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CENTRAL AIRPORT ENERGY
SYSTEMS USING ALTERNATE
ENERGY SOURCES

Prepared For

The U.S. Department of Energy
Appropriate Energy Technology
Small Grants Program

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by
TALBERT, COX & ASSOCIATES
901 East Boulevard
Charlotte, NC 28203

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I. PROJECT OBJECTIVES & SUMMARY

Of the total energy used in the U.S. in 1977 for transportation, approximately 8% of 1.61 quads were consumed by the aviation industry. Commercial air carrier operations accounted for 91% of the aviation energy used including, in 1977, over 256,948,000 barrels of jet fuel.

Since 1950, the domestic demand for refined petroleum products in the U.S. has almost tripled. The greatest increases have occurred in the demand for transportation fuels, with demand for gasoline increasing 165%, distillate fuel 20%, and jet fuel 269%. Considering current and anticipated future demands on the conventional petroleum energy resources, it is necessary to look to alternative sources of fuel.

The purpose of this project was to develop the concept of a central airport energy system designed to supply energy for aircraft ground support and terminal complex utility systems using municipal waste as a fuel. The major task was to estimate the potential for reducing aircraft and terminal fuel consumption by the use of alternate renewable energy sources. Additional efforts included an assessment of indirect benefits of reducing airport atmospheric and noise pollution.

In order to make the development of such a concept more realistic, an actual airport was used as a "guinea pig" subject for preliminary designs and performances projections. Douglas Municipal Airport in Charlotte, North Carolina was the subject facility.

Preliminary designs for a solid waste to energy incinerator plant producing electricity and steam were developed. The plant would burn 375 tons per day of

waste generated by the City of Charlotte to supply the thermal and electrical requirements of the airport terminal and the estimated ground energy needs for commercial aircraft using the terminal. Cost estimates indicate that such a system, consisting of the incinerator plant, steam turbine generators, an electrical distribution and pneumatic air distribution systems for inter-connecting with aircraft would cost over \$11,000,000 to construct. However, the annual energy it could provide would be over 52,000 gallons of heating oil, over 923,000 gallons of jet fuel and over 3,000,000 KWH of electrical power.

Economic savings would accrue to the city owned airport and the airlines. While the system would offer the city an environmentally acceptable alternative means of waste disposal versus landfilling, the disposal cost would be significantly higher than current costs. The system appears to offer lower disposal costs, however, when compared to a large centralized resource recovery facility which is presently being considered.

On the negative side, it appears that it would be difficult to successfully interface a waste burning energy plant with airport operations. The plant would have to be located and operated separately from the airport.

The concept of supplying airport and aircraft energy from a centralized resource recovery based energy system should be seriously considered at large airports located near metropolitan centers where fuel and electrical rates are high and long term waste disposal needs cannot be met thru landfilling.

II. TECHNICAL APPROACH

A. CHARACTERIZATION OF AIRPORT ENERGY USAGE PATTERNS AND RENEWABLE FUEL AVAILABILITY

1. GENERAL

An observation of airport energy consumption reveals some energy usage patterns which are common to all major airports. Jet fuel is used by aircraft during takeoffs, landings, while taxiing to and from the terminal, and by the aircraft auxilliary power units. Other petroleum fuels are used by ground service and baggage handling vehicles. Energy from gas, oil, and electricity is used by the terminal itself for heating, air conditioning, lighting, etc.

The aircraft auxilliary power unit (APU), mentioned earlier, is a small gas turbine engine mounted inside the fuselage of large turbine powered air transport aircraft. The APU uses jet fuel from the aircraft tanks and supplies onboard electrical and pneumatic power. Although they are inefficient users of energy, the APU's have traditionally been used for aircraft ground support. This is due partly to the unique ground support requirements of the aircraft, which include large quantities of low pressure air for engine starting and for operating the onboard air conditioning systems, and 400 HZ electrical power for the aircraft electrical systems. All aircraft currently in service and planned however, are equipped with electrical and pneumatic connections so that they may be supplied from external sources.

2. THE AIRPORT TERMINAL

A plan of the Douglas Municipal Airport is shown in Figure 1. During the course of this project the airport owner, the City of Charlotte, completed a new terminal building. Since passenger operations have been transferred to the new terminal, this study will focus on the new terminal only.

Figure 1
 Douglas Municipal Airport
 Charlotte, NC

The new terminal building consists of a main passenger terminal with two concourses as shown in Figure 2. Total area exceeds 256,000 square feet. Heating, ventilating and air-conditioning system (HVAC) are of the variable volume terminal reheat type.

The HVAC systems use hot water for heating and chilled water for cooling which is supplied by four separate chiller/boiler plants distributed throughout the building. All HVAC systems and equipment are of the latest state of the art design and provide substantially reduced energy consumption rates versus conventional systems used in the old terminal building. Each of the central heating/cooling plants consists of an oil/gas fired hot water boiler and one or more electric chillers.

The new terminal building having been in operation only a few months has not compiled an operating history from which to determine its actual energy consumption. Therefore, for the purpose of this project, it was necessary to estimate energy consumption and demand. This was accomplished using the U.S. Army developed BLAST (Building Loads And System Thermodynamics) computer program.

The BLAST program simulates building energy supply system operation under varying loads imposed by the complex interactions of building dimensions and materials of construction, local climate, internal heat sources such as lighting, occupational patterns and other variables. It calculates energy consumption and demand on an hourly basis for a typical year and provides monthly utility (energy) consumption summaries. A copy of the total annual energy summary produced by the program for the new terminal building is shown in Table I.

Schematic Plan

Schematic Section

Figure 2
Terminal Building

BUILDING ENERGY UTILIZATION SUMMARY

PROJECT: NEW CHARLOTTE TERMINAL

TABLE 1

PLANT NUMBER = 1 PLANT LOCATION = 13722 SIMULATION PERIOD = 1/ 1/1965 - 12/31/1965
PLANT NAME = HEATING, COOLING PLANTS

MONTH	LIGHTING AND ZONE EPT. (KWH)	ZONE GAS EQUIPMENT (BTU)	FAN WH	ELECTRIC HEATING (KWH)	GAS HEATING (BTU)	HUMIDIFIER (BTU)	DX CONDENSING UNIT (KWH)	HOT WATER AND STEAM (BTU)	BUILDING ELECTRIC (KWH)
1	1.2194E+05	0.	4.9824E+04	0.	0.	0.	0.	1.1029E+09	1.9178E+05
2	1.1040E+05	0.	4.3062E+04	0.	0.	0.	0.	9.0990E+08	1.7544E+05
3	1.2272E+05	0.	4.9824E+04	0.	0.	0.	0.	9.0915E+08	1.9255E+05
4	1.1870E+05	0.	4.7628E+04	0.	0.	0.	0.	8.4957E+08	1.8633E+05
5	1.2194E+05	0.	7.0308E+04	0.	0.	0.	0.	5.6400E+07	1.9227E+05
6	1.1870E+05	0.	4.8082E+04	0.	0.	0.	0.	5.7352E+07	1.8678E+05
7	1.2247E+05	0.	7.0688E+04	0.	0.	0.	0.	2.2149E+05	1.9314E+05
8	1.2247E+05	0.	7.0308E+04	0.	0.	0.	0.	3.4021E+06	1.9327E+05
9	1.1844E+05	0.	4.8064E+04	0.	0.	0.	0.	9.6089E+06	1.8651E+05
10	1.2170E+05	0.	4.9847E+04	0.	0.	0.	0.	2.3741E+08	1.9157E+05
11	1.1844E+05	0.	4.7577E+04	0.	0.	0.	0.	4.8543E+08	1.8402E+05
12	1.2247E+05	0.	4.9824E+04	0.	0.	0.	0.	8.2935E+08	1.9230E+05
ANN	1.4404E+06	0.	8.2554E+05	0.	0.	0.	0.	4.9587E+09	2.2660E+06

MONTH	CHILLED WATER (BTU)	ELECTRIC CHILLER (KWH)	ABSORPTION CHILLER (BTU)	COOLING TOWER (KWH)	CHWATER AND CONDENSING PUMPS (KWH)	HOT WATER & SOLAR PUMPS (KWH)	TOTAL ELECTRIC (KWH)	FOSSIL BOLLER FUEL (BTU)	ELECTRIC BOLLER INPUT (KWH)
1	1.3444E+08	2.1208E+04	0.	1.7723E+04	1.9254E+04	8.7044E+03	2.5847E+05	1.5814E+09	0.
2	1.7119E+08	2.0544E+04	0.	1.6954E+04	1.8243E+04	7.8622E+03	2.3746E+05	1.3355E+09	0.
3	1.7809E+08	2.8179E+04	0.	2.3574E+04	2.5616E+04	8.7046E+03	2.7861E+05	1.3014E+09	0.
4	4.8910E+08	3.8331E+04	0.	2.8324E+04	2.9619E+04	8.4004E+03	2.9099E+05	5.6917E+08	0.
5	1.0773E+09	5.6326E+04	0.	3.2131E+04	3.1346E+04	8.4004E+03	3.2045E+05	1.2154E+08	0.
6	1.1251E+09	5.7324E+04	0.	3.1419E+04	3.0335E+04	8.0494E+03	3.1389E+05	1.2239E+08	0.
7	1.5244E+09	7.3847E+04	0.	3.3914E+04	3.1346E+04	8.1898E+01	3.3230E+05	4.9474E+05	0.
8	1.5504E+09	7.5440E+04	0.	3.4023E+04	3.1346E+04	1.8720E+02	3.3424E+05	6.5107E+06	0.
9	1.2190E+09	4.1783E+04	0.	3.1803E+04	3.0335E+04	1.0062E+03	3.1141E+05	1.9734E+07	0.
10	5.5049E+08	4.0742E+04	0.	2.9349E+04	3.0503E+04	7.4645E+03	2.9961E+05	3.8924E+08	0.
11	2.9086E+08	3.2654E+04	0.	2.6517E+04	2.8439E+04	8.3419E+03	2.8196E+05	7.5596E+08	0.
12	1.6632E+08	2.5790E+04	0.	2.1483E+04	2.3552E+04	8.7046E+03	2.7201E+05	1.2106E+09	0.
ANN	8.4771E+09	5.3256E+05	0.	3.2742E+05	3.2993E+05	7.5908E+04	3.5316E+06	7.4139E+09	0.

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The most important energy values to be considered in this project are the total electrical and fossil fuel consumption rates. A monthly plot of these two parameters is included as Figure 3. These curves reflect the increase in electrical consumption during warmer months and the corresponding decrease in heating fuel consumption that is characteristic of buildings in the southern climate region.

From Table I, total yearly electrical energy consumption is projected to be 3,531,600 KWH while fossil energy requirements are 7,413,900,000 BTU. Using current rate schedules, energy costs should then be approximately \$151,000 for electricity and \$56,000 for oil.

3. AIRCRAFT ENERGY CONSUMPTION DURING GROUND OPERATIONS

An observation of airport energy consumption reveals some energy usage patterns which are common to all major airports. Jet fuel is used by aircraft during takeoffs, landings, while taxiing to and from the terminal, and by the aircraft auxiliary power units. Other petroleum fuels are used by ground service and baggage handling vehicles.

The aircraft auxiliary power unit (APU), mentioned earlier, is a small gas turbine engine mounted inside the fuselage of large turbine powered air transport aircraft. The APU uses jet fuel from the aircraft tanks and supplies onboard electrical and pneumatic power. Although they are inefficient users of energy, the APU's have traditionally been used for aircraft ground support. This is due partly to the unique ground support requirements of the aircraft, which include large quantities of low pressure air for engine starting and for operating the onboard air conditioning systems,

ENERGY CONSUMPTION PROFILES
TOTAL THERMAL AND ELECTRIC LOADS

DOUGLAS MUNICIPAL AIRPORT
CHARLOTTE, N.C.

Figure 3

and 400 HZ electrical power for the aircraft electrical systems. All aircraft currently in service and planned however, are equipped with electrical and pneumatic connections so that they may be supplied from external sources.

The Air Transport Association (ATA) has completed an exhaustive investigation into the potential for reducing APU fuel usage by using fixed ground support systems (Ref. I). As part of this effort, procedures were developed for estimating APU fuel consumption and operating costs. Using the ATA procedures and data furnished by DMA officials on the type and number of aircraft served by airport, estimates were made on fuel consumption and costs for this particular airport (Table 2.).

4. RENEWABLE FUEL AVAILABILITY

The most promising renewable fuels available for use as an energy source are wood and municipal solid waste (MSW).

Wood in the form of chips is available at a low cost in a few regions, notably the Southeastern U.S. and the Northwest. Excess wood results from logging operations and various wood products processing industries such as paper and furniture mills. At this point in time no major wood distribution systems exist for wood fuel. In addition, future growth in demand for wood in consumer products plus increases in the efficiency of conversion to those products could substantially reduce the quantity of wood waste available for fuel use. This competing market situation could cause radical price increases for wood fuel users in the future should wood become a popular fuel. For these reasons wood was rejected as an alternative fuel for the airport energy system.

TABLE 2
ESTIMATED ENERGY CONSUMPTION AND COSTS
FOR AIRCRAFT GROUND OPERATIONS - CHARLOTTE, N. C.

Aircraft Type	Flights/ Day	Turnaround Time (hrs)	APU Fuel (gallons/hr)	APU Operation (hrs/yr)	APU Operating Cost (\$/hr)	Total APU Fuel (gallons/yr)	Total APU Cost (\$/yr)
727	30	0.5	48	5475	68.10	262,800	372,848
737	50	0.5	40	9125	57.00	365,000	520,125
L1011	2	1.0	55	730	87.30	40,150	63,729
DC9	35	0.5	40	6388	57.00	<u>255,520</u>	<u>364,116</u>
						923,470	\$1,320,817

Municipal solid waste, on the other hand, offers great potential as an alternative fuel and it is truly renewable. The quantity available will grow with population which is the source of MSW generation. It is not a regional fuel but is generated nationwide.

For the City of Charlotte in particular, studies (Ref. 2) have estimated that over 555,400 tons of MSW are generated annually. This quantity is expected to increase to over 822,100 tons per year by the year 2000. When expressed on a daily basis, the current waste generation rate is over 1500 tons per day.

Presently, the city's cost of disposal is approximately \$5.00 per ton of MSW. However, landfills currently being used are expected to expire within 2 years. New landfill sites are being investigated which will offer a long term means of disposal. The costs associated with procurement and operation of a landfill which meets stringent new environmental standards are significantly higher. Estimates (Ref. 2) range from initial disposal costs of \$8.20 per ton in 1985 to over \$14.90 per ton in 2000.

B. DESCRIPTION OF PROPOSED RENEWABLE FUEL ENERGY SYSTEM

1. GENERAL

Fixed power distribution systems which furnish ground support pneumatic and electric power for aircraft at boarding gates have been developed. A typical system which is commercially available is illustrated in Figures 4 and 5. The rising cost and shortage of jet fuel has made such systems attractive economically even though they rely on purchased electrical power with diesel backup. Although they do supplant the usage of jet fuel for APU's by electrical energy, these systems increase the airport's and the local

utility's electrical demand.

The availability of such distribution systems makes the concept of supplying power from a central power plant the next logical step in addressing the fuel usage problem. A central power plant would offer much flexibility in that more energy efficient technologies such as cogeneration may be utilized. Other options would also be available. For example, to take advantage of the economy of scale, the plant size could be increased to supply energy to the airport terminal also. Instead of one large unit the plant could consist of several smaller units to enhance the availability and reliability of power supply.

The central plant envisioned for Charlotte would be based upon waste to energy incinerators of the modular controlled air design. Steam will be supplied to the terminal for heating during the winter months. Electricity will be generated for the terminal, and both the electrical and pneumatic distribution systems. Excess electrical energy will be sold to local utilities during periods when supply exceeds demand.

2. PNEUMATIC REQUIREMENTS

The pneumatic demand which a ground based system would have to supply depends upon the number type and schedule of aircraft served by the system. Manufacturer's specifications for ground supplied air call for pressures ranging from 30 to 45 psig at a temperature of 150 degrees F.

The ATA (Ref. I) has established recommended procedure for determining flow requirements and compressor sizes. Based upon the ATA guidelines, a total flow of 3000 lb/min would be required to service 20 gates at Charlotte. Assuming low-pressure centrifugal compressors would be used, the total power

400 HZ DISTRIBUTION SYSTEM

Figure 5

requirement would be 6350 HP.

3. AIRCRAFT ELECTRICAL GROUND SUPPORT REQUIREMENTS

Aircraft electrical systems are not compatible with standard utility electrical systems. Aircraft systems require 400 HZ rather than the U.S. standard 60 HZ frequency and voltage levels differ from utility standards. Thus, specially designed electrical distribution systems are used. Such systems have been installed at numerous airports, including Charlotte. These 400 HZ distribution systems convert power from the utility system to voltage/frequency levels required by aircraft.

As is the case with pneumatic systems, the ATA (Ref. 2) has issued guidelines for designing electrical distribution systems. They recommend each gate be supplied with 60 KVA. For the 20 gates at Charlotte, this means total system capacity of 1200 KVA.

4. CENTRAL PLANT DESIGN

The total energy demand to be served by a waste to energy incinerator plant consists of the terminal thermal and electric load, the electric loads associated with the 400 HZ distribution system and the electric load imposed by electric compressors which supply air for the pneumatic distribution system. These loads are summarized as follows:

ELECTRIC LOADS

Pneumatic System	4693 KW
400 HZ System	1200 KW
Terminal	600 KW
	6493 KW

THERMAL LOADS

Terminal Heating	3000 LB/HR steam
------------------	------------------

A waste to energy plant capable of meeting these loads would produce

over 97,000 LB/HR of steam. Approximately 94,000 LB/HR would be supplied to a multi-stage condensing type turbine generator with the remainder used as heating steam in the terminal. The heating steam would be used to heat the existing terminal hot water loop via a heat exchanger installed in parallel with the oil fired boilers. The turbine generator will be connected to the utility grid so that excess power generated can be sold to local utilities when plant output exceeds demand. Figure 6 illustrates the proposed method of interfacing the waste to energy plant with all systems involved and shows energy balances based upon design conditions.

Waste incinerators of the modular controlled air type would be best suited to the application. To produce steam at the design rate, total processing capacity of approximately 375 TONS/DAY would be required.

III. RESULTS

A. PROJECTED PERFORMANCE AND ENERGY SAVINGS

The results of calculations to simulate the operation of the waste to energy plant are shown in Table 3. These figures are based on waste heating values of 4500 BTU/LB and manufacturers published values for steam conversion efficiency, auxillary fuel consumption and other parameters.

Energy savings for the terminal building would be the total of electrical energy and fuel oil which would otherwise be consumed if the system were not available. This would, on an annual basis, be 3,531,600 KWH and over 52,956 gallons of oil. Using current energy costs, this equates to an energy cost savings of over \$247,194.

Energy savings for the airlines consists mainly of aircraft jet fuel that would normally be consumed during ground operations. Savings

FIGURE 6
AIRPORT ENERGY SYSTEM FLOW DIAGRAM

TABLE 3

PROJECTED WASTE TO ENERGY SYSTEM OPERATING PERFORMANCE

WASTE PROCESSED (TONS) <u>126,000</u>	WASTE RATE (TONS/DAY) <u>375</u>	STEAM OUTPUT LB/HR <u>94,459</u>
STEAM DELIVERED (LBS) <u>13,809,600</u>	KW OUTPUT (KW) <u>6493</u>	KWH PRODUCED (KWH) <u>56,722,348</u>
AUXILLIARY FUEL CONSUMED (THERMS) <u>315,000</u>	AUXILLIARY POWER CONSUMED (KWH) <u>3,150,000</u>	

of over 923,420 gallons of jet fuel are possible. This represents an operating cost savings, including reduced maintenance of over \$1,320,817 as shown in Table 2.

B. ECONOMIC AND ENVIRONMENTAL BENEFITS

1. ECONOMIC ANALYSIS

The first step in the economic analysis involved determining all the costs and potential revenues associated with a 375 TPD modular incinerator plant. This was accomplished using a computer program to project costs over a 10 year planning period. Capital and O & M costs for existing plants of the same size range were used. Other assumptions included:

- . 10 year amortization
- . 12% interest rate
- . Electricity sold at existing parallel generation rates

This scenario is based on electricity being sold to airlines at the cogeneration rates which are significantly less than retail rates which would be charged if the pneumatic and electric distribution systems purchased power from the utility grid.

The results of the computer analysis are shown in Table 4. Figures in line 17 of the report reflect disposal costs per ton which would be charged to the City of Charlotte for waste delivered to the plant.

The City of Charlotte is presently attempting to develop a resource recovery system as a long-range alternative to the city's solid waste disposal problems. Preliminary studies (Ref 3) have estimated disposal costs for a large city owned incinerator plant ranging from \$30 - \$40 per ton initially to approximately \$22 - 32 per ton in 1993. By way of comparison, the same studies project disposal costs for continued landfilling to rise from approximately

 * WASTE PROFIT *

 * IS A PROPRIETARY SOFTWARE PRODUCT OF ROSS *
 * HOFMANN, TALBERT, COX & ASSOCIATES. WASTE PROFIT *
 * PROVIDES TEN YEAR PROFORMAS AND SENSITIVITY ANAL *
 * YSES OF MUNICIPAL OR INDUSTRIAL WASTE-TO-ENERGY *
 * PROJECTS *

Table 4

WASTE PROFIT CASH FLOW FORECAST

PROJECT NAME= CHARLOTTE AIRPORT

C O S T S	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1 CAPITAL PAYMENT	1130000	1130000	1130000	1130000	1130000	1130000	1130000	1130000	1130000	1130000
2 INTEREST @ 12.0 %	2033249	1220399	1084799	949199	813599	677999	542399	406799	271199	135599
3 LABOR	416000	428479	441334	454574	468211	482258	496725	511627	526976	542785
4 ADMINISTRATIVE	43000	44289	45618	46987	48396	49848	51344	52884	54471	56105
5 MAINTENANCE	69000	71069	73202	75398	77660	79989	82389	84861	87407	90029
6 INSURANCE	28000	28839	29705	30596	31514	32459	33433	34436	35469	36533
7 OPERATING FEE	129000	132869	136856	140961	145190	149546	154032	158653	163413	168315
8 LEGAL & ACCOUNTING	8000	8239	8487	8741	9004	9274	9552	9838	10124	10438
9 UTILITIES	228000	241679	256180	271551	287844	305115	323422	342827	363397	385201
10 RESIDUE DISPOSAL	126000	129779	133673	137683	141814	146068	150450	154964	159613	164401
11 OVERHAUL RESERVE	126000	129779	133673	137683	141814	146068	150450	154964	159613	164401
R E V E N U E										
12 STEAM SALES @ 0.00 (\$/KLE)	0	0	0	0	0	0	0	0	0	0
13 POWER SALES @ 2.4 (CT.KWH)	1338659	1418978	1504117	1594364	1690018	1791427	1898913	2012848	2133619	2261636
14 TIPPING FEES @ 0.00 (\$/TON)	0	0	0	0	0	0	0	0	0	0
15 NET OPERATING INCOME	-2997590	-2146442	-1969410	-1789009	-1605020	-1417197	-1225283	-1029005	-828073	-622171
16 CUMULATIVE INCOME	-2997590	-5144032	-7113442	-8902451	-10507471	-11924668	-13149951	-14173956	-15007029	-15629200
17 NET DISPOSAL COST (\$/TON)	-23.79	-17.04	-15.63	-14.20	-12.74	-11.25	-9.72	-8.17	-6.57	-4.94
18 NET COST (\$/HOUSEHOLD)	-27.47	-19.67	-18.05	-16.40	-14.71	-12.99	-11.23	-9.43	-7.59	-5.70

ACTION DESIRED: (1-PROFORMA, 2-SENSITIVITY, 3-END)

? 3

\$6.00 per ton to over \$12 per ton during the same time period. Table 4 shows disposal costs for this plant to be lower than those associated with the large plant and even lower than projected landfill costs by roughly 1990. Thus, this plant could offer the city some advantages depending on which approach the city takes with respect to solid waste disposal. It should be noted that the city is experiencing difficulties in locating suitable landfill capacity as is the case with most large metropolitan areas around the nation. This may force implementation of a major resource recovery program in the next few years.

As mentioned earlier, the economic advantages offered to the city by this project depend upon whether the city continues landfilling or implements a resource recovery program. If the latter approach is taken, this project should be viewed as an alternative to a large centralized plant. In that case, the savings would be the difference in disposal costs for this project versus those projected for the larger plant.

A summary of the initial annual economic savings for all three parties, the airport, the airlines and the city, is as follows:

Airport	\$151,000	Electricity
	\$ 56,000	Oil
	<u>\$207,000</u>	Total
Airlines	\$1,320,817	APU Operating Costs
	- 30,752	Electricity
	<u>\$1,290,065</u>	Total
City	\$782,460	Waste Disposal

* Note: Savings for the city is assumed to be the difference between \$30.00 per ton for a centralized plant and \$23.79 per ton for this project. Thus, the savings figure is based on \$6.21 per ton savings times 126,000 tons per year processed.

2. ENVIRONMENTAL BENEFITS

Modular controlled air incinerators are guaranteed to meet emission standards and will do so without complex, costly, energy consuming air pollution control equipment. This is not the case with mass burning waterwall technology. Several inherent design features make this possible including:

- . Low air flow rates through the burning bed reduce entrainment of particulates.
- . High temperatures present in both chambers reduce hazardous and unburned hydrocarbon materials to elementary form.

Modular Controlled Air plants actually provide positive environmental effects. The reduction of waste volume extends landfill life by a significant term. Since the ash is dry, inert and dense, it reduces leachate production. It also provides excellent fill material that is dense, easily compacted and not attractive to varmints.

Ash byproducts resulting from plant operations would either be land-filled, used as fill material to raise the grade of low-lying land areas, or used as an ingredient in road patch mix.

A brief explanation of the operating theory of Modular, controlled-Air Incineration Systems is in order at this point.

Referring to Figure 7, Waste (1) is loaded into an automatic feeder (2) by skid steer type tractors. The material is then charged into a refractory lined main combustion chamber (3).

In the main chamber, air is added at a controlled rate to permit combustion of the glowing bed. Only enough air (approximately 30% of that required for complete combustion) is added to sustain combustion and drive off hot, combustible gases from the bed. At the beginning of a firing period,

combustion is initiated by gas fired ignitors which turn off during steady state operation. Air flow is insufficient to entrain large quantities of particulates.

From the main chamber gases flow to the secondary chamber (5) where the combustion process is completed upon admission of the remaining air portion. Hot gases then pass through a boiler section (6 & 6) and up the exhaust stack (8). To enhance system operational redundancy in the event of loss of steam load, an emergency by pass stack (9) is provided. This permits continued waste incineration until boiler operation is again possible.

Ash removal operations proceed continuously and are completely automated. Automatic ash rams (4) sequentially convey the burning bed down the stepped hearth into a water quench and cooling tank (10). The ash is then removed by a conveyor (11) and deposited into a standard dumpster container (12).

C. PROJECT IMPLEMENTATION STRATEGIES

In all waste-to-energy projects, one of the first consideration that needs to be resolved is the issue of who will own and operate the energy facility. From the city's standpoint, it is usually most desirable if an energy customer can be located who is willing to finance and run the plant entirely on its own, and who is paid a tipping fee by the city for accepting their solid waste. In practice, there have been very few instances in the entire nation where a waste-to-energy plant has been built on such a basis; that is, where the plant was completely financed using private money, where it was run by the energy customer, which in this case is the airport and where municipal solid waste was used as the primary fuel source to meet the owner's energy needs. Even in these cases, tax-exempt

industrial revenue bonds had to be authorized by the city to make the arrangement feasible. It is not likely that a similar approach can be successfully pursued in Charlotte, mainly because the airport operating department is not set up to manage such a project.

Another ownership option is to have a third party finance and operate the waste-to-energy plant, taking waste from the city and selling steam to a customer. This approach also has not been adopted frequently, and, when used, has usually required that the county provide at least a portion of the financing plus signing away streams which the county controls. Implementing such an arrangement is difficult at best, and probably will prove to be impractical in Charlotte.

A third and more realistic approach is for the city to finance and operate the facility completely on its own. Most waste-to-energy projects in the U.S., especially those employing modular incinerators, have been implemented in this way. Only thru city ownership can the public reap the long term benefits which will result from sale of the energy value which the wastes contain. It is likely that the same method will have to be used in Charlotte and all analyses presented in this report have been prepared based on this assumption. If the city is unwilling or unable to take on this task, then a waste-to-energy project is probably not practical.

In the third ownership approach the city would be responsible for operating the plant. This is a difficult job and has recently proven to be more than some cities could handle. Successful operation of the facility will require that the city attract and retain experienced individuals familiar with the steam generating process. It will also require that they place a

high priority on the plant working properly, and give it constant attention. For this reason we recommend that actual operation of the proposed plant be contracted to the equipment vendor. While this approach will require that the city pay the operator, it will eliminate the need to hire the twelve or so people necessary to run the facility, and will make the vendor responsible for successful efficient plant operation.

Assuming that the waste-to-energy project proposed will be paid for by the city there are three basic financing tools available:

- . General Revenue Funds
- . General Obligation Bonds
- . Municipal Revenue Bonds

General Obligation Bonds have been used to finance a number of waste-to-energy projects in the U.S. G.O. bonds are long-term, tax-exempt obligations issued by political jurisdictions having the ability to levy taxes. They are secured by the full-faith-and-credit of the issuing authority and, as such, usually carry a lower interest rate than most other long-term financing mechanisms. G.O. bonds are usually more marketable than other financing instruments since they provide the greatest assurances to the bond holders. Although G.O. Bonds will most likely continue to be a popular financing mechanism for these plants, they suffer from a number of deficiencies. First, they transfer the risk of plant failure almost entirely to the county, since general revenue funds are usually pledged to secure them. Second, voter approval is required before they can be issued, a time-consuming process that most counties wish to avoid. Third, and probably most importantly, statutory limits (debt ceilings) prevent the general obligation debt from exceeding a specified percentage of the issuing body's assessed valuation. If this ceiling

has been or is about to be reached in Charlotte, this financing tool will be impractical.

Municipal Revenue Bonds are also long-term, tax-exempt obligations issued by political jurisdictions with tax levying authority. They differ from General Obligation Bonds in that they are secured by project revenues (and possibly other government assets), rather than the full-faith-and-credit of the county. As such, they transfer more of the project risk to the bond holder and carry a slightly higher interest rate. While less marketable than General Obligation Bonds, they offer several attractive features. First, voter approval is not required before they can be issued. Second, and very importantly, debt ceilings do not usually apply. Third, they require that detailed documentation of project feasibility evaluations be provided. While this increases the cost of issuance relative to G.O. Bonds, it forces careful planning on the part of the issuer, and permits a final evaluation of project soundness by prospective bond purchasers. Because of these features, Municipal Revenue Bonds are beginning to play an increasing role in the financing of waste-to-energy plants.

Finally, while federal government financial support has been available for waste-to-energy projects in the past, little assistance is provided today. The federal government should not be looked to as a source of funding.

In summary, it is likely that either General Obligation or Municipal Revenue Bonds will be the most practical financial instruments used to pay for a waste-to-energy plant in Charlotte.

Closely coupled to financing consideration is selection of a procurement approach. Historically, three options have been used by the waste-to-energy industry:

- . Conventional, or Architect/Engineer Approach
- . Turnkey Approach
- . Full-Service Approach

In the conventional approach, an architect/engineer is hired to develop a comprehensive plant design and prepare detailed system specifications as part of a bid package submitted to prospective proposers. Bidders respond to this package consistent with specified design requirements. In this approach the county assumes almost all plant performance risks since the successful bidder is required only to build to specification. Performance guarantees are typically not provided. On the other hand, the approach permits maximum input on the part of the county in the plant design process, and tends to be the least expensive method available.

On the turnkey approach a technical consultant is hired to develop a less detailed request for proposal and to evaluate responses. A single system supplier is then selected to install the equipment and to start-up the system. This turnkey supplier also must guarantee system performance, and hence assumes an increased share of the project risk. Upon satisfactory completion of the supplier's contractual obligations, plant ownership and operation are turned over to the county. Since this approach transfers some risk to the system supplier, it is usually more expensive than the conventional approach. It also allows only a minimum to county input during the design process.

The full service approach is identical to the turnkey approach, with the exception that the consultant provides contract and legal services, prepares plant designs and equipment specifications and the equipment supplier is made responsible for operation of the plant. With this method the system vendor assumes most of the risks in the project. Since this arrangement minimizes risk to the county, it is usually the most expensive.

to implement.

The most practical procurement method for this project is the full service approach. It divides project risks among project participants, and is employed in most modular incineration systems being procured today. The conventional approach, although least expensive, places all project risks on the county.

Among the many advantages offered by modular plants is the fact that they can be designed, constructed within an 18 month period after completion of the planning process.

IV. CONCLUSIONS AND RECOMMENDATIONS

It appears that a resource recovery based airport energy system offers significant promise for reducing the quantity of fossil fuel consumed by aircraft and the airport terminal. By recovering energy from municipal solid waste material, such a system could save over 900,000 gallons of jet fuel and over 56,000 gallons of heating oil per year at Charlotte, N.C. Operating cost reductions commensurate with those savings would accrue to the airport authority and the airlines.

At the same, such a system could offer the city an alternative to the current method of solid waste disposal by landfilling. Even though tipping fees charged by the plant would be higher per ton of waste than landfill rates in the short term, the future availability of landfill capacity remains uncertain. Thus, over the long term the proposed plant could offer economic advantages to the city. When compared to disposal costs projected for the city's planned resource recovery program the economic advantages appear more immediate.

One of the problems encountered in this study was the fact that overall project economics were not as good as expected. This was due primarily to the relatively low electric rates prevailing in the Charlotte area (and the Southeastern U.S. in general). Low electric rates and correspondingly low "buyback" rates which utilities pay for excess power generated by plants like the one proposed adversely affect overall project economics. In other words, the tipping fee required to provide adequate income to the project is high compared to landfill costs. This situation would probably be reversed in other urban areas in the Northeast or in coastal cities.

Exhaustive analysis of the environmental impact of siting a resource recovery plant near the Charlotte Airport was beyond the scope of this study. However, no major environmental barriers were uncovered during the investigation that would preclude implementation.

A major factor that affects the overall feasibility of the proposed project is the compatibility of resource recovery with airport operations. Airport operators and airlines are engaged in the business of providing transportation for the public. They are not involved in solid waste disposal or energy conversion. For this reason, it is imperative that the resource recovery plant be city owned with operation contracted to a qualified plant operator. It should be sited remotely from the terminal with esthetic architectural treatment to reduce adverse reaction from travelers passing through the terminal. In addition, the plant should be viewed by the airlines and airport operators as a separate energy source offering them the potential for operating cost reductions. If these requirements can be attained adequate incentive will exist to promote the essential cooperation between all parties involved that will be conducive to implementation.

In the particular case of Charlotte, whether or not the proposed system can be implemented depends on the path chosen by the city regarding its own resource recovery program. If suitable long term landfill capacity can be obtained, it is doubtful that the tipping fees required by this project will be competitive. If the city pursues resource recovery then this project should be evaluated further as a segment of their overall plan. If the large centralized plant approach is actually adopted by the city, then this project will probably not be feasible because the larger facility will utilize all available solid waste.

Due to the relatively low thermal (steam) demand at the Charlotte Airport, cogeneration systems were not feasible. Electricity to power aircraft ground support systems would have to be generated by condensing type turbines with the large quantity of low-grade energy present in the exhaust wasted to the atmosphere. The entire system could be less costly, more energy efficient and more cost effective if cogeneration could be utilized. At other similar airports this could be accomplished by supplying low pressure steam to industrial users near the airport. In the northern climates airports would probably have a greater thermal demand for heating the terminal or de-icing runways.

Based on the work done during this project we offer the following recommendations.

1. The project at Charlotte should be evaluated in further detail by the city as a part of their on-going resource recovery program.
2. To avoid placing undue burden on airlines/airport operators, the local municipality should be the owner of the resource recovery plant. Plant operations should be kept separate from airport operations.
3. Systems of this type should be included in the designs of future large airport facilities which are built near large metropolitan cities.
4. Resource Recovery based airport energy systems should be seriously considered at large airports in northern climates or in areas with acute waste disposal problems and relatively high energy costs.

V. BIBLIOGRAPHY

1. AIRCRAFT GROUND SUPPORT AIR SYSTEMS PLANNING GUIDEBOOK -
Air Transport Association, Nov. 1981.
2. RESOURCE RECOVERY IMPLIMENTATION -
Progress Report No. 1 - City of Charlotte - Dec. 1981.
3. SOLID WASTE DISPOSAL IMPLIMENTATION PLAN -
City of Charlotte - Nov. 1980.
4. ENVIRONMENTAL ASSESSMENT - NEW PASSENGER TERMINAL, INTERNAL CONNECTIONS
TUNNEL, AND CARGO AREA - Douglas Municipal Airport.