New ways to make MBT sustainable

Case Study – Bio-drying for RDF production in Sulaimaniyah, Iraq, 2013

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Abstract

The projection of the future waste quantities in the Municipality of Sulaimaniyah in Iraq (365.000 tons in 2013) shows an annual increase rate of 3%. Within 20 years the waste amount will increase by 75%. In this context, an appropriate waste management system was urgently required.

A feasibility study has been prepared in 2013 in order to design a mechanical-biological treatment (MBT) facility with maximized refused derived fuel (RDF) production and a landfill for the disposal of MBT refuse.

The MBT concept consists of three steps: pre-treatment, bio-drying and post-treatment. The pre-treatment phase consists of two lines with pre-shredders. The second step is a biological treatment with the aim to dry material. The post-treatment phase treats the dried waste and consists of three lines with sorting of ferrous metals, sieves, density separators, inert screens, a manual sorting line, re-shredders and storage bunkers.

The landfill is planned for stabilized materials for 20 years, with no biogas management and light leachate treatment. The landfill will cover an area of approximately 11 ha divided in 3 cells.

As a conclusion, the final mass balance shows that more than 40% RDF can be produced, anyhow some issues related to the composition of waste need further assessment in order to verify the quality and quantity of RDF.

Keywords

MBT, RDF, biowaste, bio-drying, waste to energy

1. Introduction

Since the demand for energy has significantly increased in the last few years and the primary fuels are getting more expensive, the big challenge today is to find new energy alternatives. One of those alternatives will be the reuse of waste into energy, namely the production of secondary fuel from waste called refused derived fuel (RDF).

A promising and cost-effective method for producing RDF is the bio-drying of waste through biological treatment. With this aerobic biological process the high-caloric fraction as well as native and artificial organic materials will be dried (not degraded). Nowadays, there is an increasing demand for secondary fuel in big energy consuming factories, like cement industries.

In this context, the Client, one of the biggest cement producing companies in the world, has contracted ICP, the Consultant, with the aim to develop a feasibility study including conceptual design regarding a waste treatment plant for Sulaimaniyah Municipality in Iraq.

It is known that the price of energy in Iraq is currently very low and makes it difficult to justify RDF production. Actually the average price of one liter gasoline in Iraq was estimated by 0.34 euros in April 2014. But the aim of this project is to look for a long term sustainable solution with positive environmental impacts.

The project represents an opportunity for the client to provide their Iraq based cement plants with controlled good quality and long-term sustainable of RDF as a cost-efficient alternative fuel source that will contribute to maintaining their leader position on the cement market in Iraq while promoting the group's awareness of its social and environmental responsibility in the country.

Thus, ICP carried out last year a feasibility study to check the requirements for construction of a MBT facility and to dimension and design the plant on a conceptual level.

2. Framework conditions

2.1. Project area

The project area is the Municipality of Sulaimaniyah which is located in the Kurdistan Region in the northeastern part of Iraq and is the capital of Sulaymaniyah Governorate, as shown in Figure 1. The project takes place in a region with a semi-arid climate, which means very hot dry summers and cool wet winters.

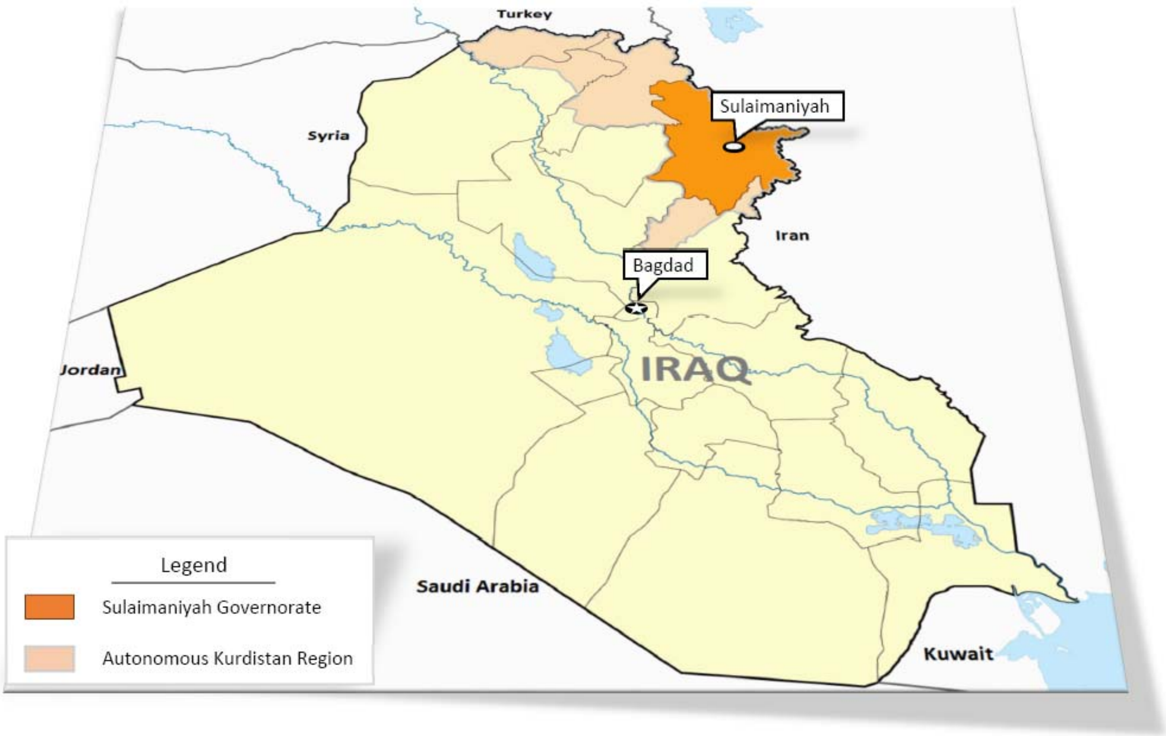

Figure 1: Map of the project area: Municipality of Sulaimaniyah

The Municipality of Sulaimaniyah has today a population of more than 1 million inhabitants. As Sulaimanyiah is considered as the most industrial developed Governorate in Iraq, the Municipality has been confronted in the recent years with a significant increase of population of approximately 3% per year.

2.2. Waste production

For 2013 it was estimated in the project area a quantity of 365,000 tons of generated waste wherefrom 85% is household waste (HHW) and 15% commercial and industrial waste (CIW). The projection of the future waste quantities shows an annual increase rate of 3%. Under these assumptions within 20 years the waste amount will increase by 75%, as represented in Figure 2.

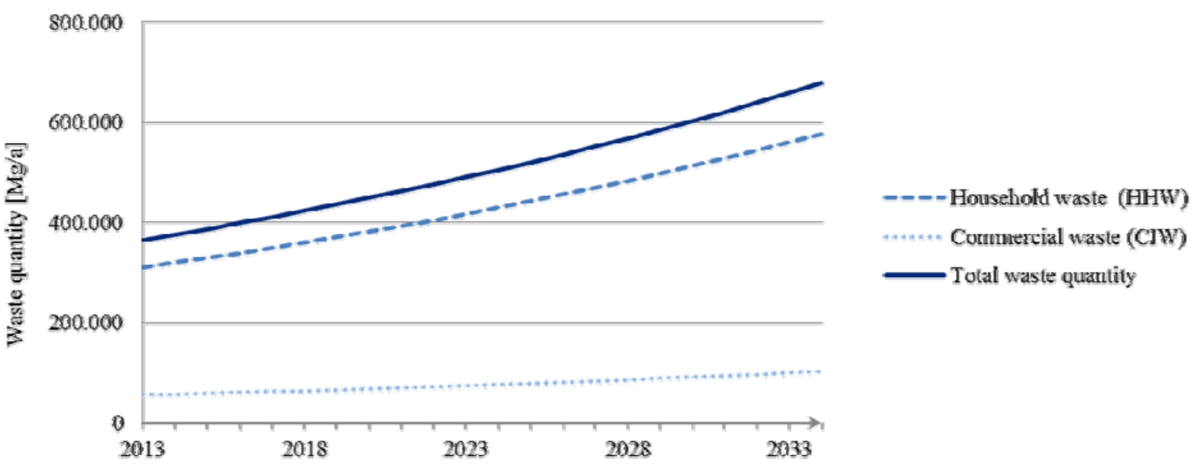

Figure 2: Evolution of waste quantities over 20 years in Sulaimaniyah Municipality

2.3. Objectives of the project

The target of the plant is to treat 365,000 t/y (start-input) of domestic waste obtaining at least 30% of input as RDF for several cement plants. The main objectives of this project are:

- to produce as much RDF as possible;
- to provide a complete waste management solution (treatment and disposal) for the Municipality of Sulaimaniyah;
- to adapt technical requirements to local conditions.

The system will include mechanical treatment facilities combined with a bio-drying unit and a sanitary landfill.

3. RDF requirements

To determine the fuel quality, there are a few criteria [1] which can be defined such as:

- Biomass content;
- Net calorific value;
- Moisture content;
- Chlorine content (dry) which causes corrosion and fouling;
- Ash content (dry) which affects melting and sintering temperatures; and
- Bulk content (density) which affects transport/space and feed/input levels.

For cement manufacturer, RDF can be added at two stages during the process and therefore two qualities of RDF product can be produced. At the first stage, a high quality RDF can be inserted to the primary incinerator and the second stage is the calcinator in which low quality RDF is burned.

In order to produce the maximum RDF, the cement manufacturer in the case of Sulaimaniyah's project, prefers to burn RDF in the calcinator. Therefore the RDF provided to the cement kilns will have pre-defined parameters under control such as:

(1) Calorific value on average at 15 GJ/ton
(2) Moisture content < 20 Mass %
(3) Chlorine content < 1%

All other process parameters important for the cement kilns (H_2O, S and heavy metals) will be monitored.

4. Waste analysis

As a basic input for the feasibility study, a waste characterization describing the MBT input material has been carried out in the year 2013. The waste composition is shown in Figure 3.

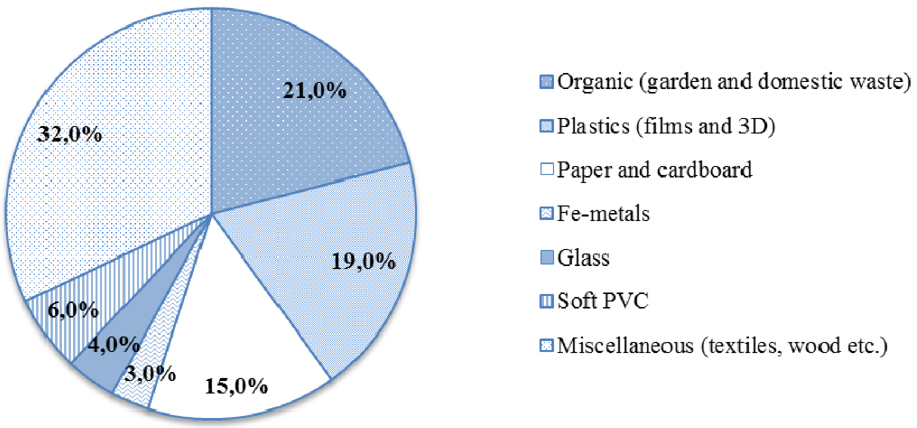

Figure 3: Waste composition

The results of the waste characterization show an organic fraction of 21% and an average content of the high calorific fraction (plastics, paper and cardboard) of 34%.

The Table 1 shows in theory how much RDF product can be sorted out of this waste composition.

Table 1: Potential RDF production

Sorting fractions	**Composition [%]**	**Potentially useable as RDF [%]**
Organic waste	21.0	~ 50
Plastics	19.0	~ 80
Paper and cardboard	15.0	~ 80
Fe-metals	3.0	0
Glass	4.0	0
Soft PVC	6.0	0
Miscellaneous	32.0	~ 50
Total	**100.0**	**~ 50**

According to the waste composition analysis done on site, about 50% of the waste amount could potentially be used as RDF. However, to verify the data, further waste composition analysis should be foreseen.

5. MBT concept

5.1. Generalities

The MBT process is developed in 3 steps as shown in the Figure 4.

Figure 4: MBT process

Step1: Pre-treatment
Household waste and commercial and industrial waste will be collected directly from Sulaimaniyah Municipality and will be delivered to the reception area. The HHW will be pre-shredded (particle size ≤ 300 mm) and transferred to the bio-drying step. CIW will go after primary shredding directly to the post-treatment.

Step 2: Bio-drying
Pre-shredded wastes are conveyed to the biological treatment: bio-drying. The shredded material is placed in heaps, covered with a membrane and equipped with aeration for 3 to 4 weeks. The aim of this step is to dry the material < 20% moisture content.

Step 3: Post-treatment
In the post-treatment, the dried material will go through a mechanical treatment. The aim of this step is to sort out efficiently recyclables and RDF (particle size ≤ 50 mm, water content ≤ 20%) out of the waste and to reduce the amount of residual waste for disposal (quantity for disposal shall be ≤ 20%).

5.2. Mass balance

During the feasibility study, the Consultant had to develop a process to maximize RDF production. The detailed flow chart of the MBT process is given in the Figure 5 below.

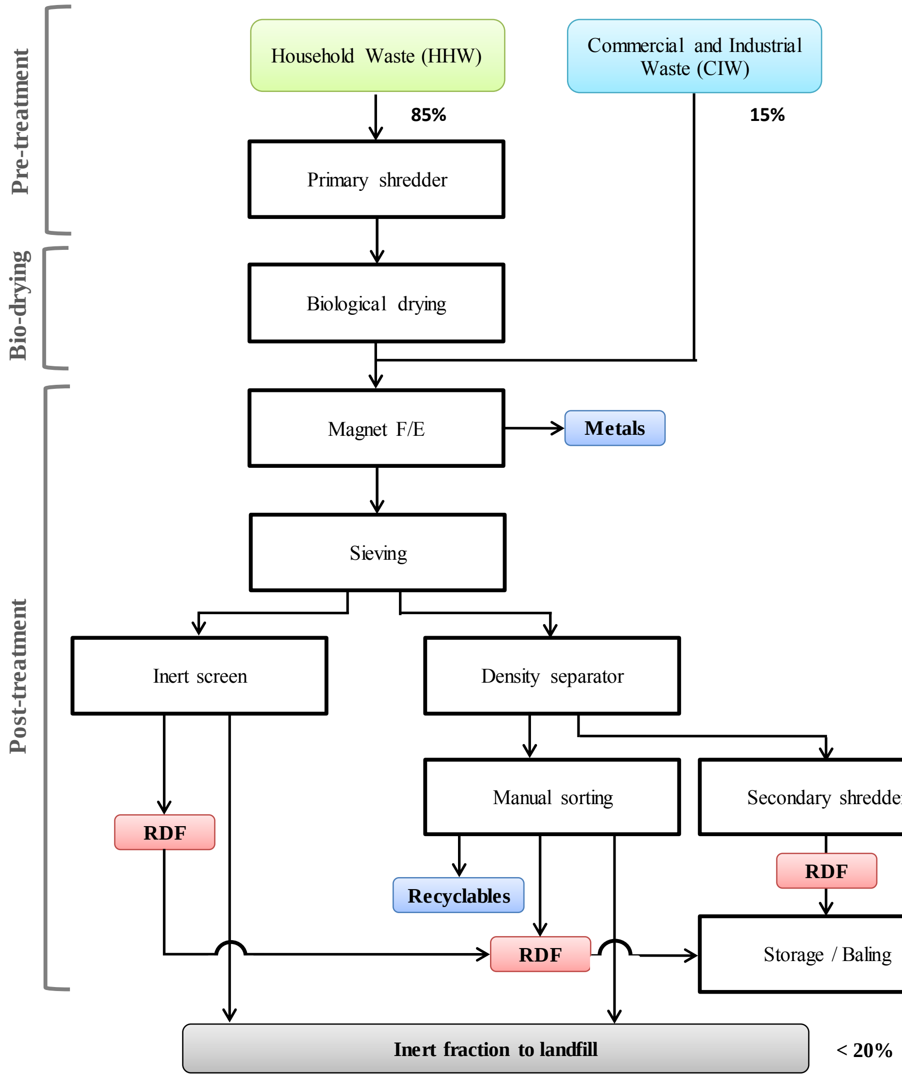

Figure 5: Flow chart of MBT process

5.3. MBT process

5.3.1. Step1: Pre-treatment

In the pre-treatment phase, HHW (85% of total waste quantity) will be delivered with different types of collection trucks to the reception area and unloaded on a platform. At this stage, it is essential to sort out problematic and bulky waste as they may damage the pre-shredder (like metals, stones, mattresses, washing engine blocks, etc.).

In a second step a loader pushes the waste towards the conveyor belt that feeds two shredders. Generally a particle size of ≤ 300mm is acceptable for the bio-drying procedure foreseen. The pre-treatment process is shown in the Figure 5.

Moreover, separate bunkers are foreseen for the reception of CIW (15% of total waste quantity). This stream will - after primary shredding - directly be transported to the secondary treatment.

5.3.2. Step 2: Bio-drying

The waste for drying will be delivered by conveyor to the roofed handover area and it will be transported by loaders to the drying bays.

The waste undergoes a biological drying step in a membrane covered, aerated, temperature controlled drying bays. The input material will have an initial moisture content of approximately 50%-60%. After the biological drying of about 3 to 4 weeks, the dried waste will have a moisture content of approximately 20% and will be ready for further processing.

The main objective of the drying stage is to dry the waste in order to allow an efficient post-treatment to meet the criteria of the final products as well as to increase the effective calorific value of the produced RDF.

The membrane cover separates the waste material from ambient conditions, allows water vapor to be released but retains bio-aerosols and reduces odor emissions. These covers are impermeable for rain. Rain water runs off the covers and is collected separately between the bays. A schema of a heap cross section with membrane cover is given in the Figure 6.

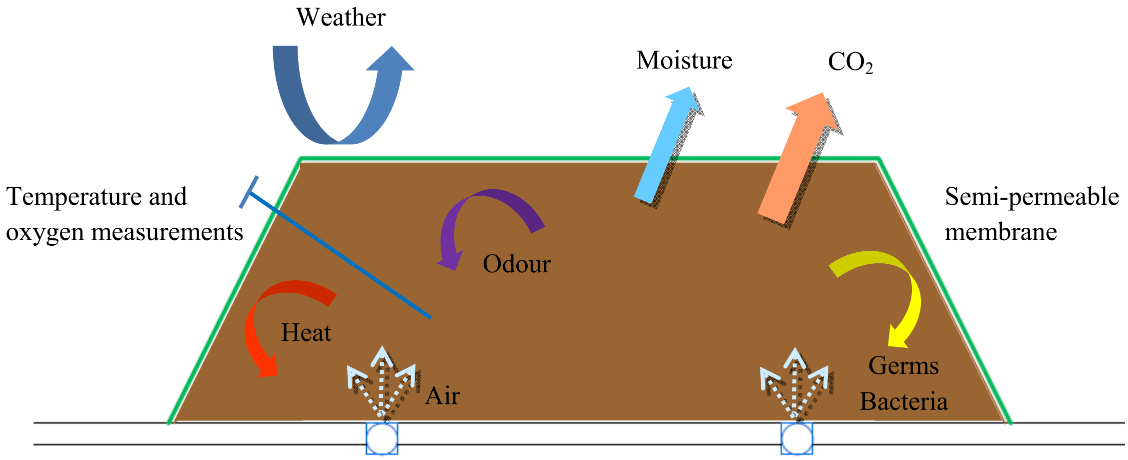

Figure 6: Heap cross section with membrane cover

The aeration pipes provide the necessary oxygen for the microorganism, the air to remove the moisture in this aerobic process and in parallel act as drainage for the little amounts of leachate water arising during the first few days of the drying process. The pipes are connected to the leachate water collection system via a water trap.

The drying process is controlled via a specialized software using process data as temperature profile, air flow etc. to control the process according to the process requirements.

A winding device is used to remove the cover from the drying material before shifting and to cover it after the heap filling is completed.

Due to the very energy efficient static system mechanical turning of the material is required only three times each batch for an efficient drying process. The turning is carried out by loaders.

After a drying process of 3 to 4 weeks, the dried material is removed by loader and sent to the post-treatment line.

5.3.3. Step 3: Post-treatment

The dried material will be transported on conveyors to the post-treatment line fall into a hopper and will be divided in three main treatment lines. These three lines shall allow more flexibility and security to the process. The material passes following process steps, also presented in the Figure 5:

1. Sorting of ferrous metals
   A magnet will sort out ferrous metals.

2. Sieving
   In the second stage, the material passes a sieve, which separates waste into two fractions:
   - Fraction > 50 mm is going to the density separator;
   - Fraction < 50 mm is going to the inert screen.
3. Density separator
   The fraction > 50 mm passes a density separator (wind sieve), which separates waste into two fractions:
   - Fraction > 0.2 t/m³ is conveyed to the manual sorting;
   - Fraction < 0.2 t/m³ is conveyed to the re-shredding.

4. Inert screen
   The fraction < 50 mm passes an inert screen which separates waste into two fractions:
   - RDF fraction shall go to the -NE separator (optional) or baling/de-baling stage or directly to the RDF storage bunkers;

- Inert fraction will be transported to the landfill.

5 Manual sorting
The objectives of the manual sorting line, after the density separator (fraction > 0.2 t/m³), is to conduct a negative sorting in order to sort out materials not needed/required for RDF such as:
   - Inert (stones, minerals…) and non-valuable fraction, and
   - Recyclables

The remaining fraction after the manual sorting line is considered as RDF and will continue the treatment process.

6 Re-shredding
Material (fraction > 50 mm) coming from density separator (fraction < 0.2 t/m³) and manual sorting will be re-shredded in order to obtain particle size < 50 mm.

7 NE separator
If needed, non-ferrous metals can be sorted out (optional) after the re-shredding process step.

8 Baling / De-baling / Baler storage area
A baling and de-baling station is foreseen in case of technological breaks or interruptions of the process will occur during operation of the plant and the RDF material has to be compacted in baler and stored on a baler storage area.

9 Storage bunker
Storage bunker are foreseen to convey the material into the trucks, which bring it to the cement factories.

Finally in the post-treatment process, the following main fractions will be produced:

- Ferrous metals
- Non-ferrous metals (optional)
- RDF fraction (particle size max. 50 mm, moisture content max. 20%)
- Waste from air cleaning (dust and used filter material)
- Residual waste for disposal (max. water content 20%)

6. Landfill concept

Based on a 20-year time frame, the total landfill capacity has been calculated for maximum 20 % of the annual waste amount of 2013, including a 3 % increase. The landfill is planned for stabilized materials (residues from the RDF production). The following characteristics for material going to landfill have been taken into consideration:

- Moisture Content ≤ 20 Mass %
- Grain size 0 - 50 mm
- Residues are mostly stabilized

A general slope of 1:3 for backfilling is recommended in order to accommodate the total amount for 20 years. The landfill will cover an area of approximately 11 ha and will be divided in 3 cells.

The protection of soil and water will be achieved by the combination of a geological barrier and an asphalt lining system. The asphalt lining system may consist of the elements shown in Figure 7:

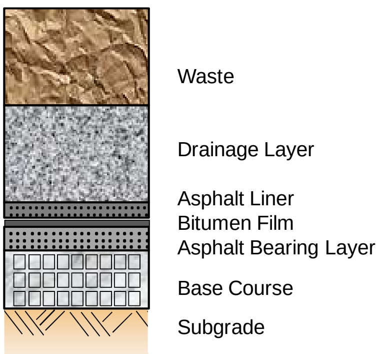

Figure 7: Example for an asphalt lining system

Leachate will be collected and treated in an onsite reverse osmosis plant. Entering of surface water and groundwater into the landfill shall be prevented and leachate deriving from precipitation will be collected and treated accordingly.

Due to the low moisture content of 20 % and low organic matter, the collectable gas quantities will be in comparison to a landfill for untreated waste so low, that the installation of a gas extraction and treatments system does not seem viable for the given waste characteristics.

However wastes analysis have been carried out during the feasibility study, anyhow actually there is no sufficient studies or data on the behavior of this type of material (bio-dried residues from the RDF production) for landfilling, so the quality and behavior of this material e.g. regarding the stability of the landfill and the subsequent consequences are not well known. Further practical based investigations are required.

7. Final results

7.1. Mass balance

The final mass balance is summarized in the Table 2.

Table 2: Final mass balance

Fractions	**%**
Total quantity recyclables	4.0
Total quantity RDF	43.0
Total waste quantity to landfill	14.0
Biodegradation rate in % of total input	1.0
Total loss of water in % of total input	38.0
Total waste treated (wet)	**100.0**

Finally, according to the feasibility study, 43% of the waste amount could be transformed as RDF product.

7.2. Concept

The pre-treatment stage consists of two lines. The pre-shredders are treating the incoming waste for further treatment. The bio-drying unit foresees for the initial stage approximately 6 ha for 8 years operation. In the post-treatment, disturbing fractions will be sorted out in a negative manual sorting and the rest pass in a secondary shredding stage to finally produce RDF. At the end of the MBT-process, the amount of waste going to landfill will not exceed 20% of the total input waste quantity.

A low impact landfill with a capacity of 20 years (total area of 11 ha in 3 cells) shall be built. Emissions into the ground shall be prevented due to an asphalt sealing system. Leachate shall be collected and treated in an onsite reverse osmosis plant. Landfill gas generation due to the low moisture content of 20 % and organic matter, is initially not anticipated.

The waste treatment part represents 80% and landfilling 20% of the total costs.

8. Conclusion and outlook

As a conclusion, the feasibility study has shown that the project is technically and financially feasible.

Beginning 2014, ICP has been contracted to carry out the detailed design of the landfill, which should be operational in 2015. However, some issues related to the composition of waste will need further assessment in order to clarify whether:

- the estimated quantity and quality of RDF can be produced;
- the estimated quality and quantity of residues disposed on the landfill are sufficiently accurate.

9. Literature

[1] Waste & Resources Action Programme — 2012 — A Classification Scheme to Define the Quality of Waste Derived Fuels - www.wrap.org.uk/efw

[2] Ingenieurgesellschaft Prof. Czurda und Partner mbH (ICP) — 2013 — Feasibility study - Pre-Treatment Facility and Landfill for Sulaymaniyah Wastes, Iraq