was to develop a list of sites which appear to meet, based on all data available to the ISWDA or its contractors, environmental and public health and safety standards set by federal, state and local authorities.

In addition, local criteria were developed to further clarify what characteristics needed to be addressed on potential sites for geological investigation. These criteria were grouped into exclusionary and discretionary criteria. Exclusionary criteria were used to screen areas. Typically, these areas were sections of land. Areas which contained any of the exclusionary characteristics were not considered further in the site identification process. Areas which remained after the exclusionary criteria were screened against the discretionary criteria to identify parcels within these areas for consideration and on-site investigation.

The suitable sites were identified by applying these criteria and were assumed to be environmentally satisfactory pending verification by on-site investigation. Finally, ISWDA staff evaluated potential sites for on-site investigation based on:

- Minimizing the road distance from the proposed MR/TF;
- Minimizing the amount of road reconstruction required for transfer vehicle access;
- Minimizing vehicle operation and maintenance costs;
- Minimizing the acquisition of residences required to establish a 200 acre parcel or greater; and
- Minimizing the number of residences within one mile of the landfill site.

The intent of these staff-generated criteria was the identification of economical sites for acquisition and development which minimizes the effect on surrounding properties and land uses. For the context of the Champaign County landfill site identification process, these five staff generated criteria were used only after the identification of geologically suitable sites.

The approaches used in the landfill facility site identification process worked from the premise that, based on the best available data, a candidate pool of sites could be identified which were geologically similar. That is, they avoided major groundwater resources and were cognizant of other cultural and environmental factors in the site identification process. This process produced 33 potential sites and identified 17 preferred sites for more detailed economic and locational evaluation. These 17 preferred sites are shown in Figure 1. Based on this evaluation, five sites appear to be distinct (economically and locationally) from the other sites remaining in the preferred pool.

Based on this approach, the following staff recommendations were made to the ISWDA Board for site acquisition:

1) Approach the owners of the identified top five parcels with a presentation of the proposed facility;

2) Negotiate and secure options for on-site investigation of two sites and subsequent purchase;

3) If no landowner is willing to execute an option, direct ISWDA staff to identify one site and request condemnation to be exercised on behalf of the Association by the Champaign County Board.

The ISWDA Board directed staff to contact the 17 property owners of the top five parcels in August with an inquiry of interest. In September 1990, specific price per acre offers were made to these same property owners. Concurrent with this approach, ISWDA staff has been preparing its access condemnation recommendation for the Board, should it so direct. A decision was to be made in November 1990.

TABLE 1

Transfer and Processing Facility Site Identification Criteria

Inclusionary	Exclusionary
■ Parcel Should Be:	■ Exclude parcels less than 1,000 feet from nearest property zoned residential or residential dwelling
• 10 to 30 acres	■ Exclude areas inside the 100 year flood plain
• Located along major transportation routes including railroad	■ Exclude parcels with residential structures
• Properly zoned County: I-1, I-2, AG-1, AG-2 Champaign: I-2, I-3, I-4 Urbana: IN, AG	■ Exclude parcels greater than ten miles from center of waste generation (approximately two miles north of Rt. 45 and I-74)
• Near the center of waste generation	■ Exclude parcels greater than five miles from the geographic center of Champaign-Urbana (the intersections of Wright and Springfield)
• No more than two and one-half times as deep as it is wide and uniform in shape	■ Exclude sites with multiple owners
• Utilities access	■ Exclude sites with steep slopes, surface water features or environmentally sensitive areas
	■ Exclude sites more than one-half mile from a state highway or major collector
	■ Exclude sites requiring construction of at-grade rail crossing over major arterials

Source: Material Recovery/Transfer Facility Site Identification Study, ISWDA, November 1989.

TABLE 2

Landfill Site Identification Criteria[1]

Exclusionary

- Exclude all areas which overlay regional aquifers.[2]
- Exclude all other areas overlaying sand and gravels as mapped with thickness greater than five feet and at a depth of 75 feet or greater.[3]
- Exclude all areas within 1,000 feet from any public or industrial water supply (in-use or plugged).
- Exclude all areas within 200 feet of all other water wellheads (in-use or plugged).
- No more than 10 percent of the parcel may be within the 100 year flood plain. The portion of the parcel within the flood plain must be contiguous to the outer property lines. No part of the permitted area may be within the flood plain.
- Exclude all areas within 10,000 feet of currently permitted runways for jet planes.
- Exclude all areas within 5,000 feet of currently identified runways for propeller-driven planes.
- Exclude all areas within 500 feet of a perennial stream.
- Exclude all areas and easements with railroads, roadways, pipelines, or transmission lines which transverse the parcel.
- Exclude all areas within one and one-half miles of municipal corporate limits, in or outside the county.
- Exclude any mine and pit areas.
- Exclude all areas within one and one-half miles of schools.
- Exclude all public lands, except University of Illinois lands. University of Illinois lands are to be reviewed on a case-by-case basis.
- Exclude from the permitted area two or more contiguous acres of woodlands.
- Exclude wet lands, including lakes and ponds.
- Exclude cemeteries.

TABLE 2 (Continued)

Inclusionary	
The Parcel Should Have:	
▪ Area	200 acres or more of suitable land is preferred.
▪ Ownership	Three or fewer owners are preferred.
▪ Parcel Shape	A regular shape is preferred.
▪ Zoning	Industrial or agricultural zoning is preferred.
▪ LESA/Productivity Evaluation	A lower productivity rating is preferred (to be used in conjunction with on-site investigation).
▪ Archaeological Evaluation	The absence of any significant archaeological site is preferred.
▪ University of Illinois	Include all properties and make determination on a case-by-case basis to exclude research areas.
▪ Threatened or Endargered Species	Include all areas of sightings; make determination on habitat impact on a case-by-case basis.
▪ Historic Places	Include all sites; make determination on appropriate remediation, if necessary, on a case-by-case basis.
▪ Parcel Setbacks	Measurement of setbacks is to be from the edge of the parcel rather than from the edge of permitted area, where possible.

Source: Landfill Facility Site Identification Study, ISWDA, July 1990.

1) Landfill site identification criteria used by ISWDA staff. These criteria were generated from staff discussion with the ISWDA Board and the Board Advisory Committee. Additional exclusionary criteria were used by ISWDA staff.

2) Defined as mapped sand and gravel thicknesses in the Glasford and Banner Formations in the 25 to 100 feet category

3) Due to the nature of the way in which sand thickness data was mapped in the GIS system, this criteria actually applies to areas mapped as having five to 25 feet of sand at a depth of 75 to 100 feet. Applied by ISWDA staff on a site specific basis.

Locations of Preferred Sites for Processing Facilities and Landfill Facilities

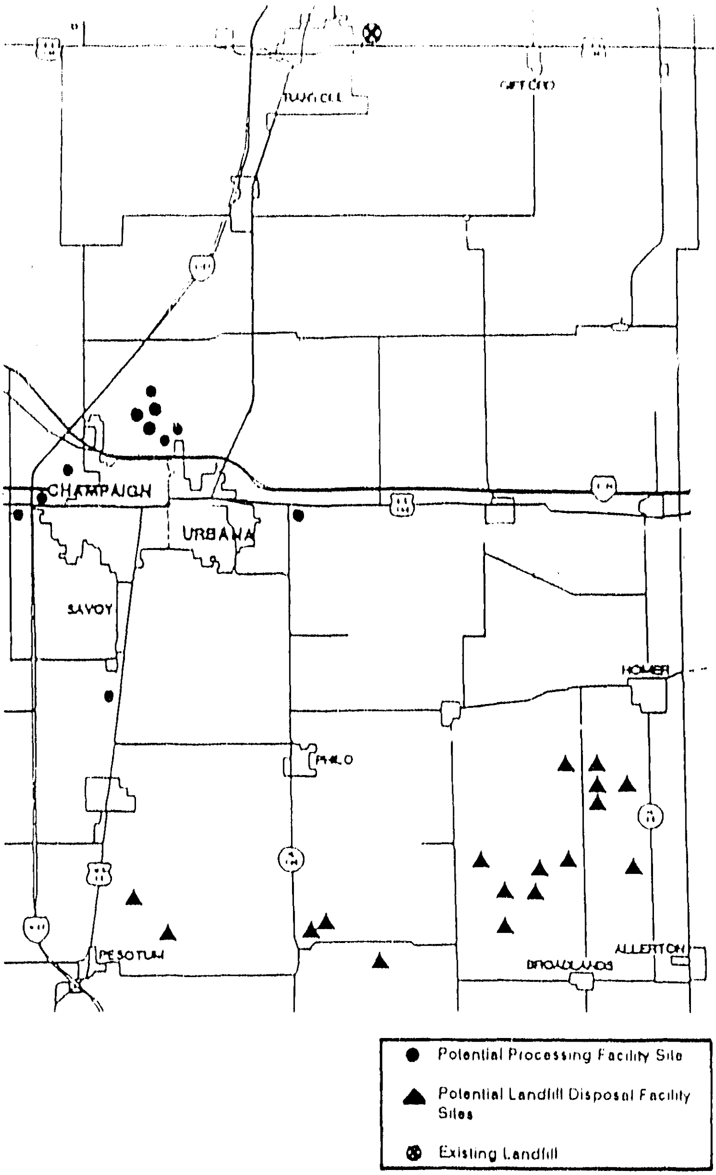


Figure 1

SITING THE ROBBINS FACILITY

Barry Neal, Vice President
Project Development
Reading Energy Corporation

INTRODUCTION

Siting a resource recovery (or waste-to-energy) facility anywhere in the U.S. typically involves a very complex and lengthy process which encompasses a wide array of technical, economic and social issues. The siting of the Robbins Resource Recovery Facility (the "Facility") may be different from other landfill and resource recovery facility siting processes in that the Village of Robbins sited the Facility many years prior to Reading Energy Company's involvement in the project. The Village spent considerable efforts over a number of years developing the Facility conceptually and attempting to push forward the project and gain public acceptance within their community. However, even with years of the Village's diligent efforts, Reading Energy spent a number of months evaluating the feasibility of the site that had already been selected before initiating the formal site approval process.

This paper is a case study of siting the Robbins Facility which is under development in the Village of Robbins and the many issues that must be addressed before, during and after the formal siting process. The Facility successfully received formal site approval pursuant to Illinois siting laws in 1988, and more recently has received all environmental permits necessary to begin construction from the Illinois Environmental Protection Agency (IEPA). The Facility is scheduled to begin its three-year construction schedule next spring and commence commercial operations in 1994.

OVERVIEW OF THE ROBBINS RESOURCE RECOVERY FACILITY

The Facility is designed to process 1,600 tons-per-day (TPD) of nonhazardous municipal refuse and incorporates a front-end materials recovery and fuel preparation system with a circulating fluidized bed boiler to recover energy. Reading Energy Company of Philadelphia, a developer and owner of resource recovery facilities, is the developer of the Robbins Facility.

The front-end system will remove various recyclable materials such as ferrous metals, aluminum, glass, compostable materials and some plastics. After these recyclables are removed, the remaining materials are processed into a fuel, or "refuse derived fuel" (RDF), which is then combusted in the boiler where its energy value is recovered in the form of steam. The high-pressure, high-temperature steam then drives a turbine-generator to produce about 40,000 kilowatts of electric power on a continuous basis for wholesale to the local utility. This power will meet the needs of approximately 50,000 homes.

The environmental control systems include the front-end materials removal, in-situ (or in the furnace) scrubbing of some gases, a thermal "deNOX" system for added nitrogen oxide control, a spray dryer absorber stack gas cleaning (scrubber) system and fabric filter baghouses.

The concept and intent of the entire system at Robbins is to maximize the recovery of valuable resources from an otherwise wasted material, and to significantly reduce the volume of what must be disposed of in ever-diminishing landfills.

EARLY HISTORY OF ROBBINS FACILITY SITING

In the late 1970's, the Village of Robbins began pursuing the idea of creating an "energy park" at a site they had zoned for industrial use alongside the Calumet Sag Canal. The hub of the energy park would be a resource recovery facility with the intention of bringing in additional industrial or commercial businesses which might benefit from the Facility's energy output.

Up through the mid-1980's and encompassing three different mayoral administrations, the Village studied the feasibility of such a concept and attempted to move the ideas forward into concrete planning and implementation. The Village has been, and continues to be, economically distressed and therefore had few resources to move the project forward into actual development. During this period, they made attempts to bring in private developers to fund the project and manage its development which were unsuccessful.

It is important to look more closely at and understand the economic stature of the Village to appreciate some of the motivation in developing the project concepts for the energy park and the Facility. The Village, which was originally incorporated in 1917, has a long and proud history but also a troubled one. As people from this area may be aware, Robbins has experienced significant financial problems over the years. The Village has very little tax base to support its activities. For this town of approximately 9,000 people, there are only about 25 small businesses and approximately 2,000 homes (with an average value of $25,000) to form the tax base. There are no industries in the Village and no Chamber of Commerce. Over the years, the Village has watched the communities surrounding it grow and prosper with many industries and commercial businesses and corresponding employment opportunities. The Village views the resource recovery facility and any additional businesses that follow as the cornerstone to their economic revival.

Reading Energy was brought into the Village in late 1987 to meet with Village officials to discuss the project and to explore whether or not the company was willing to commit to working with the Village to move the project forward.

SITE AND PROJECT FEASIBILITY ASSESSMENT

As mentioned earlier, the Robbins siting experience may be somewhat different from other projects in that the Village had selected and defined the site many years prior to Reading Energy's involvement. Our initial meetings in 1987 with Village officials were favorable, so we began to analyze the feasibility of the project before formally committing to work on the project. More specifically, we evaluated the following major areas related to the site and overall project feasibility: needs assessment, economics, technical and environmental feasibility, and political/social considerations.

THE NEED

The solid waste disposal crisis has struck the Chicago metropolitan area and the rest of Illinois just as it has in most other parts of the United States. As other papers have documented, the greater Chicago area is quickly running out of landfill capacity and is not bringing on-line new disposal capacity and waste reduction and recycling systems quickly enough to avert a very serious problem. The predictable result has been rapidly escalating disposal costs with no relief in sight.

Cook County alone generates about 15,000 TPD of garbage. The southern suburbs of the county produce over 2,500 TPD of that total. The Robbins facility was sized significantly smaller at 1,600 TPD due to the assumption that a recycling and composting program may develop over time to reduce the total available for processing.

ECONOMIC FEASIBILITY

Typical of any new potential project opportunity, we evaluated the economic feasibility. We looked at such items as disposal fees, electric power rates, capital and operating costs. We have computer financial models which allow us to quickly input any assumptions and evaluate a wide variety of sensitivity cases in addition to the base (or most likely) case.

TECHNICAL AND ENVIRONMENTAL FEASIBILITY

We evaluated a number of technical parameters concerning the project site. For example, we assessed: foundation suitability, site size, accessibility, traffic flow, utility connections, site drainage and so on. We also met with IEPA to evaluate air and water quality considerations and attempted to determine whether or not a facility could, in fact, be permitted on the site selected by the Village. We brought in an engineering firm to conduct soils tests on the site and to look at the history of the site to determine if there was any evidence of past industrial uses or contaminants.

POLITICAL AND SOCIAL CONSIDERATIONS

A number of issues are evaluated in this category including: land use compatibility, impact on property values, noise and odor impacts, and the level of political and community support.

Although it was very clear that the elected officials in Robbins were formally behind and committed to the project, we also wanted to assess the feelings and concerns of other people in the community. We met with a number of community leaders and other residents in the Village, and we found substantial support of the project as well.

The end result from the initial feasibility analysis outlined above was that the project concept was viable, and we would work with the Village to move it forward.

THE SITE APPROVAL PROCESS

In 1981, the Illinois General Assembly passed Public Act 82-782 (commonly referred to as Senate Bill 172) which shifted the responsibility of site approval for all new regional pollution control facilities from the state to county and municipal governments in which the facilities are proposed to be located. The Act established a siting review and appeal process and the criteria for decision making and increased public involvement. The Act has created tremendous controversy and debate and has been challenged by various interest groups since its enactment. Some have argued that the law has effectively created insurmountable barriers to the development of new disposal capacity, while others have stated that it provides the necessary and required controls over siting new disposal facilities.

As part of the formal approval process, the facility developer or owner must comply with specific notice requirements and must submit a proposal which addresses and meets the site criteria pursuant to the applicable laws. The local officials are responsible for examining the proposal, conducting public hearings and then determining whether the site meets the criteria as outlined in the law. The public is notified of the proposal and is provided an opportunity to formally comment.

The IEPA will not review an environmental permit application for a facility until the applicant shows evidence of the official site approval from the appropriate governing municipal entity. If the governing entity denies site approval, the applicant may appeal the decision to the Illinois Pollution Control Board.

In June 1988, Reading Energy submitted a site application and proposal to the Village of Robbins. The application addressed a significant number of issues of interest in addition to the specific legal criteria. Issues that were addressed included impacts on existing air quality; ash disposal; noise, odor and dust impacts; traffic; waste inspection practices; spill prevention and control measures for on-site storage of fuel, lubricants and chemicals; landscaping; aesthetic quality of buildings and structures; water use conservation and wastewater control; fire protection; conservation of property values and land use compatibility.

At the time of the Robbins Facility site approval, the specific site suitability criteria as put forth by SB172 and outlined in Section 39.2 of the Environmental Protection Act was as follows:

1) The facility is necessary to accommodate the waste needs of the area it is intended to serve;

2) The facility is so designed, located and proposed to be operated that the public health, safety and welfare will be protected;

3) The facility is located so as to minimize incompatibility with the character of the surrounding area and to minimize the effect on the value of the surrounding property;

4) The facility is located outside the boundary of the 100 year flood plain or is flood-proofed;

5) The plan of operations for the facility is designed to minimize the danger to the surrounding area from fire, spills or other operational accidents;

6) The traffic patterns to or from the facility are so designed as to minimize the impact on existing traffic flows;

7) If the facility will be treating, storing or disposing of hazardous waste, an emergency response plan for the facility which includes notification, containment and evacuation procedures to be used in case of an accidental release; and

8) If the facility is to be located in a county where the county board has adopted a solid waste management plan, the facility is consistent with that plan.

The site was officially approved by the Village in November 1988 after the application review, public hearings and comment period. The site approval represented a major milestone for Robbins and the project after many years of efforts by the Village. Following the site approval, Reading Energy submitted an environmental permit application to IEPA in December 1988. The permits were issued by IEPA in June of 1990.

What was interesting and perhaps unique about the Robbins site approval process was that even with public notices, formal hearings and informational public meetings, there was very little public reaction during that time period. More intensive public interest and subsequent media coverage did not surface until the draft environmental permits were issued in January 1990, over a year after formal site approval.

BENEFITS TO THE VILLAGE OF ROBBINS

As with most host communities to resource recovery facilities, the Village of Robbins will reap many benefits from the facility's location and operation. Through a long-term lease agreement between the Village and Robbins Resource

Recovery Company (a subsidiary of Reading Energy), the Village will collect lease and royalty payments. Additionally, taxes and the purchase of water from the Village will contribute substantially to the Village economic base. In total, the Village will receive over $1,000,000 per year (and increasing each year with an inflation adjustment factor) which will significantly enhance their current budget of $1,600,000.

Bechtel Corporation, a large construction and engineering firm selected as the contractor for the Facility, will employ up to 600 people at any given time during the three-year construction period. The permanent operating staff at the facility will include over 90 employees. Reading Energy and Bechtel are currently working with Village leaders to establish training programs and other mechanisms to maximize employment opportunities for Village residents.

Many businesses and services in the area will be needed to support the operations of the facility. For example, at Bechtel's SEAMASS facility in Rochester, Massachusetts, there are approximately 85 different businesses in the surrounding area which provide supplies and services to the resource recovery facility.

We are also in the process of establishing a college scholarship program for high school students from Robbins and developing other contribution programs for various needs of the community. We view our role in Robbins as a long-term neighbor with significant responsibilities to the community.

Additionally, the Village has not lost sight of their original concept of an energy park adjacent to the facility. We have been working with Village leaders to attract additional business to the site. For example, Reading Energy owns a seven acre greenhouse adjacent to a 50 MW cogeneration facility we operate in northeastern Pennsylvania and is planning to study the feasibility of locating a similar greenhouse adjacent to the Robbins facility. The greenhouse would be able to utilize low-cost steam for heating and cooling purposes.

We are in the final stages of completing a study for the development of a Materials Recovery Facility (MRF) adjacent to the site. The MRF would process recyclable materials collected by community curbside and drop-off programs for further processing and ultimate sale to end markets.

Both the greenhouse and MRF would add significant tax revenues to Robbins and provide additional employment opportunities for area residents.

POST-SITE APPROVAL ACTIVITIES AND CURRENT STATUS

Within the past year, a citizen's advisory committee has been established by the Village of Robbins to act as an independent liaison between the Village and Reading Energy on a wide variety of Facility-related matters. The committee evaluates the overall project and its progress on an ongoing basis and makes recommendations to both Village officials and Reading Energy as to ways in which the Facility can be improved to meet various needs of residents in the Village. The committee consists of a broad cross-section of professionals (including engineers, scientists, clergy, educators) and community interests. The committee has met with various community groups within Robbins to present the facts about the project and address questions. Reading Energy representatives meet with the committee on a periodic basis to review the status of the project and discuss any suggestions or ideas of the committee, which range from facility design considerations to employee training programs.

The South Suburban Mayors and Managers Association (SSMMA), which represents 38 of the 56 communities which comprise Cook County's southern suburbs, has recently completed a draft solid waste plan for their membership area. The draft plan specifically identifies the Robbins Facility as an economically viable option for waste disposal for their member communities. The study also states that the Facility complements community recycling programs and will enhance the overall recycling recovery rates for the area. We are currently working with the SSMMA to put in place a qualified independent expert who would be a technical representative to the communities who send their waste to the Facility. This representative, who would probably be an engineer with some expertise and knowledge of resource recovery facilities, would provide oversight (or "watchdog") capabilities (which would be in addition to IEPA's continuous monitoring and other regulatory compliance requirements). We and our contractor have confidence that the Facility will perform as designed and well within all environmental permit limitations, so an independent reviewer should provide an additional level of confidence to Robbins and surrounding communities.

In addition to working with large organizations such as the SSMMA, we have initiated a series of small, informal group meetings or "neighborhood dialogues" in communities throughout the south suburbs over the past several months. Since some opposition to the project has surfaced in the past few months in some areas outside of Robbins, we have extended our public education campaign considerably. We also are meeting with various community groups and organizations throughout the area. We cannot just be a good neighbor in Robbins, but must extend that approach to surrounding communities.

CONCLUSION

With the growing supply/demand imbalance of waste generation and disposal capacity in Illinois (as well as in the rest of the United States), it is clear that all solid waste disposal options are needed to practically and responsibly manage the problem. We all are painfully aware that these solutions are much easier to talk about than put into operation. Well proven and environmentally safe technologies exist today to fill the need. Yet these technical facts do not necessarily carry sufficient strength in the overall siting equation.

Many times, political and social issues are the overriding factors which influence the decision-making process for the siting of any new waste processing or disposal systems--including landfills, energy recovery facilities, transfer stations, composting plants and recycling centers. We in the solid waste industry must acknowledge the fact that in some cases there are substantial reasons for the incredulity and concerns expressed over siting of a new facility--perhaps reasons which have absolutely nothing to do with the technical or economic merits of the specific facility. Rather, these may be cases where a proposed facility is living with the legacy of a past business or industry who caused environmental problems in the area. It may only take one facility with a poor track record which shapes the decision-making agenda for everyone who follows.

Companies who are siting any type of new waste processing facilities today must take a more active role in the community (or communities) where they are siting the facility. Even with such additional involvement and even with the cleanest facility feasible, you must recognize that you may never convince everyone, and there may always be a loud, vocal few who oppose your facility. However, the larger, silent majority will be better educated and informed, and ultimately influence the political decision-makers who typically control the siting process.

We in industry have a responsibility to do a better job of educating the public and addressing concerns about facilities that may be sited in someone's "backyard." Siting decision-makers have a responsibility to do a better job in giving ample consideration to the objective technical and environmental merits of new facilities. In the long run, we may then have better success in siting new facilities and ultimately provide the balance of solid waste disposal options necessary to control our mounting garbage crisis.

Robbins Resouce Recovery Facility

Site Location

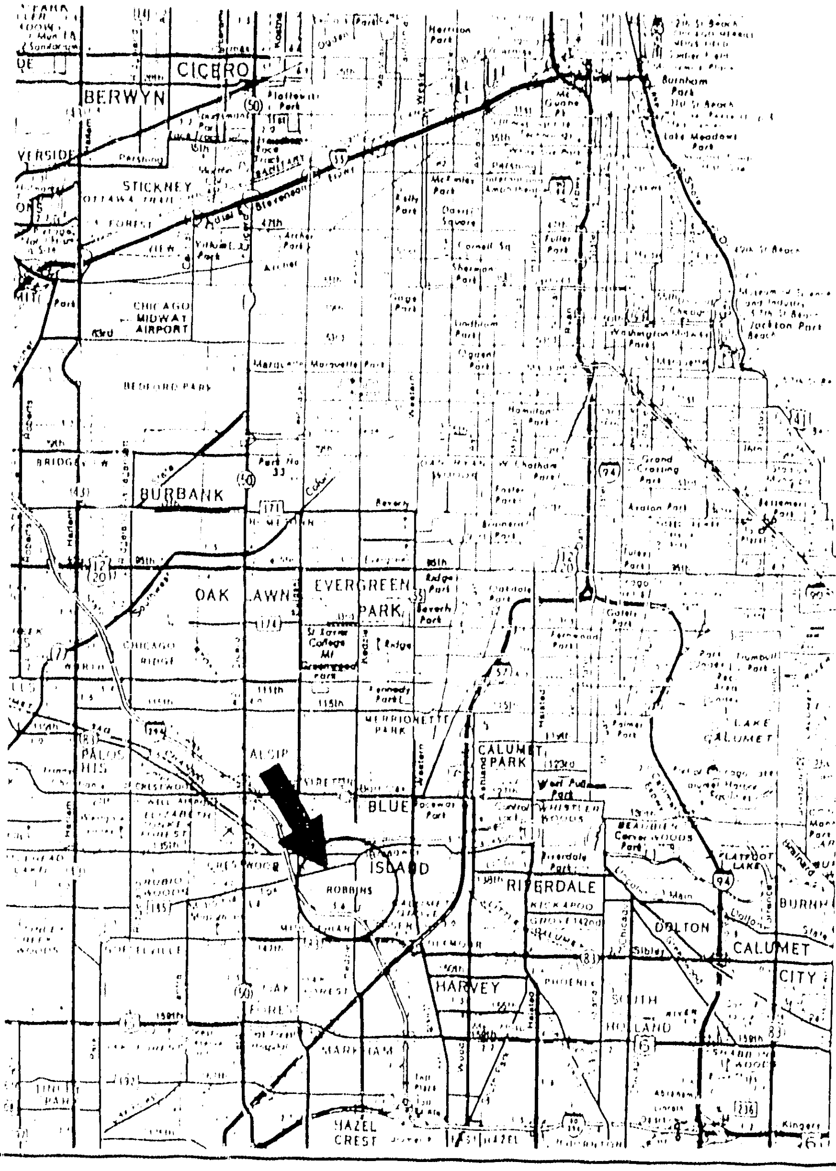


Figure 1

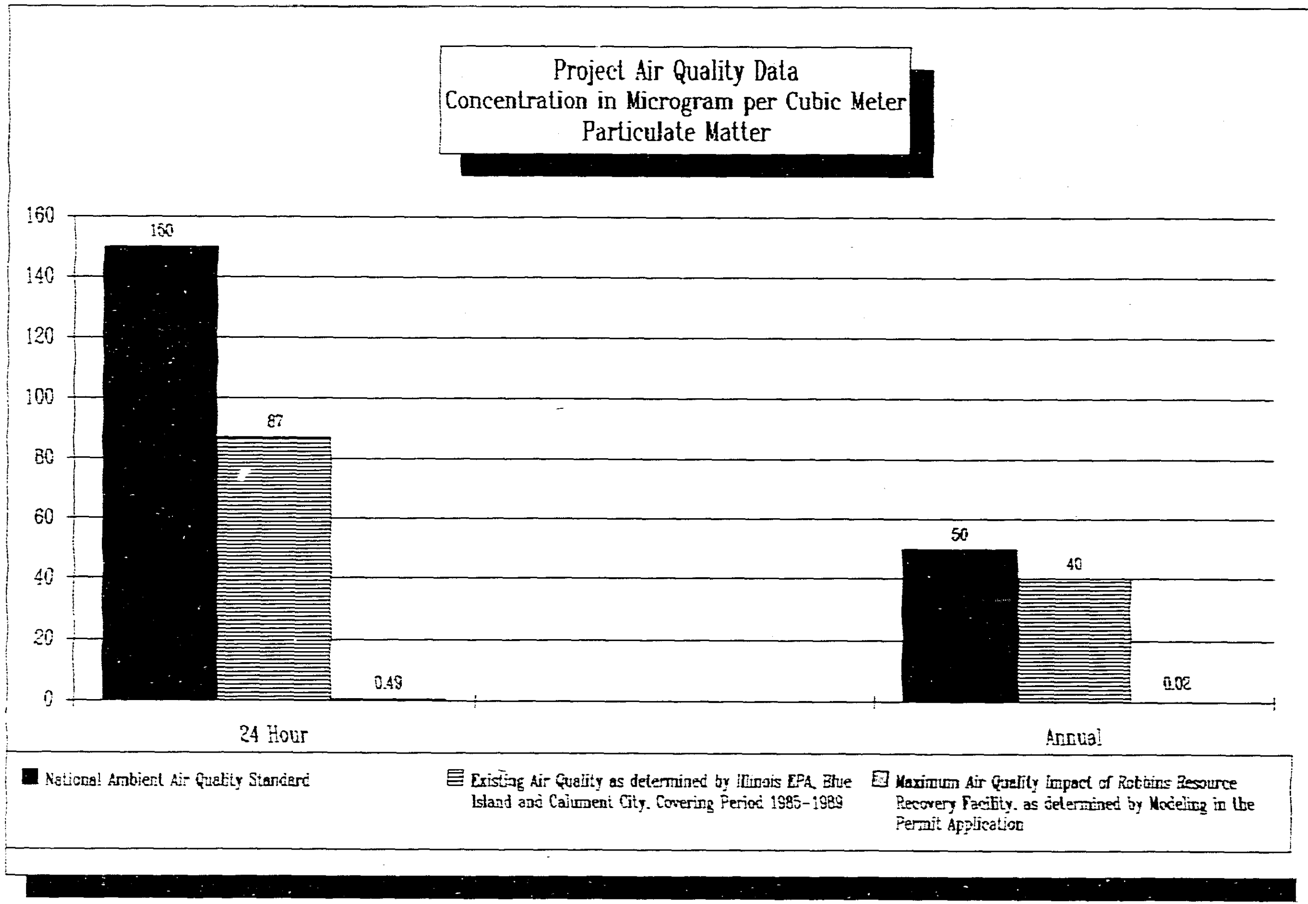

Project Air Quality Data
Concentration in Microgram per Cubic Meter
Particulate Matter
160
140
120
100
80
60
40
20
0
150
87
0.49
50
40
0.02
24 Hour
Annual
National Ambient Air Quality Standard
Existing Air Quality as determined by Illinois EPA, Blue Island and Calument City, Covering Period 1985-1989
Maximum Air Quality Impact of Robbins Resource Recovery Facility, as determined by Modeling in the Permit Application

Figure 2

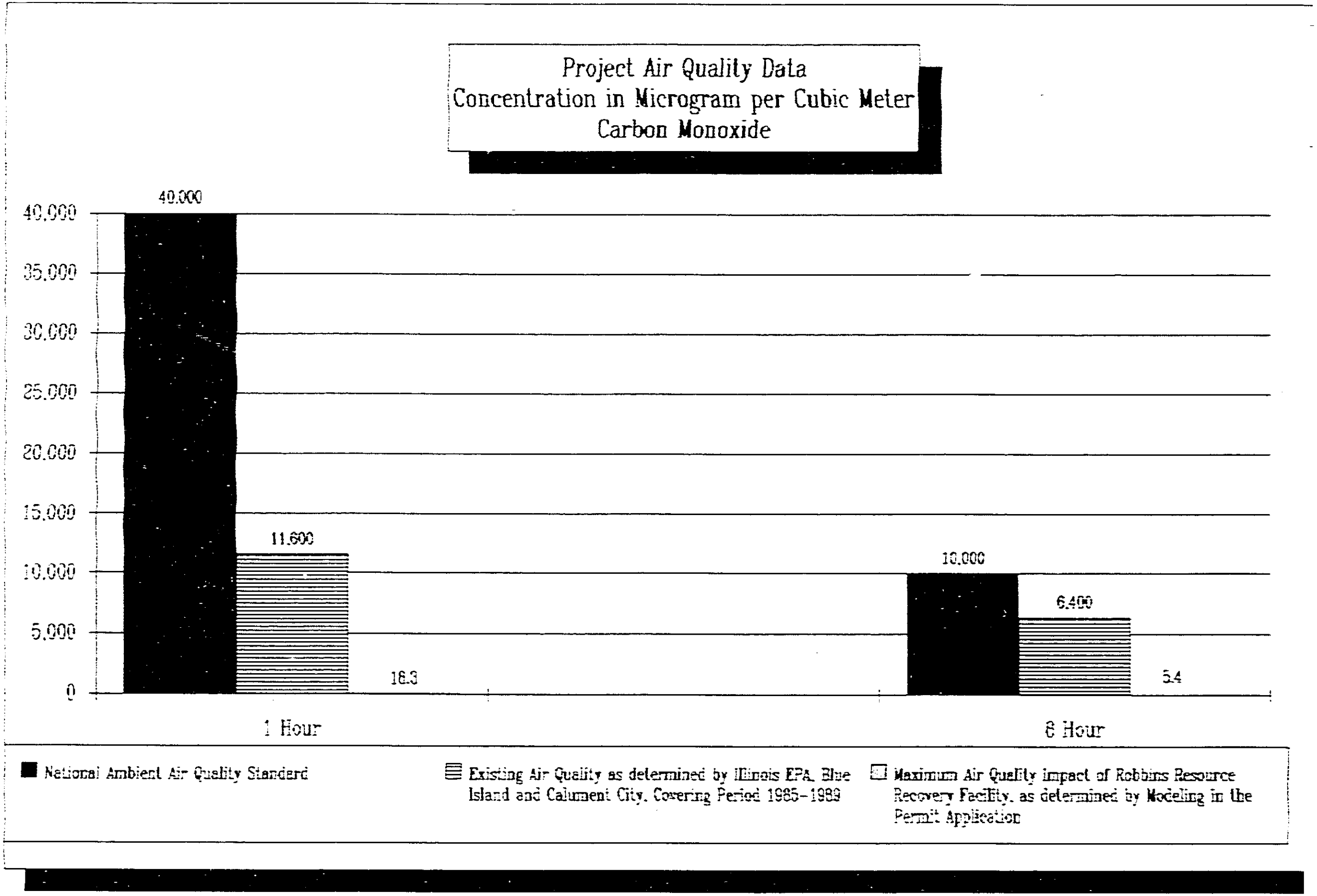

Project Air Quality Data
Concentration in Microgram per Cubic Meter
Carbon Monoxide
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
40,000
11,600
18.3
10,000
6,400
5.4
1 Hour
8 Hour
National Ambient Air Quality Standard
Existing Air Quality as determined by Illinois EPA, Blue Island and Calument City, Covering Period 1985-1989
Maximum Air Quality impact of Robbins Resource Recovery Facility, as determined by Modeling in the Permit Application

Figure 3

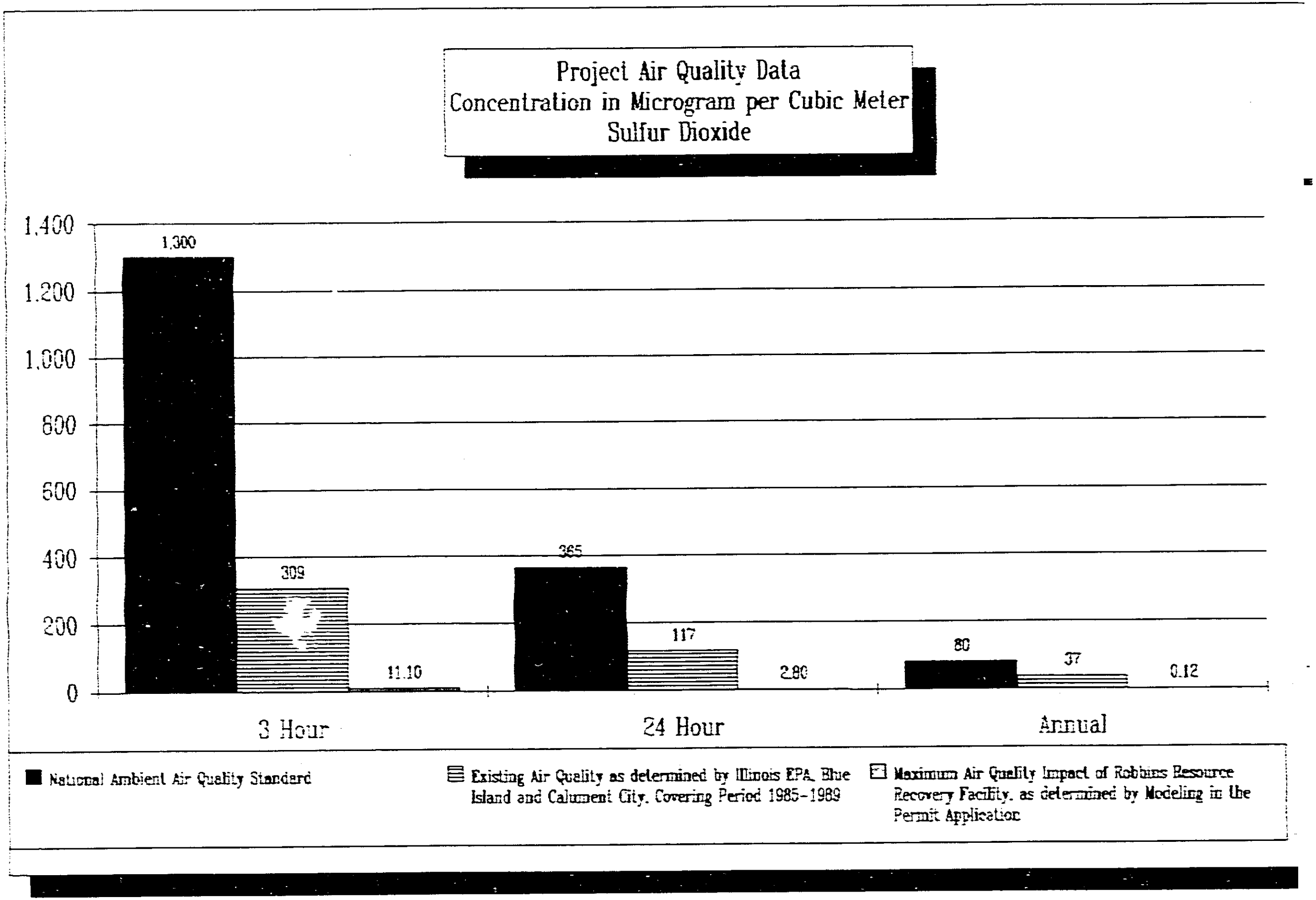
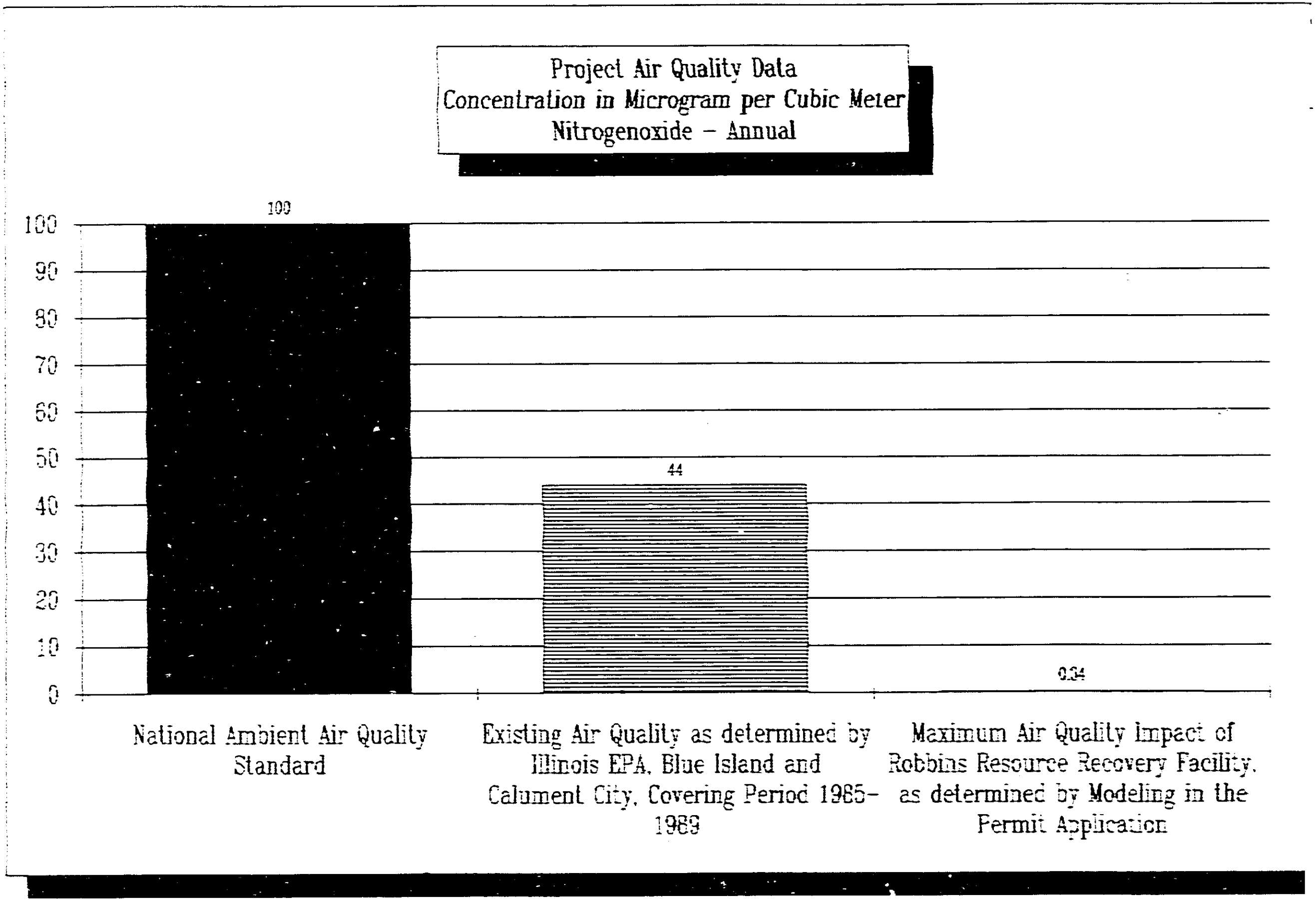

Project Air Quality Data
Concentration in Microgram per Cubic Meter
Sulfur Dioxide
1,400
1,200
1,000
800
600
400
200
0
1,300
309
11.10
365
117
2.80
80
37
0.12
3 Hour
24 Hour
Annual
National Ambient Air Quality Standard
Existing Air Quality as determined by Illinois EPA, Blue Island and Calumet City, Covering Period 1985-1989
Maximum Air Quality Impact of Robbins Resource Recovery Facility, as determined by Modeling in the Permit Application

Figure 4



Project Air Quality Data
Concentration in Microgram per Cubic Meter
Nitrogenoxide – Annual
100
44
0.34
100
90
80
70
60
50
40
30
20
10
0
National Ambient Air Quality Standard
Existing Air Quality as determined by Illinois EPA, Blue Island and Calument City, Covering Period 1985-1989
Maximum Air Quality Impact of Robbins Resource Recovery Facility, as determined by Modeling in the Permit Application

Figure 5

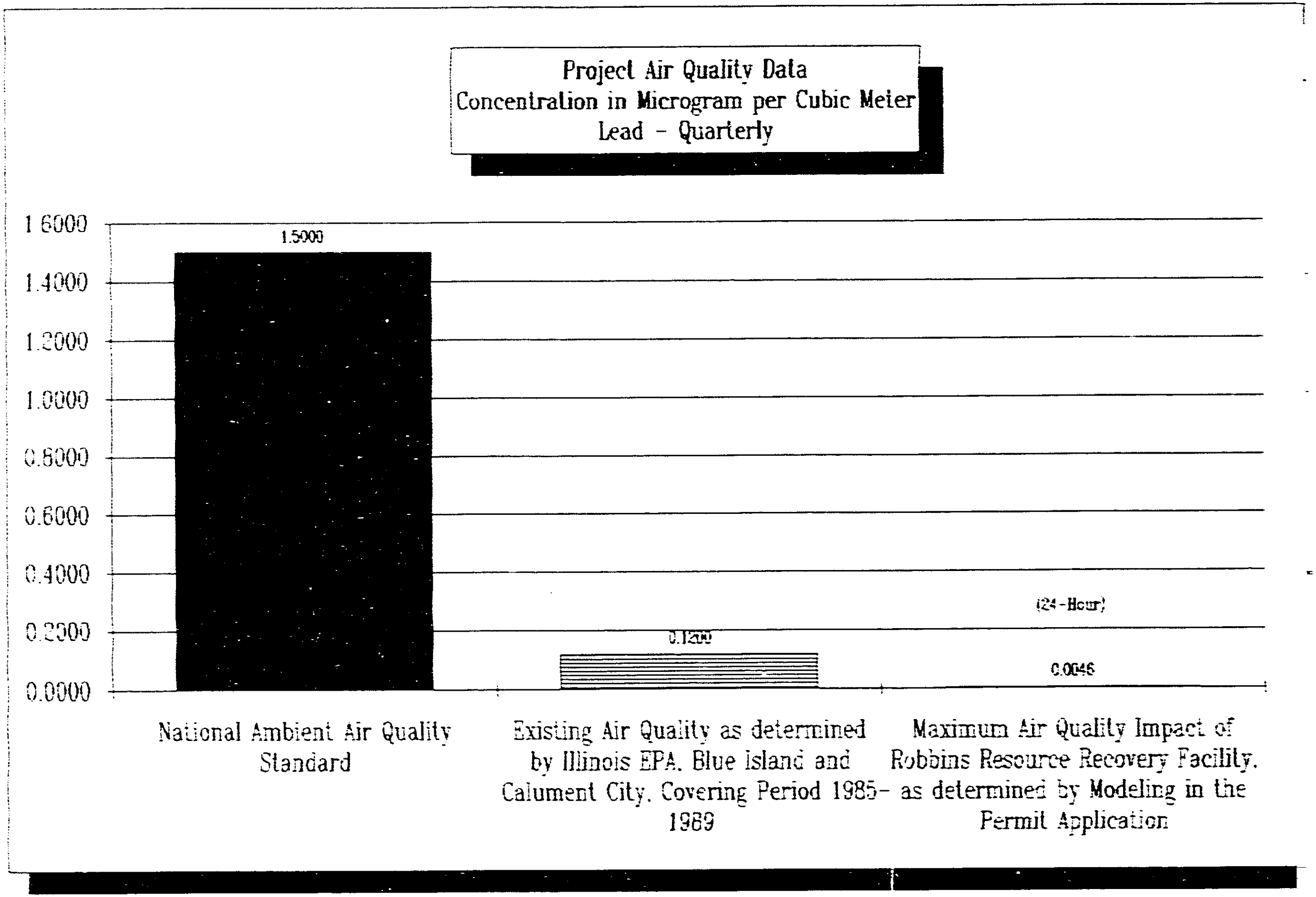

Project Air Quality Data
Concentration in Microgram per Cubic Meter
Lead - Quarterly
1.6000
1.4000
1.2000
1.0000
0.8000
0.6000
0.4000
0.2000
0.0000
1.5000
0.1200
(24-Hour)
0.0046
National Ambient Air Quality Standard
Existing Air Quality as determined by Illinois EPA. Blue Island and Calument City. Covering Period 1985-1989
Maximum Air Quality Impact of Robbins Resource Recovery Facility. as determined by Modeling in the Permit Application

Figure 6

END

DATE
FILMED
5/29/92