Thermal Processing of Biomass Using Downdraft Gasification

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Waste to Energy Group

Waste to Energy Ltd
Technology Owner

Shawtech Ltd
Control and Telemetry System Design

Morecroft Engineers
Engineering & Manufacturing Works

Company established in: 1992
Total number of employees: 34 including manufacturing
ISO9002 approved

Recently Installed Plants

250-450 kg/h 90% ds Operating on Dried Sewage Sludge

50-100 kg/h 90% ds Operating on Sewage Sludge & other hazardous solid wastes

50-100 kg/h 90% ds Operating on Leather Industry Wastes

Coming on Stream 2003-2004

2 x 1000 kg/h 90% ds Operating on Sorted Municipal Solid Wastes

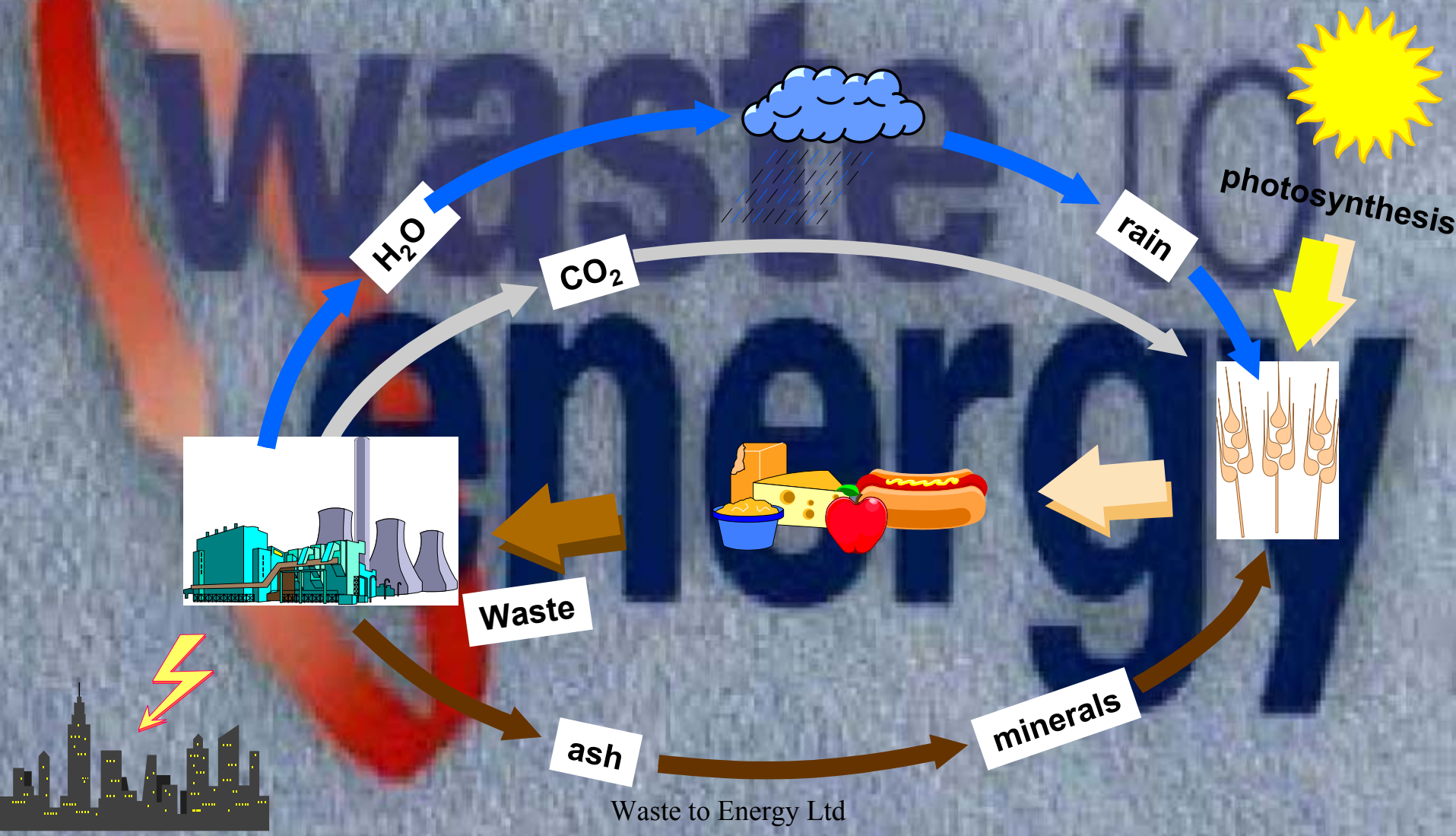
2 x 1000 kg/h 90% ds Operating on Sewage Sludge

1 x 1000 kg/h 90% ds Operating on Forestry Wastes

1 x 1000 kg/h 90% ds Operating on Leather Industry Wastes

Biomass circuit

Waste helps to reduce CO_2 - emissions



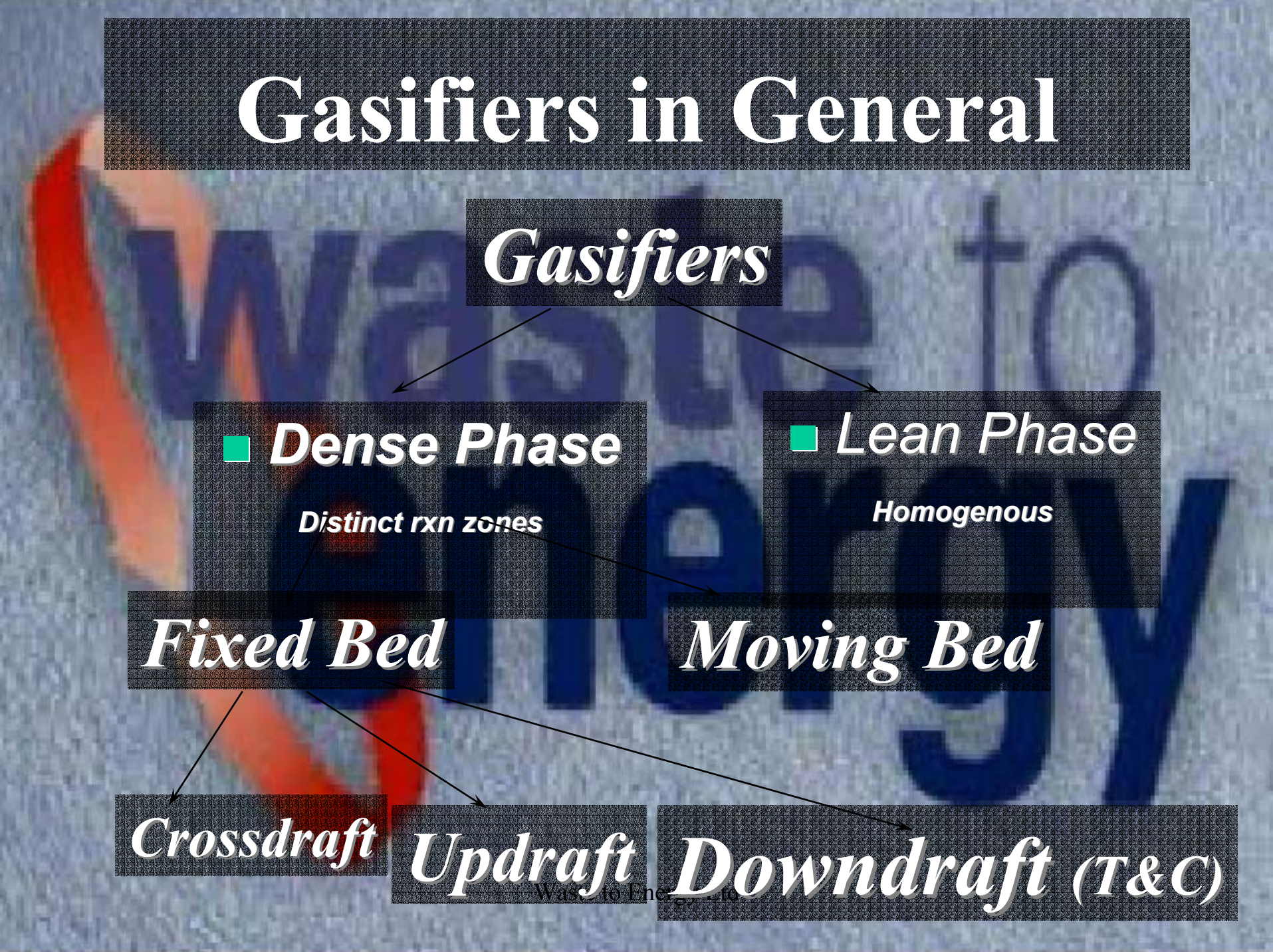
Main Drivers for Thermal Processing of Wastes

- Waste Management Policy - Discouraging Landfill
- Pollution Control - Increasing the cost of operation of thermal process
- Renewable Energy Policy - Encouraging energy recovery
- Public Concern - Frustrating planning permission

Gasification

- **Definition :** Gasification is a method for converting solid organic materials into combustible gaseous products.
- **Method :** The solid material is thermo-chemically decomposed in oxygen limited atmosphere.
- **Objective :** Production of low energy clean gas - can be burnt in a conventional boiler, a gas turbine or an IC Engine to produce electricity and/or heat.

Gasifiers in General



Why Gasification via Downdraft ?

» **ADVANTAGES**

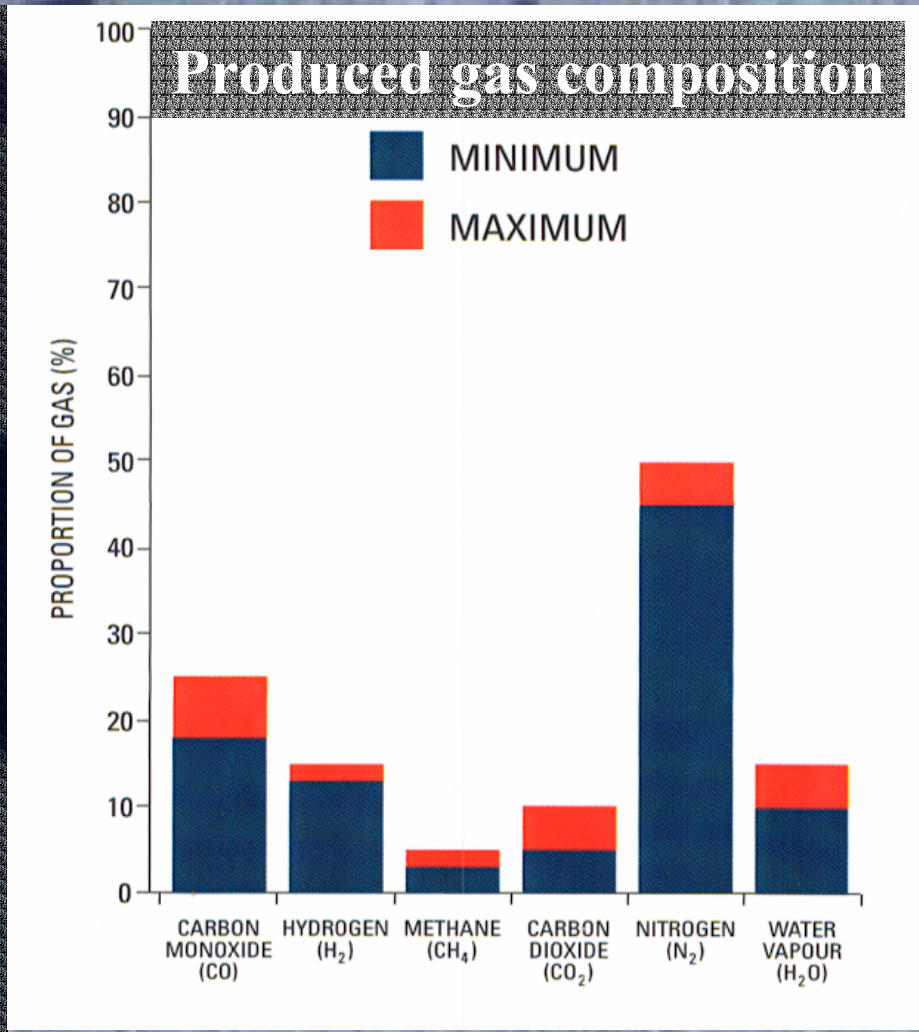
- Low Tar Yield (for ICE)
- High Carbon Conversion
- Low Ash Carry Over
- Simple Construction and Operation
- Quick Response to Load Change (Turndown 3:1)

» **DISADVANTAGES**

- High Gas Exit Temperature
- Uniformly Size Feed Stock
- Limited Moisture Content of Feed (H_2O<30%)

Facts about the produced gas

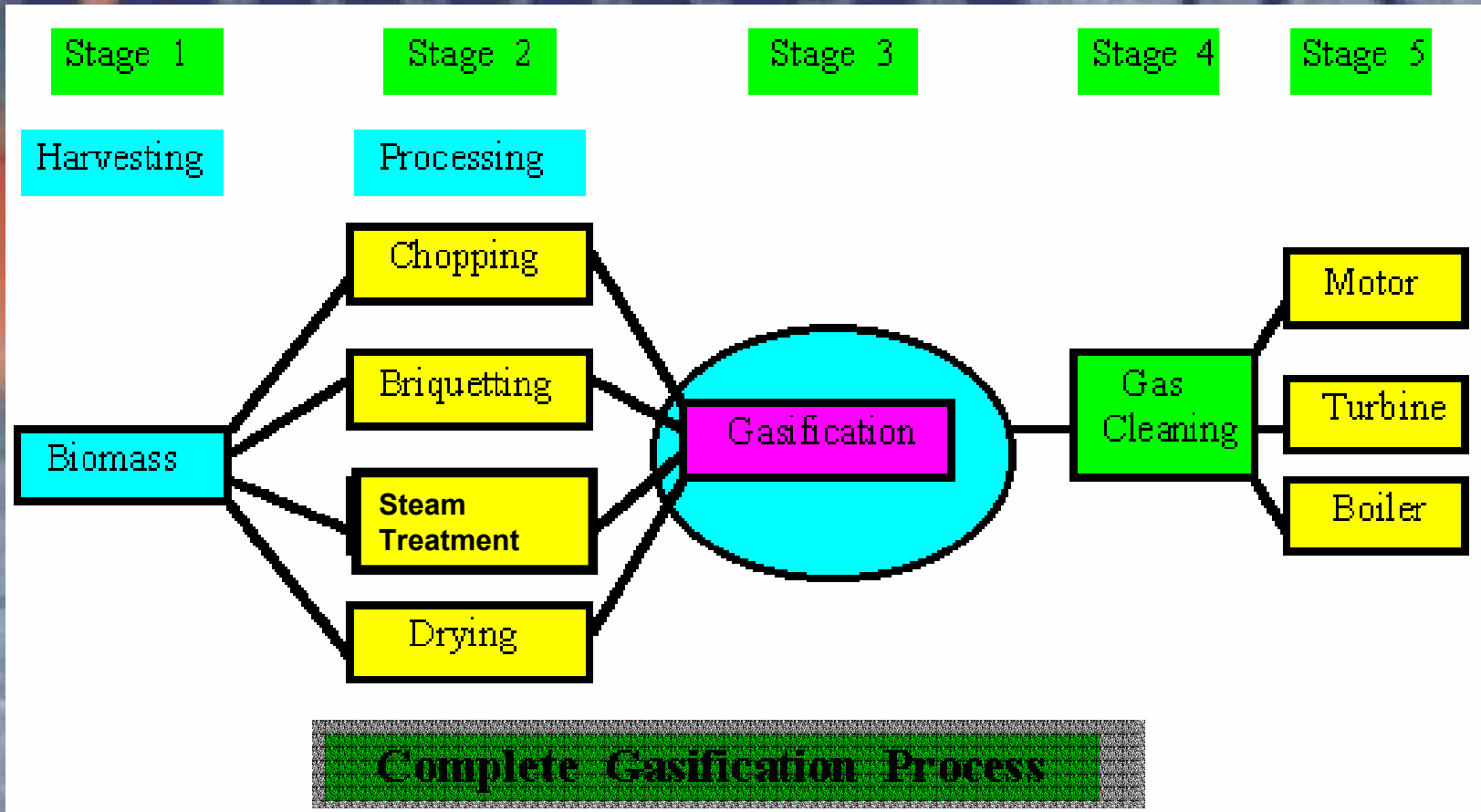
- 1kg of biomass (at 12% moisture content) produces 2.5-3.0 m^3 of product gas.
- Cool and clean gas density is app. 1.027 kg/nm^3.
- Produced gas has an energy content of approximately 5,500 kJ/m^3.
- Biomass consumption of the gasifier is app. 1.22kg/kWe electrical output.



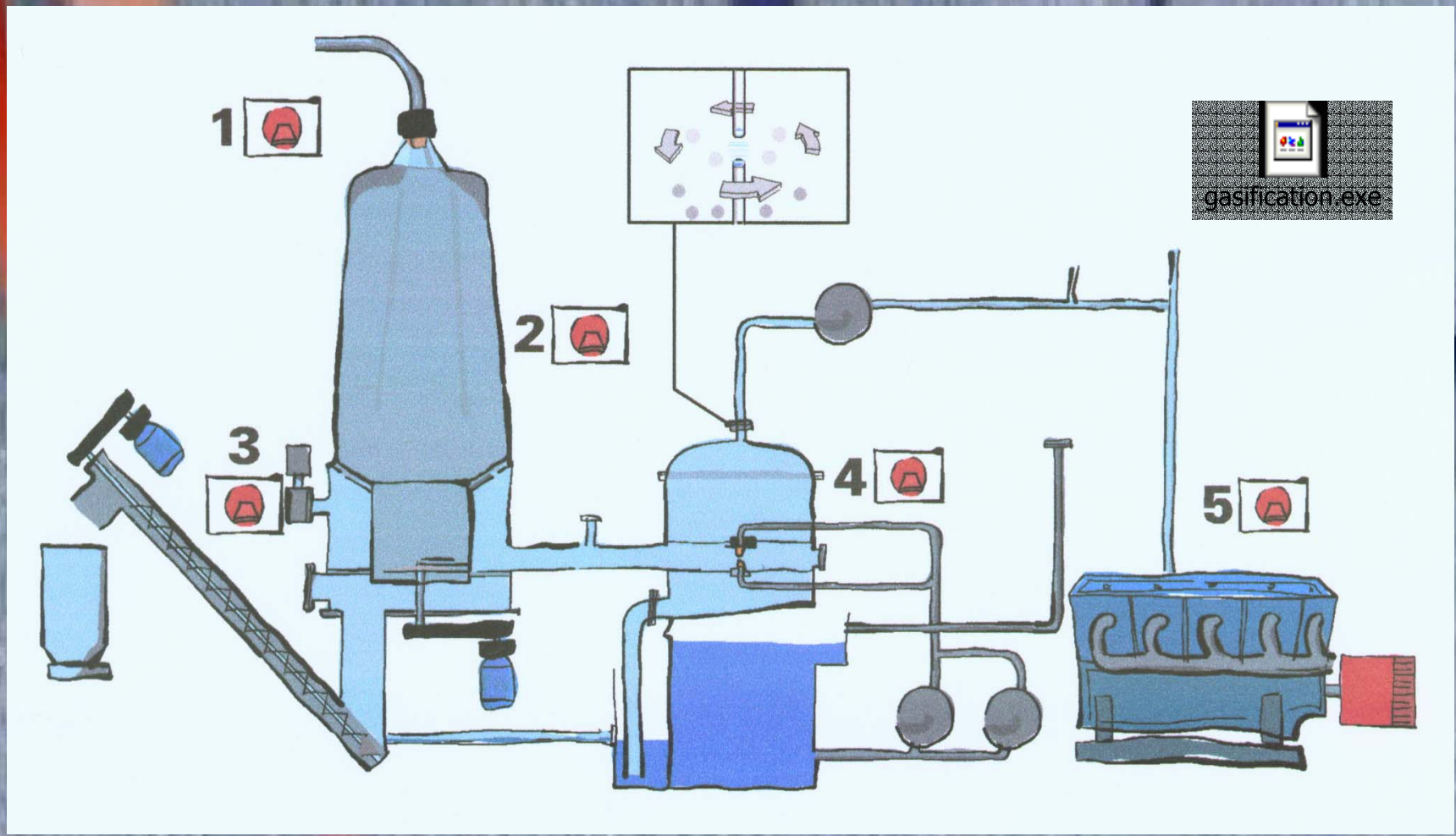
Key Features of Gasification Process

- SUSTAINABLE CHP GENERATION
- RESPONSIVE TO MARKET NEEDS
- SAFE OPERATION
- LOW CAPITAL AND OPERATING COSTS
- ENVIRONMENTALLY FRIENDLY

COMPLETE GASIFICATION SYSTEM



Downdraft Gasifier Operation



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Key Design Upgrades

- Continuous densification and feeding
- Easy flow oval shape vessel
- Bridge breaking device
- No Ceramics construction
- Air nozzles to provide better air fuel mixing
- Fully Automatic Start up and Shut down
- Grateless Ash discharge system
- Extended Reduction Zone For High Cold Gas Efficiency

Gasifier Inside the Container 500 kg/h (90%ds)

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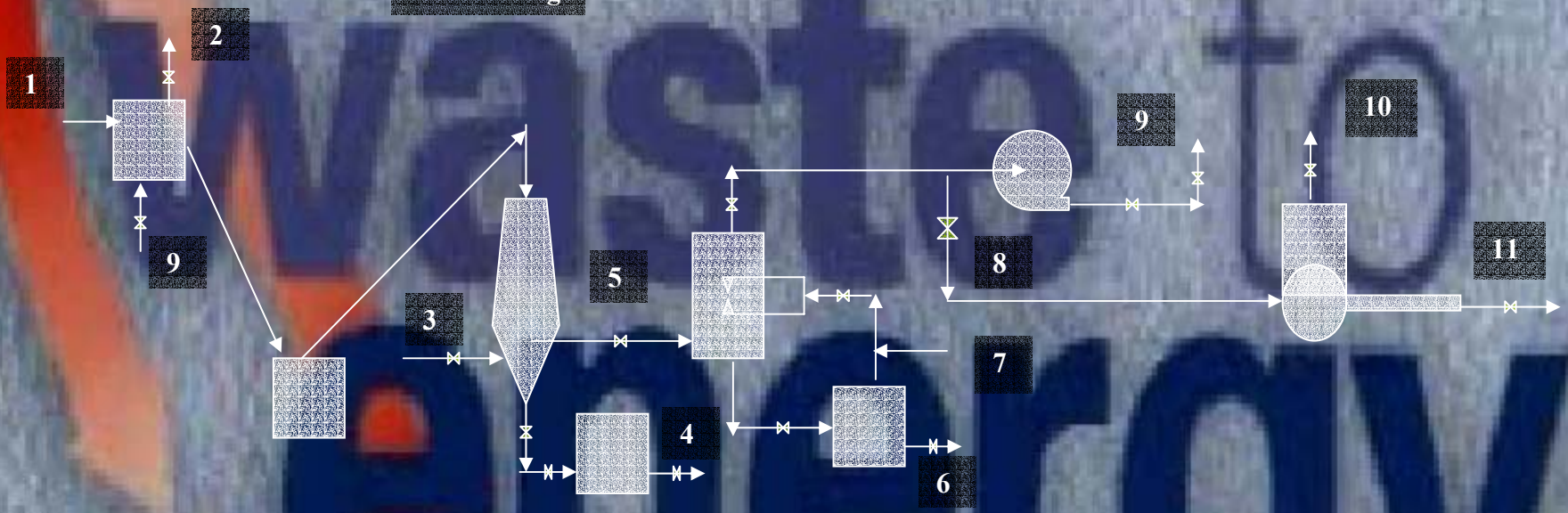
Simple WTE Process Schematic

Drying | Briquetter | Downdraft Gasifier With ash conditioning | Producer Gas Scrubber | Closed circuit Effluent Filtration | Booster fan | Gas Engine and Generator



1- After centrifuge sludge enters into the dryer at 20-25% ds
2- Clean dust free exhaust gases after scrubber
3- Air enters the gasifier at about stoichiometric levels
4- White ash (low carbon) with leachable metals but when used as road aggregate, produce zero leacheate.

5- Hot producer gas at ~300°C exits the reduction zone of the gasifier and enters the scrubber where it is quenched to <50°C thereby removing dust, acid gases, tars and also eliminate dioxin reformation.
6- Scrubber residue - Tars, dust
7- Make up water

8- Clean producer gas mainly consisting of H_2, CO, CH_4, CO_2, H_2O, N_2, to duel fuel compression engine
9- Clean gas to dryer or invisible flare

250-400kg/h Sludge Drying & Gasification System
Anglian Water

MOBILE and SKID-MOUNTED

Drying and Gasification - A Complete Emission Free Solution Key Features

-Self sustainable

-Ability to treat all types of wastes i.e. MSW, Biosolids, Clinical Waste etc.

-Process is designed to meet all current and expected legislative requirements, EU Waste Incineration Directive.

-No moving and ceramics internals. Novel air distribution mechanism , Bridge breaking device and World-wide process patents.

-Meets the proximity principle requirements.

- Zero effluent generation process using polymers filters to remove metal ions, tars and oils.

-Low CAPEX and OPEX

Typical Plant Performance Data
Producer Gas Composition

	%v/v
H2	10
O2	1.2
N2	60
CO	8.4
CO2	12
CH4	2.8
Ethane	0.25
Ethylene	1.7
Acetylene	0.18
CV, kJ/kg	4.49

Typical Gasifier Efficiencies

Hot Gas – 68.97%

Cold Gas – 64.35%

Raw Gas – 70.39%

Comparison with WID Ash

<3% Carbon in ash

by using

Ash conditioning system

Typical Gasifier Operation Data
Other Emissions

Dioxins & Furans - Process destroys any present in the fuel and discourages its reformation

NOx & SOx - Most of the sulphur can be removed in the scrubbing process and for NOx control appropriate technology is available

Ash- Almost all of the metals in the ash are non-soluble and no fly ash is generated – can be used as BB aggregate or air emmission control

Effluent - Scrubber effluent can either be discharged back to the head of the works or filtered to recycle the water

Key Plant Performance Highlights
Anglian Water Plant

Sewage sludge 85-90% ds and ash content >30% (iron content of the order of 12% of ash) successfully gasified.

Syngas calorific value is found in the range of 3.5-4.9MJ/nm3 and combusted in the dryer burner.

Depending on the type and moisture content of the sludge, throughput of 250-450kg/h is achieved.

Key Plant Performance Highlights
Anglian Water Plant

In order to minimise the cost of chemical treatment scrubber water temperature was raised to keep the toxic nitrogen compounds in the gas phase offering increased gas CV.

NH3 was also present in the gas reducing the formation of NOx to below <100 ppm.

Carbon in ash leaving the gasifier was observed of the order of 10-20% which is then conditioned under controlled thermal condition for 24hrs to bring the levels <3% prior to disposal.

The ash analysis showed it to be 99.99% non-leachable.

Key Plant Performance Highlights
BLC Plant

The plant consists of an air swept dryer, briquetter and gasifier all within a portable ISO container.

The plant is fitted with a specially designed grateless reduction zone to handle variable ash contents in the fuel feed when using a number of tannery waste streams i.e. Cr shavings, Veg Shavings, Sludge, Trimming/Tallo, Wet white shavings and EoL with an average CV of 20MJ/kg for 90% ds.

The plant is fitted with a three stage poking device to help maintain free fuel flow.

Key Plant Performance Highlights
BLC Plant

The average moisture level of the wet feed was 50%.

Syngas CV was found to be in the range of 4.2-5.5MJ/kg.

35-50% of the energy in the feed was used for drying and remainder was available for power generation.

Cold gas efficiency was found to be in the range of 61-65%.

The average produced gas composition (%) of H2 7.8, CO 20, CH4 1.7 (balance as N2 & CO2).

Key Plant Performance Highlights
BLC Plant

While using shavings, Chromium stays in the ash closing the Chromium loop.

Ash using other waste streams has shown immense potential for use as constituents for carbon filters.

Scrubber water analysis has been completed with ppb levels of aromatics present. These can be easily removed in the conventional treatment systems.

The plant has completed its phase one operation and is due to be transferred to a tannery in June.

Typical Cost of Thermal Treatment For Various Wastes

Waste Type	Incineration cost £/wet tonne	Gasification cost £/wet tonne
Leather & Food Industry	105	75
Sewage Sludge	120	80
Meat Processing	95	69
Domestic Waste	80	55

WTE Process Applications

- Most solid wastes that can combust
- Biomass & high ash toxic and hazardous residues
- Can handle wastes with CV as low as 10 MJ/kg
- Grateless design can handle sharps and small size non-combustibles
- Recycling precious materials and energy recovery
- Replacement to incineration

CONCLUSIONS AND WAY FORWARD

- **Produces Electricity from a Renewable Resource**
- **Reduces CO_2 Emission Thereby Saving fossil fuels**
- **Long Term Waste Disposal Outlet Enables the Producer Become Master of Its Own Destiny with No Transport and Landfill Costs**
- **Offers Significant Benefit for the Water, Waste and Other Associated Industries**

Reference List

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2) Loram G, "Local Gasification", Energy World April 2001 No.288 pp 16-17

3) Riches S and Evans I, "Trial Results from the Implementation of Gasification Technology at Broadholme Sewage Treatment", IQPC, 2002

4) Bowden W, "Gasifier Operates in Closed Loop on Tannery Wastes", Journal of BLC Leather Technology Centre September 2002. pp 141-143

5) Waste to Energy Ltd, Web address: www.waste-to-energy.co.uk

Gas Burning Inside the Enclosed Flare
Clean Emission Free Low CV Gas

Typical gas characteristics:

H_2 - 8-12%
CO - 12-18%
CH_4 - 3-6%
CO_2 - 10-12%
N_2 - 45-55%
H_2O - 2-5%
CV - 4.5-5.5MJ/nm^3

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