RECYCLE ENERGY SYSTEM - CITY OF AKRON, OHIO

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ABSTRACT

Akron’s Recycle Energy System is designed to process 1,000 tons per day of Municipal Solid Waste for material recycling and production of steam. Design parameters of the project and current status are discussed, together with the marketing concepts and project economics.

BACKGROUND

The Akron Recycle Energy System project was initiated by the city’s Department of Planning and Urban Renewal in 1969. In broad terms, the objectives of the program were to develop an economic and acceptable means of solid waste disposal with such other social benefits as might be obtainable with minimum technological risk. Energy needs in the immediate area were identified early in the program as a significant potential for cost recovery. This also held the potential of alleviating other energy related problems of the central city.

A detailed study of energy recovery from solid waste was completed by 1971, recognizing the alternative approaches available at that time.

The focus on direct burning of shredded waste was prompted by the high conversion efficiency obtainable as well as the enhanced possibilities of other resource recovery. A schematic diagram of the mass and energy balance is included herein; however, certain highlights are in order: 3.9 lb (1.7 kg) of steam will be net from each pound of solid waste received with a boiler efficiency of 78.2 percent.

GENERAL

The Akron Recycle Energy System is a project designed primarily for production and sale of steam to be produced from 100 tons per day (907 t/day) of municipal, commercial and suitable industrial solid waste, and for present and future recycling of the heavier inorganic materials. The process consists of coarse single stage shredding of the solid waste, combustion of the light fraction in semi-suspension fired boilers, recovery of ferrous metals, and future recovery of glass and aluminum.

Gross steam production is projected to be 378,000 lb/hr (171,600 kg/h) with the cycle selected with internal plant usage appropriate to the heat balance. A multitiered array of steam consumers has been established to achieve essentially 100 percent initial utilization of the steam produced and yet provide sufficient flexibility to exploit the more favorable future energy marketing potentials.

STATUS OF THE PROJECT

The project is now under construction on a 7½ acre (30.35 ha) site in the Opportunity Park Urban Renewal Area, with ground breaking taking place just prior to January 1, 1977. Construction is expected to be completed by the summer of 1979.

Direct capital construction cost is approximately $31 million, including $4.8 million in new and additional steam distribution mains. Major contracts include: (1) boilers, (2) general construction, (3) mechanical, (4) electrical, and (5) heating, ven-
PROCESS AND EQUIPMENT

The location of the Recycle Energy System was selected for suitability to serve the potential steam users, availability of land, and convenience of access. The available traffic network will permit vehicle access to the facility through freeways and major arterials. Both collection and compactor transfer vehicles will be accommodated. Private cars and trailers will not be accepted.

From the entrance ramp to the tipping floor, the trucks pass over a scale which is automated for credit card operations and billing. The scale is within the tipping floor to avoid the necessity for a separate scale house and operator(s). The tipping floor is 130 ft wide x 240 ft long (43 m x 78.7 m) and provides 14 dumping stations.

Trucks dump into a pit which is self unloading by means of two lines of hydraulic multi-ram positive displacement unloading lines. This arrangement appears as a hybrid between the “shuffle grate stoker” and stationary compactors. Each of the two lines will discharge in excess of 100 tons per hour (91 t/h) and can operate satisfactorily with part of the rams out of service. Pit capacity is 1350 tons (1225 t).

The multi-rams discharge to a surge bin from which flight conveyors of 8 ft (2.6 m) width elevate the bulk waste to the shredders. The flight conveyors are solid state controlled for 25:1 turndown in response to shredder current.

The two shredders are “American Pulverizer,” 72 in. x 108 in. (2 m x 2.9 m), powered by 1500 hp (1120 kW) shredder duty squirrel cage motors. Each is conservatively rated at 60 tons per hour (54 t/h) based on a mixture of normal domestic pickup and bulky waste. Only single stage coarse shredding is required for the burning process of the project and 6 in. x 9 in. (0.15 m x 0.23 m) shredder grates will be employed.

From each shredder the material is conveyed to an air classification density separator manufactured by Triple S Dynamics. Density separation is not essential to the ultimate combustion process. It is included in the project for the advantage of superior ferrous metal recovery and the future potential of nonferrous metals and glass recycling. Although the heavy fraction is not normally detrimental to this combustion process, examination of ash does suggest that high-grade markets for nonferrous metals or glass would be more difficult to accomplish after the material had been fired.

The heavy fraction from density separation passes through 2-stage magnets for ferrous recovery and then is conveyed either to outloading for landfill or to further processing for recycling. Space is provided for glass and nonferrous recovery and upgrading; however, the equipment is not presently incorporated in the project’s contracts.

The light fraction is conveyed to a double-sided “Miller-Hoffit” storage bin of 1900 tons (1720 t) capacity. Each pair of augers is designed to outfeed 60 tons per hour (54 t/h) of RDF to a surge bin which provides the final feed and metering to the pneumatic transport system supplying fuel to the boilers.

Three “Babcock-Wilcox” boilers, spreader stoker fired, are provided, each with a nominal capacity conservatively rated at 126,000 lb/hr (57.20 kg/h). Space is provided for a future fourth boiler. Boiler efficiency is guaranteed at 78.2 percent with the specified fuel. Single boiler efficiency is summarized on Table 1.

The shredded refuse is fed from the 2 ton (1.8 t) surge bin into the pneumatic feeder. The feeder is controlled by the combustion control system on the basis of steam line pressure. The mixture of air and refuse is conveyed through 8 in. (0.203 m) pipe to the cyclone separator at the top front of each boiler. The air flow through these swept spouts carries the fuel into the furnace. The spouts utilize a curtain of air entering at the rear of the spout to carry the light density refuse into the furnace. Motorized rotary air dampers control the air to each air swept spout by alternately increasing and decreasing both the quantity and the pressure of the air during several cycles per minute to assure even fuel distribution from the front to rear of the furnace. Under each of the air swept distributing spouts are five high-pressure jets placed in such a manner as to fan the flow of air and fuel from the spout to provide uniform side-to-side distribution.

This feed system is designed to provide rapid response to varying steam flow demand or changes...
TABLE 1 SINGLE BOILER EFFICIENCY SUMMARY

<table>
<thead>
<tr>
<th>Table Entry</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons refuse/day unit (nominal capacity)</td>
<td>333</td>
<td>302</td>
</tr>
<tr>
<td>Steam capacity, lb/hr (kg/h)</td>
<td>126,000</td>
<td>57,200</td>
</tr>
<tr>
<td>Steam pressure at outlet, psig (kg/cm²)</td>
<td>560</td>
<td>39.4</td>
</tr>
<tr>
<td>Steam temperature</td>
<td>Saturated</td>
<td></td>
</tr>
<tr>
<td>Feed temperature, F C</td>
<td>240</td>
<td>116</td>
</tr>
<tr>
<td>Exit gas temperature, F C</td>
<td>325</td>
<td>163</td>
</tr>
<tr>
<td>Excess air leaving unit</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Efficiency %</td>
<td>78.2</td>
<td></td>
</tr>
</tbody>
</table>

in heating value of the fuel. A change in the feed rate of the pneumatic feeder will be reflected in the furnace within approximately 7 sec. Forty to 60 percent of the fuel is expected to be burned in suspension, and the remaining heavier and harder-to-burn material falls on the grate. This permits additional time to consume these particles.

The grate and the underfire air are controlled for the quality and density of the materials on the grate to achieve complete burn-out. This grate is designed with a high pressure drop to provide even air distribution throughout the grate area. The grate is made of ductile iron to be more resistant to shock and should give a long grate life. The Detroit stoker is rated 694,000 Btu/hr/ft² (1,882,000 cal/h/m²) of grate, which is conservative in light of similar experience with bark burners.

On mass burning units where, because of the heavier fuel bed, it is difficult to get good mixing of air with fuel, the lower furnace must be protected with a refractory to guard against corrosion. Experience to date has shown this is not necessary on this type of unit as the intimate mixing of the air and fuel reduces the tendency for localized alternate oxidizing and reducing atmospheres, which is thought to be a major cause of corrosion. Without refractory-covered walls, there is less slugging and lower furnace maintenance. Excess air leaving the unit is in the order of 40 percent.

The convection surfaces of the boiler, consisting of the boiler bank and economizer, are of the in-line arrangement. The boiler is designed without baffles or turns and with low gas velocities to minimize the tendency of erosion. The economizer is designed with cavities to permit the use of mass blowing retractable soot blowers. The use of the economizer permits the reduction of gas temperatures from 812 F (433 C) to 524 F (274 C) while heating the feedwater to 346 F (174 C). This contributes to the predicted efficiency of 78 percent.

The flue gas, after passing through the economizer, makes a 180 deg. turn before entering the precipitator. This change in direction provides for separation of the larger particulates which are deposited in a hopper and then reinjected to the furnace for further bum-out. This reinjection reduces the carbon loss of the unit.

The flue gases then pass through an electrostatic precipitator to remove the particulate matter in the gas stream. The precipitator is designed with four fields to provide for maximum emissions at 0.11 lb/million Btu (0.003 gr/cal). This precipitator operates at 524 F (274 C) providing for collection while the dust and gases are well above the dew
### TABLE 2 ESTIMATED ANNUAL GENERATION AND SALE OF STEAM

<table>
<thead>
<tr>
<th>Description</th>
<th>Pounds of Steam</th>
<th>Megagrams of Steam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Amount of Steam Generated with 365,000 tons of Solid Waste with a Heating Content of 5,000 Btu’s per Pound</td>
<td>2,897,000</td>
<td>1,315,238</td>
</tr>
<tr>
<td>Less: In-Plant Use</td>
<td>555,000</td>
<td>251,970</td>
</tr>
<tr>
<td>Scheduled Maintenance</td>
<td>14,000</td>
<td>6,356</td>
</tr>
<tr>
<td>Surplus Steam Not Sold</td>
<td>26,000</td>
<td>11,804</td>
</tr>
<tr>
<td>Total Plant Sendout</td>
<td>2,302,000</td>
<td>1,045,108</td>
</tr>
<tr>
<td>Less: Distribution System Losses</td>
<td>248,000</td>
<td>112,592</td>
</tr>
<tr>
<td>Total Amount of Steam Available for Sale</td>
<td>2,054,000</td>
<td>932,516</td>
</tr>
</tbody>
</table>

**Sales of Steam**

- **Long Term Signed Customers in Central Business District**: 221,000, 100,334
- **Akron City Hospital**: 260,000, 112,090
- **University of Akron**: 268,000, 121,672
- **B. F. Goodrich Company**: 871,000, 395,434
- **Government Buildings**: 59,000, 26,786
- **Major Unsigned Existing Customers**: 188,000, 85,352
- **Remaining Unsigned Customers**: 103,000, 46,762
- **Unsigned Potential Customers**: 84,000, 38,136

**Total Steam Sales**: 2,054,000, 932,516

A regenerative air heater follows the precipitator, reducing the flue gas temperature to 325°F (163°C) while heating the combustion air to 325°F (163°C). Locating the air heater after the precipitator reduces the cleaning required in the air heater with the economy provided by the 325°F (163°C) exit gas temperature.

The unit is also equipped with three auxiliary oil burners with steam atomization for operation to maintain steam production in the event of disruption of the refuse supply to the unit. These steam atomized oil burners are equipped with high energy spark igniters eliminating the need for natural gas or high oil pressures for mechanical atomization during light-off. The oil burners are also equipped with a burner safety system.

Beyond the boilers, house turbines are provided to provide backpressure steam to the deaerators and provide “house power” for essential internal electrical loads. Control systems permit venting of any excess steam production and also automatically curtail steam to interruptible customers in the event of shortfalls which are inherent within the marketing concept.

Estimated annual generation and sale of steam is summarized in Table 2.

**MARKETING**

Solid waste projects benefit from high utilization factors. Generally, there will be a dump charge or tipping fee for anything that comes through the front door. However, there will also be a processing cost and some additional cost for everything that goes out the back door for disposal. Consequently, the best economics will occur when the process is efficient in production of a maximum of saleable products and when all such products are sold. The Akron Recycle Energy System is designed to produce steam. Markets also exist today to make it economical to recover ferrous metal for sale. In the future, when markets exist to make recovery of nonferrous metal and glass economical, this equipment may be installed in the plant.
The existing steam distribution system serving some 200 customers in the Central Business District of downtown Akron was faced with rising costs and pollution control problems and, for various reasons, had long been considered economically unviable. This constituted an obvious and important market for energy from solid waste. In itself, however, the district steam system did not provide a sufficient demand for an economical project. In addition, the 30 percent load factor of the district steam system could not provide particularly effective utilization of the energy produced. Heating plus cooling could raise this to about 50 percent load factor; but most of the buildings were currently using electric air conditioning and rapid conversions seemed both unlikely and insufficient to solve the problem of maximum utilization. The addition of Akron University and Akron City Hospital to the system on an interruptible-for-cause basis provided an additional tier of customers having both heating and cooling of considerable magnitude. Adding these two customers on a rate preferment basis improved the utilization factor to about 50 percent.

The real key to the project was the B. F. Goodrich Company which had a substantial need for industrial steam and was favorably located with respect to available sites and close to the Central Business District. Their willingness to procure all of the steam in excess of the other user's requirements on a fuel-offset basis ($1.74/million Btu) was the key to the successful marketing package to develop favorable economics for the project.

FIG. 1 MODEL OF THE AKRON, OHIO RECYCLE ENERGY SYSTEM
FIG. 2 CONSTRUCTION SITE OF THE AKRON, OHIO RECYCLE ENERGY SYSTEM
FIG. 3 SCHEMATIC DIAGRAM OF THE RECYCLE ENERGY SYSTEM
FIG. 4 LOCATION MAP OF THE RECYCLE ENERGY SYSTEM
FIG. 5  A TYPICAL MASS AND ENERGY BALANCE
APPLICATIONS

It should be evident that each application depends on the specific economics. Where there is a reasonable match between direct energy and solid waste disposal requirements, the approach outlined can develop quite favorable economics. For any solid waste project, the economics involve a matrix between alternative disposal costs, value of recovered products, operating, maintenance and amortizing costs.

Process steam requirements of appropriate size are among the most favorable applications because of the high load factor. Frequently, the addition of back pressure generation (cogeneration) increases the economic attractiveness of such projects.

ACKNOWLEDGMENTS

Acknowledgment for boiler data as actually being constructed, and boiler cross section, Fig. 6, is hereby gratefully given to G. P. Hileman, Project Administrator, Industrial & Marine Division, Power Generation Group, Babcock & Wilcox, North Canton, Ohio.

Key Words: Burning, Municipality, Refuse, System, Waterwall