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# LIFE09 ENV/GR/000307

# Deliverable 3.1

## Review of alternative pre-treatment equipment

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<tr><td colspan="3">Summary:<br>EPANA SA operates material recovery units of pre-sorted waste (commonly known as blue bin collection system). During the standard production process, a series of materials are recovered (i.e. different types of plastics and papers, ferrous and non ferrous metals and glass) while a certain stream of remaining materials results. This stream consists of species that are not recovered due to technical limitations (plastics, papers, metals etc), and from materials that are not targeted for recovery (organic fraction, wood, stones etc.). This residual stream is characterised as Recovered Derived Fuel (RDF) due to its combustible nature as shown at a later stage of this report. The characteristics and the physical and chemical properties of the RDF are critical for the handling and the energy utilisation which is targeted through the project. The technical and operational standards of the energy utilisation unit (feeding procedure and gasification process) require the achievement of certain RDF characteristics. Those characteristics are achievable through certain pre-treatment.<br><br>Critical characteristics are the homogeneity and the flowability of the material and critical physical properties are the size, the moisture and the density. It is obvious that by controlling the physical properties, the characteristics could be optimised. A review of the methods and the equipment that are suitable for the pre-treatment of RDF was conducted and the outcome is outlined though this report.</td></tr>
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# 1 Introduction

EPANA SA operates material recovery units of pre-sorted waste (commonly known as blue bin collection system). During the standard production process, a series of materials are recovered (i.e. different types of plastics and papers, ferrous and non ferrous metals and glass) while a certain stream of remaining materials results. This stream consists of species that are not recovered due to technical limitations (plastics, papers, metals etc), and from materials that are not targeted for recovery (organic fraction, wood, stones etc.). This residual stream is characterised as Recovered Derived Fuel (RDF) due to its combustible nature as shown at a later stage of this report. The characteristics and the physical and chemical properties of the RDF are critical for the handling and the energy utilisation which is targeted through the project. The technical and operational standards of the energy utilisation unit (feeding procedure and gasification process) require the achievement of certain RDF characteristics. Those characteristics are achievable through certain pre-treatment.

Critical characteristics are the homogeneity and the flowability of the material and critical physical properties are the size, the moisture and the density. It is obvious that by controlling the physical properties, the characteristics could be optimised. A review of the methods and the equipment that are suitable for the pre-treatment of RDF was conducted and the outcome is outlined though this report.

# 2 RDF characteristics and properties

RDF is produced at the end of the production line of EPANA in the form that is shown below (Picture 2.1). The size of the RDF is usually between 65-280mm (sieved through the process) but a smaller fraction is always present. This size of material is acceptable for commercial applications where the feeding rate is counted in units of tones per hour and the feeding system is sized accordingly. In this project the designed unit is not at commercial scale but at a testing scale. The capacity of the designed gasification unit is an order of magnitude lower since the capacity will vary between 25-50 kg/h. The feeding concept of the gasification unit (dosing screw feeder) requires size reduction of the handled material and absence of long parts that could cause the blocking of the feeders and rotary valves such us ropes, metal wires, long plastic stripes and ribbons etc. Size reduction also leads to fuel homogeneity which is critical for the control of the gasification process. To obtain both size reduction and fuel homogeneity the first essential pre-treatment step is RDF shredding. A shredder is already installed and operates producing shredded material with nominal size 40mm, as shown in figure 2.2 (a pen was placed as size indicator).

Picture 2.1: Produced RDF

Picture 2.2: Shredded RDF (40mm)

Critical property of the RDF is the moisture. High moisture content (>15% wt) is not preferable due to the high amount of energy that consumes during the thermo-chemical process. On the other hand some moisture content may favour some critical steps of the thermo-chemical process but this is to be seen during operation and evaluation of results. The main source of moisture is due to the presence of specific waste species, namely organics and papers and textiles.

The conducted analysis of daily taken samples shows a considerable variation and a general trend of growth (figure 2.1). The trend will be evaluated at the end of that action (regarding RDF characterisation) when the annual profile of the RDF will be available.

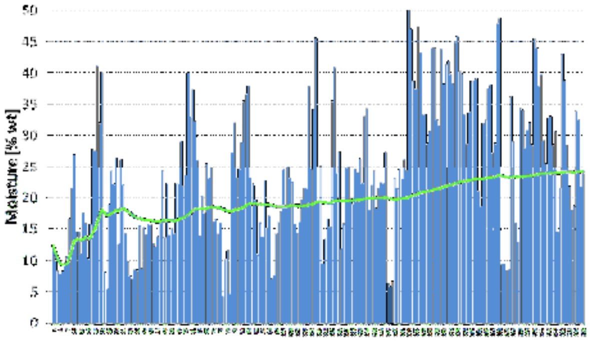


Figure 2.1: Daily sample moisture

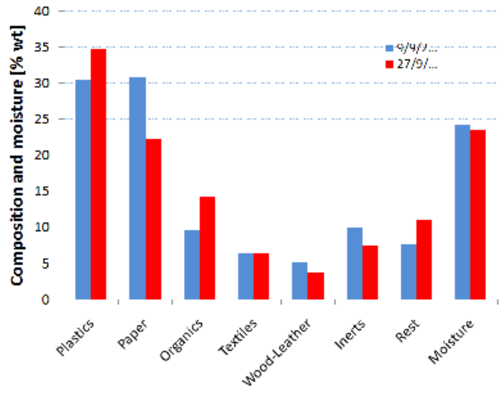


Figure 2.2: RDF composition

Detailed RDF composition analyses were conducted twice and the different waste categories are presented in figure 2.2. The interrelation between several species and the total moisture will be evaluated when more tests will be conducted till the end of the sampling period. Moisture could be controlled through changing process parameters and taking out high moisture categories. Alternatively (or additionally) could be used a step of thermal drying. By applying drying, moisture control is more precise, requiring though considerable thermal input. Air drier is usually used in RDF drying processes and is considered afterwards.

The third property which is important when handling RDF is the bulk density which is the volume that occupies a certain mass quantity of RDF. Volume is the critical parameter in the feeding process since screw feeding is a volume controlled process. The produced RDF (Picture 2.1) is shredded as shown in Picture 2.2. Shredded RDF is rather fluff material (100-150kg/m3) which means that requires rather large volume storage hoppers and wide diameter of screw feeders. Also the fluff form requires special equipment design to secure flowability. To overcome flowability problems (sticking and bridging of material), large storage volumes and excessive sized feeders, compression can be applied. Through compression the fluff material is compacted giving higher bulk density. The compressed form has a positive effect in the flowability since bridging is recued (when the compression rate is high bridging does not happen at all). The appropriate equipment is RDF pelletizer and the industrial applications are numerous in European level.

The abovementioned characteristics and properties are important both for the efficient handling of RDF and for the better control of the thermo-chemical process. The evaluation of several pre-treatment equipment follows based on the operating experience of EPANA and Helector Recycling Centre of Osnabruck GmbH (experience gained through the FP7 project POLYSTABILAT) and from technical discussions with specialized equipment providers.

# 3 Controlling size – Shredder

Controlling size and homogeneity is essential as a first pre-treatment stage. The shredder handles RDF in a size range 65-280mm consisted of easily definable species such as small size packaging (i.e. plastic bottles, paper boxes, tetra pack), organics, textiles, rubbers and leather (i.e. clothes, towels, shoes), tins and cans, pieces of wood and inert materials (i.e. broken glasses, stones). The shredder (Picture 3.1) operates reducing the size at such a level that a mixed homogenized material of the abovementioned species is produced (Picture 3.2).

Picture 3.1: RDF shredder

Picture 3.2: Shredded RDF

*Installation: EPANA SA, Equipment provider: Lindner-Recyclingtech GmbH*

Different sizes of RDF are achievable by selecting different meshes. Two sizes are available (have been obtained by EPANA before the initiation of the project) 40 mm and 20 mm and an option for 10 mm has been tested (temporarily obtained for testing purposes).

The 40 mm is the option that is currently used. This size is small enough and will be easily handled by the feeding system of the gasification unit. This size allows the shredder to operate at a rate that can follow the production rate of EPANA. Smaller mesh produces finer and more homogenized material but results in a lower production rate hindering the standard production rate. For the testing purposes of the project the 20 mm will be also used (Picture 3.3) and a comparative analysis will be conducted. It is expected that the smaller RDF size will give better results in the sense of heating rate.

Picture 3.3: 20mm size mesh

Shredding is the first pre-treatment step that might follow (prior to any drying or compression). The existing shredder will be used to produce two sizes of RDF, namely 40mm and 20mm. An option for further size reduction could be achieved (10mm) but this is considered as a possible future scenario. The necessity will be shown during the testing of the unit and the evaluation of the results.

# 4 Controlling moisture – Dryer

Moisture is a critical property when RDF gasification is under consideration. There are numerous references regarding the beneficial results of high moisture content of solid fuels due to steam reforming reactions that take place in the reactor. The role of H2O is beneficial for the production of hydrogen and methane, species with high energy content. On the other hand the high heat content that is required to evaporate the water content of the input fuel is an aspect that puts limits into the maximum moisture. The presence of materials with considerable water content (i.e. organics, wet textiles and cardboards, plastic bottles containing liquids) and the effect of weather conditions (i.e. seasonal raining, ambient humidity) result in the considerable variation of the final moisture (Figure 2.1 is indicative).

Air drying is a commonly used method to evaporate water content and achieve low levels of RDF moisture (even at levels below 10 % wt). The concept of heating air at temperature ~80°C using steam or exhaust gases has been commercially applied. The temperature should not exceed 80°C because RDF contains categories of plastics that have softening point below 90°C. Softening is the precursor of sticking which leads to the formation of particle agglomeration. This problem is encountered even in areas of the dryer that hot spots could be created.

Picture 4.1: RDF air dryer

*Source: Amandus Kahl GmbH*

Therefore temperature control and stable temperature profile are essential during RDF drying.

Moisture control can be achieved through rejecting (hand sorting or optical methods) specific waste categories that have high moisture content (i.e. organics, wet textiles and cardboards, plastic bottles containing liquids). Hand sorting is feasible for the rejection of easily definable items (bottles containing liquids, large parts of organic waste) and optical separation also for the rejection cardboards and papers that absorb moisture (also for the rejection of easily definable items).

Tests for controlling moisture through the production process by placing extra hand sorting and setting optical separators are in progress. A first attempt was made in a single day test once with the normal process setup (indicated as 'Normal') and right after with the change in the programming of one optical separator to select items with RDF characteristics (indicated as 'Positive'). The impact of additional hand-sorting is under evaluation.

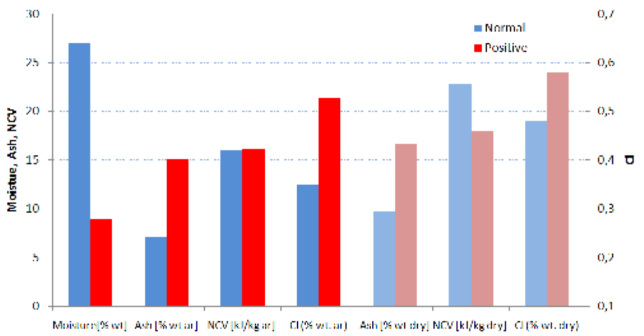


Figure 4.1: Test with normal setup and positive sorting.

In Figure 4.1 is presented the impact in moisture and in other characteristics (ash, Cl, heating value). It should be mentioned that the drastic reduction might be a combination of the above setup change but also due to the change in the composition of the incoming waste.

# 5 Controlling density - Pelletizer

Material density is a critical property for the transportation and handling of RDF but also for the feeding and heating rate through the process of gasification. The density of the RDF in the fluff condition (shredded and uncompressed) varies between 100 to 150 $kg/m^3$. There are some advantages regarding the handling of such a light material such as the pneumatic transport and the very high heating (in thermal treatment applications). That combination makes the fluff RDF as ideal fuel for process in which feeding is pneumatic and the heating of the material should be done instantaneously (main burner in cement kilns). Drawback of the light materials are the high transportation cost, the bridging during storage, the low volumetric feeding rate and the absorption of moisture (if dried and then stored for long period in wet atmosphere). Pre-treatment process for increasing density is the compression of the material for the production of pellets in two alternative forms, either soft or hard.

The compression is realised in pelletizing equipment, henceforth pelletizers, and the compression rate results either in the production of soft pellets (compression rate of 2) or hard pellets (compression rate of 6). The different compaction rate leads to the different density of the final product. Soft pellets of RDF have a density of 250 kg/m3 and hard pellets have density of 700 kg/m3. A test conducted in a test unit of an equipment provider (CPM Europe BV) and the produced pellets, as well as the original fluff material, are shown in Figure 2.3.

Figure 2.3: Pelletized (left), fluff (right) RDF

The compression results positively in the transportation and the handling of the material, especially for the flowability, as well as in sustaining low moisture in wet atmospheres. The main drawback, regarding the thermo-chemical process of gasification, is the lower heating rate compared to the fluff form. Laboratory analyses have shown that heating and reaction rates are critical for optimising the process. Henceforth, fluff will be the main form that will be used for the experiments and pellets will be an additional scenario.

During the market research and the evaluation of different pellezing technologies, several equipment providers were conducted and several technical data were communicated. Although the main concept of compressing RDF does not differ among the different types of pelletizers, there are some critical differences in the design and operation of the core part of these machines which is the compression disc (or ring).

A certain approach is the vertical compression of material that results when rolling cylinders are moving on a perforated disc (die) forcing (and compressing) the fluff material. The basic working idea of a flat die pelletizer as well as a photo of an installation is shown in the flowing figures.

Figure 2.X: Flat die pelletizer (working concept)

Figure 2.X: Flat die pelletizer (photo)

*Source: Amandus Kahl GmbH*

An alternative approach is press rolling pelletizer in which two rolling cylinders are pressing the material towards an external rolling ring. The basic working idea of the press rolling pelletizer as well as a photo of an installation is shown in the flowing figures.

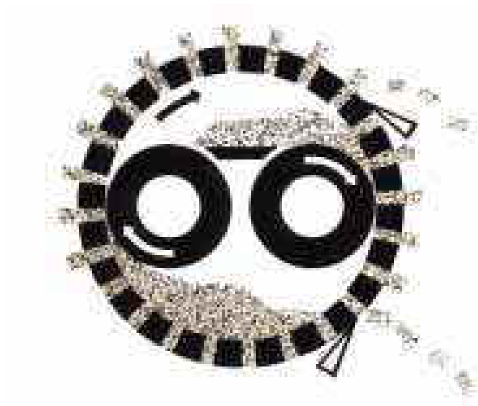

Figure 2.X: Press roller pelletizer (working concept)

Figure 2.X: Press roller pelletizer (photo)

*Source: CPM/Europe BV*

The approach of press rolling pelletizer is installed and operates in the facilities of Helector Recycling Centre of Osnabruck (HRO GmbH) in Germany as shown in the following figures.

Figure 2.X: Press roller pelletizer (photo)

Figure 2.X: Press roller pelletizer (photo)

*Installation: Helector Recycling Centre Osnabruck GmbH, Equipment: Andritz GmbH*

The production line produces both soft and hard pellets and the operating experience shows that pelletizing is an energy consumption and maintenance intensive process.

# 6 Outline

Pre-treatment of RDF is essential when thermal treatment is under consideration. Three commonly used pre-treatment techniques targeting in the upgrade of RDF quality were analysed. Upgrade is considered the optimisation of three critical characteristics / properties of RDF, namely size, moisture and density. Input from commercial applications and from market experts was used in order to evaluate pre-treatment technologies that are currently used. Shredding for size reduction, drying for moisture reduction and pelletizing for density increase are state of the art techniques. Moreover an additional technique namely process setting (either by extra hand sorting or by optical separator's setting) targeting in moisture control is under evaluation.

In the framework of ENERGY WASTE some of the above will be applied and the impact on the process will be evaluated. Different shredding settings (size variation) will be used to define the impact of RDF size. Changes in the standard process of RDF production are already in progress (hand sorting and optical separator's setting) and their impact on the moisture (as well as on other properties like heating value, ash content, chlorine content) will be evaluated. Compression could not be beneficial for this specific application due to the fact that the process requirements seem to favour fluff material instead of compressed. Nevertheless small quantities of RDF might be pelletized to evaluate the performance of the unit.