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The status of municipal waste combustion in the United States

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Abstract

This paper examines changes in municipal waste combustion practices over a 10 yr period (1982–1992). It reviews the public policy environment surrounding solid waste disposal and its impact on municipal waste combustion (MWC). Based on a series of surveys of MWC projects in the United States conducted since 1982, the paper examines the status of projects, technologies employed, air pollution control methods, fuel products, project revenues, and the extent of public and private sector participation [1].

Keywords: Municipal waste combustion; Solid waste disposal; Waste incineration; Waste-to-energy; Biomass; Pollution control; United States Solid Waste Policy

1. Introduction

As recently as 20 years ago, MWC was embraced by federal, state, and local governments and their citizens as a viable disposal alternative and a method to conserve energy resources. The federal government stimulated the development of projects. However, in the last several years, the viability of waste incineration has been seriously challenged on environmental, economic, and political grounds. The result has been a slowdown in the application of MWC throughout the United States.

A series of surveys of MWC facilities undertaken every 2 years since 1982 by Governmental Advisory Associates, Inc. (GAA) forms the basis of this study. These telephone surveys were conducted by trained research personnel, using a pretested interview protocol. Plant managers and other solid waste directors were interviewed. The regularity of these surveys affords a unique opportunity to examine how this municipal waste disposal alternative has evolved over the past decade [2].

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As a caveat, only facilities which generate energy or a refuse-derived fuel (RDF) are discussed. Incinerators without energy recovery are not covered in this paper. Facilities burning industrial or hazardous waste are also excluded. Unless stated, all findings refer to facilities in operation, under construction, in shakedown, or in advanced stages of planning, e.g., those which have designated a technology and vendor. Projects which are permanently decommissioned or in preliminary stages of planning are left out.

2. The policy environment

Before proceeding with the findings, it is useful to briefly review the policy environment which stimulated the municipal waste incineration industry in the United States. Municipal waste combustion is a highly regulated enterprise. Siting, financing, energy product pricing, pollution control, residue disposal, and feedstock composition are all circumscribed by federal, state, and local laws. In addition, the regulations governing municipal waste combustion have changed significantly over the last decade, affecting project development. In conjunction with these changes, general economic conditions have fluctuated (electricity rates have declined; waste stream growth has slowed) and these factors have altered the profitability of projects.

The federal government became directly involved with solid waste management with the passage of the 1965 Solid Waste Disposal Act and its 1968 Amendments. In 1970, the Act was further amended to provide greater financial assistance for the demonstration and construction of solid waste disposal facilities. Known as the Resource Recovery Act of 1970, it promoted better management of collection, storage, and disposal of solid waste. Section 208 of the Act specifically promoted municipal waste combustion (referred to as Resource Recovery) with energy production as a sound alternative to landfilling [3].

Between 1970 and 1972, the US Environmental Protection Agency (EPA) was created. The Clean Air Act of 1970 and the Water Pollution Control Act of 1972 were passed by Congress. These laws created the regulatory framework for EPA's monitoring of air and water pollution. Groundwater pollution by landfills and harmful stack emissions from municipal waste combustors were covered under the regulations. The 1976 Resource Conservation and Recovery Act (RCRA, Public Law 94-580) required the closing of all remaining open dumps and stimulated even greater state and county oversight of municipal solid waste management. The federal government continued to encourage MWC as a strategy that could conserve energy and material resources, and protect the physical environment [4].

MWC received a boost through the 1970s into the 1980s from another source outside the federal and state environmental initiatives: the Middle East Oil Embargoes of 1973 and 1978. Due to soaring prices of oil and fuel shortages, Congress enacted legislation to encourage energy conservation and the development of alternate renewable energy sources. Burning refuse to produce steam or electricity was promoted as a method to manage waste and reduce dependence on foreign oil. In 1978, the Public Utility Regulatory Policies Act (PURPA) was passed, requiring public utilities to purchase power from non-utility alternative energy producers at an avoided cost rate [5]. Taking advantage of this law, MWC facilities producing electricity were able to find a ready market for their fuel product.

A final impetus to municipal waste combustion at this time came through the federal tax code and ensuing developments in public finance. The tax code permitted private entities to recoup part of their investments in MWC facilities by shortened depreciation schedules (5 years) and a 10% investment tax credit for pollution control capital outlays [6]. In addition, projects could be financed with tax-exempt revenue bonds, such as pollution control or industrial development bonds, if they were built under the aegis of a local authority. These policies lowered the cost of capital investment, stimulating the entry of private firms into the field.

By the end of the 1970s, the Congressional Office of Technology Assessment reported 25 MWC facilities in operation or start-up. Eight were demonstration projects funded in part by the US EPA. Ten employed dry and two reported wet pulp RDF technologies; three utilized pyrolysis; four involved modular combustion; and five used mass-burn incineration. In addition, the newly created US Department of Energy (DOE) was also providing for feasibility studies and stimulating the application of waste incineration technology with energy recovery [7].

However, a decade later by 1989–1990, many of the government incentives for the development of MWC had disappeared. Solid waste management policy began to stress recycling and waste reduction. Recycling, seen as the most environmentally benign of all disposal strategies, was incorporated into local, state, and federal initiatives. With respect to waste combustion, the emphasis was placed on reducing environmental risks through pollution control technology and monitoring [8]. A wider array of stack emissions from municipal combustion facilities fell under federal and state regulation. The Clean Air Act Amendments of 1990 required that EPA put a numeric limit on mercury emissions from municipal waste combustors. States such as New York, New Jersey, Florida, California enacted *de jure* or *de facto* moratoria on the building of additional incinerator capacity. Laws also mandated continuous emissions monitoring (CEM).

The Tax Reform Act of 1986 severely restricted the use of tax-exempt industrial revenue bonds. Depreciation rules were changed and the investment tax credit eliminated, increasing the cost of private investment capital. With the easing of the energy crisis and the drop in the price of oil from over $30.00 per barrel to under $20.00, the attractiveness of MWC as a means of conserving energy waned. Public utilities no longer wanted to purchase the electricity generated by the waste combustion facilities. As electricity rates dropped overall, revenues at MWC projects dropped. Through conservation efforts and other developments, growth in the demand for power slowed, thereby decreasing the utilities' need for additional power [9].

Highly publicized environmental disasters such as Three Mile Island and Love Canal heightened public concern over the environmental impacts of large facilities and cynicism regarding governmental response. Siting of many types of public facilities, among them MWC projects, became extremely difficult [10].

In 1994, the US Supreme Court ruled on two cases directly affecting MWC. In *Chicago vs. Environmental Defense Fund*, the Court held that the ash residue of a municipal waste combustion facility must be tested for toxicity. If the ash tests hazardous, then it must be disposed of in a specially designed landfill [11]. This ruling could increase the operating costs of those projects which are not using a hazardous waste landfill. Furthermore, the Court in *Carbone vs. Town of Clarkstown* struck down a local flow control ordinance [12]. Flow control legislation allows a local, county, or state government to require that refuse generated within the jurisdiction be taken to designated facilities. Such ordinances guarantee a flow of waste to the facility and, thus, provide financial stability. The Court's decision may affect the economic viability of those MWC projects which rely upon flow control to guarantee the necessary amount of waste feedstock to the plant.

To add to the economic and political uncertainty facing MWC plants, there is excess disposal capacity at some facilities. Because of the economic recession of the late 1980s and early 1990s as well as the implementation of recycling and waste reduction policies, projected stability or increases in the waste stream were not always realized. Some waste facilities have been receiving lower than anticipated volumes of waste, reducing revenues [13].

Thus, over the last 28 years, the public policy direction for municipal waste combustion has shifted from active encouragement and support to regulation of environmental impacts. Recycling and source reduction strategies are currently the cornerstone of most waste management policies. MWC has been relegated to a lower priority. In large part, the findings reported in the remainder of the paper reflect this changing policy.

3. Findings

3.1. Basis characteristics of MWC facilities

The major characteristics of municipal waste combustion facilities planned or operating as of 1993 are shown in Table 1. The average design capacity is approximately 789 tons per day with an ash residue amount of about 176 tpd (wet basis). Most plants run with two boilers with a capacity of 300–400 tpd. The average power

Table 1
Characteristics of MWC facilities: 1992

	Mean	Minimum	Maximum	Standard deviation	*N*
Capacity (tpd)	785.85	13.00	4000	790.14	171
Ash residue (tpd)	175.82	1.00	935	177.67	160
Average power output (MW)	32.13	0.50	364	39.72	117
kwh/t	515.89	50.00	920	185.79	44
lb/h of steam	231 593	2500	2 300 000	265 224	158
psig	568	30	2400	310	159
Temperature (°F)	642	213	1005	193	159

output is 32 megawatts (MW) of electricity. Approximately 232 000 pounds per hour of steam is produced under a pressure of 568 psig and a temperature of 642 °F.

3.2. Status of MWC facilities

There are 171 MWC facilities with energy recovery, in advanced stages of planning or operational identified by GAA as of the end of 1992. If one includes 27 in early stages of planning and 50 which have been shut down, the total number is 248. By region, the Northeast has or is planning projects with the largest per ton capacity, averaging 914 tpd. The smallest projects, on average, are found in the Western United States, averaging 579 tpd. Interestingly, since 1984, the design capacity of MWC facilities has averaged 765 t; there has been no upward or downward trend over this period.

3.2.1. Operating status

Table 2 shows the operating status of projects by year. The 'conceptual planning' designation means that a locality has conducted a feasibility study and/or issued a Request for Qualifications (RFQ) or Request for Proposals (RFP); an 'advanced planning' classification means that a vendor or developer for the project has been selected and permitting has commenced. It should be noted that a project in either category of planning may not actually be built. The 'operational' category includes all facilities which are running, as well as those which are under construction, in shakedown, or temporarily shut down. The 'shutdown' classification includes projects which are permanently closed or decommissioned.

Table 2
Percent of facilities by status by year

Status	Year					
	1982	1984	1986	1988	1990	1992
Conceptual planning	15.9[a] (17)	49.2 (124)	27.9 (75)	37.8 (139)	18.7 (55)	10.9 (27)
Advanced planning	18.7 (20)	16.3 (41)	26.8 (72)	24.7 (91)	21.1 (62)	8.5 (21)
Operational[b]	55.1 (59)	29.8 (75)	38.3 (103)	30.2 (111)	47.6 (140)	60.5 (150)
Permanent shutdown	10.3 (11)	4.8 (12)	7.1 (19)	7.3 (27)	12.6 (37)	20.2 (50)
Total % (Total #)	100.0%[c] (107)	100.0% (252)	100.0% (269)	100.0% (368)	100.0% (294)	100.0% (248)

[a] Percentage of column.
[b] Includes projects under construction and temporarily shutdown.
[c] Percentages may not add up to 100 due to rounding.

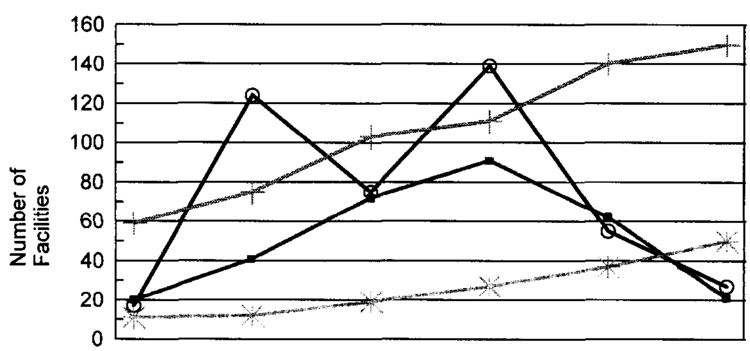
As can be observed, the total number of projects more than tripled from 1982 through 1988, with 107 surveyed in 1982 and 368 listed in 1988, the peak year for MWC in the United States. By 1990, the number of facilities fell to 294, and in 1992, the number of plants identified dropped further to 248. This decrease is the result of a precipitous decline in planned projects. Very few new projects are currently in the pipeline.

Since 1984, the operating projects as a percentage of the total samples have doubled from 30% in 1984 to 61% in 1992. On the other hand, whereas planned projects in the conceptual and advanced phases comprised two-thirds of all projects in 1984, by 1992 this proportion had dropped to about one-fifth. To complete this picture of a maturing industry, the percentage of permanently closed facilities grew from about 5% in 1984 to 20% in 1992. Faced with expensive retrofitting costs and dropping energy revenues, small modular plants have closed. Facilities in planning have been canceled or put on hold, as other less politically sensitive disposal alternatives are found.

The decline of projects over the decade is shown graphically in Fig. 1, which displays the number of projects by status by year. In absolute numbers, the only categories showing sustained growth are operating projects and closed facilities.

3.2.2. Regional location

The regional distribution of MWC facilities has not changed very much over the past 10 years. Table 3 illustrates the number and percentages of advanced planned and operational facilities by region between 1982 and 1992. The Northeastern region of the United States has emerged as the dominant region for MWC currently containing 37% of the planned and operating projects. By 1986, the Northeast had overtaken the South in terms of constituting the largest percentage by region. In



YEAR	1982	1984	1986	1988	1990	1992
Conceptual Planning	17	124	75	139	55	27
Advanced Planning	20	41	72	91	62	21
Operational Planning	59	75	103	111	140	150
Shutdown	11	12	19	27	37	50

Fig. 1. Percent of projects in planning, operation and shutdown: 1982–1992.

Table 3
Percent of advanced planned/operational facilities by region by year

Region	Year					
	1982	1984	1986	1988	1990	1992
Northeast	30.6[a] (22)	29.7 (38)	37.1 (72)	36.6 (74)	36.1 (73)	37.4 (64)
South	44.4 (32)	37.5 (48)	32.5 (63)	33.2 (67)	31.7 (64)	30.4 (52)
Northcentral	16.7 (12)	15.6 (20)	14.9 (29)	19.8 (40)	21.3 (43)	20.5 (35)
West	8.3 (6)	17.2 (22)	15.5 (30)	10.4 (21)	10.9 (22)	11.7 (20)
Total % (Total #)	100.0%[b] (72)	100.0% (128)	100.0% (194)	100.0% (202)	100.0% (202)	100.0% (171)

[a] Percentage of column.
[b] Percentages may not add up to 100 due to rounding.

contrast, there has been a steady drop in the relative proportion of plants situated in the South, from 44% in 1982 to 30% in 1992. This drop is due in part to the closing of many modular facilities, which were disproportionally located in this part of the country. In addition, projects located at military installations have been closing down as regulatory and economic factors rendered them obsolete. Again, these locations tend to be in the Southern region.

There has been slow but steady growth in the Northcentral region, and the West has held somewhat steady, currently containing 12% of the projects. As can be observed in Table 3, the West enjoyed a growing proportion of projects from 1982 through 1986. During this time period, there were a number of projects planned throughout the State of California. By the late 1980s, however, many of these projects were canceled due to political opposition and economic and environmental concerns.

3.3. Technology

3.3.1. Description

Prior to a discussion of specific findings, a brief description of the types of technology used at MWC facilities is in order. Mass burning is the most commonly used process at United States plants. Raw municipal solid waste (MSW) is taken 'as is' with little or no shredding or separation prior to combustion. At a few locations, sewage sludge is co-fired with the refuse. At most sites, large bulky items such as 'white goods', e.g., washing machines, refrigerators, car and other batteries, and hazardous materials are either prohibited or removed from the tipping floor by crane operators and other personnel. In conjunction with recycling programs implemented in some areas, there may be front-end separation of other materials.

After the refuse is dumped into a pit or onto a tipping floor, it is fed into individual furnaces by overhead cranes or front-end loaders at small facilities. The heat produced by the combustion of the waste is used to create steam which may be used directly as an energy product or as a fuel to power a turbine for the generation of electricity. This electricity is typically sold to an investor-owned or municipal utility.

Hot or chilled water can also be produced for use in nearby commercial or industrial facilities or in district heating systems. A related technology is used to generate energy from tires. Two plants are operational in the United States and a third is currently in planning.

In a waterwall furnace, the sides of the combustion chambers contain closely spaced steel tubes through which water circulates. The water is heated by the burning refuse and steam is produced. A rotary combustor is a type of waterwall incinerator which slowly revolves, not unlike a cement mixer, and mingles the burning refuse. This approach is supposed to lead to a more complete combustion of the refuse. Older incinerators may use a refractory furnace, which does not have the built-in tubes, resulting in a less efficient heat exchange.

Materials such as ferrous metals can be reclaimed from the waste stream before or after combustion. The quality of the recycled product tends to be higher when it is removed at the source prior to burning. There are several precombustion materials recovery systems on the market, although their use is still somewhat limited. Typically, materials reclamation efforts at MWC facilities use magnetic separators to remove ferrous metals at the back-end of the combustion train.

The ash residue of municipal waste incineration has two components: bottom ash and fly ash. Bottom ash is that portion of the unburned waste that falls to the bottom of the grate or furnace. Fly ash consists of small particles which rise from the furnace during burning. They are removed from the flue gases by use of air pollution control equipment such as fabric filters and scrubbers. Fly ash is environmentally the most hazardous portion of the residue, containing concentrations of heavy metals and organic compounds [14].

Although the volume of the raw solid waste is usually reduced by up to 90% by mass burning processes, typically ash can comprise up to 25% of the input waste by weight due to the water absorbed during the ash quenching process. Other residue such as scrubber sludge and bypassed materials are either recycled or disposed in a landfill.

Modular mass burning facilities have one or more small-scale combustion units to process smaller amounts of waste, usually less than 200 tpd. These units are mainly prefabricated and can be shipped fully assembled or in modules to the site. Many modular units recover heat from the hot flue gases and produce steam. A two-chamber design is used. The flue gases that are not completely burned in the first chamber are channeled into a secondary chamber where final combustion occurs. The steam can be sold directly to a customer or used to generate electricity. Often, the two-chamber combustion design does not have any additional air pollution control devices to mitigate air pollution.

Refuse-derived fuel technologies (RDF) employ a two-stage production–incineration system. Wastes are preprocessed to produce a more homogeneous fuel product than raw MSW. The RDF can be sold to outside customers or burned on site in a dedicated furnace. The refuse is usually dried and shredded to reduce particle size for burning in semi-suspension or suspension-fired furnaces. Ferrous metals can be recovered using magnetic separators and glass, grit and sand may also be removed by screening. In some RDF plants, air classifiers, trommel screens or rotary drums are used to further process the solid waste.

Several more complex RDF processes have been developed which create powdered, pelletized, 'wet pulped' and gasified fuel products. The application of these technologies has generally not been successful. The most promising of the new RDF technologies is the use of fluidized-bed furnaces which are more efficient and less polluting than conventional boilers. RDF has been successfully co-fired with coal and in some instances sewage sludge.

Pyrolysis and anaerobic digestion are two other technologies which have been tried using municipal waste as a feedstock. These have not been successful on a commercial scale.

3.3.2. Type of process

There has been some change in the type of processes used over the 1982–1992 time period. Table 4 groups projects by three major technologies: (1) mass-burn in which the garbage is burned in a specially designed waterwall boiler, refractory furnace, or rotary combustor; (2) refuse-derived fuel (RDF) technologies in which wastes are shredded, pelletized or densified for use as a fuel either in a dedicated boiler or as a supplemental fuel in a conventional utility boiler; and (3) modular

Table 4
Percent of facilities by technology by year

Technology	Year					
	1982	1984	1986	1988	1990	1992
Mass burning[b]	46.6[a] (17)	40.7 (46)	46.4 (77)	47.8 (96)	52.0 (105)	51.5 (88)
RDF[c]	27.3 (24)	23.9 (27)	18.1 (30)	17.9 (36)	21.3 (43)	21.6 (37)
Modular	26.1 (23)	35.4 (40)	35.5 (59)	34.3 (69)	26.7 (54)	26.9 (46)
Total % (Total #)	100.0%[d] (88)	100.0% (113)	100.0% (166)	100.0% (201)	100.0% (202)	100.0% (171)

[a] Percentage of column.
[b] Mass burning includes waterwall and refractory furnaces, as well as co-disposal with sludge and tire burning facilities.
[c] RDF includes all types of RDF processes such as fluff, coarse and pellets.
[d] Percentages may not add up to 100 due to rounding.

incineration in which the refuse is burned in a small, prefabricated unit. The few projects employing other technologies such as pyrolysis have not been included in this table.

As can be seen, reliance on the mass burning process has grown. In the mid-1980s, this technology was used in about 46% of all projects. As of 1992, this percentage has grown to 52%. Modular incineration is now the second most frequently used process, found in 27% of the projects. Its use, however, peaked in 1988 and has been declining since that time. Very few modular units are currently in planning and several have been closed since 1988. Most of these plants did not have air pollution control devices, relying on their after-burn or two-chamber design for emissions control. In addition, retrofitting modular units to meet best available control technology (BACT) is often uneconomic. RDF technologies appeared to have reached a plateau of about 22% of all projects. These processes incorporated front-end materials separation into their designs and were once viewed as a low-cost, low maintenance alternative to mass burning. However, many RDF plants have had problematic operating histories.

3.3.3. Air pollution control technologies

Air pollution control (APC) is an aspect of the technology of a facility. The type of equipment has become more sophisticated since 1982, as technological applications have advanced and the number of regulated air pollutants has grown. The data in Table 5 illustrate the changes in APC technologies. In 1982, the predominant type of equipment was electrostatic precipitators (ESPs), used in 59% of the reporting facilities. From 1984 on, however, reliance on ESPs began to drop. By 1992, only 40% of the plants were using or planning to use this type of APC technology.

Similarly, the after-burn or two chamber system, incorporated in the design of the modular projects, has declined in usage. In 1982, 19% of the facilities had this type of system in place; by 1992, this percentage had dropped to 9%. Many of these small-scale MWC projects had closed by the early 1990s, removing this type of air pollution control.

The technology showing the greatest increase in use is the dry scrubber/baghouse (fabric filter) combination. Baghouses were employed by only 17% of facilities in 1982 and are now in one-half of the advanced planned and existing projects. A similar dramatic increase has occurred with dry scrubbers which were used in only 6% of projects in 1982. By 1992, they were found in 51% of all projects. The scrubber/baghouse combination is considered by the US EPA to be the most effective means to remove both particulate emissions and acid gases [15]. In addition, states such as California, Connecticut, Michigan and New York consider scrubber/baghouses to be best available control technology.

Table 5 also illustrates the growth of NO_x and mercury control. By 1992, NO_x and mercury control systems were found in 18% and 6.4% of the plants, respectively. Certain states are requiring both NO_x and mercury control equipment in all new facilities. It is expected that current federal Clean Air Act regulations will mandate these systems in all MWC facilities processing 250 tpd or more [16].

Table 5
Percent of facilities using air pollution control equipment by year

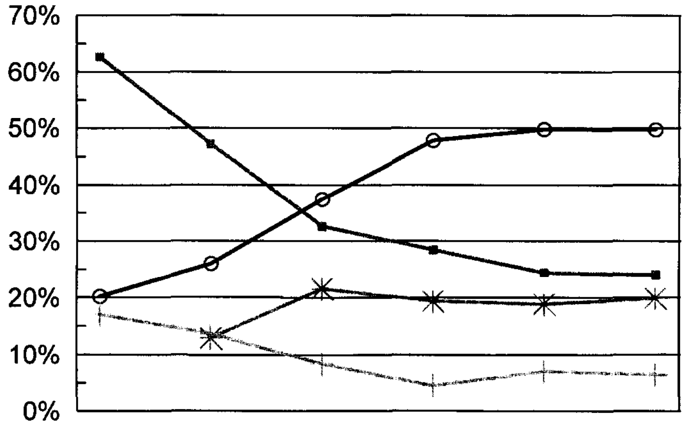
APC equipment	Year					
	1982	1984	1986	1988	1990	1992
Electrostatic precipitators	59.0[a] (49)	52.7 (59)	46.2 (79)	41.3 (83)	36.5 (72)	40.4 (69)
Baghouse or fabric filter	16.9 (14)	16.1 (18)	34.5 (59)	44.3 (89)	53.3 (105)	50.3 (86)
Dry scrubbers	6.0 (5)	8.0 (9)	35.1 (60)	43.3 (87)	51.8 (102)	50.9 (87)
Wet scrubbers	7.2 (6)	4.5 (5)	5.3 (9)	3.0 (6)	4.6 (6)	6.4 (11)
After-burn or two-chamber system	19.3 (16)	14.3 (16)	15.2 (26)	12.4 (25)	10.7 (21)	9.4 (16)
NO_x control	0.0 (0)	0.9 (1)	1.8 (3)	2.5 (5)	14.7 (29)	17.5 (30)
Mercury control	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	6.4 (11)
Other technology	1.2 (1)	0.9 (1)	4.1 (7)	2.5 (5)	2.5 (5)	1.8 (3)
Nothing used	4.8 (4)	6.3 (7)	4.7 (8)	3.0 (6)	4.1 (8)	2.9 (5)
Total % (Total # of facilities)	114.5% (88)	103.6% (113)	146.8% (166)	152.2% (201)	178.2% (202)	186.0% (171)

[a] Percentages were derived by dividing the number of responses by the number of projects reporting air pollution control data for each year. Up to three types of pollution control equipment were recorded for each plant.

3.3.4. Energy product

The main types of fuel generated at MWC projects are electricity, steam, a combination of electricity and steam, and refuse-derived fuel. As shown in Fig. 2, there has been a steadily increasing percentage of projects producing electricity as the main energy product. In 1982, only 20% of the plants generated electricity as the primary energy product, but by 1992, this percentage increased to 50%. Growth came at the expense of steam producing facilities. The proportion of these facilities dropped from 63% of the sample in 1982 to 24% in 1992. Projects co-generating electricity and steam comprised a steady 19–22% of the sample since 1986. The proportion of plants that only produce RDF for off-site customers has declined steadily from 17% of the sample in 1982 to only 6% in 1992.

There are several explanations for this trend toward electricity production. While generating equipment adds to an MWC plant's initial capital costs, the assurance of a stable utility customer for the electricity (as a result of PURPA) is helpful in



YEAR	1982	1984	1986	1988	1990	1992
Electricity Only	20.2%	26.0%	37.4%	47.8%	49.8%	49.7%
Steam Only	62.6%	47.2%	32.6%	28.4%	24.4%	24.0%
Electricity & Steam	N.A.	13.0%	21.6%	19.4%	18.9%	19.9%
RDF	17.2%	13.8%	8.4%	4.5%	7.0%	6.4%

Fig. 2. Percent of projects by primary fuel product: 1982–1992.

securing financing and ensuring an adequate cash flow for the project. Once generated, electricity is easily transportable. Steam production is only viable when there is a nearby steam customer.

3.4. Project financing

3.4.1. Capital costs and financing

On average, the capital cost in 1993 dollars of a MWC facility is about $104 000 per daily ton processed. Planned sites have a higher capital cost than existing ones, $146 000 per ton versus $96 000. Furthermore, of the 145 existing sites, 61 have reported additional capital cost expenditures for plant modifications. These modifications have averaged a total of $17 000 000 (1993 dollars) per facility or $21 600 per ton. Modifications are for boiler retrofits and air pollution control upgrades. Prior to the enactment of the 1986 Tax Reform Act, MWC projects could be financed using tax-exempt revenue bonds. These bonds were secured by the project revenues obtained from tipping fees and energy revenues. Often a public authority issued the bonds, allowing a private firm which owned and operated the facility to take advantage of a low-cost capital investment. After 1986, it became more difficult to use tax-exempt financing as numerous limitations were placed upon this type of underwriting. As a result, projects have relied on a variety of new financing instruments including taxable bonds, leases, and a higher level of private equity or, on the contrary, have reverted to a greater degree of public ownership.

Table 6
Average tipping fees by region by year[a]

Region	Year					
	1982	1984	1986	1988	1990	1992
Northeast	$11.82 (22)	$15.62 (29)	$23.32 (53)	$41.88 (63)	$62.34 (62)	$66.67 (57)
South	$7.43 (14)	$13.42 (25)	$16.70 (33)	$25.28 (48)	$37.24 (48)	$45.41 (44)
Northcentral	$8.82 (7)	$13.65 (12)	$17.50 (16)	$29.08 (33)	$46.33 (36)	$53.46 (31)
West[b]	$10.99 (4)	$11.71 (12)	$16.18 (8)	$31.61 (17)	$45.03 (16)	$55.61 (15)
All regions (Total #)	$9.77 (42)	$14.00 (78)	$19.62 (110)	$33.23 (161)	$49.64 (162)	$56.39 (147)

[a] Reflects only those facilities for which tipping fees were reported in dollars per ton.
[b] For the years 1988, 1990 and 1992, does not include a plant in Alaska which charged $270.00 per ton.

3.4.2. Project revenues: electricity rates and tipping fees

Tipping fees: While energy payments represent an important source of revenue for MWC facilities, a large portion of the operating revenue comes from tipping fees. These fees are charged, usually on a per-ton basis, as either a contracted or spot rate to public and private waste haulers. Specifically, the price may be based on a long-term 'put-or-pay' contract between the project operator and users (frequently local governments) or it may be a negotiated spot market rate. In a put-or-pay contract, a supplier must guarantee a certain quantity of waste on a periodic basis or else pay the facility the difference if the specified amount of waste is not delivered. In contrast, a spot rate is a short-term arrangement. The available capacity of the facility has a major influence on the price of spot tipping fees. A plant with excess capacity may try to attract customers by lowering its disposal rates. The spot market rate has actually dipped below the contracted rates in parts of the country.

Table 6 presents average unadjusted tipping fees by region by year. These tipping fees reflect the average rate charged by the plants including both contract and spot rates. Overall, tipping fees have increased more than six times between 1982 and 1992. This trend holds in all regions with the exception of the West, where tipping fees have increased by five and one-half times. Specifically, between 1982 and 1992 tipping fees at MWC projects in the Northeast have risen from $11.82 to $66.67 per ton; in the South, from $7.43 to $45.41; in the Northcentral region, from $8.82 to $53.46; and in the West, from $10.99 to $55.61.

While tipping fees have increased substantially beyond the rate of inflation over the past 10 years, the rate of increase has been dropping. This trend is illustrated graphically in Fig. 3. The economic slowdown of 1989–1992 resulted in a decrease in the amount of commercial and residential refuse generated. In addition, recycling programs have diverted waste from MWC plants, leaving excess capacity. Cheaper

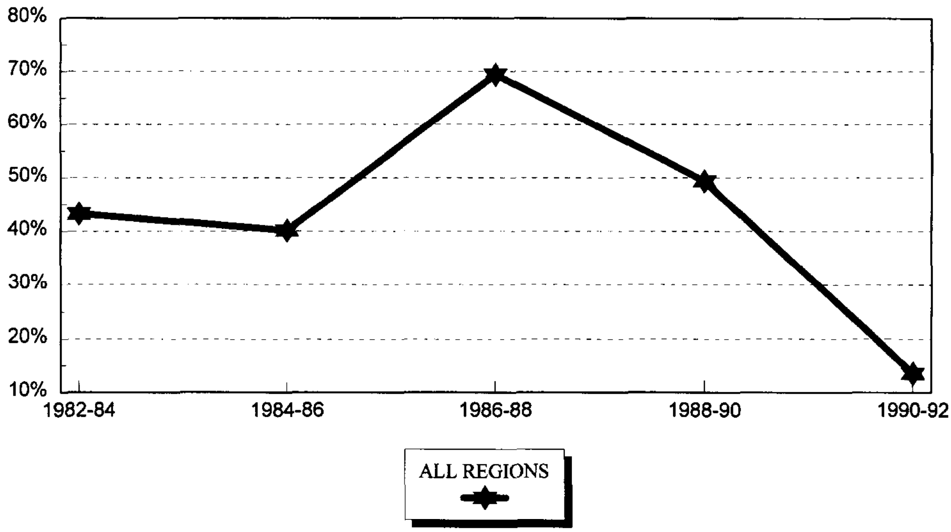


Fig. 3. Percent change in average tipping fee: 1982–1992.

Table 7
Average cents per kwh by region: 1988, 1990, 1992

Region	Year		
	1988	1990	1992
Northeast	7.19 (51)	6.86 (49)	6.75 (47)
South	3.36 (25)	3.49 (25)	3.15 (24)
Northcentral	4.39 (15)	4.69 (16)	4.84 (14)
West	6.00 (13)	5.96 (12)	6.43 (11)
All regions (Total #)	5.80 (104)	5.59 (102)	5.53 (96)

landfills are also competing for waste. Thus, while the average tipping fee charged at MWC facilities increased in each 2 yr period between 40 and 70%, by 1992 the rate of increase had dropped to 13.6%.

3.4.3. Electricity rates

The data on contracted electricity rates also reveal a downward trend for the years 1988–through 1992. As shown in Table 7, the average price of electricity received by MWC plants in cents per kilowatt-hour (cent/kwh) was 5.53 cents by the end of 1992. This represents a 4.7% decrease from the 5.80 cent/kwh reported in 1988. In the Northeast rates fell by 6.1%, while in the South the drop represented 9.7%. On the other hand, the relatively few MWC projects in the Western and Northcentral regions have reported that electricity rates have actually increased slightly since 1988.

3.5. The role of the private sector

The private sector has been prominently involved in the MWC since its evolution as a disposal technology. Given the changing regulatory involvement and the maturation of certain technologies, a market shift with respect to public and private sector responsibility can be observed.

In the most simplified terms, a project can be owned and operated by the public or private sector. Three major arrangements are possible. A facility can be owned and operated by the public sector, meaning a government or public authority, or by the private sector, meaning one private firm or a joint venture of firms. Projects can be owned by the public sector and operated by the private sector or there can be other combinations of joint public/private sector involvement. For example, a public authority may hold tax ownership and a private firm may lease the equipment and operate the plant. Often private firms have long-term, full-service contracts with public authorities, with contractual responsibility for the facility from development and construction through operation for a period of 20–25 years.

As Fig. 4 shows, in 1982 most projects were publicly owned and operated. During this time, federal grants were available to local units to experiment with emerging MWC technologies. By 1986 and 1988, privately owned and operated plants were in the majority. Interestingly, in 1992, the percentage of publicly owned and operated

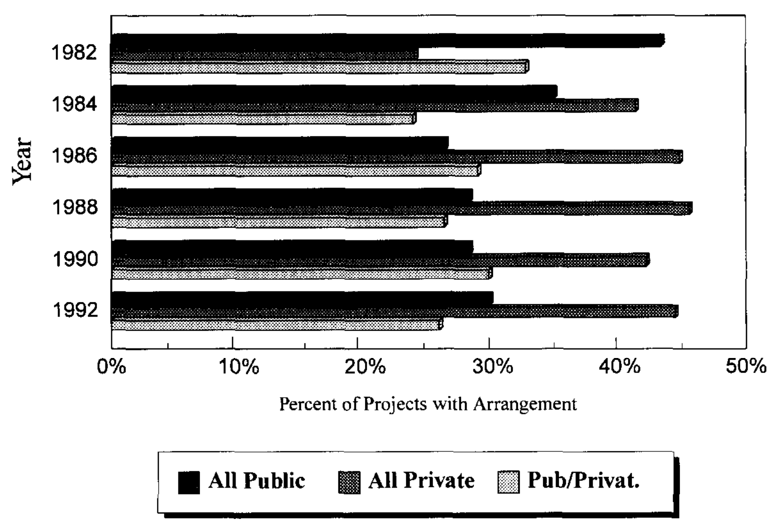


Fig. 4. Extent of public/private sector participation in plant ownership and operation.

projects had risen to a 6 yr high. This may be the result of tax reform and the need of local governments to ensure control of the waste stream within their boundaries.

The number of different private firms developing and operating projects has decreased dramatically. Companies have declared bankruptcy, merged with other firms, or exited the MWC industry. The reasons for this decrease include the economic slowdown of 1991–1993, the difficulty of siting a plant and the decline in profitability. As of 1993, two firms have 51% of the market share in the industry according to total design capacity of projects in planning, under construction and in operation. By way of contrast, in 1990 the same two firms controlled 37% of the market and in 1988 their share was about 35%. The result of this trend is a more concentrated and mature industry with a lowered degree of competition for new projects.

4. Conclusions

Over the past 4 years, there has been a slowdown in the implementation of MWC projects. The political, regulatory and public policy environment has changed, no longer providing the incentives to MWC that once existed. The number of planned projects in the pipeline has decreased. Project electricity revenues have declined and tipping fees increases have slowed, negatively affecting the economic viability of many facilities. On the positive side, a number of proven combustion methods have successfully been implemented. In addition, many operational MWC facilities have significantly upgraded their APC technologies and are now an environmentally acceptable and essential part of the solid waste disposal system of the United States.

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