Attachment G.1: Raw Materials

G.1.1 Raw Material Use

A list of all raw and ancillary materials requirements for the Meath waste-to-energy facility is provided in Table G.1.a. The quantities given are based on a nominal design capacity of 9.35 MJ/kg, 26.7 tonnes per hour, which is the point of maximum demand for consumables.

All chemicals will be stored and handled in accordance with relevant health, safety and environmental guidelines.

Further information on expanded clay (Dioxorb), which was not included in the previous Waste Licence application, is provided in Appendix G1.

Table G.1.a: Raw, Product and Ancillary Materials, Substances, Preparations, Fuels and Energy Used or Produced by Activity

Ref. Nº or Code	Material/ Substance(1)	CAS Number	Danger(2) Category	Amount Stored (tonnes)	Annual Usage (tonnes)	Nature of Use	R(3) - Phrase	S(3) - Phrase
M1	Ammonia solution (NH_4OH) (24.9%)	1336-21-6	Corrosive, dangerous to the environment	1	30	Boiler feedwater additive	34	(1/2), 26, 36/37/39, 45, 61
M2	Ammonia solution (NH_4OH) (24.9%)[1]	1336-21-6	Corrosive, dangerous to the environment	66	400	SNCR reagent	34	(1/2), 26, 36/37/39, 45, 61
M3	Urea[1]	57-13-6		83	448	SNCR reagent		
M4	Activated carbon	7440-44-0	N/a	35	122	Flue gas treatment	N/a	22, 24/25
M5	Expanded clay (Dioxorb)	1305-62-0	Irritant	35	122	Flue gas treatment	38, 41	22, 24, 25
M6	Hydrated lime ($Ca(OH)_2$)	1305-62-0	Irritant	217	1,000	Flue gas treatment	41	26, 39
M7	Quick lime (CaO) (95%)	1305-78-8	Irritant	432	2,647	Flue gas treatment	41	26,39
M8	Trisodium phosphate (Na_3PO_4)	7601-54-9	Corrosive	0.5	6	Boiler feedwater additive	34	26, 36/37/39, 45
M9	NaOH (50%)	1310-73-2	Corrosive	1.6	27	Demineralisation	35	(1/2),26, 37/39, 45
M10	HCl (30%)	7647-01-0	Corrosive	1	30	Demineralisation	34, 37	(1/2)26, 45
M11	Light Fuel Oil	68334-30-5	Harmful, dangerous to the environment, Flammable	34	300	Auxiliary firing in furnace	10, 51/53, 65, 66, 67	16,24, 29/35, 61, 62
M12	Diesel oil	68334-30-5	Harmful, dangerous to the environment, Flammable	6.8	15	Fuelling onsite vehicles	40, 65, 52/53	24, 36/37, 43, 62
M13	Hydraulic Oil	Mixture	Harmful	0.9	5	Lubrication of moving parts	N/a	N/a

[1] Either Ammonia solution or Urea can be used as a SCNR reagent

Ref. Nº or Code	Material/ Substance[(1)]	CAS Number	Danger[(2)] Category	Amount Stored (tonnes)	Annual Usage (tonnes)	Nature of Use	R[(3)] - Phrase	S[(3)] - Phrase
M14	Oil free of Polychlorinated biphenyl (PCB)	63148-62-9	N/A	7.3	0	Transformers	N/A	N/A
M15	Electricity import	N/A	N/A	N/A	2,380 MWh[2]	Provide site load in event of shutdown	N/A	N/A
M16	FGT-residues	Mixed, need analysis on a case by case basis	Harmful to aquatic organisms, may cause long term effects in the aquatic environment	126	10,000	Products of flue gas treatment process	R52/53	N/A
M17	Boiler ash	Mixed, need analysis on a case by case basis	Harmful to aquatic organisms, may cause long term effects in the aquatic environment	84	1,000	Products of waste combustion	R52/53	N/A
M18	Bottom ash residue	Mixed, need analysis on a case by case basis	N/A	1,240	50,000	Products of waste combustion	N/A	N/A

Notes:
1. In cases where a material comprises a number of distinct and available dangerous substances, please give details for each component substance.
2. c.f. Article 2(2) of SI Nº 77/94
3. c.f. Schedules 2 and 3 of SI Nº 77/94

[2] Anticipated to be no more than 980 hours per year at 2.48MW

G.1.2 Modifications to Raw Materials

The principle modifications to raw material use approved in Waste Licence 167-1 are outlined in Table G.1.b below.

Table G.1.b: Modifications to Raw Materials

Aspect	Difference
G.1.1	The consumption of a number of reagents has decreased in line with an increased plant efficiency. The consumption of ammonia, lime and limestone has significantly decreased. Lime and limestone have been replaced with lower quantities of hydrated lime and quicklime as there is no longer a wet flue gas treatment stage. Expanded clay, Dioxorb, is now being used and has replaced some of the activated carbon previously used in the flue gas treatment system. Lignite cokes will no longer be used. Light fuel oil rather than natural gas will be used in the auxiliary burners. The consumables required for the solidification of flue gas treatment residues are not included as it is not envisaged this activity will take place onsite unless suitable landfill capacity is made available, as explained in Attachment H.4. Increased quantities of trisodium phosphate, caustic, hydrochloric acid and hydraulic oil will be used and stored onsite in line with the increased throughput. Greater quantities of ash will also be stored onsite.

Attachment G.2: Energy Efficiency

G.2.1 Energy Efficiency

G.2.1.a Waste Framework Directive

The recently revised Waste Framework Directive (see Annex II of text adopted in Parliament on the 17th June 2008 in Appendix G2) considers energy efficient waste-to-energy facilities to be recovery plants, assigning them a R1 code. To qualify for this recovery code, new plants must have a 0.65 efficiency factor according to the R1 formula used in the Directive. This is calculated as follows:

$$(E_p - (E_f + E_i)) / (0.97 \times (E_w + E_f))$$

Where:

E_p = annual produced and utilised energy from waste (total of heat/steam plus electricity as equivalents) (MWh/h). According to the BREF notes, this includes both exported and circulated energy. Electricity output is multiplied by 2.6 as it is considered to be more valuable[3] than heat. Heat output is multiplied by 1.1.

E_f = annual energy input to the system by imported energy (fuels) with steam production (MWh/h), e.g. auxiliary fuels. Only the energy contributing to normal operations is included here.

E_i = annual imported energy without steam production (MWh/h) e.g. for start up and shut down

E_w = annual energy input to the system by waste (MWh/h)

0.97 = factor accounting for energy losses in bottom ash and by radiation

As per the Waste Framework Directive, the formula has been applied in accordance with the reference document on the Best Available Techniques for waste incineration (Annex 10.4 as attached in Appendix G3). The parameters used are listed in Table G.2.a below.

Table G.2.a: Parameters used in R1 calculation

Parameter	Value used[1]	Comment
E_p	(17.2MW x 2.6) + (2.7MW x 1.1) = 47.65	The total electricity production from the plant is 17.2MW. Approx. 2.7MW steam is also produced and circulated within the plant for pre-heating combustion air, SNCR injection and other requirements.
E_f	1.0MW x 0.33 x 1.1 = 0.36	Only one third of the auxiliary fuel is used during normal operations - the remainder is used during startup so does not contribute to the production of steam. This is multiplied by the heat conversion factor.
E_i	(0.08MW x 2.6) + (0.12MW x 1.1) = 0.34	Approx. 0.08MW electricity and 0.12MW steam are used for startup. These are multiplied by the relevant conversion factors.
E_w	69.3MW	The total heat input to the boiler from the waste is 69.3MW

[1] Units are 1 MWh/h

[3] The range of potential uses for electricity is greater than that for heat.

From this calculation, the Meath waste-to-energy facility will have an efficiency of 0.70 and should therefore qualify for a R1 code.

A spreadsheet of calculations is included in Appendix G4. This was completed by Dr. D. Reimann, Scientific and Technical Advisor to CEWEP[4], an expert on this subject and author of a comprehensive review of the energy efficiency of waste-to-energy plants across Europe[5].

G.2.1.b Energy Efficiency in Design

The facility will be designed with energy efficiency as a priority in order to maximise electricity production.

Heat from the combustion of waste will be converted to electricity at a gross efficiency of 25% and a net efficiency of 21% (when in-house consumption is netted off). The energy efficiency of a waste-to-energy plant is lower than that of a typical power plant because of the requirement to maintain temperatures and pressures below levels at which corrosive flue gases attack boiler components. This reduces the potential for steam output from the boiler and limits electricity generation. Waste-to-energy plants must also operate with a higher quantity of excess air, compared with power plants, to meet lower emissions limits. This also reduces the energy efficiency of the plant because heat is lost to the additional combustion air.

Some of the Best Available Techniques selected for the plant to optimise energy efficiency are outlined in Attachment L.1.3. These include:

- Minimising flue gas heat losses by:
    - optimising primary and secondary air distribution to minimise excess air requirements
    - minimising the boiler exit temperature to ensure the maximum transfer of energy from the flue gases to steam
    - selecting a flue gas treatment technique that does not require re-heating at any stage (i.e. where the temperature decreases from the boiler exit to the stack)
- Ensuring the thermal conversion efficiency of the boiler will be greater than 80%
- Selecting a turbine suited to high energy efficiency and maximum expansion of steam to very low pressure (0.1 bar, in vacuum)

The overall energy demand on the site has been minimised by:

- Selecting low energy systems, such as the SNCR system for NO_x abatement
- Minimising the use of primary fuels by using energy produced onsite
- Sourcing secondary combustion air from the main process building where it is effectively pre-heated
- Installing variable speed drives on fans and pumps

As well as factoring efficiency into design considerations, the efficient use of energy and resources is an ongoing concern at all Indaver facilities. It is one of the

[4] Confederation of European Waste-to-Energy Plants, see http://www.cewep.com
[5] Reimann, Dr. D., *CEWEP Energy Report (Status 2001-2004)*, Germany, 2006

11 key objectives in the Indaver Improvement Plan (see Attachment C.2). Targets set out under this objective include items such as:

- Reviewing in-house energy and resource usage by:
    - conducting electrical inspections
    - conducting regular energy efficiency audits
    - establishing Key Performance Indicators (KPIs) for these resources
- Developing energy reduction initiatives including:
    - awareness campaigns
    - energy management systems
    - installing motion detectors for lighting

An example of an awareness campaign run at existing Indaver facilities in Ireland is attached in Appendix G5.

G.2.1.c Energy Balance

In summary, for a 69,3MW waste thermal input per incineration line the following heat balance is expected:

- Heat loss by radiation from the hot equipment (furnace, boiler, steam cycle) is approximately 1.5 MW (2% for the boiler furnace, 1% for the remainder). This heat is not recovered but does heat the building before being evacuated through the natural draft building ventilation to atmosphere,
- 61.3MW is converted into steam. The remaining 9.7 MW of heat is released from the boiler to the flue gas treatment system,
- Steam at 40 bar / 400^oC enters the turbine and steam at 0.15 bar / 46^oC leaves the turbine The 61.26 MW steam is converted to 17.2 MW electricity. The vacuum steam leaving the turbine is condensed in a closed loop in the air cooled condensers. The excess heat is released into the atmosphere,
- Because of the power of the ID-fan, 0.5 MW is added to flue gas going to the stack,
- 1.2 MW is lost over the wet deslagger,
- 0.04 MW is lost over the flue gas residue silo.

A heat balance for the site is shown in Figure G.2.a below.

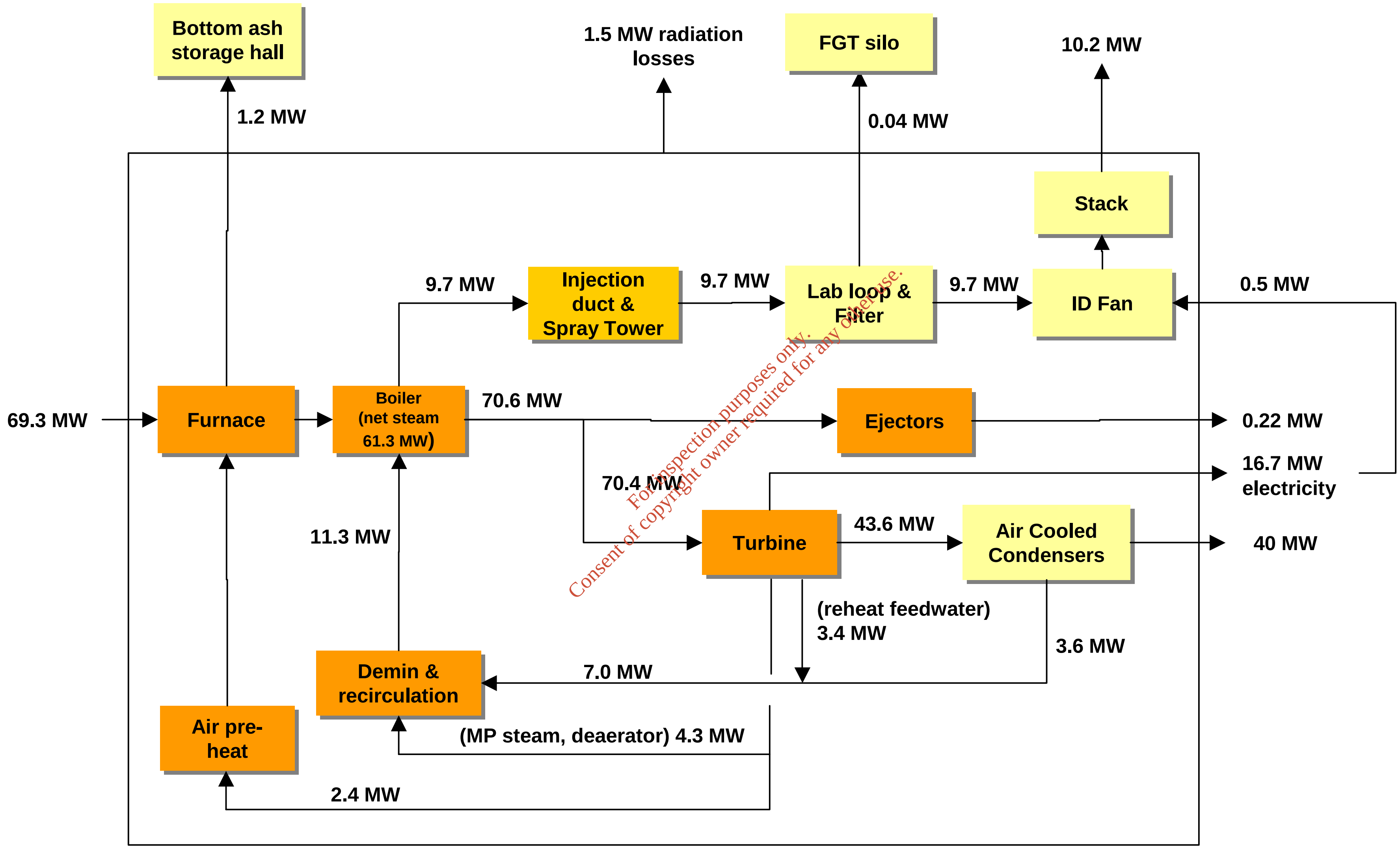

Figure G.2.a: **Heat Balance for Meath Waste-to-Energy Plant**

G.2.2 Modifications to Energy Efficiency

The principle modifications to energy efficiency initiatives approved in Waste Licence 167-1 are outlined in Table G.2.b below.

Table G.2.b: Modifications to Energy Efficiency

Aspect	Difference
G.2.1.1	The Waste Framework Directive has been revised since 2001 to include a new energy efficiency criteria, which determines whether waste-to-energy plants can be classified as recovery operations. According to the R1 formula in the Directive, the facility will have an efficiency of 0.70 and therefore qualifies as a recovery plant.
G.2.1.3	The revised plant design has a greater focus on energy efficiency, resulting in an increase in gross energy efficiency from approximately 23% to 25% and in net energy efficiency from approximately 18% to 21%. The steam at the turbine outlet will have lower temperatures and pressures than previously envisaged, increasing energy recovery. The flue gases are no longer re-heated prior to discharge via the stack for plume abatement, reducing energy consumption.