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Region VIII
1860 Lincoln Street
Denver, Colorado 80295

MARCH, 1982

Solid Waste

EPA

A TECHNICAL ASSISTANCE PROGRAM REPORT

WASTE-TO-ENERGY OPTIONS FOR LARIMER COUNTY, COLORADO

A TECHNICAL ASSISTANCE PANELS PROGRAM REPORT:

WASTE-TO-ENERGY OPTIONS FOR LARIMER COUNTY, COLORADO

Prepared for:

U.S. Environmental Protection Agency

Region VIII

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ENVIROMENTAL PROTECTION AGENCY REGION VIII

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Technical assistance by personnel teams. 42 USC 6913

RESOURCE RECOVERY AND CONSERVATION PANELS

SEC. 2003. The Administrator shall provide teams of personnel, including Federal, State, and local employees or contractors (hereinafter referred to as "Resource Conservation and Recovery Panels") to provide States and local governments upon request with technical assistance on solid waste management, resource recovery, and resource conservation. Such teams shall include technical, marketing, financial, and institutional specialists, and the services of such teams shall be provided without charge to States or local governments.

This report has been reviewed by the Project Officer, EPA, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Project Officer: William Rothenmeyer

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EXECUTIVE SUMMARY

Fred C. Hart Associates (FCHA), under contract to the Region VIII office of the U.S. Environmental Protection Agency, conducted a preliminary evaluation of the solid waste management system in Larimer County, Colorado, and an assessment of the potential for incorporation of a waste-to-energy resource recovery facility. The evaluation consisted of estimating solid waste quantity and composition, determining seasonal generation patterns and assessing collection, transportation and disposal practices. Several sites were considered as possible locations for modular or waterwall incinerator facilities. The existence of an energy consumer as well as ease of access, availability of land, proximity to existing steam distribution lines and expected public attitudes were considered for each site.

After completing these evaluations, it was concluded that a waste-to-energy facility is not economically feasible at the present time in Larimer County. The major reasons for this are:

- lack of suitable energy consumers;
- existence of an efficient and comparably low-cost landfilling operation;
- high capital and operating costs of incineration facilities; and
- relatively low energy costs.

A brief review of independently-developed cost figures for construction and operation of a waste-to-energy facility performed by the Platte River Power Authority corroborated the FCHA finding that waste-to-energy is not currently feasible on economic grounds.

The study further determined that changing conditions in the future may combine to create a favorable climate for the installation of a waste-to-energy plant in Larimer County. Also, present and future recycling activities are desirable rather than detrimental in terms of waste-to-energy feasibility

because these programs may be integrated into a diversified waste management system which can optimally utilize waste stream components with regard to current market and technology conditions.

The process of studying the solid waste management system in Larimer County pointed out a need for current, accessible local solid waste data for planning purposes. As a result, remaining funds were utilized to prepare a recommended solid waste data management system for the county to begin compilation of needed statistics.

INTRODUCTION

The purpose of this report is to present a preliminary evaluation of alternative systems that could be used by Larimer County to retrieve usable energy and/or materials from the controlled burning of solid waste. Resource recovery technologies such as source separation recycling, composting and methane recovery, though also potential alternatives, were not considered since the project scope was limited.

The study assesses available solid waste data in the County and consolidates this baseline information. For example, per capita solid waste generation rates, waste volumes entering the County landfill, costs associated with collection and disposal, and costs associated with resource recovery were estimated to the level of accuracy permitted by existing records. Sites were investigated to determine their suitability for location of either a modular or waterwall incinerator facility. These two waste-to-energy technologies were chosen for specific study as national operating experience has indicated that modular and waterwall incineration would be most appropriate for the Larimer County area. This study represents an initial feasibility assessment to determine whether waste-to-energy should be examined in greater detail as a solid waste management tool and conservation strategy at the present time in Larimer County. Much more specific analysis of the individual options will have to be performed prior to a decision to implement a resource recovery project.

Nationally, public demands for mitigation of negative impacts of existing solid waste management practices, particularly landfilling, were formalized in the Resource Conservation and Recovery Act (RCRA) of 1976. Specifically, Subtitle B, Section 2003 of RCRA charges the Environmental Protection Agency (EPA) to provide technical assistance to federal, state, and local governments in the area of solid waste management, resource recovery, and resource conservation.

In January, 1979, Larimer County Commissioners began the process of investigating the feasibility of energy recovery from solid waste generated in the County. This resulted in a request by the Larimer County Health Department for technical assistance from the EPA in more fully examining resource recovery options. The request was approved by the EPA and Fred C. Hart Associates, Inc. (FCHA), EPA's Region VIII Technical Assistance Panels contractor, was authorized to begin work on the project. Work commenced July, 1981.

BACKGROUND

Some key variables that affect the waste stream available for a resource recovery system need to be identified and the level of documentation for each assessed before a preliminary assessment of resource recovery can be attempted. These variables include: 1) the study area, 2) the study area population and expected growth, 3) waste generation rates, 4) waste load, 5) waste composition, and 6) facility start-up-date.

STUDY AREA

The study area, as defined in the scope of work, includes the service area of the Larimer County landfill near Ft. Collins. Presently, this encompasses the whole County except for a small population using the Wellington landfill and a larger number of residents and tourists utilizing the Estes Park landfill. There is a possibility that both of these landfills will close during the twenty year study period and the solid waste loads will be diverted to the County landfill. The solid waste load from the Wellington area is negligible relative to the County's total waste load (approximately 1 percent). The waste load from the Estes Park landfill, while more substantial, would not be enough to significantly affect the feasibility of a resource recovery system. Therefore, for the purpose of this study, the study area has been assumed to include the areas currently using the County landfill.

POPULATION

Population figures used in this study were obtained from the U.S. Census Bureau and various local planning agencies. As in many other places in the country, Ft. Collins officials question the accuracy of the 1980 census results. Evidence to support the city's contention that the population of Ft. Collins is substantially higher than the number reported by the Census Bureau is being prepared. The city has considered bringing suit against the U.S. Census Bureau but has taken no legal action to date. Loveland officials also question the census figures but plan no formal objection. For the purposes

of this study, the population figures generated during the 1980 Federal Census count were utilized. The purported discrepancies in the population figures for these two cities will not substantially affect the results of this study.

Larimer County has experienced widely variable rates of growth throughout its history. The absence of a steady trend makes predicting future growth difficult. Projected growth rates supplied by the cities of Ft. Collins and Loveland and the Larimer-Weld Regional Council of Government were applied to the 1980 figures to generate future population characteristics in the County (see Table 1).

According to the U.S. Census Bureau, in April 1980, Larimer County had a population of just over 149,000 people. Of this total, 64,600 or 43 percent resided in the City of Ft. Collins, 30,200 or 20 percent resided in the City of Loveland and 48,000 or 32 percent resided in the unincorporated areas of the county. Of this last group, the great majority of that population live in the eastern third of the county. The western two-thirds of the county, exclusive of the Estes Park area, is almost wholly owned by the U.S. Forest Service.

Regional officials expect Larimer County's population to increase by 92 percent during the project period (1981-2001) with even larger gains in Ft. Collins (117 percent) and Loveland (123 percent). This continued rate of population growth requires carefully considered planning and presents the opportunity for innovation in terms of resource use and supplying public services.

One distinctive feature of the Larimer County population is the relatively large number of tourists for several months of the year. It is estimated that the Estes Park area supports a population of 50,000 during the summer months which represents almost a ten-fold increase over the resident population. Rocky Mountain National Park drew approximately 3,000,000 visitors in 1980.

WASTE GENERATION RATES--POUNDS/CAPITA/DAY

The Larimer County Landfill does not have a scale for weighing garbage hauling vehicles. Consequently, it is not possible to precisely determine local

TABLE 1

POPULATION PROJECTIONS FOR LARIMER COUNTY 1981 - 2001

	1980[1]	1981	1986	1991	1996	2001
Berthoud	2,362	2,442	2,889	3,376	3,844	4,478
Estes Park	2,703	2,798	3,337	3,936	4,388	5,187
Area	6,733	6,972	8,327	9,819	10,957	12,950
Ft. Collins[2]	64,632	68,650	88,650	108,650	128,650	148,650
Loveland[3]	30,244	31,647	39,318	48,210	58,520	70,472
Timnath	185	193	234	271	296	338
Wellington	1,215	1,260	1,493	1,686	1,951	2,328
Unincorporated Areas	47,843	48,847	54,040	58,585	62,378	67,198
Larimer County	149,184	155,828	189,961	224,714	260,027	298,651
Landfill Users[4]	141,236	147,596	180,141	213,209	247,119	283,373

Source for all growth rates except footnoted figures: Larimer-Weld Regional Council of Governments Adopted Dec. 7, 1977

1 U.S. Census - 1980 count

2 City of Ft. Collins Planning Department - Kenneth G. Waido, Senior Planner - July 22, 1981 - supplied growth rates.

3 City of Loveland Planning Department - William E. Collins III, Planner II - July 21, 1981 - supplied growth rates.

4 Population of Larimer County exclulding Wellington and Estes Park Area.

waste generation rates. Enough information is available, however, to evaluate the applicibility of published figures on per capita waste generation to Larimer County. Solid waste reference materials report a range of waste generation rates due to the fact that per capita solid waste generation rates are affected by a number of variables.

The most critical of the variables affecting per capita waste generation is whether the study area population is urban or rural. This factor affects the waste generation rate because of the way in which the rate is defined. Solid waste generation rates include household waste plus commercial and industrial wastes. Demolition wastes and bulky goods are typically not included. Since rural areas lack substantial commercial or industrial waste streams, rural waste generation rates are lower than urban waste generation rates. Currently accepted rates are approximately 5.0 lbs./person/day for urban areas and 3.0 lbs./person/day for rural areas.

Other important variables to consider are: the level and type of industrial activity, climatological factors, the existence of unique waste streams, the predominant landscaping styles of the area and the rate of economic growth.

Table 2 lists, in increasing order, examples of waste generation rates and illustrates the range of reported values. The non-local estimates are the result of quantitative analyses. As can be seen from Table 2, local estimates (examples 7 and 8) tend to be larger than the estimates specific to other areas but confidence in these estimates must be tempered by the fact that they are based on the estimated waste load at the Larimer County landfill for which there are no measured data. To determine a reasonable waste generation rate for Larimer County several sources were checked. Landfill operations personnel provided volume estimates which were substantiated by examining dump ticket and cash receipt records at the landfill office. Local haulers were contacted to further verify waste generation and to provide density figures for compacted and uncompacted refuse.

Examples 4 and 9 in Table 2 were derived when records from Loveland were compared with waste generation models from other locales. The City of Loveland operates a municipal garbage collection service for all residential customers

TABLE 2
WASTE GENERATION RATES - LBS./CAPITA/DAY

Example Number	Reported Waste Generation Rates Lbs./Capita/Day	Locale - Source
1	3.5	National - U.S. EPA, 1979
2	3.9	Monroe County, Indiana, 1980
3	3.92	Eagle County, Colorado, 1979
4	4.03	Lower Bound Estimate
5	4.70	Boulder County, Colorado, 1981
6	5.00	Used For Projections In This Study
7	5.32	Larimer County, 1974
8	5.84	Local Estimate, 1981
9	6.05	Upper Bound Estimate
10	6.50	Denver County, Colorado, 1981

(1) Materials and Energy from Municipal Waste
Office of Technology Assessment, U.S. Congress, July 1979
Page 109, 110

(2) Quantity and Composition of Solid Waste in Monroe County, Indiana
U.S. EPA Project, November, 1980
Page 11

(3) Resource Recovery Feasibility Analysis Phase I for Eagle County, Colorado
Franklin Associates, Ltd., July 1980
Page 33

(4) Derived from assumption of Loveland residential waste generation rate of 2.42 lbs./person/day as 60 percent of the total urban rate.

(5) Feasibility Analysis for Resource Recovery from Solid Waste, Volume I
Ralph M. Parsons Company, March 1976
Page 3-1

(6) Resource Recovery Options for Boulder, Colorado.
Fred C. Hart Associates, Inc., October, 1981.

(7) Larimer County Solid Waste Management Plan
Brisco/Maphis Inc., May 1974
Page 31

(8) Based on estimated landfill volumes and 1980 census figures

(9) Derived from assumption of Loveland residential waste generation rate of 2.42 lbs./person/day as 40 percent of total urban rate

(10) The Feasibility of Resource Recovery in the State of Colorado,
Fred C. Hart Associates, Inc. (Unpublished).

within the city limits. Records are maintained on the number of loads of compacted waste which are taken to the County landfill. The city trucks are weighed for a week's time, four times throughout the year to determine average waste density and seasonal variation. As a result, values for residential waste generation are reasonably accurate. In 1981 this amounted to 2.42 lbs./person/day which does not include tree waste, appliances and bulky goods. Several studies have suggested that residential solid waste in a medium to large city represents between 40 and 60 percent of the total waste stream. If residential waste represents 40 percent of the waste stream, the aggregate per capita waste generation rate is 6.05 lbs. per person per day. But, if residential solid waste is 60 percent of the waste stream, the aggregate per capita waste generation rate is only 4.03 lbs. per person per day.

Determining the exact per capita waste generation rate without current weight records of landfilled solid waste is not possible. Taking into account the higher estimates obtained from local officials and by applying the 40 and 60 percent proportions to the Loveland residential rates it was determined that, for the purposes of this study, a county-wide waste generation rate of 5.0 lbs./person/day is a reasonable estimate.

Some studies have predicted increased waste generation rates as a continuation of a trend which was observed during the 1960's and 1970's. Other studies suggest that waste generation rates have leveled off and may decline due to economic pressures to conserve and expanded participation in recycling programs. This study assumes that the present level of waste generation will remain constant throughout the project period.

WASTE LOAD

Using the population and waste generation figures presented in Tables 1 and 2 the total waste load at the landfill can be estimated. These figures are presented in Table 3. This table displays the total county waste load and the portion which is presently being disposed of in the Larimer County landfill. The landfill user population excludes the populations of the Estes Park area and the town of Wellington from the total population because these areas have local landfills for solid waste disposal.

TABLE 3

LARIMER COUNTY PROJECTED WASTE LOAD

	1980	1981	1986	1991	1996	2001
Larimer County Total - Tons Per Day	373	390	475	562	650	747
Larimer County Landfill						
-Tons Per Day	353	369	450	533	618	708
-Tons Per Year	129,200	134,685	164,250	194,545	225,570	258,420

Source: Fred C. Hart Associates, Inc. based on projected population figures in Table 1 and estimated per capita waste generation per day of 5.0 lbs. - expected to remain at the same level throughout project period.

Waste generation exhibits seasonal fluctuation. Typically, waste generation is highest during the summer and lowest during the winter largely due to the presence or absence of yard wastes in the waste stream. Most studies assume a 25 percent seasonal increase or decrease greater or less than the average. Discussions with waste haulers confirmed that this was a reasonable figure. Table 4 illustrates the probable seasonal variations in the tonnage of solid waste entering the landfill if one assumes a 25 percent seasonal difference for the resident population.

WASTE COMPOSITION

Waste composition is a significant factor in assessing the feasibility of waste-to-energy systems. Composition figures provide a basis for calculating the waste stream's heat value as well as providing estimates of the amounts and types of materials physically available for recycling.

As with waste generation, no studies of Larimer County's solid waste composition have been performed, therefore, no specific waste composition figures are available. However, several waste composition studies have been conducted in other regions and these show relatively close agreement (see Table 5). Only the components of paper and yard waste exhibit significant variation. This study has utilized the figures in the last column of Table 5 for analytical purposes. Most of the estimates for this study are simply in the mid-range of reported values. The paper component is slightly higher reflecting the increased impact of Colorado State University's waste stream which contains a very high percentage of paper products.

Municipal solid waste with a composition exhibiting the general proportions shown in Table 5 has an average heat value of 4,500 Btu/lb. This figure is widely accepted in the literature and by incinerator manufacturers. This study utilizes the 4,500 Btu/lb. of solid waste for planning purposes. Waste composition estimates are also useful in determining the volumes of resources being "lost" in the landfill which have the potential to be recycled. However in terms of recycling, even a full scale system would not recover 100 percent of the tonnage of a particular component. Table 6 translates the waste composition results into tons per day and tons per year of lost resources. (1986 is used as

TABLE 4

SEASONAL VARIATION IN THE LARIMER COUNTY LANDFILL WASTE LOAD[1] (TPD)

	1980	1981	1986	1991	1996	2001
Average	353	369	450	533	618	708
Summer	441	461	563	666	773	885
Winter	265	277	337	400	463	531
Variance	88	92	113	133	155	177
Tons Per Year	129,200	134,685	164,250	194,545	225,570	258,420

[1] Assumes 25 percent seasonal variation over the annual average during the summer and 25 percent under the annual average during the winter.

TABLE 5

SOLID WASTE COMPOSITION - PERCENT BY WEIGHT

Components	Regional 1985[1]	Typical 1974[2]	National 1979[3]	Range (Rounded Off)	FCHA Estimate
Paper Products	41.7	55	32.4	33-55	45
Newsprint		12.0			
Cardboard		11			
Miscellaneous		32			
Metallics	9.2	9	9.3	9	9
Ferrous	8.0	7	8.3	7-8	8
Non-Ferrous	1.2	2	1.0	1	1
Glass	9.0	9	10.1	8-10	9
Plastic	5.0	1	3.2	1-5	3
Yard	13.5	5	19.1	5-19	12
Food	12.0	14	16.8	13-17	13
Wood	3.6	4	3.5	4	4
Rubber and Leather	2.8		2.6	3	3
Miscellaneous	1.5	3	1.5	2-9	1
Textiles	1.7		1.5	2	1
Total Percent	100	100	100	100	100

1 Feasibility Analysis for Resource Recovery from Solid Waste, Volume 1, Ralph M. Parsons Company, 1976. (Estimated composition of solid waste for 1985 DRCOG area).

2 Larimer County Solid Waste Management Plan, 1974.

3 USEPA Resource Recovery and Waste Reduction, Fourth report to Congress, EPA Publications SW-600, Washington, D.C. U.S. E.P.A., 1977, p. 18.

TABLE 6

TONNAGE OF RESOURCES IN LARIMER COUNTY'S SOLID WASTE, 1986

COMPONENTS	Percent by Weight	Per Day	Per Year
Paper Products	45	202	73,912
Newsprint	10	45	16,425
Cardboard	9	40	14,782
Miscellaneous	26	117	42,705
Metallics	9	40	14,782
Ferrous	8	35	13,140
Non-Ferrous	1	5	1,642
Glass	9	40	14,782
Plastic	3	14	4,928
Yard	12	54	19,710
Food	13	59	21,352
Wood	4	17	6,570
Rubber and Leather	3	14	4,928
Miscellaneous	1	5	1,643
Textiles	1	5	1,643
TOTAL	100	450	164,250

Source: Fred C. Hart Associates, Inc.

the base year in Table 6 for reasons discussed in the following section). The potential for recovery of some components is much greater than others. However, this provides a baseline by which to measure maximum feasible materials recycling levels.

The waste volume and waste composition estimates are adequate for a preliminary planning effort such as this. However, in the event that waste-to-energy planning proceeds to a more detailed stage, a detailed work survey will need to be conducted to assure the accuracy of the data for more in-depth facility design and financial planning.

FACILITY START-UP-DATE

This study represents a preliminary evaluation of resource recovery in Larimer County. In the event a decision is made to pursue the development of an incineration facility detailed implementation, financial and engineering planning will have to be conducted. Given the preliminary stage of the current planning process, it is unlikely that a resource recovery facility in Larimer County would come on stream in less than five years. Therefore, in making projections of waste quantities for designing systems and for estimating resources recovered, population and waste load estimates are developed for the year 1986.

EXISTING SOLID WASTE MANAGEMENT SYSTEM

At present, virtually all of the solid waste generated in Larimer County is disposed of in one of three County-run landfills. A small amount of waste is being separated into usable materials by individual households and delivered to recycling collection points. Recycling activities will be discussed in another section.

The largest of the three landfills is the Larimer County landfill which is located approximately 2 miles west of U.S. 287, 5 miles south of Ft. Collins and 7 miles north of Loveland. The landfill is jointly owned by Larimer County (50 percent), the City of Ft. Collins (25 percent), and the City of Loveland (25 percent). It is managed by the Larimer County Public Works Department, Solid Waste Department. Area fill with daily cover is the predominant method of operation with trench fill techniques used where appropriate. Equipment in use includes two bulldozers, a compacter, a front-end loader, a blade, and a water truck. The facility consists of 480 acres of which approximately 60 acres have been filled. The landfill is expected to have sufficient capacity to remain open for over 20 years although no detailed growth and volume projections have been compiled to support this projection.

Solid waste loads are not weighed at the landfill since no scales have been installed. Instead, a fee schedule for various vehicles has been developed (see Appendix A). Commercial compactor trucks pay for their loads on the basis of volume at the rate of $.75/yd^3. Commercial haulers and frequent users of the landfill purchase "dump tickets". The gateman punchs out the amount charged to the trucks when they enter the premises. Other users are charged by the gateman on a cash basis according to the fee schedule. The facility is open 360 days a year to receive waste.

It has been estimated that the landfill accepts approximately 2,750 yd^3 of solid waste per day. Much of this volume is uncompacted. By applying a reasonable density figure to this volume and comparing it with expected waste generation figures, the actual tonnage received is about 369 tons per day. This results in an annual waste load of 134,690 tons. The 1981 budget for the land-

fill is $429,410 or $3.18/ton of waste disposed. The Larimer County landfill also maintains a disposal lagoon for septic tank waste. Approximately 252,000 gallons are accepted each week.

Several groundwater monitoring wells have been drilled in and around the landfill area and as yet have shown no groundwater contamination. In terms of cover requirements and other regulations the landfill is in compliance with the State Health Department. No major or minor improvements in the landfilling operation are required or planned.

The Estes Park landfill is the second largest of the three Larimer County landfills. The facility is located at the site of the City's municipal service center. It handles wastes from Estes Park and its environs plus the wastes generated by visitors to Rocky Mountain National Park and surrounding Roosevelt National Forest areas. The City of Estes Park owns the 10 acres which comprise the landfill area though the landfill is managed by Larimer County. County officials expect it to remain functional until sometime in 1983. Area fill is the method of operation used but a severe shortage of cover material exists. Cover material is imported and officials and are constantly on the lookout for excavations and other activities around the County where it may be acquired.

The Estes Park facility does not have scales, so again, it is not possible to obtain highly reliable figures for waste load at the landfill. It is estimated that 15,000 tons/year of solid waste are disposed of in the landfill. Estes Park is a popular summer resort, the population of which increases dramatically during the June through September season. The City of Estes Park contracts with a private hauler for collection of municipal solid waste.

Some thought has been given to acquiring land for a new landfill when the capacity of the present one is exhausted. The County has made inquiries concerning a new site. Several obstacles will need to be removed before this alternative is chosen. The lack of cover material will continue to be a problem at the new site. An easement for an access road would need to be acquired and inevitable public resistance to siting of a new landfill would have to be met. Estes Park and the County are in the preliminary stages of determining the optimal method for disposing of Estes Park's waste. Cost information on the Estes Park landfill is not available.

The third operating landfill in Larimer County is the Wellington landfill which is located approximately three-quarters of a mile west of Interstate Highway 25 and 3 miles north of the town of Wellington. The 20-acre site is owned by Larimer County and serves Wellington and the surrounding rural areas. The facility has an estimated life of at least 10 years. It is open on Saturdays and Sundays and handles approximately 50 tons per week or 2,600 tons per year.

The present solid waste disposal system as it exists in Larimer County is such that 149,000 people generate approximately 375 tons per day (TPD) or 136,875 tons per year (TPY) of solid waste. Approximately 95 percent of the waste load is disposed of in the Larimer County landfill. During the next 20 years, it is likely that the Estes Park landfill will be closed and Estes Park's wastes will be diverted to the Larimer County landfill. It also appears likely that the Wellington landfill will be closed. Therefore, by the year 2001, the Larimer County landfill may be required for disposal of twice the waste load it presently handles (see Table 3) due to population growth and landfill closures. Any problems associated with landfilling will be greatly exacerbated by increased volume.

CURRENT SOLID WASTE COLLECTION

The refuse collection system is significant in a resource recovery program because it affects the availability of refuse for materials or energy recovery. Municipal collection, commercial private collection, and individual private collection are currently being used in the study area. In a predominantly private system, such as in Larimer County, solid waste would be provided for resource recovery under two conditions: 1) if the cost to the hauler were lower than the costs of alternative disposal methods (i.e., landfilling), or 2) in response to a waste flow control ordinance (see Appendix B).

Larimer County maintains two transfer stations to collect solid wastes in outlying areas for ultimate disposal at the County landfill. The Berthoud transfer station is located approximately one-half mile inside Weld County, south of Highway 56. The transfer station is open two days a week on Saturday

and Wednesday to serve the town of Berthoud and surrounding areas. Approximately 45 tons are collected each week and hauled to the landfill by a private hauler, under contract to the County. The cost to the County is about $12.76/ton.

The other transfer station is in the Red Feather Lakes area, north and west of Ft. Collins. The transfer station is open only on Saturdays and collects 3-7 tons of solid waste per week. The difference between the high and low estimates reflects seasonal differences. Tourist and residential populations are much greater during the warm weather months. The County transports the solid waste to the Larimer County landfill. No cost information is available for this service.

The City of Loveland operates a municipal waste collection service for residents within the city limits. Households are allowed to put out any number of containers of trash. No building materials, rocks, sand or dirt are accepted. Each spring, for a 2-week period, appliances and properly bundled tree limbs are allowed. The fee for this service is $3.50 per month which is added onto the electric bill. The City owns six trucks and runs four of them five days per week. The Superintendent of the Refuse Department has estimated that the average round trip to the landfill is approximately 10 miles. Loveland disposed of 13,370 tons of solid waste (approximately 10 percent of the County landfill's waste load) in 1980. The average cost of collection and disposal was approximately $29.50 per ton.

Colorado State University hauls the trash generated on the Main and Foothills campuses to the County landfill. Approximately 8,465 tons of solid waste are generated directly by the University per year with 84 percent of this tonnage being produced during the 39 week school year. This presently represents about 6.6 percent of the Larimer County landfill solid waste load. The cost of collection and disposal is approximately $12.80/ton.

At least nine private commercial haulers operate in Larimer County. They pick up the commercial and industrial wastes in Loveland and all types of garbage in Ft. Collins and the rural areas. Rates for residential collection vary

according to the number and location of the containers. Pick-ups are made once a week and cost from $5.00 to $10.00 per month. Collections are made 7 days per week. The sixth and seventh days are usually light days.

There are also a substantial number of individuals hauling their own garbage to the landfill. In 1980 only 53 percent of the revenues of the County landfill were from private commercial haulers. This estimate is supported by discussions with the gatemen at the landfill and examination of the cash records. Approximately 150 to 200 cash transactions typically occur each day with that number rising to as many as 1,000 on weekends.

RECYCLE SOMETHING

An active member of the Colorado Recycling Cooperative Association (CRCA), Recycle Something is currently operating in Ft. Collins. The organization collects a small but steadily growing percentage of the solid waste generated in Larimer County. Its goals are to provide comprehensive and convenient recycling of a wide variety of items and to involve a substantial portion of Larimer County's population in this effort.

Recycle Something was begun in 1975 as a volunteer organization using community groups on Saturdays to pick up recyclables left at drop sites. CETA funds provided the group with their first full-time employees and the City of Ft. Collins has provided land for a storage and office site. The group incorporated as a nonprofit organization a year ago and presently (July, 1981) is run with a permanent staff of four plus three CETA workers. Community groups are still used for Saturday collections.

In addition to the main storage site, Recycle Something maintains two collection stations at Ft. Collins shopping centers. Newspaper, glass, aluminum, tin cans and high-grade paper are accepted.

At present, Recycle Something meets its expenses through three main sources: 1) sale of materials, 2) revenue sharing funds, and 3) donations. In 1980, Recycle Something had fixed operating costs of approximately $33,000 a year. Almost 94 percent of these costs, or approximately $31,000, were covered by the sale of materials and donations. The organization also receives $64,000 a year in revenue sharing funds which can be used only for vehicle maintenance. At present, Recycle Something owns one dump truck and a semi-trailer.

Newspaper is the mainstay of Recycle Something's program in terms of amounts processed and income generated. The market situation for this material illustrates some of the problems associated with development of a truly viable recycling program in Ft. Collins and throughout the State of Colorado. No local buyer of the newspaper exists. Instead, it must be sold in California which greatly reduces the revenues to Recycle Something. Additionally, the demand for newsprint, which is chiefly used for building insulation, is highly seasonal,

which may affect Recycle Something's revenues by a factor of three. High-grade paper, glass and aluminum are also only slightly profitable. Tin recycling is not currently profitable.

Although quantities of materials handled by the organization are less than 1 percent of the waste load (see Table 7) entering the Larimer County landfill, the tonnages handled have been increasing steadily. The directors of Recycle Something think they have the potential to handle a far greater amount of material.

Recycle Something's major buyer is Tri-R Systems in Denver. Tri-R is currently able to buy any quantity of goods the organization can provide. The limiting factors, therefore, appear to be the level of public participation and Recycle Something's preparation, transportation and storage of the recyclables. Economic and political conditions have hindered the organization's ability to overcome these limits.

Recycle Something has not had funds to advertise, which the directors think has the potential to greatly increase participation in the program. The organizaton has also been unable to upgrade equipment, storage, and sorting facilities. This, in turn, has severly limited their ability to increase efficiency and income. For example, mixed glass cullet currently sells for about $28 per ton whereas color-separated cullet sells for $40-$50 per ton. However, Recycle Something cannot separate the glass because they lack space and containers. Their income has also been significantly diminished by the active aluminum buy-back programs of Coors, Reynolds, King Soopers and Safeway.

Tin is a saleable product which has been unprofitable because a minimum of one rail car of flattened, shredded cans must be accumulated. Recycle Something currently has twice that amount, however, they do not have the equipment to flatten or shred it.

The group has recently acquired new warehouse and office facilities in north Ft. Collins consisting of 4,000 sq. ft. of space with rail capacity and truck loading docks.

TABLE 7

RECYCLE SOMETHING - IMPACT ON SOLID WASTE LOAD OF LARIMER COUNTY LANDFILL

(In Tons Per Year)

Materials Recycled	1975	1976	1977	1978	1979	1980
"ewspaper	15	300	450	500	520	660
igh-Grade Paper	0	10	25	30	45	60
luminum	0	6	5	4	4	-
Glass	0	1	5	65	75	125
in	0	0	5	15	20	-
OTAL	15	317	490	614	664	845
Larimer County Waste Load	111,000	114,600	118,200	121,800	125,400	129,000
ecycled Material as % of Waste Load	.01	.28	.41	.50	.52	.66

The directors would like to purchase several pieces of new equipment. A baler-shredder would allow baling of newsprint and a higher selling price as well as the possibility of stockpiling it during low-price periods. Cardboard, a potentially profitable material, could also be collected and sold. Recycle Something would ideally like to purchase another truck, a forklift and conveyors.

The directors of Recycle Something plan to institute a buy-back program for various recyclables. The start-up costs of such a program make it infeasible at the current time.

RESOURCE RECOVERY OPTIONS

There are several resource recovery options which recover either energy and/or materials. However, many of these systems are in only experimental or developmental phases. The options which will be discussed are: 1) modular incineration, 2) waterwall incineration, 3) cogeneration, and 4) a combination of two of these options.

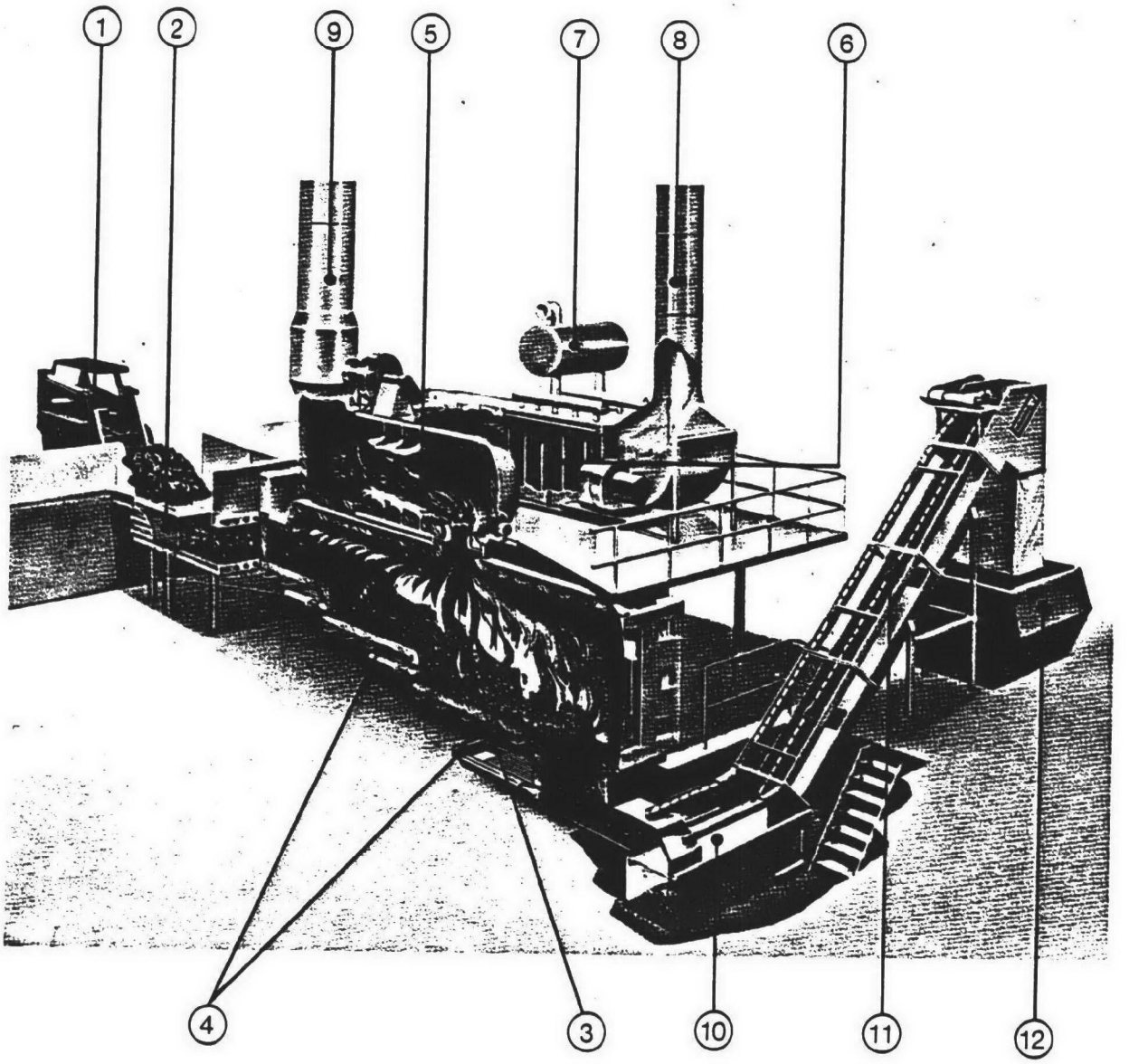
MODULAR INCINERATION

Modular incinerators are prefabricated, controlled air combustion units of relatively small capacity which can be combined to achieve capacity, reliability and redundancy specifications for a particular purpose. They were developed in response to the need for a clean incineration system for solid waste disposal and a concurrent awareness of the energy potential of solid wastes.

The most common design for heat recovery is the two chamber incinerator (see Figure 1). These operate by burning waste in the primary chamber. The hot gases from the primary chamber are mixed with air in the secondary chamber (afterburner) and ignited. If the heating value of the gases from the primary chamber is too low to sustain combustion an auxiliary fuel is used to sustain the afterburner temperature. A heat exchanger recovers the heat from the afterburner and generates energy in the form of hot air, water or steam. Ash from the primary chamber is water quenched and landfilled.

Modular incinerators are manufactured by at least 18 different companies. System configurations vary among the manufacturers. However, aside from their primary advantage of recovery of energy from otherwise wasted materials, modular incinerators have several other benefits. As mentioned before, the small volume modules can be combined to achieve optimum sizing and this in turn allows for maintaining plant efficiency even in response to seasonal variations in the waste stream and unscheduled downtime of a module. Modular incinerators producing steam have exhibited energy generation efficiencies of 50-70 percent while reducing the volume of municipal solid waste deposited in the landfill by 80-90 percent.

FIGURE 1 TYPICAL MODULAR INCINERATOR SYSTEM



A skid steer t :tor (1) pushes the waste to the automatic loader (2). The loader then a··ɔmatically injects the waste into t gas production chamber (3) w :re transfer rams (4) move the material slowly through the system. T high temperature environment in the gas production chamber is provided with a controlled quantity of air so that gases from the process are not burned in this chamber but fed to the upper or pollution control chamber (5). Here the gases are mixed with air and controlled to maintain a proper air fuel ratio and temperature for entrance into the heat exchanger (6) where steam is produced. A steam separator (7) is provided to ensure high quality steam. In normal operation gases are discharged through the energy stack (8). When steam is not required or in the event of a power failure, hot gases are vented through the dump stack (9). The inert material from the combustion process is ejected from the machine in the form of ash into the wet sump (10) and conveyed (11) into a closed bottom container (12) which can then be hauled to the landfill for final disposal.

SOURCE: CONSUMAT SYSTEMS, INC.

Given the uncertainties in providing an assured waste supply, it was decided not to design excess capacity into the Larimer County system for population growth. The average waste load for 1986 (see Table 3) was used as a design figure. A facility of this size should be able to handle the low season waste load (see Table 4) for at least 10 years. The technologies chosen for study would be relatively easy to expand to accommodate increased waste loads.

A modular incinerator with a throughput capacity of 450 TPD would have an average burning rate of 37,500 lbs. per hour (see Table 8). Municipal solid waste has an average heat value of 4,500 Btu/lb. Based on 150 psi saturated steam with 75 percent condensate return at 180°F an incinerator of this size could produce an average of 96,400 lbs. of steam per hour and a maximum steam production of 135,000 lbs./hr.

Table 9 presents the auxiliary needs for a 450 TPD modular incinerator. Supplementary fuel at a rate of 90,000-250,000 Btu per ton of solid waste is required to maintain the afterburner temperature. Several alternative fuels could be used for this purpose. Choice of auxiliary fuels would be based on cost, availability and storage facilities when a site for an incinerator is selected.

A 450 TPD modular incinerator running 24 hours per day, 7 days per week would require a total staff of about 24 people. Table 10 illustrates the labor force required. Labor costs amount to about one-third of the annual operating and maintenance budget.

The solid waste stream may contain hazardous or explosive materials. In a modular incineration system the problems with these materials are similar in nature to problems with these materials at a landfill site. Potentially explosive wastes may be identified on the tipping floor and removed. The incineration chambers are designed to withstand explosions. Toxic materials can threaten the health and safety of employees moving the solid waste. Precautions such as dust control measures and personal protection equipment for employees must be supplied. Additionally, sufficient air pollution control equipment must be installed to prevent release of these substances to the environment.

TABLE 8

POTENTIAL STEAM PRODUCTION FROM INCINERATED SOLID WASTE IN LARIMER COUNTY

Year	Daily Waste Quantity Received (tons)	Average Burning Rate (lb./hr.)[1]	Average Steam Production (lb./hr.)[2]
1986	450	37,500	96,400
1991	533	44,400	114,000
1996	618	51,500	132,000
2001	708	59,000	152,000

1 Assumes 24 hour/day, 7 days/week continuous operation.

2 Assumes 4,500 Btu/lb. SW and steam production at 1,750 Btu/lb. steam based on 150 psi saturated steam with 75 percent condensate return at 180°F. Source: Consumat Systems, Inc.

TABLE 9

AUXILIARY CONSUMPTION FOR A 450 TPD MODULAR INCINERATOR PRODUCING STEAM

Inputs	Per Ton	Per Day
Auxiliary Fuel Consumption (Btu)	90,000-250,000	$40.5\text{-}112.5 \times 10^6$
Electrical Consumption (Kwh)	25-30	11,250-13,500
Ash Quench Water (Gal)	40	18,000

Source: Fred C. Hart Associates, Inc.

TABLE 10

LABOR REQUIREMENTS FOR A 450 TPD MODULAR INCINERATOR

		Per Week
Administrative ---	1 Facility Manager	1
	1 Secretary (per refuse-recieving shift)	1-2
	1 Chief Engineer (with license)	1
Receiving and Processing ---	1 Loader-Operator per shift	5
	1 Fireman per shift	5
	1 Utility Man	3
Maintenance ---	1 Mechanic per shift	5
	1 Electrician (daylight shift, only)	2
Total ---		24

Source: Fred C. Hart Associates, Inc.

Durability of modular incinerator systems has been questioned. Manufacturers' claims range from 15-30 years and some of these may be optimistic. Conventional fuel systems generally have longer lifetimes.

In 1978 a U.S. Congressional committee completed a report following a tour of eight resource recovery plants which made three major points: 1) claims made in behalf of waste-to-energy plants were overstated and costs were understated; 2) technologies needed further development; and 3) the economics for waste-to-energy would become more favorable as the costs of disposal rise.

WATERWALL INCINERATION

The basic difference between waterwall and modular incineration is that in the waterwall incinerator both the burning of the unprocessed waste and energy recovery occur in one chamber rather than the separate chambers associated with modular incineration. Water-filled boiler tubes embedded within the walls of the burning chamber give waterwall incinerators their name. These boiler tubes recover the heat from the burning waste and produce steam to be used directly or converted to electricity.

Compared to modular incineration, waterwall incineration units are generally available in large configurations (typically 300 TPD and greater) and capital costs are significantly higher. However, energy recovery efficiencies for waterwalls are significantly higher. For very large units--on the order of 1,000 TPD--operating costs can be lower for waterwalls than modular incinerators.

Waterwall incinerators with energy recovery have been operated successfully for more than 50 years. Nearly all operating experience has been in Europe. Waterwall incineration has not been utilized to a great extent in the U.S. Significant problems have been encountered with corrosion of the boiler tubes as they are exposed to a wide range of combustion conditions associated with the burning of solid waste. Waterwalls offer less flexibility in meeting fluctuating demands for burning waste or providing energy than modular units.

COGENERATION

Cogeneration refers to the utilization of both useful heat and electric power from a combustible fuel. In this case the primary product would be electricity with simultaneous use of the "waste" steam. In a typical system steam would be generated through incineration of solid waste and used to run a turbine. The steam from the turbine, the energy value of which has been diminished, is then secondarily utilized for process or heating uses.

Either a modular or waterwall incinerator could be coupled with a superheater to provide steam sufficient to generate electricity. A "condensing" turbine is added to the incinerator for this purpose. Steam is produced and expanded in the turbine for electricity generation. Process or heating steam is extracted at whatever rate necessary after leaving the turbine. This type of system is substantially less efficient at approximately 30 percent efficiency, than straight steam production and use.

The advantage of a cogeneration facility is the increased siting flexibility and saleability of the product (i.e. electricity). In Larimer County, there is only one steam user that requires the total amount of steam which a steam-only plant could produce. Generally, to be cost-effective, steam plants must be sited within one to two miles of the consumer. Electricity is a more saleable product in that it doesn't necessarily require a specific customer but instead can enter a grid system and be utilized where needed. Also electricity can be transmitted over long distances without prohibitive losses.

A cogeneration facility of the type envisioned for Larimer County would have the same basic auxiliary requirements (see Table 9) as a modular incinerator system producing only steam. The superheater addition utilizes stack gases and radiant heat from the primary chamber to heat steam to the proper levels needed by the turbine. As a result, one significantly different requirement of a cogeneration system is the water needed for cooling of the condenser. Approximately 225,000 gallons of water would be needed per day. With installation of a cooling tower, actual discharge could be held to 22,000 to 65,000 gallons per

day. A portion of this discharge could be used to meet the 18,000 gallon per day need for ash quenching purposes. The remainder of the discharge would be disposed of in the sanitary sewer.

Currently, there are no operable cogeneration facilities which utilize incinerators. Two are in the developmental stages. In light of this situation, no operational data is available and potential problems are not known.

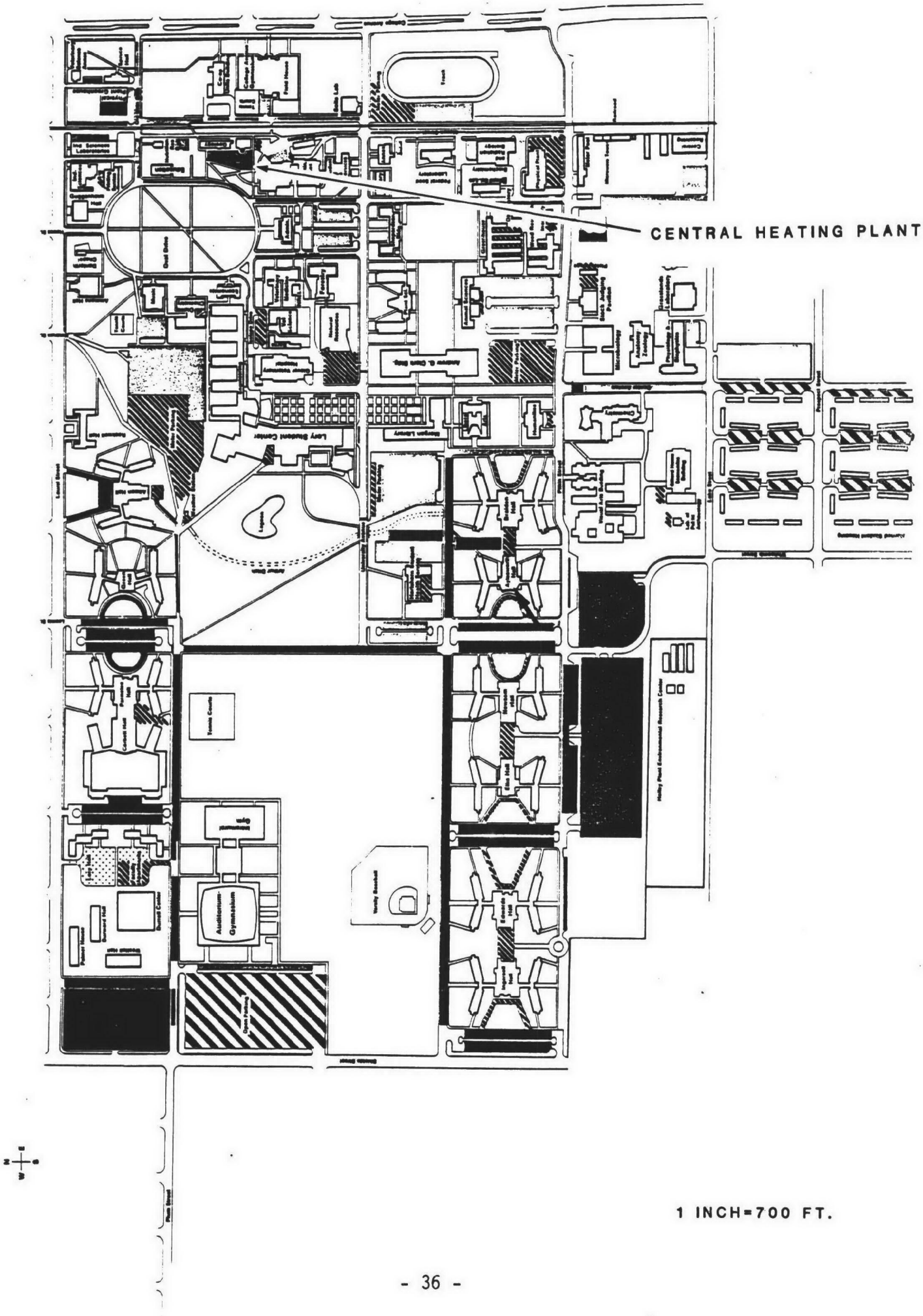
POTENTIAL INCINERATOR SITES

COLORADO STATE UNIVERSITY - MAIN CAMPUS

The main campus of Colorado State University (CSU) in Fort Collins is the single largest existing steam consumer in Larimer County. Steam, which is used for heating, cooling, laboratory equipment, laundry, cooking and hot water, is generated in the University's central heating plant. The heating plant equipment consists of four boilers capable of firing natural gas or number 6 oil, with a combined steam generating capacity of 305,000 pounds per hour (pph). At a performance design temperature of -9°F recommended by the American Society of Mechanical Engineers, the campus requires 210,000 pph of steam. Presently, the central heating plant at CSU relies heavily on Boiler #4 which has a capacity of 150,000 pph. It is expected that it will be necessary to replace the three older and smaller boilers during the 1980's to assure the campus of adequate heating capacity in the event of a failure of Boiler #4 during the winter months. A modular incinerator facility generating only steam could supply as much as 101,000 pph of steam during the winter months in 1986. Thus, the CSU main campus initially seems to have a high potential as a consumer of the steam. However, several other factors affect the feasibility of supplying the campus with steam from a modular incinerator fueled by municipal solid waste.

In general, a steam generating plant should be located within one to two miles of the steam customer or heat and pressure losses become excessive. The need for a site located on or near the main CSU campus represents a major obstacle to the installation of a modular incinerator. An incinerator facility handling the volumes of solid waste generated by Larimer County (450 TPD) would require a minimum of 5 acres including processing building, tipping area, parking area, access drives, etc. The functioning central heating plant is located on the northeast edge of the campus (see Figure 2). There is no open space near the plant and the present building occupies only about 20,000 square feet (.5 acres) itself. If a facility were to be located adjacent to the central heating plant, academic buildings would have to be demolished to make room.

FIGURE 2 COLORADO STATE UNIVERSITY



Adequate open space is available on the south or southwest side of the campus, however, distribution lines originate at the central heating plant at the extreme opposite end of the campus. Steam lines are such that they get progressively smaller as distance from the steam source increases. Therefore, siting of a satellite steam plant would require major upgrading of the existing distribution system.

In conjunction with these obstacles is the fact that the fuel supply and storage system is functioning well for the CSU main campus. The central heating plant has interruptible natural gas service from The Public Service Company of Colorado. As a backup the University stores 180,000 gallons of number 6 fuel oil in tanks adjacent to the plant with another 1,000,000 gallon tank located approximately 1 mile away. The heating plant has an overall efficiency of about 70 percent.

Additionally, it is assumed that public opposition to the siting of a solid waste incinerator in the center of Ft. Collins would be strong. Traditional prejudices associated with garbage plus concerns about increased truck traffic and siting constraints would create major difficulites in developing community support for a modular incinerator located on the main CSU campus.

For these reasons the CSU main campus does not appear to be a good location for installation of a solid waste fueled modular incinerator.

COLORADO STATE UNIVERSITY FOOTHILLS CAMPUS

A waste-to-energy plant supplying the Foothills Campus (FC) of Colorado State University is considered in this section. The Foothills Campus is an area of 1,250 acres located approximately 4 miles west of Ft. Collins (see Figure 3). The campus functions as a research facility and is in the beginning stages of development consisting of about 350,000 square feet of major building area as opposed to 4,250,000 square feet on the main campus. At present, buildings which require heating have individual heating and cooling plants which utilize electricity and natural gas supplied on a firm basis by Public Service Company of Colorado. The buildings have steam, hot water and warm air heating systems.

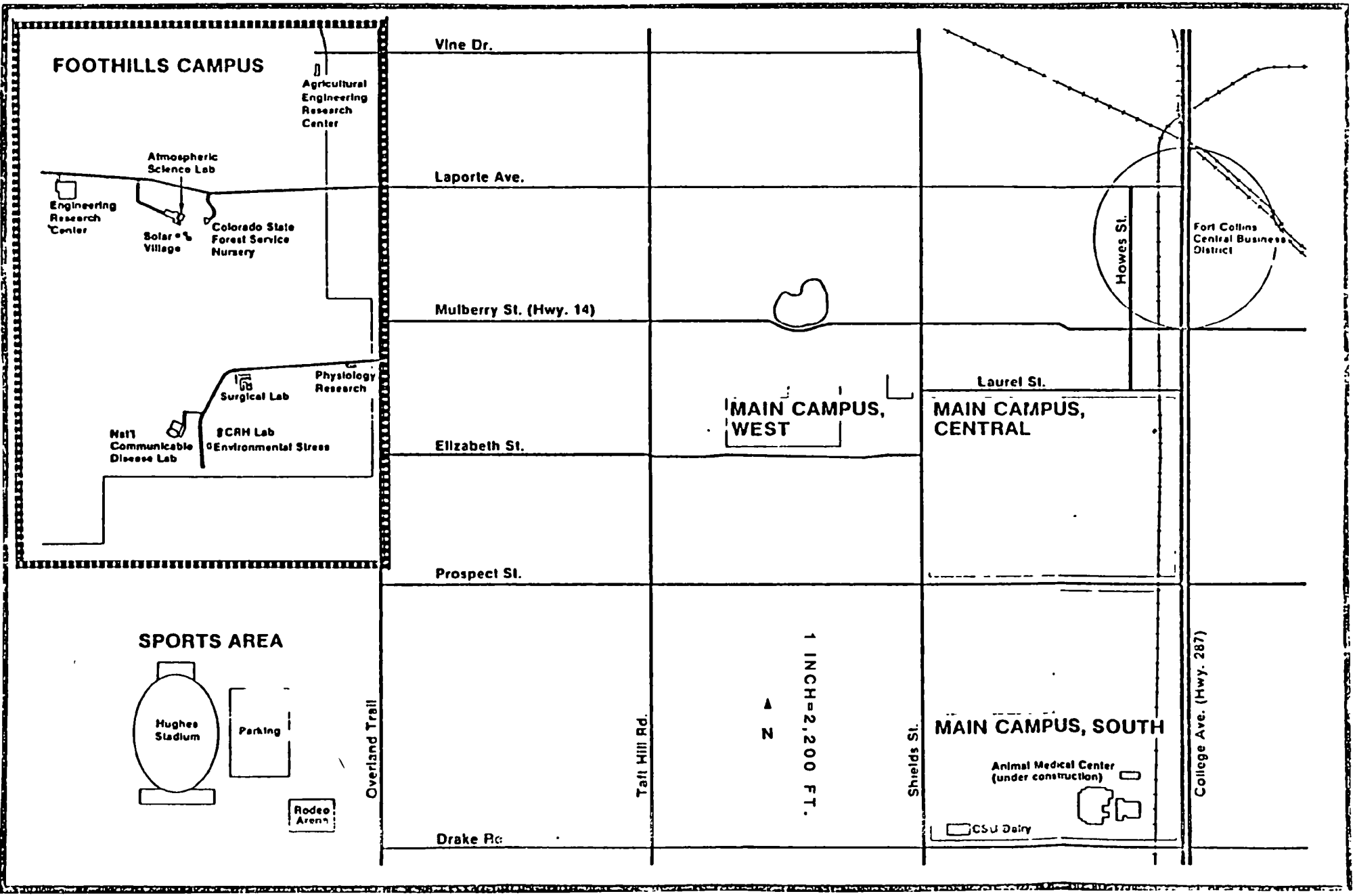


FIGURE 3 COLORADO STATE UNIVERSITY FOOTHILLS CAMPUS

The master plan for the Foothills Campus assumes the addition of 100,000 square feet of research facility every five years. Building additions proposed for the early 1980's have been dropped due to loss of expected federal funds and the accuracy of other projections is questionable, depending on economic and political factors. Energy consumption for existing buildings is not expected to change during the project period. Energy consumption for new buildings is expected to match current levels of approximately 400,000 Btu per square foot per year (including electricity).

The Foothills Campus does not suffer from the same constraints as the main campus. Space is abundant and available. Population density and building density is low in the Foothills Campus area. Presumably, public opposition would be less than in a more densely used area. However, several important factors limit its potential as a modular incinerator site.

The energy-use requirements of the Foothills Campus are extremely low compared to the potential energy produced by a modular incinerator processing all of the study area's waste. Table 11 compares the total potential energy generated by a modular incinerator with the total projected energy needs of the Foothills Campus. In 1986, the Foothills Campus would utilize only 12 percent of the energy available from the incinerator and this figure would rise to only 17 percent by 2001.

Another important consideration is that only one major building on the Foothills Campus is steam heated. An extensive steam distribution system would have to be installed and the internal heating systems of all the buildings except the Engineering Research Center would have to be retrofitted to accommodate the new steam heating.

At this point, the Foothills Campus individualized heating system is functioning well. Under conditions of major growth energy needs might begin to approach a threshold level at which a central heating plant would become practical. At this time, considering the uncertainty of future growth, the potential of the Foothills Campus as a site for a modular incinerator is limited.

TABLE 11

POTENTIAL ENERGY PRODUCED FROM MUNICIPAL WASTE VS. FOOTHILLS CAMPUS ENERGY REQUIREMENTS

Year	Quantity Of MSW Incinerated Annually (Tons)	Energy Produced[1] (Btu x 10^{10})	Foothills Campus Energy Required[2] (Btu x 10^{10})	Percent Energy Utilized Foothills Campus
1986	164,250	81	10	12
1991	194,545	96	14	15
1996	225,570	112	18	16
2001	258,420	128	22	17

1 Assumes 4,500 Btu/Lb. MSW and an efficiency of 55%.

2 Assumes, as per master plan, the addition of 100,000 GSF of research-type facility every five years with annual energy requirement of 400,000 Btu/GSF. Energy requirements include natural gas usage (74%) and electricity (26 %).

LARIMER COUNTY LANDFILL

Locating a waste-to-energy plant at the present Larimer County landfill has several advantages. The landfill consists of 480 acres which are located between Ft. Collins and Loveland near the foothills. Only about 60 acres are filled so no spatial limitations exist. The collection and hauling system in Larimer County is already geared to this location so delivery of the solid waste to the plant would present no additional problems. Since there is little residential development near the landfill, opposition to siting of a waste-to-energy plant would presumably be minimal.

However, there is one critical drawback to the site. There are no potential energy consumers near the landfill. The situation suggests a couple of possibilities. One is the possibility of a cogeneration system located at the landfill. Electricity, unlike steam, can be transmitted without excessive losses for long distances. This would necessitate the construction of a hookup to the county's present electricity grid system. A steam by-product would also be available. The city or county might identify potential industrial users of this steam and encourage the siting of such a facility on that property.

The other possibility is for the city or county to identify major residential construction planned within a reasonable distance and assess the possiblity of a district heating system. These potential users, as mentioned before, would have to be quite large as a cogeneration system could produce significant amounts of electricity and steam.

These scenarios are something to keep in mind but exclude further analysis due to the fact that no parameters in terms of energy usage, patterns and growth can be assumed.

INDUSTRIAL PARKS

The scope of work calls for evaluation of a future industrial site which is designed to maximize use of recovered energy. At the present time, industries located in Larimer County are all light industries meaning they use relatively small amounts of either steam or energy for process uses. The bulk of their

energy use is for heating, cooling, hot water etc. For example, the Desk Top Calculator Division of Hewlett-Packard on Harmony Road in Fort Collins has three buildings of approximately 170,000 square feet. Only the "skin" of the buildings is heated and the interior is cooled year round. They have no need for process steam.

This predominance of light industry is expected to continue. The amount of energy recovered from a modular or cogeneration system will be of a much higher magnitude than the needs of one such industry.

The ideal industrial customer for a 450 TPD modular incinerator would be located fairly near the present landfill so as to reduce siting problems, collection system disruption, ash disposal, etc. The customer would agree to build a heating and/or process system which would be compatible with a modular incinerator or cogeneration plant. The customer would also agree to purchase all the energy produced by the incinerator during its lifetime.

At present there are no industries or industrial parks which even approach levels of energy use which would make siting of a modular incinerator feasible.

DOWNTOWN STEAM LOOP

The scope of work for this study initially called for consideration of a downtown hotel-convention center as a potential site for an incinerator. During the early stages of the study, plans for this complex were dropped. Therefore, this site was not examined.

COST-EFFECTIVENESS

The cost-effectiveness of any resource recovery system is a function of six variables: 1) capital costs, 2) operating and maintenance (O&M) costs, 3) transportation costs, 4) revenues received for the recovered materials and energy, 5) tipping fees, and 6) costs of other disposal alternatives. These factors are combined in the following way to determine cost-effectiveness:

Cost of Option (Capital + Operating and Maintenance + Transportation) - Revenues = Required Tipping Fee

The required tipping fee for each option is then compared to the cost of the other disposal alternatives (including landfilling and recycling). In this section of the report, we first examine the meaning of each of the variables, estimate their value for each option, and finally assemble the data for comparative purposes.

Capital Costs. The capital cost of a resource recovery plant is the sum of the costs for land, site preparation, design, and construction equipment, and other costs such as bonding, insurance and interest during construction, etc. To facilitate comparisons, capital costs are expressed on a per ton-of-waste-processed basis, spread over the expected life of the facility. The formula is:

$$\text{Capital Cost (\$/Ton Processed)} = \frac{\text{Capital Cost (\$) X Capital Recovery Factor (Year}^{-1}\text{)}}{\text{365 Days/Year X Design Capacity (TPD) X Capacity Utilization Factor (Dimensionless)}}$$

The Office of Technology Assessment's report entitled "Materials and Energy from Municipal Waste" states that the "...annual tons of waste processible in a full year is usually only a fraction of 365 times the maximum daily capacity since the plant will not always operate at full capacity. This fraction, the capacity utilization factor, ranges from 0.4 to 0.9. It is usually, however, taken to be 0.7 to 0.8 for resource recovery plants."

Capital costs for the two technology options considered are derived in Table 12.

A detailed cost analysis which itemizes each of the capital cost items is beyond the scope of this feasibility study, however, Table 13, which lists the capital costs incurred by the North Little Rock, Arkansas 100 TPD modular incinerator facility in 1977, is representative of the breakdown of capital costs for either modular or waterwall incinerators.

Operating and Maintenance Costs. Literature information on operating and maintenance (O&M) costs experienced by operable modular incineration and waterwall incineration facilities is limited. The Office of Technology Assessment reported average O&M Costs of $10.40 per ton processed for modular incinerators in the 200 TPD range and $11.00 per ton processed for waterwall incinerators on the order of 1,000 TPD (both costs are in 1979 dollars). The 100 TPD North Little Rock modular incinerator incurred O&M costs of $13.78 per ton of waste processed in 1979.

Developing detailed, itemized O&M costs is beyond the scope and purpose of this feasibility study. Therefore, O&M costs per ton of waste processed were derived from the OTA data for 450 TPD facilities by increasing the costs from 1979 to 1981 dollars assuming a 15% inflation rate per year and by extrapolating the facility size cited in the OTA data to 450 TPD units. The O&M costs, therefore, are estimated to be $11.90 and $13.23 per ton processed for 100% steam, 450 TPD modular incinerators and waterwall incinerators, respectively; it is assumed that the O&M costs for 100% electricity or cogeneration would be 15% higher (same percentage as the capital costs) than for 100% steam generation for both the modular and waterwall incinerators.

To provide a perspective on the relative costs of O&M components, Table 14 presents the O&M costs experienced by the 100 TPD North Little Rock modular incinerator in 1979. Labor (salaries and benefits) represent greater than 50% of the total O&M cost, followed by maintenance at 26%, auxiliary fuel and energy at 16%, and the remainder of O&M costs at 6%.

TABLE 12

ESTIMATED CAPITAL COSTS FOR 450 TPD MODULAR INCINERATION AND WATERWALL INCINERATION FACILITIES

Technology	Capital Cost[1]	Capital Recovery Factor[2]	Design Capacity (TPD)	Capacity Utilization Factor	Capital Cost Per Ton Processed
Modular Incineration					
100% Steam	$13.5 million	0.13388	450	0.7	$15.7
100% Electricity or Cogeneration	$15.5 million	0.13388	450	0.7	$18.1
Waterwall Inceration					
100% Steam	$22.5 million	0.13388	450	0.7	$26.2
100% Electricity or Cogeneration	$25.9 million	0.13388	450	0.7	$30.1

[1] Source: EPA, Solid Waste Data, Prepared by JRB Associates, August, 1981. Assumes $30,000 per TPD of design capacity and $50,000 per TPD of design capacity for modular and waterwall incineration, respectively. Turbines and associated equipment for electricity generation are estimated to add approximately 15% to the capital cost of a 100% steam facility.

[2] Assumes 12% interest and 20-year amortization period (Note: interest rates for municipal bonds have fluctuated between 10 and 15% over the last 6-month time period).

TABLE 13

NORTH LITTLE ROCK MODULAR INCINERATOR ACTUAL CAPITAL COST BREAKDOWN

(In 1977 Dollars)

Item	Capital Cost ($)	Percent of Total Capital Cost
Land	10,000	1
Site Preparation	101,000	7
Design	38,000	2
Construction	311,000	20
Real Equipment	969,000	64
Other Equipment	63,000	4
Other Costs	38,000	2
Total Capital Costs	$1,530,000	100%

Source: U.S. EPA, Small Modular Incinerator Systems with Heat Recovery: A Technical, Environmental, and Economic Evaluation, Publication SW-797, November, 1979.

TABLE 14

PROJECTED OPTIMUM OPERATING AND MAINTENANCE COSTS FOR

NORTH LITTLE ROCK, ARKANSAS, MODULAR INCINERATOR

(In 1978 Dollars)

Item	($/Year)	($/Ton Processed)[1]	Percent Of Total O & M Cost
Salaries	$111,284	$ 6.18	46
Employee Benefits	15,750	0.88	6
Fuel - No. 2 Diesel	3,456	0.19	1
Natural Gas	16,704	0.93	7
Gasoline	2,916	0.16	1
Electricity	19,237	1.07	8
Water and Sewer	6,402	0.36	3
Maintenance	65,656	3.65	26
Replacement Equipment	--	--	--
Residue Removal	*	*	*
Chemicals	3,400	0.19	1
Other Overhead	3,209	0.18	1
Total Operating and Maintenance Costs	$248,014	$13.79	100%

* Cost included in salaries and employee benefit categories.

Source: U.S. EPA, Small Modular Incinerator Systems with Heat Recovery: A Technical Environmental and Economic Evaluation, Publication SW-797, November 1979.

1 Facility normally operates 5 days per week, 50 weeks per year at a 0.7 capacity utilization factor.

Transportation Costs. Incremental transportation costs need to be added to the cost of each option if the distance that waste will be hauled to the site of a new facility is longer than current hauling distances for disposal. Conversely, if hauling distances are shorter, the difference in cost should be subtracted from the cost of each option.[1]

Since the four potential sites considered in this study - 1) CSU Main Campus, 2) CSU Foothills Campus, 3) an undetermined industrial park, and 4) the current landfill - are within a 10-mile radius of the current disposal site, transportation costs to a resource recovery facility are not expected to increase or decrease significantly.[2] Therefore, for this draft the incremental transportation cost is taken to be zero.

Revenues. Revenues for the two technology options considered in this report would be generated from the sale of steam or electricity or both steam and electricity depending primarily upon the site chosen and energy user(s). For both the modular and waterwall incinerator options, mass burn incineration is assumed to occur without prior separation of the incoming solid waste for ferrous and non-ferrous metal and glass recovery. There is no prohibitive technical reason why the separation and incineration technologies can not be combined but, in nearly all existing modular and waterwall incineration units, separation prior to burning for energy recovery is not practiced to an appreciable extent.

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1 EPA's Solid Waste Data report prepared by JRB Associates indicates that direct haul (packer truck) costs rise at a linear rate of $0.44 per ton-minute for round trip times ranging from 0 to 50 minutes.

2 To adequately develop incremental transportation costs, a collection route analysis comparing existing versus potential future routes would have to be performed. The level of detail required for this analysis would necessitate limiting the analysis to the recommended incineration site.

Estimated revenues for each technology option with various mixtures of steam and electricity generation are presented in Table 15. For both the modular and waterwall incinerator options the maximum revenues are derived by 100 percent steam utilization followed closely by the tandem cogeneration cycle. 100 percent electricity utilization and the topping cycle reduce revenues on the order of 20 to 55 percent.

Tipping Fee. A tipping fee is the fee charged to haulers for disposing of solid waste at the resource recovery facility. For a facility to be economically competive with other disposal alternatives in Larimer County (the landfill), the fee should be in the same range as anticipated tipping fees for the alternatives.

Results of the Analysis

The required tipping fees for resource recovery options in Larimer County are derived in Table 16, using the formula (Tipping Fee per Ton = Capital Cost + O & M Cost + Transportation Cost-Revenues) developed at the beginning of this section. Tipping fees currently charged at the landfill range from $3 to $4 per ton.

TABLE 15

REVENUES FROM RESOURCE RECOVERY OPTIONS: 450 TPD FACILITY (IN 1981 DOLLARS PER TON PROCESSED)

Technology Option	BTU Steam Energy	KWH Electricity	Steam Revenue[1]	Electricty Revenue[2]	Total Revenue
A. Modular Incinerator[3]					
1. 100% Steam	4.95×10^6	-	$13.1	-	$13.1
2. 100% Electricity[4]	-	527	-	$10.5	$10.5
3. Cogeneration					
i. Topping Cycle[5]	2.77×10^6	60	$7.3	$1.2	$8.5
ii. Tandem Cycle[6]	1.07×10^6	148	$2.8	$3.0	$5.8
B. Waterwall Incineration[7]					
1. 100% Steam	6.30×10^6	-	$16.6	-	$16.6
2. 100% Electricity[4]	-	671	-	$13.4	$13.4
3. Cogeneration					
i. Topping Cycle[5]	3.53×10^6	76	$9.3	$1.5	$10.8
ii. Tandem Cycle[6]	1.36×10^6	188	$3.6	$3.8	$7.4

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1 Assumes steam can be sold at same current (1981) price of interruptible gas - $2.64 per 10^6 BTU.

2 Assumes electricity can be sold at 2¢/KWH (2/3 of price currently paid by CSU).

3 Modular incinerator steam generating boiler is estimated to be 55% efficient.

4 Assumes turbine efficiency (steam to electricity) to be 36%.

5 A topping congeneration cycle routes all of the superheated steam from the boilers through turbine; the steam exhausted from the turbine is directed to process uses before returning to the boiler as condensate. This cycle is assumed to be 60% efficient after the boiler.

6 A tandem cogeneration cycle splits the superheated steam from the boiler approximately equally to a topping turbine and a condensing turbine. The condensing turbine maximizes the usage of steam for electricity generation and routes the spent steam through a condenser (with cooling tower) and the condensate returns to the boiler. This cycle is assumed to be 32% efficient after the boiler.

7 Waterwall steam generating boiler is estimated to be 70% efficient.

TABLE 16

TIPPING FEES FOR RESOURCE RECOVERY OPTIONS (IN 1981 $ PER TON PROCESSED)

Option	Capital Cost	+ O & M Cost	+ Transportation Cost	- Revenues	= Tipping Fee
1. Modular Incineration					
1A. 100% Steam	$15.7	$11.9	These options are not site-specific adjustments for transportation cost will be developed in a later draft report	$13.1	$14.5
1B. 100% Electricity	$18.1	$13.7		$10.5	$21.3
1C. Topping Cogeneration Cycle	$18.1	$13.7		$ 8.5	$23.3
1D. Tandem Cogeneration cycle	$18.1	$13.7		$ 5.8	$26.0
2. Waterwall Incineration					
1A. 100% Steam	$26.2	$13.2		$16.6	$22.8
1B. 100% Electricty	$30.1	$15.2		$13.4	$31.9
1C. Topping Cogeneration Cycle	$30.1	$15.2		$10.8	$34.5
1D. Tandem Cogeneration Cycle	$30.1	$15.2		$ 7.4	$37.9

CONCLUSIONS AND RECOMMENDATIONS

1. A waste-to-energy incineration facility is not economically feasible in Larimer County under current conditions. There are four major factors which affect the feasibility: 1) the lack of an energy consumer; 2) high capital costs and interest rates; 3) relatively low energy costs (natural gas and electricity); and 4) relatively low landfill costs.

2. There is potential for the conditions affecting the feasibility of a waste-to-energy facility to change such that the facility would quickly become more favorable. These factors might include: 1) the location of an organization with energy needs of the magnitude which a 450 TPD incinerator can provide; 2) decrease in interest rates; 3) substantial increases in the costs of energy such as natural gas, fuel and electricity (the Reagan Administration has proposed deregulating the price of natural gas at a much more accelerated rate than allowed by currently existing legislation - if this occurs energy prices may increase at a much more rapid rate than general inflation); 4) greatly increased landfill disposal costs; and, 5) significant improvements in incinerator technology such that capital and O & M costs decrease substantially. Any one or combination of the above factors might tip the balance in favor of a waste-to-energy incineration facility for Larimer County.

3. There is no incompatibility between Recycle Something and a waste-to-energy facility. Instead, diversity of solid waste management is desirable and both systems have important and mutually beneficial effects. An expanded Recycle Something could reduce the costs of incineration by reducing volume requirements of a modular incinerator and removing the noncombustible fraction of the waste stream which tends to cause maintenance problems.

4. It is inevitable that solid waste management in Larimer County will increase in complexity and cost in the near future. Regardless of the ultimate disposal (landfilling) or usage (various resource recovery options) of Larimer County's solid wastes, accurate baseline information should be compiled by the County to assist in planning and management efforts. The baseline information regarding solid waste volumes, weights, composition, seasonal variation, and collection, transportation, and disposal costs contained within this study should be augmented by a concentrated, relatively low-cost county data tracking program.

5. Resource recovery should be periodically reviewed as a potential tool for incorporation into Larimer County's solid waste management system.

APPENDIX A

LANDFILL USER RATES

Effective Date: February 1, 1981

	$ Charged per Unit	
	Covered	Uncovered
AUTOMOBILES	$ 1.25	$ 2.50
STATION WAGON OR VANS WITH MORE THAN 3 CONTAINERS	1.75	3.50
PICKUP TRUCK WITH 3 OR LESS CONTAINERS	1.25	2.50
2-WHEEL TRAILER - MAX, CU. YD. CAP.	1.50	3.00
4-WHEEL TRAILER	2.00	4.00
PICKUP WITH RAISED BED	4.00	8.00
OTHER TRUCKS	5.00	10.00
SELF-LOADER TRUCKS	6.00	12.00
OLD AUTO BODIES	5.00	
COMMERCIAL APPLIANCES	3.00	
HOUSEHOLD APPLIANCES	1.50	
DEAD ANIMALS UNDER 100 LBS.	4.00	
DEAD ANIMALS OVER 100 LBS.	12.00	
SEPTIC DISCHARGE WHERE ALLOWED	7.00	
ALL PACKER TRUCKS	.75/CY	1.50/CY
TANDEM AXLE TRUCKS	8.00	16.00
SEMI-TRAILER TRUCKS	10.00	20.00

APPENDIX B

WASTE STREAM FLOW CONTROL

Historically, solid waste has been viewed as a nuisance, therefore, the only controls placed on its use or destination after collection were those designed to ensure its deposition in an appropriate disposal facility. Usually these controls did not require that a particular facility be used but depended upon economic considerations to regulate this.

With the advent of resource recovery technologies such as waste-to-energy and recycling, solid waste has begun to be viewed as a resource which must be managed. Waste stream flow control refers to legal or administrative (as opposed to market) strategies which may be utilized to ensure an adequate supply of solid waste to a resource recovery facility.

In the event that plans for a waste-to-energy facility are implemented, control of the waste stream will assume critical importance in the success or failure of the project. At present, only 15 percent of the landfill's waste load is under governmental control (Loveland's residential solid waste and waste transported from the two transfer stations). Assuming that the tipping fee at the incineration facility is higher than the landfill tipping fee, private commercial haulers will choose to use the landfill for disposal. If market conditions for recycling improve, private haulers may also view collected solid waste as a resource to be sold for materials recovery.

When the City of Akron, Ohio, was confronted with this situation, the City Council passed an ordinance which required that all solid waste, including commercially collected solid waste, generated within the city limits be taken to the waste-to-energy facility. The ordinance was subsequently challenged in Federal District Court. The plaintiffs challenged on the following grounds:

1. Violation of their right to due process of law under the Fourteenth Amendment.

2. Confiscation of their property in violation of the Fifth Amendment as applied to the States under the Fourteenth Amendment.

3. Interference with interstate commerce in violation of Article I, Section 8, of the Constitution.

4. Violation of the Ohio Constitution.

5. Violation of the Sherman Act.

The Federal Court upheld the ordinance and the authority of the city to require that privately collected refuse be delivered to a specified facility.

The decision on this suit represents a great advantage to waste-to-energy facilities. Under certain legal conditions, the promulgation of such ordinances is relatively easy. However, it is uncertain as to whether this type of ordinance would be permissible under current Colorado statutes.

In Eagle County, Colorado, this question was initially analyzed and it was concluded that the county could not regulate the waste stream flow within its limits. Further analysis qualified that somewhat by suggesting that if the county was the owner or joint owner of a waste-to-energy facility then flow control ordinances might be legally permittable.

Legal powers of municipalities in Colorado may allow cities to pass such ordinances. However, in January 1982, a Supreme Court ruling regarding Boulder, Colorado's regulation of cable television apparently threw the whole issue of legal powers of municipalities and home-rule cities in the State into question. The effect this ruling will have on waste flow control ordinances and many other issues is not known. The Colorado Attorney General stated that, "to try to speculate as to what this means to Denver or any other city at this point is tough to do."

To conclude, the question of waste stream control is a critical issue and the county's position in regard to methods of flow control must be investigated and resolved at the earliest stages of resource recovery planning.