Chapter 2

INCINERATION, THE SOLUTION TO THE GROWING SOLID WASTE PROBLEM?

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As the Bay Area's population and industries grow, so will the production of solid waste. This will increase the flow of waste going into already burdened landfills. In 1985 there were 26 landfills used by Bay Area cities (Morse, 1985). By the year 2000, only half of these will remain open for waste disposal. Other areas throughout the United States are faced with similar problems with landfill sites.

As landfills fill to capacity and close, their wastestream must be diverted to other landfills, which then reach their capacities at a faster rate. New landfills become necessary, but the problem is where to locate them. Because few people want to live or work near landfill sites, they will have to be located further from solid waste sources. The new landfills will have to be larger and will cost more to construct (Morse, 1985). They will take up space that may be needed in the future for housing, development or open space. With the increasing burdens on landfills, people are looking into ways to reduce the flow of solid waste. Recycling and composting programs have been implemented to decrease waste flows, but a significant flow still exists. Now many cities are looking towards incinerator (waste-to-energy) systems to reduce dramatically the waste flow (Savage, 1986).

Waste-to-energy systems accomplish two tasks. They reduce the bulk of solid waste by turning it into ash, and in the process they produce steam energy. This energy can be sold to energy markets, producing an income for the system.

One of the insoluble problems with waste-to-energy systems is that once the material is put in and turned into energy, it is lost as a future resource. Other problems include hazardous air emissions, reliability, disposal of the ash, and costs of the system. At the present time many companies are working to solve these problems, but there is a question of whether the costs of incinerators will outweigh the benefits.

In this report I will discuss some of the problems with incinerators, such as the use of municipal solid waste as an energy source, disposal of ash, hazardous emissions and control technologies. Recycling and Pyrolysis Gasification will be investigated as alternatives to incineration. By looking at the main alternatives and some of the problems of waste-to-energy systems, I will attempt to determine the practicality of incinerator units.

Waste Stream

The major problem with using municipal solid waste as a fuel source is its non-uniform composition. The inconsistency is due to the variety of sources and types of waste. This variability makes municipal solid waste a low-quality fuel source (Smith, 1986).

It is necessary to determine the composition of municipal solid waste in order to better understand how it will react as a fuel source. In the past 15 years, studies of the waste stream have given a much better understanding of the composition of municipal solid waste. A recent study analyzed waste stream samples from residential, commercial and industrial sources, and the types of waste were classified. Mixed paper and corrugated materials are a major component of all three sources (Table 1) (Savage, 1986).

Component	Residential	Commercial	Industrial
Mixed paper	20	25	15
Newsprint	15	8	4
Corrugated	15	17	12
Plastic	9	10	6
Yard waste	11	3	3
Food waste	10	11	6
Wood	1	3	17
Other organic	1	6	7
Ferrous metals	4	6	9
Aluminum cans	1	1	1
Glass	11	7	5
Other inorganic	2	4	15
TOTAL	100	100	100

Table 1. COMPOSITION OF MUNICIPAL SOLID WASTE (in % of total waste stream). Source: Savage, 1987

Another problem with municipal solid waste is that the composition is constantly changing. In the past five years the flow of plastics has almost doubled and continues to rise daily (Smith, 1986). This is primarily due to the increased use of plastics by the commercial and industrial sector (Savage, 1986). Along with daily variation of the waste stream are seasonal changes due to the increase of yard waste in the spring and summer (Oswald, 1986).

Different types of materials have different combustion rates. The more energy required for combustion, the higher the combustion rate. The lower the quality of the fuel source, the less heat released by combustion, and the less energy produced (Smith, 1986). Products such as paper, newsprint, plastics, wood, and rubber products are all relatively combustible (low combustion rates). Glass, metals, ceramics, rocks, and most yard waste (soil) have high combustion rates.

Another problem with municipal solid waste is that it has a high moisture content. Most of the moisture comes from food waste. It requires a high energy input to evaporate moisture from solid waste (about 590 calories to evaporate 1 gram of water) (Oswald, 1986). Once the evaporation level has been reached, it requires more energy to evaporate the remaining moisture (Oswald, 1986).

When water is released from waste, there is a large temperature drop (from 500°F to 200°F in some cases) (McDonald, 1986). This sudden change in temperature creates pressure changes that led to explosions in many of the early and a few of the present incinerator systems (Oswald, 1986). The temperature drop also increases the amount of primary air pollutants and other toxic gases. When the temperature drops below 200°C, primary air pollutants can be expected to increase 46% to 63%. Hydrocarbons and toxics will increase 60% to 70% (McDonald, 1986).

To combat the temperature variations due to moisture, the waste can be dehydrated before it goes into the waste-to-energy system. About 88% to 90% moisture removal is needed to ensure that a large temperature drop will not occur. The problem with dehydrating is its high cost and high energy demand (Oswald, 1986).

Ash

A byproduct of waste-to-energy systems is ash, which often contains high concentrations of heavy metals, creating problems with disposal. If the ash is determined to be a toxic waste, it must be disposed of in a Class II landfill, which is more expensive to build and costs more to use than a primary, or Class I, landfill. At present there are three Class II landfills in California, making transportation a major cost of toxic waste disposal (Thomas, 1986).

Removing heavy metals either before or after incineration can reduce the toxicity of the ash enough to permit it to be disposed of in a primary landfill. The most effective means of metal removal is magnetic separation of the waste. This method is presently in operation in Madison, Wisconsin, where it has been very effective (Smith, 1986). The waste is first compacted, then sent through a shredder that cuts the waste into two and three foot size blocks. Then the blocks are separated by magnets to remove metals. This system has been the most effective at removing metals from the waste stream (about 94% metal removal in the Wisconsin unit). The problem with magnetic separation is the high cost of construction and high energy usage (Smith, 1986).

A similar way to remove metals is to use magnetic separation on the ash. In this process the ash is screened, then sent through the magnet for separation. The disadvantage of this system is that some of the metals are lost during incineration and can't be recovered. Other problems include cost, uncleanliness, and system inefficiency (Smith, 1986).

Metals can also be removed from the waste system by hand. Aluminum cans, tin, and other metals can be removed, then sold to recycling markets. The problems with this kind of presorting system are the high cost of labor and equipment and the possibility that some of the metal may be overlooked. Even though this system is not as effective as magnetic separation, it costs less (Relis, 1986).

Emissions

A major problem with waste-to-energy systems is their emissions. The burning of organic material produces carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides, hydrocarbons, organic gases, particles and acids. Hydrocarbons react with nitrogen dioxide in the presence of sunlight to form ozone (the main component of smog). Smog causes visibility reduction, damage to vegetation, eye irritations, and it aggravates respiratory diseases (BAAQMD, 1986).

One of the most toxic substances to human health, dioxin, is produced in moderation by incinerator emissions. In the atmosphere, dioxins are broken down into less toxic substances by sunlight (Thomas, 1986). The second most toxic pollutant from incinerators are furans (about six times less toxic than dioxins), which are produced in larger amounts than dioxins (Ziemer, 1986). Levels of furans are especially high when combustion temperatures are low (below 1200°F) (Ziemer, 1986).

Another emission of great concern is acids that corrode materials in the outside environment, have adverse health effects and damage the waste-to-energy system. A system in Concord, that cost almost $500,000, was made inoperable due to acids that corroded its walls. A similar problem occurred in Richmond where acids destroyed an incinerator in less than two years (Oswald, 1986).

Control Technologies

Due to concerns about air pollutants from incinerators, various control technologies have been developed. The most commonly used technology is baghouses for particulate control and dry scrubbers to control acid emissions. Electrostatic precipitators using electrically charged plates to collect particles are being developed, but presently are not efficient or economical (Donnelly, 1986).

A baghouse is a series of fabric bags set along the route of the flue gas (the gas that leaves the system out the smoke stack). The problem with baghouses is that the fabric bags can break, leak or clog. Another problem is that they collect salts and flyash and require special disposal (Slakey, 1986).

To test improvements in baghouse performance, experiments were conducted at the Monticello generating station in Texas (Duncan, 1986). It was determined that the tighter the fabric texture, the greater the removal of particles. NH_3 injection into the flue gas also reduced particle penetration. The problem with using a poisonous catalyst such as NH_3 is that serious pollution problems can occur if it is not broken down in the combustion process. The best results were from a Gore-Tex laminate bag that essentially prevented particle penetration. The problem with the Gore-Tex system is its high cost (Duncan, 1986).

Baghouses are often used with dry scrubbers to remove HCl and SO_x. Dry scrubbing consists of spraying the flue gas with lime (a sodium-based reagent). Baghouses and dry scrubbers are capable of 98% or higher removal of particles, about 80% SO_x and HCl removal, but only 40% removal of NO_x (Jones, 1986).

A new control system has been developed called the BTU process (Jones, 1986). The operation involves injection of a proprietary material into the furnace along with a wet scrubbing process. The proprietary material converts NO to NO_2 without undesirable byproducts. The wet scrubber sprays hydrated lime, which traps gas and particulates. The wet scrubber allows for better condensation due to cooler temperatures of the wet spray compared to dry spray (from dry scrubbers). Removal of NO_x is expected to be from 70% to 90% effective, along with high removal of SO_x, HCl and other acids. Problems with the system include production of a wet sludge that must be sent back through the incinerator, increasing energy usage. This system doesn't remove particulates as effectively as baghouses (Jones, 1986).

Alternatives

The three main alternatives to incineration of municipal solid waste other than landfill are composting, recycling and Pyrolysis Gasification. Composting is the biological reclamation of solid waste, but there are few markets for composted materials (Oswald, 1986).

Recycling

The advantage of recycling over waste-to-energy systems it that the resource is reused instead of being used as a one-time energy source. Recycling also reduces the volume of the waste being processed, decreasing the burden on landfills. The main problem is finding markets for the recycled materials (Savage, 1986).

Presently the largest market is for aluminum (Smith, 1986). Markets also exist for glass, tin, newsprint, and corrugated materials. Limited markets are available for mixed paper, yard waste, plastics and wood waste. Most of this waste is produced by commercial and industrial sources (Table 2) (Savage, 1986).

The City of Berkeley did a feasibility study on increasing recycled material and set a goal of 50% recycling by 1991 (Savage, 1986). According to the report, a conveyor belt-sorting system would produce a 30% recovery at a profit of $1/ton. A maximum of 43% recovery could be achieved with a factory-type shredding, sorting and magnetic recovery system, but at a cost of $2/ton. At present the city recycles about 15% of its municipal solid waste with a voluntary recycling system (Savage, 1986).

Material	Markets	Pollutants	Primary Sources
Tin cans	Existing	Pb, Sn, Cr	Residential/Commercial
Glass	Existing	None	Residential/Commercial
Aluminum	Existing	Cr, Pb	Residential
Newsprint	Existing	Cr, Pb, Zn	Residential
Corrugated	Existing	Cr, Pb, Zn, Cl	Commercial/Industrial
Mixed paper	Limited	Cr, Pb, Zn, Cl	Commercial/Industrial
Compost	Limited	Cl	Residential
Wood waste	Limited	None	Industrial
Plastics	Limited	Cd, Cr, Pb, Cl	Commercial/Industrial

Table 2. POTENTIALLY RECYCLABLE MUNICIPAL SOLID WASTE COMPONENTS
Source: Savage, 1986

Recycling can work with and against waste-to-energy systems. By recycling, a fuel source is being removed from the waste stream. If too much of the fuel source is recycled, then it becomes uneconomical to use waste-to-energy systems, because the cost of running the system is higher than the income produced by steam energy (Relis, 1986). Recycling helps incineration by removing materials with low combustion rates and problem metal from the waste stream, increasing its combustability (Savage, 1986).

A unique system is now being developed in San Marcos, California, that involves a combination of recycling and a waste-to-energy system. The company has backed its system with a money back guarantee. A magnetic shredder will remove the metals, newspapers will be removed and recycled, and plastics will be sent to a recycling plant, then made into polyethylene. However, when the price of recycled newspaper falls below $42/ton, then it becomes more economic to burn it, and it will go to the waste-to-energy system to produce energy. Of the 23,000 tons/day of waste produced by San Marcos, 15,000 tons will be burned to produce energy (Relis, 1986).

Pyrolysis Gasification

Pyrolysis Gasification is similar to incineration, but differs in that it is a closed system, with no interaction with the outside environment. The system is designed to take advantage of four factors: time, temperature, mixing and recombination.

The waste is first placed in a stainless steel system and heated to 600°C. It is then transferred to the pyrolysis unit, after the air has been removed from inside the system, then is heated to 1200°C. The high temperature creates turbulence that allows for recombination of the partially-decomposed compounds with oxygen, which is added to the system along with the system along with the waste. The compounds are continually broken down until only water vapor, carbon monoxide, hydrogen gas and a salt compound remain (Figure 1) (Thomas, 1986).

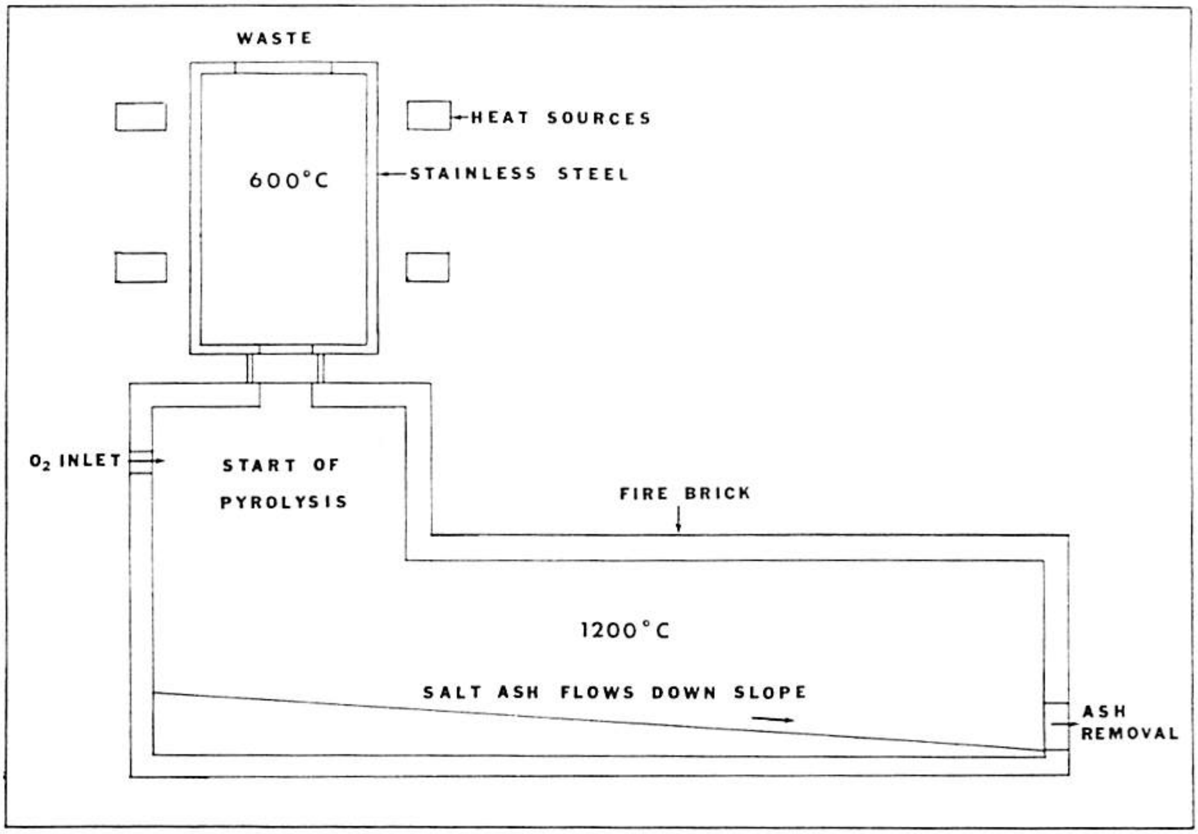

Figure 1. THE PYROLYSIS GASIFICATION SYSTEM
Source: Thomas, 1987

The reason that there is such a good breakdown of pollutants is that the system can be run for long periods of time because there is no place for the pollutant to leave the system. The emissions from Pyrolysis (carbon monoxide and hydrogen gas) can be collected and used as a fuel source (Thomas, 1987). The disadvantage of the system is that the high temperatures and pressure deteriorate and crack the brick walls of the system. Further study is needed to find suitable material that is both economical and reliable for the walls (Thomas, 1986).

Summary and Recommendations

There are both advantages and disadvantages in using waste-to-energy systems to reduce the flow of municipal solid waste. These systems reduce the amount of material going into landfills and produce steam energy. Problems with incinerators include using municipal solid waste as a fuel source, reliability, cost of purchasing, maintaining and operating the system, hazardous emissions and disposal of the ash. Once a material is burned in a waste-to-energy system it is lost as a future resource. Burning of materials produces CO_2 and will add to problems with global warning. In areas where air pollution is a problem, incinerators will make it more difficult to meet air quality standards.

Alternatives for reducing the waste stream include composting, recycling and Pyrolysis Gasification. Recycling and composting offer the advantage of reusing resources, but markets must be found for the recycled materials. With Pyrolysis there is greater breakdown of pollutants than with incinerators, but at present more research is needed before it can be considered for solid waste disposal.

There is no simple solution to the municipal solid waste problem. I believe the best way to reduce the waste flow is recycling. By increasing recycling programs, using less packaging and more reusable containers, and by replacing recyclable materials for unrecyclable ones, a large reduction in the waste stream can be achieved. The only way a recycling program will work is if the private, public, and governmental sectors cooperate and support it. The government must take the first action by supporting the programs with funding and laws (such as the Bottle Bill). There must be incentives such as tax breaks for the private sector to ensure their support of the program. I don't believe that all the waste stream will ever be recyclable due to economic problems and the lack of markets for some of the materials.

Incineration and Pyrolysis Gasification are practical for the disposal of toxic waste, but not presently reliable or safe enough to be used on municipal solid waste. Recycling will give decision makers and scientists time to investigate and develop a safe and reliable system to dispose of the unrecycled waste.

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