CASE STUDY

DERL ENERGY FROM WASTE FACILITY
DUNDEE, SCOTLAND

For
IEA Bionenergy Task 23
Energy from the Thermal Conversion of MSW and RDF

By
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NOTICE

This study has been performed for the working group of IEA Bioenergy Task 23: Energy from the Thermal Conversion of MSW and RDF. This draft report is supplied for internal use of IEA Bioenergy Task 23 members only, and the results may not be made known to third parties as having been produced by AEA Technology.

Execution of the study was limited to information in the public domain, and data provided by DERL and Kvaerner, plus a half day site visit.

Since the study was conducted shortly before the plant began operation, data on operational parameters and costs was not available.

Findings relate to the typical UK waste stream, which may differ from that in other European and North American countries. Further, market conditions and regulations will differ.

CONTENTS

1 Background

1.1 DERL

This report charts the events leading up to the commencement of daily operation of the Dundee Energy Recycling Ltd (DERL) energy from waste (EfW) facility, which is the first in the UK to use bubbling fluidised bed technology for waste treatment. At the time of writing, the DERL plant is due to begin accepting waste in autumn 1999.

The £35million turnkey design, engineering and construction contract was awarded jointly to the consortium formed by Balfour Beatty Projects & Engineering Ltd and Kvaerner EnviroPower Ltd.

Balfour Beatty is responsible for the civil engineering aspects of the facility, and for the power generation and export equipment. Kvaerner EnviroPower is responsible for the waste processing aspects of the plant and the design of the fluidised combustion technology as well as heat recovery, flue gas cleaning and ash handling processes. Once the plant is constructed, equipped and commissioned, and operating within agreed parameters, it will be handed over to DERL to operate.

The new plant, with a capacity of 120,000 tpa, will receive MSW from Dundee & Angus Councils (population 270,000) together with some clinical waste from Greater Glasgow Health Board. The waste will be processed into floc RDF for electricity generation, with additional recovery of ferrous & non-ferrous metals.

DERL is a joint venture company formed between BICC plc, Kvaerner Investments and the City of Dundee District Council. The Council holds 40% of the shares in the company and will be paid dividends reflecting its profitability. DERL will charge the Council a gate fee for every tonne of waste processed. DERL will also generate income from sales of electricity, under a Scottish Renewables Obligation (SRO) agreement, and from sales of other recovered materials such as ferrous and non-ferrous metals. The project is funded by the first Private Finance Initiative (PFI) for a waste management scheme in Scotland.

1.2 General context of waste in Dundee

The former Baldovie incinerator, located on the Baldovie Industrial Estate and in operation since 1979, was closed down in 1996. It had a capacity of 73,000 tonnes a year but in recent years had had a troubled history with technical and management problems causing unplanned downtime and local objections. The plant as it stood was not able to meet new EC emissions limits introduced in 1992 and which for existing plants came into effect in December 1996 (EC Directive 89/429/EEC).

The old plant did not recover energy, apart from a small amount of low grade heat used for in-house needs at the plant. This fact, as well as the considerable investment which would have been needed to upgrade the existing plant in order for it to comply with the new emissions limits, swung the balance of opinion in favour of either building a new waste to energy plant or relying on landfill for future disposal. Following a comprehensive review of current and future waste management practice in Dundee, the District Council concluded that incineration with energy recovery was the most economically viable and environmentally satisfactory solution to Dundee's waste disposal obligations, and represented the Best Practicable Environmental Option (BPEO) for the City.

The option chosen was to redevelop the existing incinerator site by constructing a new waste-to-energy plant which would include the latest clean technology. The level of investment needed was beyond the financial scope of the City of Dundee District Council, and a joint venture partner was sought. An approach was made to Scottish Power to consider developing the existing incinerator site at Baldovie as a joint venture waste-to-energy project and Dundee Energy Recycling Ltd (DERL) was formed by the two parties to develop the project.

The UK Government has defined electricity derived from combustible industrial and domestic waste as one of several renewable sources of energy. To stimulate the market for renewable energy, the Secretary of State for Scotland has imposed an obligation, the Scottish Renewables Obligation (SRO) on the electricity supply companies to purchase electricity generated from renewable sources. Under the terms of the SRO issued in June 1993, targets were set for new generating capacity of 30-40MWe by November 1994, with further targets to be announced for subsequent years.

Each unit of electricity would be purchased at a preferential rate by Scottish Power plc and Scottish Hydro plc if the proposed Dundee facility's application under the first round of the SRO were successful. Income from sales of electricity would give a return on the capital required to build and operate the plant. However, DERL's bid into the first allocation of the Scottish Renewables Obligation (SRO1) failed. Following this, the project was no longer sufficiently attractive to Scottish Power, and they pulled out from the joint venture.

By this stage, the Council was fully committed to the project and determined that it would go ahead, and a second joint venture arrangement was reached with Balfour Beatty and Kvaerner Enviropower, who were the partners in the turnkey consortium. This change of partners necessitated taking the PFI approach to identify funds for the project.

1.3 Site Selection and Technology

The existing 73,000 tpa incinerator was located 5 km north east of the City on the Baldovie Industrial Estate. It was surrounded on three sides by other industrial units including a ready-mix concrete supplier, a vehicle tyre producer and a gas turbine reconditioner. The entire site area - owned by the City of Dundee District Council - is around 5 hectares, of which the existing incinerator occupied 3.75 hectares in the northern part of the site. Included in that area were the main incineration block plus an amenity block, boiler house, gate house and weighbridge and ancillary storage areas.

The nearest residential areas are the Douglas and Angus and Ballumbie/Whitfield residential estates of Dundee, at a distance of 500 and 250 metres respectively. The site infrastructure already in place included water supply, drainage, gas and electricity. Since the proposed 120,000 tpa waste-to-energy plant would occupy just 2 hectares of the total 5 hectare site, it could be fitted onto the land available with some reconstruction of existing facilities such as gatehouse and weighbridge area. This would allow the new plant to be entirely constructed and commissioned before the old plant was demolished.

All of these and other factors led the City of Dundee District Council to conclude that the site adjacent to the existing incinerator was potentially ideal for the construction of a new facility, and an environmental assessment of the site was undertaken. No detailed investigations of alternative sites were undertaken.

Of 30 initial responses to the call for bids, a shortlist of 5 contenders (2 for fluidised beds, 2 stokers and 1 rotary furnace) was reached. An Environmental Impact Assessment for the proposal was carried out for bubbling fluidised bed as the preferred technology.

Planning consent for the proposed plant was obtained in January 1995. The site has been purchased from the Council by DERL. The old plant will be demolished once the new plant is completed.

1.4 Waste Contract

DERL has a 20 year waste contract which commenced at the end of the construction phase. The Authorisation allows DERL to accept up to 150,000 tonnes per annum of waste of which no more than 15% may be low grade clinical waste and no more than 5,000 tonnes non-special liquid waste.

DERL assumes the risks associated with the financing of the scheme, and for its ongoing operation and maintenance after hand-over. However it has some protection against legislative change eg emissions regulations, through the waste contracts. The contractors assume the risks associated with design and construction.

The plant has been sized to process 120,000 tpa of waste, which initially will require Dundee to commit all of its MSW to the plant. The typical waste mix will be 62% MSW; 6% CA waste; 12% trade waste; 7% industrial waste; 8% clinical waste; 3% waste liquids; 2% other wastes. However as commercial wastes are increasingly diverted to the plant Dundee will be able to further expand its existing recycling measures and divert more waste in order to meet targets already in place and those proposed under the recent Draft National Waste Strategy for Scotland.

The new facility has a required minimum annual operational availability of 7,500 hours. It is planned to operate for up to 8 weeks on part load, with two weeks down and two weeks to recover per boiler. There are punitive charges if waste is diverted to landfill.

2 Process technology

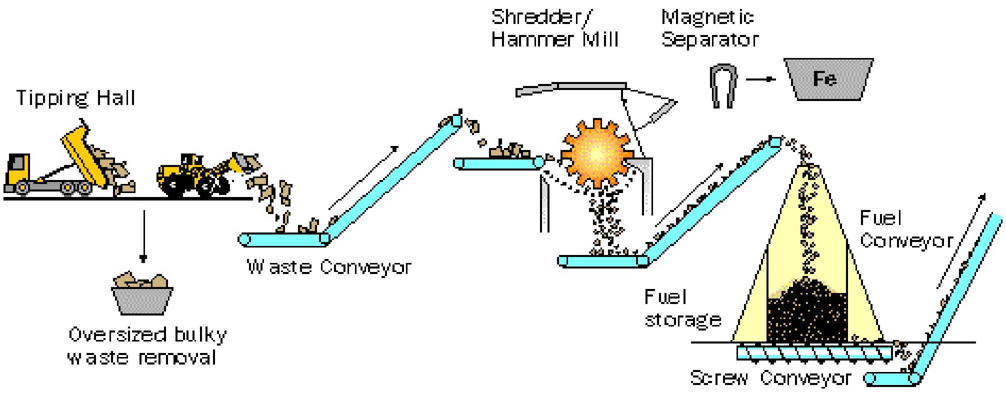


Figure 1: RDF preparation system

2.1 Material recovery/fuel preparation

Around 10% of incoming waste will be delivered in black plastic sacks, and the balance loose from wheeled and other bins. The waste is tipped onto a flat floor in the reception area in order that bulky and incombustible material can be removed for off-site disposal (or recycling if appropriate). Diesel powered front end loaders then feed the waste into one of two hammer mills (or into short term stockpiles). Each of the hammer mills can handle 30 tonnes of waste an hour, which is almost double the plant's throughput (15.6 tph), the over-capacity allowing for any unplanned shredder downtime. The shredded material will be size reduced to less than 150mm.

Magnets mounted on the primary conveyors leaving the shredders will remove most of the ferrous material and the floc will then be transferred, by a single conveyor serving both shredders, to the RDF store. The conveyor feeds the floc through the roof of the fuel storage building, a 20 metre high steel A-frame building capable of holding enough fuel for two days of boiler operation (around 800 tonnes of RDF).

2.2 Clinical waste handling

Separate procedures will be put in place for reception and handling of clinical waste. On arrival in tipping hall, clinical waste vehicles will discharge directly into a $60m^3$ hopper which has the capacity to hold 5.4 tonnes of clinical waste. Waste will be conveyed from this hopper directly to the boilers via a dedicated shredder which will reduce the material to a nominal 100mm size. The clinical waste conveying system is fully enclosed and in order to minimise any escape of odours, it will be kept under negative pressure by a fan which is ducted into the boiler.

There are separate systems for cleaning the clinical waste handling equipment during inspection and maintenance, and the residues from this process (including cleaning agents, disinfectants and water) will be routed via a sump to the boiler for destruction.

2.3 RDF feed system

From the fuel storage building, the floc RDF will be automatically fed onto covered conveyors by either of two fuel recovery screws located in a trench which traverses the length of the RDF store. The screw reclaimers have been widely used in biomass plants in Scandinavia and occasionally for waste fuel, with this the first installation in the UK.

There are no cranes to handle or feed the material. A system of covered conveyors leads to the boiler house where two waste hoppers, one for each boiler, are located. The hoppers are kept full, and they feed the floc by gravity into the boilers using a variable speed apron feeder. Non compacting fuel feed and metering should ensure good boiler control and help reduce the need for excess air. A bypass reject option is available for breakdown or emergencies. Dust extraction from the waste conveyors is carried out by self-cleaning filter units.

Eddy current separators located on the final feed section before the fuel is delivered to the boilers will remove non-ferrous metals and alloys, mainly aluminium with small amounts of copper, zinc, brass and bronze. These are collected for off-site recycling.

The fuel feed system works on an overfeed basis, to ensure that there is always enough fuel available to the boilers. Any surplus fuel is returned to the store and redistributed.

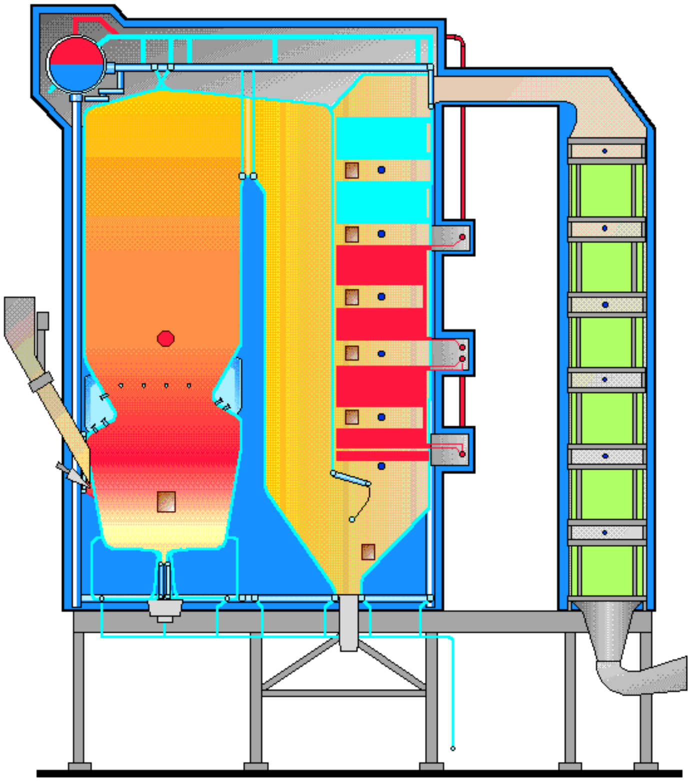


Figure 2: Boiler

2.4 Boilers

Within the boiler house there are two 17MW Kvaerner bubbling fluidised bed incineration boiler units, each sized at a maximum continuous rating to match the gross incoming waste stream of 8 tonnes per hour at an assumed gross calorific value of 10 megajoules per kilogram of waste (MJ/kg). Each fluidised bed boiler comprises a combustion chamber, a back pass including radiation cavity, superheaters, evaporation stages and economisers. The fluidised bed is designed as an integral part of the boiler; surfaces are fabricated from membrane-wall tubing and the steam drum is close-coupled. The bed of hot sand and ash at the base of the boiler is kept in constant motion by fluidising primary air injected through the bed from the wind box below via the bottom plate. Fuel is gravity fed and spread across the surface by recirculated flue gases via air-swept spouts. Most of the combustion takes place within the bed, but some fine material burns in suspension immediately above the bed.

Non-combustible material and bottom ash is continuously removed from the bed which will have dolomite added to it to reduce boiler tube fouling and control emissions of SO_x. A mixture of ash and sand is continuously removed from the fluidised bed. Water-cooled screws recover heat from the bed material prior to the sand being removed and returned to the bed via an ash classifier. Typically the remaining carbon content of the bed ash will be <0.5%.

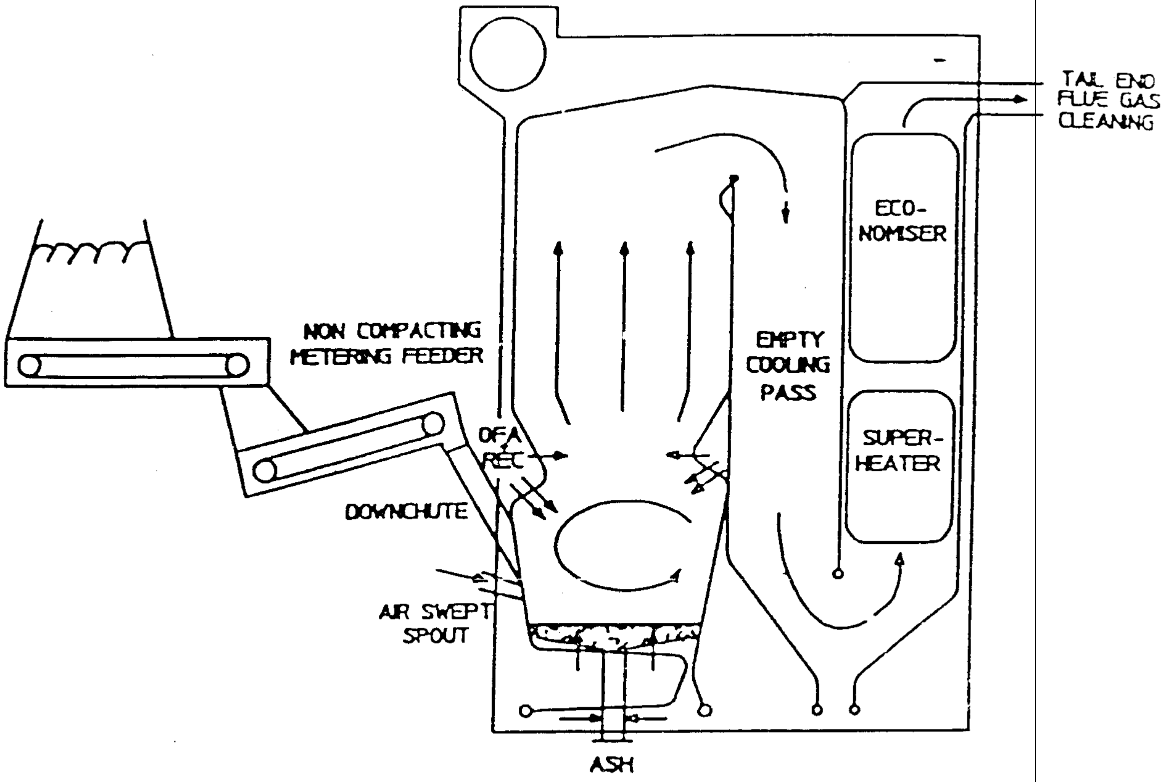
Combustion air for the process is drawn from the waste storage areas in order to control emissions of dust and odour from the plant. The boilers are fitted with forced draught fans to supply primary, secondary and tertiary air for the staged combustion process and some flue gas is also recirculated to help control the formation of oxides of nitrogen. Start-up is by gas-oil burner below the bed, which initially heats the primary air and fluidises the bed of sand. A secondary gas-oil burner above the bed raises the furnace temperature to 850 degrees C, when fuel can be fed into the boiler.

The Kvaerner bubbling fluidised bed boiler uses an Advanced Combustion Zone design which the manufacturers claim enables thermal efficiencies of 89% with typical steam conditions (40 bar and 400 degrees C). *(See Fig 3, page 10)*

Corrosion of heat recovery surfaces by chlorine, sulphur and heavy metals can be caused by reducing conditions and this is avoided by the ACZ furnace design. The lower furnace area is refractory lined to achieve uniform temperatures and reduce slagging. Superheater corrosion is avoided by the empty radiation cooling pass which conditions the flue gas prior to its entering the convective cooling surfaces.

Figure 3: BFB Advanced Combustion Zone

BFB Advanced Combustion Zone (ACZ)



- **Air swept fuel inlet spout:** the combustion of fuels which have a tendency to suspension firing is improved by introducing and distributing the fuel with an air-swept spout.
- **Directional bottom air nozzles:** the directional actin of the nozzle and the bottom sloping floor geometry aid ash removal
- **Double arch configuration and Asymmetric Overfire Air (OFA) system:** promotes controlled combsution and is designed to oeprate with a substantial ratio of overfire air.
- **Flue gas recirculation:** flue gas is recircualted for temperature control and to promote turbulence and low NOx emisisons
- **Tapered lower furnace:** optimises fluidisation and prevents clinkering
- **Plug flow type upper furnace:** makes efficient use of upper part of furnace and cooling surfaces. A tertiary air register, comprising high speed air nozzles, is installed between the lower combustion zone and the upper part.

Source: Kvaerner

2.5 Air pollution control system

A separate flue gas cleaning unit is provided for each boiler. Flue gases leaving the heat recovery sections of the boiler pass through cyclone pre-collectors where around 70% of the particulates are removed. Following this dry lime injection will react with acid gases (such as hydrogen chloride and sulphur dioxide) formed during combustion. Activated carbon will be injected after the cyclone to trap dioxin and furans as well as mercury. Fabric filters will then trap any remaining particulates together with the lime and activated carbon added previously.

After the bag filter the flue gas emissions are continuously monitored, testing each boiler in turn. Flue gases are discharged to atmosphere via a twin flue stack, 70 metres high.

The BFB's high heat transfer rates, good fuel distribution and vigorous fluidisation aim to minimise hot and cold spots and thus ensure complete combustion of fuel with low excess air. This in turn can achieve low CO and NOx emissions.

The plant's chosen dry sorbent APC system, supplied by Procedair, is claimed to increase the energy output by around half of a megawatt. However, the dry sorbent process may not readily meet the proposed 10mg/Nm^3 on HCl emissions, but once operational, DERL will be able to assess this and will in any case have a number of years to implement the new limit.

The plant can achieve 220 mg/Nm^3 NOx emissions as it is currently configured, with the possibility to retrofit ammonia injection to bring this level down.

Fluidised bed systems have the potential to allow primary acid gas abatement by the addition of lime or dolomite to the bed material. Where the feedstock has a high sulphur content and low chlorine, this is an effective and economic abatement option. The combustion temperature (850 degrees C) is optimum for sulphur absorption on ash particles and dolomite.

2.6 Electricity production

The steam turbine is a single-cylinder condensing machine designed by Austrian Energy & Environment, and the installation includes the option for future steam export for use in nearby industrial processes. Power is transmitted from the turbine to the 4-pole AC brushless generator which has a 3-phase, 11kV output. The generator (from ABB Sweden) is rated at 10.5MW. A water cooled condenser condenses the exhaust steam for re-use as boiler feed water. The electrical annex of the plant houses the switchgear connection to the grid and a new 11kV underground cable links the plant to the Scottish Hydro electricity network.

The in-house demand is an estimated 2.2MW leaving 8.3MW for export.

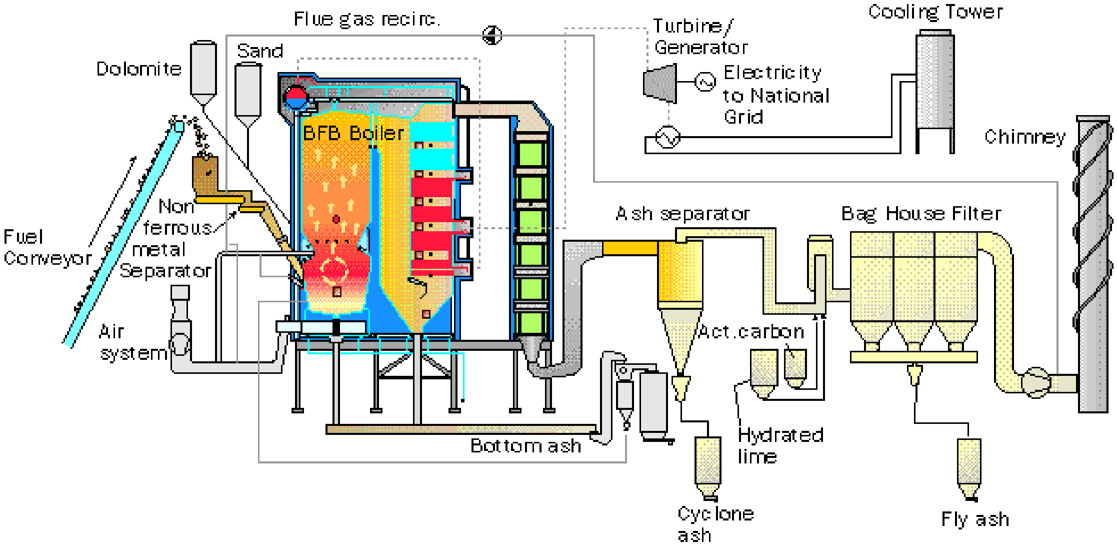
2.7 Balance of plant

Incoming waste will be recorded via two automated weighbridges which may be linked to invoicing, accounting and record keeping systems.

Boiler feed water is supplied from town mains via conventional demineralisation plant. Cooling tower make up is abstracted from the Dighty Water 200 metres away from the plant at the rate of 450,000 cu metres/pa.

In addition to transport movements of incoming waste fuel, and separated ferrous and non-ferrous metals being sent for recycling, the plant will require to bring onto site 1,200 tpa hydrated lime, 20 tpa carbon, 1800 tpa bed sand and 700 tpa dolomite.

Figure 4: Schematic of process line



3 Fuel characteristics

3.1 Design MSW composition

Annual throughput	120,000 tpa
Domestic refuse (MSW)	62% by weight
Civic amenity waste	5.5%
Commercial waste	12.5%
Industrial waste	7%
Rubber tyres	1%
Special wastes – dry	0.5%
Special wastes – liquid	2.5%
Clinical wastes	8%
Others	1%

The flow rate of each fuel stream can vary in such a way that the composition ie CV, ash content, moisture, etc of the fuel mix fed to the boiler will vary on an hourly, daily and annual basis.

3.2 Design fuel mixture

The following MSW composition is assumed before and after the fuel preparation plant (fuel analyses based on study by ETSU).

Fuel composition MSW Before fuel preparation plant		After fuel preparation plant
C	32.08 % weight, dry	37.59 % weight, dry
H	4.57	5.35
N	0.78	0.92
O	20.28	23.76
S	0.17	0.19
Cl	0.85	1.00
Ash	41.27	31.19
	100%	100%
Moisture	40%	43.8% weight
NCV	6.42 MJ/kg	7.038 MJ/kg

Fuel composition: Civic amenity wastes (source: Warren Spring Laboratory analyses)	
C	44.1% weight, dry
H	5.8
N	1.2
O	34.0
S	0.1
Cl	0.3
Ash	14.5
	100
Moisture	50 % weight
NCV	7.077 MJ/kg

Fuel composition: Commercial wastes (wood, textiles, cardboard and plastics)	
C	37.93 % weight, dry
H	4.94
N	0.08
O	31.85
S	0.13
Cl	0
Ash	25.07
	100
Moisture	27 % weight
NCV	9.23 MJ/kg

Fuel composition: Industrial wastes (wood, paper, textiles and plastics)	
C	44.17 % weight, dry
H	5.87
N	0.37
O	31.51
S	0.11
Cl	0.78
Ash	17.19
	100
Moisture	22 % weight
NCV	12.46 MJ/kg

Fuel composition: Rubber tyres (Based on an analysis made by Kvaerner Pulping)	
C	70.0 % weight, dry
H	5.9
N	0.3
O	2.3
S	1.7
Cl	0
Ash	19.8
	100
Moisture	10% weight
NCV	26.721 MJ/kg

Fuel composition: Special waste		
	Dry – assumed to be mainly paper	Liquid – assumed to be mainly oil reject
C	50.0 % weight dry	63.52 % weight, dry
H	6.0	12.08
N	0.5	0.15
O	38.5	0.1
S	0	4.15
Cl	0	0
Ash	5	20
	100	100
Moisture	10 % weight	20.1 % weight
NCV	17.30 MJ/kg	24.10 MJ/kg

Fuel composition: clinical and hospital waste	
C	**44.92 % weight, dry**
H	**6.01**
N	**0.44**
O	**27.16**
S	**0.26**
Cl	**1.21**
Ash	**20**
	100
Moisture 25% weight	
NCV 12.805 MJ/kg	

3.3 Flow rate limitations

A Maximum flow rate of liquid waste is 210kg/h/boiler
B Average flow rate of tyres to the boiler is 80kg/h/boiler ie one third approx of total energy. The maximum short term (1h/day) firing capacity of tyres is 10% of the fuel energy input.
C Maximum throughput of clinical waste is 3 t/h or 40% of the actual thermal input, whichever is most stringent.

3.4 Design Fuel Mixture at boiler inlet

Characteristic	**Design**	**Range**
Calorific value kJ/kg		
Gross calorific value as delivered to boiler	**10714 kJ/kg**	**8571-12587 kJ/kg**
Net calorific value	**9020 kJ/kg**	**6792-11005 kJ/kg**
Moisture content	**37.4% w/w**	**27.4 – 47.4% w/w**
Ultimate chemical analysis (% weight dry)		
Carbon (C)	**40.94**	**35-50%**
Hydrogen (H)	**5.68**	**4 – 6%**
Oxygen (O)	**25.54**	**20-40%**
Nitrogen	**0.66**	**<1%**
Sulphur	**0.34**	**<0.4%**
Chlorine	**0.75**	**<1.1%**
Ash	**26.09**	**<30%**

- Design density raw waste (no clinical waste) 210 kg/m3

3.5 Fuel preparation

- 1% of incoming MSW is assumed to be bulky waste ie 744 tpa (0.01 x 74400)
- 9% of the amount of MSW after separation of bulky items is assumed to be ferrous material. The ferrous separator will have an efficiency of around 90%. Total ferrous recovered will be 5966 tpa ((74400 – 744) x 0.09 x 0.9)
- ½% of MSW after separation of bulky items is assumed to be aluminium (mostly cans). The eddy current separator will have an efficiency of around 58%. Total non-ferrous recovered will be 513 tpa ((74400 – 744) x 0.012 x 0.58)

- When separating ferrous and non-ferrous material some useful fuel will also be separated. The fuel loss will equal around 7.1% of the separated ferrous material and 15% of the separated aluminium. Total loss 423 tpa (Fe) and 77 tpa (Al) = 500 tpa

4 Mass and energy balances

CATEGORY	**TPA**	**GWH**
1 MSW	74,400	133
2 COMMERCIAL	15,120	38.8
3 SPECIAL DRY	720	3.5
4 CIVIC	7,080	13.9
5 INDUSTRIAL	8,520	29.5
6 RUBBER TYRES	1,320	9.8
7 SPECIAL LIQUID	3,120	20.9
8 CLINICAL	9,720	34.6
9 BULKY ITEMS	744	1.5
10 SPILL-OVER FERROUS	423	0.8
11 SPILL-OVER NON-FERROUS	77	0.2

NOTES

- Data based on an on-stream availability of at least 7500 hours per annum.
- As a design minimum, the plant shall process 120,000 tpa
- The nominal rating of the plant shall be at least 16 tph with two streams
- It shall be assumed that the design CV shall be 10MJ/kg ± 20% (gross)

5 Products and residues

5.1 Products

In addition to the processed fuel, the plant will recover around 6,000 tonnes of ferrous metal and 450 tonnes of non-ferrous metals per annum.

Ferrous metal magnetically removed from the shredded waste as it leaves the hammer mills will be diverted unbaled to skips for off-site recycling. Non ferrous metals recovered with eddy current separators prior to the fuel being fed into the boilers will also be sold for recycling off site.

5.2 Residue handling and disposal

Around 23,000 tonnes per annum of residues will be generated at the plant: 5,000 tpa filter ash, 9,000 tpa ash from the cyclone and 9,000 tpa bed ash. Dundee City Council, through its waste contract with DERL, is responsible for the removal and disposal of ash residues. Filter and cyclone residues are being landfilled but bottom ash is being recycled as aggregate.

Bottom ash from the fluidised bed is removed continuously by water-cooled conveyors and classifiers remove oversized material before the remaining bed material is returned to the bed by gravity. The bed volume is kept constant by the controlled addition of sand.

Ash collected in the cyclones immediately after the boilers is transferred to an ash silo. Some of this ash is used to stabilise bag filter ash and the balance sent for off-site disposal. The bag filter - which has trapped remaining particulates, plus lime and activated carbon injected to clean gases - is cleaned using pulsed air and the dust collected is conveyed to a separate silo. All ash systems are handled using dry systems to avoid generation of liquid effluents.

6 Environmental emissions performance

The Dundee plant began accepting MSW in Autumn 1999. No bed ash analysis, fly ash analysis or continuous emissions monitoring tests results are yet available for the plant.

Some emissions data in a similar Kvaerner BFB facility in Lidkoping, Sweden is shown for information only in the table below.

Typical emissions – mg/Nm3 (dry gas 11% O2) – Lidkoping, Sweden 1997		
Pollutant	**BFB test results**	**IPC Guidance Note S2 5.01 (95% hourly average)**
Particulate	1	25
CO	41	50
HCl	29	30
NOx	209*	250-300

* Without the use of non catalytic reduction

Dioxin emissions at Lidkoping, without the use of activated carbon, average 1.1 ng/Nm3 TEQ before flue gas cleaning, and in the stack after cleaning 0.071ng/Nm3. Dioxin and furan concentrations in bottom ash were 0.01 – 0.04 ng/g TEQ, in cyclone ash 0.041 ng/g and in the filter ash 0.19ng/g.

The annual availability of the Lidkoping plant is 97%.

7 Capital, operating and maintenance costs

DERL will charge Dundee City Council a £29 per tonne gate fee. DERL's revenues will come from three long-term waste disposal contracts, the SRO2 contract, short-term commercial waste disposal contracts, sales of metals, and revenues from Packaging Recovery Notes (PRNs). The revenues from PRNS will provide support for the expansion of materials recycling schemes, diverting more recyclable waste from the plant. Diversion of recyclable materials, particularly those which are not combustible, will help to improve the plant's operation as well as generating additional income.

Projected operating and maintenance costs (as at 1 September 1999, plant is not yet accepting MSW):	
Maintenance costs (includes equipment, emissions testing clothing, lubricants etc)	
	£404,000 pa
Consumables (eg sand, lime, carbon)	£260,000 pa
Basic administration costs/stationery etc	£30,000 pa
Staffing (26 staff + social costs)	£620,000 pa
Professional fees	£50,000 pa
Property taxes	£262,000 pa
Insurance	£320,000 pa
Ash disposal	£55,000 pa
External disposal of surplus clinical waste	£120,000 pa
Technical support	£50,000 pa
Combined contingency	£90,000 pa
TOTAL OPERATING COSTS (Estimated) £2.3million at 1996 prices	

Annex 1: Glossary of terms

ACZ	**Advanced Combustion Zone**
BFB	**Bubbling Fluidised Bed**
BPEO	**Best Practicable Environmental Option**
DERL	**Dundee Energy Recycling Ltd**
DCC	**Dundee City Council**
EFW	**Energy from Waste**
FB	**Fluidised Bed**
GGHB	**Greater Glasgow Health Board**
JVC	**Joint Venture Company**
MSW	**Municipal Solid Waste**
NFFO	**Non Fossil Fuel Obligation**
PFI	**Private Finance Initiative**
PRN	**Packaging recovery Note**
REC	**Regional Electricity Company**
SEPA	**Scottish Environmental Protection Agency**
SRO	**Scottish Renewables Obligation**
WDA	**Waste Disposal Authority**