SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Design of Long Term Solutions for Solid Waste Management

Mechanical Biological Treatment Facilities (MBTs)

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SWIM and Horizon 2020 SM Title of Meeting

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MBT Concept

The mechanical-biological-treatment (MBT) is a combination of two processes:

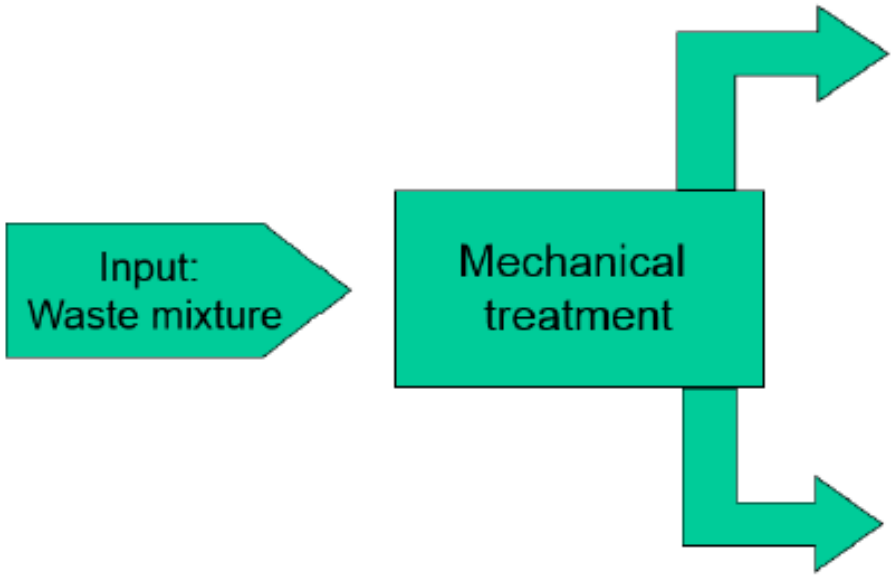
- The **mechanical process** - dedicated to the separation of recyclable materials and the organic fraction from the bulk waste
- The **biological process** – dedicated to the stabilization of this organic material. The biological step can be either **aerobic** or **anaerobic**

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.

Mechanical-biological treatment

MBT Basic Approach

Separation and individual treatment of waste fractions



Fine fraction to biol. treatment

Humid

High content of putrescible organics

Low calorific value

Often significant content of minerals (sand)

Coarse fraction, fuel & recyc.

Less humid

High calorific value

Plastics, paper, wood, textiles

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Goals of the MBT

Typical aims of MBT plants include the:

- ✓ **Pre-treatment** of waste going to landfill;
- ✓ **Diversion** of non-biodegradable and biodegradable MSW going to landfill by means of **mechanical sorting** into materials for recycling and/or for 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

Process stages

The purpose of **the mechanical stage** is three-fold:

- To maximise resource recovery;
- To prepare materials for the core biological stage; and
- To refine outputs

The core **biological processes** is chosen depending on a number of factors:

- The type of output materials required (fully bio-stabilised solids, partially bio-stabilised solids, SRF or biogas);
- The quantity of waste to be treated;
- The prevailing regulatory requirements (on process and outputs); and;
- A number of other economic, technical and commercial factors.

Inputs of MBTs

Mainly:

- the mixed residual fraction left over after source-separated waste collections
- unseparated, mixed household
- household like commercial waste

also a small amount of:

- commercial waste,
- bulky waste,
- sorting residues,
- sewage sludge
- grit chamber residues

Outputs of MBTs

Outputs	Application
Compost-like output (CLO)	Fertiliser, on crops, for use in domestic gardens, on contaminated land
Solid fuel (SRF)	Co-fuel for combustion in power plant, co-fuel for cement kilns, co-fuel in dedicated incinerator
Biogas	Produce electricity, produce a transportable fuel, blend with other gas
Stabilised residue	Landfill

Outputs of MBTs

SRF hard pellets

Pelletized SRF < 10 mm

(Source: Stephanie Thiel, Karl J. Thomé-Kozmiensky)

Outputs of MBTs

Compost Like Output (CLO) *(Source:)*

Types of MBT

Mechanical-biological waste treatment plants may be grouped into **three** types based upon the main **technology used in the biological stage**:

1. **Conventional MBT** with a humid fine and a coarse high calorific output fraction
   - Aerobic processing (composting)
   - MBT with dry anaerobic treatment
   - MBT with wet anaerobic treatment

2. **MBT with biological drying (MBS)** for solid recovered fuel (SRF/RDF) production
   - Short aerobic drying process and efficient material separation after biological drying for combustion and recycling

3. **Mechanical-physical drying plant**, similar to MBS, but drying with fossil energy and no biological step

1. **Conventional MBT** with a humid fine and a coarse high calorific output fraction

Conventional MBTs split their input into a:

- **fine fraction** for biological treatment
- **coarse high-calorific fraction** that undergoes extended mechanical treatment

The fine fraction is either handled as a **stabilised landfill input fraction** or in some countries also used as **low grade compost**.

Mechanical-biological treatment

Conventional MBT with a humid fine and a coarse high calorific output fraction

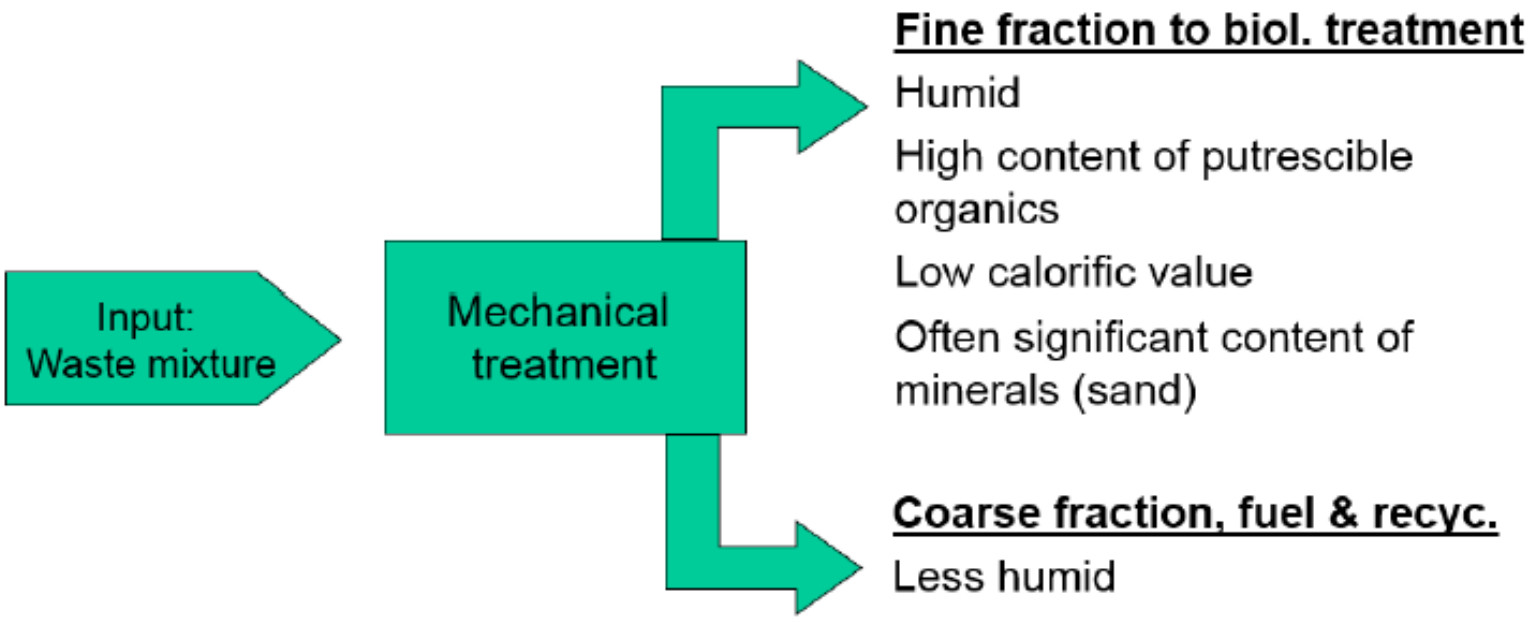

Figure 7 **Input splitting in a conventional MBT**

(Source: Wasteconsult)

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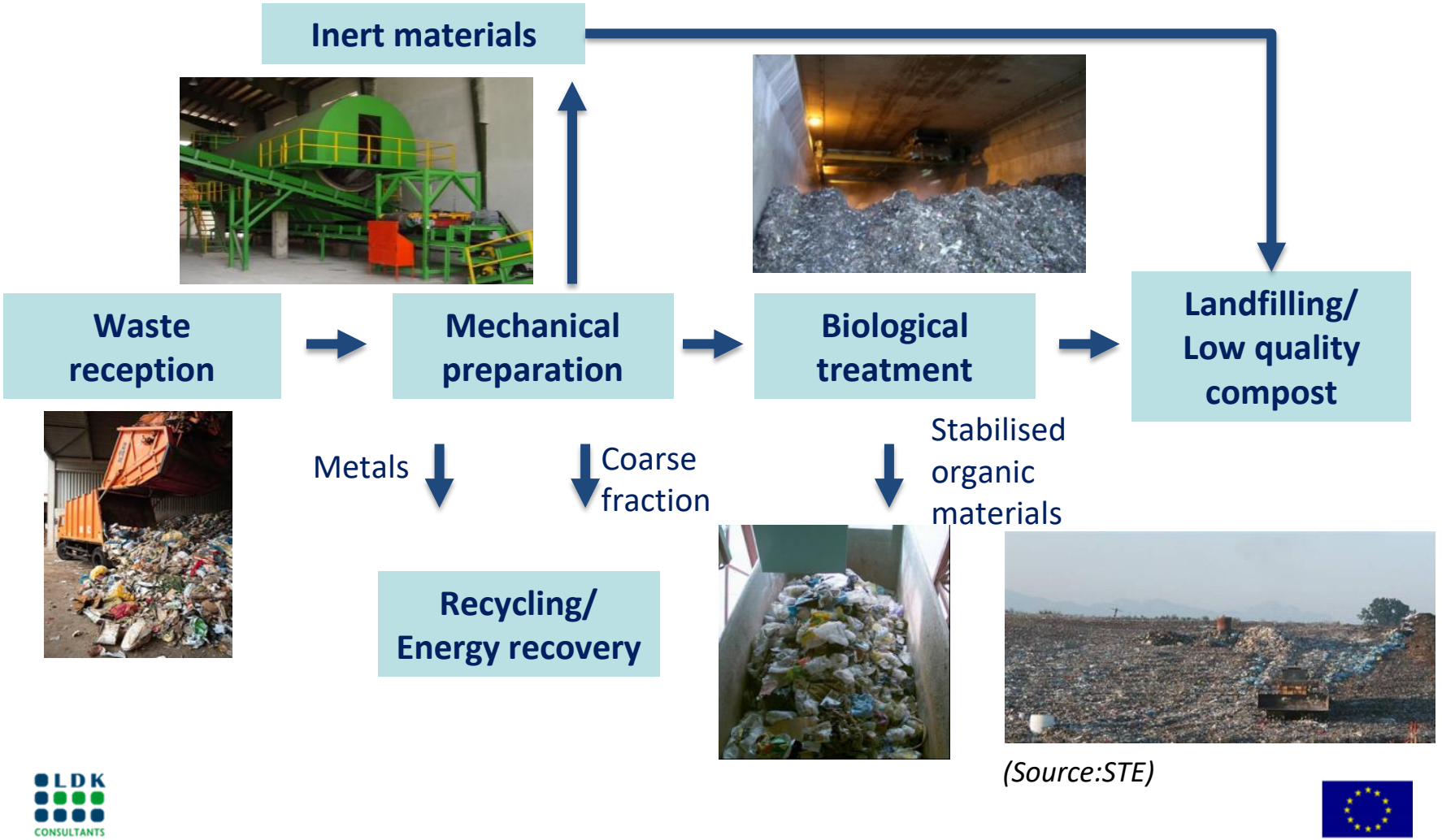
Mechanical-biological treatment

Illustration of MBT concept



(Source:STE)

Mechanical-biological treatment

Process elements

Figure A1: Typical mechanical and biological process elements used in MBT processes

Process Stage	Possible Process Elements						
Mechanical	Trommel	Screen (static or vibrating)	Magnet	Eddy current	Hand picking	Air classification	NIR
Biological	Open windrow composting	In-Hall composting	Tunnel Composting	In-Vessel Composting (IVC)	Anaerobic digestion	Percolation	Bio-drying

NIR = Near Infrared detection - devices that make use of the absorbance of certain unique light wavelengths by materials to separate, for example, different types of plastics.

(Source SITA, Juniper, Assurre)

A large number of permutations are possible for MBT because of the wide range of mechanical and biological elements that can be implemented

Mechanical stage of the MBT

Reception of mixed waste

Preparation

- simple removal of contrary objects (mattresses, carpets, bulky wastes, etc.)
- split open refuse bags (liberate materials inside)
- Shred and homogenise the waste (smaller particle sizes)

Separation

- simple removal of contrary objects (mattresses, carpets, bulky wastes, etc.)
- split open refuse bags (liberate materials inside)
- Shred and homogenise the waste (smaller particle sizes)

Mechanical-biological treatment

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)

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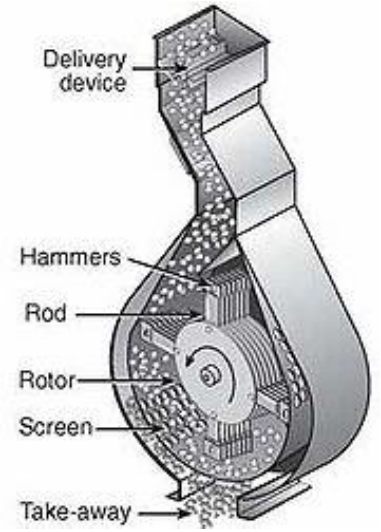
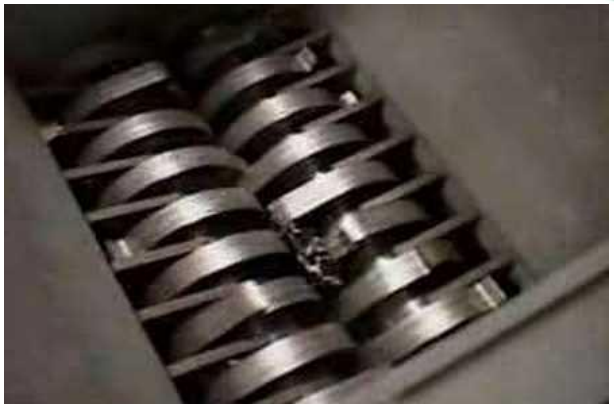
Waste Preparation



Hammer mill

Bag splitter



Shredder

Rotating drum

Ball mill

Mechanical-biological treatment

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)

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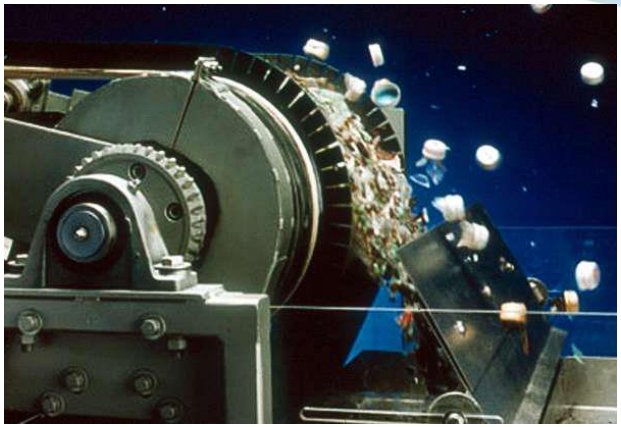
Waste separation

Trommel

Manual separation



Eddy current separation

Optical sorting

Magnetic separation

Also:
Air classification
Ballistic Separation
Wet Separation
Etc.

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Mechanical-biological treatment

Conventional MBT

Aerobic treatment (Composting)

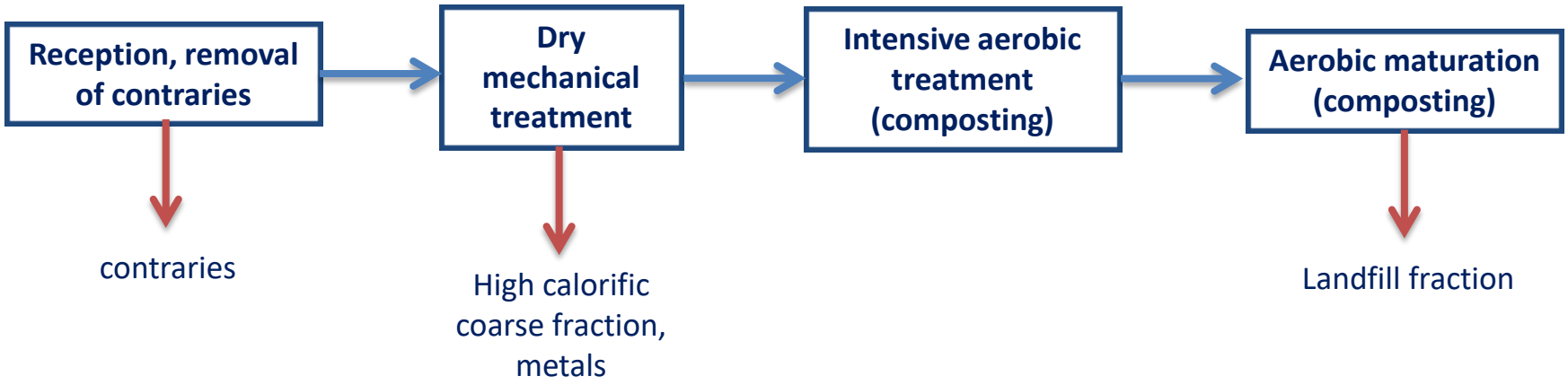
MBT with dry anaerobic treatment

MBT with wet anaerobic treatment

- Wet and dry digestion differ by virtue of the level of **dry solids (DS)** in the fermenter
- DS content around **4% to 15%** in wet processes
- DS level in dry processes ranges between **30% and 35%**

Aerobic treatment (composting)

- The oldest and most widespread process.
- Process similar to composting plants for organic waste, but the heterogeneous MSW sets higher and different demands on the machinery.
- The duration of the biological treatment depends on the treatment target (degree of stabilisation of the output) and legal requirement



Aerobic treatment (composting)

Objectives:

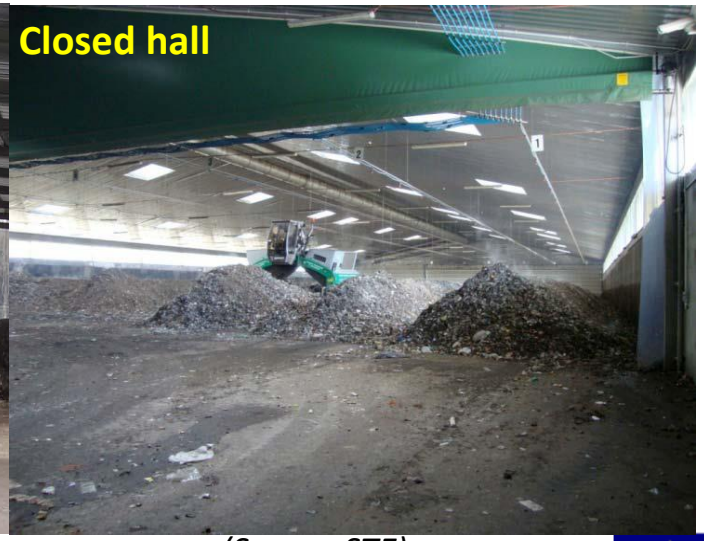
- maximum stabilization of waste
- reduction the water content of treated waste
- reduction of gas emissions
- reduction of the volume to eliminate

TMB types with active aeration:

- Open windrows
- Membrane covered
- Semi-open roof
- closed hall / in-vessel / tunnel

Mechanical-biological treatment

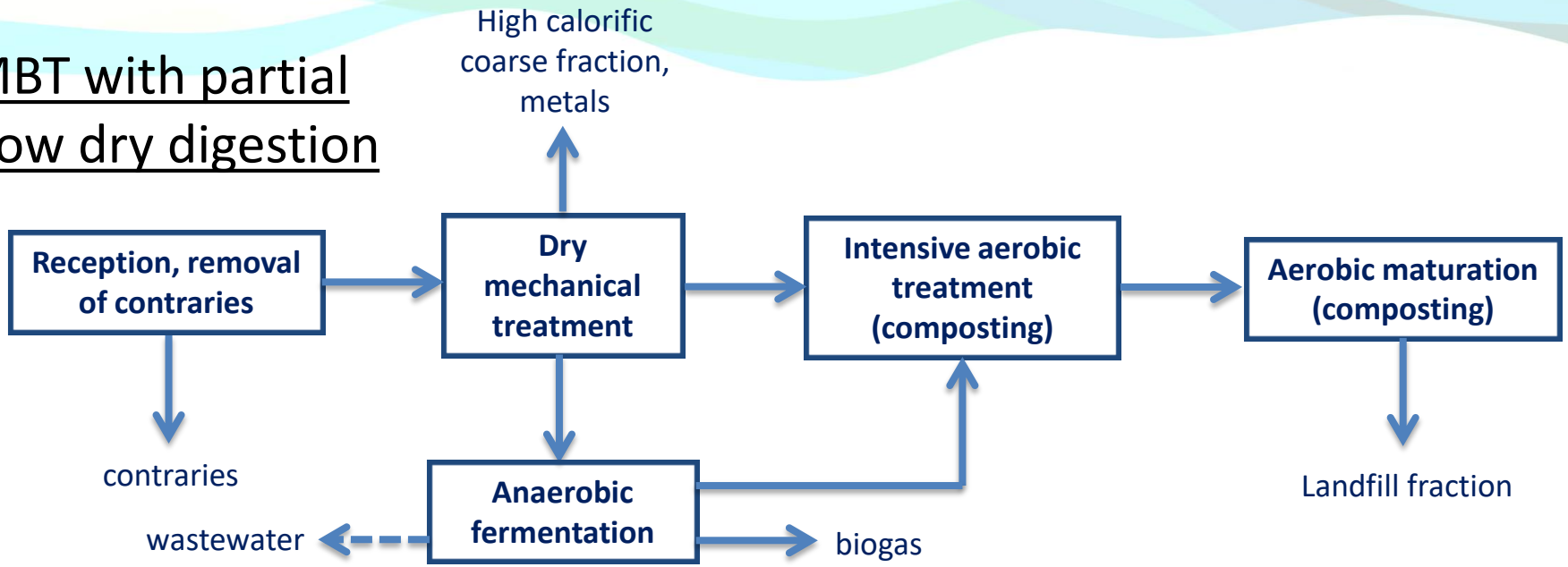
Composting



(Source:STE)

Mechanical-biological treatment with dry anaerobic treatment

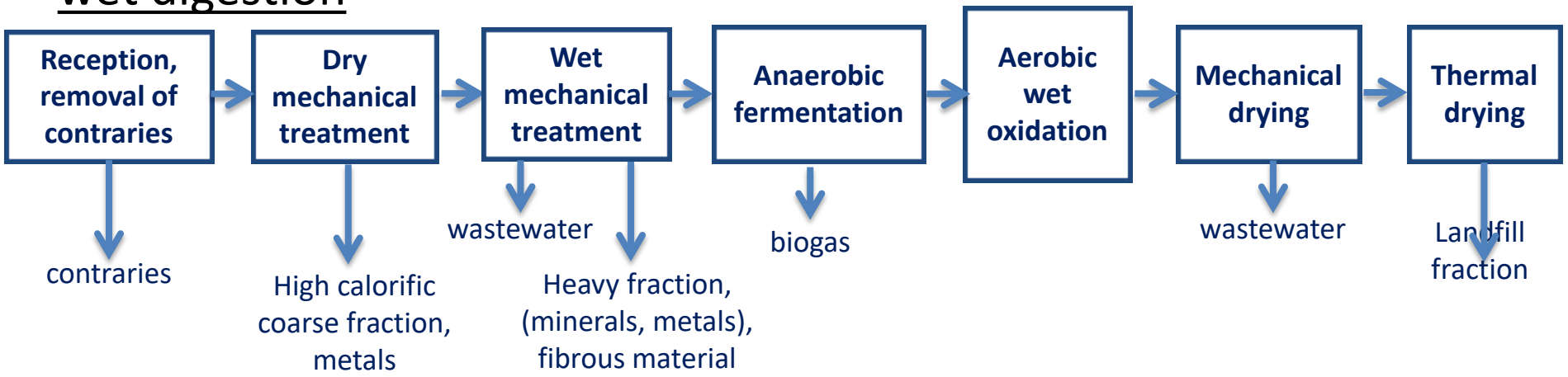
MBT with partial flow dry digestion



- Anaerobic MBTs usually **produce wastewater**
- AD step is **followed by an aerobic process** that stops the methane production, reduces odour and further stabilises the output biologically
- Concept of **partial flow AD uses the wastewater** to compensate the water demand of the aerobic process step

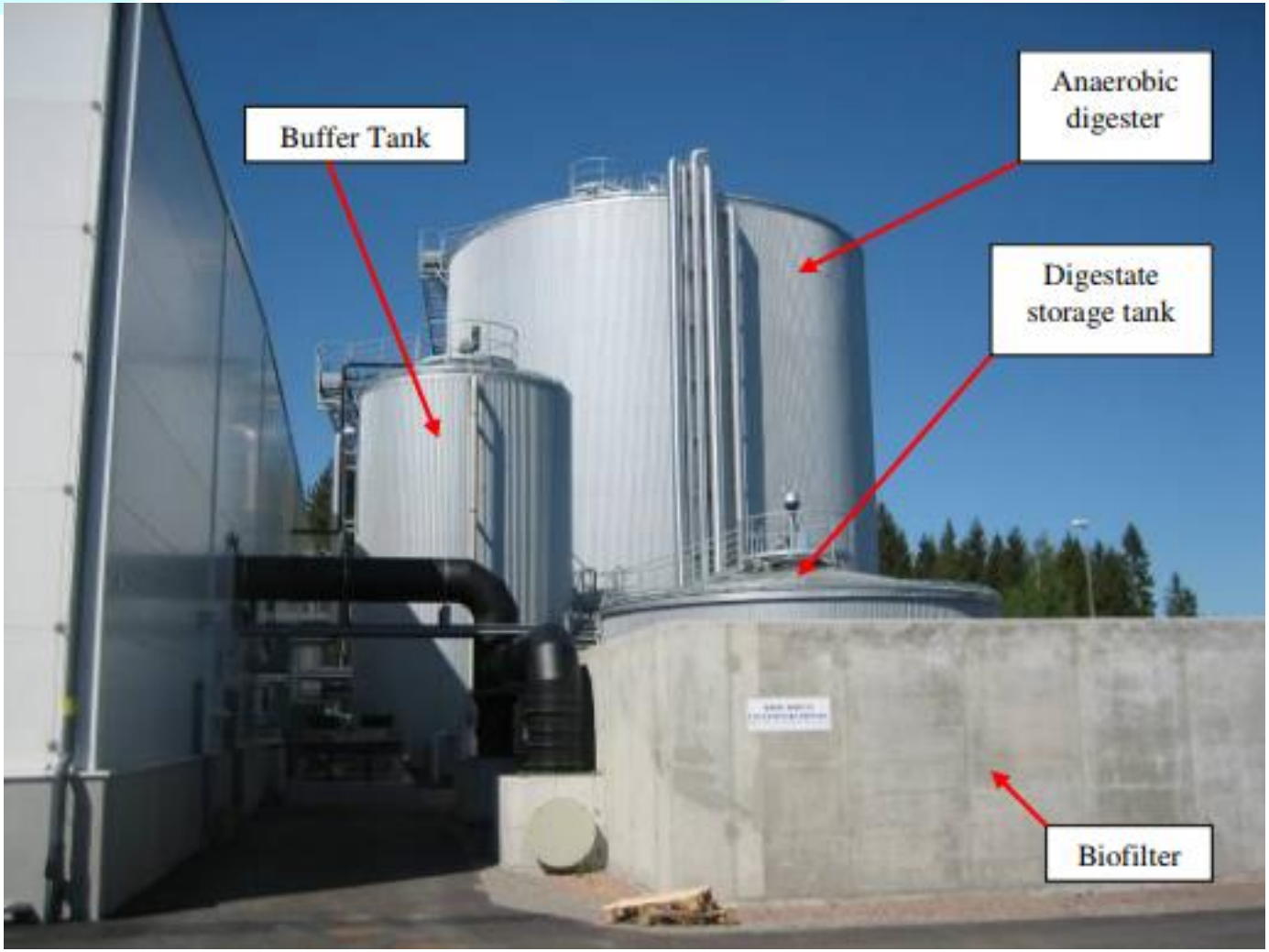
Mechanical-biological treatment with wet anaerobic treatment

MBT with full flow wet digestion



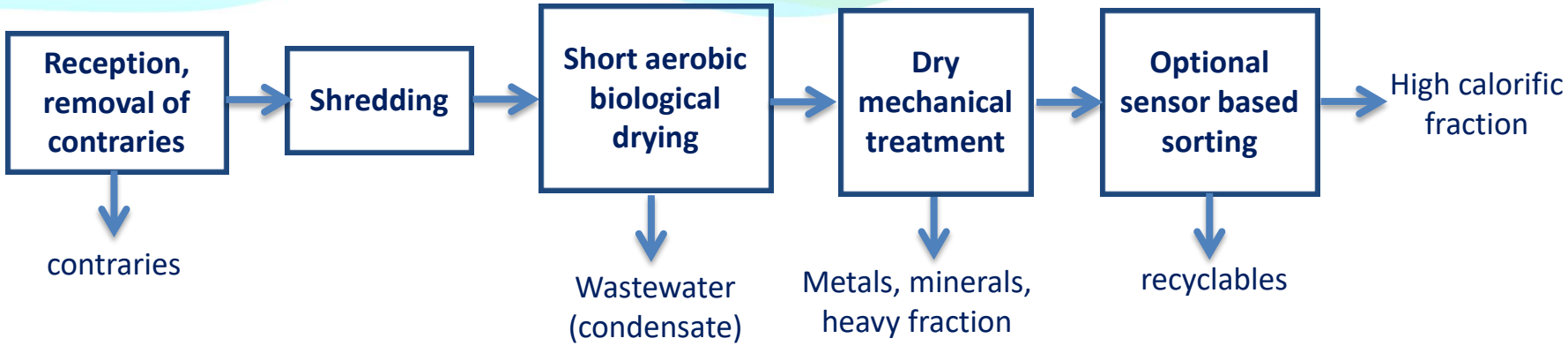
- Full flow AD often operated as wet fermentation -> also the aerobic treatment can be done in the liquid phase
- Output of biological step is mechanically and thermally dried
- A special kind of wet anaerobic MBT plants are percolator plants (the putrescible organic matter is washed out of the waste and the organic matter enrich liquid is anaerobically digested)

Anaerobic digestion facility



(Source: SERC, U of Glamorgan)

MBT with biological drying (MBS) for solid recovered fuel (SRF/RDF)



- **MBS are aerobic MBTs**
- After removal of contraries, the **whole input** is shredded and **without** splitting up in various fractions **completely fed** to the aerobic biological treatment
- The process is **short** and **hot**. The heat comes from the bacteria in the biological degradation. Humidity leaves the waste via the warm exhaust air
- Afterwards, both the coarse and the fine waste particles have a low moisture content and an increased calorific value

MBT (MBS) with biological drying process SRF/RDF production

- After the drying, the different waste fractions are much **easier to sort**
- The drying also enhances the applicability of sensor based and other sorting processes

MBT (MPS) with physical drying process SRF/RDF production

- **MPS** plants are similar to mechanical biological drying plants (MBS) but the drying is done in gas heated drum driers

The MBT Concept – Biological treatment

Closed biodrying Box

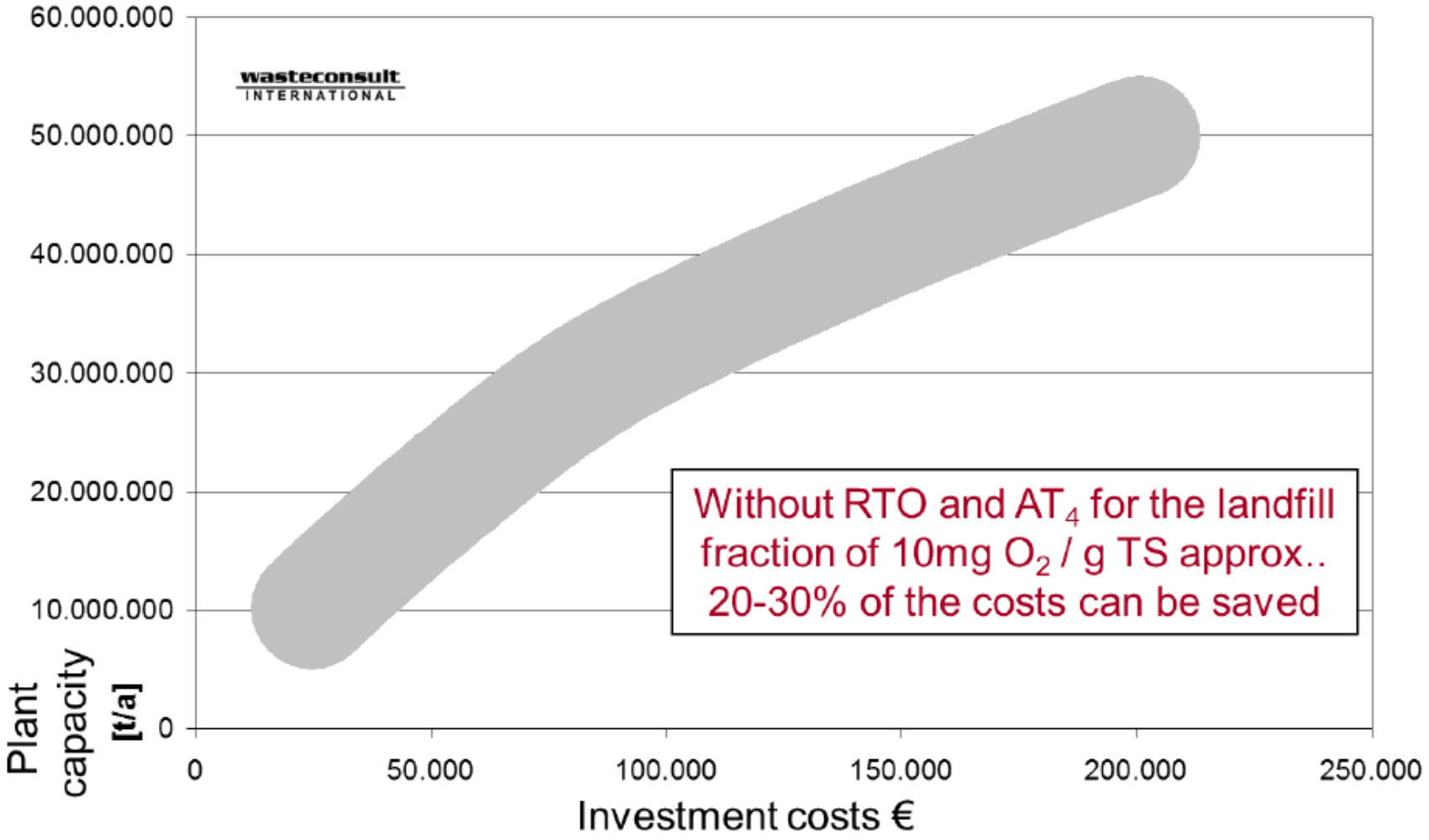
(Source: SERC, U of Glamorgan)

MBT Costs

- Cost depend on local prices, treatment targets, waste properties and many more varying factors
- Each MBT is an individual case
- These factors often have more influence on the costs than the chosen technology.
- Costs need to be calculated for each individual location and it's local conditions

(Source: wasteconsult Int.)

MBT approximate investment costs for a MBT compliant to German stds



(Source: wasteconsult Int.)

MBT approximate investment costs for a MBT compliant to German stds

Treatment costs:

- 10 – 30 Euro / t for low technical standard
- 40 – 60 Euro/ t medium standard
- 50 – 90 Euro / t for high technical standards (e.g. compliant to German regulations)

Total costs are significantly influenced by the costs for landfilling of the fine fraction and for the combustion of the high calorific fraction

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For further information

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