4.5 ENERGY RECOVERY

4.5.1 Process Description

The steam generated in the heat recovery boiler at 40 bar and 400 °C will enter the turbine, where it will be expanded across the turbine blades to a 90/10% steam/condensate mixture at a pressure of 0.15 bar and at a temperature of 56 °C. This low pressure will maximise the energy recovery from the turbine, which will be used to drive the generator set and give an electrical output of about 14 MW. As approximately 3 MW will be required for electrical demand within the site, the net electrical output from the plant for export as a renewable energy source to the ESB distribution network will be approximately 11 MW.

The steam from the turbine will exhaust into an air-cooled condenser. This will maintain the low pressure at the turbine exhaust and dissipate the waste heat into the air via banks of heat exchangers similar to a car radiator. An air-cooled condenser will be installed as this will reduce the water requirement of the plant and will also reduce the amount of process effluent produced. A condensate tank will then collect the condensate from the air-cooled condenser and it will then be pumped to the boiler feed-water tank.

If the turbine is out of operation for any reason it will be possible to bypass it and to dump the steam directly into the condenser at atmospheric pressure through a pressure reducing and de-superheating station. There will be a motorised isolation valve on the inlet to the turbine that will be PLC-controlled so that in the event of loss of the turbine, this valve will close and the bypass line to the pressure reducing and de-superheating station will open automatically.

The steam pipes will be provided with pressure relief valves which will automatically activate in the unlikely event of the steam pressure exceeding a set level. These will be located on top of the boiler house.

The electrical generator will be cooled by a smaller air cooler, using oil as the heat transfer fluid.

A process flow diagram for this unit operation is included overleaf.

4.5.2 Process Control

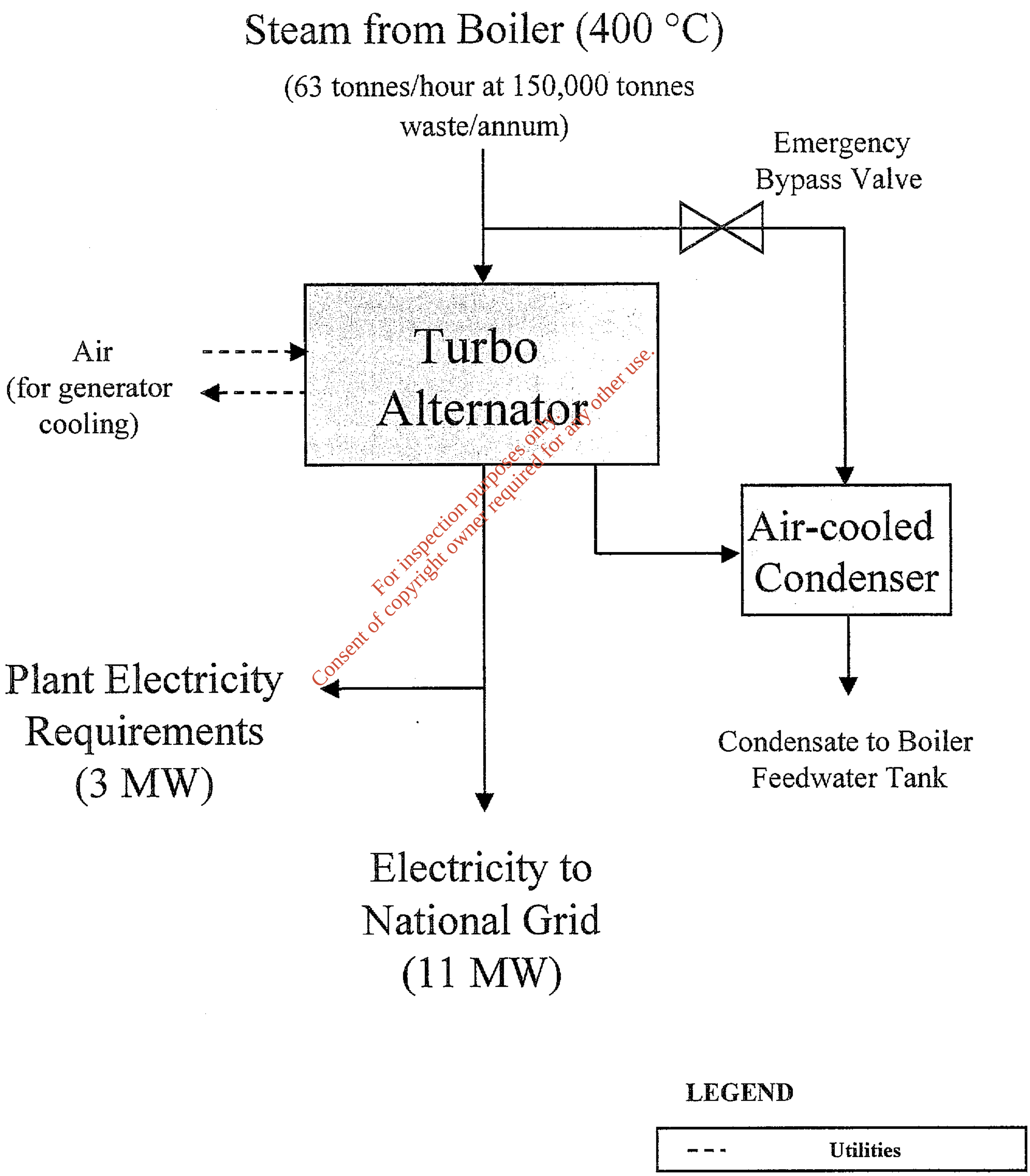
The steam flow will be controlled by valves, which will control the flow of the steam to the turbine according to the specified load or other operating conditions. The system will be equipped with stop valves, which will cause the steam flow to bypass the turbine in the event of turbine or generator failure.

Alarms, controls and measurements from the steam turbine control and protection system will be connected to the main plant control system, so that the operation of the turbine can be monitored and controlled from the central control room.

4.5.3 Emissions

There will be no emissions from the turbo-alternator set.

ENERGY RECOVERY PROCESS FLOW DIAGRAM



4.5.4 Inputs and Outputs

Inputs will include superheated steam from the boiler. The flow of steam through the cycle will be 63 tonnes/hour at nominal load of 20 tonnes/hour of waste. Outputs will include electricity generation (14 MW) and condensate which will be returned to the boiler feedwater system.

4.5.5 Abnormal Situations

In the event of turbine or generator failure, the motorised isolation valve on the inlet to the turbine will close, the bypass line will open automatically and steam will be dumped directly into the condenser at atmospheric pressure through a pressure reducing and de-superheating station. Therefore the plant will be able to continue operating in the event of turbine or generator failure until the corrective maintenance is complete.

4.6 Flue Gas Cooling

4.6.1 Process Description

The combustion gases leaving the boilers will still be relatively hot at approximately 230 °C. They will be further cooled in the evaporating spray towers to a temperature of about 170 °C. A photo of a typical evaporating spray tower is shown below. The evaporating spray towers will serve the dual function of cooling the flue gases prior to activated carbon/lime mixture injection and the baghouse filter, and also reusing any process effluent generated at other stages within the waste to energy plant process, e.g. from the wet scrubbers. The process effluent will be evaporated during the cooling of the flue gases.

The evaporating spray towers will be essentially large, empty vessels measuring approximately 15 m high with a diameter of 8 m. Coolant (process effluent and some rainwater or groundwater) will be sprayed into the vessel either by a rotary atomiser or spray nozzles. The combustion gases will come into the top of the tower by forced draft and travel in a downwards spiral.

A very small quantity of dried residues will fall into a bag at the base of the tower, while the majority will remain entrained in the combustion gases. These small residues will be collected in flexible intermediate bulk containers (FIBCs) and then combined with flue gas cleaning residues from the baghouse filter, described in detail in Section 4.7.

A process flow diagram for this unit operation is included in overleaf.

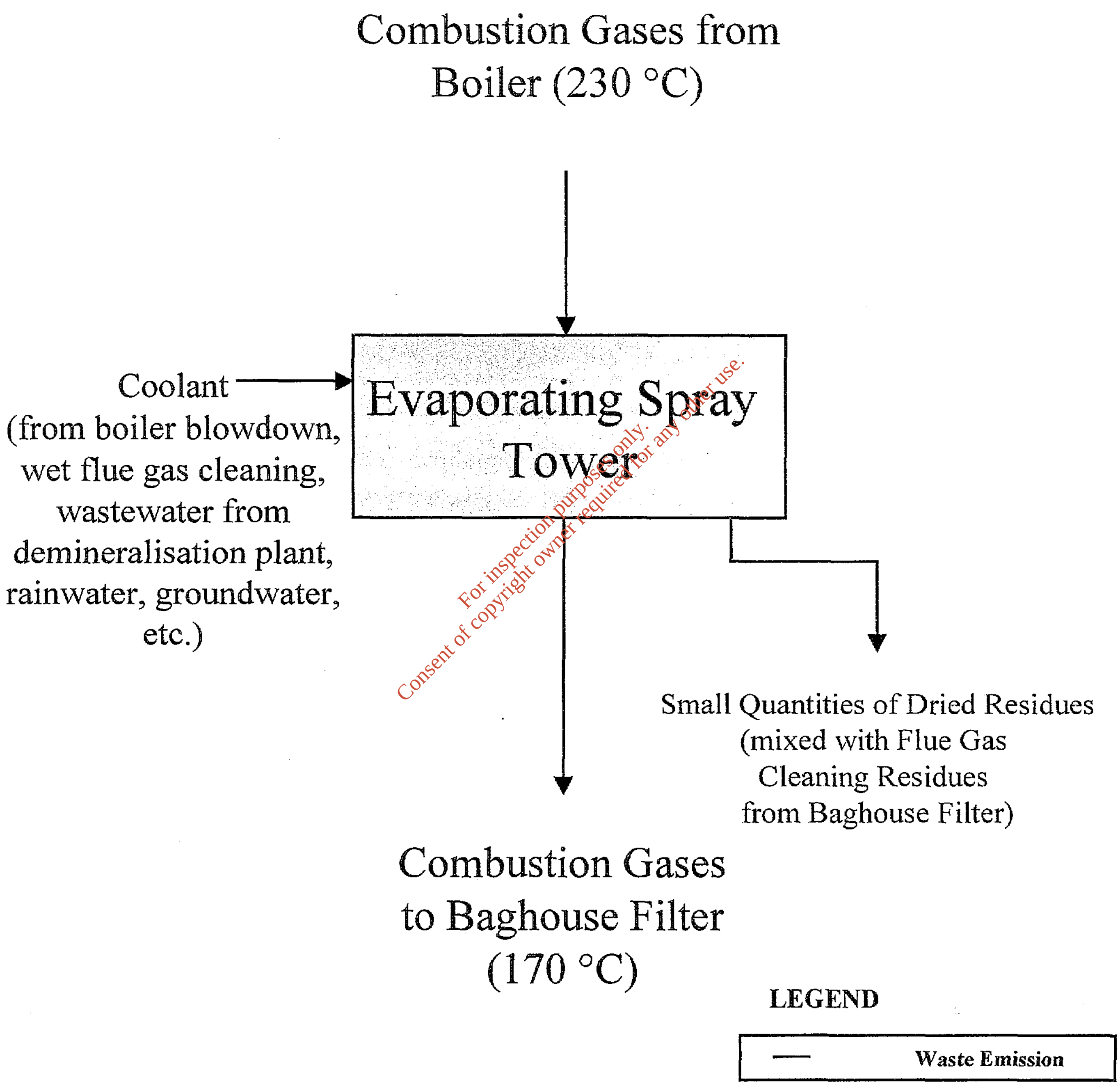
4.6.2 Process Control

The required temperature of the combustion gases leaving the evaporating spray towers will be monitored and maintained at the required temperature of about 170 °C by controlling the rate of water injection.

4.6.3 Emissions

There will be no emissions from the evaporating spray tower.

FLUE GAS COOLING PROCESS FLOW DIAGRAM



4.6.4 Inputs and Outputs

Inputs to the evaporating spray tower will include hot flue gases and water from a number of sources while outputs will be cooler flue gases and a very small quantity of solid residues.

When each furnace is operating at its nominal capacity of 10 tonnes per hour, approximately 5 m^3/hour of water will be injected into each evaporating spray tower.

4.6.5 Abnormal Situations

The main failure that could occur in the evaporating spray tower will be failure of one of the nozzles or the rotary atomiser used to spray the liquid to cool the combustion gases. Each nozzle will be changed weekly to reduce the risk of failure. This will be done by opening a flange on the spray tower, withdrawing the nozzle for cleaning and replacing it with a spare. Once cleaned, the nozzle will be returned to operation. The atomiser will be changed fortnightly to reduce the risk of failure.

Typical Evaporating Spray Tower

4.7 Activated Carbon/Lime Mixture Injection & Baghouse Filter

4.7.1 Process Description

After the evaporating spray tower an activated carbon/lime mixture will be injected into the flue gases leaving the tower. For further details on the activated carbon/lime mixture, see Table 1.10 in Attachment E5.2. Heavy metals, trace levels of organics and dioxins in the flue gases will be adsorbed and removed by filtration in the baghouse filter.

The activated carbon/lime mixture will also remove Hydrochloric Acid (HCl) and Sulphur dioxide (SO_2) in the flue gases although this is not its primary function. HCl and SO_2 will primarily be removed by the Wet Flue Gas Cleaning System, described in detail in Section 4.8.

The particulates in the flue gases will consist primarily of fly ash carried over from the boiler and also of dry residues from the evaporation of process effluent in the evaporating spray towers. These will be removed in the baghouse filter. This will ensure that dust emissions from the waste to energy plant will be less than the EU limit of 10 mg/m^3.

A schematic of a baghouse filter is shown below. This details the activated carbon/lime mixture silo, filter unit and flue gas cleaning residue silo.

Each baghouse filter will be equipped with about 1,000 bag filters in separate compartments. The separate compartments will allow the cake that will accumulate on the sleeves to be removed while the filter is on line. As dust accumulates on the sleeves, an individual compartment will be isolated and the dust cake will be blown off using compressed air. The compressed air used will enter the combustion gases steam. The cake, known as flue gas cleaning residues, will then be removed by conveyor and collected in a silo.

Schematic of Baghouse Filter

After passing through the baghouse filters, the combustion gases from both furnaces will be combined into one stream, and whereas up to this point each furnace will have its own dedicated flue gas cleaning equipment, the rest of the equipment will be common to both furnaces.

In order to regulate the flow of flue gases and the degree of underpressure on each line, there will be a set of valves and fans on each line before they are combined.

A process flow diagram for this unit operation is included overleaf.

4.7.2 Process Control

The activated carbon/lime mixture will be injected at a fixed rate controlled by a volumetric dosing screw. This fixed rate will initially be based on operating experience at other Indaver plants. The rate of dosing will allow for the maximum reduction in dioxin emissions. The rate will be approximately 15 kg/hr per baghouse filter. Pressure differential across the sleeves of the baghouse filter will be continuously monitored to detect any faults with the sleeves.

A low level alarm will be fitted on the activated carbon/lime mixture silo. The activated carbon/lime mixture silo will be monitored and weighed to ensure that dosing is continual. Should the weight of the feed container remain steady (i.e. feed to the process has stopped) an alarm will sound in the process control room.

4.7.3 Emissions

The only emission from the baghouse filter will be flue gas cleaning residues. Approximately 2-3% (on the basis of dry weight) or 3,500 to 5,000 tonnes/annum of flue gas cleaning residues will be produced based on a nominal throughput of 150,000 tonnes/annum. The activated carbon/lime mixture silo will be located externally and will be equipped with High Efficiency Particulate Abatement (HEPA) filters to prevent fugitive emissions from the silo.

4.7.4 Inputs and Outputs

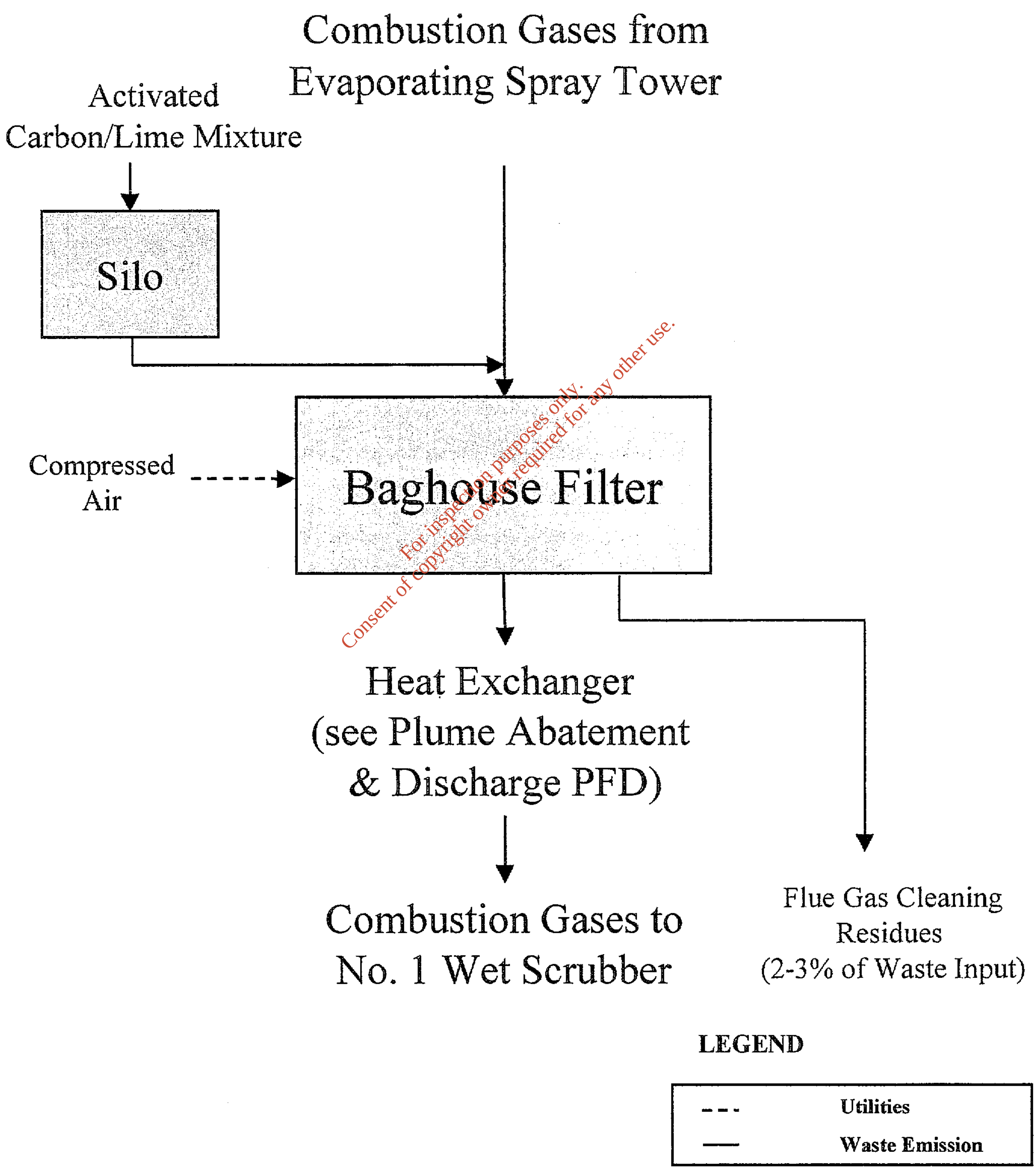
Inputs will include combustion gases, compressed air and the activated carbon/lime mixture. As described above, a total of 30 kg/hour of activated carbon/lime mixture will be injected into the ductwork when the plant is operating at a nominal capacity of 20 tonnes/hour. Outputs will include cleaner combustion gases and flue gas cleaning residues discussed above.

4.7.5 Abnormal Situations

At temperatures greater than 180 °C, heat is generated due to oxidation of the carbon granules. The heat generated could cause hot spots in the baghouse filter leading to holes in the filter sleeves. The injection of activated carbon/lime mixture rather than pure activated carbon will minimise the possibility of hot spots in the baghouse filter.

Sleeves will be replaced as required, usually every 3 to 6 years. In addition, if a drop in differential pressure across the sleeve fabric occurs due to a hole in the

ACTIVATED CARBON/LIME MIXTURE INJECTION & BAGHOUSE FILTER PROCESS FLOW DIAGRAM



sleeve, an alarm will be activated in the control room and replacement of the sleeve will be required. This will require the shutting down of this particular module to facilitate this work. However, emissions will not be effected as the remaining modules will be kept on line.

Dust accumulation in the baghouse filter could lead to an overpressure. However, this will be prevented by the installation of differential pressure indicators and a high level alarm on the baghouse filter.

4.8 WET FLUE GAS CLEANING

4.8.1 Process Description

After the baghouse filters, the combustion gases from both furnaces will be combined and the remaining flue gas cleaning plant will be common to both furnaces.

There are two possible options for the wet flue gas cleaning system, of which Option 1 is considered the most likely. Therefore, for discussion purposes, Option 1 has been assumed as chosen for the following unit operations that will be effected:

- Flue Gas Cooling (Section 4.6)
- Activated Carbon/Lime Mixture Injection and Baghouse Filter (Section 4.7)
- Ash Handling (Section 4.11)

Option 1 is as follows: The plant will be provided with a system of two wet based scrubbers in sequence. Each scrubber tower will be approximately 15m high and 5m in diameter. The wet scrubbers will remove SO_2, HF and HCl (which are formed if sulphur, fluorine and chlorine are present in the waste stream) and heavy metals. The scrubbers will use a calcium based reagent, either lime or limestone. Either reagent would be equally effective and the final choice will be made on the basis of potential suppliers of the reagent prior to operation. For further details on lime/limestone, see Table 1.10 in Attachment E5.2. Lime/limestone will be stored in a silo from where it will be placed in a mixing tank where water will be added to produce the scrubbing liquid. A schematic for Option 1 is provided overleaf. This schematic shows both scrubbers and a covered truck removing gypsum. Also included in this schematic is the tail end flue gas cleaning system (coloured blue).

Neither of the scrubbers will contain packing material. Instead, the scrubbers will be equipped with nozzles which will form liquid curtains through which the combustion gases will be forced to pass. Acid gases and heavy metals will be absorbed into the circulating liquid. The lime or limestone will react with the acid gases captured in the solution. The flue gases will enter through the bottom of the scrubbers and leave through the top after a residence time of about 2 seconds.

Schematic of Wet Flue Cleaning System Option 1

The first scrubber will normally operate at a pH of 2-3, and will absorb mainly HCl, HF and heavy metals to produce calcium salts. The following reactions occur in the first scrubber:

$CaO + 2HCl \rightarrow CaCl_2 + H_2O$

$CaO + 2HF \rightarrow CaF_2 + H_2O$

The second scrubber will be operated at a pH of about 6 and will absorb SO_2 to produce gypsum as follows:

$2CaO + 2SO_2 + O_2 \rightarrow 2CaSO_4$

At the first stage of the first scrubber the flue gases will be quenched, cooling them to about 60 °C by saturating them with water. In this process, some of the solution will evaporate off, leading to increased concentration of salts in the circulating liquid. These salts and heavy metals will accumulate in the circulating solution. In order to prevent crystallisation of these salts and fouling of the pipework, a quantity of the circulating solution is purged and replaced with fresh make-up.

There will also be a purge from the second scrubber, which will contain gypsum ($CaSO_4.2H_2O$) in suspension. This gypsum solution will pass through a vacuum belt filter, where gypsum will be filtered out as an approximately 90% solids content cake.

The purge from the first scrubber and the recovered water from the vacuum belt filter (after gypsum has been removed) will go to a neutralisation tank where further lime/limestone will be added to neutralise the acidic solution. It will then be recycled for use in the evaporating spray towers.

Should maintenance be required on one of the scrubbers outside of normal maintenance, the plant will be able to continue operating with the other scrubber operating at a pH of 5-6. The operation of one scrubber will ensure that the facility will meet EU limits for emissions of the above gases and heavy metals.

A possible variation to Option 1 for the wet flue gas cleaning system, described as Option 1a, would involve the addition of water only to the first scrubber. Lime/limestone will still be added to the second scrubber. The balance of lime/limestone will then be added at the neutralisation tank stage. The neutralised solution will then be recycled to the evaporating spray towers.

Process flow diagrams for Options 1 and 1a for this unit operation are included overleaf.

The second option, Option 2, for the wet flue gas cleaning system would be the removal of the first wet scrubber and the injection of lime/limestone solution in addition to process water into the evaporating spray towers. This would mean that the evaporating spray towers would become reactors and the reactions to remove HCl and HF would now take place here.

Lime/limestone solution will still be used as the scrubbing liquid in the remaining scrubber and SO_2 removal will take place here. The purge from this scrubber will pass through a vacuum belt filter to remove gypsum and then will go to the neutralisation tank where it will be neutralised with lime/limestone. The neutralised liquid will then be recycled to the evaporating spray towers. The emissions of HCl and HF from either Options 1, 1a or 2 will be the same. The decision on which option will be used will be dependent on the suppliers of this equipment. A process flow diagram for Option 2 for this unit operation is included overleaf, including an amended Flue Gas Cooling process flow diagram.

4.8.2 Process Control

The circulating liquid in the scrubbers will be continuously monitored for:

- Density or conductivity
- pH

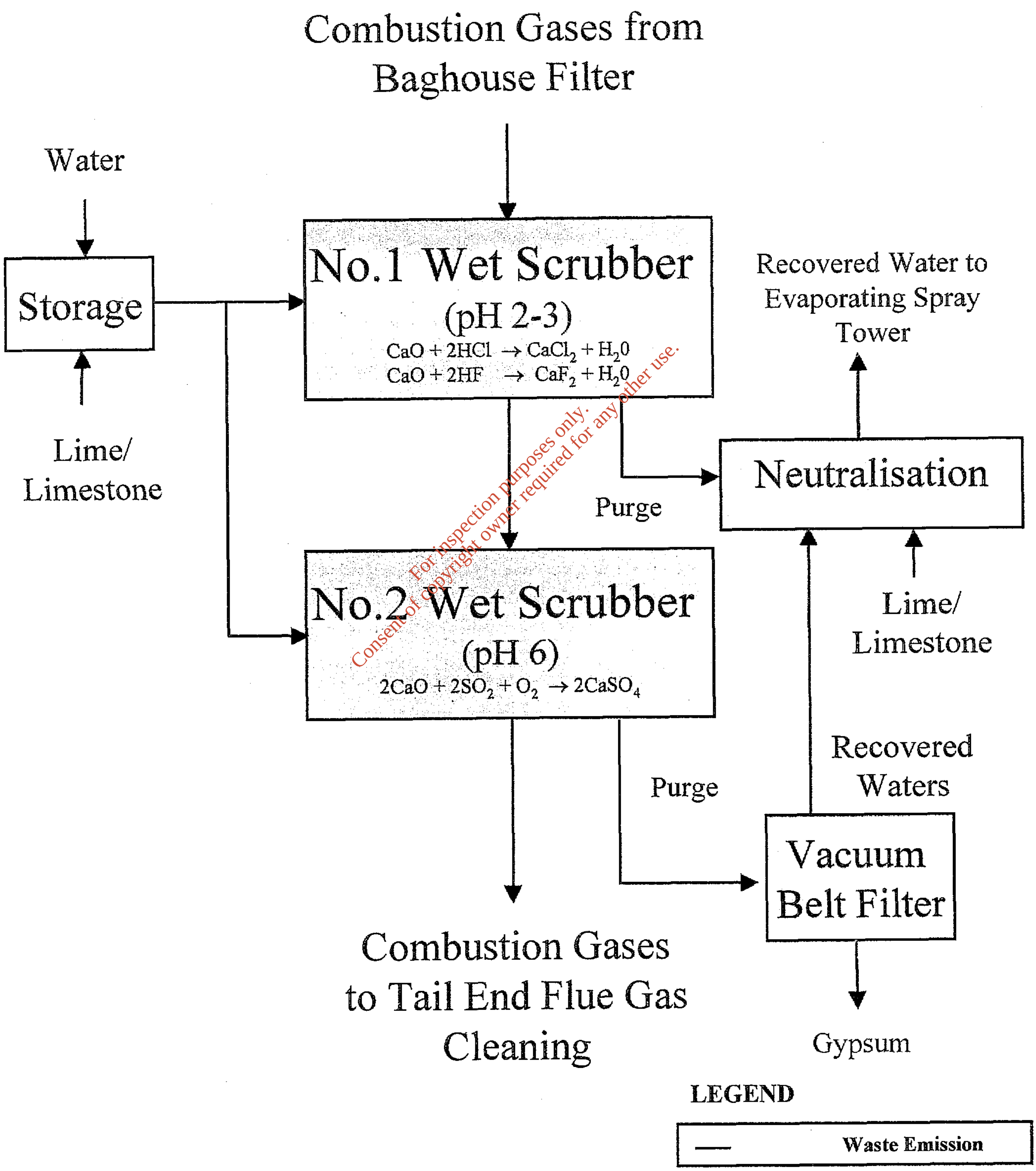
The rate of purge will be controlled by the measurement of the density or the conductivity of the solution in the scrubber (either of which are an indicator of the level of dissolved salts). The rate of addition of lime/limestone will be controlled by the pH measurement. In Option 1, the first scrubber will be controlled to approximately pH 2 while the second scrubber will be controlled to pH 6.

Each scrubber will be equipped with a flow detector on the circulating liquid system and will be provided with a back-up circulating pump which will automatically be brought on line should a low flow alarm be activated.

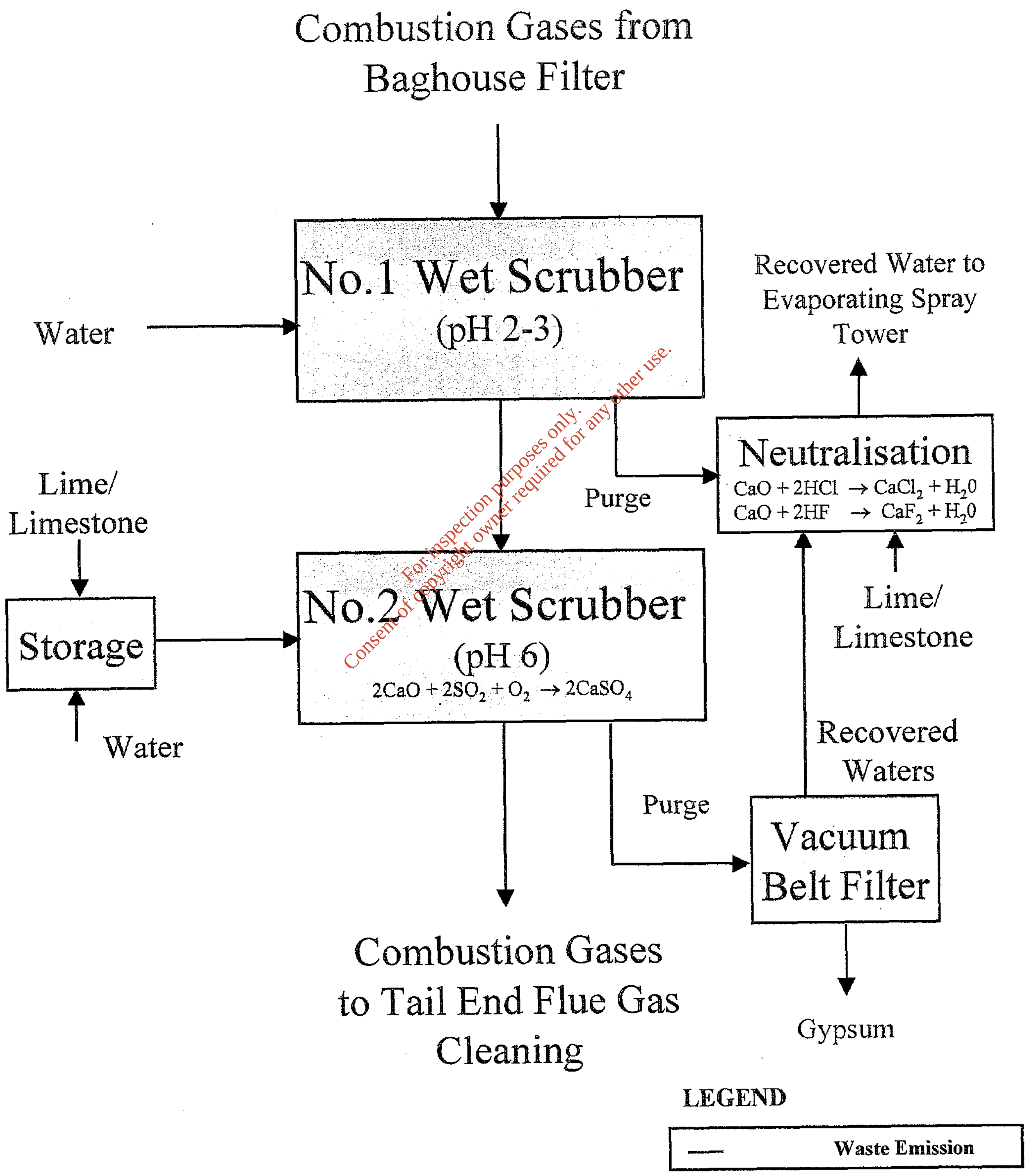
4.8.3 Emissions

The only emission from the scrubbers will be gypsum from the purge of the circulating solution. Approximately 1,000 tonnes/annum of gypsum will be produced based on a nominal throughput of 150,000 tonnes/annum.

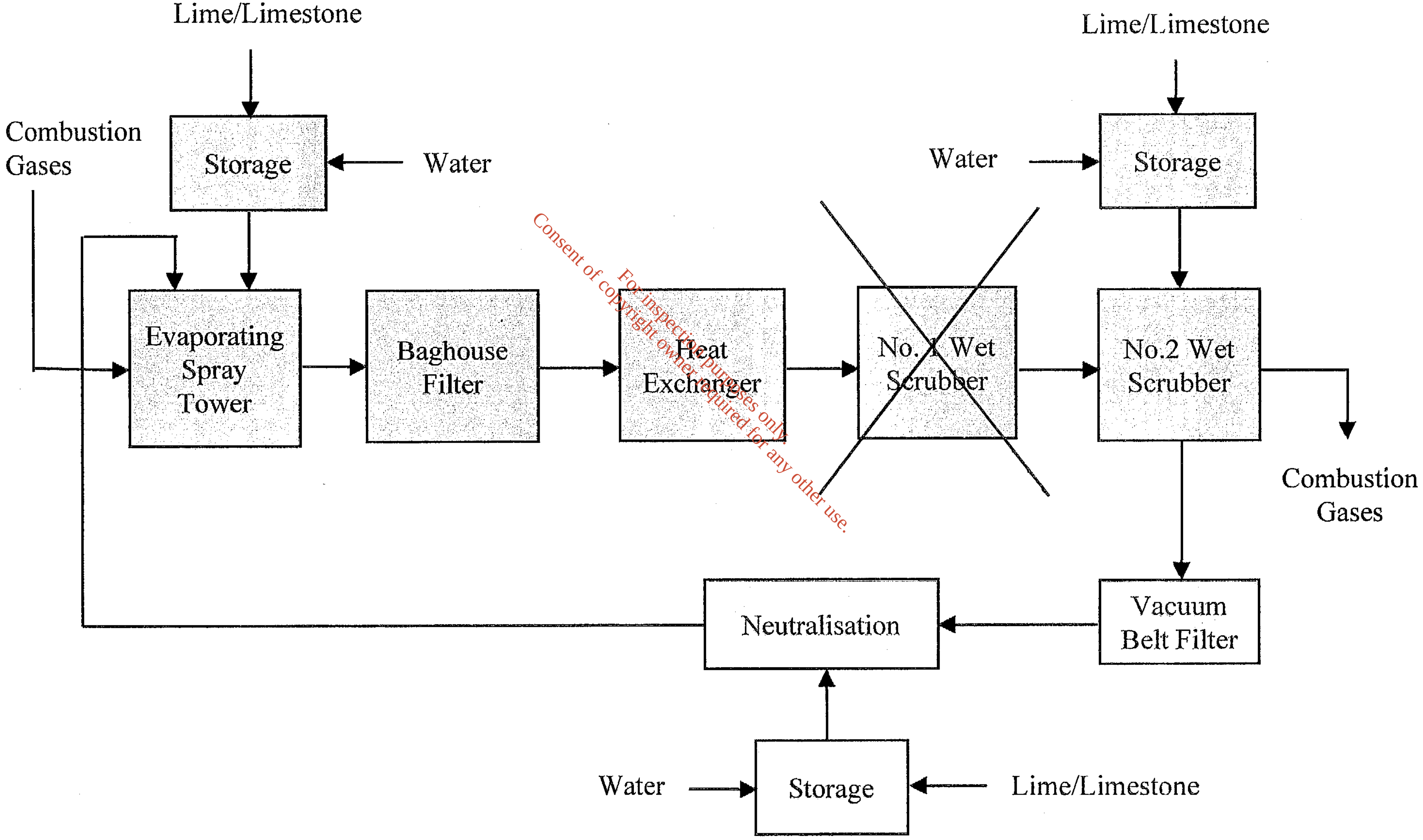
WET FLUE GAS CLEANING PROCESS FLOW DIAGRAM - Option 1



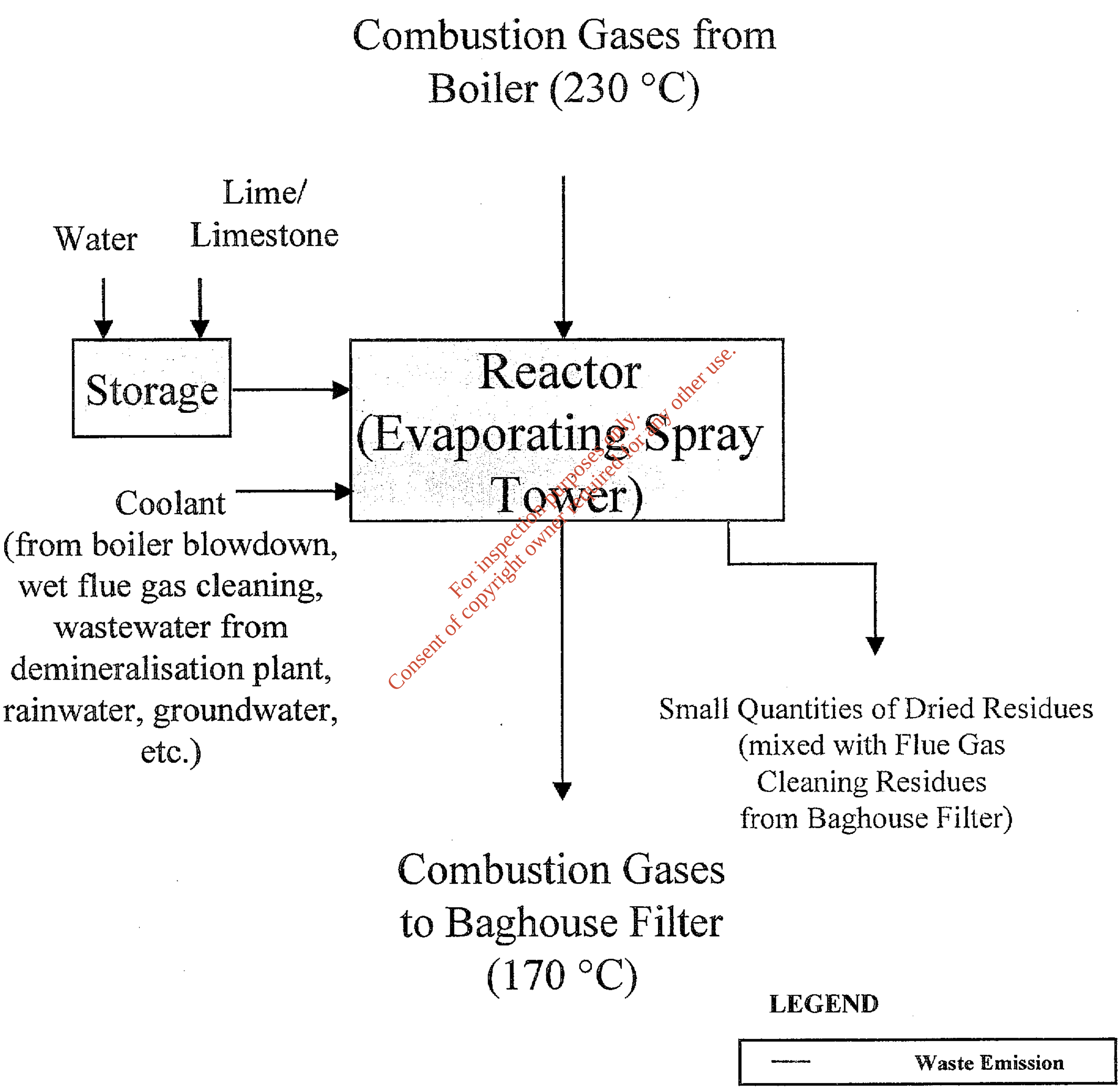
WET FLUE GAS CLEANING PROCESS FLOW DIAGRAM - Option 1a



WET FLUE GAS CLEANING PROCESS FLOW DIAGRAM
OPTION 2



FLUE GAS COOLING PROCESS FLOW DIAGRAM – Option 2



4.8.4 Inputs and Outputs

The inputs into the wet flue gas cleaning system will be flue gases, water and lime/limestone solution. The exact quantity of lime/limestone used in any year will depend on the sulphur and chlorine content of the waste input. It is anticipated that approximately 1,600 tonnes/annum of limestone or approximately 900 tonnes/annum of lime will be used in the scrubbers, based on a throughput of 150,000 tonnes/annum of waste per annum.

Outputs will include wet combustion gases, gypsum discussed above and the recovered water from the neutralisation tank that will be recycled back into the process for use in the evaporating spray towers.

4.8.5 Abnormal Situations

In the event of loss of the scrubbing liquid to either scrubber, melting of the lining material in the scrubber would occur. Both low flow and no flow alarms will be provided on the scrubbing liquid supply and a back-up water injection system from the fire ring main will be interlocked to the loss of scrubbing liquid. In the event of loss of either scrubber in Option 1, the other scrubber could continue to operate to remove HCl, HF and SO_2 to the required levels.

If the second scrubber fails, the first scrubber will be operated at a pH of approximately 6, rather than normal operating pH of 2, to ensure SO_2 removal. In the event of loss of the single scrubber in Option 2, the plant will undergo an emergency shut down.

4.9 Tail End Flue Gas Cleaning

4.9.1 Process Description

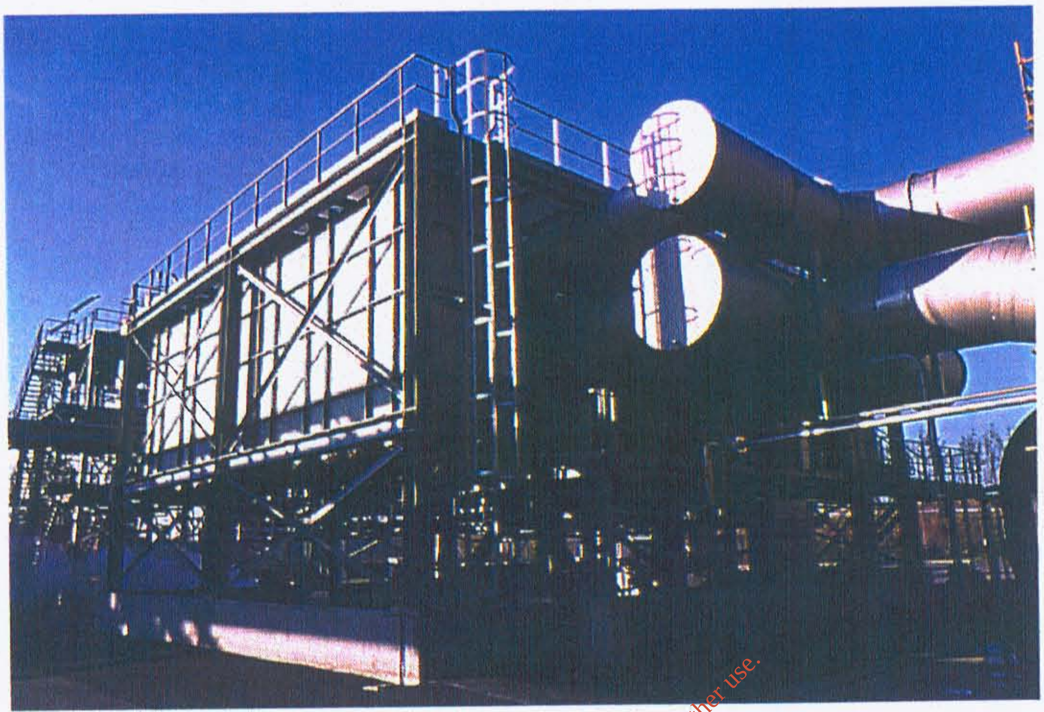
The wet combustion gases from the wet flue gas cleaning will pass through the final tail end flue gas cleaning system prior to discharge. The tail end flue gas cleaning system will consist either of a second stage of activated carbon/lime mixture injection and a second baghouse filter, or a carbon bed. The baghouse filter option is considered the more likely option. The activated carbon/lime mixture injection and baghouse filter system would be similar to that described in Section 4.7.

Carbon Bed

The carbon bed would consist of a fixed bed of activated lignite cokes. For further details on lignite cokes, see Table 1.10 in Attachment E5.2. A photograph of a carbon bed at a similar Indaver plant is provided overleaf. The flue gases will pass upwards through the bed of cokes (approximately 2 m in depth) that will absorb remaining trace dioxins, heavy metals and hydrocarbons. The flue gas temperature leaving the tail end flue gas cleaning system will be approximately 60 °C.

Approximately once a week a small fixed amount of cokes will be extracted from the bottom of the filter. This will ensure that the cokes most exposed to the flue gases are removed. The removal will be effected by adding water into the coke bed and opening a valve at the bottom through which the cokes can be extracted. The lignite cokes and water removed will be recovered for incineration in the furnace.

Carbon Bed



A very small amount of solid residues will be collected from the baghouse filter system, which will also be sent for incineration in the furnace. During maintenance, a depth of 0.5 m of lignite cokes will be added to the top of the carbon bed to replace any carbon removed during weekly extractions.

Both the baghouse filter system and carbon bed system will be based on a modular design, containing separate modules, allowing one or more modules to be shut off. The flue gases must still pass through the remaining modules and therefore will be treated.

Induced Draught Fan

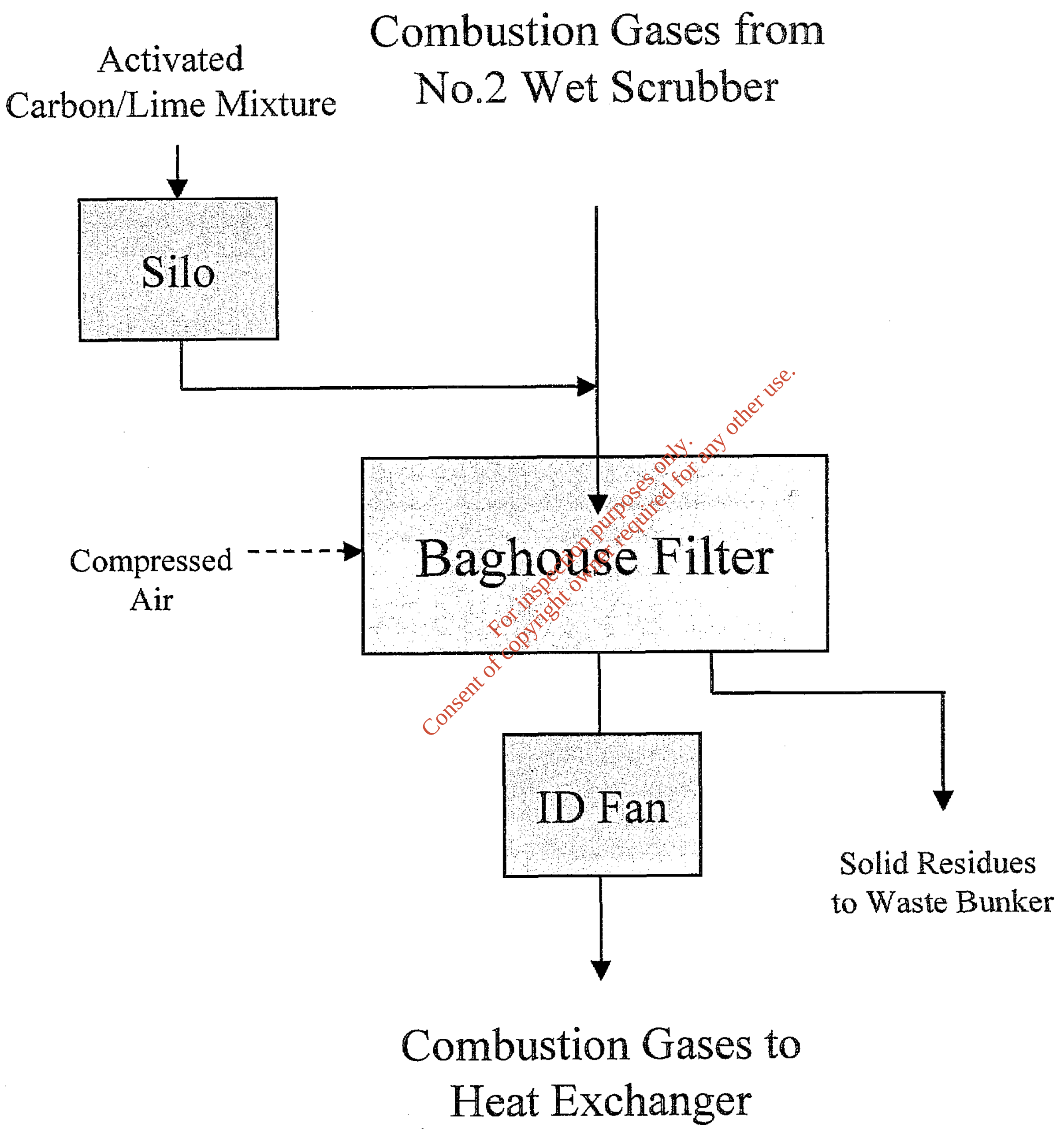
An Induced Draught (ID) fan will draw the combustion gases through the flue gas cleaning plant and maintain the plant in underpressure.

In the case of the carbon bed, the fan will be located between the wet scrubbers and the tail end flue gas cleaning system, as the carbon bed operates more effectively in overpressure.

In the case of the baghouse filter, the fan will be located downstream of the tail end flue gas cleaning system as the baghouse filter operates more effectively in underpressure.

Process flow diagrams for both options for this unit operation are included overleaf.

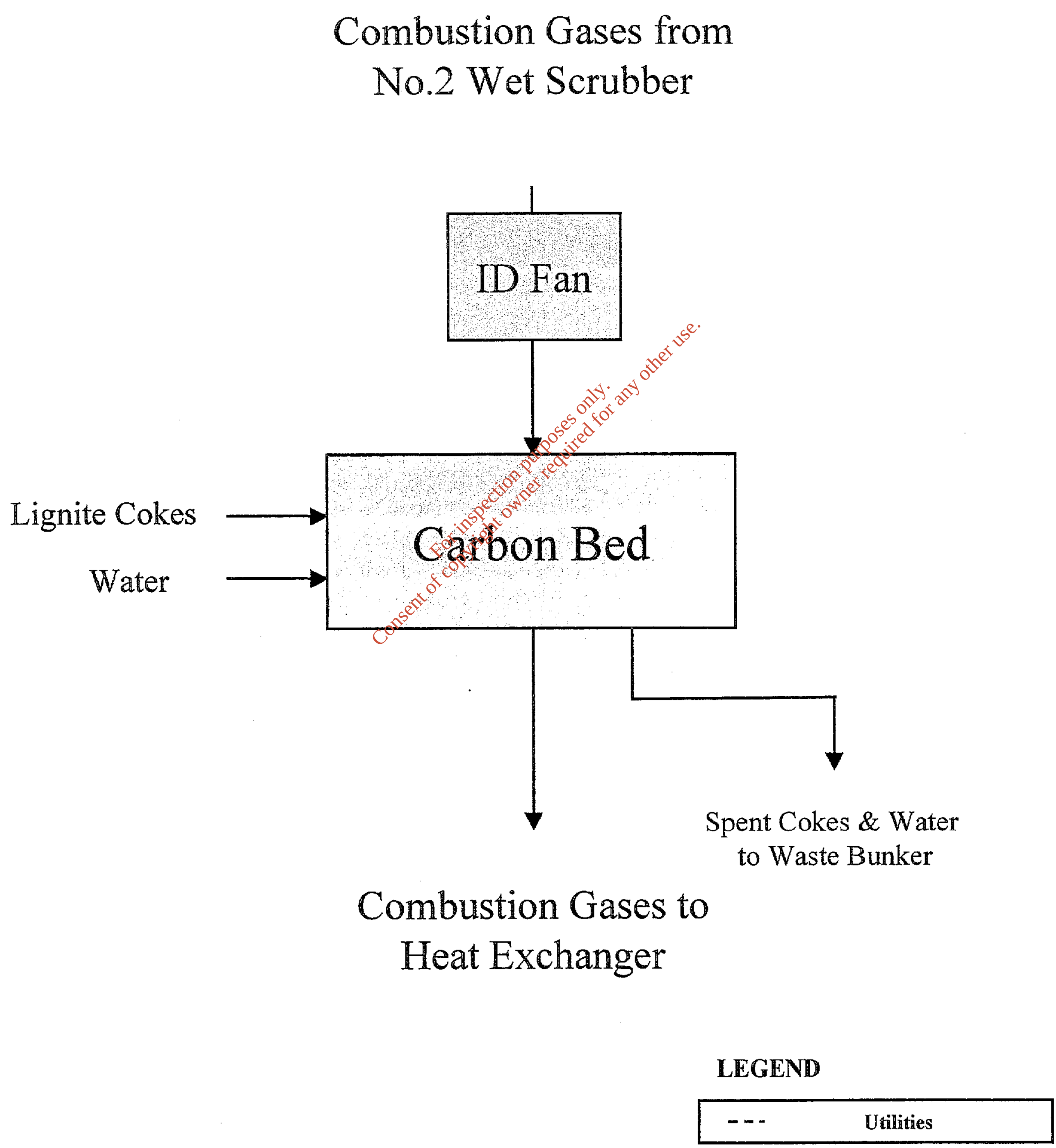
TAIL END FLUE GAS CLEANING PROCESS FLOW DIAGRAM - Option 1



LEGEND

- - -	**Utilities**

TAIL END FLUE GAS CLEANING PROCESS FLOW DIAGRAM - Option 2



4.9.2 Process Control

Process control of the activated carbon/lime mixture injection and baghouse filter system would be similar to that described in Section 4.7.2.

For the carbon bed, the rate of extraction of the cokes will be fixed at a set amount. This amount will be determined during the initial operating stages of the plant to ensure that the bed operates to its maximum effectiveness.

4.9.3 Emissions

There will be no emissions from either the activated carbon/lime mixture injection and baghouse filter system or carbon bed system.

4.9.4 Inputs and Outputs

Inputs will include combustion gases and the activated carbon/lime mixture or lignite cokes, depending on the system employed. Based on the experience of similar plants it is expected that approximately 225 tonnes/annum of activated carbon/lime mixture or 100 tonnes/annum of lignite cokes will be used, based on a throughput of 150,000 tonnes/annum of waste. Outputs will be cleaner combustion gases, and spent cokes or solid residues as appropriate.

4.9.5 Abnormal Situations

The activated carbon/lime mixture injection and baghouse filter system would have similar potential problems to those described in Section 4.7.5.

Blockages could occur in sections of the carbon bed if the lignite cokes are not changed at the required frequency. As the flue gases must pass through the entire carbon bed, dioxins will still be removed.

In the event of ID fan failure, overpressure would be generated in the waste to energy plant and an emergency shutdown sequence, described in detail in Section 4.12.3, would be automatically initiated. An emergency motor will be provided on the ID fan to keep it running in the event of failure of the main motor. The fan will be a critical item of plant and therefore will be inspected regularly. Vibration detection and thermocouples will also be provided on the ID fan.

4.10 PLUME ABATEMENT AND DISCHARGE (STACK)

4.10.1 Process Description

The use of wet scrubbers will both cool the flue gases and saturate them with water. The lower temperature and high water content of the flue gases would lead to the formation of a visible plume from the stack if discharged directly.

In order to reduce the formation of a visible plume, the wet flue gases at 60 °C will pass through a heat exchanger prior to discharge.

This heat exchanger will use heat in the combustion gases prior to the wet scrubbers to reheat the flue gases after the scrubbers and tail end flue gas cleaning system.

The flue gases prior to the scrubber are cooled from about 170ºC to 130ºC, while the wet flue gases are heated from about 60 °C to 100 °C.

Dependent on equipment supplier, electricity generation and conditions of the connection to the ESB distribution network, it may be necessary to heat the flue gases prior to discharge using steam from the boiler or turbine rather than the hot flue gases prior to the scrubber. This would ensure a more uniform electrical output from the plant.

In the case of the carbon bed, the heat exchanger will be located between the carbon bed and the stack. In the case of the baghouse filter, the heat exchanger will be located between the wet flue gas cleaning system and the baghouse filter, as the baghouse filter operates more effectively at a higher temperature.

A process flow diagram for this unit operation is included overleaf.

4.10.2 Process Control

Continuous on-line analysis of stack emissions using fixed installed emissions monitoring equipment will be carried out to monitor stack emissions.

4.10.3 Emissions

This is the final stage of the flue gas treatment system from which flue gases will be emitted to atmosphere via a 40 m stack. The substances emitted from the waste to energy plant may include the following:

- Oxides of nitrogen (NO_x)
- Sulphur dioxide (SO_2)
- Carbon monoxide (CO)
- Particulates (Dust)
- Hydrocarbons (expressed as Total Organic Carbon (TOC))
- Hydrogen Chloride (HCl)
- Hydrogen Fluoride (HF)
- Poly-Chlorinated Dibenzo Dioxins (PCDD) and Poly-Chlorinated Dibenzo Furans (PCDF)

Heavy metals: Cadmium (Cd), Thallium (Tl), Mercury (Hg), Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), Vanadium (V).

The typical emission concentrations from the stack, along with the relevant EU limit values, are listed in Table 4.1 overleaf. The expected emissions from the stack are well below the new EU limits as set in Directive 2000/76/EU.

PLUME ABATEMENT & DISCHARGE PROCESS FLOW DIAGRAM

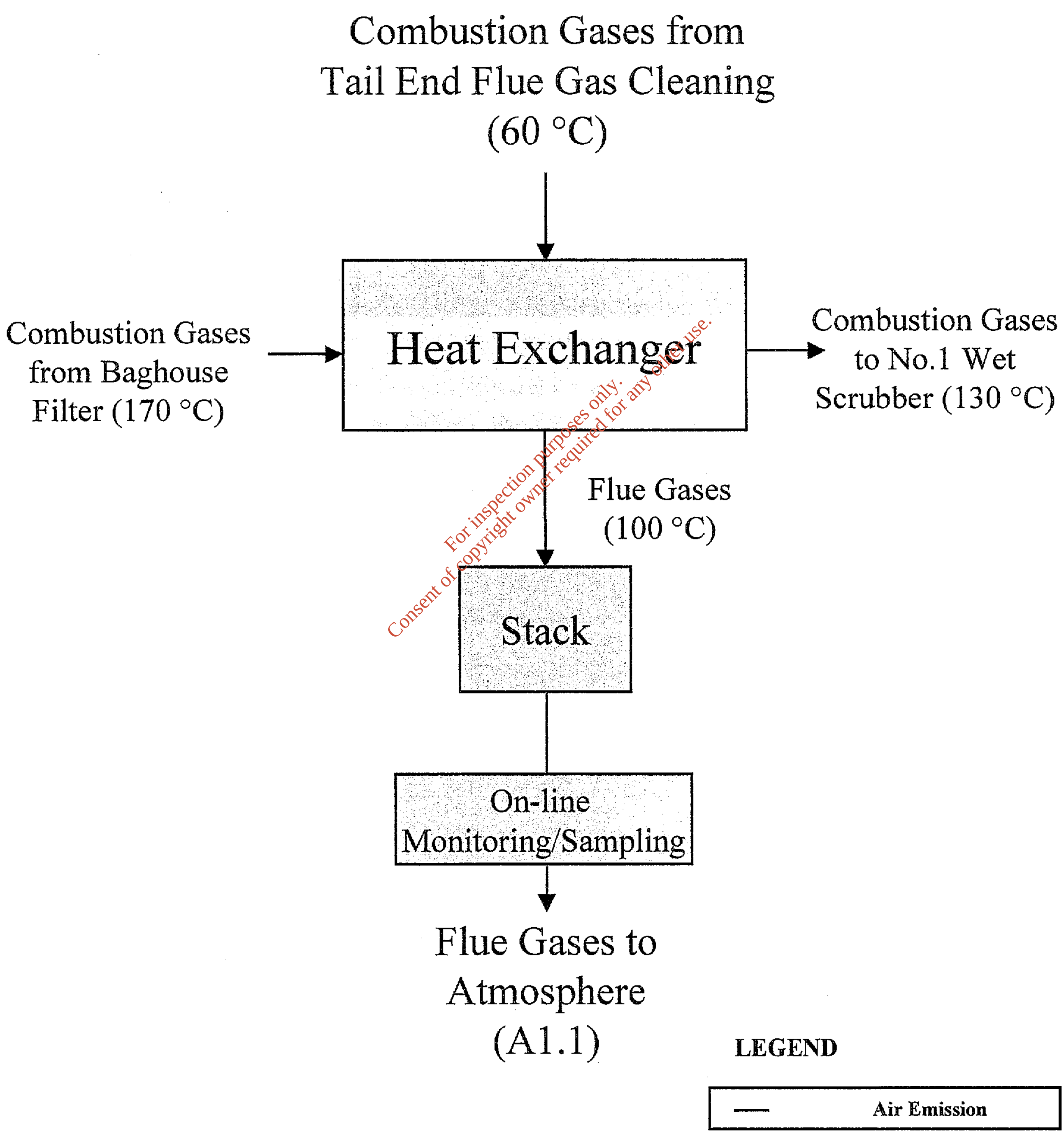


Table 4.1 Comparison of Typical Emission Data with EU Limit Values

Emission	Typical Emission Concentrations (mg/Nm^3)*	EU Limit Value (mg/Nm^3)
NO_x (as NO_2)	150	200
SO_2	20	50
Dust	1	10
CO	20	100
TOC	1	10
HCl	1	10
HF	1	1
PCDD / PCDF	0.01 ($ngTEQ/m^3$)	0.1 ($ngTEQ/m^3$)
Cd & Tl	0.025	0.05
Hg	0.025	0.05
Sum of 9 Heavy Metals: Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	0.25	0.5

* These are typical emissions. There may be short term fluctuations, however these will still be well below the EU limit values.

Air dispersion modelling was carried out to determine a stack height, which would adequately disperse the atmospheric emissions without creating any undue impact. The potential impact of these atmospheric emissions is addressed in Attachment H1.1.

Continuous monitoring of dust, Total Organic Carbon (TOC), Hydrochloric acid (HCl), Sulphur dioxide (SO_2), Nitrogen oxides (NO_x), Oxygen (O_2), Carbon monoxide (CO), temperature and water content will be carried out at different stages throughout the waste to energy plant. Fixed installed emissions monitoring equipment will be provided at the stack for continuous monitoring of the above emissions.

Continuous sampling of dioxins will also be carried out at the stack. The AMESA dioxin/furan monitoring system, or equivalent, will be installed, which is used for measuring dioxins/furans in other plants that comply with the German Environmental Regulation 17BIm SchV and TA Luft. Further details on the AMESA dioxin/furan monitoring system are included in Attachment J1.2.

4.10.4 Inputs and Outputs

Inputs to the heat exchanger will include flue gases (at 60 °C) from the tail end flue gas cleaning system and flue gases (at 170 °C) from the baghouse filters. Outputs will include flue gases (at 100 °C) to be discharged from the stack and flue gases (at 130 °C) going to the wet scrubbers. When the plant is operating at nominal capacity of 20 tonnes/hour (throughput of 150,000 tonnes/annum of waste), 142,000 Nm^3/hr of flue gases will be discharged via the stack.

4.10.5 Abnormal Situations

In the unlikely event of a heat exchanger tube leak, leakage will occur from the "clean" flue gas side (combustion gases after tail end flue gas cleaning) into the "dirty" flue gas side (combustion gases after baghouse filter) due to the higher pressure on the "clean" side. Therefore there is no possibility of untreated flue gases discharging via the stack. Any heat exchanger leakage will be detected by the increase in HCl and SO_2 levels in the flue gases. This will be controlled by interlocks which will result in a plant shutdown.

4.11 Ash Handling

4.11.1 Process Description

As described in the previous sections, the waste to energy plant will produce the following streams of solid residues:

- Bottom ash - Approximately 20% of waste input (by weight) or 30,000 tonnes (as dry material) per annum will be bottom ash, mainly consisting of inert material such as sand, glass, scrap and stones. This will be collected in the ash bunker.
- Boiler ash - Approximately 1-2% or 1,500 to 3,000 tonnes per annum will be collected as boiler ash, which will be removed by conveyor and collected in a silo.
- Flue gas cleaning residues - Some 2-3% or 3,500 to 5,000 tonnes per annum of the waste input will be removed by conveyor and collected in a silo.
- Gypsum - Approximately 1,000 tonnes of gypsum will be collected from the wet flue gas cleaning plant.

The bottom ash coming from the furnace will discharge into a water bath called a "wet bath" to cool the ashes to ambient temperature. The ash will be transported via conveyor to the ash bunker. Metal (approximately 2,100 tonnes/annum) will be recovered from the bottom ash using either a sieve or magnetic system prior to the ash bunker. The bottom ash in the ash bunker will be loaded by grab crane into trucks within the waste to energy plant building, eliminating the potential for windblown ash. These trucks will be covered and transported off site to a licensed landfill. This metal will be sent off-site to an appropriate recycling facility.

The boiler ash in the hoppers beneath the boiler will be brought by conveyor to the boiler ash silos. The boiler ash may require solidification prior to landfill. This will be dependent on the composition of the ash. If solidification is required, a solidification plant may be installed within the facility, where the boiler ash would be mixed with cement/iron silicate and water and placed into large bags. The solidification process will chemically bind the ash to the cement/iron silicate producing a solid, inert material, also eliminating any dust generation. These bags would then be transported from the plant via covered trucks. For further details on cement or iron silicate, see Table 1.10 in Attachment E5.2. If a solidification plant is not installed at the facility, the ash will be solidified off site, if required, prior to landfill.

In a similar fashion, the flue gas cleaning residues will be conveyed to the flue gas cleaning residue silos which will be located within the waste to energy plant building. The flue gas cleaning residues will require solidification prior to disposal at a hazardous/non-hazardous waste landfill. If the solidification plant is installed at the facility, these residues will be solidified with cement/iron silicate and water and transported in large bags on covered trucks. If a solidification plant is not installed at the facility, the flue gas cleaning residues will be solidified off site prior to landfill.

If installed, there will be one solidification plant which will be used for both boiler ash and flue gas cleaning residues but at different times for different batches of material. In the solidification process, cement/iron silicate, at 20% of the ash input, and water, at 50% of the ash input, will be mixed with the ash in an agitated tank. This mixture will then be discharged into $1m^3$ flexible intermediate bulk containers (FIBCs). The FIBCs will be loaded into covered trucks and sent to an appropriate licensed landfill.

Gypsum from the vacuum belt filter in the wet flue gas cleaning system will be collected in a storage unit. It will be loaded into covered trucks and transported off site for recovery or disposal to a licensed landfill.

Process flow diagrams for this unit operation and for the solidification plant are included overleaf.

4.11.2 Process Control

The ash collection and handling systems will be controlled locally and will be monitored from the central control room via the plant's main control system. The boiler ash and flue gas cleaning residue silos will be located on load cells which will provide indication if the silos are reaching full capacity.

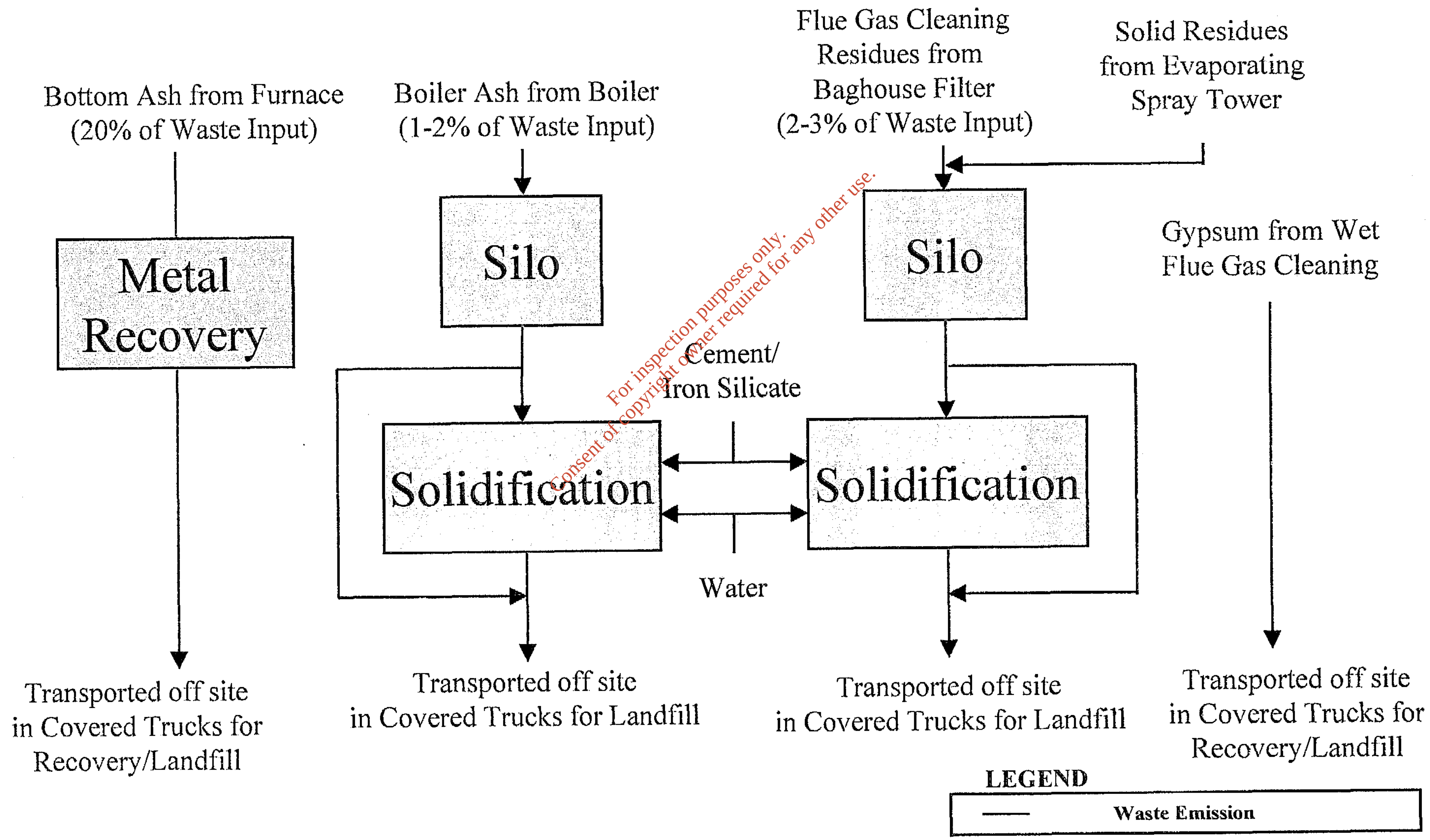
4.11.3 Emissions

Bottom ash, boiler ash, flue gas cleaning residues and gypsum constitute waste emissions. Waste disposal arrangements for these wastes are discussed in detail in Attachment H11.1.

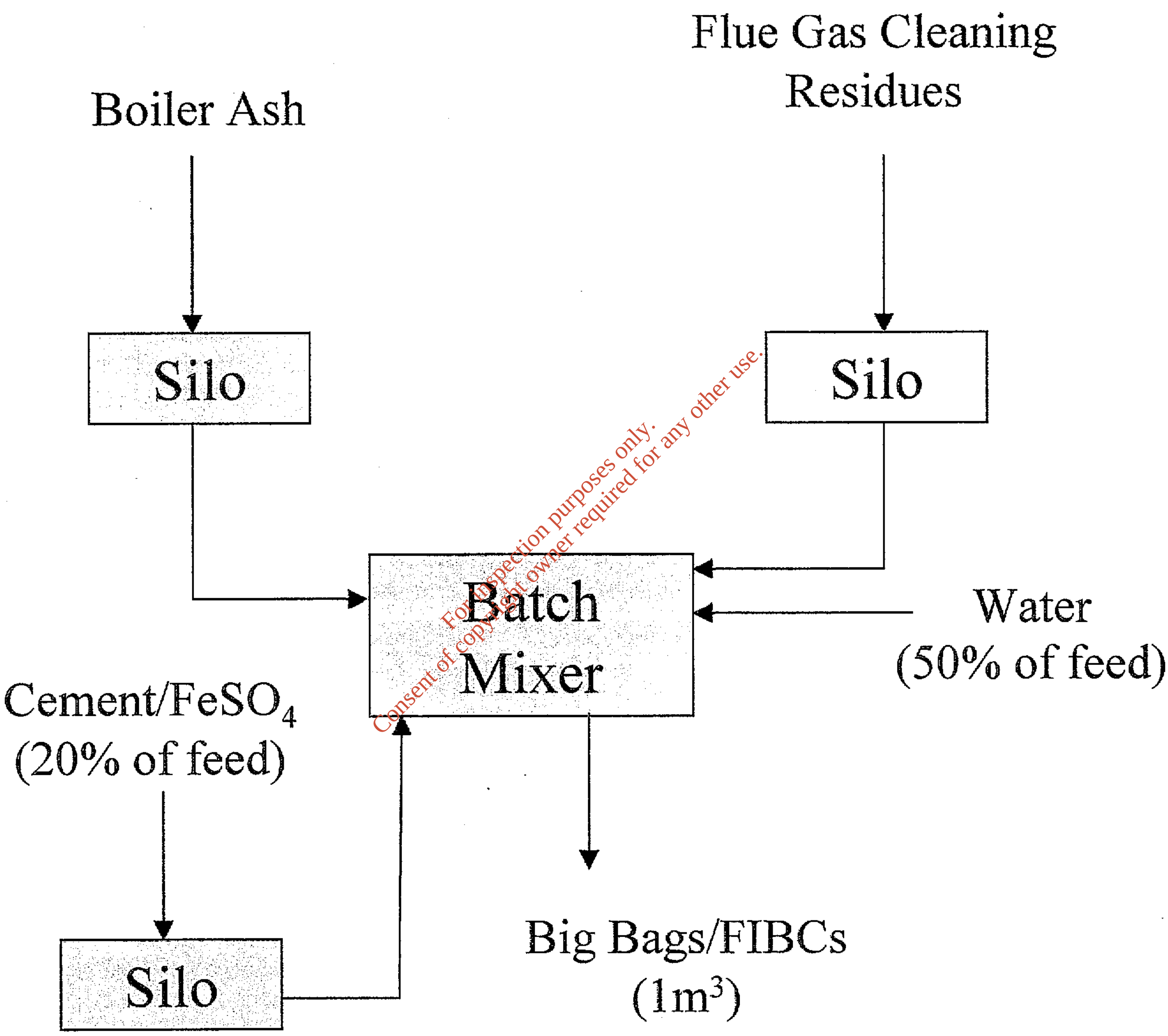
The only potential atmospheric emission from the ash storage and handling process is that of fugitive windblown ash emissions. The ash bunker and ash loading area will be enclosed within the main building, eliminating the potential for windblown ash. All trucks dispatching ash from the plant will be covered to remove any potential for windblown ash whether solidified or not.

Boiler ash and flue gas cleaning residues will be transported by enclosed conveyor to their respective silos. The silos will be equipped with High Efficiency Particulate Abatement (HEPA) filters to prevent fugitive emissions from the silos. The solid wastes from the silos may go directly to solidification, after which there will be no

ASH HANDLING PROCESS FLOW DIAGRAM



SOLIDIFICATION PROCESS FLOW DIAGRAM



Note: Solidification of Flue Gas Cleaning Residues and Boiler Ash will take place separately.

LEGEND

——	**Waste Emission**

potential for fugitive windblown emissions. All trucks dispatching ash from the plant will be covered to remove the potential for windblown ash.

4.11.4 Throughput

The quantities and descriptions of solid wastes that will be produced are summarised below.

The classification and descriptions of the wastes as described below are obtained from the European Waste Catalogue,

Section 19 refers to "Wastes from waste management facilities, off-site waste water treatment plants and the preparation of water intended for human consumption and water for industrial use"

Section 19 01 refers to "Wastes from incineration or pyrolysis of waste"

Table 4.2 Solid Wastes produced in Waste to Energy Plant

Waste Stream	European Waste Code	European Waste Code Description	% of Waste Input	Approximate Production (based on waste throughput of 150,000 tonnes/annum)
Bottom Ash	19 01 12	Bottom ash and slag other than those mentioned in 19 01 11*	20	30,000
Boiler Ash	19 01 15 19 01 16	Boiler dust containing dangerous substances Boiler dust other than those mentioned in 19 01 15	1 – 2	1,500 – 3,000
Flue Gas Cleaning Residues	19 01 13 19 01 10	Fly ash containing dangerous substances Spent activated carbon from flue gas treatment	2 – 3	3,500 – 5,000
Gypsum	19 01 99	Wastes not otherwise specified	0.67	1,000
Metals	19 01 02	Ferrous materials removed from bottom ash	1.4	2,100

* 19 01 11 refers to bottom ash and slag containing dangerous substances

4.11.5 Abnormal Situations

In the event of conveyor failure from the boiler or baghouse filter, there will be sufficient storage within both systems for approximately one day to allow the conveyor to be repaired. If the conveyor cannot be repaired within this timeframe, the plant will be shutdown. Bridging of material could occur in the baghouse filter hoppers. The design of the hoppers, i.e. sides of hoppers sloped at different angles, will prevent bridging occurring.

4.12 OPERATION OF WASTE TO ENERGY PLANT IN ABNORMAL CONDITIONS

The malfunctions that could arise during normal operation for the particular process steps are described above under the heading "Abnormal Situations". The following scenarios are described below:

- Start-up Sequence
- Shutdown Procedure
- Emergency Shutdown Sequence

4.12.1 Start-up Sequence

The start-up sequence will be as follows:

- The waste to energy plant process computer system will be started up, which will mean that measurements and interlock systems are in operation.
- Utilities such as water, electricity, instrument air, the firewater system and safety systems will then be started up.
- Monitoring of some of these utilities will be carried out as certain conditions such as firewater availability must be satisfied before the start-up procedure can progress any further.
- Start-up of peripheral equipment, such as the equipment to supply chemicals to the plant, to receive the process stream from the plant and the stack emissions monitoring equipment will then commence.
- After verification of process parameters and correction (liquid levels, pressures, steam cycle, etc.) the flue gas cleaning systems will start up.
- The ID fan will commence running and pre-ventilation of the plant for a pre-set time period of 20 minutes will occur.
- The gas-fired burners to initiate combustion in the furnace will be started up and the flue gas temperature will be raised to 850 °C at a gradient of 50 °C/hour.
- Once the temperature in the furnace has stabilised, the supply of waste will then commence and firing with natural gas will be stopped.

4.12.2 Shutdown Procedure

The normal shutdown procedure will be as follows:

- The first step will be that the waste supply to the furnace will be shut off.
- To ensure complete combustion of the waste remaining in the furnace, the burners will be re-started to ensure that a temperature of 850 °C is maintained for a period of one hour.

- The furnace will then be allowed to cool down to a temperature of 200 °C at a gradient of 50 °C/hour (a period of approximately 13 hours), which will be controlled by supplementary firing (to reduce the cooling rate).
- The ID fan and flue gas cleaning systems will remain operating to ensure that the flue gases are treated to the emission limits as during normal operation.
- Once the temperature at the stack outlet is sufficiently low at approximately 60 °C (the plant has stopped incinerating waste for a number of hours, there is no waste remaining in the grate and therefore there are no flue gases to be cleaned) the flue gas cleaning systems will then be stopped.
- Some utilities such as instrument air, etc. and the majority of peripheral equipment will also be shut off.
- Other utilities such as electricity supply will continue operating as they will be required even when the plant is shut down.
- If there is waste remaining in the waste bunker, the ID fan will continue operating at a lower capacity to ensure that the waste acceptance hall and materials recycling facility are kept under negative pressure to prevent odours.

4.12.3 Emergency Shutdown Sequence

In the event of situation requiring an emergency shutdown, the following sequence of events will take place:

- Both the air supply fans and waste feed to the furnace will be shut off.
- The combustion of any waste remaining in the furnace will be complete within a half hour. However, the ID fan will be kept running for a period of one hour to ensure that any combustion gases generated will still pass through the abatement/treatment systems to ensure that they are treated.
- The evaporating spray towers will cool the flue gases but not to a particular set point as during normal operation.
- The activated carbon/lime mixture supply will continue to be injected for the removal of heavy metals, dioxins, HCl, HF and SO_2 that may be present in the flue gases. Although it is not envisaged, there may be some emergency situations that require injection of activated carbon/lime mixture to be stopped, e.g. a catastrophic failure of the baghouse filter. However, the activated carbon/lime mixture present on the sleeves of the baghouse filter will continue to remove these substances from the combustion gases.
- The combustion gases will then pass through the baghouse filter and particulates will be removed as efficiently as possible.
- From there the flue gases will pass through the two wet scrubbers, which may not be as effective in this emergency shutdown mode as there will be no lime/limestone addition to the circulating solution in the scrubbers and therefore the efficiency of removal of HCl, HF and SO_2 will be decreased. However, the

activated carbon/lime mixture injection after the evaporating spray tower will assist in removal of these compounds.

- The combustion gases will then pass through the tail end flue gas cleaning system where dioxins will be removed by either an activated carbon/lime mixture injection and baghouse filter system or a carbon bed system.
- The combustion gases will then pass through the heat exchanger, which like the evaporating spray towers, will heat the flue gases but not to a particular set point as during normal operation.
- The flue gases will then discharge to atmosphere via the stack and there may be a visible plume.
- The fixed installed emissions monitoring equipment located on the stack will continue to continuously monitor the emissions from the stack and in the event of loss of power, the monitoring equipment will be supplied with electricity from the Uninterruptible Power Supply (UPS) for a period of at least one hour.

5. WATER SUPPLY AND TREATMENT

5.1 PROCESS DESCRIPTION

As the waste to energy plant will use an effluent-free flue gas cleaning process and an air-cooled condenser rather than cooling towers, it will have a significantly lower water requirement than would otherwise be the case. The main water requirement will be for the Wet Flue Gas Cleaning process. Process water (for the steam cycle), domestic potable water and water for cleaning will account for the rest of the demand. The expected water requirements are listed in Table 5.1 following:

Table 5.1 Expected Water Requirements

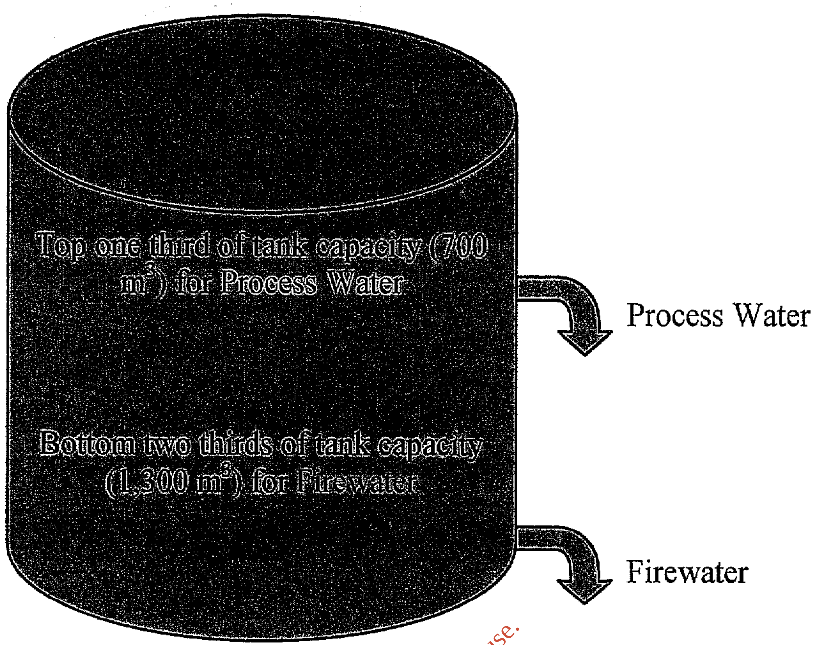
Use	Quantity (m^3/hr)
Wet flue gas cleaning	10
Process (steam cycle)	1
Domestic supplies (including drinking water)	3
Cleaning	1
Total	**15**

The raw water requirement will be supplied by retaining rainwater, groundwater abstraction and a small supply of potable water from the local water main. Approximately 1m^3/hr will be supplied from Meath County Council's water main on the R152 for drinking water supplies. Of the remaining 14 m^3/hr required, up to 10 m^3/hour of rainwater can be used in the process if available, with the balance being supplied from groundwater abstraction. Only rainwater collected within the site boundary will be used in the process. A hydrogeological test was carried out at the site to ensure that there was an adequate supply of groundwater available, which was found to be the case.

The abstracted groundwater will be stored in a 2,000 m^3 storage tank, which will store both process water and firewater. The bottom 2/3 of the tank (about 1,300 m^3) will supply firewater and the top 1/3 (about 700 m^3) will store process water. Due to the location of the take-off point for process water on this tank, it will be physically impossible to use the firewater supply for process water (See sketch of groundwater storage tank overleaf). Rainwater will be stored in a 1,500 m^3 underground storage tank located underneath the main building. A process flow diagram for the water supply process is included overleaf.

A small amount of demineralised water (approximately 1 m^3/hour) will be required for use as boiler feedwater make-up. This demineralisation plant could be based either on ion exchange or membrane technology. Process flow diagrams for both options are included overleaf.

Demineralised water will be produced in batches of about 30 m^3. With the membrane technology system there will be a continuous wastewater stream (20% of feed), which will be recycled for use in the evaporating spray towers. Both systems will require regeneration of the ion exchange resins with hydrochloric acid and caustic. For further details on the regeneration chemicals, see Table 1.10 in Attachment E5.2.



Sketch of Groundwater Storage Tank

Regeneration will be required for a period of one hour for every 30 hours the demineralisation plant is run. The spent regeneration solutions will then be recycled for use in the evaporating spray towers.

Process water will preferentially be taken from the rainwater storage tank, with the balance of the water requirement being supplied from the groundwater storage tank, which will be supplied by groundwater abstraction.

There will be small quantities of wastewater generated throughout the waste to energy plant from the process and general wash waters, which will be recycled for use in the evaporating spray towers.

5.2 Process Control

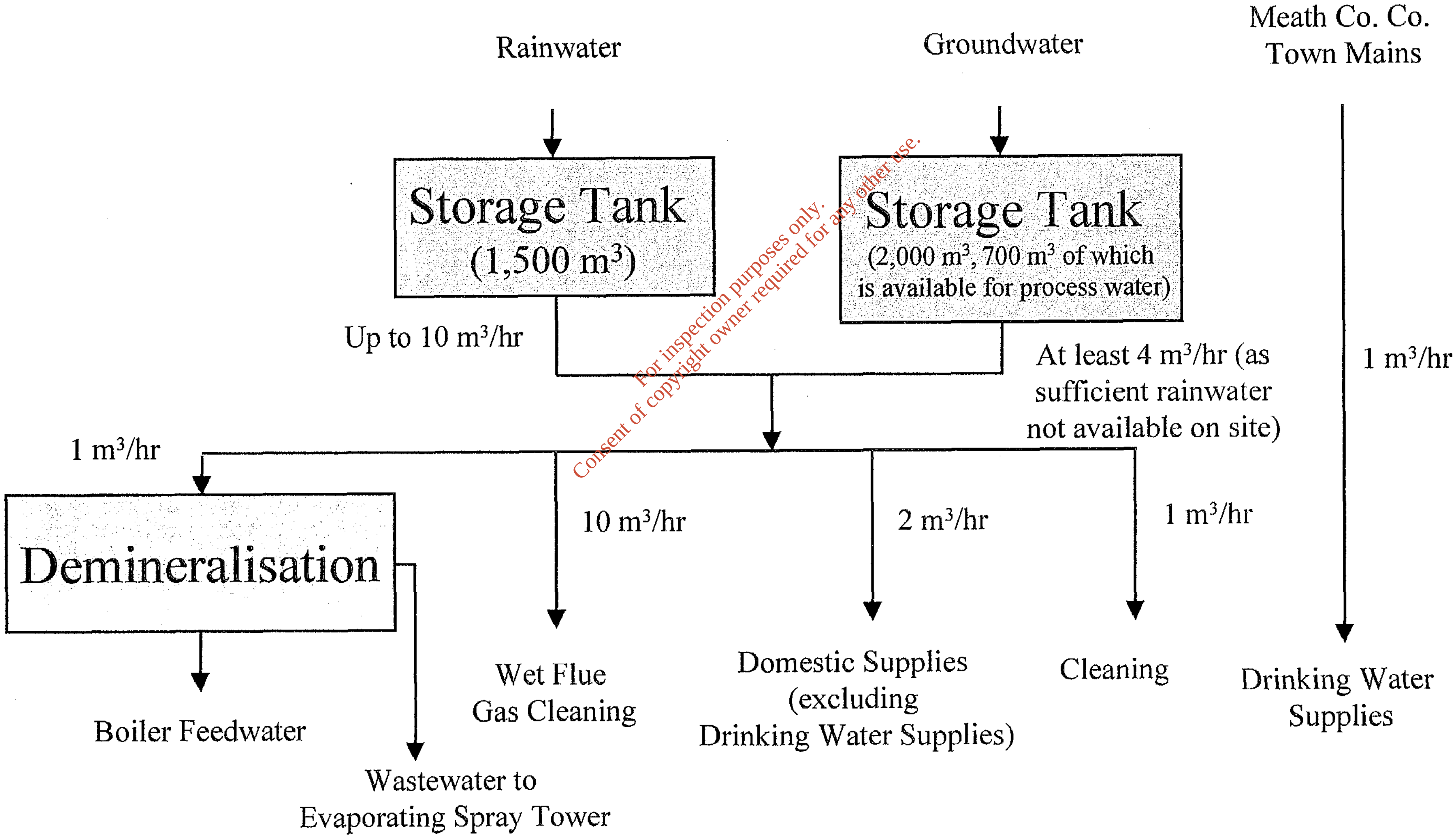
Both the groundwater storage tank and the rainwater storage tank will be provided with level switches, which will be linked into the plant's main control system. When there is sufficient rainwater in the rainwater tank up to 10 m^3/hour will be used for the process with the remaining water being supplied from the groundwater storage tank.

When the level in the groundwater storage tank falls below a set level, the submersible pumps in the groundwater abstraction well will be automatically switched on to supply water to the groundwater storage tank.

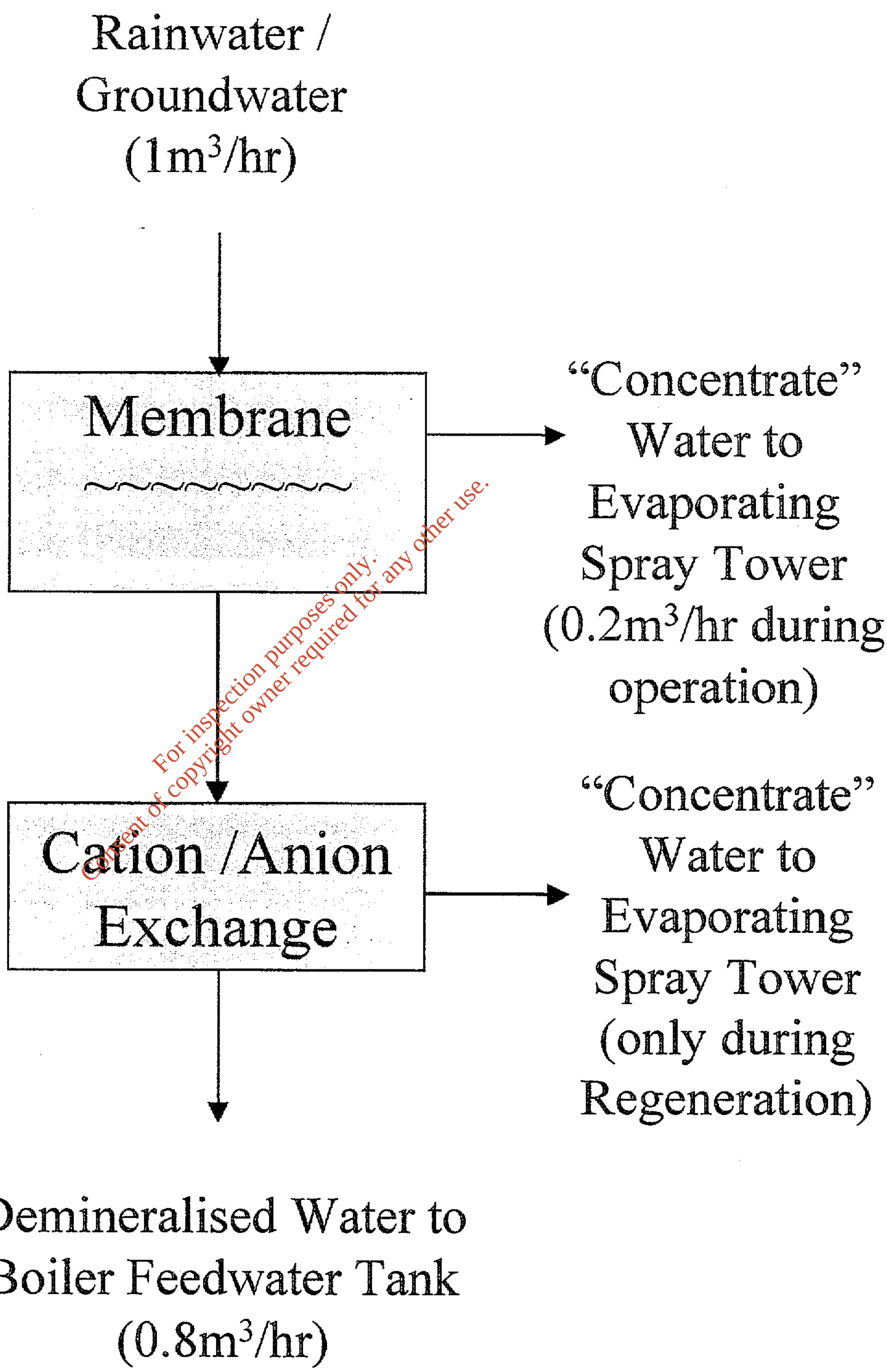
5.3 Emissions

There will be no emissions from the water supply and treatment systems other than during periods of prolonged heavy rainfall (for example a 1 in 20 year storm), when the amount of rainwater collected exceeds the process water use and storage capacity

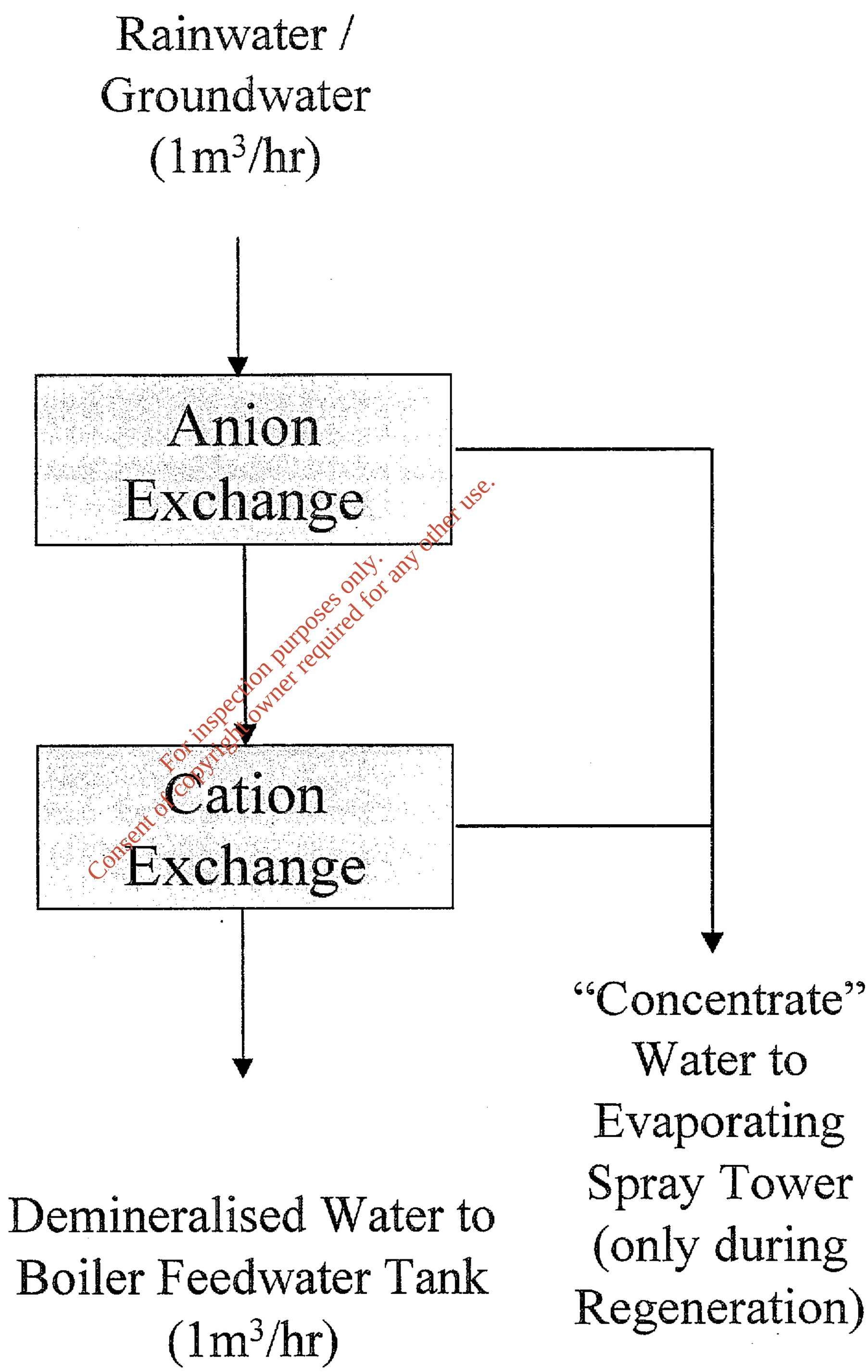
WATER SUPPLY PROCESS FLOW DIAGRAM



DEMINERALISATION
PROCESS FLOW DIAGRAM - Option 1



DEMINERALISATION
PROCESS FLOW DIAGRAM - Option 2



of the tank, the overflow will be discharged to the wet drain to the west of the site, as described in Attachment H9.1.

The construction of large areas of hardstanding can potentially lead to flooding during periods of heavy rainfall. This will be prevented by using rain water in the process and by storing excess runoff in the 1,500 m^3 storage tank.

There will be approximately 4 hectares (40,000 m^2) of hardstanding on the proposed facility. The natural runoff from 4 Ha greenfield site was calculated using the method contained in the Institute of Hydrology Report No 124 and rainfall data from the Duleek weather station. On this basis it is estimated that the natural runoff is 10.73 l/s.

Table 5.2 shows the runoff that would be discharged to a ditch for a 1 in 20 year storm and a 1 in 50 year storm.

Table 5.2 Runoff to ditch before and after development

Rain Event	Runoff from hardstanding area (litres/s)	Natural Runoff (litres/s)	Impact (litres/s)
1 in 20 year	7.57	10.73	-3.16
1 in 50 year	13.29	10.73	2.56

As can be seen, the facility will not lead to any impact for a 1 in 20 year storm, (that is the most rainfall over a day that will occur once in twenty years). Based on the institute of hydrology methodology of calculating the existing runoff, the volume of runoff to the ditch will be increased by about 25% during a 1 in 50 year storm. However, the overburden on the site consists of impermeable clay and during a 1 in 50 year storm it is likely that the site would flood and that all the rain water would run off to the ditch. The above is therefore a very conservative assessment.

5.4 INPUTS AND OUTPUTS

The average annual rainfall in the Duleek area is approximately 900 mm per annum. Over a hardstanding collection area of 40,000 m^2, approximately 36,000 m^3 of rainwater will be collected each year. The total water requirement for the plant will be approximately 112,500 m^3 per annum. Therefore, some 76,500 m^3 of groundwater will therefore be have to be used each year, or an average of about 4 m^3/hr, to supplement the water requirements. Approximately 1m^3/hr will be supplied from Meath County Council's water main on the R152 for potable supplies.

5.5 ABNORMAL SITUATIONS

In the event of loss of the demineralisation plant, it will still be possible to operate the waste to energy plant for a relatively long time period as only 1m^3/hr is required, there will be capacity in the boiler feedwater tank and then if the demineralisation plant is not back in service, the plant could be operated on demineralised water brought to site by tanker from external sources.

6. ELECTRICAL SYSTEMS

6.1 PROCESS DESCRIPTION

The electrical systems will comprise of the following:

- Electricity Generator (approximately 20 MVA)
- Connection to the ESB 20 kV (expected) lines on the HV bushings of the generator transformer
- 400 V supply to motors and equipment provided by distribution transformers.
- 220 V supply to lights, main control system etc. provided by distribution transformers.
- Uninterruptible Power Supply (UPS)
- 500 kW Back-up Natural Gas Generator

The steam turbine generator will produce electricity at between 11 kV and 15 kV. The generator transformer will step up to an expected voltage of 20 kV for export.

The distribution transformers will step the voltage down from 20 kV to 400 V and 220 V. This will allow power from the electrical distribution system to be used to start up and shut down the plant if required.

In the event of a failure of the plant, and a simultaneous failure of the supply from electrical distribution system, the plant's UPS will supply electricity to the critical control systems. The UPS will be designed to maintain supply to the control systems for at least one hour.

In the unlikely event of this occurring, the back-up gas generator will come on line and will supply electricity to critical motors, pumps and fans until the plant is safely shut down as per the emergency shutdown procedure described in Section 4.12.3.

6.2 PROCESS CONTROL

The main electrical systems will be monitored and controlled by the main control system. The 400 V supply to the motors etc. will be controlled by switches in the Motor Control Centre (MCC).

6.3 EMISSIONS

There will be no emissions from the electrical systems. The oil in the transformers will be Polychlorinated Biphenyls(PCB)-free oil. There will be emissions to atmosphere from the back-up electricity generator during the half hour testing period once per month and also in the unlikely event of the back-up generator being required.

6.4 THROUGHPUT

The plant will generate about 14 MW gross, will use about 3 MW and will export about 11 MW to the grid.

7. OTHER UTILITIES

7.1 PROCESS DESCRIPTION

The other utilities at the facility will be:

- Compressed air for baghouse filter
- Space heating and hot water for waste sorting facility and administration building
- Potable water
- Natural gas for start-up and supplementary firing

About 1,000 kg/hour of compressed air will be supplied to the baghouse filters at about 7 bar gauge by an electrically driven air compressor.

The waste to energy plant itself will supply space heating and hot water for the materials recycling facility.

The administration building will be heated using electric heater batteries in air handling units. Water heating for domestic use will be provided by electric hot water storage calorifiers or point-of-use water heaters.

A small amount of potable water for drinking water will be supplied to various areas on site.

Natural gas will be required for start-up and supplementary firing of the waste to energy plant.

7.2 PROCESS CONTROL

The compressors and compressed air supply will be controlled by the plant's main control system, with local control at the Motor Control Centre (MCC) and at the compressors themselves.

7.3 EMISSIONS

The only emission will be from the consumption of natural gas in the waste to energy plant such as carbon dioxide and water vapour, which will be emitted from the waste to energy plant. There will be no other emissions from utilities at the site.

7.4 INPUTS AND OUTPUTS

The air compressors will use 750 MWh per annum in supplying compressed air.

Approximately 202,400 Nm^3 of natural gas will be used per annum.

7.5 ABNORMAL SITUATIONS

Two air compressors will be provided (duty and standby) to ensure that compressed air is available when required.