# Disaggregation of technologies

## Contents

## i. Preface

As described in "Annex 7.2.1: Selection of technologies and preliminary disaggregation", the following options where identified regarding waste collection:

- Source separation of different fractions of dry recyclables (paper, glass, plastic, metals)
- Source separation of a comingled stream of dry recyclables (all the materials aforementioned in one bin)
- Source separation of food waste
- Mixed waste without source separation
- Residual waste ("rest" waste bin after source separation of dry recyclables and organics)
- Wet fraction bin ("rest" waste bin after source separation of dry recyclables but WITHOUT source separation of organics)

The concept of collecting wastes, on which the tool has been based for its development, is that the user will be able to choose among the following collection options (see figure 1):

1. One – bin collection system: a system without any source-separation of materials, where all mixed waste is collected in a single bin, called "mixed wastes bin"
2. Two – bin collection system: a system with source-separation of co-mingled dry recyclables (paper, plastic, metals, glass) in one bin ("rest recyclables" bin), and collection of the rest wastes in a second bin, called "wet fraction" bin"
3. Three-bin collection system: "rest recyclables" bin for source-separation of co-mingled dry recyclables (paper, plastic, metals, glass), "bin for organic" for source-separation of organic wastes and "Bin for Residuals" for the collection of rest wastes
4. Multi-bin collection system: combination of dedicated bins for source separation of paper, metal, glass and plastics and/or source separation of co-mingled dry recyclables ("rest recyclables" bin), with/without source separation of the organic fraction. Rest wastes are collected in the "Bin for Residuals" if source separation of organic wastes is selected by the user, otherwise the "wet fraction" bin is used

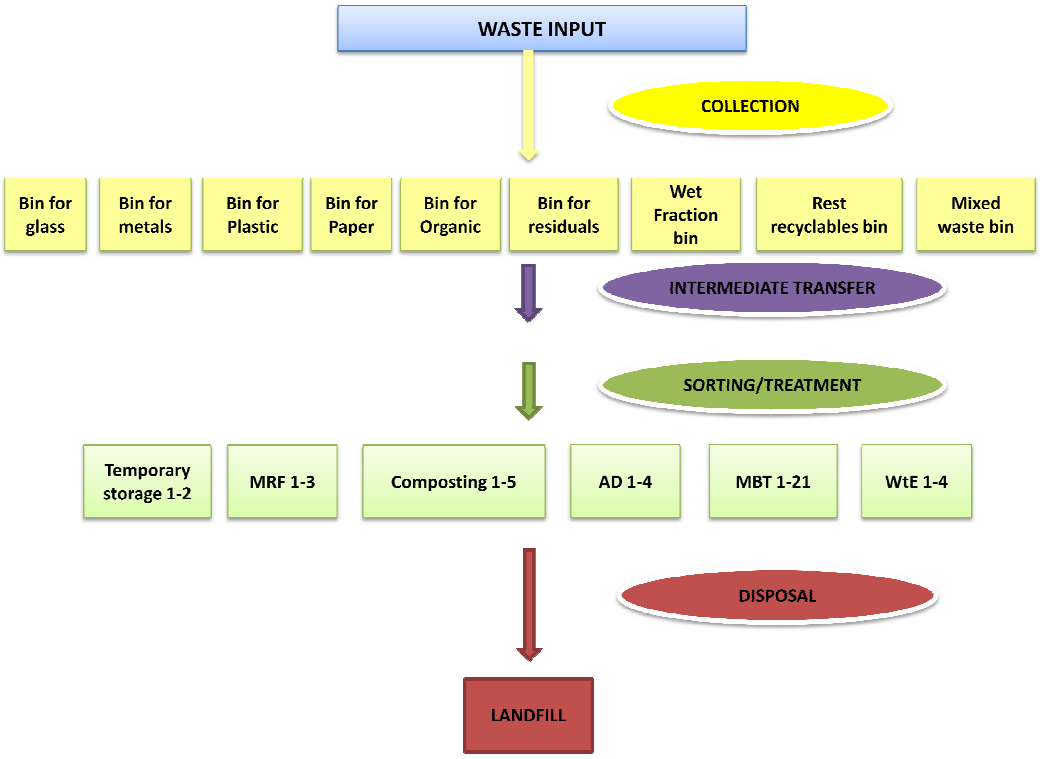


Figure 1: Main collection options in the software tool

## ii. Compatible and non-compatible combinations for each waste stream

The collection scheme that is chosen by the user results in waste streams that may subsequently be treated in various ways, as identified in Action 1 and shortly described in ANNEX 7.2.1.

The various treatment options are categorised into the following categories:

(a) Options that are not always technically meaningful or compatible for the specific waste stream
(b) Options that are technically meaningful or compatible for the specific waste stream under specific conditions
(c) Options that are always technically meaningful or compatible for the specific waste stream

Compatible and non-compatible combinations are presented in the following table:

Table 1: Compatible and non-compatible combinations for a given waste stream

| Treatment option / Stream | Temporary Storage | MRF | Composting | Anaerobic Digestion | MBT | Biodrying | WtE | Sanitary Landfill |
|---|---|---|---|---|---|---|---|---|
| Source segregated glass | ⊕ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ! |
| Source segregated paper | ⊕ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ! | ! |
| Source segregated plastic | ⊕ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ! | ! |

| Treatment option / Stream | Temporary Storage | MRF | Composting | Anaerobic Digestion | MBT | Biodrying | WtE | Sanitary Landfill |
|---|---|---|---|---|---|---|---|---|
| Source segregated metals | ⊕ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ! |
| Source segregated organics | ⊗ | ⊗ | ⊕ | ⊕ | ⊗ | ⊗ | ⊗ | ! |
| Co-mingled recyclables | ⊗ | ⊕ | ⊗ | ⊗ | ⊗ | ⊗ | ! | ! |
| Residuals | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ | ⊕ |
| Wet Fraction | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ | ! |
| Mixed wastes | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ | ! |
| RDF/SRF | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ | ! |

⊕ : compatible
⊗ : non-compatible
! : compatible under specific conditions

To make matters clear, the following should be noted:

## Temporary Storage Facilities

Temporary Storage Facilities are used for the storage of recyclables prior to their sale to recyclers. Such facilities include minimal processing of the incoming material(s), since they receive recyclables coming from “multi-bin” collection systems (separately collected paper, plastic, glass, etc). In this sense, one can say that temporary storage facilities are MRFs (Material Recovery Facilities) of the simplest form.

Such facilities, in the way they are defined above, cannot receive any co-mingled streams or streams that contain organic waste (residuals, wet fraction, mixed wastes, source segregated organics)

## Material Recovery Facilities (MRFs)

The MRF comprises a large shed or several industrial buildings in a complex, where several types of recyclable wastes ('co-mingled' - as sorted by the householder) is sorted further, bulked up into load sizes suitable for transport, made ready for collection and transportation, sold, stored, and shipped to the buyers including some of the original manufacturers. The Material Recovery Facility is made up of a series of conveyor belts and a mix of manual and automatic procedures to separate the materials and remove the items that are not needed.

Such facilities, in the way they are defined above, cannot receive streams that contain organic waste (residuals, wet fraction, mixed wastes, source segregated organics).

## Composting Facilities

Composting facilities receive either source segregated organics or the organic fraction of residual waste.

In the model, the term “composting facility” applies for facilities that receive only source-separated organics.

In case a composting facility aims to treat the organic fraction of residual or mixed waste it is combined with an extensive mechanical separation step. Such facilities are more known as Mechanical Biological Treatment facilities and are included in the model as a separate technological option.

### Anaerobic Digestion (AD) Facilities

AD facilities receive either source segregated organics or the organic fraction of residual waste.

In the model, the term "Anaerobic Digestion facility" applies for facilities that receive only source-separated organics.

In case an Anaerobic Digestion facility aims to treat the organic fraction of residual or mixed waste it is combined with an extensive mechanical separation step. Such facilities are more known as Mechanical Biological Treatment facilities and are included in the model as a separate technological option.

### Mechanical Biological Treatment (MBT) Facilities

MBT is a generic term for an integration of several processes commonly found in other waste management technologies such as Materials Recovery Facilities (MRFs), sorting and composting or anaerobic digestion plant.

MBT is a residual waste treatment process that involves both mechanical and biological treatment processes.

Therefore, MBTs may receive various types of municipal waste: mixed wastes (no separation at source of any materials), wet fraction streams (mixed wastes after source separartion of dry recyclables) and residual waste (mixed wastes after source separartion of dry recyclables and organic waste).

### Biodrying (biological drying)

Biodrying is an option for the bioconversion reactor in mechanical–biological treatment (MBT) plants, an alternative for treating residual municipal solid waste.

As already mentioned, waste treatment plants defined as MBT integrate mechanical processing, such as size reduction and air classification, with bioconversion reactors, such as composting or anaerobic digestion.

In the model, the user under the term "biodrying" actually selects an MBT plant incorporating a biodrying reactor. It has been separated from the generic "MBT" term because it is a relatively new technology compared to the more "conventional" MBTs incorporating composting or anaerobic digestion.

Typically, biodrying facilities receive the same streams as "conventional" MBTs and produce a biodried output which undergoes extensive mechanical post-treatment. The final output is a solid recovered fuel (SRF).

### Thermal treatment technologies

Waste to Energy (WtE) Facilities (incineration facilities in the model) may receive various types of municipal waste: mixed wastes (no separation at source of any materials), wet fraction streams (mixed wastes after source separartion of dry recyclables) and residual waste (mixed wastes after source separartion of dry recyclables and organic waste).

However, they may receive source separated plastics and paper or co-mingled dry recyclables in case the calorific value of the input waste needs to be increased or in cases of market failure for such materials. However, this is not the typical option for such streams.

Additionally, WtE facilities may receive RDF and SRF produced by MBTs and Biodrying Facilities.

### Sanitary Landfill

According to Directive 99/31/EC sanitary landfills should be designed to receive only residual waste or residues after waste treatment. All other streams may be landfilled but this would be a viable option only in case of market failure or if the user wishes to create such a scenario just for comparison reasons.

## iii. Compatible and non-compatible combinations of technical components

The identification of possible treatment options for each waste stream, according to table 1 and the preliminary disaggregation elaborated in Action 1 are followed by the detailed disaggregation of technologies. Each option is further split into their technical components. The split involves all the stages of the various technologies: Reception, Preparation, Sorting, Treatment, Storage and Disposal.

In order to create technologically feasible configurations, the available components are categorised according to the following:

(a) Options that are not always technically meaningful or compatible
(b) Options that are technically meaningful or compatible under specific conditions
(c) Options that are always technically meaningful or compatible

Compatible and non-compatible combinations are presented in the table 2.

**Table 2: Compatible and non-compatible combinations between various treatment components**

| Treatment option / Component | Temporary Storage | MRF | Composting | Anaerobic Digestion | MBT | Biodrying | WtE |
|---|---|---|---|---|---|---|---|
| Waste Reception | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |
| Bag splitter | ! (depends on how collection is performed, with or without bags) | ! (depends on how collection is performed, with or without bags) | ! (depends on how collection is performed, with or without bags) | ! (depends on how collection is performed, with or without bags) | ⊕ | ⊕ | ⊕ |
| Shredding | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |
| Screening | ⊗ | ⊕ (In high cost MRFs) | ⊕ | ⊕ | ⊕ | ⊕ | ! |
| Magnet for Metals | ⊗ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |
| Eddy current for Aluminium | ⊗ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |

| Component \ Treatment option | Temporary Storage | MRF | Composting | Anaerobic Digestion | MBT | Biodrying | WtE |
|---|---|---|---|---|---|---|---|
| Hand-picking | ! (only to remove impurities) | ⊕ | ⊗ | ⊗ | ⊕ | ⊕ | ⊗ |
| Advanced sorting equipment | ⊗ | ! (In high cost MRFs) | ⊗ | ⊗ | ⊕ | ⊕ | ! (in case specific streams i.e. PVC have to be removed. Rarely used) |
| Other separators (ballistic, air classifiers, etc) | ⊗ | ! (In high cost MRFs) | ! (post - treatment (refinement) of compost) | ! (post-treatment (refinement) of compost) | ⊕ | ⊕ | ⊗ |
| Baler | ⊕ | ⊕ | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ |
| Composting unit | ⊗ | ⊗ | ⊕ | ⊗ | ⊕ | ⊗ | ⊗ |
| Anaerobic Digester | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊗ | ⊗ |
| Storage of biogas | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊗ | ⊗ |
| Biogas Engines | ⊗ | ⊗ | ⊗ | ⊕ | ⊕ | ⊗ | ⊗ |
| Maturation (composting) | ⊗ | ⊗ | ⊕ | ⊕ | ⊕ | ⊗ | ⊗ |
| Biodrying reactor | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ | ⊗ |
| Furnace/Boiler | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ |
| Steam turbine | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊗ | ⊕ |
| Air Pollution Control | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |
| Temporary storage of products/residues | ⊗ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ | ⊕ |

⊕ : compatible
⊗ : non-compatible
! : compatible under specific conditions

According to the above mentioned categorisation the most common configurations for each option are formulated. In this way, the user may choose among a series of configurations according to their needs. Each configuration is a different technology module in the tool so that the user may formulate a waste management plan that deals with the various streams with a combination of modules.

The available configurations included in the model are presented in detail in the following:

## Temporary Storage 1-2

Temporary Storage 1: This is a Temporary Storage facility intended for separate collection of plastic and paper and includes baling of plastic and paper as well as storage.

Temporary Storage 2: This is a Temporary Storage facility intended for separate collection of glass, but also for metals if it is collected in small amounts and no baling is required. Storage is done in containers.

### MRF 1-3

MRF 1 is a configuration of low mechanical intensity, in which only metals are sorted mechanically (magnet), while rest materials are sorted manually.

MRF 2 is a similar configuration, incorporating also an eddy current for aluminium recovery.

MRF 3 includes also advanced sorting equipment such as Near Infra Red (NIR) technology.

### Composting 1-5

Each of the five available configurations is of similar design and includes: reception, bag splitter, shredding, removal of metals, sieving, composting, refining of composted organics and maturation to produce fine compost.

The difference lies in the design of the composting system, in particular:

Composting 1: open air system (windrows)

Composting 2: covered windrows

Composting 3: composting in tunnels

Composting 4: composting in boxes

Composting 5: composting in closed halls

### Anaerobic Digestion 1-5

Each of the five available configurations is of similar design and includes: reception, bag splitter, shredding, removal of metals, sieving, anaerobic digestion, dehydration of digestate, maturation of digestate and refining to produce fine compost. It also includes storage of biogas and biogas engines to produce electricity and/or heat.

The difference lies in the design of the AD system, in particular:

AD 1: dry AD system and open air composting system for post-treatment of dewatered digestate

AD 2: dry AD system followed by covered windrows composting system for post-treatment of dewatered digestate

AD 3: wet AD system followed by open air composting system for post-treatment of dewatered digestate

AD 4: wet AD system followed by covered windrows composting system for post-treatment of dewatered digestate

AD 5: complete dry AD system followed by covered windrows composting system for post-treatment of dewatered digestate

### MBT 1-21

Each of these options differ in the degree of mechanical pre-treatment applied to wastes (according to the amount and types of recyclables the user “wishes” to recover from residual waste), as well as to the biological treatment element (composting or AD).

MBT 1-4: Advanced Recycling with composting

This configuration includes advanced mechanical sorting for the recovery of recyclables & the production of RDF followed by a contained system for the composting of the organic fraction. The contained system may be in covered windrows (MBT 1), in tunnels (MBT 2), in boxes (MBT 3), or in closed halls (MBT 4). The post treatment (maturation) of the biostabilised organic fraction is done in covered windrows.

MBT 5-7: Advanced Recycling with anaerobic digestion

This configuration includes advanced mechanical sorting for the recovery of recyclables & the production of RDF followed by Anaerobic Digestion (AD) of the sorted organic fraction. The anaerobic digestion process may be a dry AD (MBT 5), a wet AD (MBT 6), or a complete dry AD system (MBT 7). Usually, the dewatered digestate undergoes a maturation phase (aerobic composting). The most common approach for this maturation step is to incorporate a contained composting system such as covered windrows

MBT 8-11: Conventional Recycling with composting

This configuration includes “conventional” mechanical sorting for the recovery of metals and production of RDF, followed by a contained system for the composting of the organic fraction. The contained system for the composting of the organic fraction and maturation in covered windrows. The enclosed system may be in covered windrows (MBT 8), in tunnels (MBT 9), in boxes (MBT 10), or in closed halls (MBT 11). The post treatment (maturation) of the biostabilised organic fraction is done in covered windrows.

MBT 12-14: Conventional Recycling with anaerobic digestion

This configuration includes “conventional” mechanical sorting for the recovery of metals and production of RDF / Anaerobic Digestion of the organic fraction and maturation (composting) in covered windrows. The anaerobic digestion step may be a dry AD (MBT 12), a wet AD (MBT 13) or a complete dry AD (MBT 14), system. Usually, the dewatered digestate undergoes a maturation phase (aerobic composting). The most common approach for this maturation step is to incorporate an enclosed composting system such as covered windrows.

MBT 15-18: Combination of mechanical sorting and handpicking with composting

This configuration includes combination of mechanical sorting and handpicking for the recovery of recyclables & the production of RDF, followed by a contained system for the composting of the organic fraction. The enclosed system may be in covered windrows (MBT 15), in tunnels (MBT 16), in boxes (MBT 17), or in closed halls (MBT 18). The post treatment (maturation) of the biostabilised organic fraction is done in covered windrows.

MBT 19-21: Combination of mechanical sorting and handpicking with anaerobic digestion

This configuration includes combination of mechanical sorting and handpicking for the recovery of recyclables & the production of RDF, followed by Anaerobic Digestion of the sorted organic fraction. The anaerobic digestion step may be a dry AD (MBT 19), a wet AD (MBT 20) or a complete dry AD (MBT 21), system. Usually, the dewatered digestate undergoes a maturation phase (aerobic composting). The most common approach for this maturation step is to incorporate a contained composting system such as covered windrows.

### Biodrying 1-3

The first two options mainly differ in the process they utilize for the treatment of ammonia and VOCs produced by the biodrying reactor. Also, the first type (biodrying 1) has a more complex design of its post-mechanical treatment.

The third option includes also a mechanical **pre**-treatment step to recover recyclables **prior** to the biodrying reactor.

Biodrying 1: This configuration incorporates biodrying of mixed MSW (and mechanical post-treatment of dried waste. Post treatment aims to recover some recyclables (ferrous and non ferrous metals) and to remove inorganic (non-combustible) material, heavy particles (i.e. stones) and unsuitable material (i.e. batteries) from the dried waste in order to produce a fuel to be used in high energy demand industries: cement kilns, power stations, incinerators.

In this type of process, off-gases are treated by means of a Regenerative Thermal Oxidation – RTO system.

Biodrying 2: This configuration incorporates biodrying of mixed MSW (and mechanical post-treatment of dried waste. Post treatment aims to recover some recyclables (ferrous and non ferrous metals) and to remove inorganic (non-combustible) material, heavy particles (i.e. stones) and unsuitable material (i.e. batteries) from the dried waste in order to produce a fuel to be used in high energy demand industries: cement kilns, power stations, incinerators.

In this type of process, off-gases are treated by means of a biofilter.

Biodrying 3: This configuration is more complicated than “biodrying 1” and “biodrying 2” in the sense that a higher number of mechanical sorting equipment is used, **prior** to the biodrying reactor, to enhance the recovery of recyclables apart from producing SRF.

### Waste to Energy 1-4

These configurations include an incineration process for the treatment of waste. Option 1 includes grate incineration with electricity production, option 2 is the same technology but additionally heat is produced, while options 3 and 4 involve the fluidise bed technology. Again, they are distinguished according to the production of energy (electricity only-option 3 and combined heat and power – option 4).

A schematic representation of the above configurations follows in the next pages.