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Resource Recovery from Solid Waste: The Story of Union Electric's Solid Waste Utilization System

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Abstract

This paper covers the design and development of a comprehensive resource recovery system capable of serving the solid waste disposal needs of the Greater St. Louis area comprising 11,500km^2 (4500 sq. mi.). This 7.2x10^{6}kg (8000 ton) per day operation will convert solid waste into milled fuel for cofiring with pulverized coal in utility boilers, and will recover magnetic and non-magnetic metals, all in an environmentally acceptable manner. Scheduled for operation in 1979, the system will be built and operated as a private enterprise venture of Union Colliery Company, a subsidiary of Union Electric Company.

1. INTRODUCTION

Studies of existing methods of solid waste disposal in the St. Louis area (landfilling and incineration) indicate that by 1980 there will be insufficient sites for environmentally acceptable landfills in the area, which will cause problems of serious proportions, affecting the 2,500,000 residents of St. Louis and the adjoining seven counties in Missouri and Illinois.

As the result of the successful operation of a full scale prototype "Refuse to Energy" system, built and operated as a joint venture of Union Electric, the City of St. Louis, and the United States Environmental Protection Agency, Union Electric Company announced on February 28, 1974 that it would build and operate a private enterprise Solid Waste Utilization System to process 7.2x10^{6}kg (8000 tons) per day of residential, commercial and industrial waste in the 11,500km^2 (4500 square mile) St. Louis Metropolitan area.

This paper describes this pioneering achievement and covers principal engineering and environmental matters embodied in its design and development.

2. GENERAL DESCRIPTION

The Solid Waste Utilization System (SWUS) will serve the City of St. Louis and seven contiguous counties, namely St. Louis, St. Charles, Franklin and Jefferson in Missouri and St. Clair, Madison and Monroe in Illinois. This region has a population of some 2,500,000 and contains over 150 governmental units. Solid Waste operations are handled by some 150 public and private organizations who haul to incinerators, landfills and roadside and promiscuous dumps. Presently, it is estimated that 7.2x10^{6}kg (8000 tons) per day of residential, commercial and industrial solid waste is generated. The projection for 1980 is 9x10^{6}kg (10 000 tons) per day.

The St. Louis region is well served by major highways and railroads. The highways and arterial roads radiate from the central city and encircle the metropolitan area. The railroad lines radiate from the core of the city like spokes of a wheel. This ground transportation network provides for efficient local truck collection of solid waste and for expeditious mass rail transport of the material to a processing site.

Union Electric Company and its utility subsidiaries is investor owned and franchised to serve the strategic center of America, a 52 000km^2 (24 000 mi.^{2}) area in Missouri, Illinois and Iowa along the Mississippi and Missouri rivers. Generating capability of the system is approximately 6,000MW, with 90% of the electricity produced at pulverized coal fired power plants. Of singular importance to SWUS due to site location and size is the 2400MW Labadie Plant some 65km (40 mi.) west of St. Louis. This plant burns about 900x10^{3}kg (1000 tons) of coal per hour.

The combination of favorable geographical factors, road and railroad adequacy, plus the operational and site advantages of Labadie Plant gave rise to a concept of a SWUS wherein a number of truck to rail transfer terminals will be conveniently located in the metropolitan area to minimize travel distance by the solid waste haulers. At the terminals, the unprocessed material will be compacted into steel shipping containers which will be loaded onto railroad cars and hauled by Unit train to a processing facility located on the Labadie Plant site, where preparation of shredded refuse derived fuel (RDF) and separation and processing of recovered metals will be accomplished. The RDF will be air conveyed to Labadie plant where it will be cofired with pulverized coal in the plant's four 600MW steam generators.

The SWUS is composed of three major operational divisions:

(1) Collection and Transport

(2) Processing

(3) Boiler Fuel

Design, construction and operation will be by Union Colliery Company, a wholly owned subsidiary of Union Electric Company. No funds for SWUS financing or operation will come from Union Electric's customers. All financing will be by private investor capital with no use of Government funds or subsidies.

Revenue to support SWUS financing and operating costs will be derived from:

(1) Trash hauler unloading fees at transfer terminals

(2) Sale of RDF to Union Electric as a boiler fuel

(3) Sale of recovered metals

Figure 1 "Solid Waste Utilization System" depicts the system diagrammatically.

2.1 COLLECTION AND TRANSPORT

The point of receipt of solid waste by the SWUS will be at any of four truck-to-rail transfer terminals, three located in the St. Louis area and one in St. Clair County, Illinois. All of the terminals are located on interstate highways and/or arterial roads. Truck traffic to and from any such terminal is less than the average vehicle volume to typical industrial sites as determined in extensive surveys by the Urban Land Institute. Hence, the transfer terminals will not significantly affect traffic patterns where they are located.

Each transfer terminal will be designed and built to handle 1.4x10^{6}kg (1500 tons) per day. The design permits future expansion to 1.8x10^{6}kg (2000 tons) per day as patronage increases. Residential, commercial, selected industrial and demolition wastes will be accepted. Acceptable materials include tires, appliances and size reduced trees and trimmings. Wastes classified as hazardous by governmental agencies as well as those determined by SWUS to be detrimental to its operation will be excluded. Only licensed waste haulers and municipalities operating their own fleets will be served.

The terminals will be open to receive waste between the hours of 6:30 A.M. and 8:30 P.M. Monday through Saturday. Daily cleanup of the terminal building and grounds will be performed after the evening closing hours.

Incoming trucks will be weighed upon entering the transfer terminal site for billing purposes (Figure 2). After weighing, the trucks will proceed into the enclosed terminal building where they will unload into the compactor charging pits or onto the floor. Sufficient space is provided for a number of the largest trucks, including 58m^3 (75 yd.^{3}) transfer trailer trucks, to unload simultaneously. When empty, the trucks will leave the building and site by a separate exit road to minimize traffic congestion on site.

Front end loaders will move the waste from the tipping floor to the stationary compactor charging pits. The four compactors each having a capacity of 8m^3 (10 yd.^{3}) per stroke, will load the waste into 69m^3 (90 yd.^{3}) containers. These containers are similar in design to conventional 58m^3 (75 yd.^{3}) end loading solid waste transfer trailers. With a tare weight of 9×10^3kg (10 tons), the containers will each carry a net payload of 27×10^3kg to 32×10^3kg (30 to 35 tons). The containers, built to ISO and AAR standards for shipboard use, are 12m (40 ft.) long and are equipped with internal ejection blades operable by external stationary power rams, and have externally power operated guillotine loading doors. The containers are set on movable steel frames which lock them to the compactors during the loading operation. Load cells in the frames will stop the compactors when the containers are loaded to a predetermined payload.

Conventional diesel powered container handling vehicles will handle the empty containers from the railroad cars to the compactors and vice versa. Two containers will be placed on each 27m (89 ft.) "Trailer Train" type flatcar. For short term storage the containers can be stacked two high when full and three high when empty. Normally, 36 to 50 containers will be loaded on 18 to 25 rail cars per transfer terminal per day.

Labadie Plant, where the "West" Processing facility will be built, is served by the Missouri Pacific and Chicago, Rock Island and Pacific Railroads. One unit train, consisting of 36 to 50 rail cars will serve two transfer terminals, and will be operated by the Missouri Pacific and a similar train serving the other two terminals will be operated by the Rock Island. 24 hour turnaround of the rolling stock is anticipated. Colliery will purchase and own 450 containers and 200 flatcars which will be dedicated to this service.

2.2 PROCESSING

The "West" processing plant is designed to provide a nominal processing capability of 6.5×10^6kg (7200 tons)/day, six days/week. Ultimate capability will be 8.7×10^6kg (9600 tons)/day, seven days/week. Expansion of processing facilities will be performed at another Union Electric coal fired power plant when system conditions warrant. The processing plant will be manned and operated 24 hours per day, 7 days per week.

Upon arrival of the unit trains at the processing plant, a Colliery owned switching locomotive will move groups of six loaded cars to the transporter roadway area, where container handling vehicles identical to those at the transfer terminals will transport the containers to stationary ejection stations, two of which are located at the head end of each of the four processing lines. When a container has been set in place, stationary equipment will open its guillotine doors and a hydraulically powered ram will enter the opposite end of the container forcing the push plate ahead of it, causing the solid waste to be discharged through the open end into the processing line. Since two ejection stations serve each line, there is no delay created by handling the full and empty containers, as the stations operate alternately. When empty, the containers are closed and the vehicles replace them on the railroad cars which are made up into a unit train which will be returned to the transfer terminals.

The solid waste is discharged from the containers onto a heavy duty steel panned horizontal variable speed receiving conveyor. This conveyor moves the waste onto an inclined panned infeed conveyor which feeds the primary shredder. This shredder is a reversible horizontal shaft unit which reduces the waste to a nominal 15cm (6 inch) size. Powered by a 1500kW (2000 HP) induction motor at a speed of 900 rpm the machine has a capacity of 90×10^3kg (100 tons)/h. The milled waste leaves the shredder via a pan type discharge conveyor, following which it moves on a rubber belt to a magnet for removal of magnetic metals.

The coarse milled waste, less magnetic metals is conveyed to the second stage shredder which is similar in design to the primary unit, but produces a nominal 2cm (3/4 inch) product size. The discharge of the second stage shredder is conveyed to the Air Density Separator surge bin for feeding dual 45×10^3kg (50 tons) or $425m^3$ (15 000 $ft.^3$)/h. upflow separators. The burnable fraction (lights) will be pneumatically conveyed to live bottom surge bins. The unburnable fraction (heavies) will be belt conveyed to a process which will condition this product for non-magnetic metal recovery.

Each processing line (including the two shredders and associated conveyors) will be served by a dust collector system to prevent processing dusts from leaving the system and creating an environmental hazard. Likewise, the Air Density Separators and Surge Bins will also have dust collectors.

The processing plant design allows for processing 6.4×10^6kg (7200 tons)/day with three of the four lines in continuous service. This allows one entire line to be out of service for maintenance, and is an important feature since solid waste processing equipment requires regular intensive maintenance.

The plant will be operated from a central control room and areas of the plant containing operating processing lines will normally be unattended.

2.3 BOILER FUEL

Labadie Power Plant is equipped with 4 - 600MW Combustion Engineering tangentially fired, pulverized coal units. Each boiler has six pulverizers and twenty-four coal nozzles. Four solid waste nozzles will be installed, one per corner, above the topmost coal nozzles in each boiler.

RDF produced by the processing plant is routed to four live bottom surge bins, one for each boiler. These bins, located in the yard west of the processing plant each have four discharge conveyors installed in trenches beneath the bin floors which are filled with RDF by the bin sweep system. The discharge conveyors meter the fuel into rotary airlock feeders which in turn place the fuel into the boiler charging pneumatic conveying systems supplied by positive displacement clean air handling blowers. Each of the four systems per bin (or per boiler) is independent of the other. Any combination of the systems can be used.

It is characteristic of RDF to be abrasive due to presence of residual ground glass and rock in addition to the native abrasiveness of the paper in the stream. To avoid excessive wear problems, the piping will be installed with elbows with replaceable wear backs at all changes of direction. Ceramic lined fiberglass pipe is planned for the straight runs. At 18 to 22kg/m (12 to 15 lb./ft.) this pipe is much easier to support than carbon steel and has proven under actual RDF usage in the prototype to have excellent wear resistant properties.

Each boiler's RDF system can provide up to 20% of the boiler's full load heat input requirements. With four units in normal service, SWUS processing capacity can be utilized at firing rates of 10% full load heat input per boiler. Thus, redundant boiler capacity is available to cover power plant outages and load reductions.

Ash residue from RDF firing will be collected by the power plant's electrostatic flyash precipitators and in the bottom ash hoppers of the steam generators. The plant's hydraulic ash disposal systems, now being renovated for better operational capability, flexibility and reliability will be adequate to convey the additional amounts of RDF ash together with the coal ash to the existing ash disposal ponds on the plant site.

3. METALS RECOVERY

Magnetic metals removed from the waste stream will be delivered to Vulcan Materials Co. for detinning. Products from the magnetic metals recovery plant, to be built on the processing plant site will be tin, tin dross, tin mud and high grade steel scrap.

A contract with a non magnetic metals processor is being finalized for recovery on site of aluminum, brass and copper from the metal rich heavies from the Air Density Separators.

4. TECHNICAL CONSIDERATIONS

During operation of the St. Louis demonstration prototype, over 650 samples of milled RDF were analyzed by an independent testing laboratory. Average of these analyses are compared with current analyses for coal burned at Labadie:

	RDF (As Fired)	LABADIE COAL (As Received)
Moisture %	26.9	12.1
Ash %	19.2	10.4
Chlorine %	0.33	1.0
Sulfur %	0.14	3.0
Heating Value kJ/kg	11400	25500
(BTU/lb.)	4902	10970

Since the RDF analyses tabulated were for residential waste only, we anticipate an increase in heating value with the addition of commercial and industrial wastes which are largely paper and plastics. It is also evident that RDF is a low chlorine and a low sulfur fuel compared to coal.

Potential boiler corrosive effects of solid waste burning require careful attention. During operation of the prototype, test sections of tubing were installed in the waterwalls, economizer, superheater and reheater of one of the test boilers. Subsequently, these specimens were removed and analyzed by three separate laboratories. All concurred that deposits from the specimens have physical and chemical characteristics similar to dry coal ash. These findings are encouraging, however they are based on limited exposure to solid waste burning, and much additional in depth corrosion studies are required to validate the preliminary results.

Similar corrosion test specimens will be installed in at least two of the four Labadie boilers for ongoing evaluations as SWUS begins full scale operations. Careful review of coal and RDF analyses and diligent monitoring of sources of RDF (especially commercial and industrial) will be required to preclude boiler damage.

5. ENVIRONMENTAL EFFECTS

Careful evaluation of SWUS environmental effects has been underway since inception of the prototype. Boiler emission tests conducted independently by the USEPA and Union Electric in late 1973 disclosed no serious emission problems. Further such tests run by both parties in 1975 verified the earlier results.

When the full scale system becomes operative, emission tests will be run on the Labadie precipitators to determine their performance with particulates from cofiring of coal and RDF. Results from these tests will determine the need for corrective action, if required.

The quality of ash pond water will be closely monitored and all results will be shared with the State of Missouri Department of Natural Resources. If treatment is required, appropriate measures will be undertaken.

SWUS does not contribute to aesthetic degradation of the countryside and there are no leachates to contaminate ground water. Many landfills and dumps place these burdens on the environment.

6. CONCLUSION

Although currently SWUS development has been suspended due to problems in locating a site for the fourth transfer terminal, it is hoped that resolution of this problem should shortly provide our management with the basis for a decision to proceed with the project.

SWUS is designed to provide an environmentally sound economic system to utilize the resources in the solid waste stream. It will significantly reduce the air, water and aesthetic degradation of the environment which is characteristic of landfills. It will help conserve irreplaceable fossil fuels and metals. These benefits will be secured within the framework of the free enterprise system.

7. BIOGRAPHIES

Name: Paul R. Brendel
Title: Assistant Manager, Solid Waste Utilization System
Education: B.S. in Electrical Engineering, Washington University, St. Louis, Mo., 1945.
Professional: Manufacturing Methods, Engineer, White-Rodgers Electric Co., St. Louis, 1946-1948.

Employed by Union Electric Co. in 1948, and was assigned as a staff engineer at 500MW Venice Power Plant. Remained at Venice Plant in a number of varied engineering responsibilities, culminating in position of Superintendent of Plant Engineering, until 1968. Transferred to new 2400MW Labadie Plant as Assistant General Superintendent. Remained in this position through startup and initial operation of all four units at Labadie.

In March 1974 was assigned as Assistant Manager of Union Electric's Solid Waste Utilization System.

Name: David L. Klumb
Title: Manager, Solid Waste Utilization System
Education: B.S. in Mechanical Engineering, Syracuse University, 1953
Professional: Joined Union Electric in 1953 and after two years in U.S. Army was assigned to Engineering and Construction Department. Involved in "engineering design and economic evaluation of electric generating facilities".

In 1969 was assigned as project engineer responsible for St. Louis-Union Electric-USEPA Solid Waste Prototype program. In March 1974 was given responsibility of designing and building 8,000 ton per day Solid Waste Utilization System.

Solid Waste Utilization System

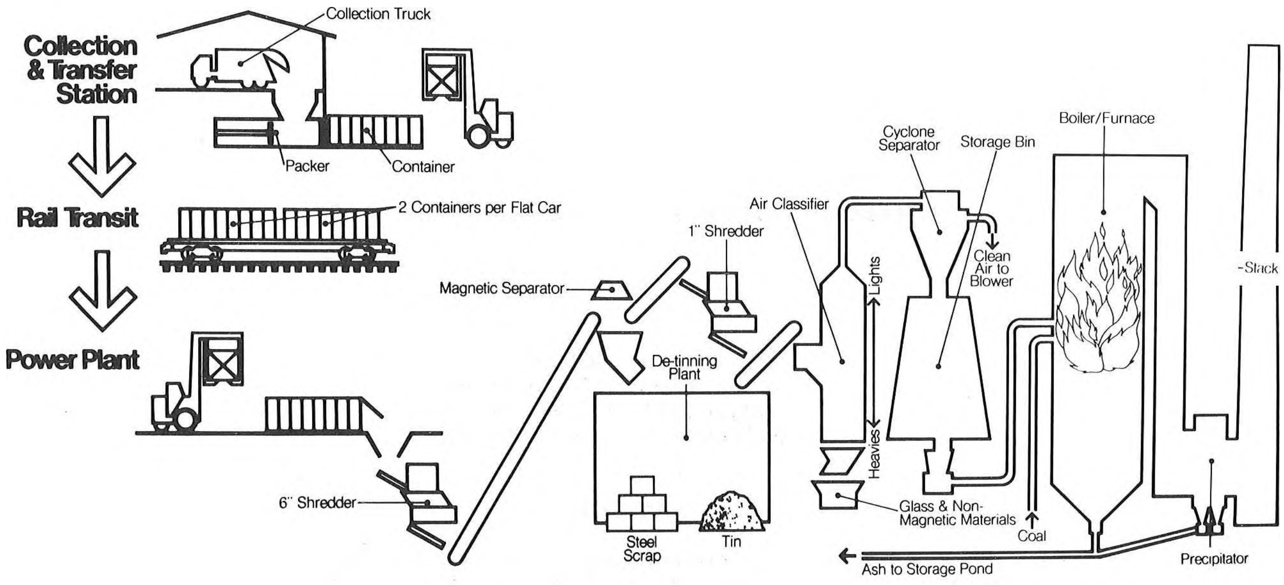

FIGURE 1

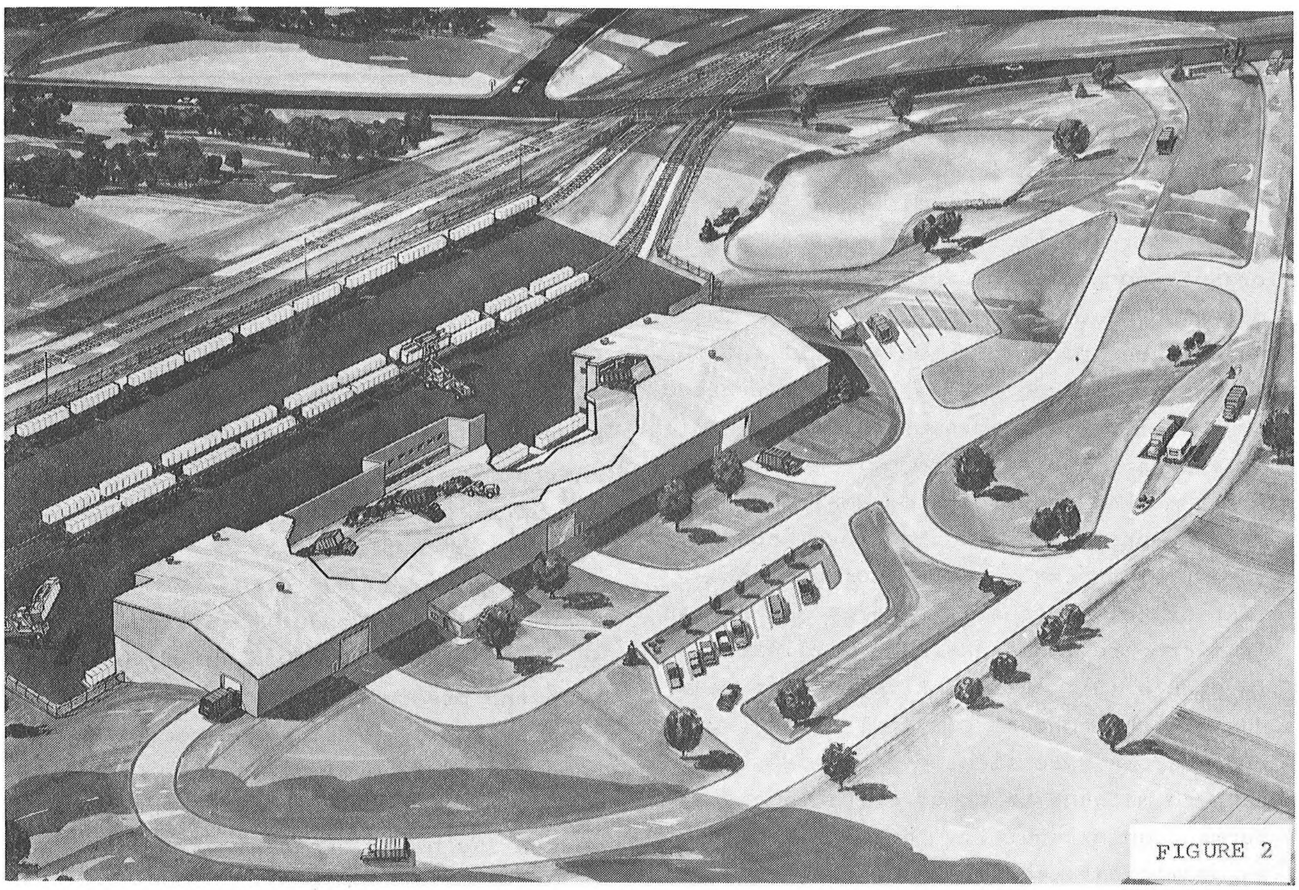

FIGURE 2