



Waste-to-Energy

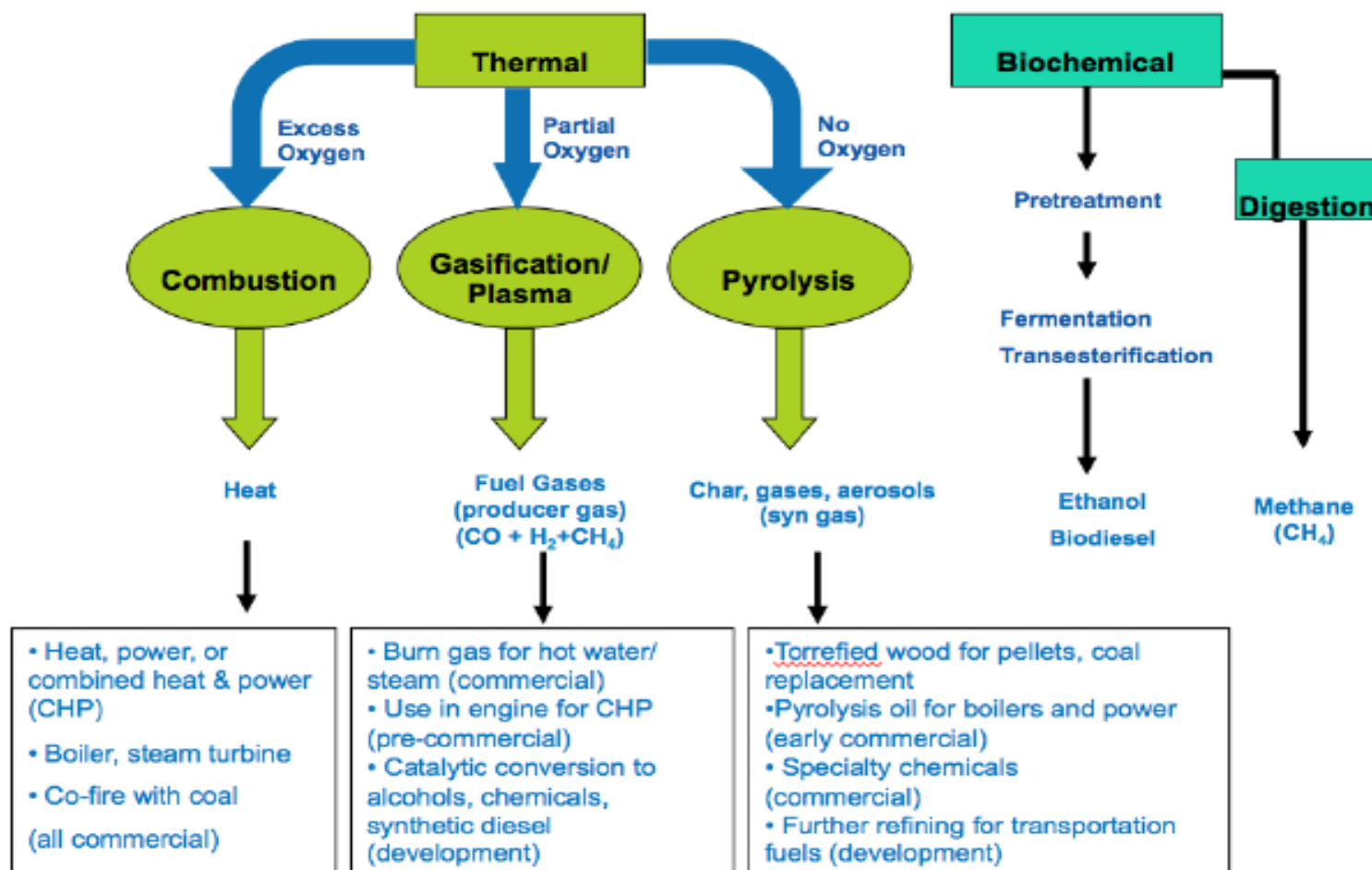
A Case Study

Waste Expo – October 2014

Part 1 - The pathways



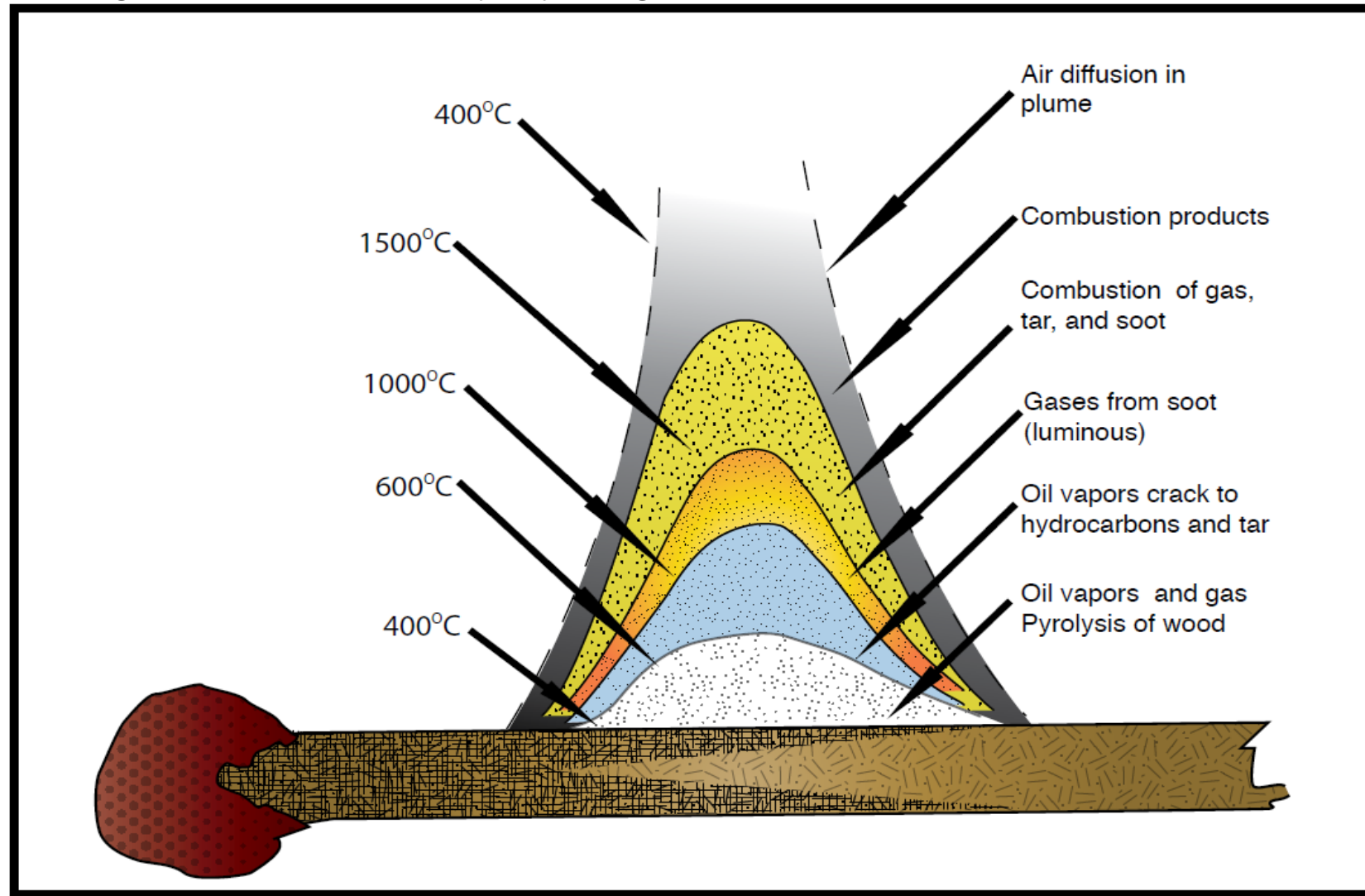
Waste-to-Energy Pathways



The humble match

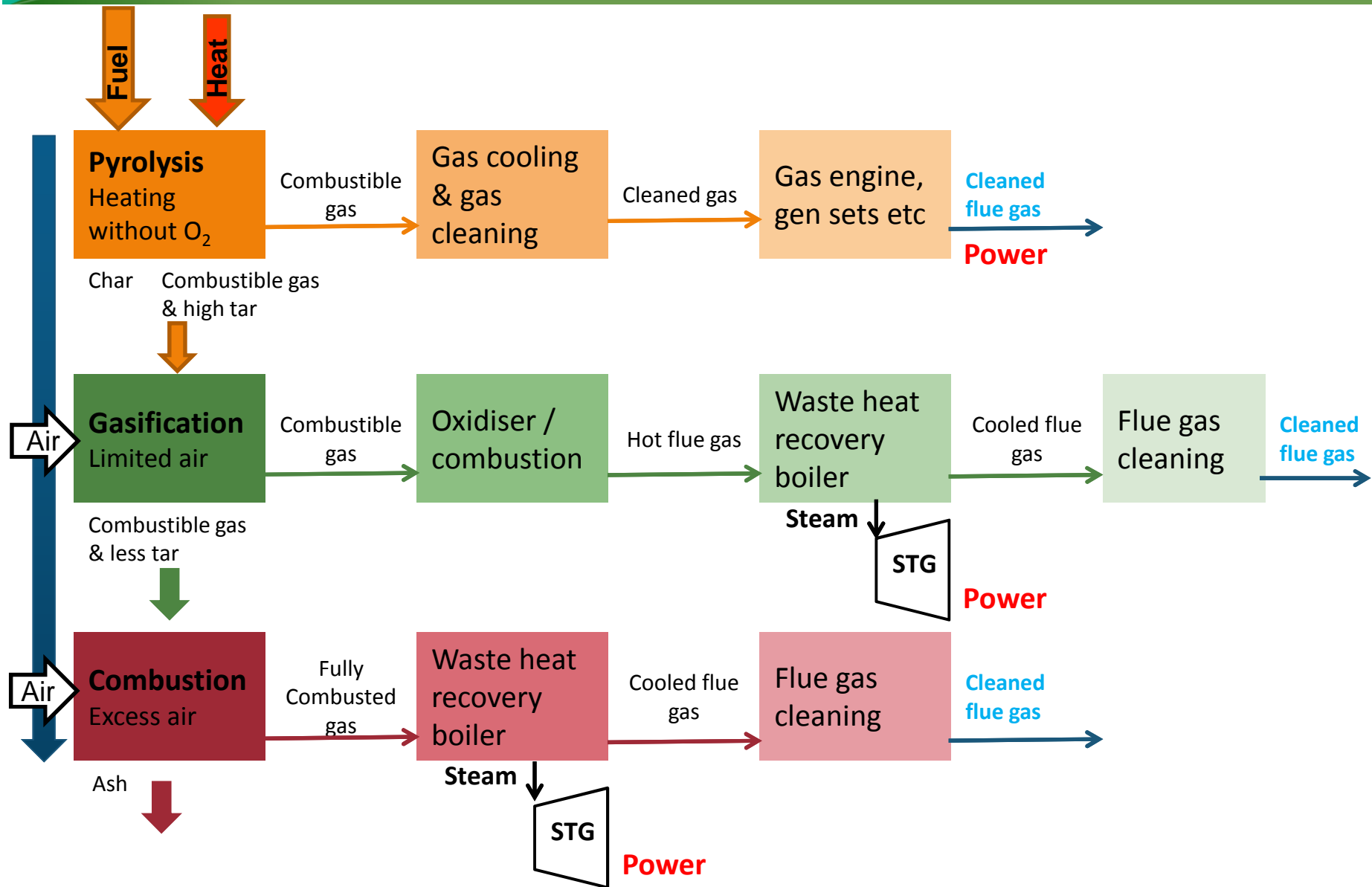


Stages of combustion: pyrolysis, gasification and complete combustion



Adapted from Tom Reed

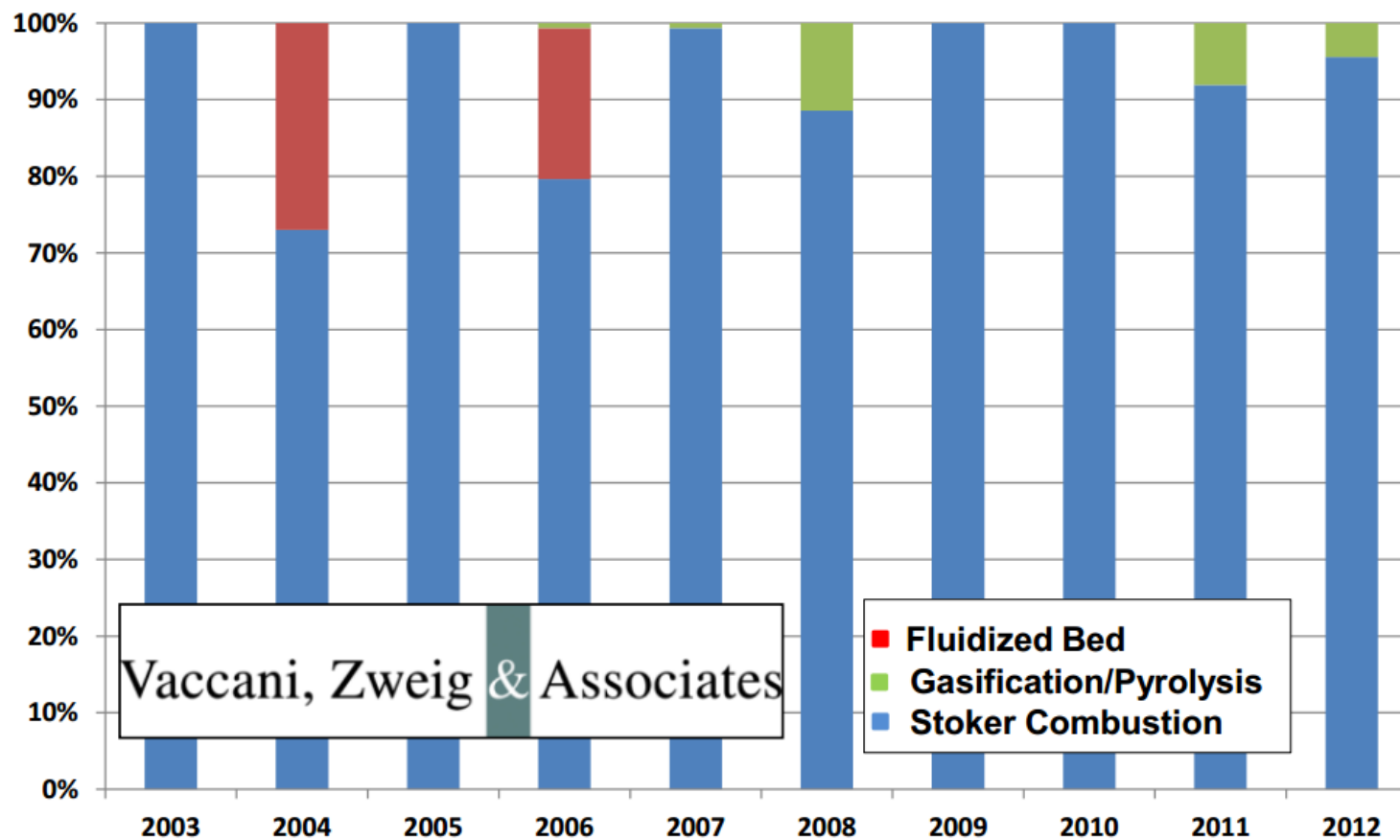
Conversion steps



What are Europeans buying?



Market Shares of Technologies in Europe



Part 2 - The study



- In 2009 Privately owned C&D waste recycling company initiate 3MWe WtE enquiry
- Budget pricing received from European WtE power plant supplier
- European cost levels would not support WtE projects in Australia

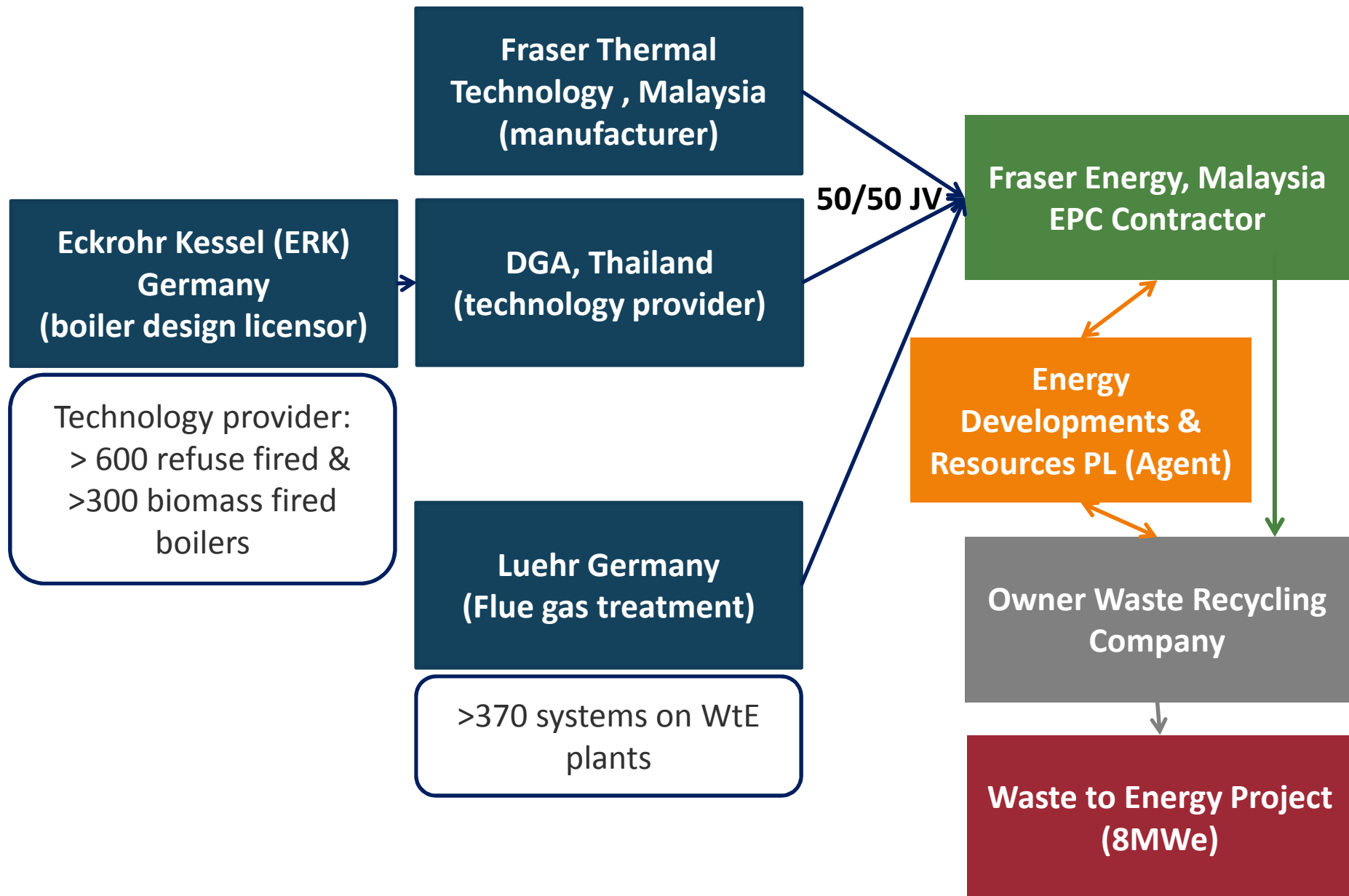
The challenge



Find a more viable alternative waste-to-energy plant that would provide:

- the comfort of proven **European technology**
- at a cost more in line with **Asian pricing**
- while meeting **Australian Commonwealth and State legislation.**

Main parties involved



Brown field environment: constrained site



Accommodating brown field location



Initial viability study included waste-to-energy plant sizes from 3MWe to 15MWe with customer final selection being 8MWe gross output.

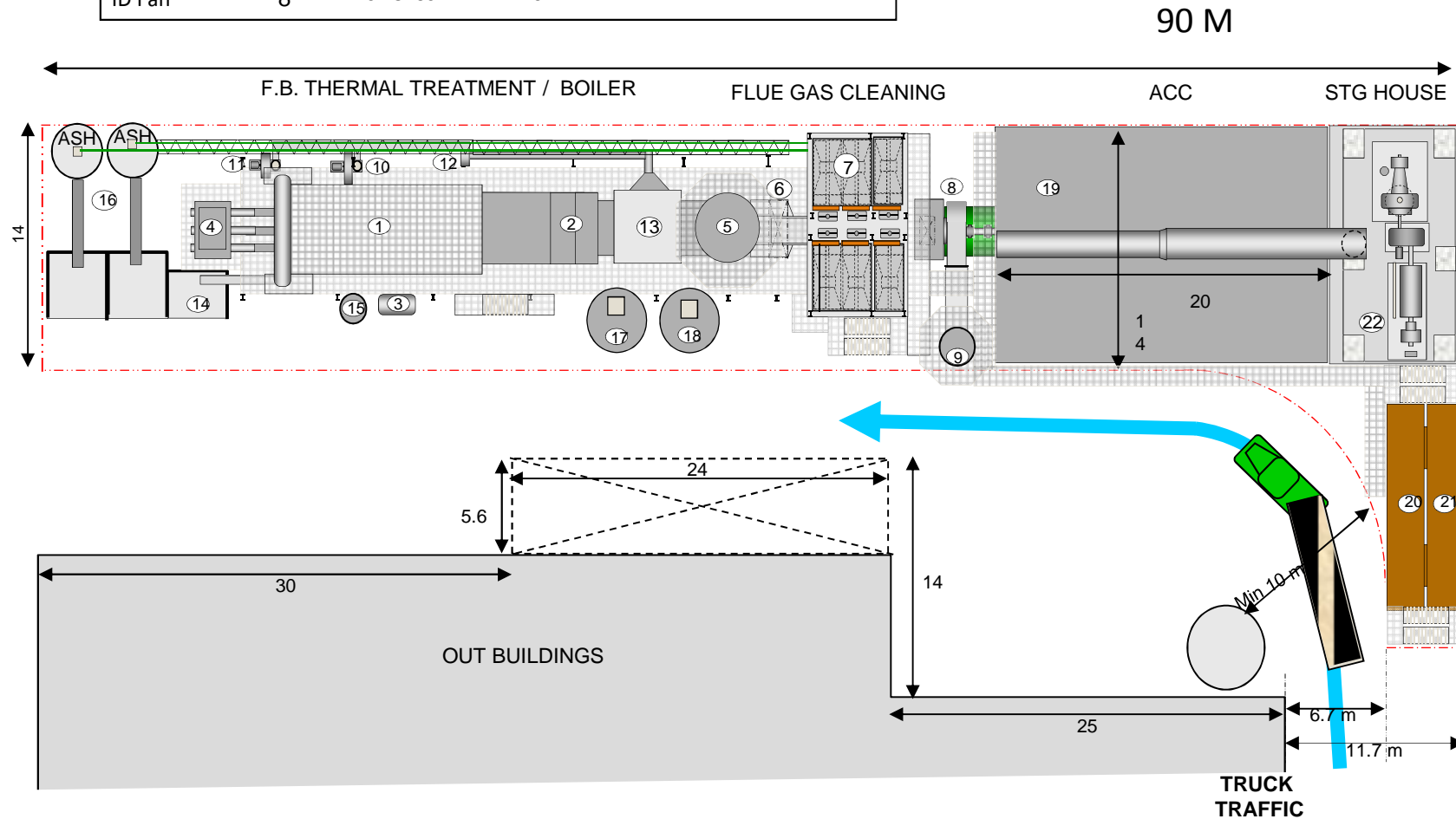
Gross electrical output:	8MWe
Power for WtE plant auxiliaries:	1MWe
Power for recycling facility:	1MWe
Net electrical output to grid:	6MWe
Steam generation pressure and temperature:	67bar(a) @ 420°C
Design waste fuel consumption: STG @ 8 MWe:	11t/h or 81,900t/y
Design waste fuel consumption: Boiler @ MCR (Cogen mode)	13t/h or 96,800t/y

Waste-to-energy plant layout



KEY

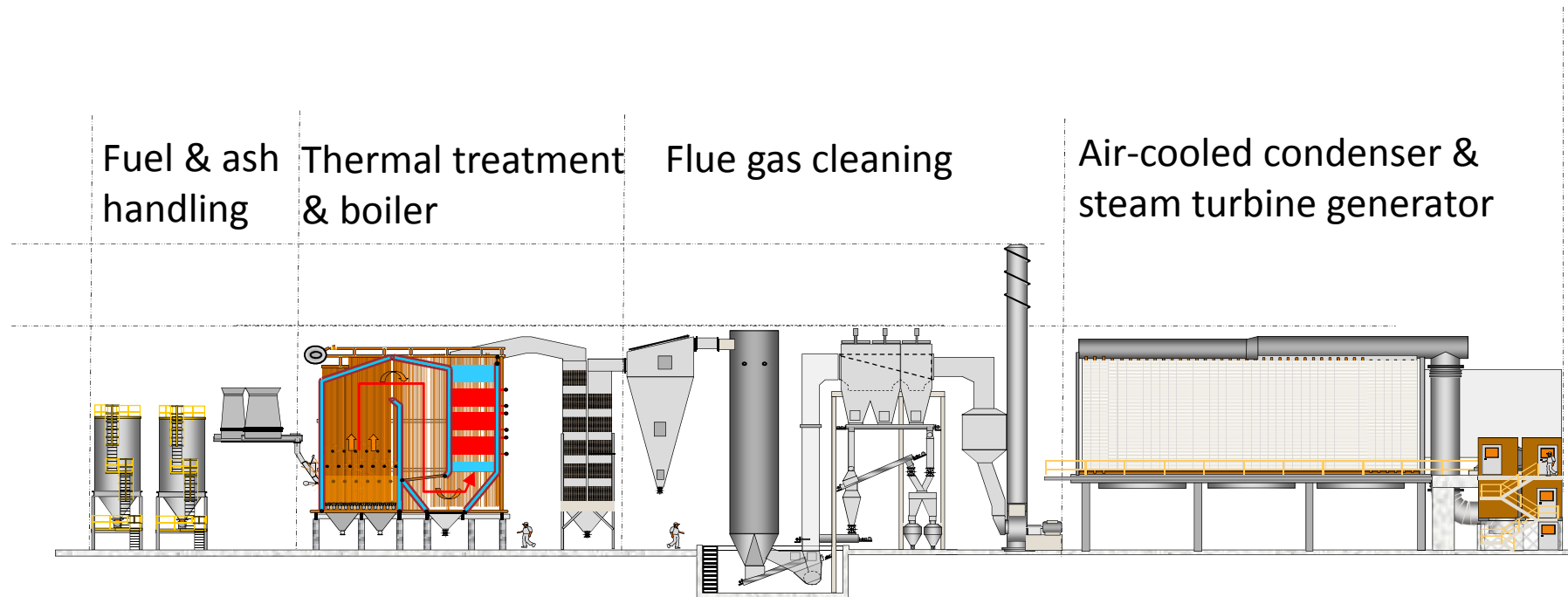
Boiler	1	Stack	9	Lime Hydrate silo	17
Economiser	2	PA Fan	10	Active Carbon	18
Deaerator	3	SA Fan	11	ACC	19
Fuel Hopper	4	FGR fan	12	Control Room	20
Quench tower	5	Multicyclone	13	Electrical Switch	21
Dry Scrubber	6	Bot Ash Bunker	14	Turbine Gen Set	22
Bag Filters	7	TWT Tank	15		
ID Fan	8	Ash Silos	16		



Fluid bed WtE power plant



- side elevation



Proven technology developed over several decades



Importance of understanding fuel



Waste Analysis (%)	Original	Design	Worst
Date	2009	2014	2014
CARBON	41.23	27	15.21
HYDROGEN	6.77	3.74	2.08
OXYGEN	23.88	12.63	7.02
NITROGEN	0.55	0.48	0.27
SULPHUR	0.25	0.48	0.27
CHLORINE	0.00	0.29	0.16
ASH	7.39	20.0	30.00
MOISTURE	20.00	35.00	45.00
TOTAL	100	100	100
LCV (KJ/kg)	17,938	10,931	5,446
HCV (KJ/kg)	19,904	12,604	7,002

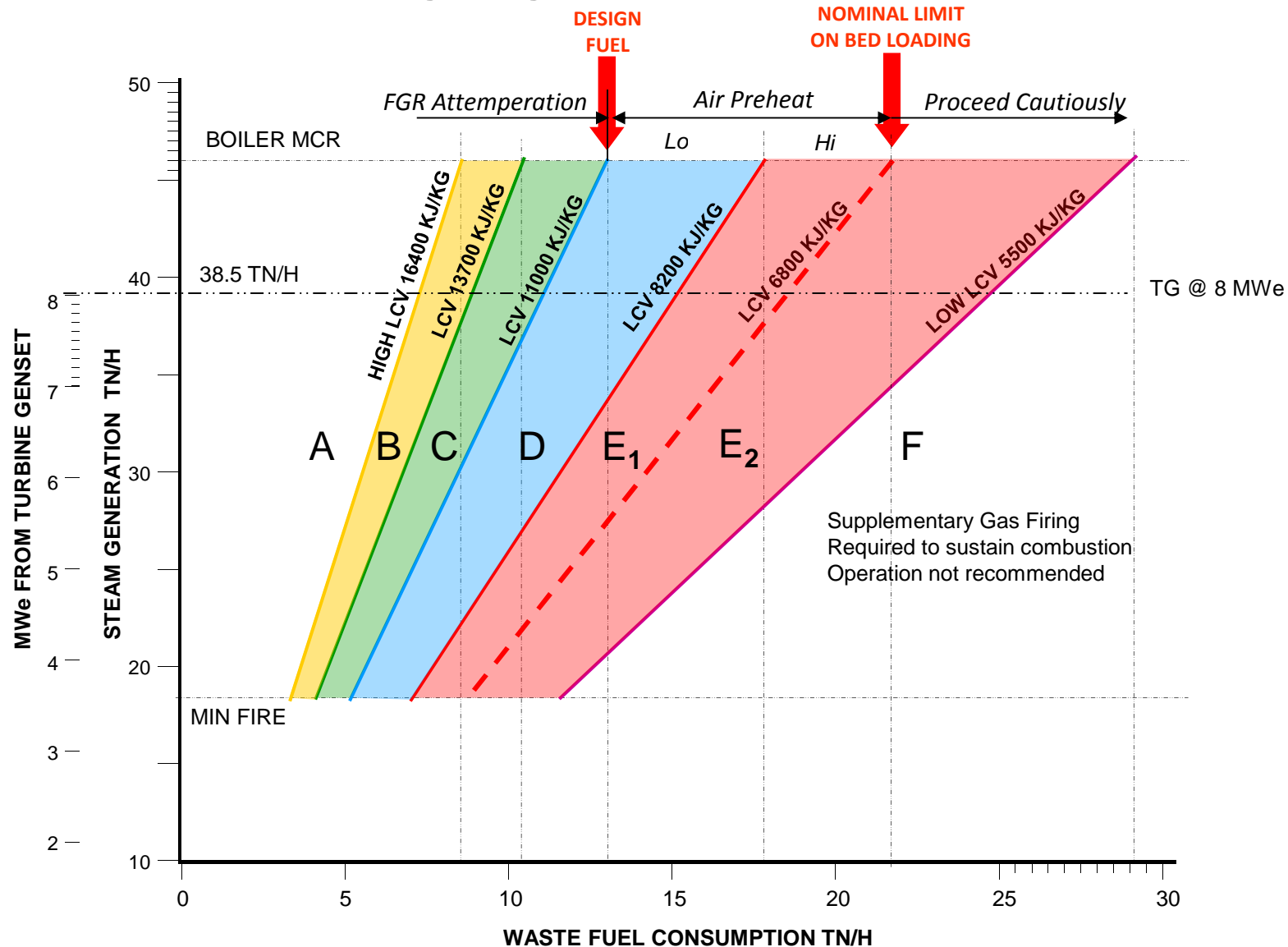
Rain affected
waste fuel

The effect of the above on thermal treatment is illustrated in the Firing Diagram

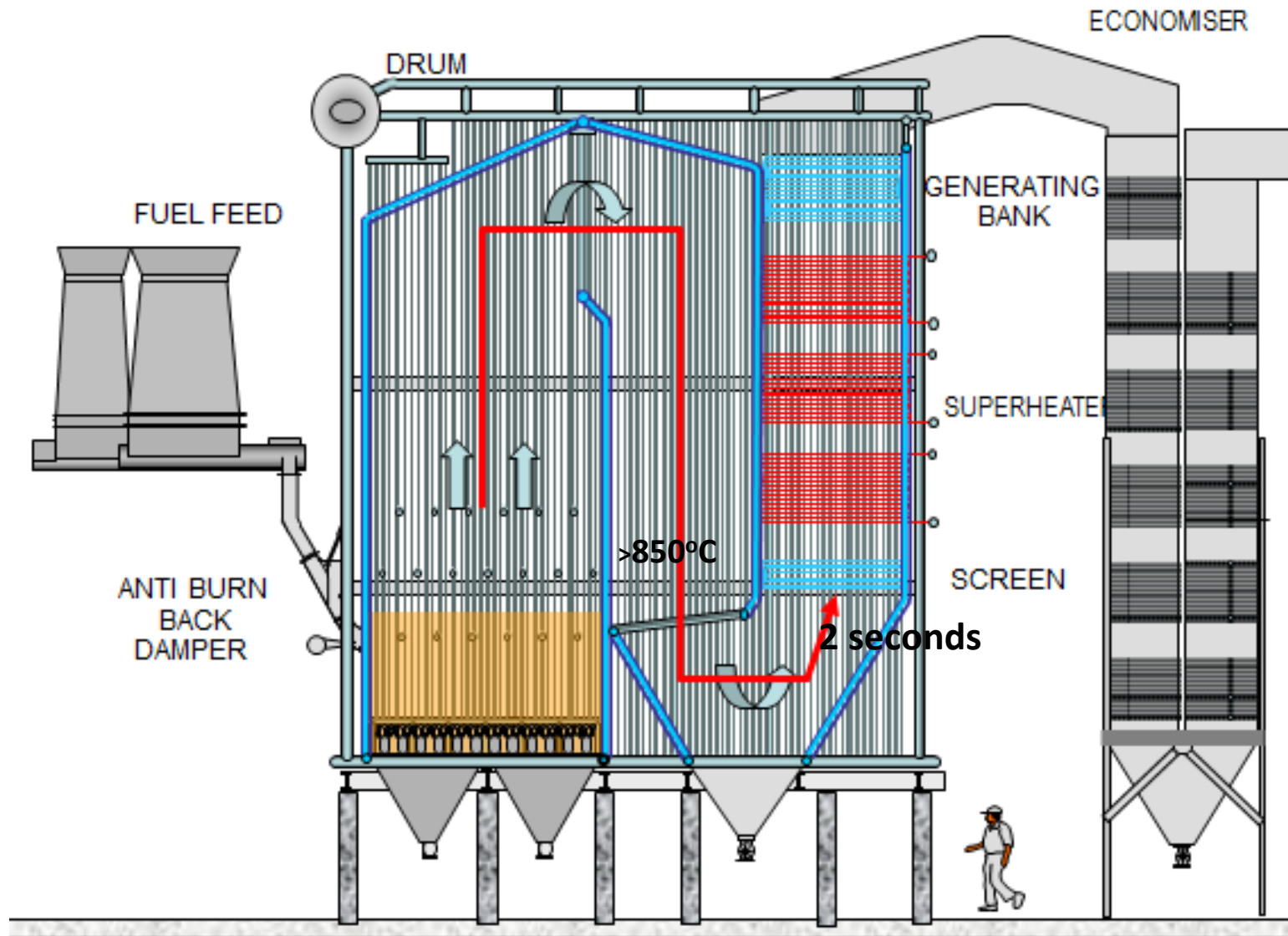
Effect of fuel quality on thermal treatment



Firing diagram with RFD waste



Fluidised bed thermal treatment & boiler



Ash constituents impact



Ash composition analysis results

HRL Sample ID	Sample Description	% element in ash											
		Si	Al	Fe	Ti	K	Mg	Na	Ca	S	P	Cl	CO3
CMM/13/0694-03	Fuel Sample 3 C/ Norton 20-9-13	25.2	4.7	1.9	1.2	0.84	0.68	0.48	11.9	3.0	0.12	0.18	9.2

Ash fusion temperature ($>1100^{\circ}\text{C}$) is affected by ash constituents and determines the propensity for fouling of the boiler heat transfer surfaces

Trace element analysis results

HRL Sample ID	Sample Description	mg/kg dry basis													
		F	Sb	As	Be	Cd	Cr	Co	Pb	Mn	Hg	Ni	Se	Sn	Zn
CMM/13/0694-03	Fuel Sample 3 C/ Norton 20-9-13	67	2	3	<1	11	27	8	49	106	0.21	10	<1	3	270

Volatile polluting elements including sulphur and chlorine mineral matter in the ash and trace element affect flue gas cleaning requirements

Flue gas comparison with EU WID limits



Flue gas analysis at boiler exit

Flue gas analysis % by volume	Design	Worst
CO ₂	10.53	9.42
H ₂ O	20.27	28.68
SO ₂	0.07	0.06
O ₂	3.93	3.51
N ₂	65.17	58.29
HCl	0.04	0.03
TOTAL	100.00	100.00

Flue gas analysis	Design	Worst
FLOW Nm ³ /min	1,017	1,341
HCl mg/Nm ³	1,964	1,757
SO ₂ mg/Nm ³	619	554
Dust mg/Nm ³	28,536	68,920

EU WID not to exceed limits

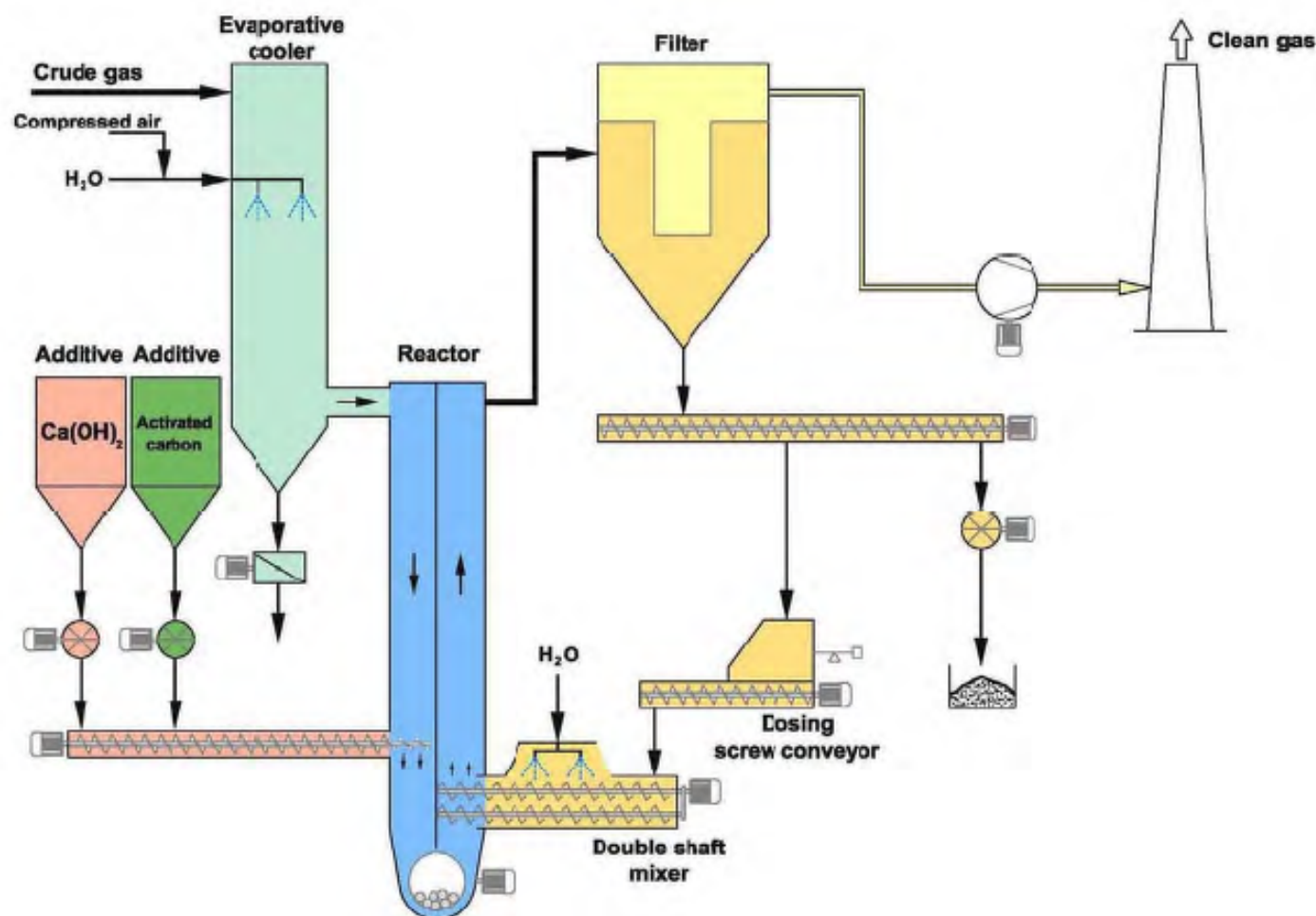
Pollutant	Concentration	Units
PM10 <10 particulate	50.00	mg/Nm ³
TSP total parts	50.00	mg/Nm ³
HCl	10.00	mg/Nm ³
HF	1.00	mg/Nm ³
SO ₂	50.00	mg/Nm ³
CO	50.00	mg/Nm ³
NO ₂ as Nox	200.00	mg/Nm ³
Dioxin & Fns (ng/Nm ³)	0.10	ng/Nm ³
Type 1 & 2 substance	0.50	mg/Nm ³
- Cadmium	0.05	mg/Nm ³
- Mercury	0.05	mg/Nm ³

What goes in has to come out somewhere!!

European technology to meet European Environmental standards



Chemisorption with gas and particle conditioning



Positive economic case



			Capex	47.02
Revenues				
				\$ M pa
			Export 6.0 + 1 = 7MWe @ 85% availability @ \$70 / MWh	3.60
			Tipping fees for Feedstock @ 11 Tn / Hr @ \$160 / Tn	13.10
			Revenue	16.70
Operating costs				
				\$ M pa
			Total O & M + Contingency	
			Opex	8.40
Financing costs				
				\$ M pa
			Debt / Equity ratio: 60 / 40. Period 10 yr @ 8%	
			Debt + Interest repayments	4.2
			Financing	4.2
Cash flow before tax				
				\$ M pa
			Revenue	16.70
			Opex	(8.40)
			Debt + interest repayments	(4.20)
			Net profit before tax	4.10

**IRR =21% over 10 year loan
repayment period**

20 year IRR = 27%

The challenge has been met!



An Economically viable solution, based on proven **European technology** exists for waste-to-energy plants in **Australia**.

However, it is essential to fully understand the **variability of the waste fuel** and its implications on thermal and environmental treatment.

Madrid, Spain Waste-To-Energy Plant.



This plant has been in operation since 1996. It uses ERK designed boilers firing RDF in fluidised beds and produces 29 MWe.

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