University of Verona, Department of Biotechnology

Lecture 11 - Mechanical pre-treatment processes for residual wastes and Anaerobic Digestion

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

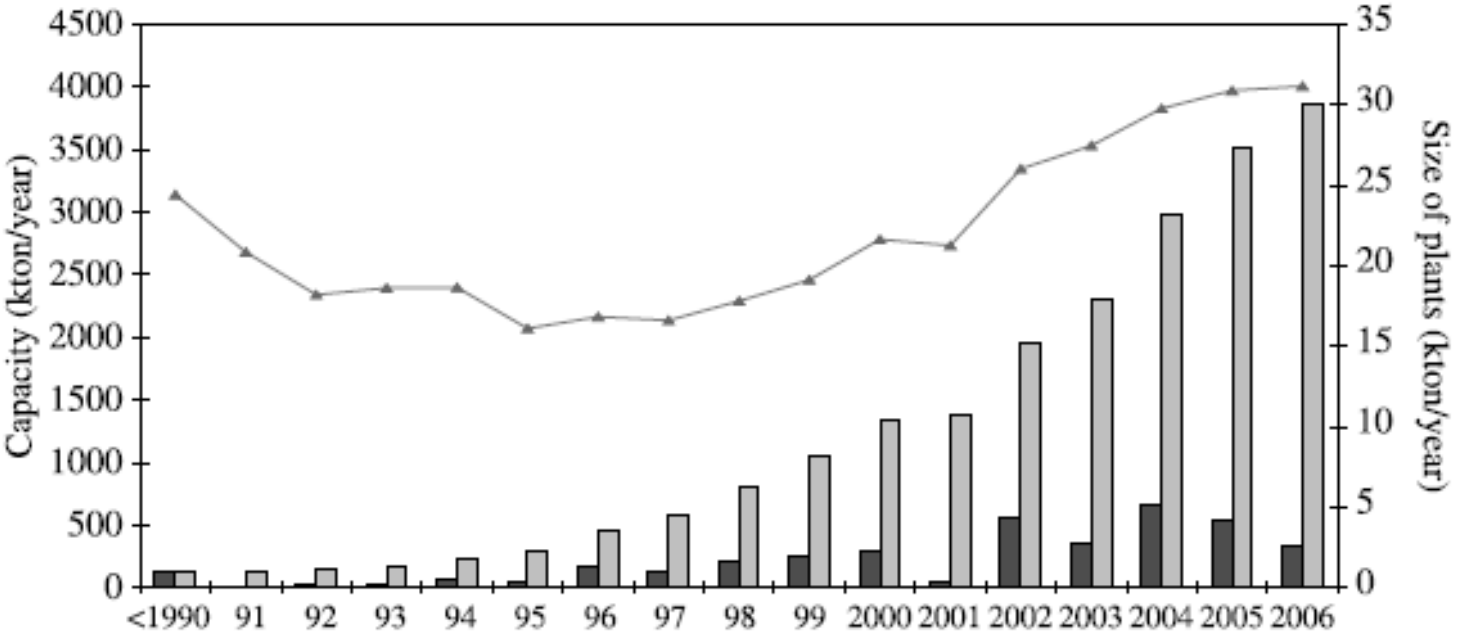


Figure 1 annual ■, cumulative ■, and cumulative average installed capacity -◆-

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

An EU technology …. so far ….

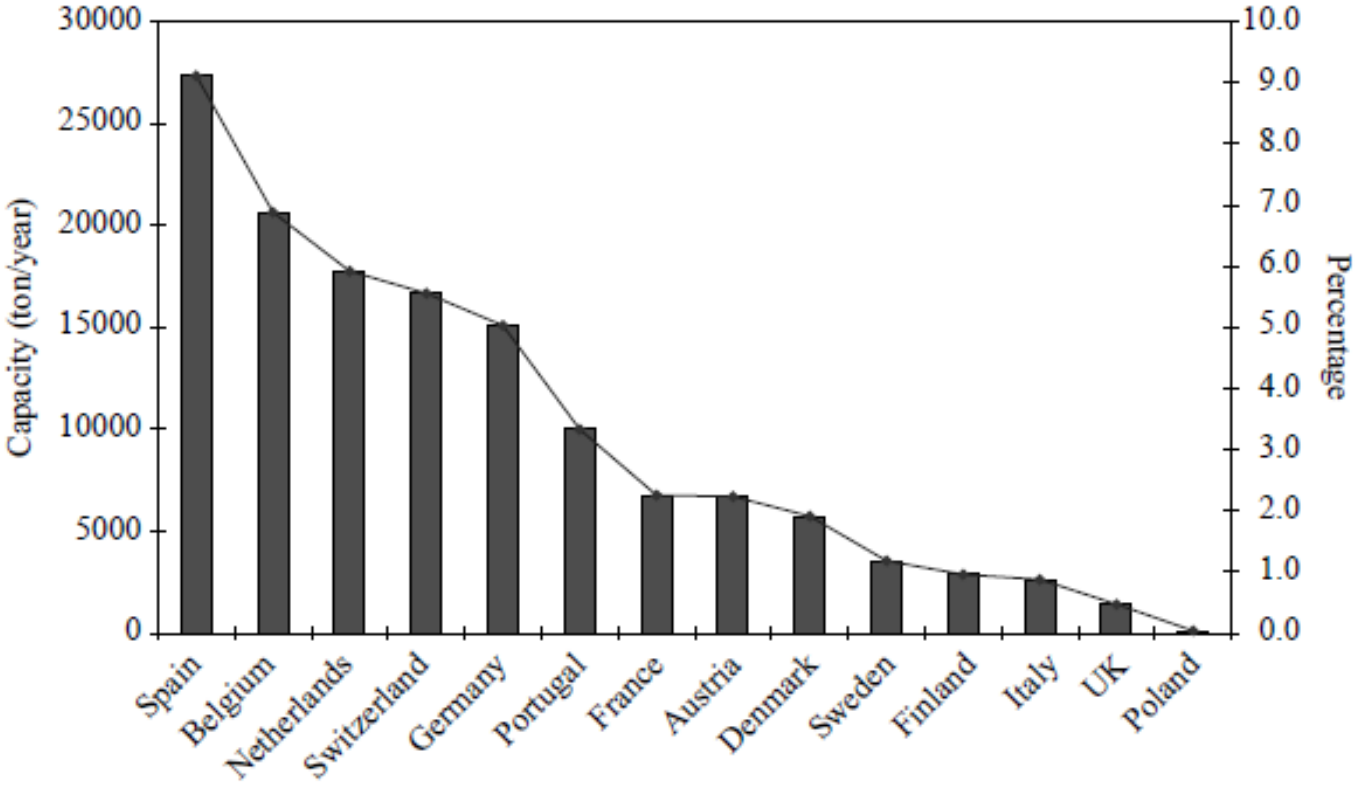
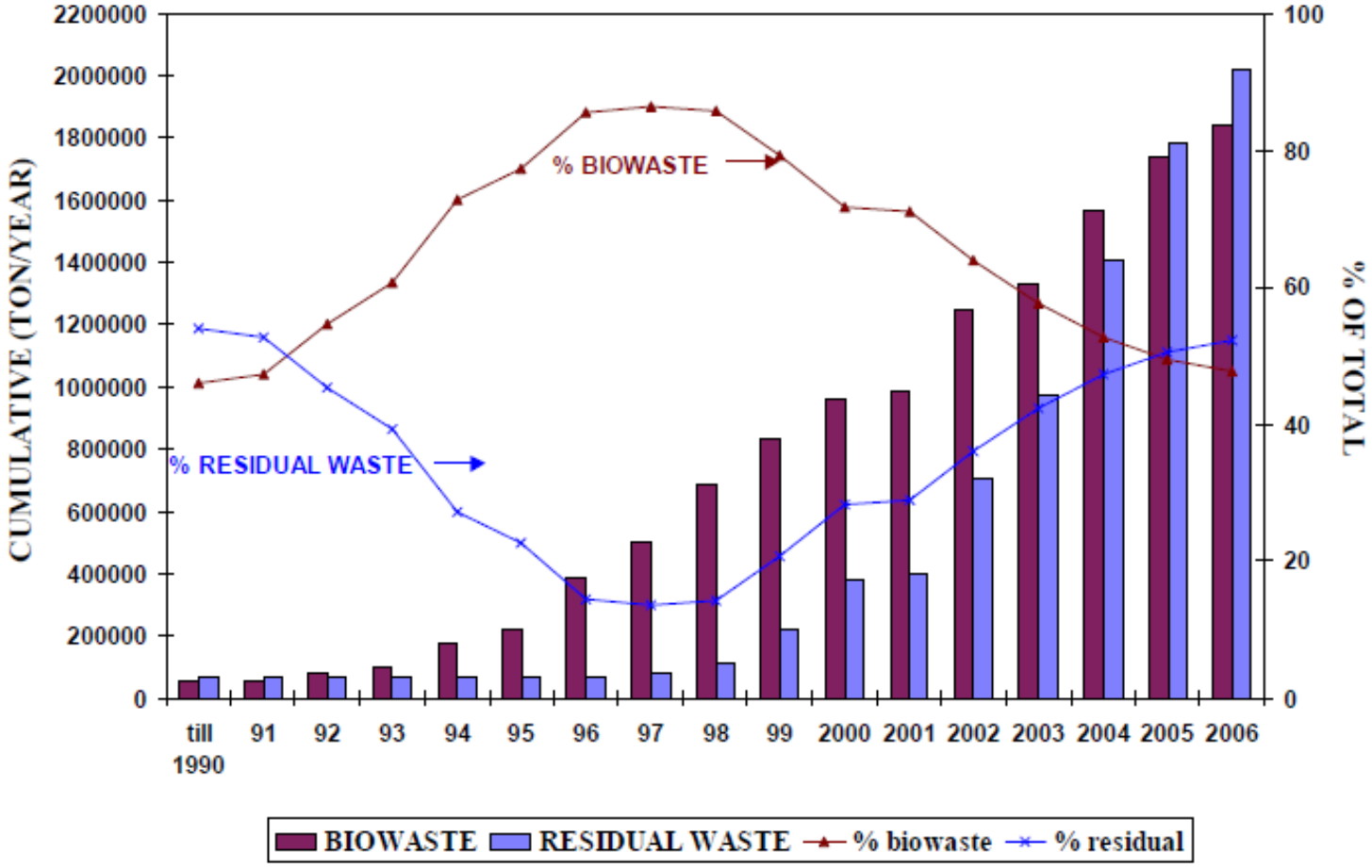


Figure 2 Capacity per million inhabitants ■ and percentage of potential theoretical capacity -◆-

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

“Bins in the street” separate collection

«Door to door» separate collection


Household waste
Garden waste
Garden waste
Lightbulbs & batteries
Cardboard
Glass & tin
Newspaper & magazines
Plastic
Kitchen waste
Food waste

Generic bins … (unsorted waste)

Unsorted waste

Paper

Plastic

Glass

Shredded food waste

When applied for the treatment of residual material from unsorted waste, AD is typically part of a Mechanical Biological Treatment **(MBT)** process

This technology is dedicated to the treatment of

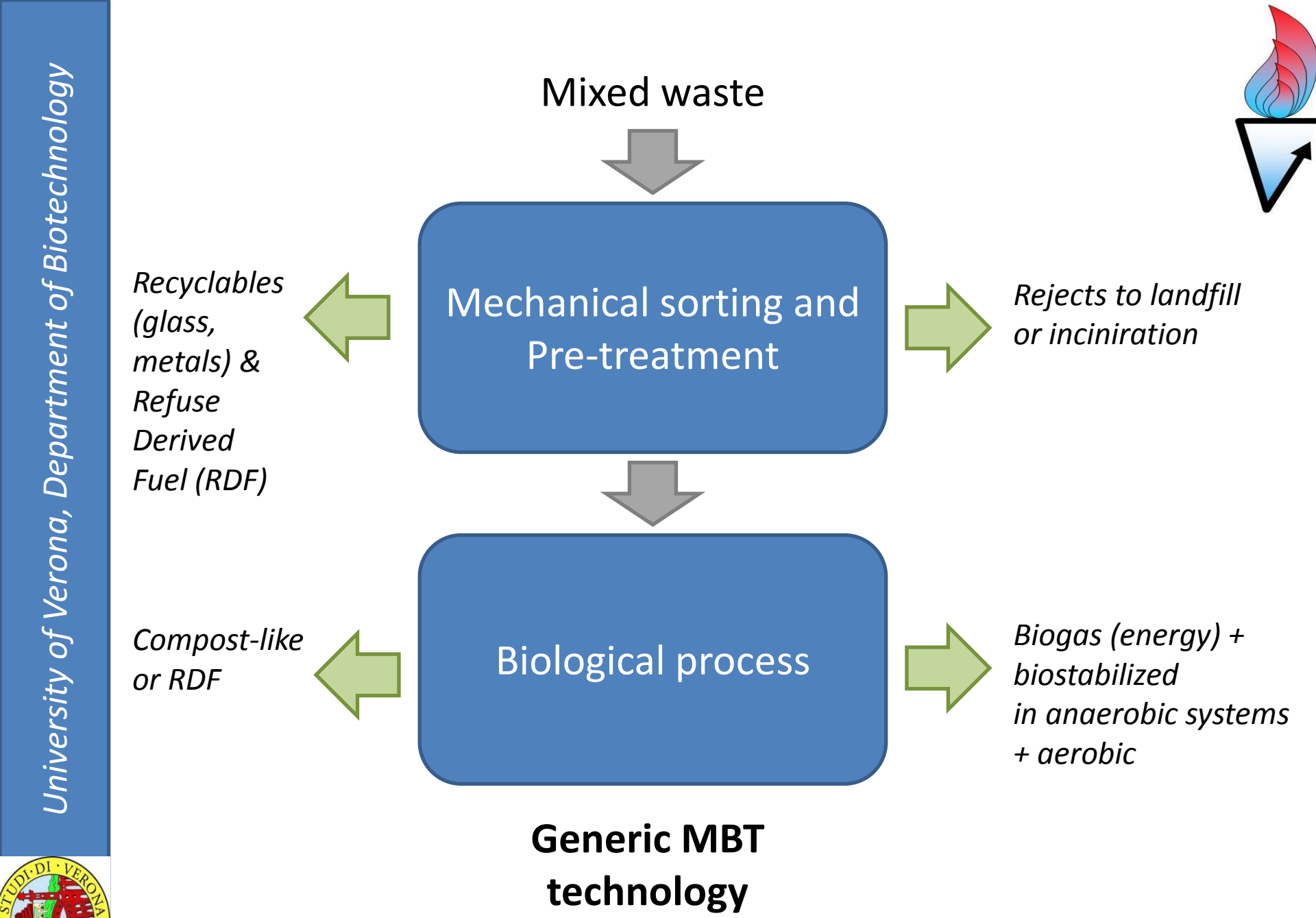
✓ unsorted Municipal Solid Waste (MSW)

✓ industrial waste

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

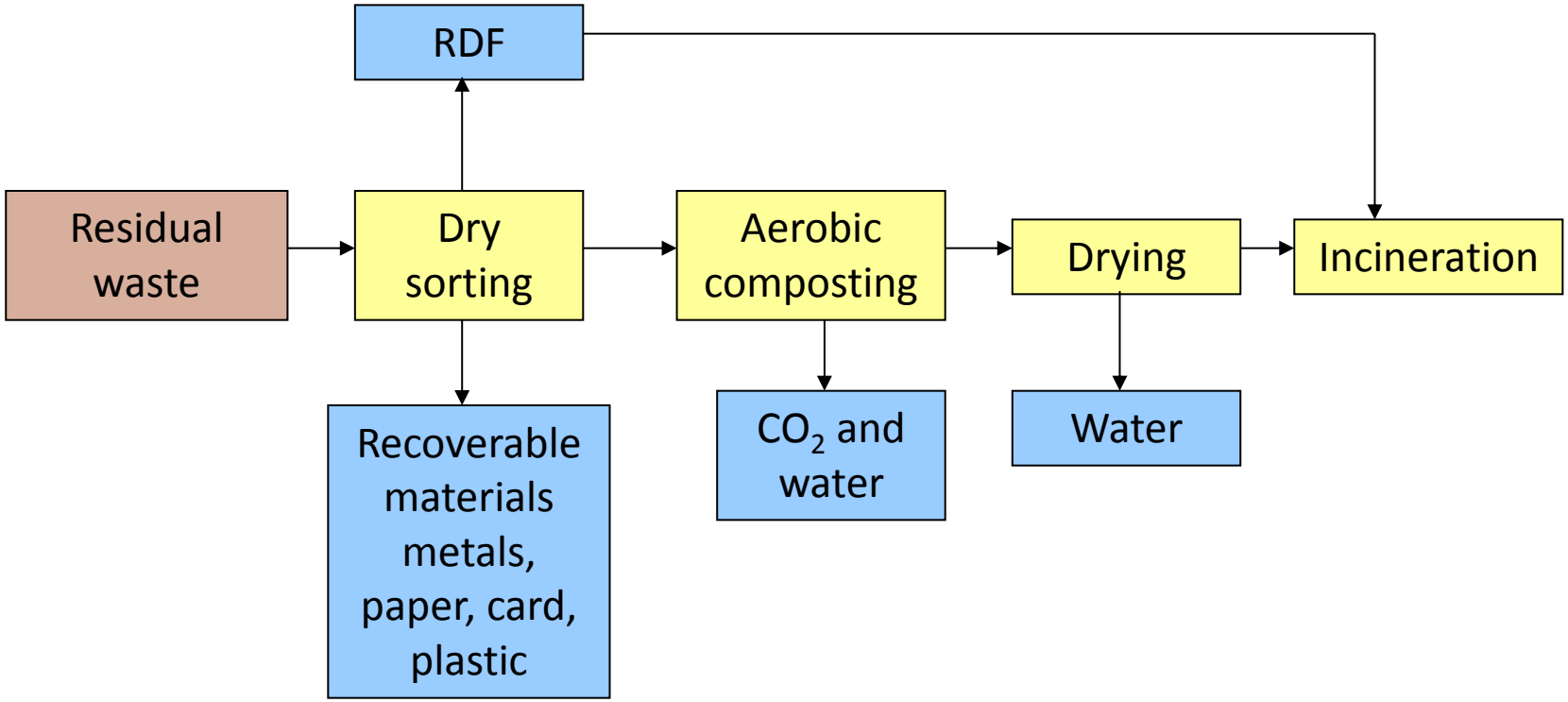
The mechanical-biological-treatment (MBT) is combination of two processes:
the first one, mechanical, is dedicated to the separation of recyclable materials and the organic fraction from the bulk waste while the second one, biological, is dedicated to the stabilization of this organic material.
The biological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

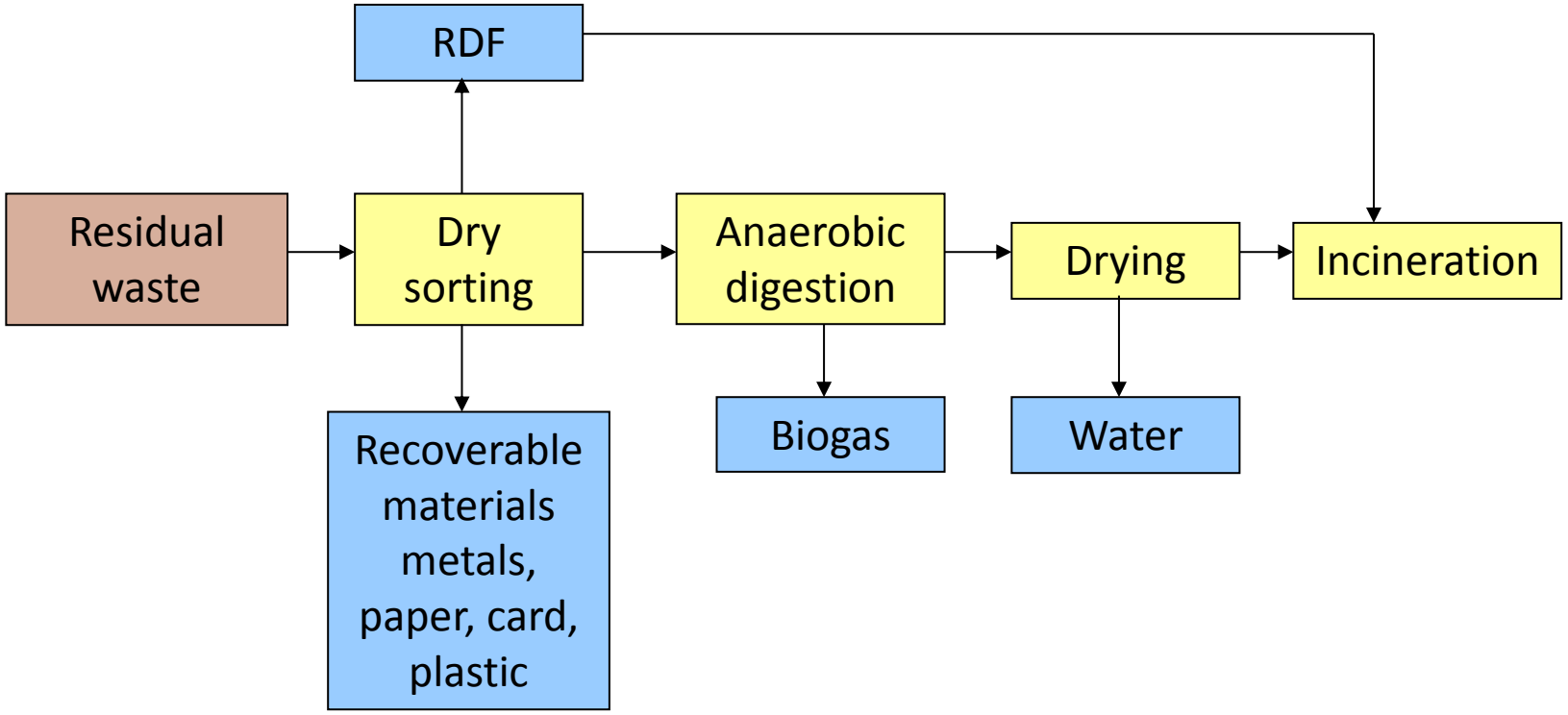


Generic MBT technology

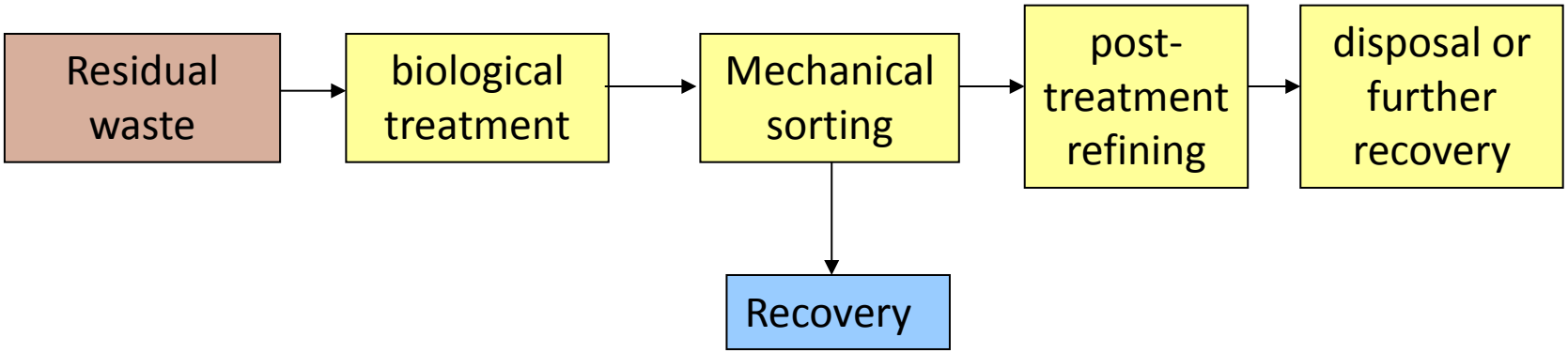
Typical AEROBIC (composting) MBT



Typical ANAEROBIC MBT



A second option: invert mechanical and biological
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 (if possible);
✓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:

1. **to brake down the waste in smaller parts and**
2. **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

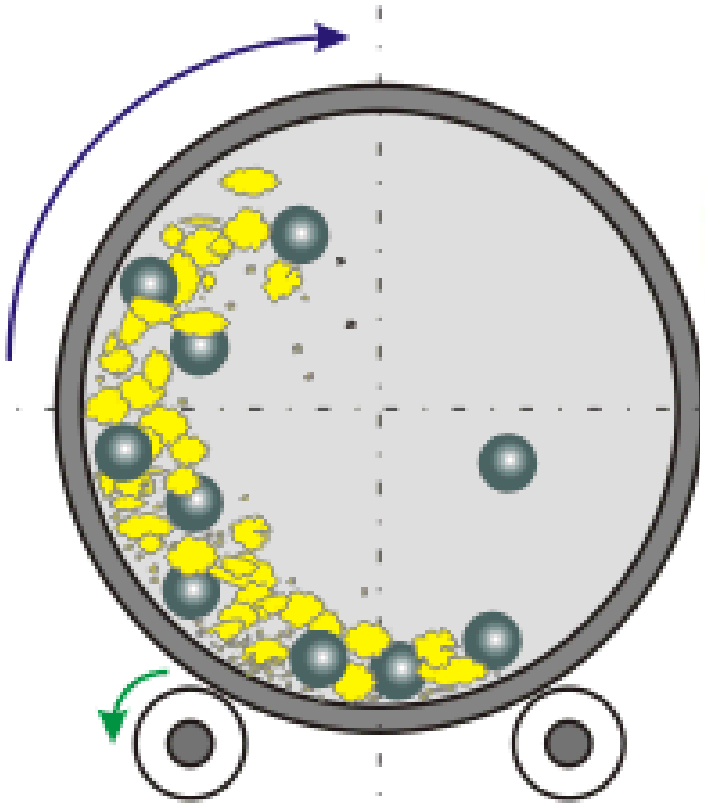
Source DEFRA (UK)

Bags opening and size reduction

Shredder

Hammer mill

Ball mill



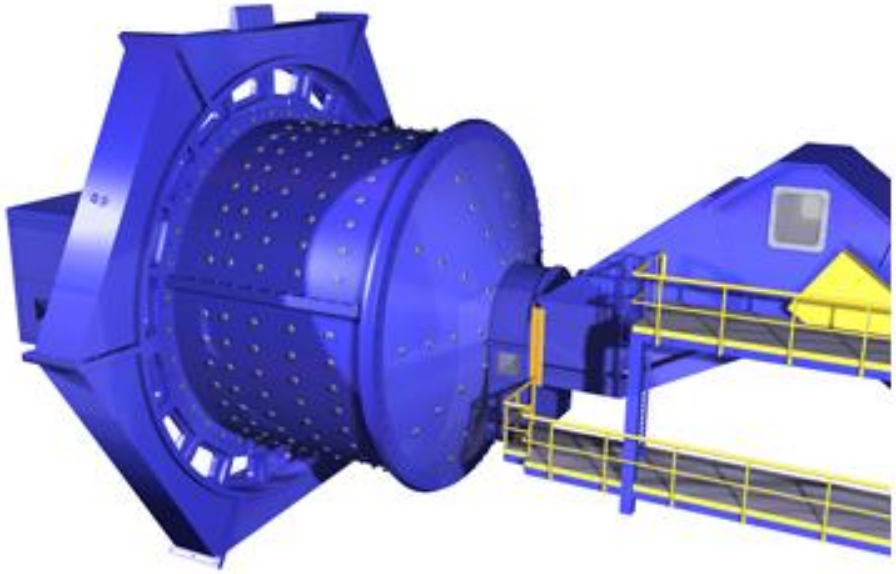
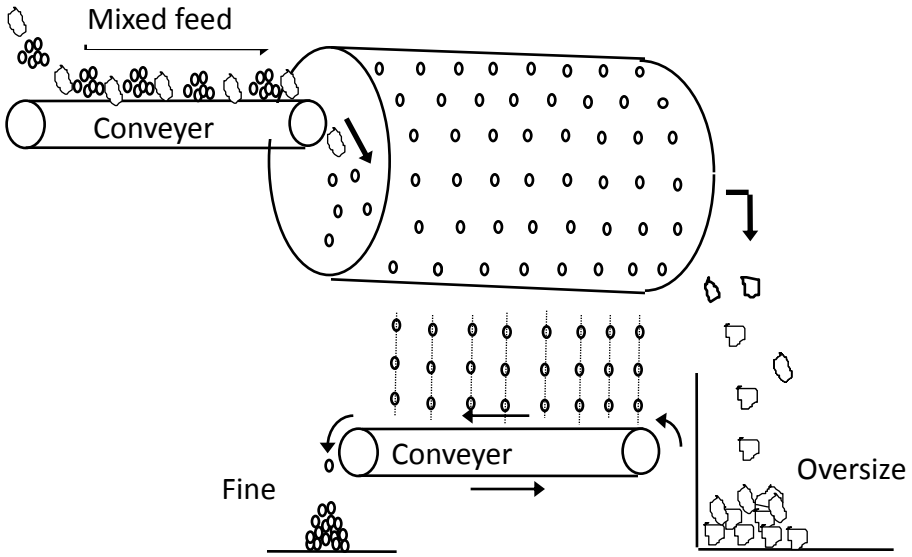


Table 2: Waste Separation Techniques

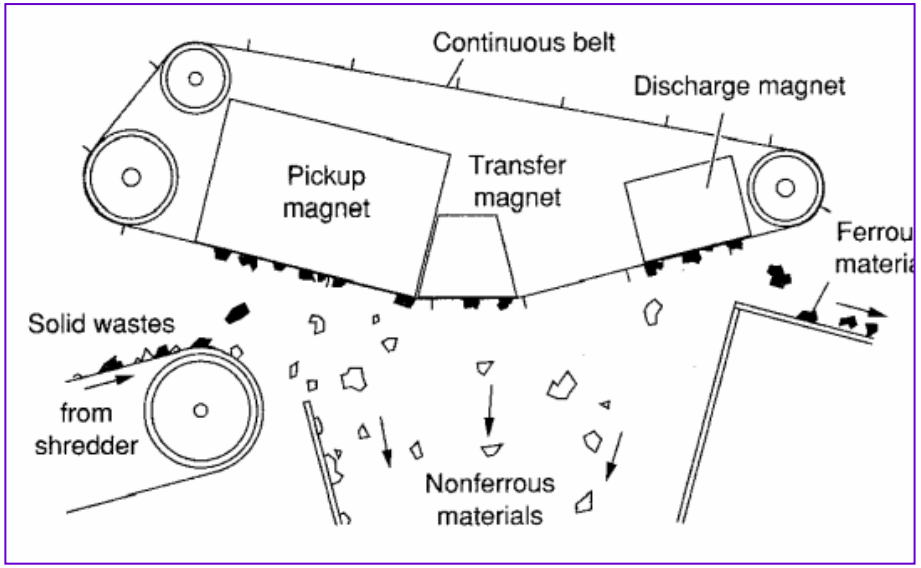
	Separation Technique	Separation Property	Materials targeted	Key Concerns
1	Trommels and Screens	Size	Oversize – paper, plastic Small – organics, glass, fines	Air containment and cleaning
2	Manual Separation	Visual examination	Plastics, contaminants, oversize	Ethics of role, Health & Safety issues
3	Magnetic 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)

Figure 2: Waste separation using a trommel screen

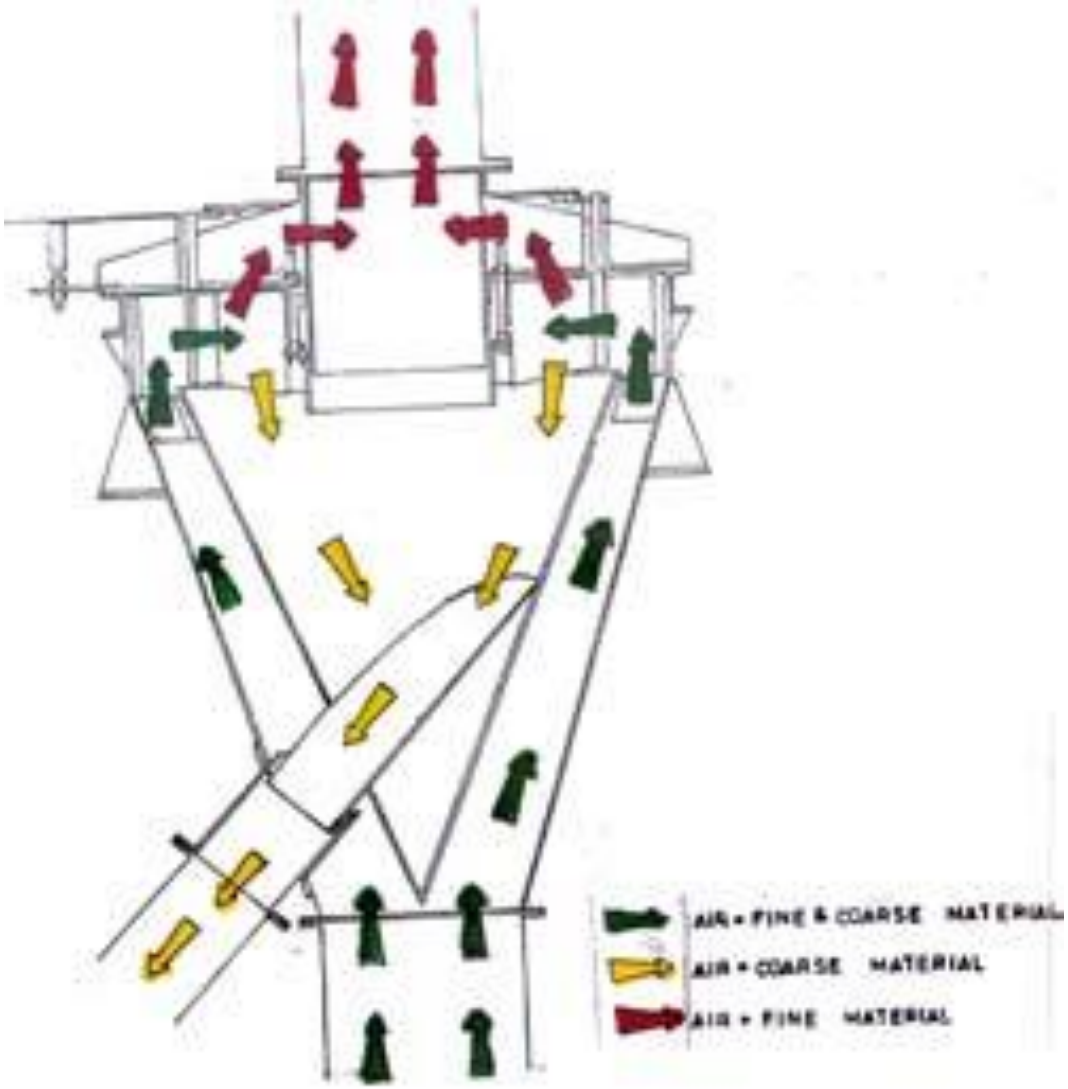


Metals separation and recovery



Note:
2 classes of metal compuonds !

Air classifier



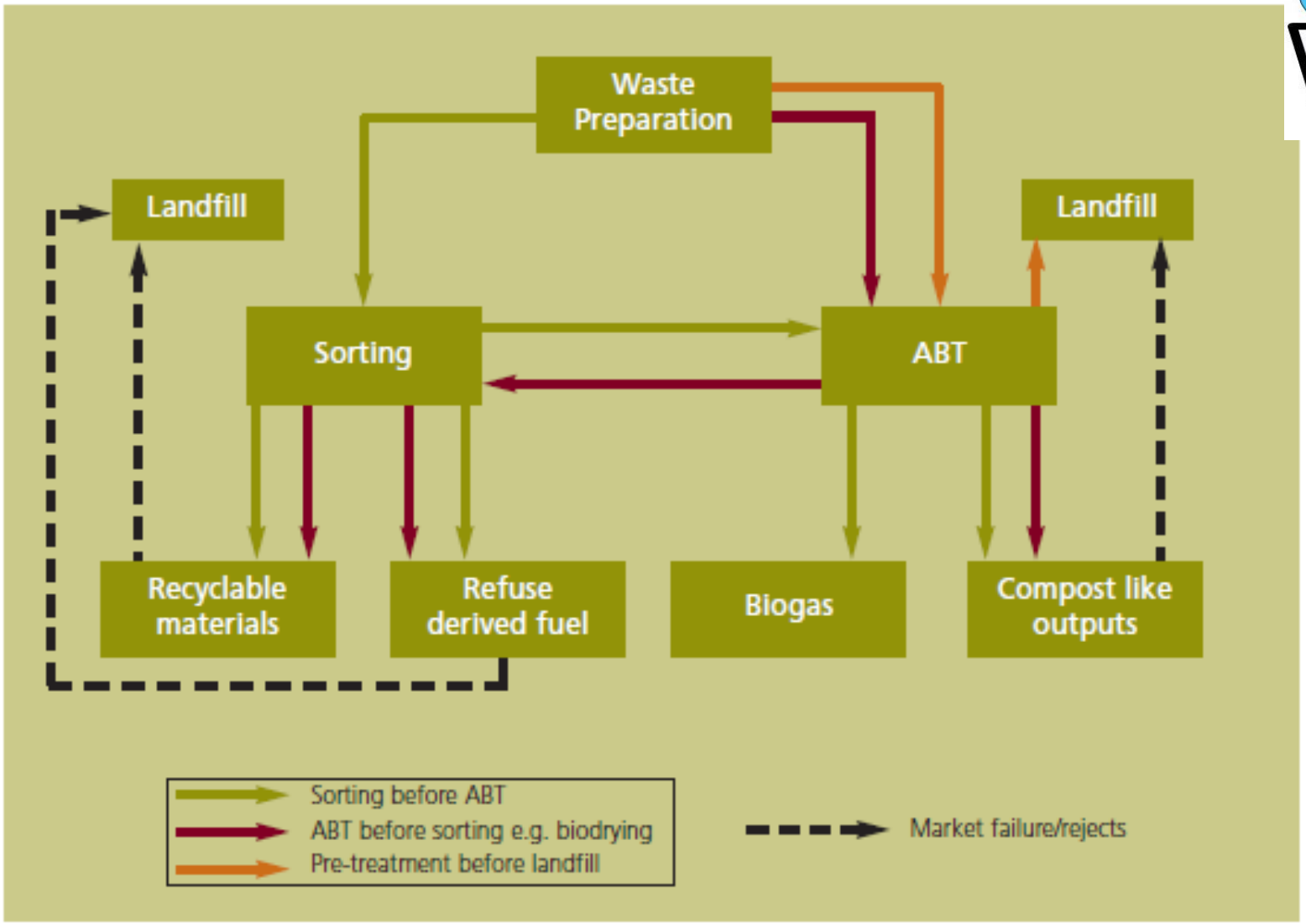
Manual separation

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 (wet or dry)



Source DEFRA (UK)

The typical AD application is the DRY process

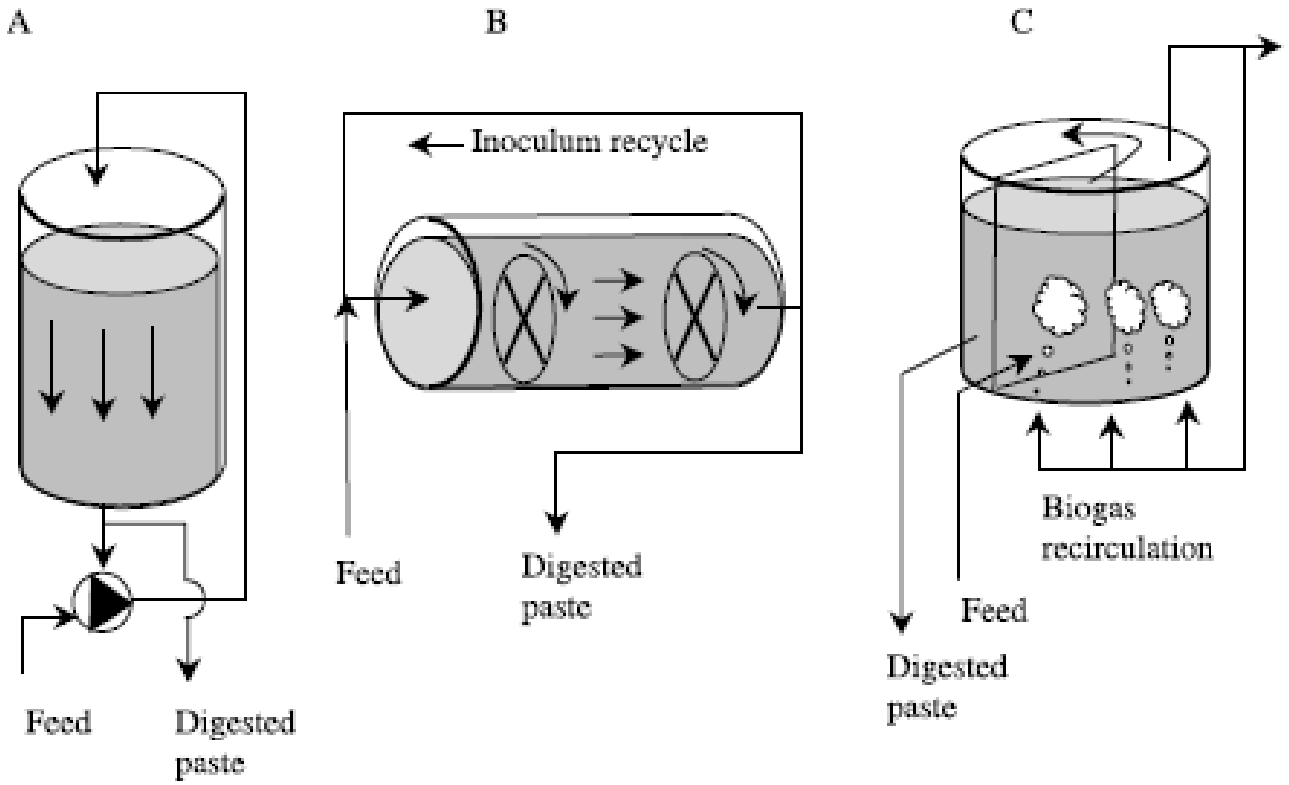
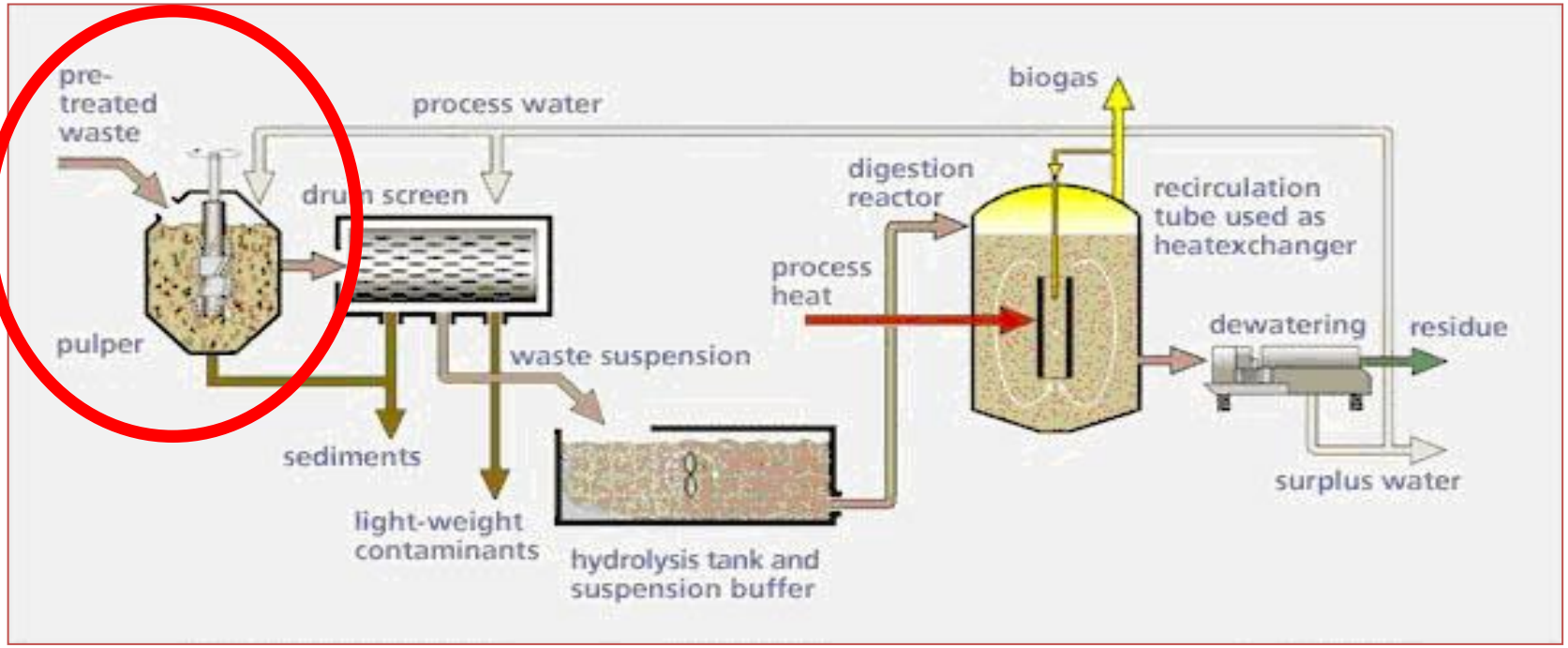


Figure 1 Different digester designs used in dry systems (A illustrates the Dranco design, B the Kompogas and Linde design, and C the Valorga design) (from Lissens *et al.*, 2001)

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.

Separated paper

Carton baler

Plastic baler

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

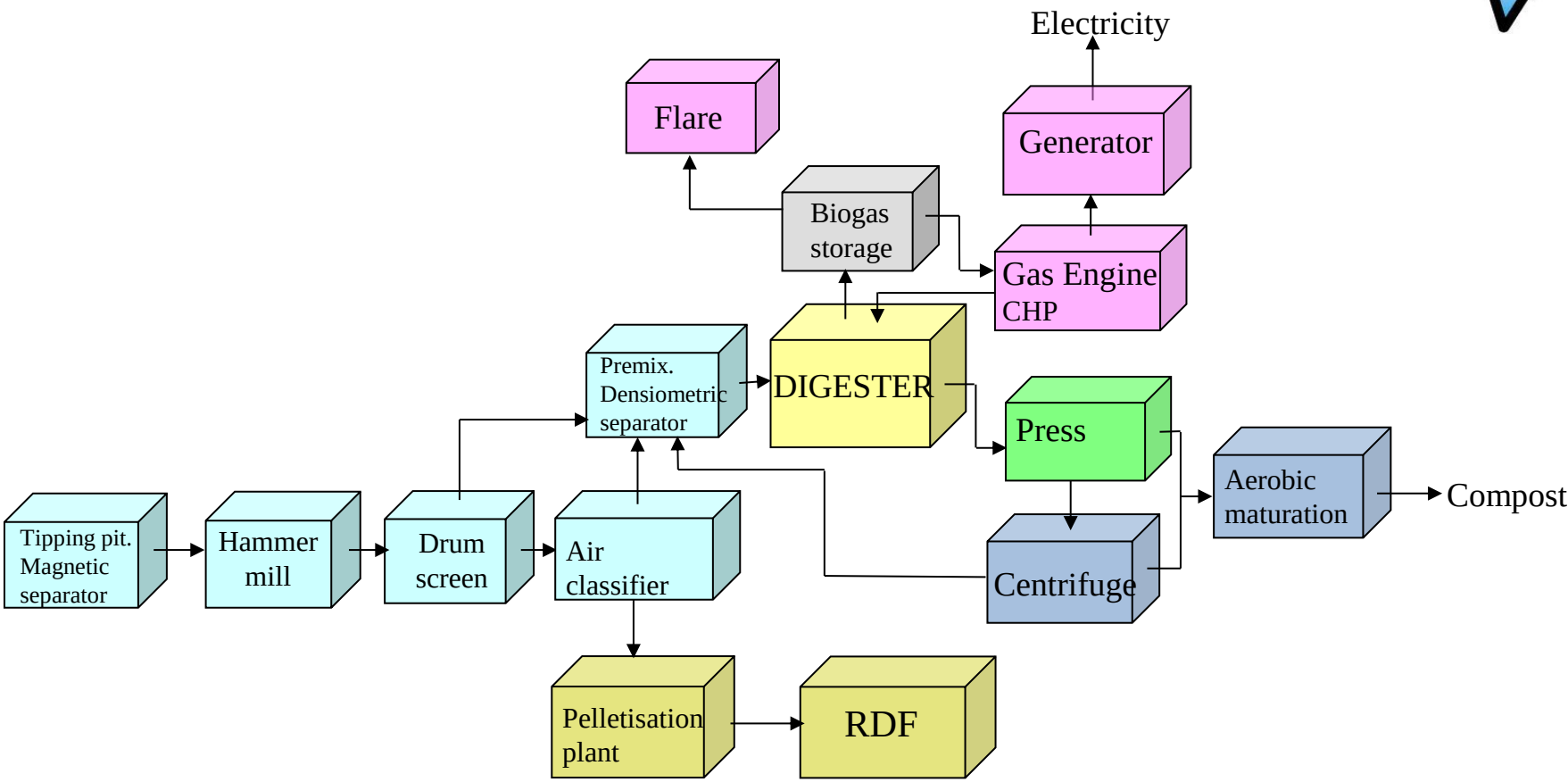
Biological I - AD application

Biogas can be produced, but at low extent, rarely exceeding **60 m³ per tonne** of waste(equivalent to some 120-140 kWh).

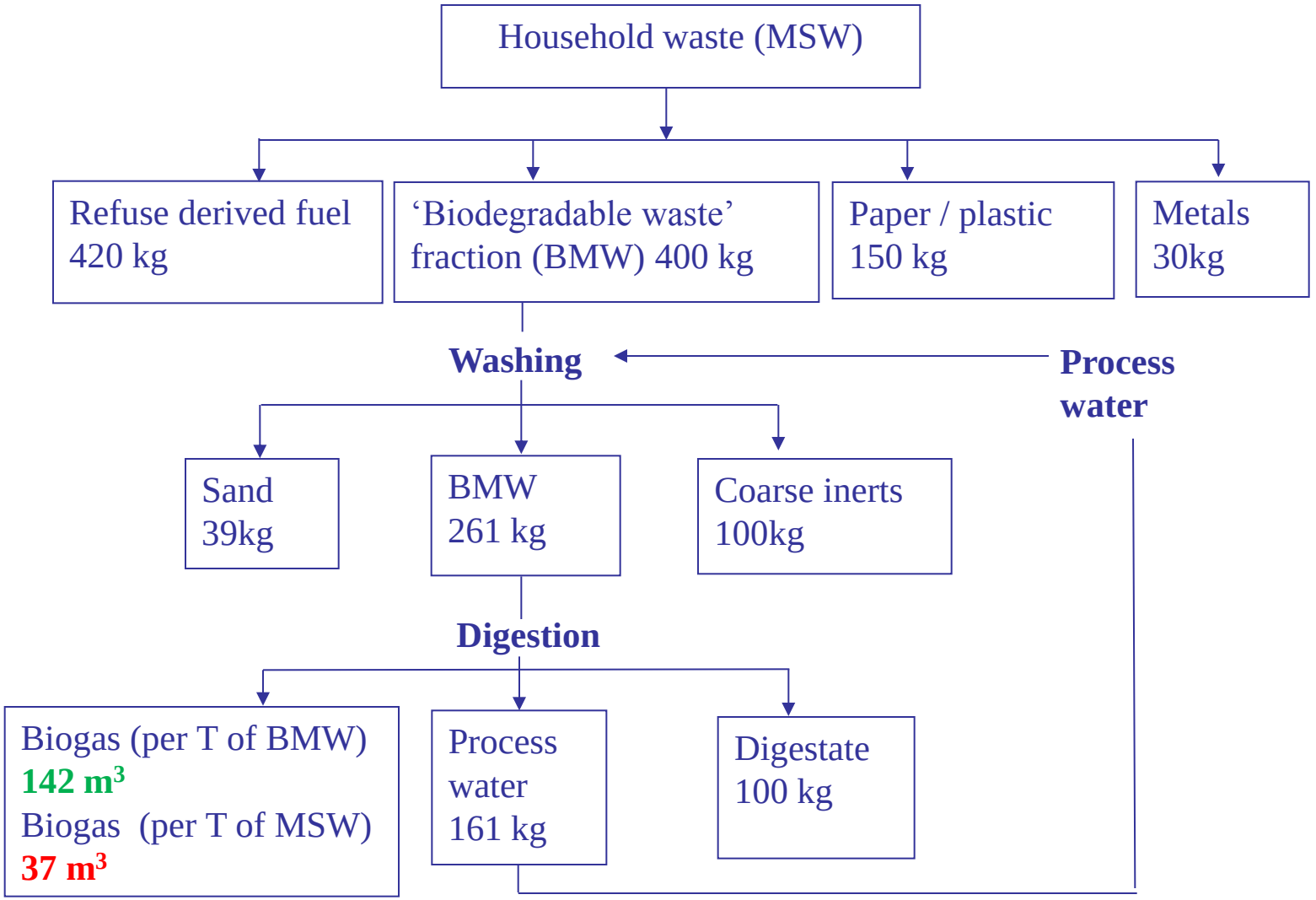
Where the MSW is sorted / treated to produce a high calorific value waste stream comprising significant proportions of the available combustible materials such as mixed paper, plastics and card, this stream may be known as Refuse Derived Fuel (RDF).

Biological II - Compost – like output (CLO)

Typical CITEC Process



Mass balance for 1 tonne of waste



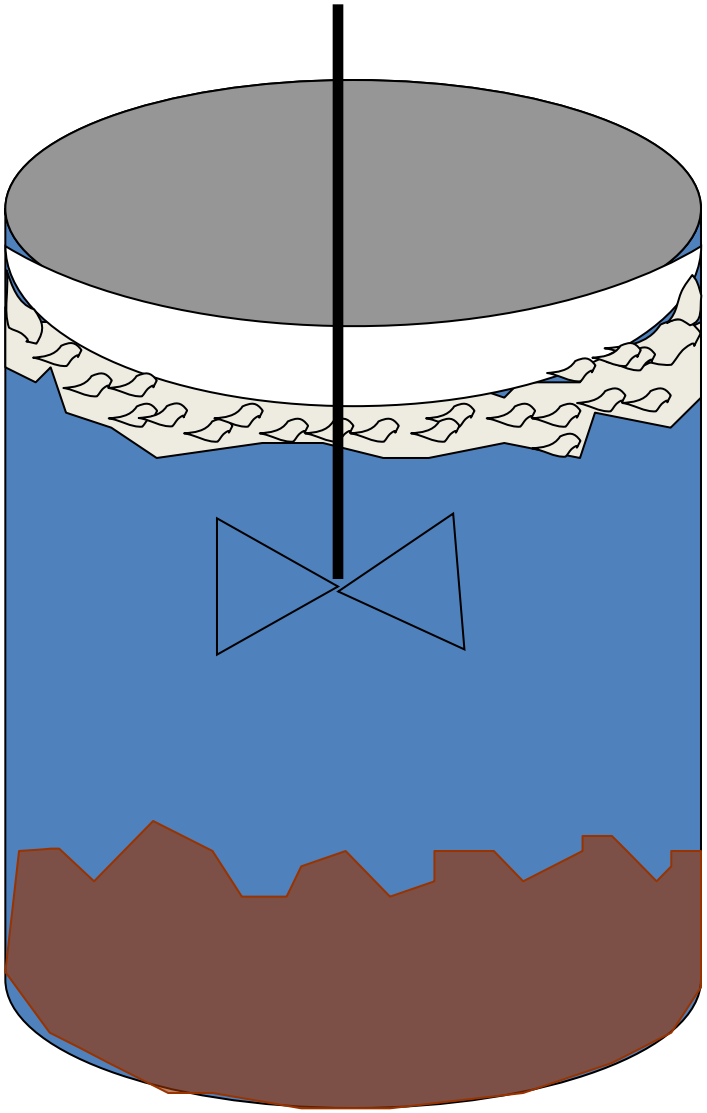
Based on a 230,000 tonne/year plant at Vargon, NL

Inert accumulation in AD reactors part of MBT plants

Accumulation of inert material in the wet AD reactor

Problem:

phase separation



BIOGAS

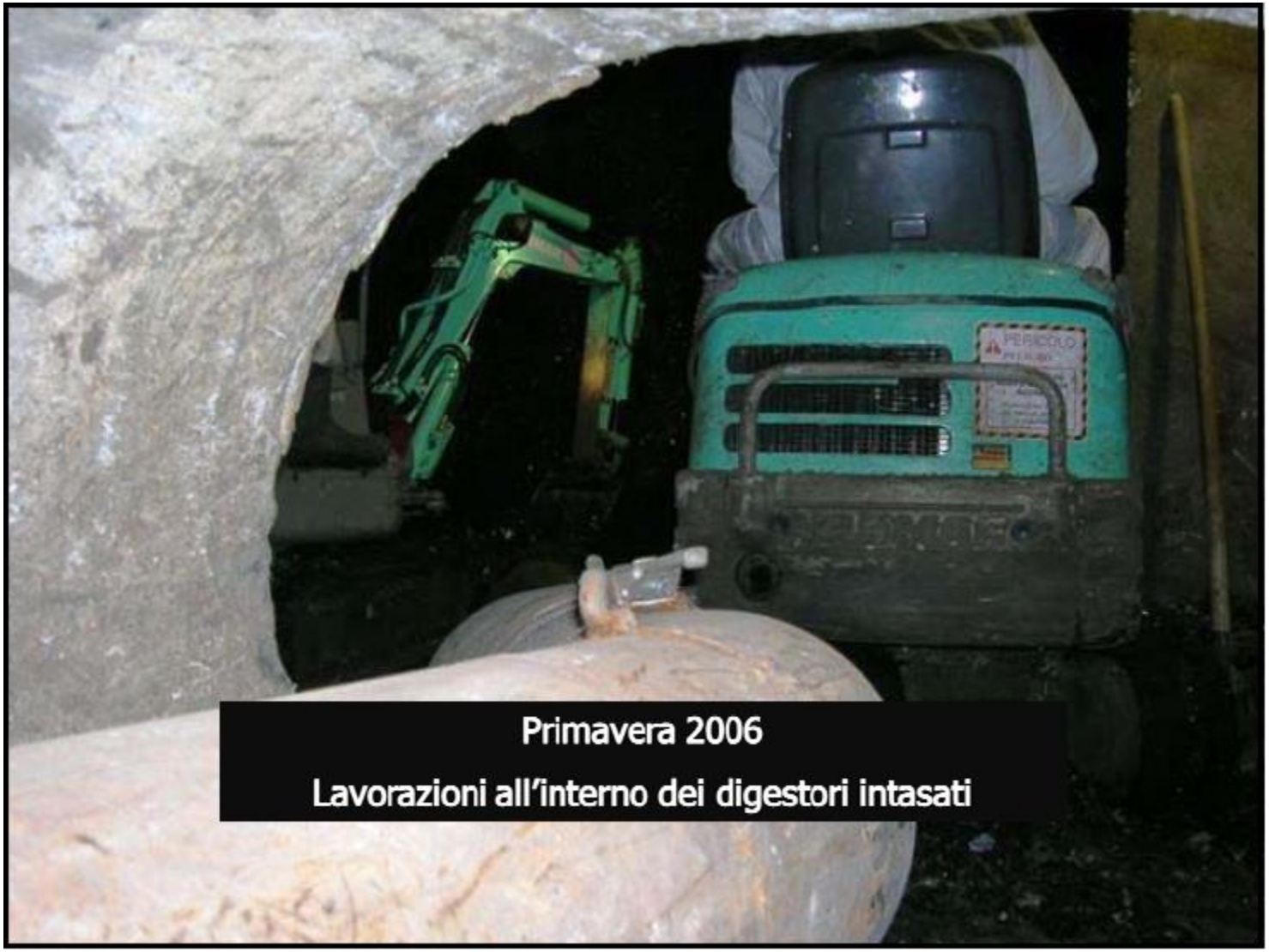
Grease/oil/scum

Liquid

Solid (inert)

Accumulation of inert material in a dry AD reactor

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



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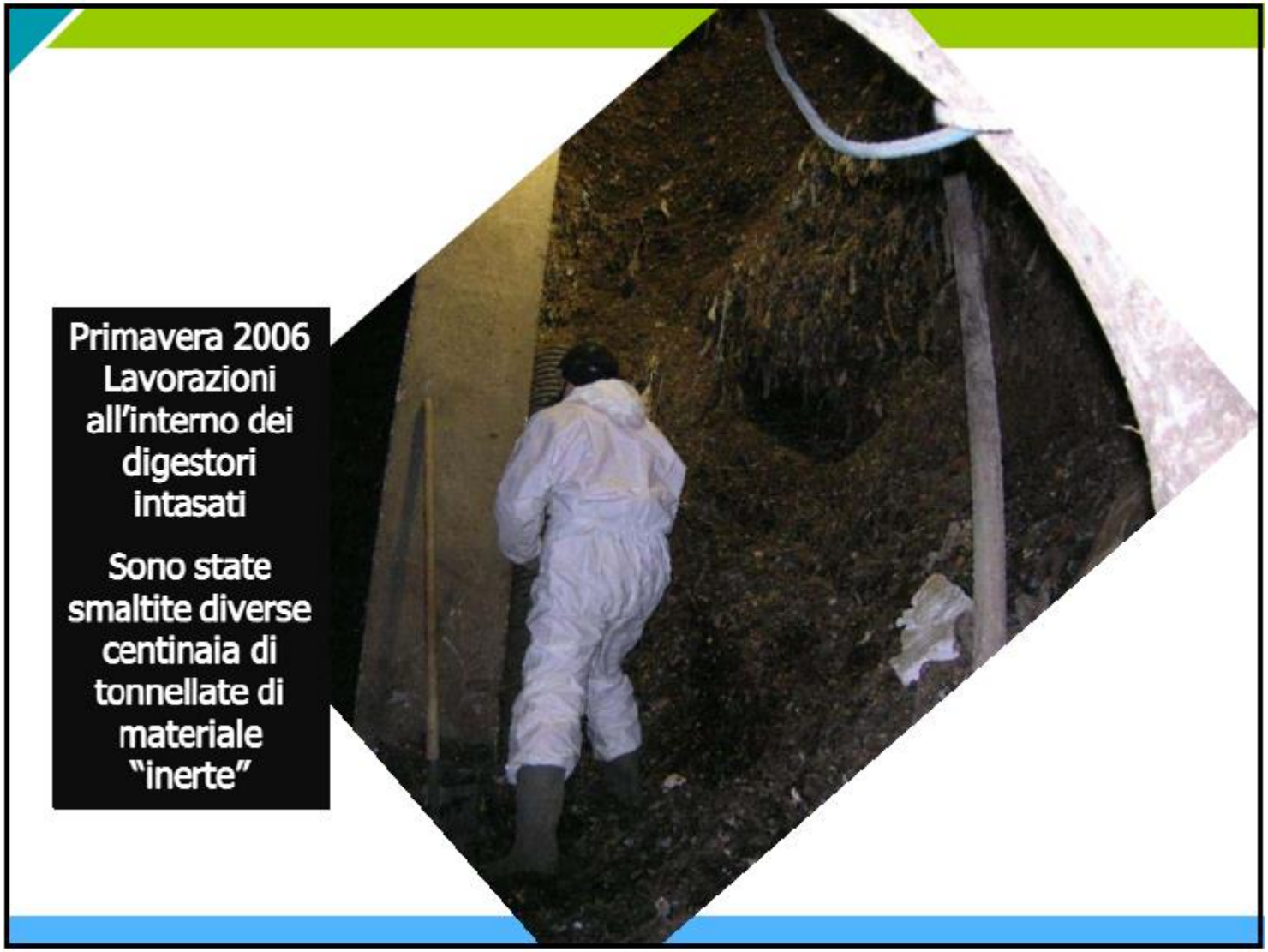
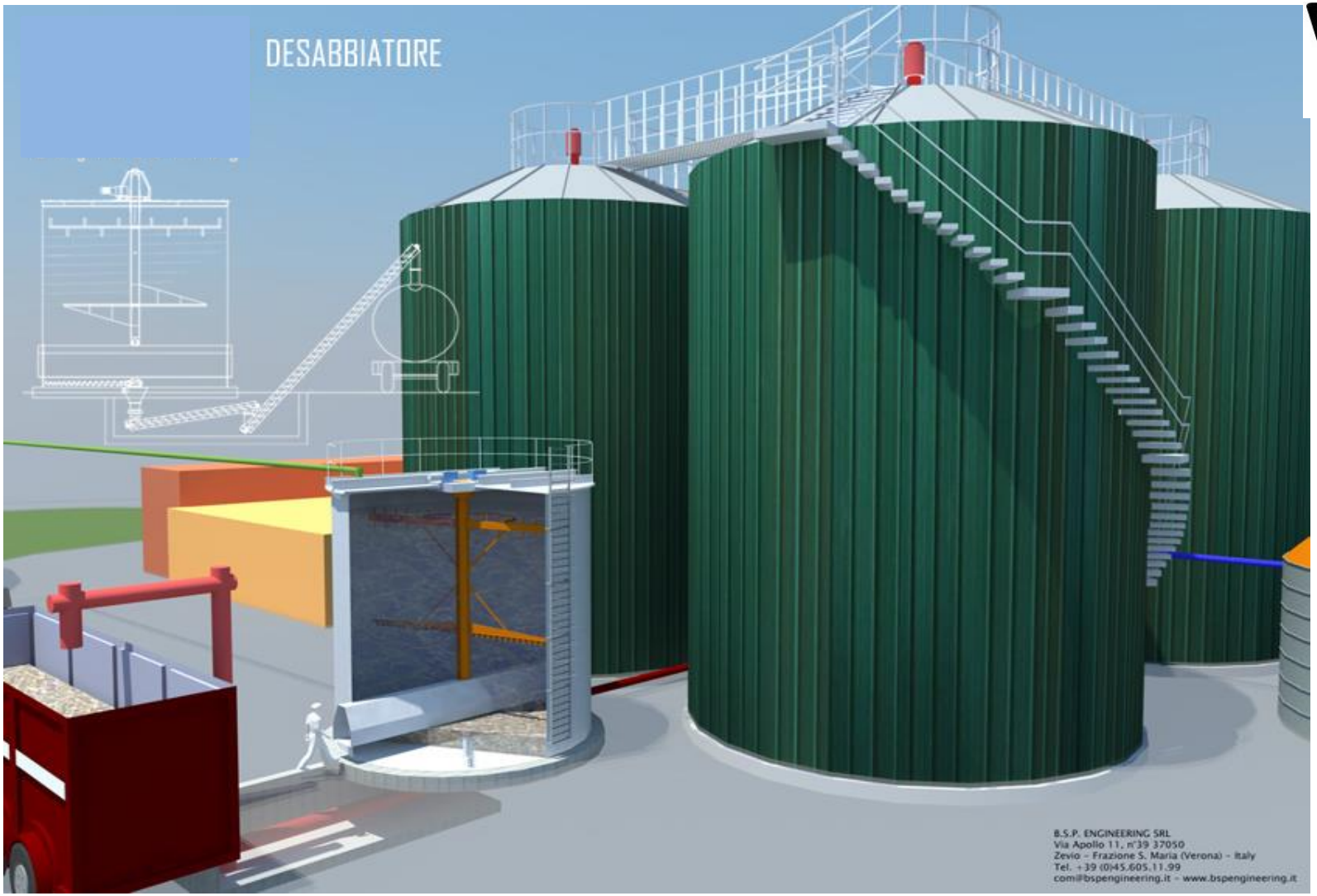
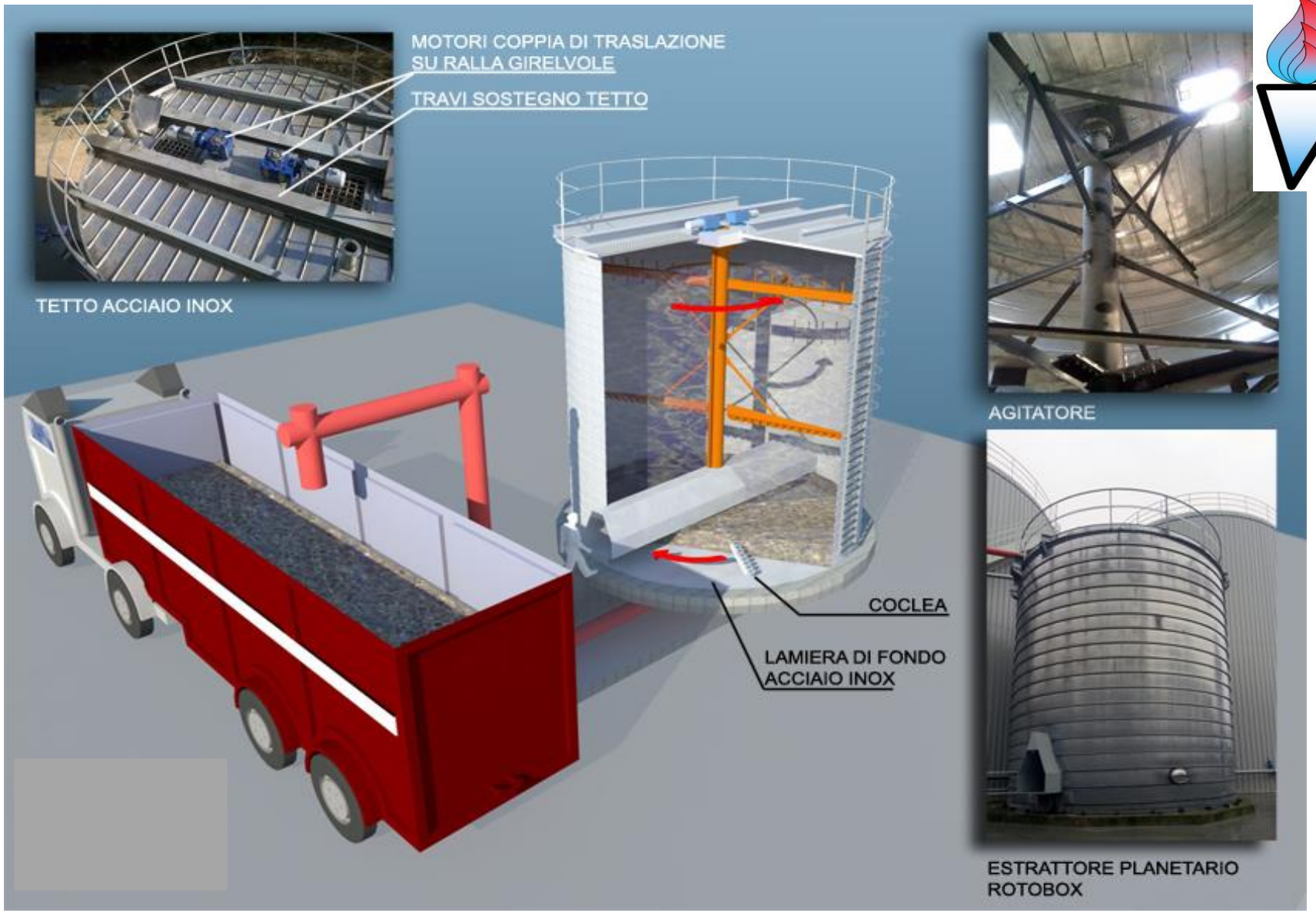


Giacetti, Contri, Muraro (2009). BIOWASTE, Milano 24 febbraio 2009

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

Prevention: heavy inerts removal




MOTORI COPPIA DI TRASLAZIONE
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TETTO ACCIAIO INOX
AGITATORE
COCLEA
LAMIERA DI FONDO
ACCIAIO INOX
ESTRATTORE PLANETARIO
ROTOBOX

Take home message

MBT can be a valide alternative to separate collection but the quality of the output streams is typically lower compared to the one obtained with, e.g., door to door collection.

However, it can be sometime the first step to establish the diversion of recyclable materials from landfills !