Mechanical-Biological Treatment of Municipal Waste in Poland
– Dominating Technologies and their Efficiency in Diverting Waste from Landfills –

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In Poland mechanical-biological treatment (MBT) technology is a prevailing method of mixed waste treatment. It is applied both as a way to recover waste fractions for material and energy recovery and to stabilize the biodegradable waste prior to landfilling. The first plants were constructed over 20 years ago, initially as *composting plants* for mixed waste. They have gradually evolved MBT plants. The newer installations include much more advanced mechanical treatment technologies combined with biological treatment of mechanically separated biodegradable fraction of municipal waste. In this paper an overview of the current legal situation of MBT technology in Poland is provided. The prevailing MBT technologies have been characterized, along with the average efficiencies, which are achieved.

1. Legal situation of municipal waste management in Poland

Municipal waste management in Poland in regulated by the Act of 13 September 1996 on maintaining cleanliness and order in municipalities (Dz.U. of 2012, pos. 391, as amended), hereinafter referred to as the *Act on maintaining cleanliness* [1].

On January 1, 2012 the provisions of the Act of 1 July 2011 amending the Act on maintaining cleanliness and order in municipalities and some other acts (Dz. U. of 2011., No. 152, pos. 897) [2] came into force. The Act introduces as far going changes in the existing municipal waste management system that often it is referred to in Poland as the *revolution of waste management*. The amendments of the existing regulations on municipal waste were aimed at the following objectives:

- improved control over the municipal waste management system;
- higher separate collection of municipal waste *at source*;
- reducing the amount of municipal waste, including biodegradable waste going to landfills;
- increasing the number of modern installations for the recovery, including recycling, and disposal of urban waste other than landfilling;
- complete elimination of illegal landfills, thus reducing litter, in particular, in forests and recreation areas;
- elaborating efficient method of monitoring the treatment of municipal waste,
- the reduction of additional risks to the environment resulting from the transport of municipal waste from the area where they were generated to the place of their recovery or disposal, by the division of provinces into waste management regions, in which any activities related to the management of municipal waste are carried out.

The major perceivable difference, after 1 of July 2013 was that the municipalities overtook the power of waste managing authorities. For the first time waste collection companies had to be selected in a public procurement procedure, which in some regions let to a severe competition and a complete change of already established structures.

It is expected that the new rules governing municipal waste management in Poland will enable healing of the existing waste management system, which in many aspects operated inefficiently and as a consequence Poland will be able to fulfill the European waste targets, related especially to recycling targets and diversion of biodegradable waste from landfills.

The Act on maintaining cleanliness imposes separate collection of municipal waste including at least: (i) paper, (ii) metals, (iii) plastics, (iv) glass, (v) composite packaging and (vi) biodegradable waste. While the requirements for the first five streams are clear, in the case of selective collection of biodegradable waste, there is a fairly large interpretive ambiguity. Generally, biowaste – kitchen and garden from residents and green waste from urban areas – should be selectively collected. Separate collection of biowaste would enable directing this waste stream to composting or fermentation processes, which are more environmentally justified and generally cheaper than processing the mixed waste stream. However, the Polish municipalities are very reluctant in implementing the separate collection of biowaste from households. In most municipalities only green waste from municipal areas are collected separately. Some municipalities have introduced separate collection of garden waste from inhabitants, e.g. in Wrocław and in Poznań, belonging

to the largest cities in Poland, garden waste is collected from single family housing areas. Poznań is in fact in a process of implementing separate collection of kitchen biowaste from households, in selected districts in order to provide feedstock for the biowaste digestion plant which is planned to be constructed and operated from January 2016.

It is important to mention that under the Act of 14.12.2012 on waste (Dz.U. 2013 nr 0 poz. 21, with amendments) [4] the municipal mixed waste, residues from waste sorting and green waste must be managed within the waste management region they were generated. Moreover they must be treated in a regional treatment installation. The definition of a regional municipal waste treatment installation defines the following conditions which must be met:

- a capacity sufficient to receive and process waste from the area inhabited by at least 120,000 inhabitants,
- fulfilling requirements of best available technique or technology.

The technologies which may be applied for mixed waste treatment are: thermal treatment and mechanical-biological waste treatment. Since the recent amendment from January 2015 (Dz.U. 2015 poz. 122) [10] also *new technologies* for mixed waste treatment were admitted and the thermal treatment plant may acquire a status of trans-regional installation, which means that it may accept mixed waste from other regions, out of the region where it is located. This is expected to ensure sufficient quantity of waste for the incineration plant. Currently in Poland 6 incineration plants are constructed, with a total capacity of app. 1 mln Mg/a, which have been co-financed from the European Fund – Infrastructure and Environment. Full list of waste management regions and regional waste treatment plants is provided in provincial waste management plans, which were elaborated in 2012.

2. Legal status and conditions of mechanical-biological treatment of waste

Mechanical-biological treatment (MBT) of waste in Poland is governed by the Regulation of the Minister of Environment dated from 11 September 2012, on the mechanical-biological treatment of mixed municipal waste (Dz. U. 2012 pos. 1052) [8].

It specifies: (i) requirements regarding performance of mechanical and biological treatment of mixed municipal waste and (ii) requirements for waste from these processes. Pursuant to § 2 of the Regulation, MBT consists of *mechanical treatment* and *biological treatment of waste* combined into one integrated technological process of processing of mixed municipal waste in order to prepare it for the recovery, including recycling, energy recovery, thermal conversion or landfilling. MBT installation can not be located at a landfill.

Mechanical processing of mixed municipal waste is aimed at separating fractions for material and/or energy use, and the fraction requiring further biological treatment. Waste generated in the mechanical process are classified, as wastes codes of subgroup 19 12

beyond waste code 19 12 09 minerals (eg. sand, stones). It is also admissible to generate waste classified under codes: 15 01; 16 02; 16 06 i 20 01. Waste generated in the process of mechanical treatment of mixed municipal waste are to be processed in accordance with the waste hierarchy.

The regulation imposes that in the *mechanical treatment* of mixed waste the fraction of at least 0 to 80 mm is separated (designated as code 19 12 12) requiring *biological treatment* which can be conducted under aerobic or anaerobic conditions. Three types of biological treatment are defined: aerobic stabilization, anaerobic stabilisation and biodrying.

The biostabilisation under aerobic conditions is carried out in accordance with the following requirements:

- waste is processed, including turning of the waste, for a period of 8 to 12 weeks in total;
- for at least two the first weeks the process takes place in a closed reactor or in the hall, with active aeration and prevention of the entry of untreated process air to the atmosphere, until reaching the AT_4 values of less than 20 mg O_2/g d.m.;
- the total processing time may be shortened or extended, depending whether the specified parameters are met.

The biostabilisation under anaerobic conditions is carried out in two stages:

- in the first stage mesophilic fermentation for at least 20 days or thermophilic fermentation for at least 12 days needs to be carried out
- in the first stage mesophilic fermentation for at least 20 days or thermophilic fermentation for at least 12 days needs to be carried out;
- in the second stage aerobic stabilization in a closed reactor or in the hall, with active aeration for at least two weeks should be carried out. It is allowed to carry out the second stage in the open windrows, while waste should aerated by turning at least once a week, for at least three weeks.

The biodrying

- the process is carried out under aerobic conditions, with active aeration in the closed reactor or hall, with protection that prevents the entry of untreated process air to the atmosphere for at least seven days.

The Regulation classifies the waste of MBT in the following way: Waste generated in the biostabilization process (called *stabilate*), which fulfills the requirements specified in § 6.1 are classified under waste code 19 05 99. After screening, the stabilate with the particle size < 20 mm may be used for recovery process, under waste code 19 05 03. However, the options for recovery are limited to its application within biological layer of a landfill cover.

The waste generated in the process of bio-drying is classified as waste code 19 05 01 – *non-composted fraction of municipal waste and the like*, and subjected to further processing in order to produce waste derived fuel classified as 19 12 10 and the fraction of 19 12 12,

which in order to be disposed of must be biologically processed in accordance with the conditions specified above. In the process of further mechanical treatment other waste codes can be generated belonging to subgroup 19 12 (beyond waste code 19 12 09); 15 01; 16 02;16 02 or 20 01. 16 06 and 20 01.

In § 6. 1 of the Regulation the criteria are defined that must be met by stabilate so that it can be considered biologically stable and thus, as such, approved for landfilling:

- loss on ignition is less than 35 percent dry matter and organic carbon content is less than 20 percent by dry weight or
- loss of the organic mass weight in the stabilate, referred to the weight of organics in initial waste, measured by ignition loss, or the organic carbon content is greater than 40 percent, or
- AT4 value is less than 10 mg O_2/g d.m.

The regulation does not specify requirements for the waste generated in the processes of biodrying, classified as 19 12 10, except for stating that it must meet the requirements specified by the recipient of waste derived fuel.

The existing installations were supposed to adjust to the requirements of the Regulation no later than 24 months from the date of entry into force of Regulation .

3. Diversion of the biodegradable waste from landfills

Based on the values provided in the National Waste Management Plan the following quantities of biodegradable waste balance is assumed:

- In 2013: 7.3 million Mg of biodegradable waste was produced,
- In 2020: 7.8 million Mg of biodegradable waste will be produced.

The respective limits for landfilling of biodegradable waste are:

- In 2013: 2.2 million Mg,
- In 2020: 1.5 million Mg.

In 2013, it was necessary to divert from landfilling a minimum of 4.7 million Mg of biodegradable waste, and in 2020 more than 6.0 million Mg of biodegradable waste.

Figure 1 presents the percentage shares of individual methods of management of mixed municipal waste in 2012.

The statistical data shows that in 2012 8,575 thousand Mg of residual waste was collected. The total amount of residual waste treatment was 2,667 thousand Mg of waste, of which 2,079 thousand Mg was treated in MBT plants. 5,908 thous. Mg of waste was landfilled, which accounts for almost 70 percent of waste collected in the form of mixed and 62 percent of the total amount (9.581 thous. Mg) of municipal waste.

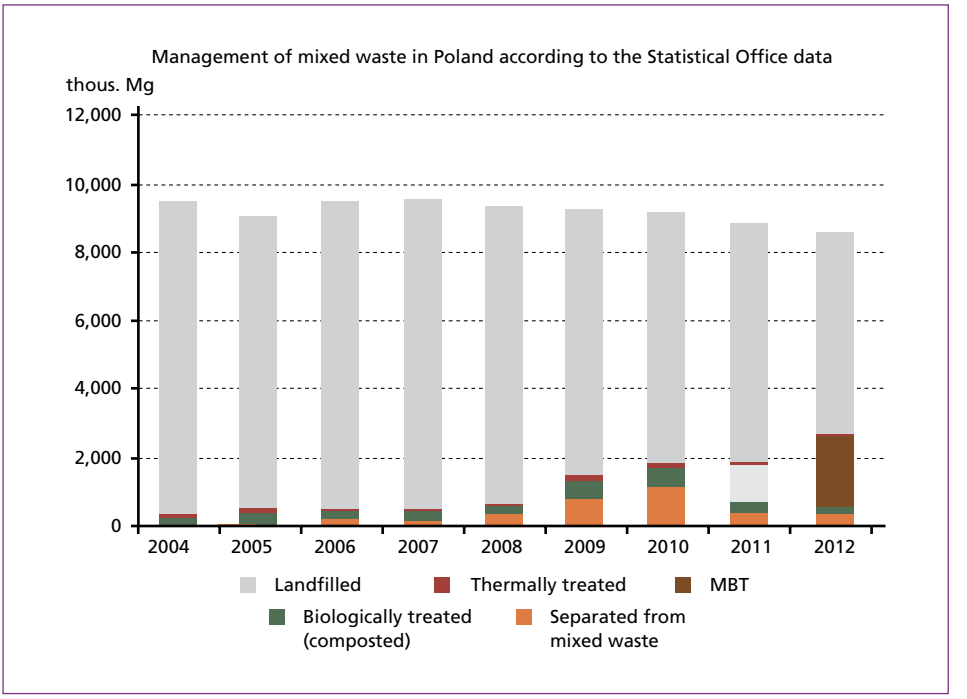

Figure 1: Treatment of residual municipal waste in Poland, based on GUS (Central Statistical Office)

Source: Głowny Urzad Statystyczny (GUS) Ochrona Środowiska 2008 – 2013

4. Waste treatment installations

The capacity of installations for mixed municipal waste treatment, according to 16 provincial waste management plans which were elaborated in 2012 are presented in figure 2. As of December 2012, there were 233 plants for processing municipal waste, including 93 MBT installations, one incinerator, 133 composting plants and 6 fermentation plants of organic waste [7]. In the recent years, a very fast increase of waste treatment capacity took place. Especially, new MBT plants were constructed as well as the existing sorting plants were upgraded to MBT plants, in order to be allowed to acquire a status of a regional waste treatment plant.

The provincial waste management plans indicated high capacity for waste treatment. In fact some of these capacities were overestimated, which was due to a lack of clearly formulated technical requirements for regional installations at that time. Since the formulation of the new principles of waste management there was a strong intensification of investment activities. Investments are carried out both by municipalities and their associations, mainly based on the support of EU and domestic funds, as well as by private entrepreneurs. The level of investment (technology advancement) and the attainable level of recovery is very diverse in the existing MBT plants.

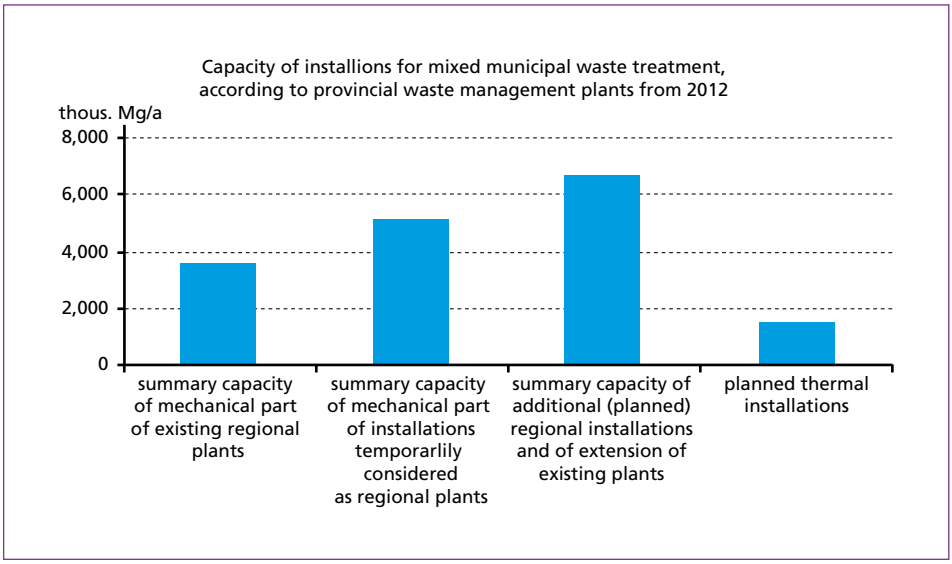

Figure 2: Mixed waste treatment installations according to provincial waste management plants from 2012

5. The MBT technologies applied in Poland

In 2013 survey of existing MBT plants in Poland, commissioned by the General Directorate of Environmental Protection, was performed [5]. According to the report 74 MBT plants were visited in order to collect their performance information. Figure 3 shows the split of technologies by major types.

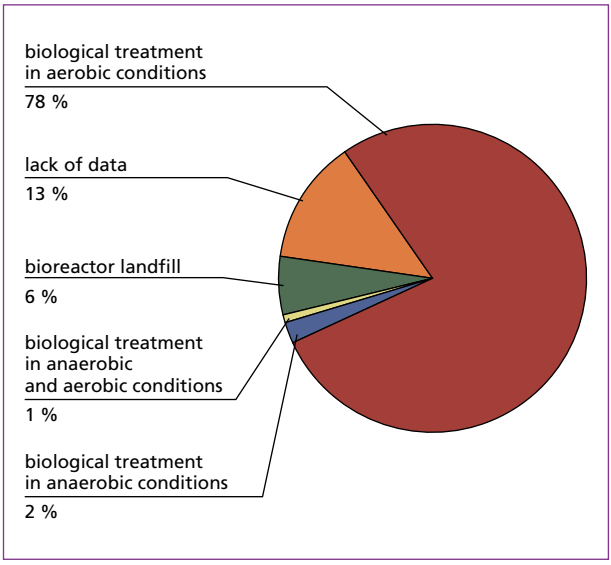

Figure 3:

Main technologies applied in Polish MBT plants based on survey from 2013

Source: Regulation of the Minister of Environment dated from 11 September 2012, on the mechanical-biological treatment of mixed municipal waste (Dz. U. 2012 pos. 1052)

Generally, MBT plants based on aerobic biostabilisation dominate in Poland. More recently the aerobic plants are operated either as biostabilisation or as biodrying, depending on the current needs.

In order to characterize further the available aerobic stabilization technology, the following categories have been defined:

- windrows in the hall,
- reinforced concrete boxes in the hall,
- enclosed reinforced concrete reactors with reinforced concrete ceiling,
- enclosed reinforced concrete reactors with a plastic ceiling,
- enclosed steel reactors,
- enclosed reinforced concrete reactors with a membrane ceiling,
- windrows with a membrane cover,
- biostabilisor,
- the so called *composter*, being a rotating drum,
- impermeable foil sleeves;
- open windrows.

Figure 4 provides shares of individual aerobic stabilization options, identified in a MBT technology review [5].

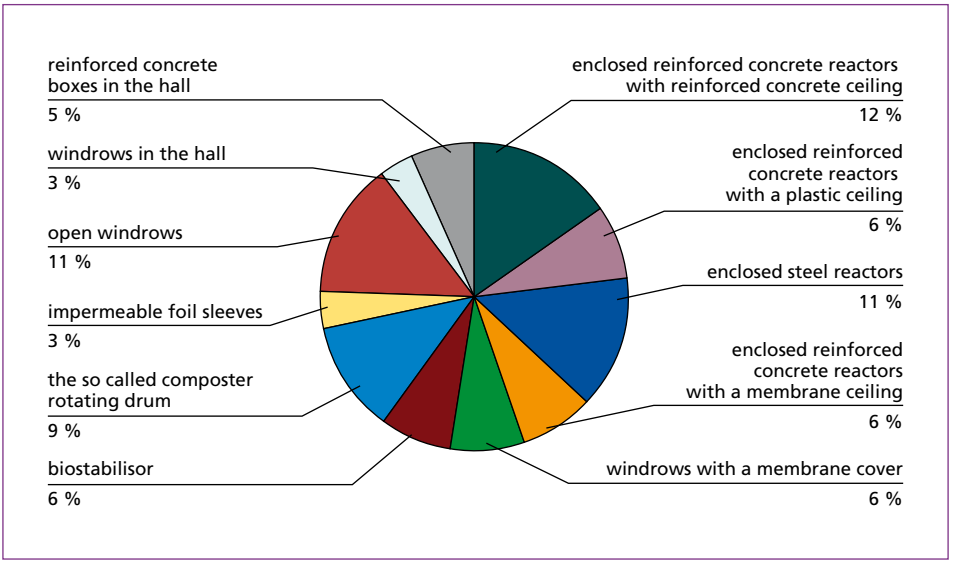

Figure 4: Dominating aerobic stabilization technologies used in Polish MBT plants

based on 2013 data: AK Nova technologie dla środowiska, The final report of the II stage of expertise aimed at the survey of existing MBT installations in Poland, including visiting of 50 istallations and selecting 20 instalactions for further analyses within stage III, Poznań 2013

Enclosed concrete reactors constituted the largest share of aerobic MBT plants in 2013 (12 percent, e.g. MUT technology), followed by enclosed steel reactors (11 percent, e.g. Kneer technology) and open windrows (11 percent). Since then especially the share of concrete reactors with plastic or membrane roofs has increased (e.g. CompostSystem technology or Hantsch technology). Lange share of open windrows indicates lower advancement of the stabilization technology. These installations were admitted as regional plants in the transitional period. However, they need adjustment to the requirements of MBT technology standard.

It can be noted from figure 3 that also bioreactor landfill was classified as MBT technology. In fact it was actually only one province in which such plants were classified as MBT technology. The anaerobic MBT is practiced to a much lesser extent, however 5 new MBT plants based on dry anaerobic digestion technology have been or will be finalised until the end of 2015.

As demonstrated by the MBT review study [5], on average in the MBT plants 14 percent of the input waste has been recovered, either as recyclables or as combustible fraction, 22 percent of the input mass has been landfilled in the form of stabilate and 35 percent has been landfilled as the so called *sorting residue* (under waste code 19 12 12), while 15 percent constituted the mass loss, as a consequence of biological treatment. In some installations, recovery of recyclables/waste derived fuel did not exceed 3 percent of input mixed waste mass. On average at least 57 percent of input waste was landfilled and in many cases the landfilling exceeded 80 percent of the initial mixed waste mass.

6. Examples of advanced MBT installations

The recently constructed MBT plants are much more advanced than the initial ones. Many of them apply a multi-stage automated sorting technology, using multiple screens, ballistic separators and air separators to classify waste according to size and physical properties/geometry. In figure 5 an example of an advanced mechanical treatment applied in some of the modern MBT plants in Poland is presented. Apart from mechanical sorting, near-infrared (NIR) technique is applied to separate individual materials (especially plastics, composite packaging and paper) or colors. In most of the plants ferrous metals are separated and the more advanced plants apply also Eddy current separators to sort out non-Fe metals. Despite the advancement of the automated sorting, it has been proven that the manual sorting can not be completely eliminated. Manual sorting is applied both at the preliminary sorting stage, as well as, at the final stage of recyclables conditioning. The combination of manual and automated sorting allows high sorting efficiency.

Figure 6 provides photographs of a highly advanced MBT plant which is currently constructed in Gać, in the Lower Silesia Province (ZGO Gać).

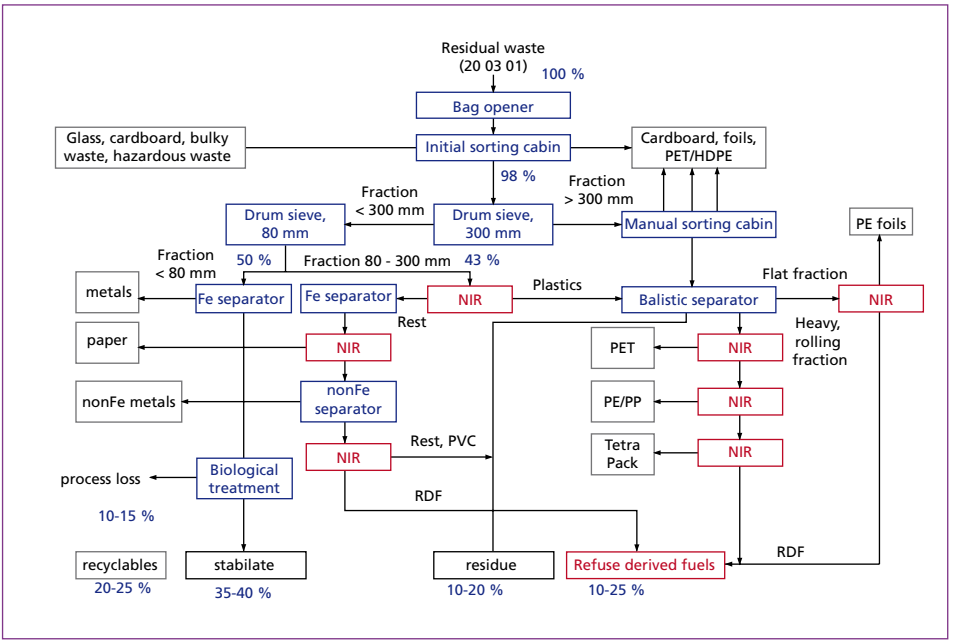

Figure 5: The concept of MBT technology, with mass balance used in some of Polish MBT plants

based on: Rajca, M. 2009. Możliwe poziomy odzysku surowców wtórnych i frakcji stanowiącej paliwo z odpadów. Redukcja strumienia odpadów na przykładzie instalacji MBP. II Ogólnopolska Konferencja Szkoleniowa Mechaniczno-biologiczne przetwarzanie odpadów komunalnych TiTech Sp. z o.o., Starachowice-Radom, 06.05.2009

ZGO Gać MBT plant is a regional installation providing:

- residual waste treatment in a MBT technology consisting of an advanced sorting plant (Sutco technology, including 6 NIR separators, according to the cheme presented in figure 5), with a capacity of 65,000 Mg/a;
- 3 stage biological treatment consisting of
  - dry anaerobic stabilization in Kompogas technology (2 horizontal digesters with total capacity of 28,000 Mg of mechanically separated organic fraction of waste);
  - aerobic stabilization in enclosed reactors;
  - aerobic maturation in windrows;
- additional mechanical line for RDF production
- regional landfill for stabilate
- regional composting plant for separately collected biowaste. The investment was co-financed by the EU Fund Infrastructure and Environment and the National Fund of Environment Protection and Water Management and will be competed in the current year.

7. Current problems related to MBT technology

Advanced waste sorting technology in MBT plants leads to increased volume of recyclables and waste derived fuels (WDF). On the other hand the quality of materials separated from mixed waste deteriorates and results in a lower market value.

Figure 6: Advanced MBT plant, based on dry anaerobic digestion

Nevertheless, increasing waste recovery of recyclable materials and combustible fractions from waste is a must, as of 2016 in Poland, there will be no possibility to landfill waste with a higher heating value exceeding 6 MJ/kg d.m. At present, the most serious problem, in the context of MBT technology development is the lack of possibilities to recover energy from WDF of lower quality in Poland.

Applying an advanced MBP technology approximately 30 to 40 percent combustible fraction can be recovered. In Poland, the only recipient of WDF are now cement kilns whose maximum processing capacity is approx. 1.5 million Mg per year. The quantity of WDF is increasing more and more, and assuming further expansion of MBP plants, the amount of available fuels may increase up to 3 to 4 million Mg per year. In addition, cement kilns have high quality requirements, which do not meet the inferior quality WDF produced solely from municipal waste. In this situation it is absolutely essential to build a system of energy recovery installations dedicated to this waste fraction. The development of infrastructure for the management of WDF requires a coherent state policy and the mechanism of incentives and support. In large cities, the most effective method of waste management is a thermal treatment in modern incineration plants to ensure a high degree of energy recovery from waste in the form of electricity and heat. In Poland, until now only one MSW incineration plant was operated (in Warsaw), a significant increase in capacity will take place only after the construction of six installations for thermal treatment of waste by the end of 2015.

8. Conclusions and outlook

MBT becomes more and more established technology in Poland. In some locations the initially simple *mixed waste composting plants* have evolved into much more advanced technologies, applying multi stage sorting techniques. The newly constructed plants show much higher efficiency of separation of specific waste fractions, due to combination of manual and automated sorting.

MBT has been applied in Poland as a remedy to low separate collection problem and as a way to pretreat waste before landfilling. However, the MBT technology is not the final solution. It allows to separate mixed waste to waste fractions requiring further processing. The quality of recovered materials/fuel is rather low, which prevents its optimal use.

Separate collection of recyclables allows achieving a fairly better quality of secondary materials with higher market price. Separate collection of biowaste allows to generate high quality compost which is not possible in MBT plant processing mixed waste. Thus in the future, in order to reduce waste landfilling, it is essential to further stimulate development of separate collection. The MBT technology is flexible, as most of the plants process both mixed and separately collected fractions. In the mechanical part of MBT plants separately collected dry recyclables can be separated to individual marketable materials, like paper, metals, various plastics, etc, achieving higher quality and value than the products of mixed waste sorting. In the biological parts, the modular design allows to designate some of the reactors to process separately collected biowaste. Moreover, extending the energy recovery options is required to ensure recovery options for non-recyclable materials.

9. References

[1] Act of 13 September 1996 on maintaining cleanliness and order in municipalities (Dz.U. of 2012, pos. 391, as amended)

[2] Act of 1 July 2011 amending the Act on maintaining cleanliness and order in municipalities and some other acts (Dz. U. of 2011., No. 152, pos. 897)

[3] Act of 14.12.2012 on waste (Dz.U. 2013 nr 0 poz. 21, with amendments)

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