# **Energy recovery of waste using incineration technology**

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## Introduction

In light of the ambitious goals set by the National Waste Management Plan promoting the development of Energy Recovery Facilities (ERF), combustion seems the most viable solution for the treatment of residual waste albeit public objections. An opportunity has arisen given the circumstances; including the introduction of the Landfill tax which could make energy recovery cheaper than Landfill disposal, as well as the energy and fuel crisis seeking for renewable energy and the goals set by the government minimising coal usage.

An example of a quite large state of the art ERF would be operating in 2 processing Lines with a capacity to deal on average 25 tonnes/hr each for approximately 7.800 hours annually with circ. 90% availability processing 400.000 tonnes annually. The good operational record will be ensured by having an Outage period for maintenance activities scheduled, usually taking place twice per annum with a duration of 2 weeks. The operator would charge the authorities for the gate fee, for the electricity that would be exported to the grid, as well as for the Intermediate Pressure steam extracted in a CHP facility and sent to nearby facilities or the steam distributed at a lower range to district heating networks. Given the arrangements in place ie the use of vibrating tables, overband magnets or drums the operator could make additional profit secondarily from the metals that could be recovered from the bottom ash fraction.

#### Discussior

The purpose of an ERF following the waste hierarchy is to recover the non recyclable waste which would otherwise been driven to Landfill for subsequent disposal. Although incentives are given for the use of recyclates as a raw material to convert into new materials thereby reducing virgin raw materials including plastics, there can be challenges. In a highly adaptive and constantly changing market with many drivers affecting the supply chain ie prices, purity protocols, incidents with a global scale impact like the China Ban effect etc. sometimes it is highly improbable the recyclates to be absorbed by the Producers and would therefore be disposed to Landfills. The use of ERFs can be used complimentary for the waste fraction that cannot be recycled.

Primarily non-hazardous Municipal Solid Waste (MSW) and similar waste may be fed to the incinerator. The grate type that has predominantly been used, is the moving grate technology one. It's widespread application relies on the robust design and it's technological advanced features. The untreated waste offers in theory several benefits including the avoidance of treatment costs and the processing of a wider range of feedstock. By doing so, it seems as if the operator is provided with benefits and flexibility however, there are several limitations that shall be considered. By the diverse nature of the treating waste and the incineration practice, combustion could create several issues to mechanical equipment, frequent blockages, unstable operation due to inhomogeneous calorific value, non combustible materials coming of the bottom ash, while pollution problems could be caused. Even the type of waste that by it's state could be seen as being non hazardous ie plastics a common type of waste within the refuge which might offer a good heating value, however during the burning process it releases pollutants such as high Cl, S emissions.

The recovered biodried RDF or certified SRF gives more confidence to the operator as it follows a standard regime which requires routine sampling procedures and monitoring laboratory analysis. By doing so the feedstock is certified for it's performance on low moisture, ash percentages, suitable calorific value, low impurities ie Cl etc. To avoid operational issues, the Environmental Permit sets among other things, a list of accepted materials under the European Waste Catalogue (EWC) which can be treated and request from the operator to provide means of compliance assessment including; protocols for dealing with non-conforming waste and carrying out regular sampling and

 Waste code
 Description

 03
 TS 01 02; 15 02
 Minel packaging: Aborbents, filter materials, wiping cloths and protective clothing, but only the fraction that is contaminated or can not be practically recycled or reused and would otherwise be destined for landfill.

 19 05 01
 Waste from excelbe treatment of solid wastes

 19 06 04
 Waste from excelbe treatment of solid wastes

 19 06 04
 Waste from anaerobic treatment of municipal wastes, but only the fraction that is contaminated or can not be practically recycled or reused and would otherwise be destined for landfill.

 19 12 01; 19 12
 Waste from machanical treatment of wastes

 07;
 Paper and cardboard; Wood other than mentioned in 19 12 06\* and textiles, but only the fraction that is contaminated or can not be practically recycled or reused and would otherwise be destined for landfill.

 20 01 01; 20 01
 Manicipal Wastes

 19 12 001 01; 20 01
 Municipal Wastes

 20 01 10; 20 01
 Municipal Wastes

 11;
 Paper and cardboard; Biodegradable kitchen and canteen waste; clothes; textiles; Wood other than mentioned in 20 01 37\*; Plastics, but only the fraction that is contaminated or can not be practically recycled or reused and would otherwise be destined for landfill.

 20 01 10; 20 01
 Municipal Wastes

 11;
 03 01; 20 03

 03 03; 20 03
 Garden and Park wastes

 12 03 01; 20 03
 Garden and Park wastes

 13 01; 20 03
 Garden and Park wastes

Figure 1 List of acceptable waste indicated by the Environmental Permit including RDF and other waste fractions ie digestate. Additional measures shall apply ie for the fractions contained in the mixed MSW under Chapter 20 of the EWC which might pose operational hazards. An example might be the bulkies which would require additional treatment such as shredding.

monitoring analysis to assess compliance with their outputs including ash and emissions.

As part of the planned maintenance activities and the annual maintenance plan, by law there are requirements for periodic inspection and testing of Pressure Equipment by the competent authorities, checks of the steam boiler, expansion valves and so on. Additionally, preventative maintenance shall cover calibration of measuring equipment, regular periodic inspections, e.g. Non Destructive Tests (NDT) and inspections of the heat exchangers part for wear ie measuring the thickness of heat tube exchangers, replacement of refractory materials, regular cleaning of parts ie the boiler, tensioning belts, lubrication of moving parts, filters change and parts of the auxiliary equipment ie lifting beams to be inspected by competent authorities and so on. Outage covers the Worker Orders that can be conducted as appropriately. The primary objective is to run the plant at it's highest availability and offset any downtime costs.

In addition to preventive maintenance requirements, there are ongoing issues that require continuous monitoring and regular attention is treatment of blockages. Although training and supervision has been provided by the EPC, these issues could not always be claimed under contracts, as the EPC might prove that these failures are attributed to operational misuse. Although the contractor has provided the necessary warranties e.g. 40.000 guaranteed hours of operation for a type of heating tubes and the number of critical spare parts required, many times wear resulting from omissions or failures by the operator, e.g. not properly monitoring the demineralised water, ineffective cleaning of soot deposits and so on can halve lifespan of tubes. Lifetime of tubes at elevated temperatures is reduced exponentially and relatively to the Temperature drifting, resulting in thinning of tubes which in turn has a knock on effect to the steam boiler and therefore to the operation of the plant. The formation of soot driven mainly by the high operating Temperatures from combustion and the acidic environment by the acid gases formed inside the boiler leads to heating tube failures. Frequent breakdowns in the feeding system ie failure of the cranes can on efficiency - Carbon in ash hinder the grate supply. The level of water in the Boiler Drum could cause operational issues. The non-calibration of measuring equipment could lead

	a same				434	HV works,	Inspection maintenance & testing		6 hrs	
	an Lood	Durati	on Start		435	General lig	fiting external		96 hrs	
229	a se indiate		start	Finish	430		hting internal		0 hrs 0 hrs	
230	Prep turbine Pre-heat	48 hrs	s Sat 08/04/17 19	:00 Mon 10/04/17	438	Work Orders			72 hrs	
231		6 hrs	Sat 08/04/17 19:	00 Sun 09/04/17 0	439	Gland repac	uge slight steam leak on pipework - 565470- 23LBA30CP k and valve overhaul - 23LBA10AA002N	\$100P01	12 8/3	
6	Start up turbine and export power	6 hrs	Sun 09/04/17 01	500 Sun 09/04/17 0	440		N/5 - sight glasses require maintenance - 23HAD10CL5	100901	12 hrs	
	Pre-Outage Line 4 Cool Down	36 hrs	Sun 09/04/17 07:	Contraction of the contract of	441		ar door of ash extractor line 3 left - 23HDA21CL101-801		12 hrs 12 hrs	
	Off Waste	0 hrs	Mon 10/04/17 19	00 Mon 10/04/17 : 00 Mon 10/04/17 :	442		eseal and Furmanited flange repair - 23LAE11BRXXXX		12 8/5	
	Cool down period	22 this	Writ 27/02/37.10	WGN 10/04/1/1	443		n is leaking oil from the seal - 23HHC10AE002		12 hes	
	Perint new Period	9 days	Wed 29/03/17 19	:00 Sat 01/04/17 19	445		e wiring to the motor pillar - Defect 66 n work packs P2WP 390 and 391		36 hrs 36 hrs	
	Permit prep & isolations	0 hrs	Wed 29/03/17 19:	00 Wed 29/03/17 1	446		iot close - 23HLA60AA002F		12 hrs	
	Englection and a second s	60 hrs	Wed 29/03/17 19:	00 Sat 01/04/17 07:	447	United Street Managers	e dump valve condition - 23ETG14AA020-S01		6.hrs	
1	Engineering Works	12 hrs	Sat 01/04/17 07:00	Sat 01/04/17 19:0	448		e dump valve condition - 23ETG14AA020-S01		6 hrs	
	Furnace, Boiler & Pressure Parts	434 hts	SAUGIJON/17-07-SK		449	Overhaul and	test boiler level gauge - 23HAD10CL510QP01		72 hrs	
1	Furnace External	414 hrs	Sat 01/04/17 07:00	Tue 18/04/17 13:	450		23QKD15AP001		12 hrs 12 hrs	
1	Open all furnace doors	411 hrs	Sat 01/04/17 07:00	Tue 18/04/17 10-0	451		sak on bags - 23RJC18CL301-F01		12 hrs	
	Remove blocks	2.5 hrs	Sat 01/04/17 07:00	Sat 01/04/17 09-34	452	Suspect dust le	ak on bags - 23RUC15CL301-F01		12 hrs	
	Check clinkers via level 9 doors	1 hr	Sat 01/04/17 07:00	Sat 01/04/17 08:00	453	Suspect dust les	ak on bags - 23RJC11CL301-F01		24 hrs	5
	Furnace	1 hr	Sat 01/04/17 08:00	Sat 01/04/17 09:00	154	Drain valve over	rhaul regulred - 23HANXXBRXXX ube water leaks - 23QKC42BR012C 🖛		72 brs	
	Rope access to remove clinkers 1st pass	0.5 hrs	Sat 01/04/17 09:00	Sat 01/04/17 09-20	55	Theodore marker 12 hi	the tile connector leaks and sheared bolt - 23QKC428	R013C 🖛	72 hrs	
	Install bridge & hand rail	360 hrs	Sat 01/04/17 19:00	Sun 16/04/17 19:00	56.	Under grate o to	Clutch is bent and sticks in when depressed in - 23LB/	10AA002N-M01	6 hrs	
	Install furnace lighting	5 hrs 2 hrs	Sat 01/04/17 19:00	Sun 02/04/17 00:00	4	PERCEPTION	Contraction of Contraction Contraction Contraction		Page 10	
	Internal clinker inspection	30 mins	Sun 02/04/17 07:00	Sun 02/04/17 09:00			and the second sec			
	Clean grate (ash extractor minning and sch askes)	30 mins	Sun 02/04/17 09:00	Sun 02/04/17 09:30	1					
	Clean grate (ash extractor running and ash grabs in auto) - To include a jet wash of all tiles (screening to be installed Grate snots - "Out" stroke	15 hrs	Sun 02/04/17 09:30	Sun 02/04/17 10:00		A ANIS	PARTIN			
	Install 1st pass scaffold	4.5 hrs	Sun 02/04/17 10:00 Sun 02/04/17 15:00	Sun 02/04/17 15:00	-		and the second		ORTABLED SPECIFICATION	-44
	Hard clean of existing inconel	9 hrs	Mon 03/04/17 07:00	Sun 02/04/17 19:30						
	Grit blast 1st pass existing inconel	3 hrs	Mon 03/04/17 16:00	Mon 03/04/17 16:00	here					
	Clean down scaffolding - 1st pass	12 hrs		Tue 04/04/17 07:00						
		1 hr		Tue 04/04/17 08:00						
	Mobilise refractory company	2 hrs	the second	Tue 04/04/17 10:00	1	feest Morgal	67616-239-51-7647		Remarkant Leasting for puting	-go
	Set up of equipment for refractory works (anternal)	0 hrs	Tue 04/04/17 10:00	Tue 04/04/17 10:00						
	Grit blast 1st pass existing income	9 hrs		Tue 04/04/17 19:00		Hossier	67610 236 51 5002		Grate the	
	Clean down scattelding - 1st pass			Ved 05/04/17 07:00		Rossner	57045 236 61 1052		and the second second	-
	Defeater weeks Child 1		Wed 05/04/17 07:00 V	CONTRACTOR OF STORE STORE STORE STORE STORE		Researce			Gratis (in	
				/ed 05/04/17 19:00			57075 236 07 1064	-	finite work the soft	
				10 06/04/17 10:00 10 06/04/17 19:00		Rossner	57016 236 D1 1061		lipster west tim but	0
				07/04/17 07:00		Planaster	87016 236 01 1062	Contraction of	Side wat the rig	-
				07/04/17 19:00		Photosovar	67016 206 00 1062	1	and the second	-
				Contraction of the Contraction o	the second se				Nide wall be no	ALC: NO.

**Figure 2** Typical Outage breakdown (on the left and side). Work Orders are executed, defects are rectified, changes are implemented during the Outage as a window of opportunity arises (at the bottom right section). Part of the critical spares list inventory supplied by the EPC which is monitored by the operator considering the spares consumption and lead time (At the top right side)

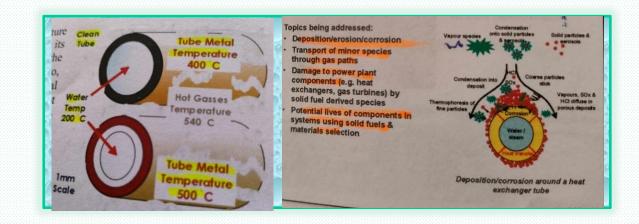




Figure 3 Root causes of boiler tubes failures including scale inside the heat exchanger and

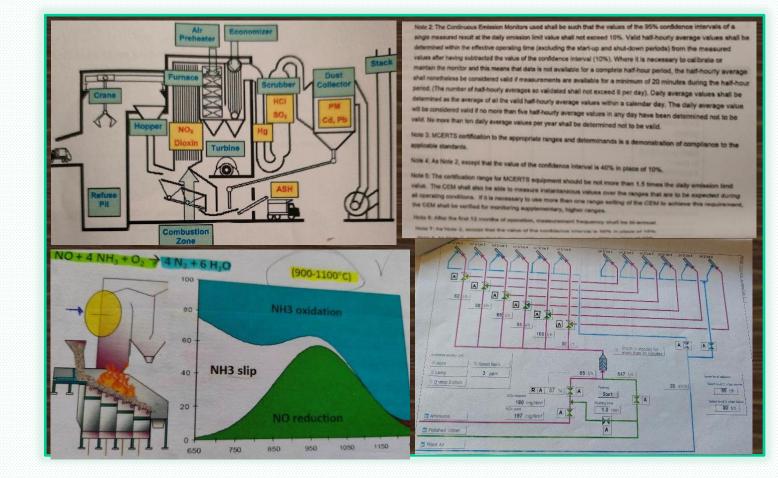
deposits formation around the heat exchanger tube (at the top). Effects on Boiler tubes

thinning, scabbing, pitting, Flow Accelerated Corrosion and cracking (at the bottom)

Frequent breakdowns in the feeding system ie failure of the cranes can hinder the grate supply. The level of water in the Boiler Drum could cause operational issues. The non-calibration of measuring equipment could lead to operational parameters drifting and major operational control issues. The damage of the cooling system in a water-cooled grate could cause the fast reduction of the grate tiles lifespan. The ineffectiveness of boiler cleaning e.g. insufficient Pressure on rapping gear system, operating in the heat exchangers section, or the interruption of cleaning flow on the shower cleaning system operating in the 2<sup>nd</sup>/3<sup>rd</sup> pass section, would lead to fouling, transfer heat inefficiencies, thinning and wear to the heat exchanger tubes. The deficient monitoring of water quality would cause scale and failures to the tubes and other parts of the boiler by the steam carry over. Auxiliary Burners failure, the noncalibration of the Continuous Emissions Monitoring System (CEMS), the incorrect supply of chemicals or failure of equipment ie SNCR supply, may result in abnormal operation and could result in environmental fines. **Figure 4** Indicative key operational parameters which must be monitored



#### Figure 7 The boiler rapping system



**Figure 8** Indicative hazardous pollutants generated at different stages of the plant and treatment technologies, Any dioxins reformed as part of cooling within the economiser zone are treated with the addition of activated carbon (At the top left corner). Continuous Emissions Monitoring System (CEMS) requirements according to EN 14181 (At the top right corner). SNCR dosing system (at the bottom side)

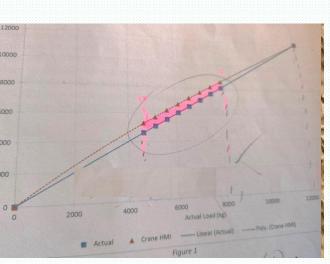


Figure 5 Waste Cranes load cells quarter calibration regime against calibrated weighbridge carried out with the use of load tests.
Calibration results to be plotted to monitor inconsistencies of drifting between the DCS values and the actual operating envelope

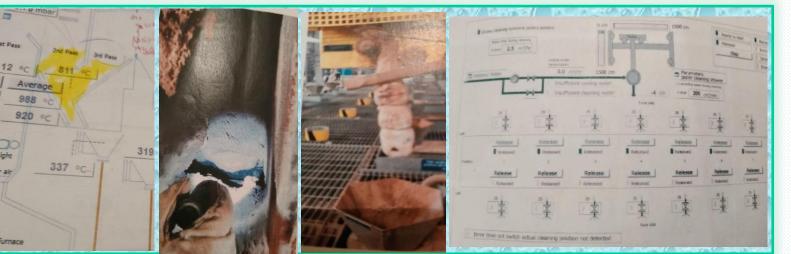


Figure 6 2<sup>nd</sup>/3<sup>rd</sup> pass blockages and the Boiler shower cleaning system