THE BURGKIRCHEN C-RPP PLANNERS CUT THE GORDIAN KNOT OF RESOURCE RECOVERY

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ABSTRACT

The "Zweckverband Abfallverwertung Südostbayern" (ZAS) project at Burgkirchen is presented as a most unusual regional waste disposal project. Both municipal refuse and sewage sludge are to be taken to a single central combustion facility. Waste heat will be recovered for electrical power production and cogenerated process steam. The installed waste disposal capacity will be 1190 $STPD_7$ (short tons per day on a 7 day basis) (1080 $MTPD_7$).

A multistage wet scrubbing system will be used for compliance with the strict guidelines for air pollution control of "Technische Anleitung zur Reinhaltung der Luft von 1986" (TA Luft 86). Effluent wastewater will be eliminated by recovering salt for sale to industry. Leftover residues from the scrubber will be combined with fly ash for conversion into impervious glass fragments. Ferrous scrap and construction aggregates will also be recovered for reuse.

Because of an overloaded network of rural highways, a unique two-way rail haul system will be built which allows wastes to move in one direction and residues in the other.

In the paper, the planning process and especially the criteria used for technology selection and integration are discussed.

INTRODUCTION

At a time when incineration is once again under attack from some quarters, the Burgkirchen project offers a refreshingly new perspective.

Is it possible to build a high tech resource recovery facility to serve a score of rural counties from one central site? Can a regional partnership be implemented which allows its participants to share waste disposal benefits and residue disposal obligations on an equal basis?

Can all of this be done without adding burdens of pollution to an already heavily stressed environment? Can energy be recovered efficiently for industrial production from a source which is renewable and which is all too often wasted?

Does a transportation system exist that allows wastes to move in one direction and residue to move in the opposite without adding additional traffic to already crowded highways?

During planning of the Burgkirchen project, all of these seemingly contradictory questions were addressed. The methodology employed may appeal to American communities beset by similar problems.

PROJECT STATUS

In order to provide a full scope of architectural and engineering services for the project, several firms formed the joint venture called "Ingenieurgemeinschaft Abfallverwertung Südostbayern". One of its members is Kessler Engineering, i.e., the same firm which had previously designed the refuse rail haul system for the Schwandorf RPP.

The permit to construct calls for a phased approach to construction. Site work at Burgkirchen was started in April 1989 and completion is expected during December 1992. There is no single turnkey contract, but instead separate contracts have been given out. L&C Steinmüller of Gummersbach will furnish the furnace/boiler combinations, while Saarberg-Hölter-Lurgi (SHL) of Saarbrücken will supply the integrated air pollution control and residue management systems.

Contracts for the transportation system have not been placed as yet. However, in lieu of a single general contract, it is intended to break up the transportation system into individual bid packages. The two strongest competitors are BHS and RTU of West Germany.

Three complete chute-to-stack systems will initially be installed, any two of which will be needed for operations while the third will be in reserve. (Note: This is in line with the traditional goal of German plant operators to completely refrain from bypassing raw waste to the landfill, even during periods of equipment outages.)

PLANNING FOR REGIONAL WASTE MANAGEMENT SERVICES

The Zweckverband Abfallverwertung Südostbayern (ZAS) was formed in 1984 to provide a regional and total system for waste management and resource recovery [1]. The best translation for ZAS is "Resource Recovery Authority". The ZAS service area is located southeast of Munich, which is the capital of the State of Bavaria in the Federal Republic of Germany (FRG).

This part of Bavaria is essentially a rural area with a number of small towns interspersed throughout. Eight different counties are involved, with a service population of 670,000 people, covering some 2800 square miles. This population has a waste disposal need for the aggregate of about 275,000 STPY (short tons per year) (250,000 MTPY) of refuse and 66,000 STPY (60,000 MTPY) of sewage sludge. (See Table 1 for details.)

Because of a shortage of permitted landfill space, both wastes were considered to be equally pressing disposal problems. Subsequently, with an eye towards similar disposal technologies, the planners adopted the codisposal concept. However, it was also agreed that residues resulting from waste processing were to be limited to the smallest amount possible. In fact, by-product recovery was to be given special attention.

The cost of building and operating separate facilities for each county would have been prohibitive. This is especially true since, due to environmental concerns, resource recovery facilities have become much more complex and costly. Thus, during the planning process, the idea emerged of building a single central processing facility which would receive waste from six different transfer stations. (Note: Two jurisdictions have direct truck haul service.)

In terms of technological choices and from the viewpoints of both efficiency and marketing, it was decided that mass burning with steam production represented the lowest risk investment. In addition, from the viewpoint of public health, thermal processing of the refuse sludge combination was considered to be the safest method.

As a result of the mass burning choice, a dependable long-term market was required for recovered energy. Furthermore, it was stipulated that the preferred energy customer should be a large steam user, because the sale of thermal energy would bring a better price than that of electrical energy. Only a small amount of electrical power was to be generated for in-plant use.

In order to bring all of these elements together, the plan was developed to build a codisposal and cogenerating refuse power plant (C-RPP) at a central location. In addition, provisions were to be made for the incineration of medical wastes.

With these planning criteria, the choice of available sites was narrowed down from twelve alternates to one at Burgkirchen, where Hoechst A.G. has a large chemical plant. Thus, by building a new facility adjacent to an existing industrial complex, the esthetics of the area would not be adversely effected. Also, Burgkirchen is the approximate center of the service region and has easy rail access. For these reasons, it was fortunate for the project that Hoechst A.G. agreed to be the steam purchaser.

During the planning process some adverse publicity was encountered. In addition to growing concerns over potential air emissions, there was the question of what to do with the inevitable residues of thermal processing. The first concern was answered by demanding the latest in air pollution control technology. The second was addressed in three different ways:

(a) The participating counties agreed to collect recyclables such as glass, newsprint and metal separately, to the extent possible. This would diminish the overall waste stream and thereby lessen the amount of residue to be landfilled.

(b) Whatever residues resulted from combustion

TABLE 1 WASTE DISPOSAL SERVICE BY ZAS AUTHORITY (1)

Participating County	Service Population	Service Type (2)	Employees #	Refuse Supply	Sludge Supply (3)	Residue Return
Name	Inhabitants	Type	#	STPY	STPY	STPY
Dingolfing Landan	74,500	Rail/TS	2	28,500	<7,400	11,000
Rottal-Inn	100,800	Rail/TS	2	39,000	<9,900	15,000
Mühldorf	91,400	Rail/TS	2	33,800	<9,000	13,000
Altötting (4)	92,700	Truck/DH	0	39,000	<9,100	15,000
Rosenheim (5)	73,800	Rail/TS	3	36,400	<7,300	14,000
Traunstein	144,000	Rail/TS	3	61,000	<14,200	23,500
Berchtes - Gadener Land	92,600	Rail/TS	2	37,700	<9,200	14,500
Burgkirchen C-RPP (6)	669,800	Rail & Truck	2 x 3 + 4	275,400	41,300(7)	106,000
System Totals	669,800		24	275,400	41,300(7)	106,000

Notes: (1) Design values, i.e. actual values for commissioning in 1993 may vary. Source: ZAS permit application
(2) Legend: TS ≙ transfer station; DH ≙ direct haul
(3) Sludge cake @ 40% TS.
(4) Host county for C-RPP with direct hauling
(5) Transfer station is oversized because ZAS serves as a back-up for RPP existing there.
(6) The Town of Burgkirchen is the site at which has been permitted for construction of C-RPP.
(7) The maximum sludge processing rate is limited to 15% by weight of refuse.

were to be processed for a maximum in materials recovery. Consequently, ferrous scrap, construction aggregate and industrial salt were to be recovered as byproducts.

(c) In order not to burden the host community with the task of residue disposal for the entire region, it was agreed that each of the participating counties would take back an amount of residue proportionate to its contribution of waste.

By having refuse and sludge move in one direction and residues in the other, additional heavy truck traffic was to be expected. How could this be avoided, considering that the service region measured about 94 miles (150 km) along one axis and 63 miles (100 km) along the other? ZAS opted for the railroad as the primary transportation medium.

To some degree, this decision was influenced by the Schwandorf RPP in a neighboring region. Although bigger in capacity, Schwandorf has successfully concluded 8 years of rail operations [2]. The main difference is the fact that Burgkirchen requires a two-way haul, compared to Schwandorf which so far uses only a one-way haul.

In this connection, it is worth mentioning that a similar two-way haul system is presently under procurement in Montgomery County, Maryland [3, 4].

For the preparation of plans and specifications, a model was developed which traces the flow of materials to and from the Burgkirchen C-RPP. A simplified version of this model is illustrated in Fig. 1. The inputs include refuse, sludge, caustic, and make-up water. The outputs consist of aggregate, ferrous scrap, salt and glass. The interfaces with the rail haul system are identified as well.

RAIL HAUL SYSTEM DESIGN

Figure 2 shows the railroad network which will connect the participating jurisdictions with the Burg-

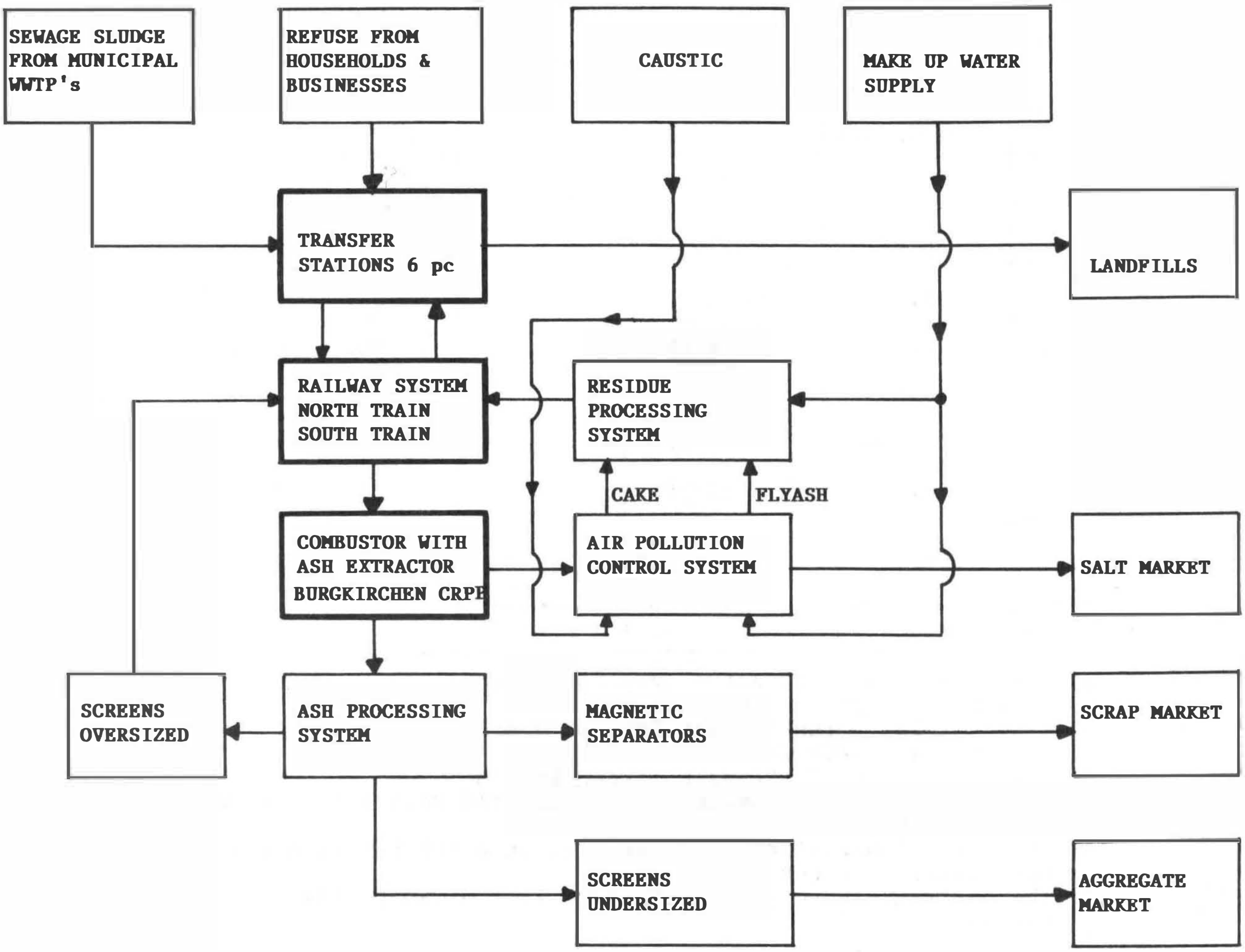

FIG. 1 MATERIALS FLOW MODEL AND TRANSPORTATION INTERFACES FOR BURGKIRCHEN C-RPP

kirchen C-RPP. Basically, there will be one movement per day of each unit train; i.e., a North Train and a South Train. The exceptions are Sundays and holidays when there will be no movement.

Two types of refuse containers are under consideration. One consists of reinforced cylinders which measure about 8 ft (2.439 m) in diameter and 30 ft (9.146 m) in length. The wall thickness is 0.197 in. (5mm). Compactors will be needed to charge refuse directly into these containers. They are suitable for high density compaction. Average net refuse loads are expected to average about 26.00 ST (23.60 MT) [5]. The manufacturer is Bayrische Hütten Salzbergwerke (BHS) and its containers are in use at the aforementioned Schwandorf RPP.

The other type involves reinforced box containers, which measure about 8 ft (2.439 m) by 8 ft (2.439 m) in cross section and 30 ft (9.146 m) in length. The wall thickness is 0.118 in. (3 mm). Either compactors or prebalers can be used. For the latter case, a bale is built outside the container in a baling press. The ready bale is then pushed into the container. Average net refuse loads should amount to 24.20 ST (22.00 MT) [5]. The manufacturer is Rocholl Tankbau & Umwelttechnik (RTU).

In addition to 30 ft (9.145 m) refuse containers, shorter 20 ft (6.098 m) units will also be needed for the transport of sludge and residue. They were chosen because of over-the-road limitations and the ease with which they can be unloaded. Net payloads are scheduled to average 13 ST (12 MT). For operation in landfills, a tilt type of truck chassis will be provided.

Although a decision has not been made yet, there is a preference for the BHS design because its tare

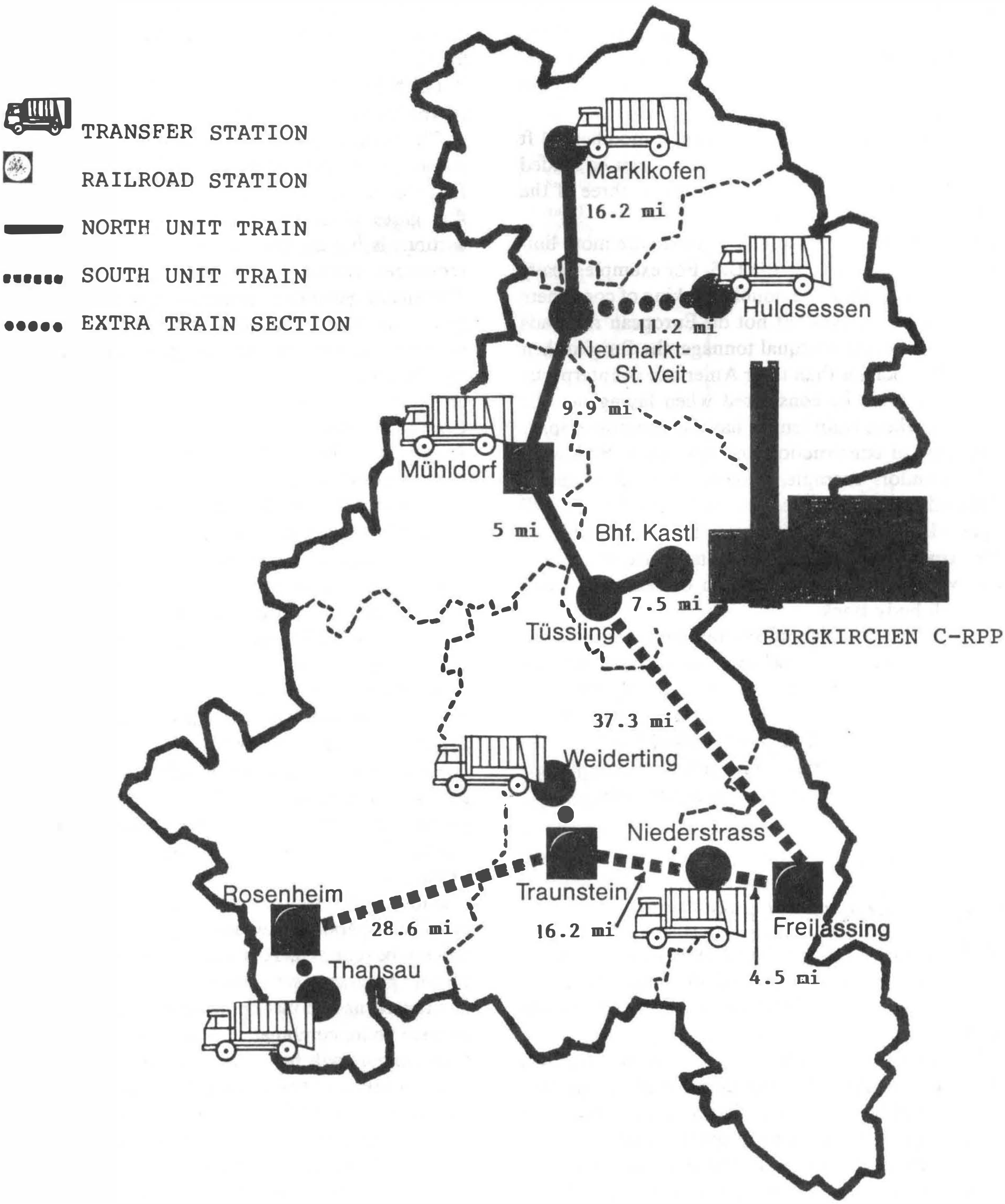

FIG. 2 SERVICE AREA FOR BURGKIRCHEN C-RPP

weight is lower by about 1.25 ST (1.13 MT). Consequently the legally permissible payload capacity of rail cars can be better utilized. Also, there is a larger operating data base from Schwandorf which backs this particular design.

With regard to rolling stock, slightly modified 64 ft (19.512 m) flat cars will be used. They can be loaded with either two of the 30 ft (9.145 m) or three of the 20 ft (6.098 m) containers.

Choices for the Burgkirchen planners are more limited than they would be in the U.S. For example, heavy lift cars which permit the double stacking of containers are legal on American but not on European railroads [5]. As a result, for an equal tonnage, the Burgkirchen trains will be longer than their American counterparts.

This fact must be considered when laying out the rail yards, where train length has considerable impact on the cost of construction and operation. Following the Schwandorf example, a series of parallel tracks, called body tracks, will be used, on which the cars will be placed. These body tracks will be connected to ladder tracks by means of turnouts. Thus, the ladder tracks will permit placing cars on or removing them from each body track.

Another factor which affects rail yard design is the type of equipment to be selected for loading and unloading. This is especially true when a high degree of automation is desired. As in the case of Schwandorf, the Burgkirchen C-RPP will use tracked bridge cranes rather than mobile cranes. The goal is to couple operational speed with high personnel productivity.

MAJOR DESIGN FEATURES

The state of the art of European mass-burning refuse power plants is well known. At the Burgkirchen C-RPP, however, several design elements are worth mentioning.

The furnace grate will be of the three-step type. Each step as well as the sides and the roof of the furnace will be cooled by waterwalls. On the grate, fixed rows alternate with moving rows in order to impart a forward motion to the fuel bed. The grate bars are alloy steel castings. They are sloped in a way which forms gaps in between adjacent bars for the admission of underfire air. The grate itself will be inclined, forming an angle with the horizontal plane. It has a waste burning capacity of 16.5 stph (15.0 mtph) or 397 $STPD_7$ (360 $MTPD_7$). Three identical grates will be installed, for a total plant capacity of 1190 $STPD_7$ (1080 $MTPD_7$). L&C Steinmüller will be the supplier of the grates. Both municipal refuse and sewage sludge cake will be charged onto the grates. The design values for the lower heating value are: refuse at 4140 Btu/lb (2300 kcal/kg) and sludge with a 40% solids concentration at 810 Btu/lb (450 kcal/kg).

The boilers will be of the tail-end design with two empty passes following the radiation section of the furnace. A tail end design means that the axis of the flue gases while passing through the various boiler sections is horizontal. These sections are hung in the sequence: evaporator, superheater and economizer. The steam generation parameters are 752°F (400°C), 1160 psia (80 bar) and 108,000 lb/hr (49 mtph). Two of these, i.e., temperature and pressure, were dictated by the conditions in the main steam header of the chemical plant next door which is the steam buyer. Condensate will be returned at 248°F (120°C). L&C Steinmüller will supply and erect the boilers.

In response to TA Luft 86 requirements, the furnace geometry will be such that gases will be retained for at least 2 sec at a temperature of 1472°F (800°C). This should ensure the complete burnout of gases.

Electrical power production will be limited to in-plant usage only. Two identical condensation-extraction turbines will be installed with a nameplate capacity of 4.9 MW each. The condensing pressure will be 2.00 in. Hg (0.07 bar) with full extraction. The throttle flow will vary between 44000 lb/hr (20 mtph) and 55,000 lb/hr (25 mtph) per turbine.

Extraction steam is to be taken at 60.9 psia (4.2 bar) for in-plant needs such as feedwater heating, air preheating, scrubber sludge drying and space heating. Up to 26,500 lb/hr (12 mtph) per turbine can be extracted.

Equipment selections were motivated by the goal of an island operation, i.e., back-up from a public utility will not be required. This will be possible because either turbine-generator set alone can carry the plant, i.e., any two furnace-boiler combinations. (Note: The third furnace-boiler combination will be on cold standby and steam export will be on an interruptible schedule.)

In addition to the three refuse-fired systems, there will be two medical waste incinerators. They will be located between the refuse units. Manufactured by Hoval in Liechtenstein, these are modular, two-stage combustors. Partial combustion will start in the larger first stage, i.e., the furnace, while combustion will be completed in the smaller second stage, i.e., the afterburner. The design value for the lower heating value of medical waste is 6480 btu/lb (3600 kcal/kg). In spite of this relatively high Btu content, there will be no direct wasteheat recovery from these incinerators. However, their hot exhaust gases will merge with the exhaust from the refuse-fired boilers in a common duct. Thereafter, they will proceed to the common air pollution control systems where they will participate in regenerative heat exchange.

The refuse storage pit is configured for a minimum of excavation work. To some extent, this approach was facilitated by putting the container discharge cars on an elevated platform outside of the pit wall. This could easily be done since the container bridge crane travels on tracks whose minimum elevation was dictated by container storage requirements.

Other special features concern the air pollution control, residue processing and sludge handling systems which, because of their significance to the American market, are discussed below in separate sections.

INTEGRATED AIR POLLUTION CONTROL AND RESIDUE MANAGEMENT

Compared to those found in U.S. resource recovery facilities, the air pollution control systems at Burgkirchen are more sophisticated. To a large extent, this is due to the West German Clean Air Act which was rewritten in 1986. The technical guidelines for implementing the act are internationally known as "TA Luft 86".

These guidelines stipulate that it is not enough to severely limit particulate emissions to the point where it can be assumed that heavy metals emissions are implicitly controlled. TA Luft 86 goes beyond this point by specifying that heavy metals must be limited according to their toxicity. For the classification of specific heavy metals and the limits of emission for each class, refer to Table 2.

Since problematic heavy metals such as mercury must be reduced regardless of whether or not they are present in the vapor phase, the planners felt that wet scrubbers with regenerative heat exchangers would be the most efficient way to accomplish this.

The emission limits for gases, solids and vapors are shown in Table 2. For planning purposes, limits were set which are more stringent than those contained in TA Luft 86. During the procurement process, the manufacturers submitted guaranty values with their proposals which are lower than the regulatory limits by a comfortable margin.

For several species, the guaranty values are even lower than the planning values. This holds true especially for acid gases, carbon monoxide and NO_x.

In order to implement these requirements with existing control technology, a multi-stage gas cleaning process was chosen. Following the schematic presentation in Fig. 3, the raw flue gases are first passed through a two-field electrostatic precipitator (ESP) for the removal of fly ash.

After the ESP, the flue gases are cooled in a glass tube heat exchanger, because subsequent scrubber treatment is more effective at a lower temperature. The scrubber itself has two sequential stages through which the flue gases and the reagent move in opposite directions, i.e., countercurrently.

Thus, in the second stage, fresh solution with caustic soda first contacts the SO_2 component in the flue gases. This component is the more difficult one to remove. The partially spent solution then continues into the scrubber's first stage where the HCl component is attacked. (This is the easier one to remove.) The temperature of the saturated flue gas exiting from the scrubber is 140°F (60°C).

Following the last scrubber stage, the flue gases pass into a wet ESP for the separation and containment of aerosols. For reasons of reliability and flow control, two induced draft fans of different capacity are arranged parallel to each other. Together they push the cleaned flue gases into the other side of the glass tube heat exchanger where they are reheated to 167°F (75°C). Such reheating serves two purposes: first, it helps to avoid stack corrosion; second, it promotes the rise and dispersion of the clean flue gas plume.

The last step in the cleaning process is the NO_x reduction stage.

TABLE 2 EMISSION LIMITS FOR BURGKIRCHEN C-RPP (1)

Contaminant	TA Luft 86 Limit	Planning Value	Manufacturer's Guaranty
Carbon Monoxide	100	<100	50
Class I (solid & vapor phase) Cadmium Mercury	0.2	<0.1	0.1
Class II Cobalt Nickel	1.0	0.00003	0.5
Class III Chromium Copper Lead Zinc	5.0	0.00018	1.0
Fluorine	2	<1	0.5
Hydrogen Chloride	50	<10	5
NO_x	500	170-330	100
Organic Matter	20	<5	-
Particulates	30	<5	10
Sulfur Dioxide	100	<30	25

Notes: (1) All units in mg/Nm^3 (dry, 0°C, 1 atm) and corrected to 11% O_2 by volume.

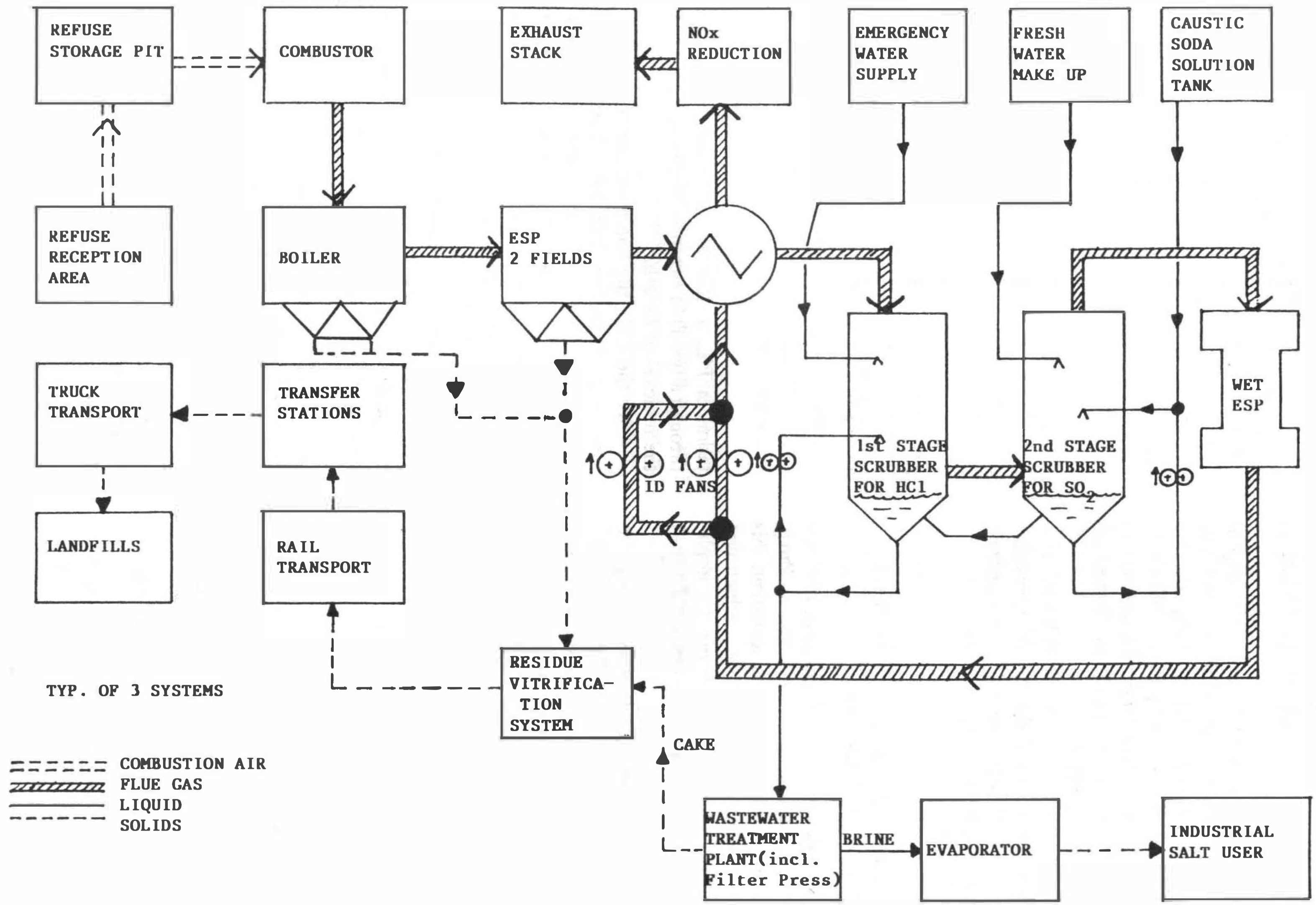

FIG. 3 INTEGRATED AIR POLLUTION CONTROL AND RESIDUE MANAGEMENT SYSTEM FOR BURGKIRCHEN C-RPP

The question as to which type of system is to be installed has not yet been decided. Selective non-catalytic reduction (SNCR) is believed to have the advantage of simplicity and low cost. Furthermore, it does not require additional space in a rather crowded facility. In principle, the SNCR is accomplished by injecting one or more reducing agents at one or more levels into the furnace.

On the other hand, selective catalytic reduction (SCR) requires a substantial structural change in that a separate reaction chamber must be inserted into the flue gas stream downstream of the boilers. While both SNCR and SCR are under consideration, ZAS will ask for a guaranty not to exceed 70 mg/Nm^3 in any case.

Special care is given to disposal of these pollutants which were removed from the flue gas during their cleaning. Simple transfer from the gaseous medium to the liquid medium for disposal as wastewater (a procedure used in older facilities) is no longer acceptable. In fact, the Burgkirchen C-RPP was designed in a manner which precludes liquid effluents.

As Fig. 3 indicates, the scrubber effluent will go to an on-site wastewater treatment plant (WWTP), where it is to be neutralized with the addition of chemicals and where heavy metals will be precipitated. The resultant slurry will be charged into a filter press which has two outputs, i.e., a filter cake and a filtrate, or brine. The filter cake will contain the insoluble heavy metals. The brine will be rich in salts which are the product of chemical reactions between acid gases and caustic soda in the scrubber.

The original intention was to mix the filter cake with fly ash and a cement binder. The mixture was to have been cast into inert blocks for shipment back to the participating jurisdictions. The thinking was that the heavy metals were safely bound in the structure of the blocks, thus eliminating special precautions for their disposal in landfills.

Very recently, this concept was dropped in favor of using an electric vitrification furnace. This followed the successful conclusion of testing a prototype elsewhere. Negotiations are presently underway with the joint venture of LURGI and SORG for the procurement of such a furnace. Typically, 2.3 MW will be required for its operation. The plan is now to use the resulting glass as a construction material. (Note: In the event that no customer is found, the glass will be landfilled. However, because vitrification also densifies the filter cake and the fly ash, less landfill space will be required in any case.)

On the other hand, the brine will be fed into evaporators, where extraction steam from the turbines will be used for concentrating the salt and driving off the moisture. The salt in turn will be shipped to the chemical factory next door for re-use as a feedstock. About 4400 lb/hr (2 mtph) of extraction steam will be consumed by the evaporators.

SLUDGE MANAGEMENT SYSTEM

Generally, the sludge cake produced by municipal wastewater treatment plants (WWTPs) in the ZAS service area consists of primary and secondary treatment components which have been subjected to anaerobic digestion. An average solids concentration at 40% by weight is expected as the result of mechanical dewatering prior to shipment.

At the WWTPs, the sludge cake will be placed in covered containers which are suitable for transportation by trucks equipped with a tilt type of chassis. The trucks will pick up the containers and haul them to the nearest railroad siding with a transfer station.

Tracked bridge cranes will be used for picking the containers off the trucks and loading them onto rail cars. After arrival by train at the Burgkirchen C-RPP, tracked bridge canes will move the containers to tracked transfer cars. The latter will also be equipped with a tilt mechanism, which allows the discharge of sludge cake into the hopper on top of the storage silo. This operational sequence is illustrated in Fig. 4.

It should be noted that the transfer cars will move along an elevated platform which intersects the craneway. This arrangement avoids the need for an elevating conveyor, i.e., the sludge cake can be dumped directly from the container into the silos.

From the silos, a combination of bottom ram extractors, elevating conveyors and transfer screws will move sludge cake up into the boiler house. Feed hoppers will be located adjacent to the refuse burning furnaces. Below each feed hopper, a movable lance will be installed at a right angle to the furnace. The tip of the lance will penetrate into the furnace at a location which will be high enough above the grate so that the trajectory of exiting sludge cake can sweep the entire width of the fuel bed below. Thus, sludge will be placed on top of refuse for simultaneous combustion. Negotiations are now underway between Martin GmbH and L&C Steinmüller to obtain a license for this method of sludge injection.

The rate of sludge addition will be adjusted by a variable speed control on the screw feeder to the lance. THe sludge feed rate must be carefully monitored in order to maintain the appropriate temperature profile inside the furnace. Proper retention time and agitation on the fuel bed are also important to ensure complete

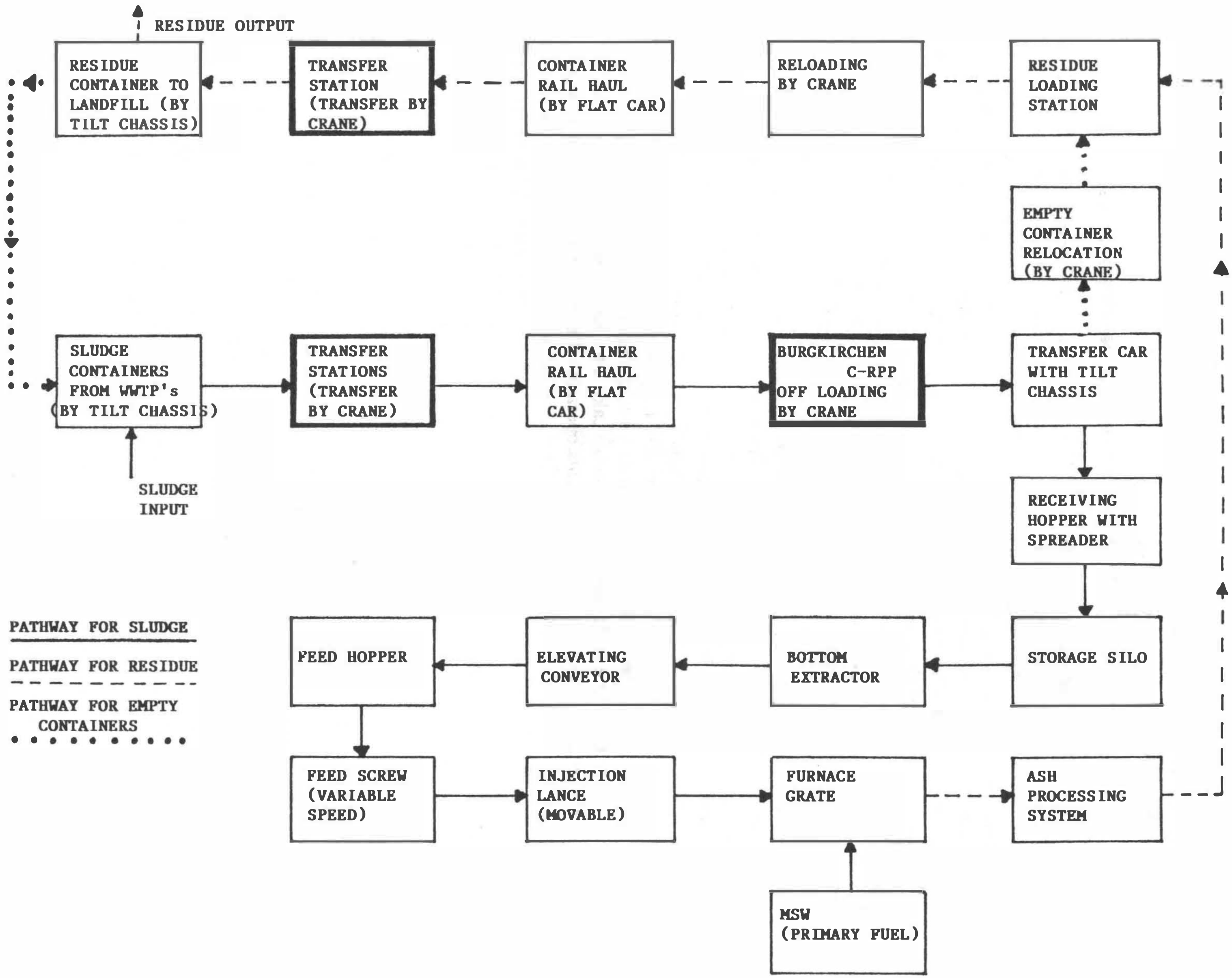

FIG. 4 SEWAGE SLUDGE MANAGEMENT SYSTEM FOR BURGKIRCHEN C-RPP

TABLE 3 IMPACT OF BURGKIRCHEN C-RPP ON AIR QUALITY (1)

Contaminant	TA Luft 86	Background Measurements (2)	Burgkirchen C-RPP Addition (3)
Carbon Monoxide	100	7.5	0.004
Class I: Cadmium	100	1.0 - 1.4	0.250
Class III: Lead	100	2.0 - 4.3	0.030
Hydrogen Chloride	100	24.0	0.010
NO_x	100	29.0 - 45.0	1.250
Sulfur Dioxide	100	6.0 - 12.0	0.070

Notes: (1) Immissions in % of TA Luft 86 limits for environmentally safe values.
(2) Measurements performed by TÜV during the period September 01, 1987 to March 31, 1988 with 62 measurement points spread over 46 impact areas at 1 km x 1 km each.
(3) Projections made by TÜV in 1988 for the effect of future emissions from C-RPP.

TABLE 4 BURGKIRCHEN SOIL CONTAMINATION FROM HEAVY METALS

Contamination Source	Concentration in [mg/Kg of dry substance] Cadmium	Lead	Mercury
Refuse Landfill(1)	4.0	500	1.0
Compost from Refuse(2)	0.6	133	0.5
Burgkirchen Soil(3)	0.9	36	0.3
Limit Concentrations(4)	3.0	100	2.0
Flyash from RPP stack(5)	0.12	1.5	0.3

Notes: (1) From Sections 1745 and 1750 in "Müllhandbuch". Heavy metal concentrations are for refuse deposited in landfills.
(2) Test averages in compost made from organic fraction of source separated residential wastes in Bad Dürkheim. Values for non-source separated refuse may be higher.
(3) Averages for 42 soil samples taken from 900,000 m^2 of surface area in Burgkirchen County within a radius of 2.5 miles (4km) around the C-RPP site.
(4) Rules for land disposal of sewage sludge on agricultural land, from Section 0526 in "Müllhandbuch" which prohibit land disposal if any one limit for heavy metals is exceeded.
(5) D. Holl, "Müllverbrennung 1986", a report from the Bavarian EPA, Munich, W. Germany.

burn-out. Any excess moisture would lead to gas temperatures which are lower than those required by law. In case of abnormally low temperatures, natural gas-fired auxiliary burners will be operated in order to satisfy TA Luft minimum temperature requirements. Because the use of such fuel is an expense item, the plant operator will carefully develop an operating strategy geared towards minimizing use of the auxiliary burners.

The empty sludge containers will then be refilled with residue from the ash processing system as well as with the glass fragments made from fly ash and filter press cake from the on-site WWTP. The reloaded sludge containers will be placed on rail cars for the return trip to the originating transfer stations. Upon arrival there, they will be transferred by crane to trucks with a tilt chassis for the trip to the nearest landfill. After discharge of the residuals, the sludge containers will be returned to their originating WWTP. Thereupon, the cycle will repeat itself.

The basic idea is that each participating jurisdiction receives its share of the residuals commensurate with its contribution of raw wastes to the Burgkirchen C-RPP. By sharing the final disposal task on an equitable basis, no one jurisdiction can complain that it is being dumped upon by the others.

BENIGN ENVIRONMENTAL IMPACT

As part of the environmental impact statement, the independent technical testing service called TÜV (Technischer Überwachungs-Verein) measured the background levels of various contaminants in the area surrounding the Burgkirchen site. By setting the TA Luft 86 limits equal to 100%, the averages of the background measurements could be expressed as percentages of allowable limits.

As delineated in Table 3, between 1% and 45% of the allowables are taken up by already existing pollution from sources other than the C-RPP, primarily automobile exhaust and the firing of coal and oil by homeowners. In contrast, the projected emissions from the C-RPP will only amount to between 0.01% and 1.25% of the allowable limits, depending on the particular contaminant involved [6].

Because much of the land surrounding Burgkirchen is in agricultural use, it is also important to deal with soil contamination due to airborne contaminants. Although it is impossible to completely eliminate the deposit of trace amounts of heavy metals, it certainly will be possible to minimize their accumulation on the soil. This minimization can be achieved by the proper choice of technology.

In Table 4, an attempt was made to relate the fate of heavy metals to the various disposal options considered during the Burgkirchen planning process. By continued landfilling, more cadmium, lead and mercury would be deposited with the refuse than certain limit concentrations would allow. (Note: In the absence of specific limits for refuse, limits for sludge are often quoted in West Germany.)

By turning source-separated residential wastes into compost, the compost would still contain too much lead when compared to the limits. On the other hand, fly ash collected from the stacks of several refuse power plants already operating elsewhere in Bavaria contained much lower concentrations of heavy metals. This test had been done by the Bavarian EPA.

Finally, in order to provide a reference data base, soil samples were taken from the area surrounding the Burgkirchen plant site, within a 2.5 mile (4 km) radius. A marked presence of lead is indicated, for which automotive traffic is the suspected culprit [6].

With the exception of mercury, the refuse-originated deposits are substantially below all others. With regard to mercury, it should be mentioned that the Bavarian EPA test program did not include air pollution control systems of the same efficiency as the ones designed for Burgkirchen. Ultimately, the results of dispersion modeling would be needed in order to predict any cumulative effects.

In terms of residual disposal, the need for landfill space will be drastically reduced. Bottom ash from the furnace grates will be processed together with riddlings. Ferrous metal will be removed by magnetic separators for sale to the scrap market. Extensive screening produces an undersized fraction which will be usable as the frost protection layer in road construction, thus reducing the need for gravel mining.

Only the oversized fraction will remain for landfill disposal, together with the previously discussed glass. The goal is to combine a high degree of thermal waste reduction with a high degree of post-incineration materials recovery. The materials balance in Fig. 5 demonstrates that for every 1000 lb (1000 kg) of refuse burnt, only 105 lb (105 kg) are expected to be landfilled. This equates to a weight reduction of 89%. The corresponding volume reduction is estimated at about 97%. These results are surprising in view of the fact that waste in the ZAS region is not believed to be particularly high in Btus.

The aforementioned lower heating design value of 4410 Btu/lb (2,300 kcal/kg) does not match the 4910 Btu/lb (2730 kcal/kg) which nowadays is often used for the design of U.S. refuse power plants. (Note: A LHV = 4910 Btu/lb corresponds roughly to a HHV = 5500 Btu/lb which is more familiar to the American reader.)

The difference in Btu content between Burgkirchen and U.S. refuse may be attributed to the fact that U.S. refuse contains less ash and inerts. Therefore, it is conceivable that a U.S. plant built with the Burgkirchen type of technology may show a somewhat higher weight reduction efficiency.

POTENTIAL FOR ENERGY RECOVERY

From the technical feasibility report, it has been gleaned that a gross heat release of about $2{,}446 \times 10^9$ kWh/year (716,600 MWh/year) will result from the burning of refuse and sludge. (Note: this figure is based on the lower heating value.) How much of this energy can be recovered for useful purposes?

Figure 6 depicts the annual energy blance which is projected for the Burgkirchen C-RPP when operating at full load. Essentially, 563×10^9 Btu/year (165,000 MWh/year) are lost from the boiler, which results in a combustion efficiency of 77% (based on the lower heating value [LHV]).

In addition, in-plant electrical power and steam needs are fully satisfied. Additional losses are caused by heat dissipation from the electrical generator and the air-cooled condenser. A total of $1{,}565 \times 10^9$ Btu/year (31,600 MWh/year) are delivered to the steam customer.

In the final analysis, energy recovery efficiency should amount to 68.4% based on the gross heat release and 88.9% based on net heat absorption. This relatively high efficiency can be obtained by maximizing thermal output and minimizing electrical output. Consequently, electrical power will be generated only for in-plant consumption, thus leaving the largest amount of steam possible for export to Hoechst A.G. The latter objective will be achieved by operating on a continuous basis all year long.

During the planning process, the question was discussed as to whether or not newspapers should be source-separated for recycling. However, for the ZAS service area, it was decided that incineration with wasteheat recovery was the better way to go [7]. This decision was based on the following considerations:

(a) Most of the forest lands are under cultivation, which means that weak timber is removed on a regular basis. Since this material is delivered to paper mills as a cellulose feedstock, there is no fiber shortage.

(b) Compared to energy, the waste paper market is unreliable and rotting paper which cannot be sold may become a source of pollution.

(c) Calculations indicate that, with combustion, almost four times the amount of energy can be recovered than could be conserved by the substitution of waste paper for waste timber.

Since the refuse and sludge burnt will be, for the better part, a renewable resource, a substantial amount of nonrenewable fossil fuel can be saved. Referring to a high quality heating oil, it is estimated that the chemical plant will save about 14.6 million gallons (55.3 million liters) per year.

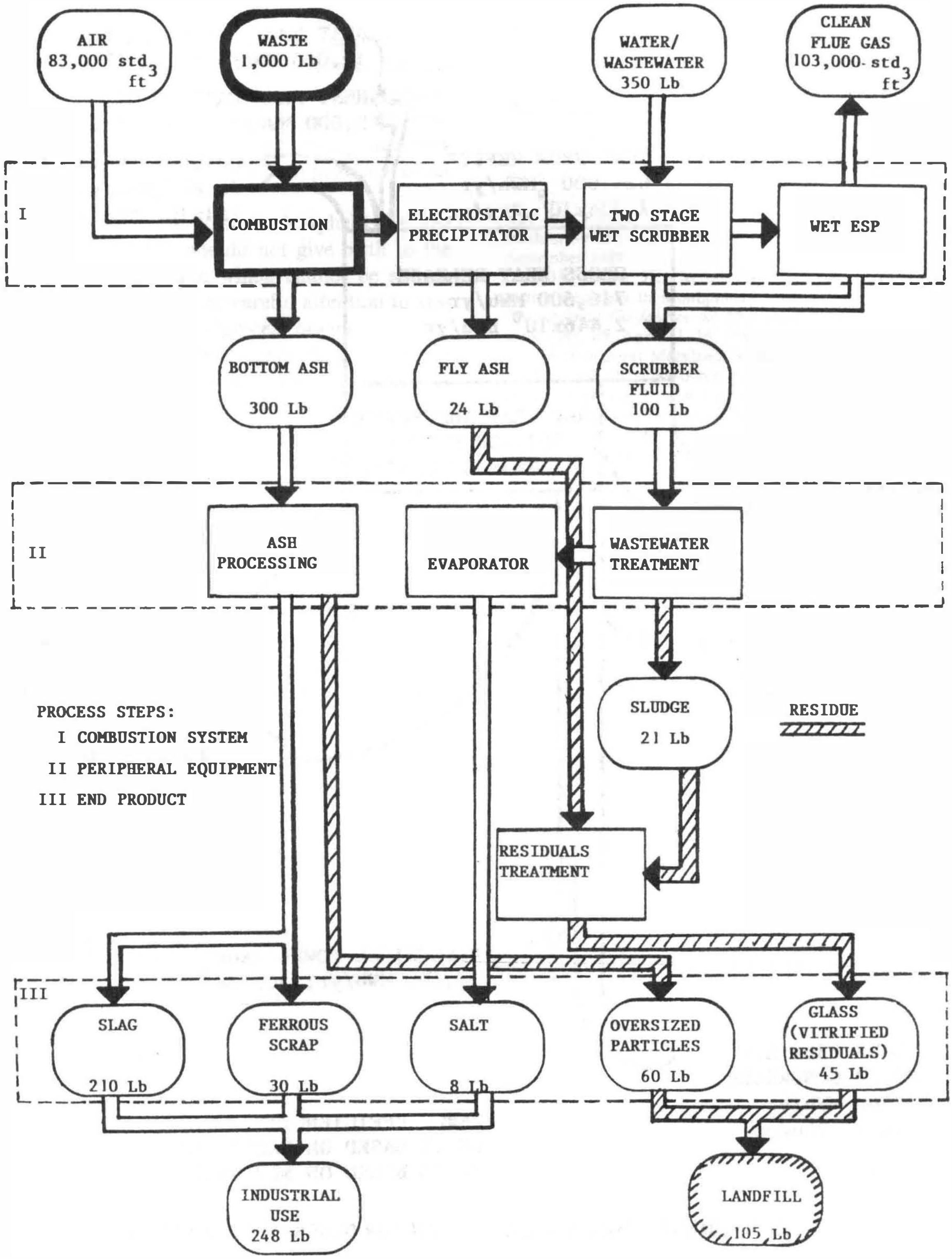

FIG. 5 PROCESS DIAGRAM FOR BURGKIRCHEN C-RPP BASIS: 1000 lb OF MSW

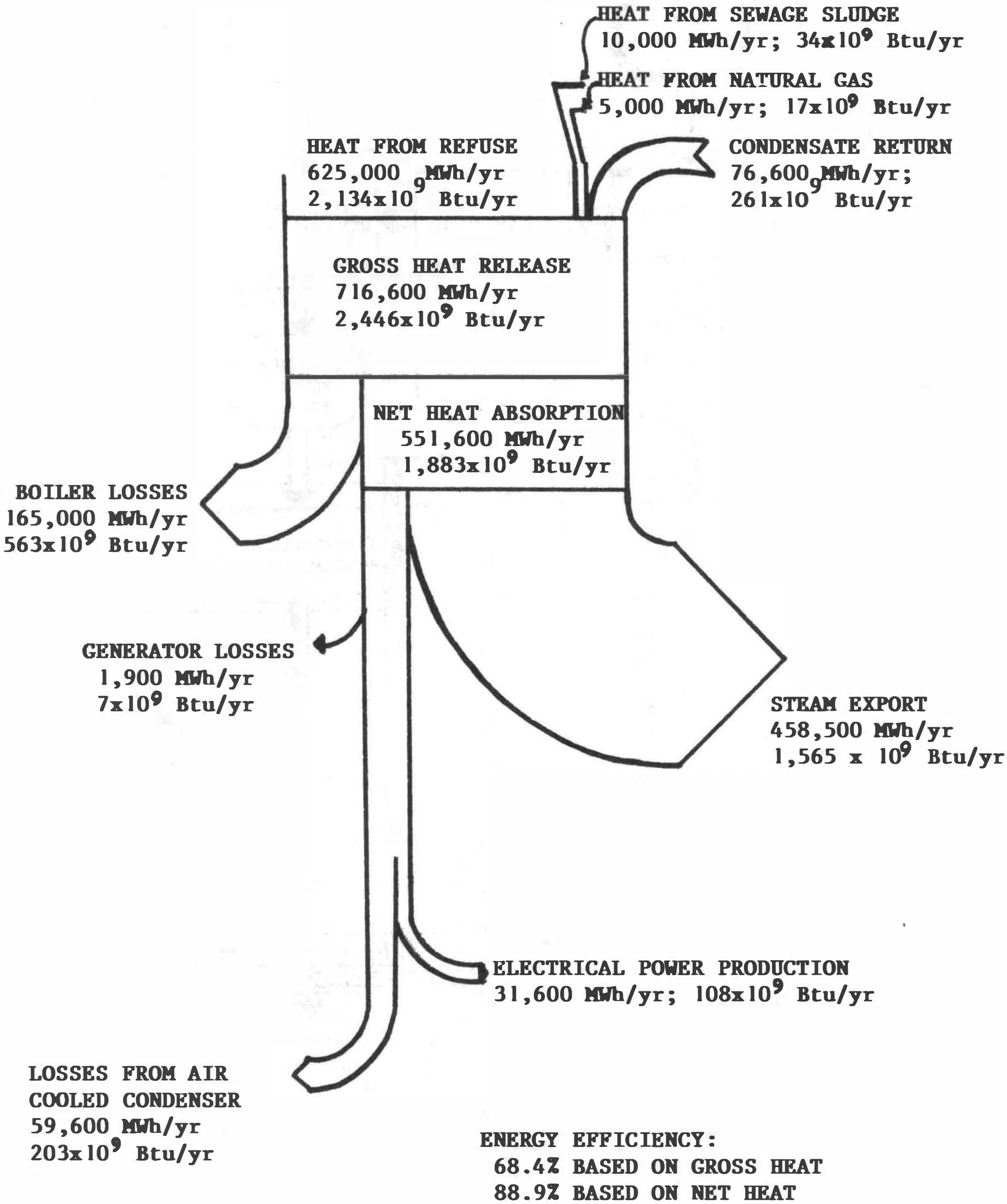

FIG. 6 ANNUAL ENERGY FLOW DIAGRAM FOR BURGKIRCHEN C-RPP

CONCLUSION

High standards of efficiency have been applied to all aspects of the Burgkirchen project, including planning and technology selection. To a large extent, the technologies chosen for transportation, waste processing, pollution control, materials recovery, energy recovery and residue disposal have already been proven in other plants in West Germany.

Most importantly, the principle is upheld that the solution of one problem should not give birth to the creation of a new problem which cannot be solved. This approach is achieved by careful attention to systems analysis in all areas of process design.

Besides being environmentally safe, the Burgkirchen C-RPP is designed to turn wastes into a maximum of recoverable resources while at the same time minimizing undesirable residues. What is more, the residues are of a stable nature, to the extent that air and water at their final disposal site are no longer affected. Political sensitivities are addressed by having all participating jurisdictions accept their share of residue disposal. Thus none of the communities is at a disadvantage.

Compared to other technological alternatives, the Burgkirchen C-RPP concept emerges as an integrated problem solution but one which stays within the realm of proven technology. It seems that if there is a way to cut the Gordian knot of resource recovery, the Burgkirchen planners have found it.

REFERENCES

[1] Hofer, F. "Zukunftsorientierte Abfallentsorgung für eine Region." *Müll und Abfall.* Berlin, Federal Republic of Germany: Erich Schmidt Verlag, December 1986.

[2] Beaumont Environmental, Inc. "Expansion of Schwandorf RPP and Refuse Rail Transportation System." Technical Memorandum 89MFF-391, unpublished, Wheatley Heights, New York, September 1989.

[3] Feindler, K. "Refuse Rail Haul: The Missing Link to Resource Recovery in Montgomery County." In *Proceedings of the International Conference on Municipal Waste Combustion,* Hollywood, Florida, April 11–14, 1989.

[4] Northeast Maryland Waste Disposal Authority. "Request for Proposals for a Resource Recovery Facility and Refuse Transportation System Serving Montgomery County, Maryland." Baltimore, Maryland, February 1989.

[5] Feindler, K. "Status of European MSW/RDF Rail Haul Systems and Evolution of American Super Train." Beaumont Environmental Inc., Technical Memorandum 87MFF-312, Rev. H, unpublished, Wheatley Heights, New York, January 1988.

[6] Hofer, F. "Umweltschutz durch Abfallwirtschaft." *Müll und Abfall.* Berlin, Federal Republic of Germany: Erich Schmidt Verlag, May 1989.

[7] Hofer F. "Altpapier als Müll-stofflich oder energetisch verwerten?" *Müll und Abfall.* Berlin, Federal Republic of Germany: Erich Schmidt Verlag, April 1986.

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