University of Verona, Department of Biotechnology

Mechanical Biological Treatment (MBT)

and

(Wet) Anaerobic Digestion

David Bolzonella
&
Charles Banks

AD of biowaste is a well established but still growing technology ….

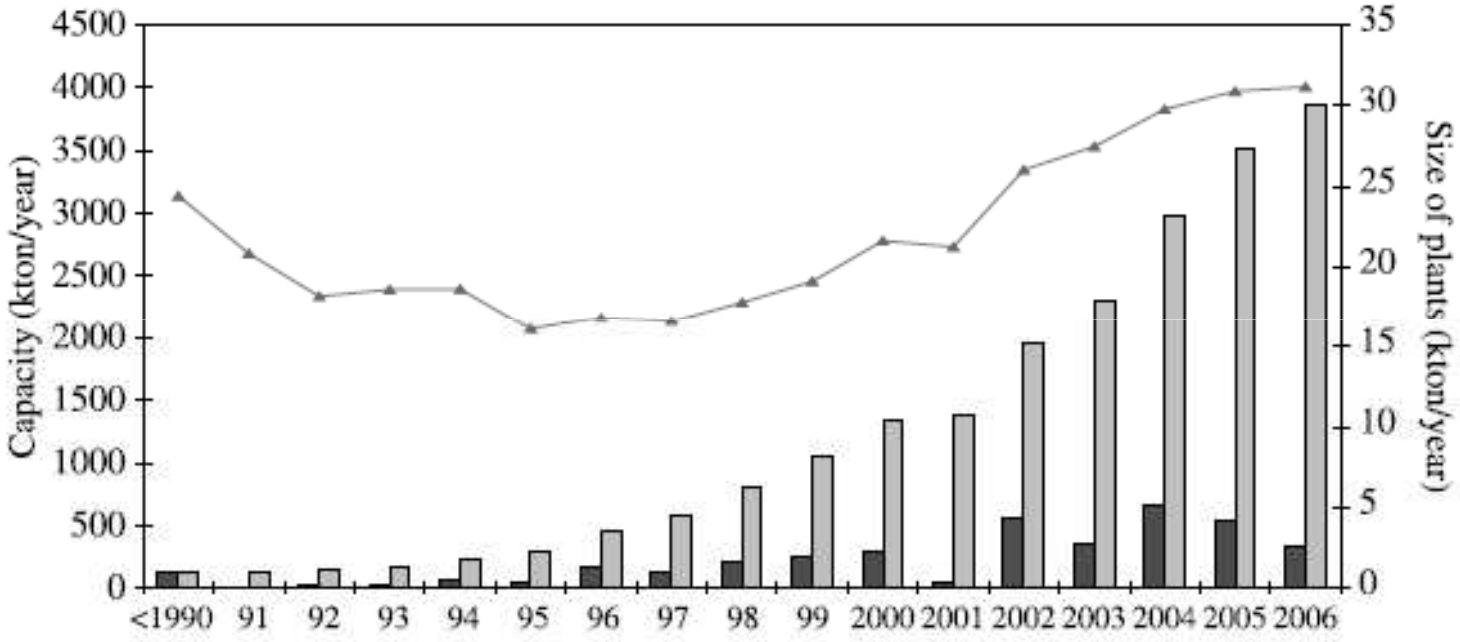


Figure 1 annual ■, cumulative ■, and cumulative average installed capacity -◆-

De Baere, WST, 2006

5 Year Development	1991-1995	1996-2000	2001-2005	2006-2010	1991-2010
# of plants installed	15	44	52	73	184
plants/y	3.00	8.80	10.40	14.60	9.20
capacity installed (t)	194,000	1,117,500	2,077,950	2,246,450	5,635,900
capacity installed (t/y)	38,800	223,500	415,590	449,290	281,795
average size of plant (t/y)	12,933	25,398	39,961	30,773	27,266

Source: De Baere et al 2010

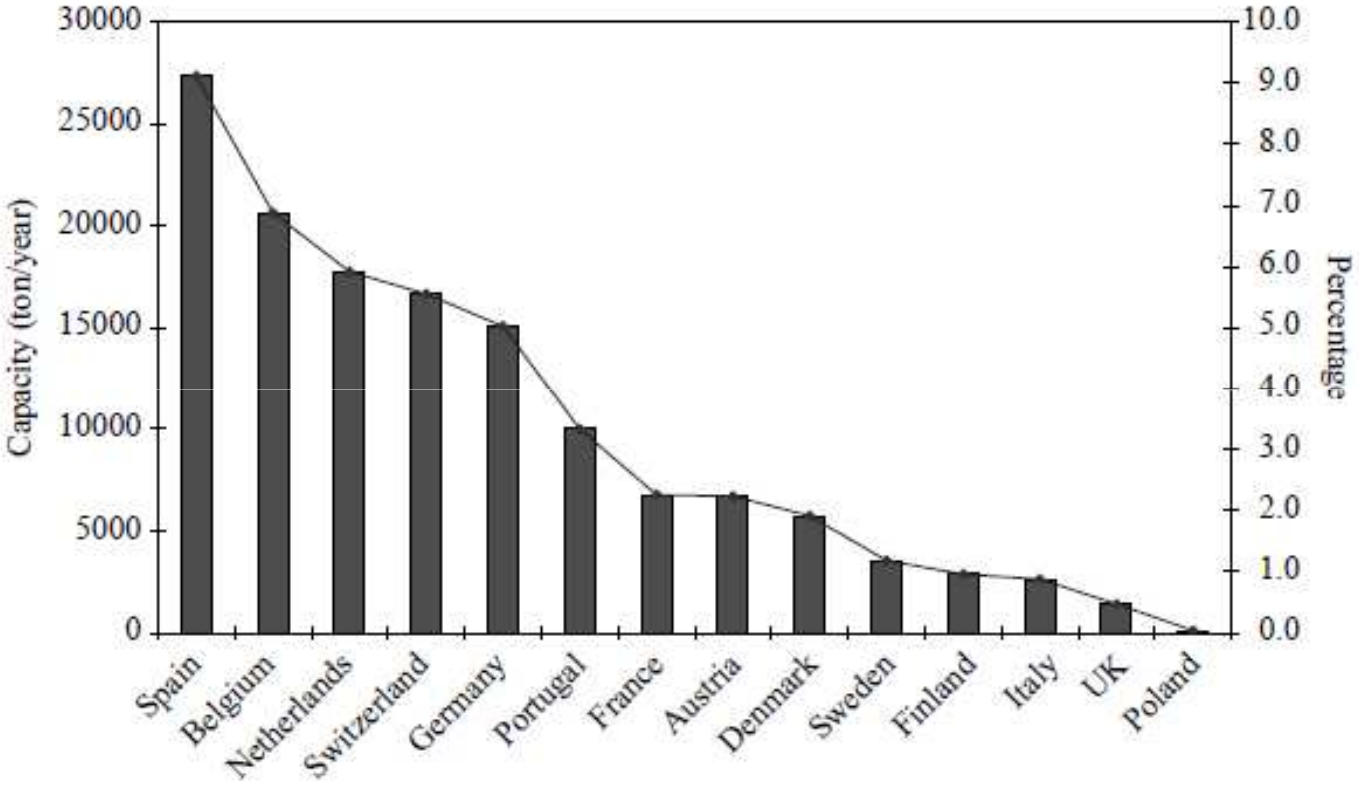
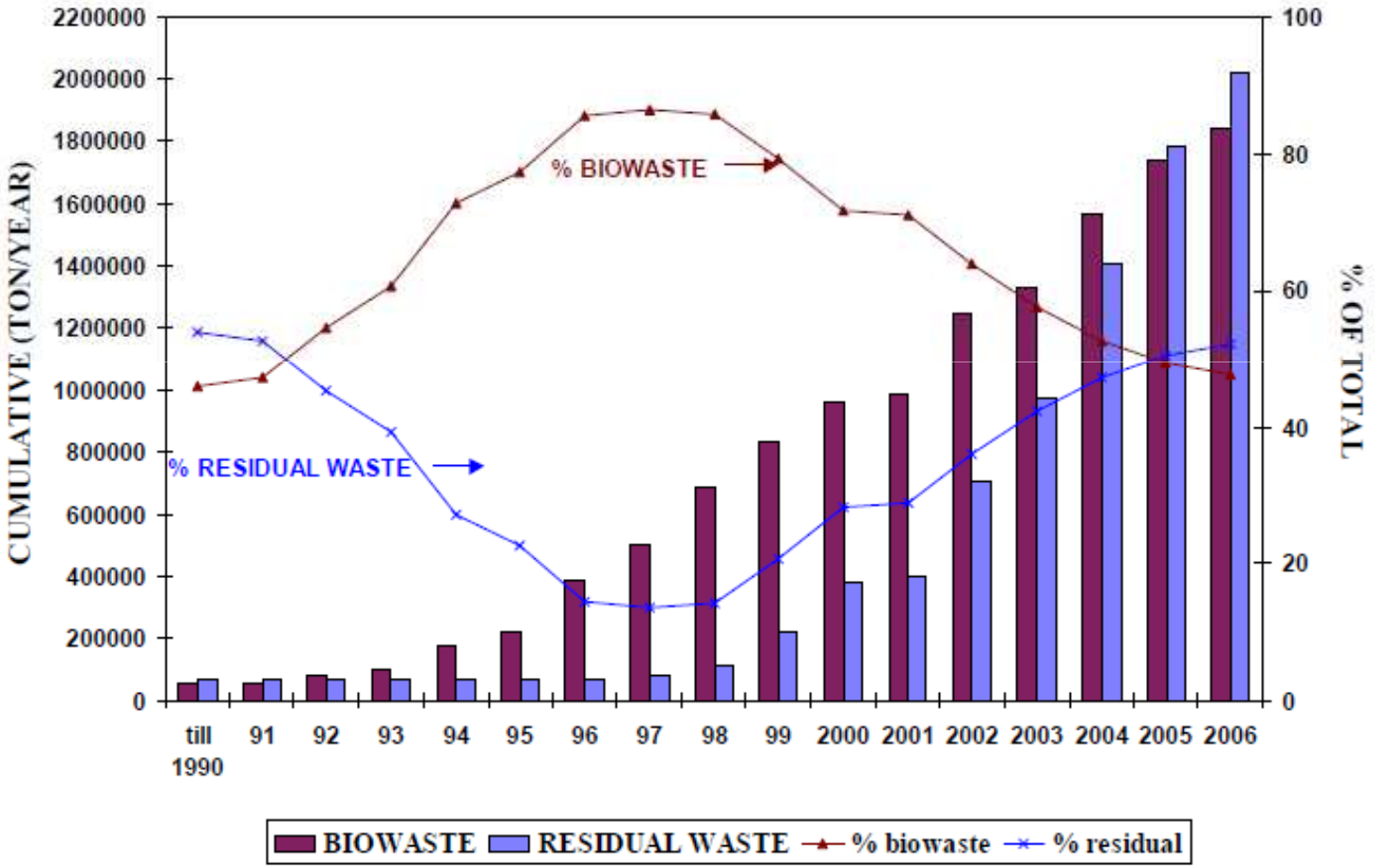


Figure 2 Capacity per million inhabitants ■ and percentage of potential theoretical capacity -◆-

De Baere, WST, 2006

The implementation of separate collection opened the possibility to treat biowaste. Despite this, the treatment of residual waste is still very important



De Baere, WST, 2006

In these cases AD is typically part of a Mechanical Biological Treatment **(MBT)** process

This technology is dedicated to the treatment of

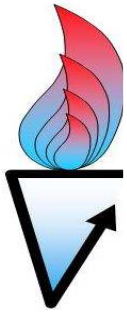
✓ unsorted Municipal Solid Waste (MSW)

✓ industrial waste

✓ the grey fraction of MSW (the residual part after separate collection)

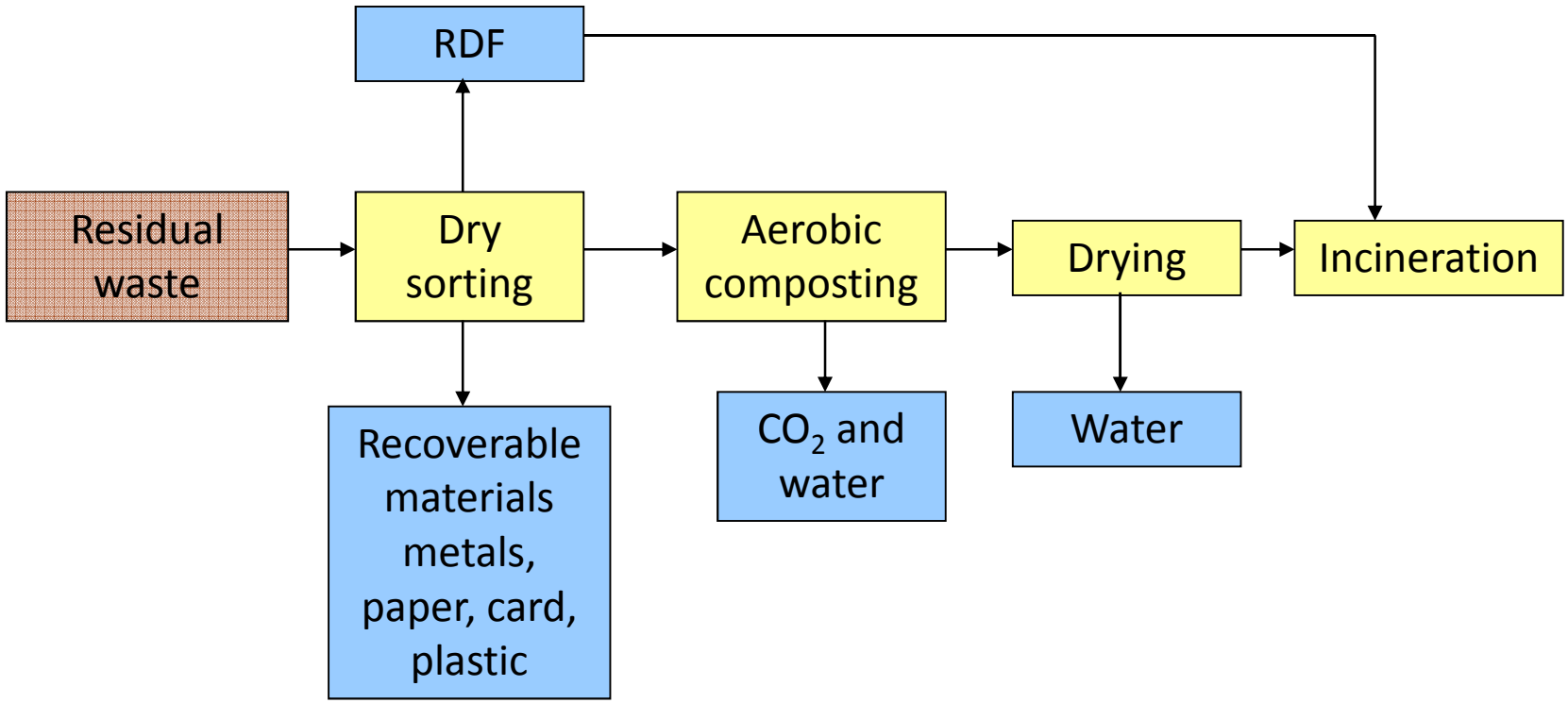
The mechanical-biological-treatment (MBT) is combination of two processes:
the first one, mechanical, is dedicated to the separation of recyclable materials and the organic fraction from the bulk waste while the second one, biological, is dedicated to the stabilization of this organic material.
The biological step can be either aerobic or anaerobic.

The main benefit of MBT technology is its capability of reducing the mass and volume of waste sent to landfills. At the same time, recyclable or thermally reusable fractions can be separated.

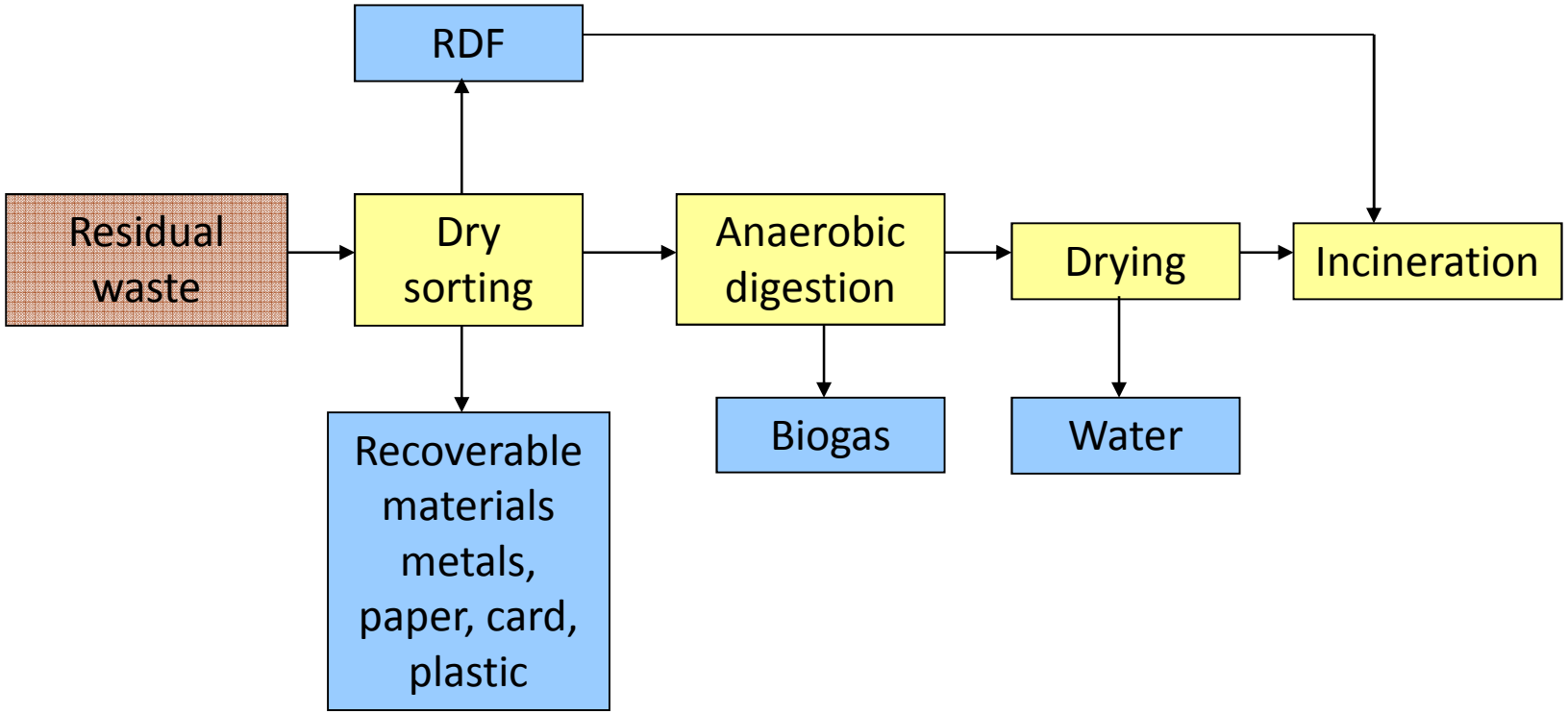


Generic MBT technology

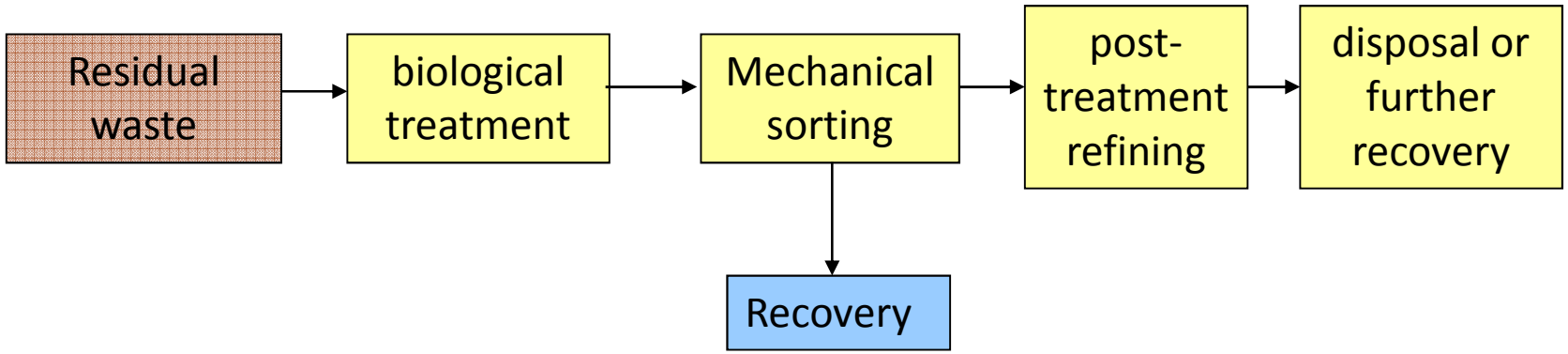
Typical AEROBIC MBT



Typical ANAEROBIC MBT



A second option:
The Biological Mechanical Treatment (**BMT**)



AIMS

typical aims of MBT plants include the:

✓Pre-treatment of waste going to landfill;
✓Diversion of non-biodegradable and biodegradable MSW going to landfill through the mechanical sorting of MSW into materials for recycling and/or energy recovery as refuse derived fuel (RDF);
✓Diversion of biodegradable MSW going to landfill by reducing the dry mass of BMW prior to Landfill and the biodegradability of BMW prior to landfill;
✓Stabilisation into a compost-like output (CLO) for use on land;
✓Conversion into a combustible (RDF and biogas) for energy recovery

MBT components and configurations

The **mechanical** stage of the process generally has two main roles:

- ✓ to brake down the waste in smaller parts and
- ✓ recovery some recyclable materials

The net result will be the reduction of the mass and volume of the treated waste due to the removal of materials for recycling and both carbon and moisture losses.

Clearly, recycled material has a worst quality than the one coming from separate collection !

Beside the recyclable materials and the biogas the residual outputs are a biostabilized material and RDF.

Table 1: Waste Preparation Techniques

Ref	Technique	Principle	Key Concerns
A	Hammer Mill	Material significantly reduced in size by swinging steel hammers	Wear on Hammers, pulverising and 'loss' of glass / aggregates, exclusion of pressurised containers
B	Shredder	Rotating knives or hooks rotate at a slow speed with high torque. The shearing action tears or cuts most materials	Large, strong objects can physically damage, exclusion of pressurised containers
C	Rotating Drum	Material is lifted up the sides of a rotating drum and then dropped back into the centre. Uses gravity to tumble, mix, and homogenize the wastes. Dense, abrasive items such as glass or metal will help break down the softer materials, resulting in considerable size reduction of paper and other biodegradable materials	Gentle action – high moisture of feedstock can be a problem
D	Ball Mill	Rotating drum using heavy balls to break up or pulverise the waste	Wear on balls, pulverising and 'loss' of glass / aggregates
E	Wet Rotating Drum with Knives	Waste is wetted, forming heavy lumps which break against the knives when tumbled in the drum	Relatively low size reduction. Potential for damage from large contraries
F	Bag Splitter	A more gentle shredder used to split plastic bags whilst leaving the majority of the waste intact	Not size reduction, may be damaged by large strong objects

Source DEFRA (UK)

Table 2: Waste Separation Techniques

	Separation Technique	Separation Property	Materials targeted	Key Concerns
1	Trommels and Screens	Size	Oversize – paper, plastic Small – organics, glass, fines	Air containment and cleaning
2	Manual Separation	Visual examination	Plastics, contaminants, oversize	Ethics of role, Health & Safety issues
3	Magnetic Separation	Magnetic Properties	Ferrous metals	Proven technique
4	Eddy Current Separation	Electrical Conductivity	Non ferrous metals	Proven technique
5	Wet Separation Technology	Differential Densities	Floats - Plastics, organics Sinks - stones, glass	Produces wet waste streams
6	Air Classification	Weight	Light – plastics, paper Heavy – stones, glass	Air cleaning
7	Ballistic Separation	Density and Elasticity	Light – plastics, paper Heavy – stones, glass	Rates of throughput
8	Optical Separation	Diffraction	Specific plastic polymers	Rates of throughput

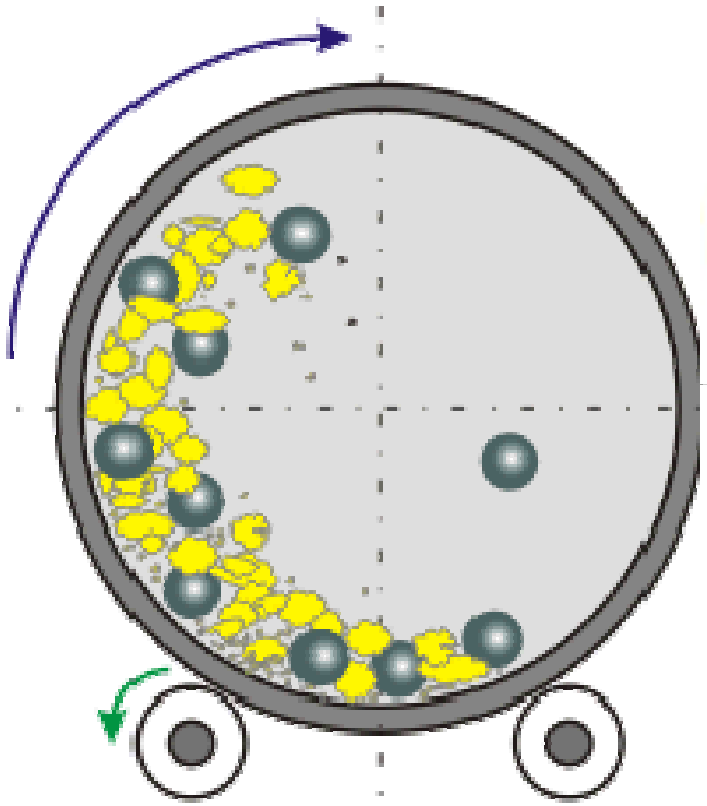
Source DEFRA (UK)

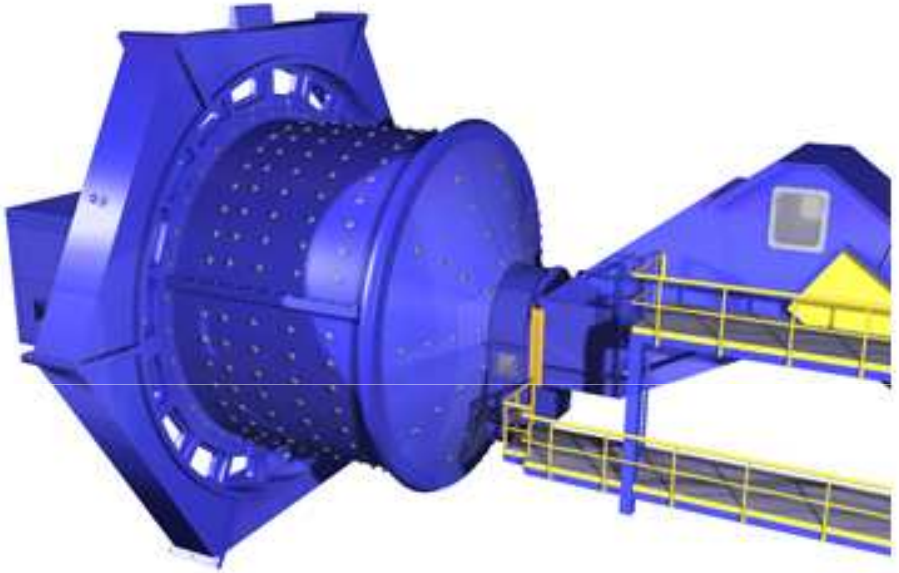
Bags opening and size reduction

Shredder

Hammer mill

Ball mill





Metals separation and recovery

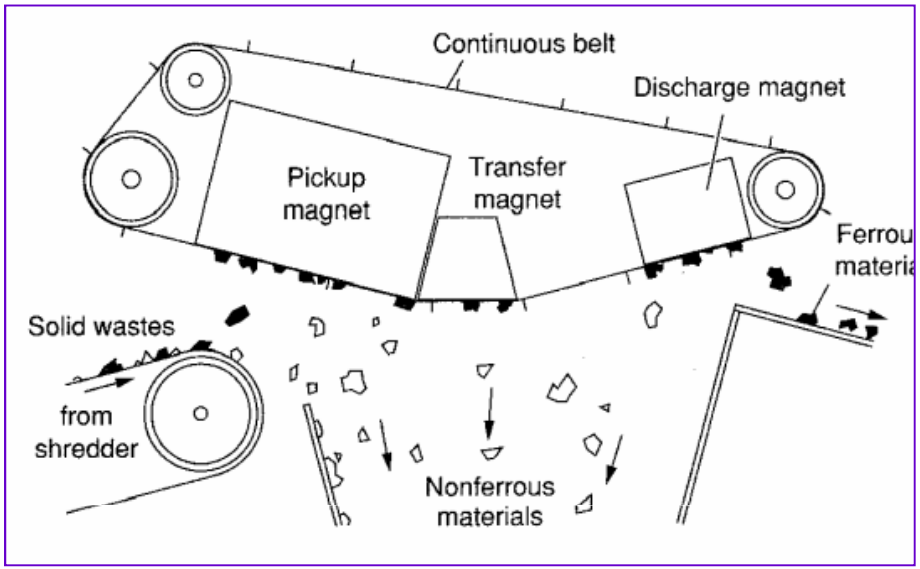
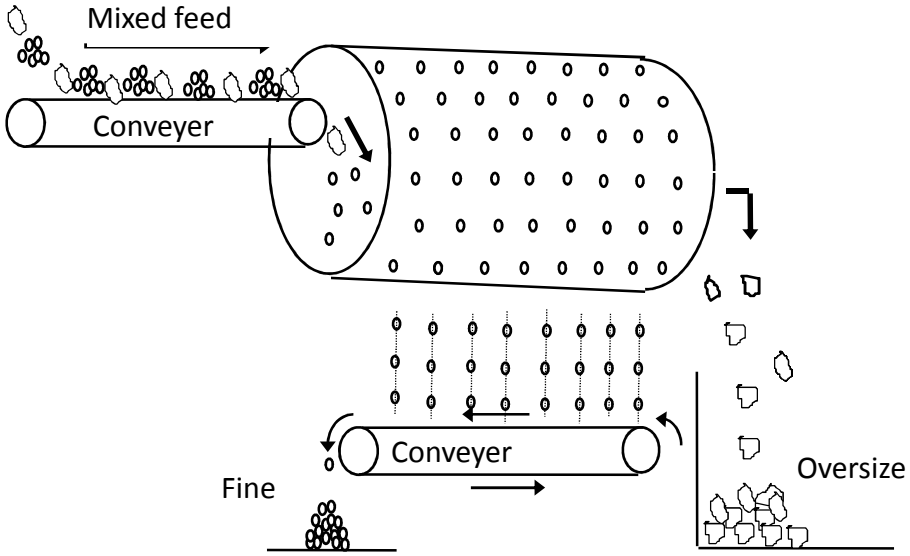
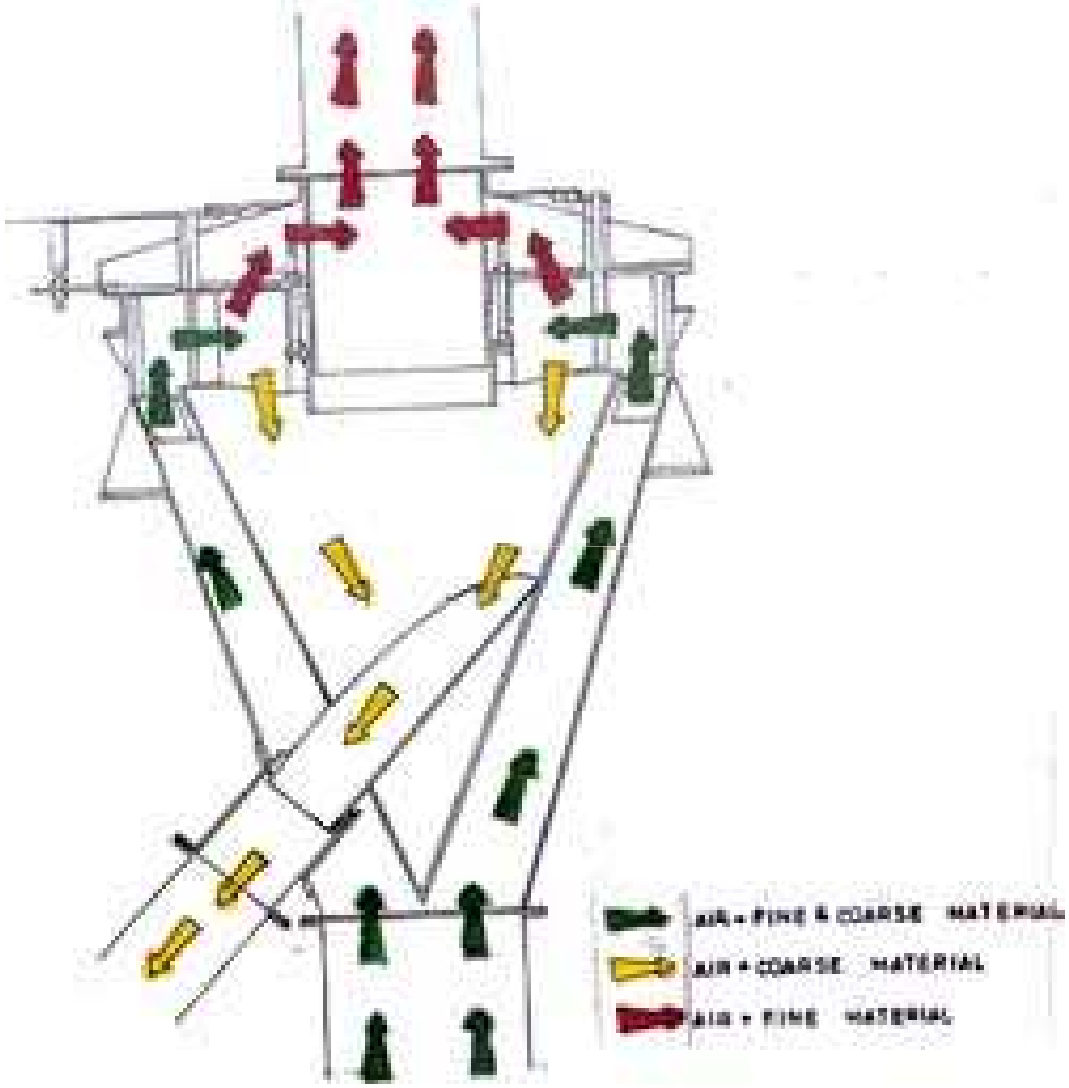


Figure 2: Waste separation using a trommel screen



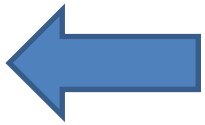
Air classifier



Manual separation

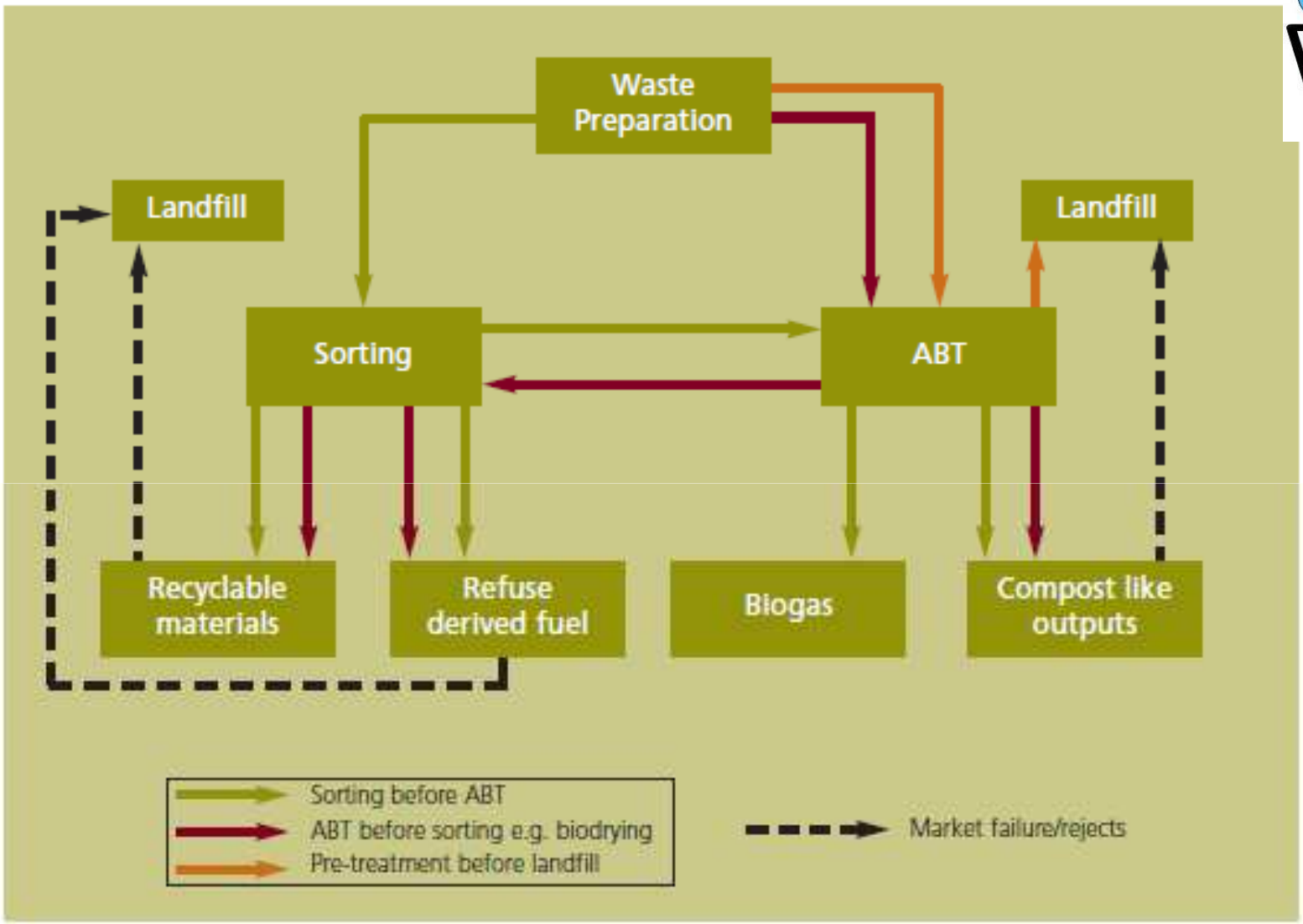
Table 3: Biological Treatment options

Options	Biological Treatment
I	Aerobic - Bio-drying / Biostabilisation: partial composting of the (usually) whole waste
II	Aerobic - In-Vessel Composting: may be used to either biostabilise the waste or process a segregated organic rich fraction
III	Anaerobic Digestion: used to process an segregated organic rich fraction



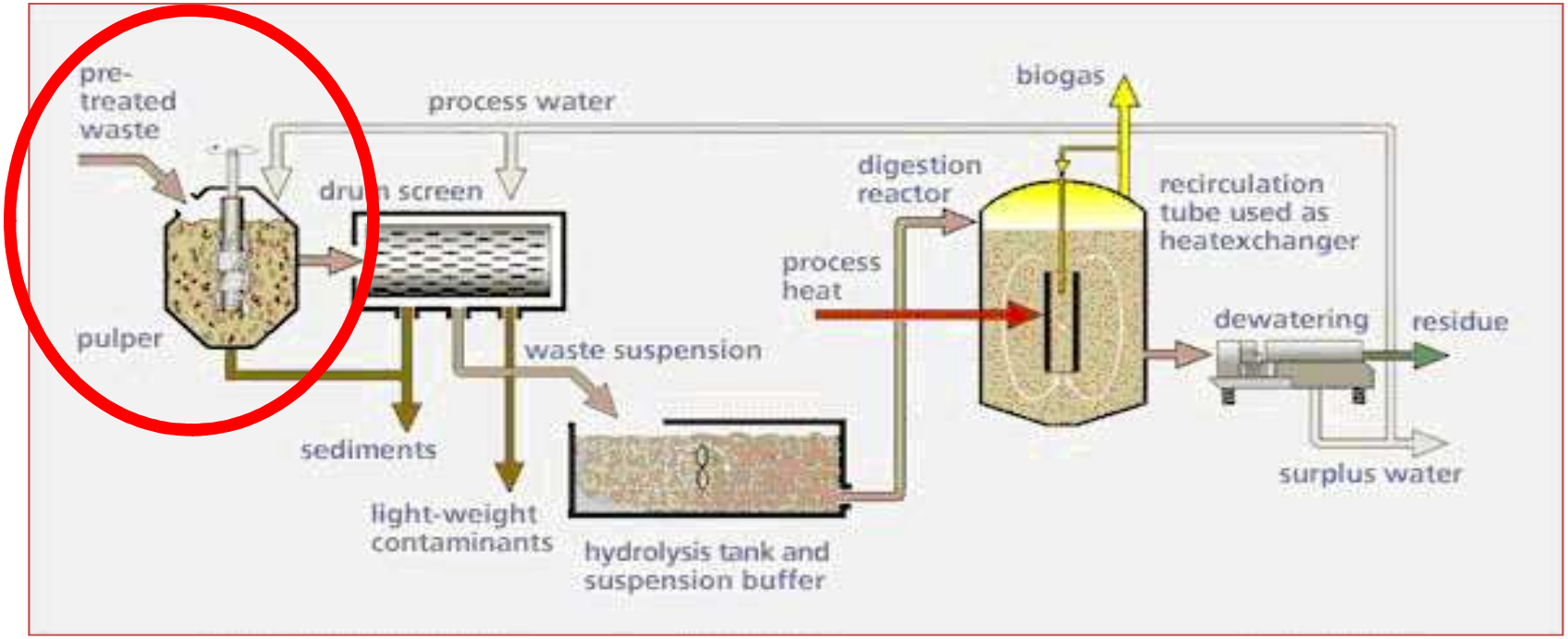
Source DEFRA (UK)

MBT + AD



Source DEFRA (UK)

The typical AD application is the DRY process.
In case of the application of a WET AD process, a further "purification" step is needed to remove the residual fraction of inert material



Linde process for wet AD

MARKETS & OUTLETS FOR THE OUTPUTS

Recyclables derived from the various MBT processes are typically of a lower quality than those derived from a separate household recyclate collection system and therefore have a lower potential for high value markets.

Materials which may be extracted from MBT processes include metals, glass, textiles, paper/card, and plastics. The most common of these is glass, which may be segregated with other inert materials such as stones and ceramics.

Carton baler

Plastic baler

Separated paper

Biogas can be produced, but at low extent, rarely exceeding 60 m^3 per tonne of treated material (equivalent to some 120-140 kWh).

Where the MSW is sorted / treated to produce a high calorific value waste stream comprising significant proportions of the available combustible materials such as mixed paper, plastics and card, this stream may be known as Refuse Derived Fuel (RDF).

Refuse Derived Fuel (RDF)

High Heating Value up to 30 MJ/kg

Potential outlets for RDF

1. Industrial Combined Heat and Power (CHP) units

2. Cement kilns

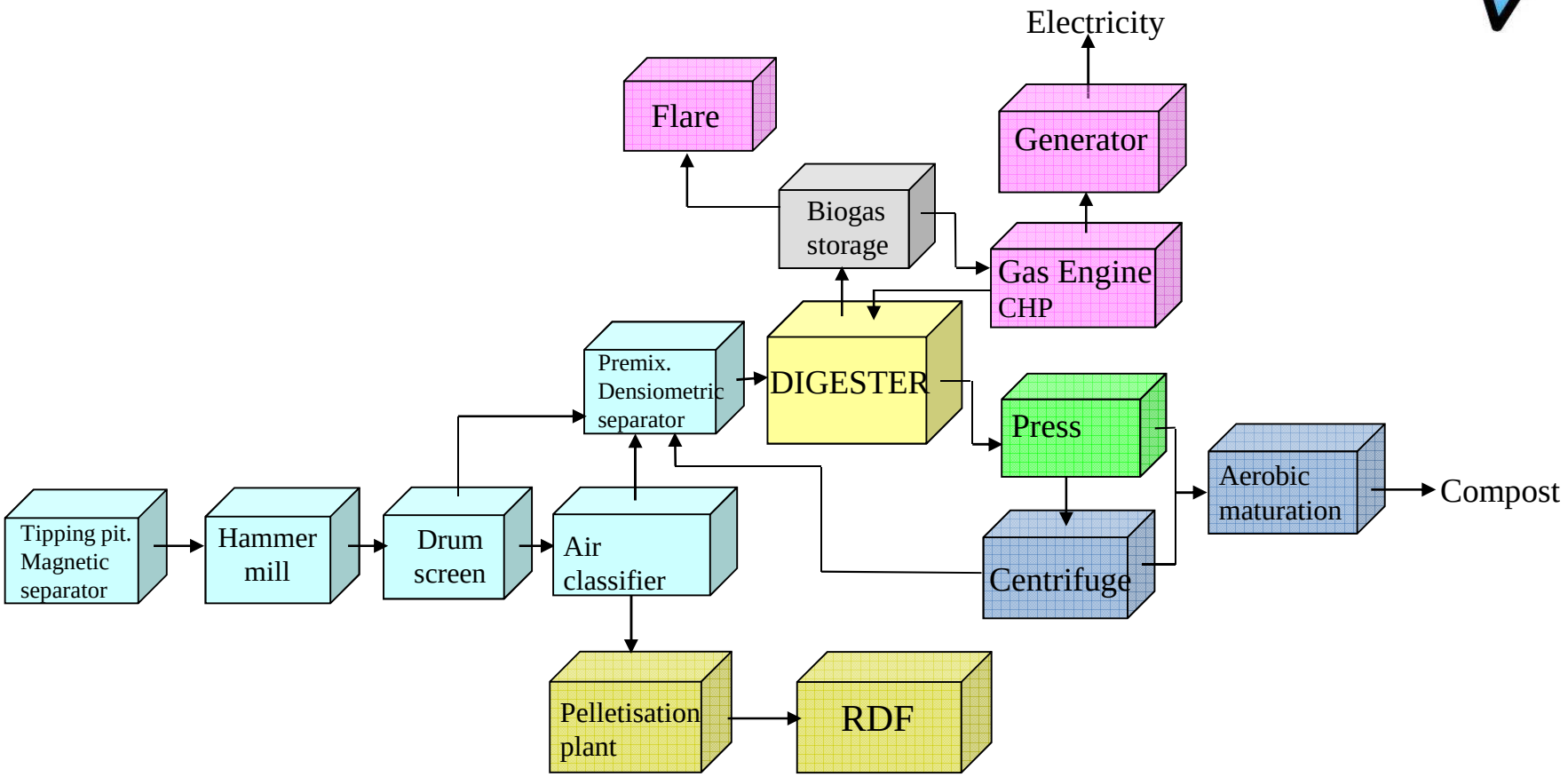
3. Co-firing with coal at power stations

4. Co-firing with fuels like poultry litter and biomass

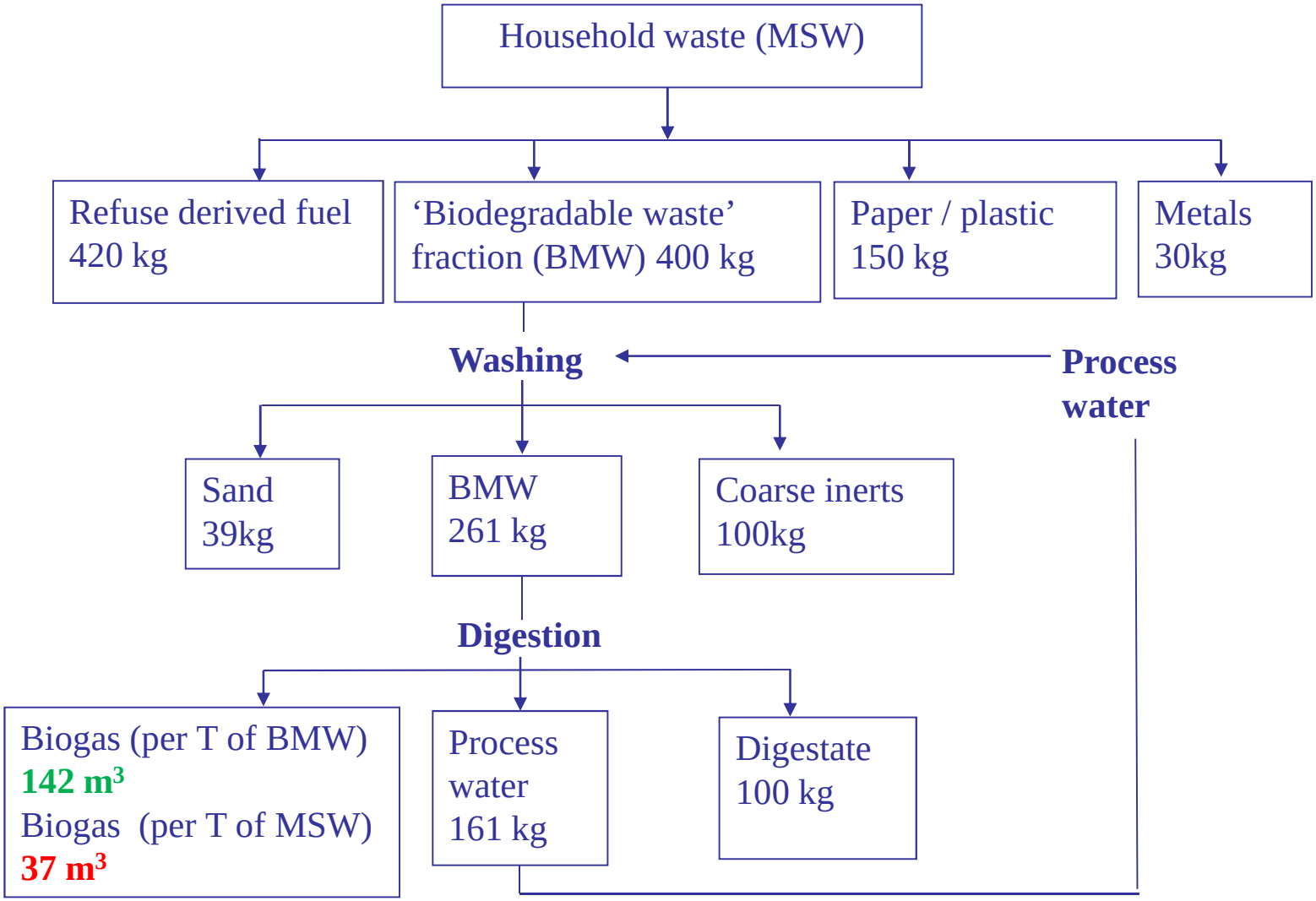
5. Advanced thermal technologies, such as pyrolysis and gasification

Compost – like output

Typical CITEC Process



Mass balance for 1 tonne of waste



Based on a 230,000 tonne/year plant at Vargon, NL

MBT
&
WET ANAEROBIC DIGESTION

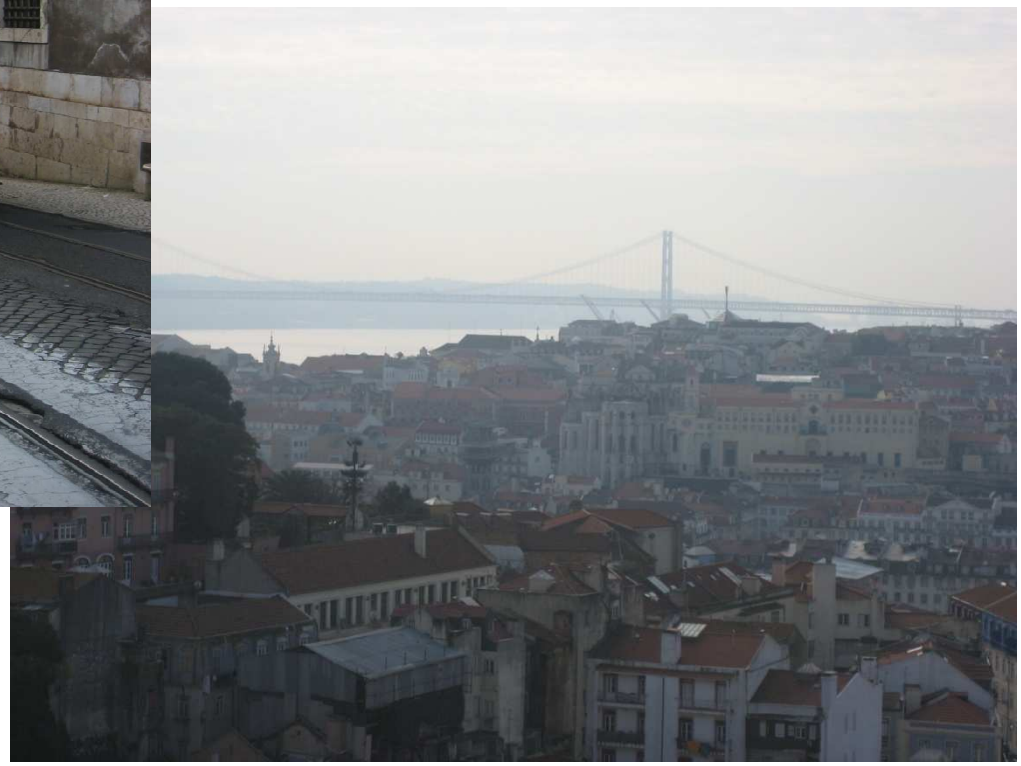
Application of the WET anaerobic digestion in MBT system

The organic material recovered from a MSW through the mechanical processes can undergo to an aanerobic treatment for energy recvoery. However, this material is generally of bad quality.

This is characterised by:

- A very high content of **inert material** (total solids typically around 50% or more and low volatile fraction, 60% of TS or lower)
- a very **low biogas potential** (normally some 60-70 m^3/tonne, never exceeding 100 m^3/tonne on the input material, but 140 m^3/tonne on the organic material entering the AD unit

A case study: Valorsul s.a. waste treatment plant in Lisbon




ESTAÇÃO DE TRATAMENTO
E VALORIZAÇÃO ORGÂNICA
O PRESENTE PROJECTO
CO-FINANCIADO PELA UNIÃO EUROPEIA,
CONTRIBUI PARA A REDUÇÃO DAS DISPARIDADES SOCIAIS
E ECONÓMICAS ENTRE OS CIDADAOS DA UNIÃO.
UNIÃO EUROPEIA
Fundo de Coesão

Collected bags from restaurants and canteens

Belt conveyor

Bags splitter / shredder

Quality of the organic material can be very low ……

“Inert” output of the trommel screen

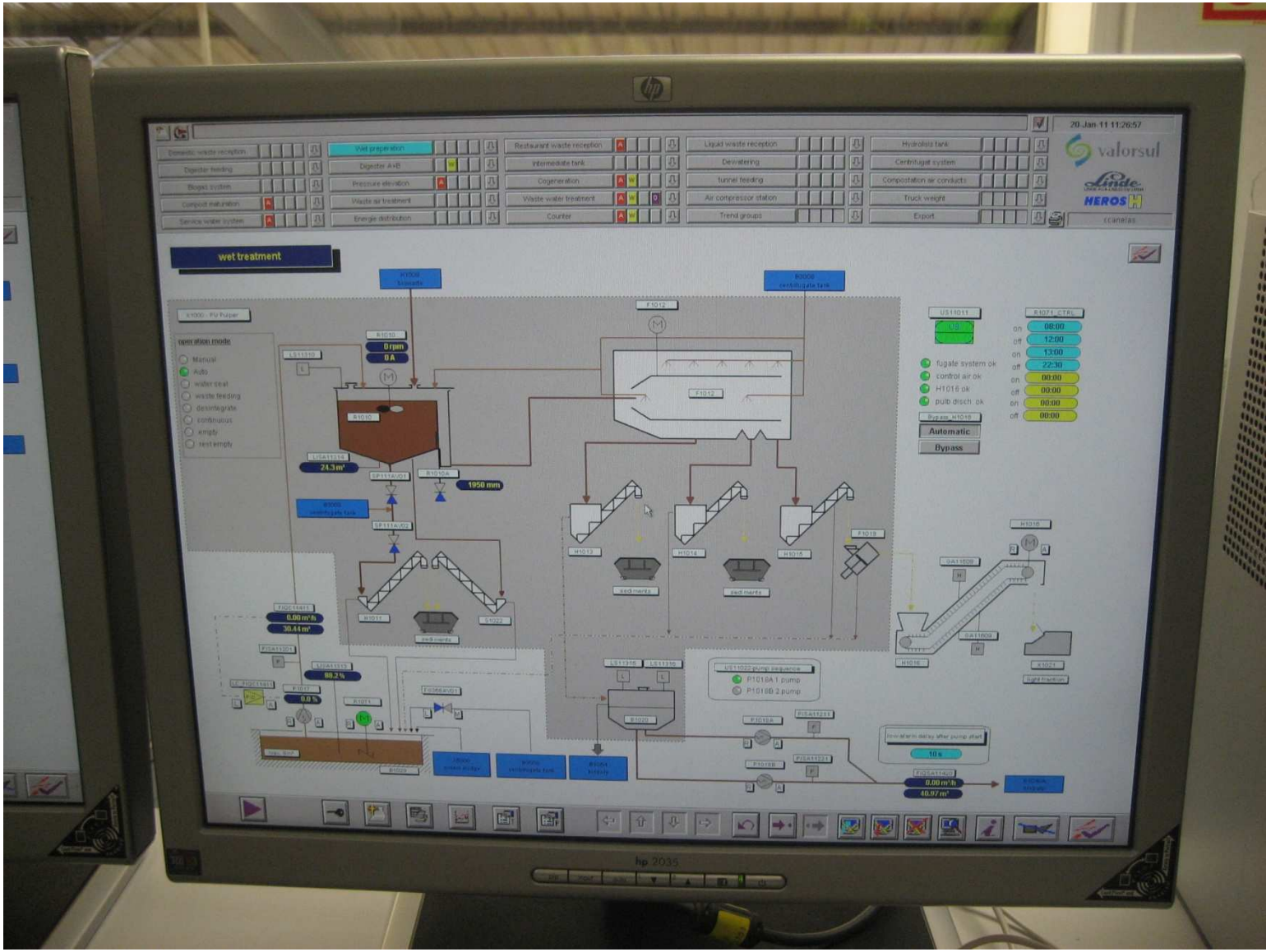
Manual sorting

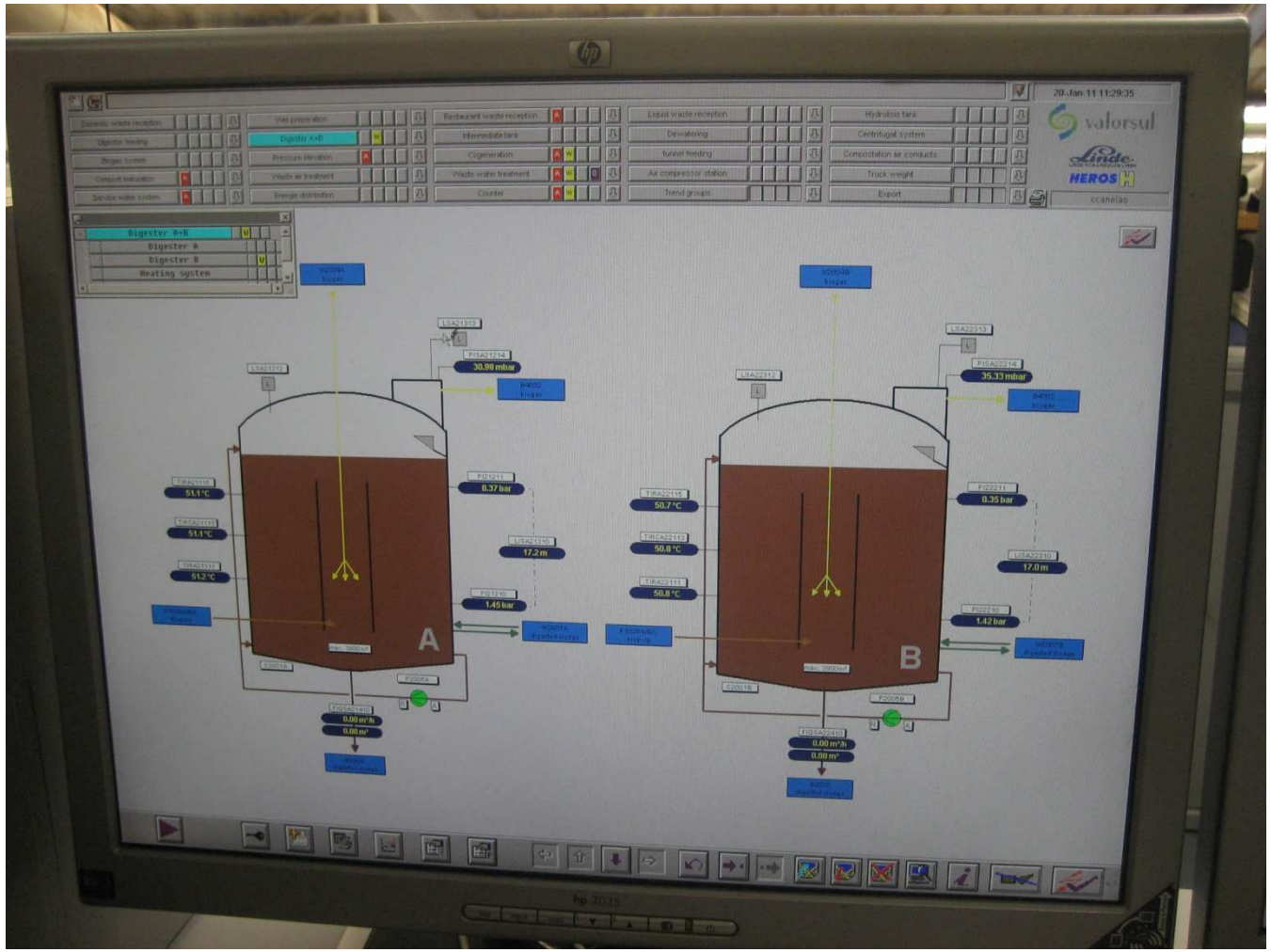
Wet rafination for heavy (glass, stones…) and light (plastic) inerts by means of a hydro-pulper

Hydro-pulper (Linde)

Hydropulper (internal view)

Inert material from the pulper (bottom) ….


wet treatment
valorsul
HEROS
Automatic
Bypass
hp 2035


valorsul
HEROS
Digester A+B
Digester A
Digester B
Heating system
30.98 mbar
35.33 mbar
0.37 bar
0.35 bar
17.2 m
17.0 m
1.45 bar
1.42 bar
51.1 °C
51.4 °C
51.2 °C
50.7 °C
50.8 °C
50.8 °C
A
B

Compost from digestate

Compost from digestate

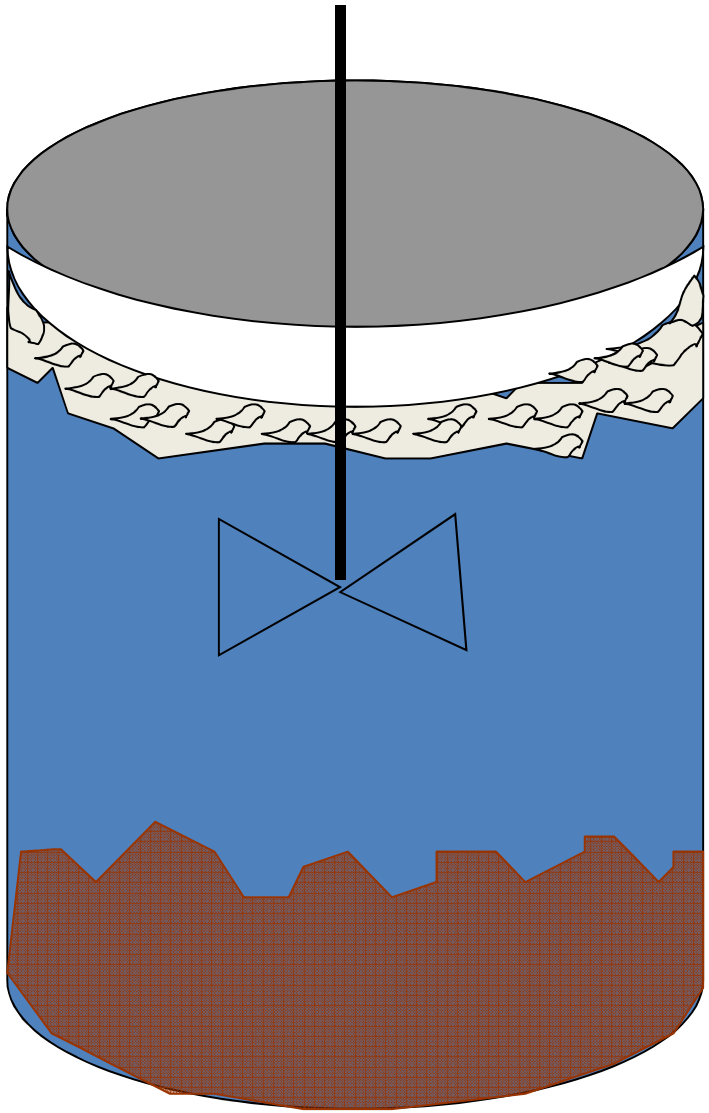
Compost from digestate (after polishing)

The problem of inert accumulation in wet AD reactors

Accumulation of inert material in the wet AD reactor

Problem:

phase separation



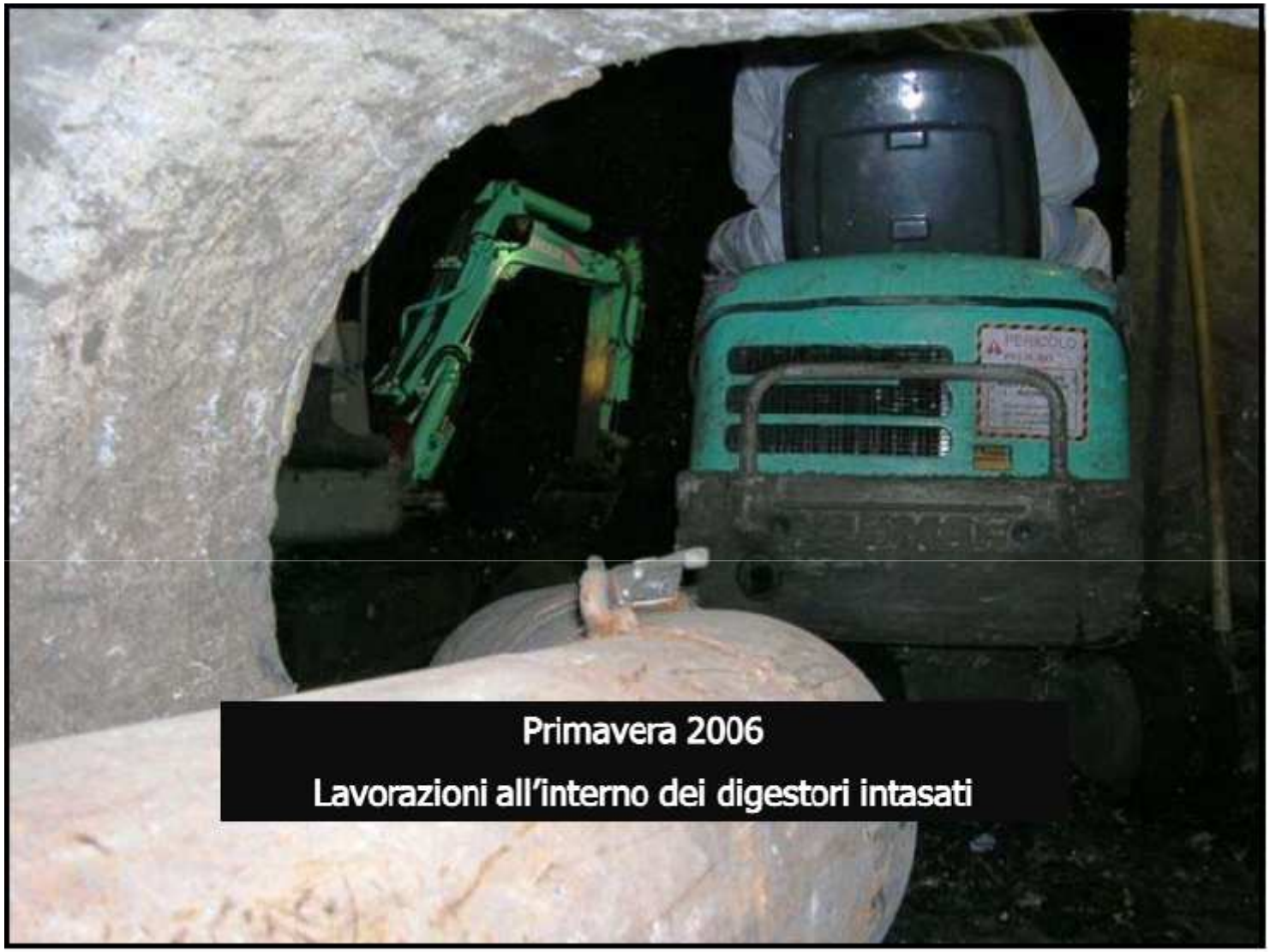
BIOGAS

Grease / oil

Liquid

Solid (inert)

Giacetti, Contri, Muraro (2009). BIOWASTE, Milano 24 febbraio 2009



Giacetti, Contri, Muraro (2009). BIOWASTE, Milano 24 febbraio 2009

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