WASTE TO ENERGY PLANTS IN AFRICA AND ASIA

1 BACKGROUND

This paper describes a typical design for a Waste to Energy plants in Africa and Asia or any other part of the world where biological waste and non-biological waste are mixed. The difference from a plant located in Northern Europe is primarily related to waste composition and that Co-Generation is not foreseen. That means that more than 70% of the plant will be more or less identical.

Typical waste flows indicated are 300 to 500 tons per day.

The waste flow will be incinerated in order to produce steam. The steam will be used for production of electricity. No other uses of steam are normally foreseen but the possibility to sell district heating or steam from 3-16 bar(g) to external consumers will normally improve the feasibility of the plant.

The project includes design of complete plants including infrastructure as well as training and establishment of an operating organisation.

2 WASTE COMPOSITION

The composition of the waste may vary quite a lot depending on plant location and local demographics. In this case we suggest large flexibility and risk is minimised.

We have based this preliminary feasibility study on several typical analyses.

Table - Waste fuel analysis with comments. The table is an indication based on typical client information and other sources.

Parameter	Typical analysis	Span	Comment
Organic matter [$\%_{w\ AF}$]	62	50-80	Moisture content 50-80% Hu 19 MJ/kg_s
Plastic [$\%_{w\ AF}$]	12	8-14	Moisture content 0% Hu 25 MJ/kg_s
Paper [$\%_{w\ AF}$]	5	2-8	Moisture content 10% Hu 16 MJ/kg_s
Textile, rubber, leather [$\%_{w\ AF}$]	4	2-7	Moisture content 10% Hu 19 MJ/kg_s
Yard waste [$\%_{w\ AF}$]	3	0-7	Moisture content 60% Hu 18 MJ/kg_s
Glass, metal, mud, ceramics etc. [$\%_{w\ AF}$]	14	5-18	Inert
Moisture content [$\%_{AF}$]	45	35-63	Waste will not burn above typically 55%
Heating value [MWh/ton AF]	2,5	1,5-2,9	Lower heating value

Notes, w = weight, AF = as fired, s = solids (dry substance), Hu = Lower heating value.

Critical parameters are mainly moisture content. An incinerator may typically be designed for operation in a range between 20-50%. This can be biased to 35-55% by means of air preheaters and adjusted refractory lining. It must be noted that these values are absolute. The incinerator will not accept even very short time deviations.

We can foresee the need of drying for most applications. In an extreme case when drying 100 tons a day from 63 to 50% moisture some 13 tons of water has to be evaporated. This can be done in line with the fuel preparation.

In the long run some sorting of the waste at the source is preferable in order to reduce moisture content. This is partly a political issue.

We can foresee that the waste composition will vary largely over time. A plant is built for at least 30 years of operation and must thus be flexible. We advocate the use of bubbling fluidised beds fort this application. The advantage is that emission demand can be met for large variations in waste composition and the boiler will also allow for operation at part loads. The drawback is that the fuel has to be more carefully prepared. All incinerators meeting emissions demands will need some waste preparation, but for the fluidised bed the sizing should typically be below 100 x 100 x 100 mm.

2.1 Fuel preparation

The waste preparation will involve:

- Weighing and visual inspection. Typically latrine, gypsum, mineral wool and other similar materials not be accepted.
- The waste will be shredded in a two stage process. The first stage involves a slow rotating machine for opening up the waste, and also handling of hazardous material like gas bottles etc in a safe way. After the first stage a magnetic separator is used to remove coarse scrap metal. The second shredder is typically a hammer mill, but there are also possible, but expensive, slow rotating machines on the market. Shredders will need daily maintenance and we suggest a redundant setup.
- After shredding iron and aluminium are separated for recycling by means of a second magnetic separator and also an Eddy current separator. This will make the life of the boiler easier, but will also typically generate an income.
- The waste will then be dried if needed. We suggest a fluidised drying system for its compact size. For drying low pressure steam from the boiler will be utilised. Typically the very same steam pressure as for steam air preheaters and also for the feed water preparation will be used.
- There are different ways for internal handling of the waste. We prefer orange peel grab cranes and belt conveyors because of longevity and minimum need for maintenance.
- We suggest indoor handling of the waste. In this case we will set the complete building at negative pressure using the indoor air for the drying process. The off gases will be

controlled for odour by means of a completely biological system based on bark. We have several references where neighbours as close as 300 m from the plant have no complaints about odour.

- We suggest a small storage of prepared waste fuel for up to 15 hours of operation.

3 BOILER ISLAND

We suggest a boiler island based on a bubbling fluidised bed for its flexibility. Of course grate fired systems are possible but will not accept large variations in the waste composition and will also be difficult to adjust to load.

A suitable size for a single boiler plant is Typically 30 $MW_{thermal}$. Possible waste flows for the basic boiler will be 300 – 500 tons depending on composition and degree of drying the output of the boiler may be between 20-30 $MW_{thermal}$. The wetter the waste, the lower the thermal output will be.

For individual projects sizes may be varied from 20 – 40 $MW_{thermal}$.

The boiler will be of a Scandinavian design with a typical live steam data of 80 bar(g) 410°C. The design is conservative with focus on reliability rather than 2% extra electricity that is useless if the trade-off is downtime.

Start-up of the boiler will be made with an oil or gas based start-up burner. There will be no need for backup fuels once the boiler is in operation. I.e. no extra coal or gas is needed during normal operation.

The size of the boiler is mainly limited by boiler structure. A larger boiler will usually need to be hanging from the building structure rather than standing on the ground. This will raise the cost of the plant extensively. We can foresee the size of standing or mid hung boilers to be extended to in the region of 80 MW. Such projects must be evaluated individually.

4 EMISSIONS AND FLUE GAS CLEANING

The plants are built to comply with current European legislation based on 2000/76/EC.

Emissions will be monitored continuously.

Flue gas cleaning will primarily be based on dry systems. Reduction of dioxins, CO and NOx will be taken care of in the boiler and if needed complemented with a SNCR system.

In the bag filter lime or bicarbonate (depending on waste composition) will be added for reduction of SO_2 and HCl.

It is also possible to add a scrubber system in series with the dry cleaning system but usually this is not needed.

5 ASH HANDLING

Ashes are extracted from the boiler in two forms with about half of each type.

- Bottom ash. This will normally be screened in two stages. Fines are reused in the boiler in order to reduce need for fresh sand. The coarse material will include some metals and are separated on site. The intermediate fraction will need to be deposited.
- Fly ash. The fly ash is the fines separated in the bag filter. This will be considered a hazardous waste (About 5%w of the total flow in to the plant). It will need to be safely deposited or cast into concrete blocks for stabilisation. There are development work going on for recovery of salts from the ash but this is not a commercial technology.

All ashes are temporarily stored in silos at the plant. Handling is fully closed and set under a negative pressure in order not to contaminate the area.

6 TURBOGENERATOR

We suggest a two stage turbine with a high pressure section as well as a condensing tail end on the same shaft. Usually a not to complicated impulse turbine is the best solution.

We usually install a water cooled vacuum condenser bud it could also be air cooled depending on location.

Typical electrical output from the turbine will be up to in the region of a little more than 9 MW. At part loads the output may drop to 3 MW depending on efficiency dropping.

7 AUXILIARY SYSTEMS

The plant will include all necessary service systems such as:

- Make up and feed water fabrication
- Compressed air systems for filters etc.
- Switch gear (HV and LV)
- Control system
- Diesel generator for uninterrupted power for feed water pumps etc.
- Vacuum cleaning odour control etc.

- Building with control room and necessary administration, workshop, ventilation lifting shafts, turbine cranes etc.

8 INVESTMENT VOLUMES

The investment volume for a 250-500 tons/day plant will be in the region of 80 M€. This is based on building conditions in Europe. Elsewhere the cost for different parts of the project may vary both up- and down.

9 TIME SCHEDULE

A project like this usually takes 2-2½ years from a firm approval before commercial operation.

10 ORGANISATION

We have built several waste fired plants and have a network with more or less every company involved in the business in Europe. Please see separate reference list.

A visit to one of our reference plants in Sweden will be possible to arrange.

At https://youtu.be/xr97476qGdU you will be able to take a video tour around the Nybro Waste to energy plant.

11 APPENDIX

1 Calambio references

2 Odour control

Calambio Engineering AB
–
Waste to Energy References

1 CHP TRANSTORP, NYBRO, SWEDEN

A 22 MW_{th}/ 5,6 MW_{el} combined heat and power plant for Nybro Energi AB. Built 2015-2016. Nybro Energi AB is a municipal company handling electricity and district heating in the community of Nybro in Sweden.

The plant is a green field installation and includes all installations on the site. Up to 70.000 tonnes of municipal and industrial waste is handled every year. All fuel handling is performed indoor. An odour control system is included. A key feature is very high flexibility regarding waste composition and load range. Iron and aluminium is separated on line.

The combustion system is based on a bubbling fluidized bed. The plant is equipped with a dry cleaning of Sulphur and chlorides. An SNCR system is also included.

The plant produces district heating and industrial hot water (that cannibalises on production of electricity)

Cooling system allows for full capacity the year round.

The Calambio scope includes investment analysis, total project management including planning, contract work (436 contracts), procurement, logistics, public authorities contacts, HSE planning, detail engineering (including all process design, 3D layouts, piping, 6 km district heating network, pressure vessels, civil engineering, power and automation.) construction site management and commissioning.

Total budget 480 MSEK (50 M€).

More information on this plant on video at www.calambio.se

W2E CHP Transtorp, Nybro, Sweden. 22 MW_{th}, 5,3MW_{el}.

2 CHP STEGEHOLM, VÄSTERVIK, SWEDEN

This plant includes a 22 MW_{th} boiler and a 5,0 MW_{el} steam turbine for Västervik Miljö & Energi AB in Sweden. VMEAB is a municipal company handling electricity, district heating and waste in the community of Västervik in Sweden. The plant is installed between an older plant and the Baltic Sea in an extremely tight location. A fuel preparation plant is included at a different location and can handle Up to 200.000 tonnes of municipal and industrial waste every year (also feeding other boilers). The plant was built 2013-2014 (planning 2010-2012).

The combustion system is based on a bubbling fluidized bed. The plant is equipped with a dry cleaning of Sulphur and chlorides but also including a flue gas scrubber. The boiler is equipped with SNCR.

The fuel receiving station is located very close to private residences. Extensive work was placed in systems for odour control and also logistics.

The Calambio scope includes several feasibility studies, investment analysis, total project management including planning, contract work (about 500 contracts), procurement, logistics, public authorities contacts, HSE planning, detail engineering (including all process design, 3D layouts, piping, pressure vessels, civil engineering, power and automation.) construction site management and commissioning.

Total budget 500 MSEK (55 M€).

W2E CHP Stegeholm, Västervik, Sweden. 20 MW_{th}, 4,8MW_{el}.

3 BIO-EL, FREDRIKSTAD AS, NORWAY

20 MW_{th} , 6 MW_{el} combined heat and power plant for Hafslund Energimiljø AS. Hafslund is a Power company in Norway.

The combustion system is based on a circulating fluidized bed boiler for municipal waste. The plant includes cogeneration of district heating and process steam for several local industries. The turbo generator is also set up for operation with a vacuum condenser. Cooling media is the accept from the nearby municipal sewage treatment plant.

Total project management including planning, contract work, procurement, logistics, public authorities contacts, HSE planning, layouts, detail engineering, construction site management and commissioning.

Total budget 400 MNOK (45 M€).

The project was executed in 2007-2008 in collaboration with BG Innovasjon AS.

Bio-El Fredrikstad. CHP 20 MW_{th} 6 MW_{el}. Also possible to operate with vacuum condenser.

4 INDUSTRIAL POWER PLANT, PERSTORP AB, SWEDEN

Calambio has been contracted for three different Waste to Energy projects has been performed for Perstorp AB in Sweden. Perstorp AB world leading in manufacturing and marketing of polyalcohols (the base ingredient in paint) and formaldehyde.

4.1 Incinerator for liquid waste

In 2001 a small incinerator with a capacity of 3 MW_{th} was docked to an existing coal/ oil fired boiler for combustion of liquid waste in accordance with EN 2000/76.

The Calambio scope included project management and detail engineering of the complete installation. The plant was made redundant about 2012 when the boiler from 1963 was made redundant.

4.2 Waste firing of existing boiler

In 2004-2006 an existing 55 MWth fluidized bed combustor was rebuilt from peat/ biomass/ coal combustion to firing of assorted waste fuels according to EN 2000/76. This includes 40.000 tonnes of by-products from the meat industry, demolition waste, some liquid waste and various waste sludges.

The flue gas cleaning was complemented with a scrubber and an ammonia stripper for a waste industrial air flow. Also a condensate cleaning plant was added.

The scope also included completely new technology for odour free and sanitary safe handling of animal by-products (all categories including mad cow disease contaminated), process control etc.

The Calambio scope included project management, environmental permits and complete detail engineering. The detail engineering included complete recalculation of the boiler, extensive rebuild of the furnace heat balance and also changes to superheaters and economizer sections.

4.3 Hazardous waste incinerator

2004 – 2007 a new 40 MW_{th} boiler for steam production was built. The boiler is on the one hand an oil based backup boiler but is also equipped with a 15 MW_{th} incinerator for hazardous waste. Hazardous waste from all of Perstorp European plants are burned in this combustor. The plant is completed with a combined WESP (wet electrostatic precipitator) and scrubber and thus yields very low emission. SO_2 emissions when burning heavy fuel oil is 2-3 ppm. A complete Atex classified Tank Park and rail/ truck unloading was also included.

The Calambio scope included project management and complete detail engineering. The detail engineering includes detail design of furnace, scrubber, hazardous waste handling system, civil works, piping, layouts, control system, environmental permits etc.

Perstorp, Sweden. Hazardous waste incinerator with WESP and animal by-products silo in the foreground. 55 MW CFBC in the background.

5 NORSKE SKOG, FOLLUM, NORWAY

In 2008 the Norwegian pulp and paper company Norske Skog, Vardar (a green energy investor) and power company Ringerikskraft AS investigated the possibility to integrate a 45 MW CFBC waste incinerator at the Follum paper mill.

Our scope included project management for a feasibility study, pre-engineering and environmental permits in cooperation with BG innovasjon AS.

Due to Norske Skog closing the Follum plant altogether the plant was never realized.

Rendered picture of the proposed Follum waste to energy plant.

6 OTHER WASTE RELATED PROJECTS

Other projects includes for example.

- Feasibility study for municipal waste combustion in Longyearbyen, Svalbard (not recommended).
- Concept design of condensing power plant based on combustion of byproducts from process for converting waste plastic/ rubber to synthetic diesel.
- Troubleshooting during rebuild of existing BFBC boiler for waste firing. Öresundskraft AB in Ängelholm, Sweden.
- Process design of 4 x 40 MW_{th} process gas fired boilers for the petrochemical industry. The fuel also involves off gases and some liquid waste streams.
- Trouble shooting and redesign of one of the very first waste fired CFBC combustors in the mid-1980s.
- Principal concept studies for plants on Cyprus, in Turkey, India and China.

For more information, please contact:

Pär Stenberg, +46 322 639293, +46 70 56 17 248

Stenberg@calambio.se

ODOUR CONTROL FROM WASTE FIRING PLANTS

1 GENERAL

Waste fired incinerators are in themselves odour free. A properly designed plant will not yield any odours from the flue gases.

However the storage and handling of in particular municipal waste fuels can easily create odour problems.

Calambio have designed a few plants where this problem has been addressed. The key parameters for this involves:

- All fuel storage is done indoors. Sometimes in a proper building and sometimes in a huge industrial tent.
- All localities have a lower pressure than the surrounding atmosphere.
- Gates and doors are kept closed when not in use for transport.
- Ventilation flows are big enough to accept temporary opening of gates.
- Ventilation flows is limited by means of leading less contaminated air flows through localities with higher contamination.

The polluted air is blown to a bio filter based upon aerobic composting, which purifies various gasses. The filters use bark form Norwegian coniferous prepared with nutrient adapted to specific gasses on each site.

Gasses from handling of municipal waste are relatively easy to handle and the smell leaving the filter will, if any, be that of bark.

Apart from the filter itself design of these systems involves filtering and moistening of the gases and control systems.

Figure – Polluted air from fuel storage/ preparation at the waste fired plant in Nybro. The capacity is 30.000 m^3/h.

Figure – Bio Filter for 30.000 m^3/h off gases for a waste incineration plant in Västervik, Sweden during construction.

Figure – Overview of the Västervik filter. This plant is situated by the sea some 250 meters from a residential area in the idyllic town of Västervik. Before installation of this filter, there where massive complaints of odour from an elderly installation.

Figure – Small bio filter for cleaning of carcinogenic trimethylamine from a plant for modified starch for the pulp and paper industry in Sweden. This filter is stage to accept various operation modes. It will accept flows from 400 – 2000 m^3/h.

Figure – Filter installation in municipal waste handling plant.

For more information please contact:

Calambio Engineering AB
Södra Strömgatan 9
SE-441 30 Alingsås
Sweden

Phone +46 322 63 92 93

Pär Stenberg stenberg@calambio.se