IEA Bioenergy Task 23

Case study: Lidköping Waste-to-Energy Plant.

December, 1999
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Process & Värme

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Notice

This study has been performed for the working group of IEA Bioenergy Task 23: Energy from Thermal Conversion of MSW and RDF, as a part of topic 3a, Fluidised Bed Combustion of MSW.

This draft report is supplied for internal use of IEA Bioenergy Task 23 members only.

Execution of the study was limited to public information, material delivered from Kvaerner, internal plant reports (Environmental Report 1998, Periodical Control Report 1999, Application for new permission 1997, Permission of Dec. 1998) and a visit to the plant. The Managing Director and other staff of the plant have been very helpful in giving access to information and demonstration of the plant. Employees from Kvaerner were also quite helpful.

Contents

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1 Introduction

This report is part of an IEA Bioenergy Task 23 study, with the aim of reporting on the performance of fluidised bed systems in Europe, by producing case studies of representative technology and comparing economic and operational performance.

2 Background

2.1 Lidköpings Värmeverk (Waste-to-Energy plant)

Lidköpings Värmeverk is the main production plant for district heating in the city of Lidköping, situated alongside Lake Vänern, the largest lake in Sweden. It is 100% owned by the municipality of Lidköping. The plant consists of two 20 MW and one 8 MW oil-fueled boilers and two 17 MW bio/waste-fueled boilers. The maximum capacity of the plant is 82 MW_{th} (thermal). In addition, there are two electrically-fired boilers, rarely in operation.

The bio/waste plant was originally put into operation in 1985, with two lines for combustion of waste and biofuel using bubbling fluidised bed (BFB) technology, delivered by Kvaerner.

The bio/waste plant has been gradually upgraded to meet more stringent requirements. The boiler output of each line was designed for12 MW. In 1994/1995 the output was increased to 17 MW. During the rebuilding process, the furnaces were improved, leading to the Kvaerner concept now called the Advanced Combustion Zone (ACZ). During 1999, the furnace section of the boilers was improved again, by adding crosswise air injection, and a new hammer mill was introduced.

Today, 70 000 tonnes of bio/waste fuel is combusted every year in the two solid fuel lines, producing 200 GWh district heat. More than half the amount received is household and industrial waste, the rest being treated wood waste. The plant's permission is limited to the incineration of a maximum 50 000 tonnes of waste (household and industrial) each year. The household waste is delivered from the municipality of Lidköping and seven surrounding municipalities. Beside the contract deliveries from the municipalities, private companies also deliver industrial waste.

A new line of 20 MW is in the planning stages. It will be a steam producing plant equipped with a turbine supplying electricity for internal use only.

For management, operation and maintenance of the entire plant, 36 persons are employed, of which 28 are assigned to production. Work is ongoing to certify the plant according to ISO 14 000.

2.2 Waste and energy management in Lidköping

There are 36 833 inhabitants in Lidköping (1998), producing a total of 11 000 tonnes of waste every year, of which 8 000 tonnes is incinerated. Hazardous waste, medicines, batteries, refrigerators and freezers are collected separately as is material included in the producer's responsibility[1] (packaging, papers, glass, tyres). There is an agreement with the plastics producers to not separate soft plastic packaging material, which is thus brought directly to the plant for energy recovery.

The collection fee for household waste in Lidköping varies between 800-3400 SEK/year (approximately US$94-400/year) for weekly collection in the city, and 625-2000 SEK/year for collection every two weeks in the countryside, with price depending on the size of the container. The gate fee for incineration is 250 SEK/tonne for household waste and 350 SEK/tonne for industrial waste. For landfilling, the fee is 260 SEK/tonne, plus 250 SEK/tonne landfill tax (beginning in 2000). Until recently, the landfill tipping fee was about 100 SEK/tonne.

The Lidköping district heating network has been expanding over several years. Today, the annual heat demand is about 234 GWh. It is still expanding, and until the year 2003, there will be room for another 20 MW. For that reason, Lidköpings Värmeverk is planning a new waste incineration line.

Waste provides the base load in the district heating system. In 1998 approximately 120 GWh was delivered from waste, followed by other biofuels (77 GWh) and oil (34 GWh). Another 3 GWh is heat recovered from industries.

2.3 Waste contract

Until a few years ago, household waste was delivered from the municipalities of Lidköping, Vara and Essingen. When the producer's responsibility was introduced in 1994, the municipalities announced that the amount of waste delivered to incineration would decrease. For this reason, the plant signed contracts with five new neighboring municipalities (Gullspång, Mariestad, Götene, Skara and Lilla Edet). As it turned out, however, the amount of delivered waste increased. This was mainly due to the announcement of a landfill tax. In1997, the plant thus applied for an increase in the proportion of waste that could be incinerated from 30 000 to 50 000 tonnes/a. The

[1] From 1994, producers are responsible for packaging, paper, glass and tyres in Sweden. Those who manufacture, import or sell a commodity covered by the responsibility are obliged to take charge of the discarded material.

permission was received in December 1998. Another four municipalities will start to deliver waste from the year 2000 (Tidaholm, Mullsjö, Grästorp and Lysekil-Sotenäs). The normal duration of a contract with the municipalities is one year.

The plant also treats about 1 000 tonnes of plastic waste from farmers, such as large bags and ensilage plastic. This is delivered from the National Farmers' Organisation situated adjacent to the plant, as a result of the producer's responsibility. Lidköping has invested in a special crusher to handle this waste, which is collected in the whole southern part of Sweden. The crusher is also used for other kinds of dry waste.

The wood waste consists mostly of material recovered from landfills, crushed on the landfill site, and then delivered to the plant. A small amount of combustible waste is delivered to the plant directly from private persons. According to an agreement with the municipality, there is no gate fee for this. Two of the new municipal contracts signed, Skara and Lilla Edet, are deliveries of a dry, sorted fraction.

In 1998, the following amount of household waste was delivered to the plant:

Origin	**Household Waste (tonnes)**
Lidköping	8 225
Vara	3 872
Essunga	1 217
Mariestad	4 916
Lilla Edet	717
Götene	2 330
Others	1 092
Total	**22 369**

Total fuel deliveries by type were as follows (1998):

Household waste	22 369 tonnes
Industrial waste	20 445 tonnes
Wood waste	21 184 tonnes
Total	63 998 tonnes

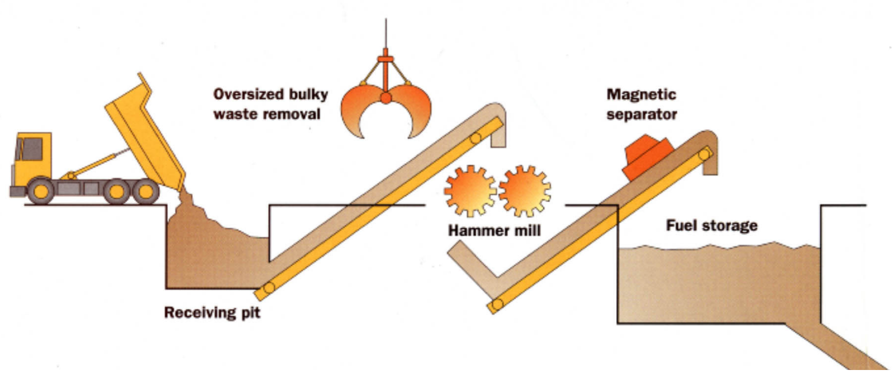
The wood waste fraction has decreased from 1999, as a result of the new permit that allows a larger proportion of other waste. The distribution from this year is about 60% household waste and 40 % industrial waste.

An adjacent municipality, Skövde, has decided to build an incineration plant. A few of the municipalities presently delivering to Lidköping, and situated closer to Skövde, will probably start to deliver to the new plant once it is put into operation. Lidköping, however, does not consider this to be a threat to their deliveries, as there is still a considerable amount of material being landfilled in the area.

3 Process technology

3.1 Fuel preparation

The waste is tipped directly into a reception bunker of 200 m^3, from where it is transported on a conveyor to a hammer mill. Private individuals can deliver combustible waste directly onto the conveyor, in an area separated from the professional deliveries (for security reasons). During transportation there is visual control, and bulky and oversized material are separated with a crane. The oversized material (117 tonnes in 1998) is either removed to the landfill, or prepared for incineration, using the dry waste crusher (described below).



Fuel preparation at Lidköping Waste-to-Energy plant

A hammer mill with a capacity of 32 tonnes/h is used for shredding of the material. This hammer mill was put in place during the summer of 1999, replacing the former 16 t/h mill. After milling, the size of the fuel is less than 10 cm in all dimensions. Finally the waste is transported to a waste fuel silo, passing a magnetic separator. Here, about 85% of all magnetic materials are removed (1095 tonnes in 1998). The waste fuel silo has a volume of 600 m^3, allowing boiler operation for approximately 24 hours on full load.

In 1996 a new tipping hall for industrial waste was built. During the summer this is mostly used for baling of household waste. During winter, it serves for reception and treatment of industrial and bulky waste, before milling.

Beginning in 1997, about 4 000 tonnes of waste per year is baled using round bale technology from Bala Press. The waste is baled during the summer when the plant is not run on full load, or when the plant is out of operation, to be used during the winter season. Baling capability allows waste collection to continue throughout the year, with energy recovery and district heat generated as there is demand. When baling, the waste is tipped onto a flat asphalt floor of 15 000 m^2, where the baling equipment is placed. The bales, each about 800 kg, are then transported outdoors on a conveyor, and stored on asphalt ground outside the plant. When it is time for incineration they are brought back to the conveyor, which transports them to special equipment for opening them up. The material is then finally brought to milling.

Bales waiting for transporting from outdoor storage back into the plant.

A new crusher has been installed for dry waste such as paper and plastics, specially adapted for handling plastic waste from the National Farmers' Organisation. After the crushing, the dry waste is stored in a special silo, from where it can be mixed into the waste silo, to the desired heating value. The 16 t/h hammer mill that was earlier used on the main line will be installed in connection with the dry waste crusher, to improve the performance.

Other solid fuel is tipped in an exterior pit and transported to two silos, each of 1000 m^3. This size corresponds to full load operation of the boiler for about two days.

There are thus four different silos, one for waste, one for dry waste, and two for other solid fuel. From each of the silos, the fuel can be transported to the boilers, allowing a wide mix of fuel.

3.2 Feeding system

The waste is dozed into the boiler on top of the bed by a dozing conveyor, through a rotary cell feeder. It is distributed with the help of pulsating air injected directly under the fuel feed. The air injection was introduced during the rebuilding of 1994/1995, and allows a much more even distribution on the bed than previously.

The operator in the control room can change the speed of the dozing conveyor. It is controlled on the basis of volume. Originally, weight was the control parameter, but it was shown that heat value correlates more closely with volume than weight.

According to the plant manager, the feeding system is the most delicate part of the process, which can create large problems if it is not working well.

There are no eddy current separators (aluminium separation) installed in the feeding system. This is due to a low content of aluminium cans in the waste stream, as there is a long tradition of collecting the cans separately in Sweden (now covered by the producer's responsibility).

3.3 Boilers

After the first years of operation of the plant, some operational problems had been identified. One was the formation of zones with unburned gases, which led to difficulties in meeting the more stringent emission requirements, particularly concerning CO. There were also problems with ash withdrawal, which resulted in some in-bed clinkering.

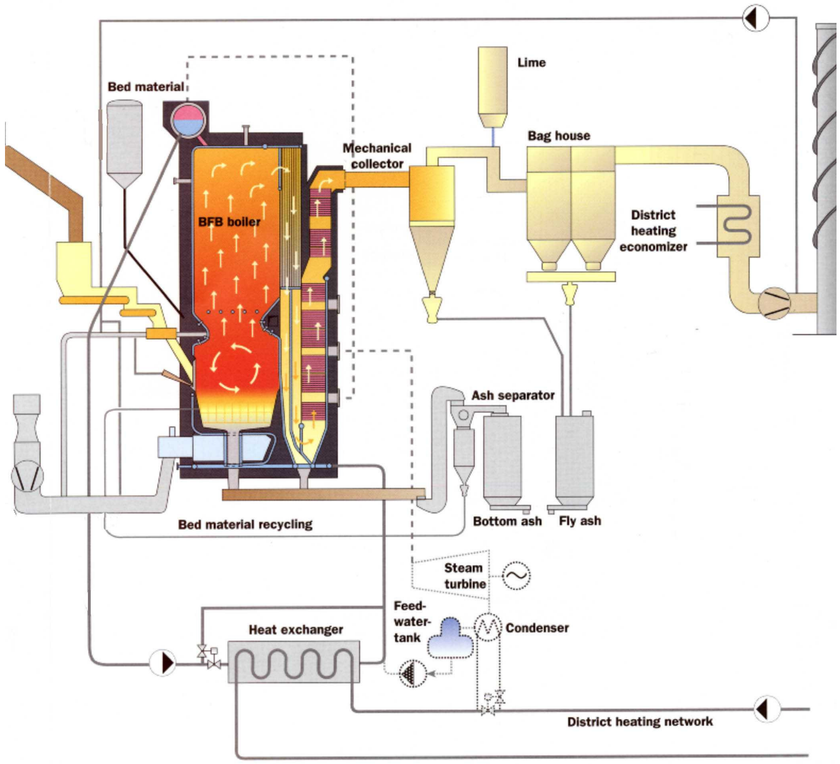
In 1993 it was decided to, in co-operation with Kvaerner, improve the performance of the furnaces, and at the same time increase their efficiency. The improvements resulted in a concept called Advanced Combustion Zone, which has later been used by Kvaerner in the design of all new furnaces.

The following changes were made:

- Tapering of the lower part of the furnace, to improve the bottom ash bleeding and improve the temperature distribution in the bed.
- Pulsating air swept fuel inlet spout (as described above, under feeding system).
- Asymmetrical overfire air system installed in a double arch configuration, creating turbulence in the combustion zone, and plug flow in the upper furnace.
- Flue gas recirculation.
- Increase of the height of the furnace (4 meters).

After the retrofit, the availability increased to 95% and the output also increased. The target for the output increase was 15 MW, but once put into operation, it was shown that 17 MW and more could be obtained.

As a result of further development of the ACZ concept, during 1999 a second rebuilding was undertaken, improving the air injection further, by crosswise injection. The resulting improvement in turbulence decreases the CO values, such that a value of 50 mg/nm^3, corresponding to the requirements in the EC-proposal, can be attained.



Boiler and air pollution control system at the plant (note: cyclone ash and filter ash are today collected separately).

The sand level is about 0,5 meters. During start up, the sand is heated with oil burners to the temperature of 600°C. Starting fuel is always wood chips.

The combustion temperature is about 800°C, and the pressure 5 kPa. The combustion takes place at an oxygen level of about 7,4 vol%, dry gas.

Primary air is injected from the bottom of the bed, below the sand. Non-combustible material sinks down into the bed by gravity, and is taken out by a cooled screw together with sand that is sieved and returned to the furnace. Approximately 1 000 tonnes of fresh sand is added to the process every year. Natural sand is used, in a size range of 0,5-2 mm. This type of sand has a high ash softening temperature, about 1000°C.

Since 1997 a reducing agent by the trade name Chemred is used to reduce the amount of NO_x formation. This consists of bicarbonate molecules with NH_3 ions. When the ions have reacted with the NO_x, the bicarbonate works as a dust absorbent, in the same way as lime. About 300 tonnes/year of the agent is injected into the combustion zone, at the same level as the secondary air injection, by the arches. It is injected in the form of dust. About 50% NO_x reduction can be obtained in this manner.

Total injected air is about 6,5 nm^3/s, of which 60-65 % is primary air. Before the reduction of the bottom surface during the rebuilding, about 90% of the total air injection was primary air.

There is some cooling in the furnace. In the upper part of the furnace, the temperature is about 700°C. Downstream of this, an empty draft region cools the flue gases to about 600°C, and in the following convection drafts the flue gases are further cooled to 150°C.

The empty draft is equipped with 7 screens, to increase the cooling surface. The free area for flue gases is 0,4x0,3 meters in each passage. When the gases enter the convection part, the maximum temperature is 600°C. Due to the discovery that dioxins are formed during cooling, in the temperature area of 200-400°C, the residence time in the convection section is kept short. At the end of the convection section, a first economiser regulates the temperature into the flue gas cleaning system.

The boiler works as a combined hot water and steam boiler. Hot water from the drum is exchanged at a temperature of 190°C with the district heating network, and then brought through the furnace and convection section back to the drum. Saturated steam is also generated in the drum, at 2,3 MPa. A maximum of 50% of the energy can be taken out as steam. Since the rebuilding in 1994/95, the boiler is equipped with a superheater that today is used as a convection surface, as no electricity is generated. Only one of the lines is equipped with a superheater fabricated with a material suitable for waste combustion use.

The district heating network return temperature is 45°C, and the forward temperature is 160°C. Some heat is delivered, at a temperature of 150°C, to an animal food factory, and steam is delivered to an alcohol factory.

The boiler is controlled by the steam pressure in the drum. When the pressure increases, the air injection and the speed of the dozing conveyor are reduced.

The furnace walls are protected with bricks up to the level of the arches, to prevent cooling and protect against erosion.

3.4 Air pollution control system

Flue gas cleaning consists of a dry system, with a cyclone as a first step, separating large particles, followed by a baghouse filter. Lime is added prior to the filter, as an absorbent. About 1 000 tonnes of lime is used for this purpose every year (for the two lines together). Lime addition is controlled by the HCl concentration in the clean flue gas.

The cyclone removes about 20-25% of the heavy metals and a few percent of the acid components. After the baghouse filter, almost 100% of the heavy metals have been removed. The clean flue gas still contains 15-20% of the HCl and 40-50% of the SO_2, however.

From 150°C at the inlet to the flue gas cleaning system, the temperature is reduced to 110-120°C (a secondary economiser is placed at the end of the flue gas cleaning train). Finally the clean gases leave the plant through a 70 meter high chimney.

As an alternative to lime reagent, bicarbonate is being tested. The price of this product is double that of lime, but is has a better yield. With lime a 5:1 stoichiometry is necessary, resulting in greater amounts of filter ash produced and requiring disposal. The optimal temperature for the lime reaction is 130°C, which can lead to corrosion. Bicarbonate can react at 180°C (above the acid dew point). Another advantage of bicarbonate use is that it removes sulfur, eliminating the need of wet flue gas cleaning to meet the new EC directive.

The introduction of flue gas condensing is also planned for the new line. Its main purpose is to improve energy recovery, but it will also improve the emissions performance further, particularly concerning acid pollutants.

4 Fuel characteristics

The average heating value for the mixed fuel (all streams) has been determined to be 3,1 MWh/tonne, or 11,2 MJ/kg.

Analyses of the fuel characteristics are unavailable. Typical composition for household waste in Sweden, sorted by the householder to separate hazardous waste and producers' responsibility material (packaging, glass, papers) is, on a weight % basis:

Organic waste	40,4
Diapers	5,8
Garden waste	8,6
Paper	19,8
Plastic	8,9
Glass	2,6
Metals	2,7
Electronic waste	0,4
Textiles	3,0
Wood	1,3
Others	6,2
Hazardous waste	0,2

Typical characteristics are as follows (g/kg):

C	300
H	42
O	200
N	5
S	1
Cl	7
Zn	0,8
Pb	0,2
Cd	0,003
Hg	0,002
Heat value	11 MJ/kg
Ash content	20 weight %
Moisture	30 weight %

5 Mass and energy balances

The mass and energy balance is based on figures for 1998.

5.1 Mass balance

Mass flows are calculated on the basis of 5 800 hours of operation. This is the estimated full load operation time. In practice, however, each line operates for about 7 500-8 000 hours/year, on partial load. The figures are reported for the two lines together, on an annual basis.

IN		
Fuel		
Waste	45 496 tonnes	7 800 kg/h
Wood waste	21 184 tonnes	3 700 kg/h
Chemicals and others		
Lime	707 tonnes	120 kg/h
Sand	1 150 tonnes	200 kg/h
Chemred (reducing agent)	343 tonnes	59 kg/h
Lubricant oil	1 503 liter	0,26 liter/h
Hydraulic oil	3 343 liter	0,58 liter/h
Degreasing and cleaning agents	1 400 liter	0,24 liter/h
OUT		
Magnetically separated material	1 095 tonnes	190 kg/h
Bulky and oversized material	117 tonnes	20 kg/h
Bottom ash	3 752 tonnes	647 kg/h
Cyclone and filter ash	5 339 tonnes	908 kg/h
Recovered oil (from oil separators, gear boxes, replacement of hydraulic oil, etc)	6 000 liter	1,03 liter/h

5.2 Energy balance

The calculated overall efficiency of the solid fuel plant is 88%. With an energy production of 198 GWh, input fuel energy is thus 225 GWh.

82 MW is the maximum output for the overall plant, of which 2x17 MW comes from the bio/waste-fueled lines. Of this, 2 MW heat is delivered to the animal food factory, and 4 MW is taken out as steam and delivered to the alcohol factory. The rest is sold as district heat. Internal electrical consumption is about 2 MW. This is taxed electricity, bought externally. For the new line, internal electricity production, covering internal needs, is planned.

6 Products and residues

6.1 Products

Ferrous material magnetically separated in the pretreatment process, about 1000 tonnes per year, is collected by a scrap firm. The firm returns combustible shredder fluff material recovered from automobiles. There is a deal between the plant and the scrap firm that the fluff material can be delivered for free, if the firm collects the iron.

6.2 Residue handling and disposal

Three types of ash are produced in the process, each about 3000 tonnes/year, corresponding to about 20 weight % of the total waste fuel:
- Bottom ash
- Cyclone ash
- Fabric filter ash

About 30% of the fabric filter ash is lime residue.

As a result of using pretreated waste, the handling of bottom ash is relatively simple, as there are no components to disturb the transport and handling process. There is practically no unburned material (<1%) in the bottom ash. This fraction is currently brought to landfill, and used as construction fill for road building at the landfill. Due to the landfill tax of 250 SEK that will be introduced from year 2000, other disposal options are being sought. Separation of magnetic material is planned, to improve the quality of the bottom ash.

The BFB produces more fly ash than does the comparably-sized grate incinerator, due to the high gas flowrate which carries particles with the flue gases. An estimate based on the flow rate of fuel input and cyclone and filter ash produced gives about 13 g/m^3 of ash in the flue gases. Typically, grate technology gives about 2 to 10 g/m^3, depending on combustion system and waste composition.

The cyclone and fabric filter ashes are classified as hazardous wastes, and landfilled. When the new incineration line is constructed, flue gas condensing will be introduced (on the old lines as well as on the new line). Sludge from the water purification process is commonly used in Sweden to mix with fabric filter ash, to produce a more stable product for landfilling. Utilisation of this handling procedure is planned for the Lidköping plant.

7 Environmental emissions performance

7.1 Fly ash and bed ash

The residues from combustion of the waste/wood mixture were analysed in January 1999, as a part of the yearly periodical control (dry material):

Parameter	Bed ash		Cyclone ash		Filter ash	
	Boiler 3	Boiler 4	Boiler 3	Boiler 4	Boiler 3	Boiler 4
C_{tot} (weight%)	0.03	0.07	0.34	0.43	0.30	0.44
Hg (mg/kg)	0.02	0.02	0.70	0.13	7.2	5.1
Pb (mg(kg)	87	84	800	510	2 900	3 500
Cd (mg/kg)	2.1	<1	12	7.7	54	46
As (mg/kg)	86	110	36	19	58	51
Ni (mg/kg)	29	17	72	55	17	15
Cr (mg/kg)	240	240	120	99	110	120
Mn (mg/kg)	290	480	1 700	1 500	300	350
Cu (mg/kg)	2 300	780	6 200	3 800	6 900	7 400

Filter ashes are classified as hazardous waste in Sweden.

7.2 Emissions

The plant's new permission, received in December 1998, allows the following emission limit values (ELV):

Parameter	ELV (mg/nm^3)		Type of value
Dust	10		24-hour average
CO	100		60-minute average
NO_x (calculated as NO_2)	250	until Dec 2005	24-hour average
	150	after Dec 2005	24-hour average
NH_3	10		60-minute average
N_2O	20		60-minute average
SO_2	50		24-hour average
HCl	50		24-hour average
HF	2		24-hour average
Hg	0,05		Periodical
Cd	0,05		Periodical
Sb+As+Pb+Cr+Co+ Cu+Mn+Ni+V	0,5		Periodical
Dioxins	0,1	(ng/nm^3)	Periodical

Emissions and calculated total emissions for 1998 were:

Parameter	**Emission (mg/m^3, dry gas)**	**Total emission (tonnes/year)**
NO_x	261 (av.)	83,8
NH_4	13 (per.)	4,7
N_2O	25 (per.)	9,2
SO_2	55 (per.)	12,3
Dust	3,3 (av.)	1,2
CO	68 (av.)	-
Hg	0,03 (per.)	0,067
HCl	40 (av.)	14,8
HF	0,25 (per.)	0,09
Dioxins	0,1 ng/m^3 (per.)	0,02 g/year

av.: average emission during the year
per.: value based on periodical measurements

8 Capital, operating and maintenance costs

When the plant was originally constructed (1984), the investment costs were 104 million SEK, including the two incineration lines, two oil-fueled boilers and buildings. As the plant then has been gradually upgraded, it is difficult to estimate what the investments for the same plant would be today.

The cost of the baling machine was 6 million SEK, including all equipment and transportation systems. The new mill installed in the summer of 1999 had a price of 10 million SEK.

An estimated economic balance is presented below. Some costs, for example operating and maintenance costs, cover the whole site, and waste incineration costs cannot be separated. The balance, however, gives a rough idea of the magnitude of various costs.

Income	**SEK**	**US$**
• **Energy production**		
Production	234 GWh	
Energy price	0,33 SEK/kWh	
Total	**77 MSEK**	**8,5 MUS$**
• **Fuel**		
MSW	22 369 tonnes	
Gate fee MSW	250 SEK/tonnes	
Industrial waste	20 445 tonnes	
Gate fee industrial waste	350 SEK/tonnes	
Total	**13 MSEK**	**1,4 MUS$**
SUM	**90 MSEK**	**9,9 MUS$**
Expenses		
• **Financial costs**	**24 MSEK**	**2,6 MUS$**
• **Fuel costs**	**25 MSEK**	**2,8 MUS$**
• **O&M costs**		
Personnel costs	7 MSEK	
Chemicals and lime	2 MSEK	

Electricity and water	4 ,5 MSEK	
Sand	1 MSEK	
Baling (200 SEK/t)	1 MSEK	
Others	21,5 MSEK	
Total	**37 MSEK**	**4,1 MUS$**
• **Residue disposal costs**		
Residues formed	9091 tonnes	
Disposal costs	200 SEK/tonnes	
Total	**1,8 SEK**	**0,2 MUS$**
• **NO_x fee (*)**		
NO_x emissions	103 mg/MJ	
NO_x fee	40 SEK/MWh	
NO_x refund	10,1 SEK/MWh	
Total	**1,2 MSEK**	**0,1 MUS$**
SUM	**89 MSEK**	**9,8 MUS$**

(*): Incineration plants in Sweden are covered by the energy producing units NOx fee system. A fee is paid every year, which is then refunded to the plants distributed according to their performance. It can thus be either an income or an expense for the plant. The ELV set for the NO_x emission must, however, always be met.

9 Lidköping Värmeverk designed today

The environmental requirements and waste management systems are not the same today as in the middle of the 1980s, when the plant was originally constructed. Today more waste is delivered, and the characteristics of the waste are changing towards a higher calorific value and different composition. The emission requirements have become more stringent, and the new EC proposal promises even tighter controls when it comes into force in a few years.

The plant in Lidköping has been continuously upgraded to meet these changes, taking advantage of the improvements that have been developed for fluidised bed technology.

Kvaerner was asked how the plant would be designed if it was built today, taking advantage of the experience gained during the past 15 years of operation, as well as experience garnered from other Kvaerner plants. The answer was the following:

- ACZ combustion zone and other improvements corresponding to the ones made during the rebuildings of 1994/95 and 1999.
- Some slightly different dimensioning of the arches and the bottom surface, more adapted to the ACZ concept.
- Refractory-lined walls all the way up the furnace, to meet up with the 850°C/2 second requirement for dioxin destruction.
- Larger surface area for the screens in the empty draft, and fewer screens, for example 3 screens with 1,2x1 meter passages (replacing the 7 screens with 0,4x0,3 meter passages). This would allow a lower speed through the

empty draft, more adapted to waste, for example 7 m/s replacing the 10-11 m/s today.
- More flue gas recycling, allowing better control of temperature and CO formation when the calorific value of the waste increases.
- Wider boiler surface. The boilers are today designed for 15 MW, but run at 17 MW, and the surface would be adapted to this.
- Bicarbonate filter to replace the current lime system.
- A more modern control system.