COINCINERATION AT HILLSHIRE FARM

MICHAEL N. MACAULAY
Foth & Van Dyke Waste/Energy Division
Green Bay, Wisconsin

ABSTRACT

A system to coincinerate plant refuse and combined sludges at a northern Wisconsin sausage-making company evolved through a study of resource recovery alternatives. Although small-scale coincineration with energy recovery is not new, several factors combined to make this project an unusual challenge. Moreover, eligibility for the federal biomass energy tax credit required a fast-track implementation.

Preassembled rotary kiln equipment was selected with auger refuse feed and modifications for sludge injection. Heat is recovered by steam and hot water generation for plant use. A baghouse is used to control flue gas particulates.

This paper presents the planning and procurement procedure along with a description of the process and economic forecast of the return-on-investment.

INTRODUCTION

Hillshire Farm, a Division of Sara Lee Corporation, is installing an incineration process to codispose sludge and refuse residuals while recovering heat. The project is the end result of a comprehensive study of resource recovery opportunities for the New London, Wisconsin Sausage making company.

Hillshire Farm, a Division of Sara Lee Corporation, is a leading producer of coarse, smoked sausage products. As a self-sufficient operation from slaughtering to shipping, the plant generates 3000 tons (2,721,500 kg) of refuse and 13,000 tons (11,793,400 kg) of sludge per year.

Plant refuse consists primarily of corrugated cardboard and low chloride packaging materials, waste pallets and the char residue from thirty smokehouses. The composite refuse is characterized as Type O due to its minimal ash and moisture content and relatively high heating value.[1]

Plant sludge is the by-product of wastewater treatment. One million gal/day (3785 m^3/day) of wastewater is treated by a system of primary solids removal by dissolved air floatation (DAF) and secondary biological treatment by activated sludge. Waste activated sludge (WAS) is dewatered after polymer conditioning.

Historically, plant refuse and sludges were land disposed. Refuse was hauled to the local landfill and sludges were spread on neighboring lands.

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[1]Type O waste includes highly combustible waste, paper, wood and cardboard with up to 10% plastic or rubber. It averages 8500 Btu/lb heating value, 10% moisture content, and 5% incombustible solids.

The coincineration project is supported with economic and environmental benefits to the owner. As an alternative energy system, the project will reduce current natural gas consumption. It will also decrease land disposal expenditures and provide a dependable alternative as regulatory agencies restrict future land disposal practices.

RESOURCE RECOVERY STUDY

A study of disposal alternatives using resource recovery was conducted by the company's consultant. Several candidate projects were examined:

(a) refuse incineration with steam generation

(b) sludge drying with product recovery

(c) anaerobic digestion of sludge with biogas recovery

(d) coincineration of refuse and sludge with steam generation

Incineration of refuse was based on burn testing and quotations by reputable incinerator manufacturers. A refuse-only project would be placed in the location of the existing compactor with very little building modification and change in materials handling practice. The discounted return on investment was very attractive and the project was eligible for the biomass energy tax credits until the end of 1985.

The sludge drying alternative was intended to use an evaporator with a light oil carrier in a process commonly used in rendering slaughterhouse residuals. Pilot tests, using a representative blend of DAF and dewatered WAS sludges at 90% moisture, revealed that a package plant would produce four tons (3628 kg) of fatty oil and six tons (5443 kg) of nonfat solids daily. The oil was valued as substitute for No. 6 fuel oil in the rendering plant bone drier. Nonfat solids were valued as a saleable high protein animal feed supplement similar to the distiller dry grain by-product from the alcohol industry.

Anaerobic digestion was given consideration in two possible contexts: *(a)* conventional plug flow digestion of combined sludges; and *(b)* high rate digestion of the forward wastewater flow. Neither approach was considered an economically attractive investment considering the primary goal of displacing ultimate disposal liability.

The last alternative, coincineration, was chosen because it solved both sludge and refuse disposal problems to the greatest extent in a single consolidated process, at least total cost. Again, pilot tests and quotations were the basis of costs definition. Incineration equipment was specified to handle the total combined sludge and/or refuse load while producing useful steam. Avoided costs in energy and disposal, uncertainty regarding future limitations on land application, and limited availability of the biomass energy tax credit supported the decision.

PROCUREMENT STRATEGY

Small-scale coincineration was a relatively undeveloped concept when selected in May of 1985. Many questions needed immediate resolution because energy tax credit eligibility required the system to be operable in that same calendar year. In light of the deadline, the consultant operated on behalf of the owner in a fast-track approach which called for:

(a) Immediate preparation of a performance specification used to prepurchase coincineration and other major equipment.

(b) Preparation of building and secondary facilities required to receive and connect coincineration equipment.

(c) Solicitation of all permits required for installation and start-up.

The performance specification was written to communicate the "intended" mode of operation and allow vendors to bid equipment within minimum constraints. Each proposer was asked to submit a lump sum price necessary to furnish and complete the coincineration system.

Specifications dictated that acceptance of the work be tied to four key dates defined as follows:

(a) Start-up Date. Date when the system produces steam for a period of 1 hr. It is the start of thermal operation during which components and controls are to be checked and adjusted leading to the state of plant operability and commercial operation. It initiates a period when the operators will be trained.

(b) Plant Operability Date. Date when the system produces steam at the specified temperature and pressure for 1 hr burning the intended combination of solid waste and sludge with or without auxiliary fuel. This state should be reached quickly after the start-up date and must be established, witnessed, and documented before December 31, 1985.

(c) Commercial Operations Date. Date when the equipment provided by the manufacturer operates to the satisfaction of the engineer according to stated *Performance Evaluation Criteria*:

(1) five day continuous, faultless operation

(2) minimum 65% heat recovery efficiency

(3) combustible content of ash, maximum 8%

(4) verification of design/performance estimates and warranties

(5) submission of plans for modifications, if necessary

(6) emissions within design estimate

(d) System Equipment Acceptance Date. Date when the system is accepted by the engineer based on performance evaluation criteria and an emissions test, after achievement of commercial operations. This test program will be conducted by an independent laboratory or testing firm acceptable to the applicable regulatory agencies with permitting authority over the intended system.

Enforcement of performance criteria were tied to both conditions of payment and assessment of liquidated damages. In the payment schedule, the vendor was required to transmit specified information and later to comply with key dates to earn partial payments. Liquidated damages were assessed per days of delivery delay and limited to the liability of the energy tax credit.

PRIMARY EQUIPMENT

Primary coincineration equipment was purchased, according to the performance specification which included the following major components:

(a) unprocessed refuse handling system with a 10 cu yd (7.65 m^3) hopper, bridge breaker and auger feeder

(b) preassembled 20 MMBH (5.86 MW) incinerator consisting of rotary drum primary oxidation chamber (POC) and stationary secondary oxidation chamber (SOC).

(c) system to inject and atomize comminuted sludge through an arrangement of three nozzles

(d) engineered auxiliary burner system designed to deliver up to 10 MMBH (2.93 MW) to each chamber using ambient or preheated combustion air via remotely located blowers

(e) heat recovery system including fire tube boiler, economizer and provisions to add a hot air recuperator to preheat combustion air

(f) flue gas cleaning by a baghouse designed to operate within a tight temperature range as controlled by the economizer

(g) system control using a programmable logic controller

Special features compared to the manufacturer's standard included the engineered auxiliary burners as compared to standard package burners; provisions to heat combustion air; multipoint sludge injection; extra POC drum length; and microprocessor control.

AUXILIARY SYSTEMS

Other facilities were required to provide a complete coincineration system including:

(a) retrofiting an existing sludge handling building and associated utilities to receive primary equipment on schedule

(b) changes in the sludge handling system to combine all sludges and smokehouse residue into an existing 50,000 gal (189 m^3) underground vessel located adjacent to the incinerator building

(c) installation of an air-lift draft tube mixer to blend combined sludge

(d) installation of a vertical hammermill disintegrator to mill combined sludge to a maximum 0.25 in. (6.35 mm) particle size

(e) installation of steam, boiler feed water and economizer cooling water pipe lines to connect the coincineration system to the existing boiler house

(f) installation of a custom designed refuse materials handling system including refuse containers for use with the existing compactor, overhead crane to stage the containers at the incinerator hopper loader, and a hydraulic lifting/dumping device to charge the hopper and feed auger

INTENDED OPERATION

Anticipated operation of the process is best described with the assistance of the process flow diagram shown in Fig. 1.

The coincineration plant will operate 24 hr/day, 5 days/week. Sludge loading will be steady with milled sludge split through the three nozzles, two on the SOC and one on the POC. Refuse loading will be variable according to availability and relative change in metered auxiliary fuel demand.

Average sludge input to the incinerator will be nominally 4100 lb/hr (1860 kg/h) at 10% solids with simultaneous refuse input of approximately 850 lb/hr (386 kg/h). Heat input from waste and auxiliary fuel is projected to average 14.5 MMBH (4.25 MW).

Two natural gas auxiliary burners, one each on the POC and SOC, will modulate according to maintenance of a set point of 1800°F (982°C) in the SOC. Each burner will be capable of adding up to 10 MMBH (2.93 MW) using hot or cold air.

Flue gas from the SOC will be drawn by the induced draft fan across a normally closed dump bypass in the stack, to the heat recovery boiler/economizer arrangement. The control condition for heat removal will be to maintain 270°F (132°C) at the induced draft fan by

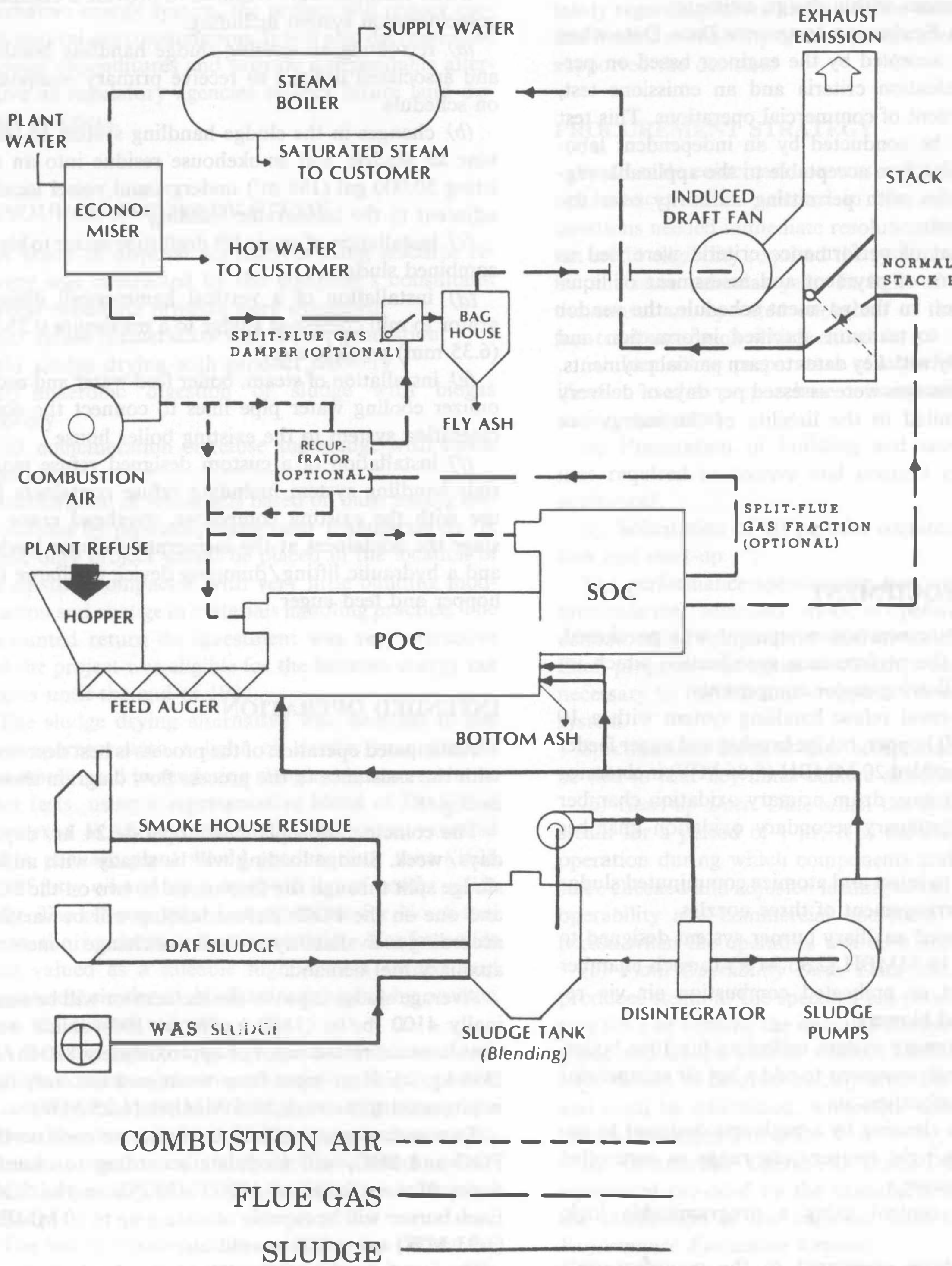

FIG. 1. PROCESS FLOW DIAGRAM HILLSHIRE FARM COINCINERATION PROJECT

varying flow of 180°F (82°C) cooling water through the economizer. During summer conditions, approximately 20,000 lb/hr (9072 kg/h) of waste gas will exit the boiler and enter the economizer at 590°F (310°C). In winter the expected boiler outlet temperature will be 478°F (248°C). The economizer heat balance will be accomplished by blending 70°F (21°C) plant cooling water to provide 180°F (82°C) at the economizer inlet and returning excess hot water to the plant for clean-up purposes.

The two-pass fire tube heat recovery boiler will produce up to 10,000 lb (4536 kg)/hr of 120 psig [827 KPa (ga)] saturated steam at the rate of 20 MMBH (5.86 MW) heat input to the incinerator. Steam will be utilized as plant base load with existing package boilers operating as slaves in providing rapid response to changing steam demand.

If start-up experience suggests rapid payback, a secondary outlet on the SOC will be used to split flue gas to a recuperative gas-to-air heat exchanger. Supplying up to 750°F (399°C) preheated combustion air to the auxiliary burners would partially regain thermal efficiency lost to the high latent load of the sludges. A damper upstream of the baghouse would control the split flue gas fractions to the parallel heat recovery systems.

The baghouse was specified to limit particulate emission through the stack to 0.08 gr/dscf (184 mg/dscm) corrected to 12% CO_2. Maximum operating temperature for the fiberglass fabric is approximately 500°F (260°C). Equal attention to the minimum temperature will be necessary for concern of caking with the sludge moisture laden gas. Thus, the flue gas temperature controlling function of the economizer is crucial.

Residue from the combustion process will be collected, without quenching, in two containers. The first container will collect bottom ash from the POC in a pan-style sealed conveyor located in the bottom of the SOC. The second container will be located directly under the baghouse to receive fly ash. Both ash handling systems will be equipped with spray devices for dust control and fire protection.

Overall control and monitoring of the total system will be aided by thirteen thermocouples with continuous digital indication, accessible to a data logging device. Two of the temperature signals will be used in process control functions. Baghouse exit temperatures will be used to modulate cooling water flow through the economizer as necessary to maintain a set point. SOC outlet temperature will be used in modulation of:

(a) heat input from the auxiliary burners
(b) air input to the POC
(c) air input to the SOC
(d) rotational speed of the auger feeder
(e) rotational speed of the POC drum

ECONOMIC FORECAST

A net present value (NPV) analysis of the coincineration project is presented in Fig. 2. The subject spreadsheet demonstrates all project costs and benefits as necessary to compute the rate of return K on the $1,200,000 capital investment. This is accomplished by iteration until K is found which discounts the net cash flow such that the total NPV over the life cycle is equal to the investment. Tax credits are not modeled.

A number of assumptions are utilized in the economic forecast which were derived from historical plant records. These include:

(a) Recovered heat is initially valued at $6/MMBH, according to alternate package boilers providing the same delivered heat using gas purchased at $4.60/MMBH. The value of the natural gas and its equivalent refuse substitute is escalated by 8%/year.

(b) Avoided sludge disposal is initially valued at $0.05/gal, such disposal costs will escalate by 6.5% per year.

(c) Avoided refuse disposal is initially valued at $20/ton. This will also escalate by 6.5%/year.

(d) Operating labor will be shared by waste treatment and boiler house personnel at an average rate of $13/hr. Labor will escalate by 6.5%/year.

(e) Ash disposal assumes 15% ash in the sludge solids and 5% in the refuse; 8% combustibles remains in the ash collected; 20% moisture added; and disposal fees of $20/ton transported. Ash disposal costs will escalate by 6.5%/year.

(f) Electrical costs will be for 78 kW absorbed initially at $0.05/per kW·h. This will escalate by 9%/year.

(g) Auxiliary fuel will be utilized at an average rate of 4.4 MMBH (1.29 MW) with preheated combustion air at 750°F (399°C). This will escalate by 6%/year.

(h) Maintenance cost will be 3% of the total investment per year after the initial warranty year. This will escalate by 6%/year.

(i) A major future capital outlay for overhaul of refractory will occur in Year 5.

(j) Depreciation is assumed using the IRS ACRS schedule and subtracted to obtain earnings before taxes (EBT).

(k) Tax costs will be incurred at the maximum 50% corporate rate.

The spreadsheet demonstrates a reasonably attractive return on investment of 24%, discounted. With

YEAR	GROSS HEAT BENEFIT	--DISPOSAL SAVINGS-- SLUDGE	REFUSE	SUM OF BENEFITS	OPERATING LABOR	ASH DISPOSAL	POWER COST	AUX. FUEL	MAINTENCE & REPAIRS	SUM OPRT. EXPENSES
0	0		0	0		0	0		0	0
1	322,000	156,000	52,000	530,000	41,000	8,500	24,000	126,000	7,500	207,000
2	347,760	166,140	55,380	569,280	43,460	9,053	26,160	133,560	36,000	248,233
3	375,581	176,939	58,980	611,500	46,068	9,641	28,514	141,574	38,160	263,957
4	405,627	188,440	62,813	656,881	48,832	10,268	31,081	150,068	40,450	280,698
5	438,077	200,689	66,896	705,662	51,762	10,935	33,878	159,072	42,877	298,523
6	473,124	213,734	71,245	758,102	54,867	11,646	36,927	168,616	45,449	317,506
7	510,974	227,626	75,875	814,475	58,159	12,403	40,250	178,733	48,176	337,722
8	551,851	242,422	80,807	875,081	61,649	13,209	43,873	189,457	51,067	359,255
9	596,000	258,179	86,060	940,239	65,348	14,067	47,822	200,825	54,131	382,192
10	643,679	274,961	91,654	1,010,294	69,269	14,982	52,125	212,874	57,379	406,629
TOTAL	4,664,673	2,105,130	701,710	7,471,513	540,413	114,703	364,630	1,660,780	421,187	3,101,713

YEAR	RETURN ON INVESTMENT "K"	CAPITAL OUTLAY	SALVAGE VALUE	DEPRECIA (ACRS)	EARNINGS BEFORE TAXES	TAXES (50%)	DEPRECIA Added	NET CASH FLOW
0		1,200,000		0	0	0	0	(1,200,000)
1	23.62%		60,000	216,000	107,000	53,500	216,000	329,500
2	23.62%			396,000	(74,953)	0	396,000	321,048
3	23.62%			300,000	47,543	23,772	300,000	323,772
4	23.62%			192,000	184,183	92,092	192,000	284,092
5	23.62%	100,000		114,000	293,139	146,570	114,000	160,570
6	23.62%			33,000	407,596	203,798	33,000	236,798
7	23.62%			25,000	451,753	225,877	25,000	250,877
8	23.62%			16,000	499,826	249,913	16,000	265,913
9	23.62%			8,000	550,046	275,023	8,000	283,023
10	23.62%		350,000	0	603,665	301,833	0	651,833
TOTAL		1,300,000	410,000	1,300,000	3,069,800	1,572,376	1,300,000	3,107,424

FIG. 2. ECONOMIC FORECAST HILLSHIRE FARM COINCINERATION PROJECT

the added incentive of investment and energy tax credits, the Hillshire Farm Coincineration project is clearly a means of improving profitability while solving a disposal problem.

CONCLUSION

The implementation of a resource recovery project at Hillshire Farm evolved through detailed assessment of four sludge and refuse disposal schemes. A system of coincineration with heat recovery was elected over continued land disposal, sludge drying and anaerobic digestion.

A fast track approach to primary equipment procurement from a single source and the delivery of this equipment to a prepared jobsite was adopted. In addition to delivery and installation requirements, the incinerator vendor was constrained by staged performance deadlines necessary to comply with 1985 energy tax credit eligibility. The system was economically justified by a 24% anticipated rate of return on an original $1,200,000 capital investment.

At present the project is in the "Commercial Operations" phase of acceptance testing. Technical and economic performance data concerning the fate of the project will be available by conference time.

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BIBLIOGRAPHY

"Design Report and Plan of Operation; Coincineration of Plant Refuse & Sludge." New London, Wisconsin: Foth & Van Dyke Industrial Inc., June 1985.

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