Potential of Development of Mechanical-Biological Waste Treatment Plants in Germany

Michael Nelles, Michael Balhar, Jennifer Grünes and Sabine Flamme

1. Introduction

In Germany there are currently operating 46 MBT-plants, with a capacity of about 6 million tons [3]. Nearly 25 % of the incoming municipal waste are treated bio-mechanically [3]. The realized varying operation concepts are difficult to compare. According to the background of the German regulatory framework of the AbfAblV (waste storage ordinance) and the 30. BImSchV (immission ordinance) two extreme variations can be generally divided. The aim of the end-rotting process is to create as much waste material as possible and the ideal dry-stabilisation-alternatives have the aim to recycle all emerging solid residue materials energetically and substantially. Beyond that there are currently 20 up to 30 plants in Germany, operating a capacity of 2 up to 3 million tons yearly, which handle the delivered waste by mechanical-physical treatment (MT-plants) to produce Solid Recovered Fuels (SRF) [3]. These can be used energetically in coal-fired power plants, in the cement-industry or more and more often in especially constructed industrial waste combustion-plants (SRF power plants).

Most of the currently operating plants with MBT-technology were planned in the years 2001 until 2005 and were constructed under a high pressure of time. Since the middle of 2005 the MBT-plants have to stand the test at the market and comply durable and securely with the high requirements of the German AbfAblV and the 30. BImSchV in the operational practice. According to this background the plants with MBT-technology have been continuously optimised, to cure the teething troubles and to fit on the operation concepts to the permanently changing frameworks on the waste market. Meanwhile the plants with MBT-technology have gained a high procedural standard and emerged into an important pillar in the waste industry.

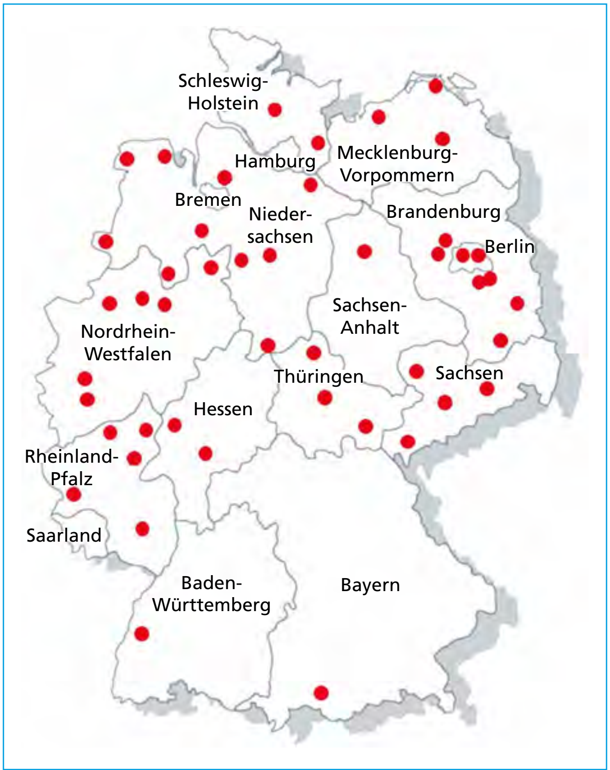

Figure 1:

Plants with MBT-technology in Germany

The present article illustrates the fundamental rudiments for the optimisation and back fitting of plants with MBT-technology in practice, which have been implemented in many cases or are currently getting realized.

The current developments in the field of facility-input, mechanical conditioning, biological treatment, air purification, waste materials and climate protection are mentioned as well as the themes energy efficiency and coast effectiveness. Afterwards the energetic recyclable waste materials will be assumed in detail by describing the possibilities of conditioning and exploitation as well as the current status of the quality management of Solid Recovered Fuels. Finally the article gives a short forecast on the enhancements of the MBT-technology in Germany and in the international area [4].

In facilities with MBT-technology the municipal wastes are conditioned on the base of a material specific waste treatment. This means that the choice and determination of conditioning phases of municipal wastes are depending on the varying substantial characteristics:

- **M**echanical-**B**iological waste **T**reatment (MBT),
- **M**echanical-**B**iological **S**tabilization (MBS),
- **M**echanical-**P**hysical **S**tabilization (MPS).

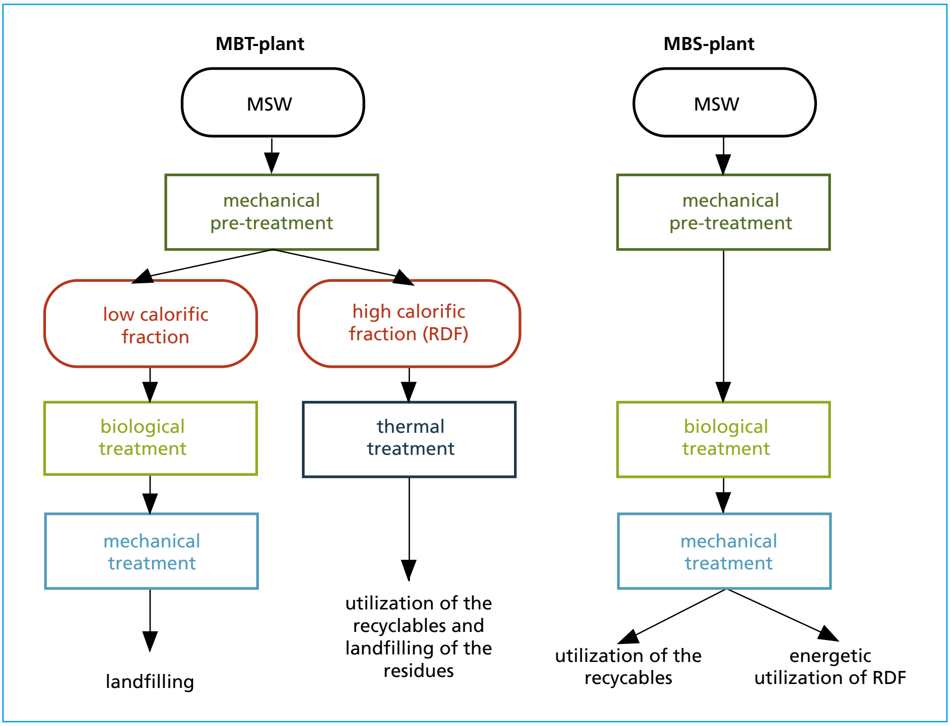

Figure 2: Simplified mechanic-biological treatment concepts for MSW

The commonly used method for the material specific waste treatment is the mechanical-biological waste treatment (MBT). Thereby the material flows are separated into recycling material, energy recovery materials and materials for further biological treatment. The biological treatment takes place in rotting phases (tunnels, lines or rents) or in fermentation phases (dry- or wet fermentation). The final product is a disposable material. The Mechanical-Biological Stabilisation (drying) separates high caloric waste materials from municipal waste by mechanical and physical selection processes and upgrades them into Solid Recovered Fuels in a multiple-stage treatment. This process includes the separation of the lower caloric parts and ferrous and non ferrous metals, as well as a multi level crushing. If it's needed even high toxic material fractions can be separated and the high caloric fractions can be dried.

2. Optimisation of MBT-technology, energy efficiency, climate protection and cost efficiency

The huge amount of up to 70 waste key numbers, which are approved as facility input of MBT-plants, allows the handling of a wide variety of waste. This has caused problems in the early operating years of many plants with MBT-technology, because of the delivery of partly fractions which cannot be treated goal-oriented. Meanwhile most of the plants with MBT-technology have developed concrete delivery data sheets, to avoid the risk of operational safety when they commit to treat a regions waste disposal. On the other side a huge amount of working experience could been collected, which allows to integrate other waste key numbers into the operating procedure without endangering the treatment success. This is necessary for a huge amount of plants with MBT-technology, because of the declining amount of delivered waste materials especially from the area of commercial waste. According to this background an additional amount of waste (litter with high organic proportion, screenings from the wastewater treatment) is attempt to be acquired on the disposal market.

A huge advantage of the MBT-technology is the high flexibility to react on the changing requirements of the waste market. Basis of that are the **mechanical conditioning levels**, which act as a switchpoint for the market orientated treatment and steering of the material flow. On this area a number of different systems have been realized and the existing process experience of six years was collected. The conditionings steps, before and after the biological treatment, are optimised permanently to improve the biodegradability and drying of the virgin organic fraction to allow the energy recovery of the high caloric fraction in industrial combustion plants with a high degree of efficiency. So it is possible to provide a constant high quality of Solid Recovered Fuels for different utilisations (coal fired power plants, cement plants or SRF power plants) by the German plants with MBT-technology.

Most plants with MBT-technology optimised the **biological treatment** in the first operating years to reduce the treatment period to produce a disposal compatible material. The plants with MBT-technology could achieve important improvements on this field of activity and can fulfill the disposal criterions in less than ten weeks. This allows it to create additional treatment capacity which is ecological beneficial and leads into an improved efficiency of the MBT. The reduced biological treatment period tends to result in many cases into a reduction of the exhaust amount and thereby to advantages on the sector of air purification. In future anaerobic systems will gain a bigger importance, because of the possibility to obtain energy from the disposal of certain fractions. By the integration of fermentation stages the energy efficiency of the whole MBT-concept can be positively affected as well as the positive ecological effects can be increased. The backfitting of an anaerobic stage can be useful even for existing MBT. For example the MBT-Rostock was supplemented with a partial current fermentation facility with three thermophile running reactors [1].

The 30. BImSchV dictates a **thermal air purification** for MBT-plants in Germany. The amount of treated air in the *new* MBT-plants was dramatically reduced, because of the limitation of freight values for total organic carbon and nitrous oxide in dependence to the treated waste amount according to the 30. BImSchV. This was achieved by multiple-shift usage and circulating air cooling of partial air currents. In many plants with MBT-technology the regenerative thermal oxidation facilities could not achieve the expectations on availability and technical maturity for the special application of waste air from the MBT-plants (corrosion signs, interlocking of heat exchanger filling material with silicon dioxide compounds). Despite to the ongoing ambitions of the technical optimisation of regenerative thermal oxidation facilities it has to be mentioned that the thermal air purification of MBT waste air has to be evaluated critically among ecological financial aspects. In the MBT-Rostock the air purification was solved elegantly and ecological reasonable by treating the waste air as combustion air in the SRF power plant on the neighboring plot in the overseas port [1].

Within the framework of the substantial recycling of the **residual materials** the metal deposition has increased, due to the rising commodity prices. Especially nonferrous metals are getting more and more interesting. Three years ago there had been problems in the energy recovery of the high caloric fraction. The reason was the lack of adequate industrial combustion-plants as customers for the produced Solid Recovered Fuels. Meanwhile there have been realized several additional SRF power plants. Today plants with an approximately capacity of 5.6 million tons per year are operating or in the construction phase and additionally 1.4 Mio. tons per year have been approved or stand in the approval phase. When these facilities are realized an overall capacity of 7 million tons per year will be available [3]. Another aspect is the steadily improved quality management of the SRF during the last years, which makes it possible to deliver a constant and individual adjusted combustible quality to the particular SRF power plants. So the situation in practice has inverted. At new agreements the additional payments by the MBT-operator for the energy recovery of SRF´s have declined and meanwhile in individual cases revenues can be earned for high caloric fuels. The disposal of a biological stabilizing or mechanical separated inert landfill fraction is a part but not the main target of MBT-concepts in Germany. The major quantitative and especially high caloric part of the treated waste is used for the substantial and energetic recycling. At present the recycling-concepts for the fine and inert fractions of the MBT-plants are checked. As long as the fine fraction is disposed on landfills, matched disposal concepts have to be developed and controlled. The fear of insufficient stability under load of MBT-landfills could be refuted in practice.

The **energy efficiency** of a combined process of plants with MBT-technology and energy recovery of the high caloric fraction nowadays is significant defined by the energy efficiency of the subsequent processes of the energy recovery. The plants energy demand for the conditioning of the waste is subordinated. By the extensive separation of the high caloric waste materials and their effective exploitation in coal fired power plants or cement plants, higher net degrees of efficiency can be achieved than the combustion of common waste in a waste incineration plant. A contribute to the climate protection can be continuously increased by upgrading the energy efficiency of the entire process. Despite to that the integration of fermentation stages, the optimisation of energy consumption, the increase of effect and quality of high caloric waste materials and the optimisation of separating ferrous and non ferrous metals as well as other partial fractions for the aim of energy recovery have to be mentioned.

The optimisation of the **cost-efficiency** of plants with MBT-technology due to the background of the current frameworks of the disposal market, including the present overcapacity in the field of thermal waste treatment, is getting in focus. The overcapacity has lead into a considerable price decline in the last two years. This situation will slowly ease off. In this difficult area of conflict the plants with MBT-technology have to compete with. The specific treatment costs including the disposal of residual materials of the most plants with MBT-technology add up to 80 to 120 EUR per ton on full working capacity. The possibilities of the influence on the common treatment costs vary for each plant with MBT-technology and depend on the specific frameworks. The advantage of a plant with MBT-technology in comparison with a waste incineration plant is the possibility to influence the mass flow including the quality, which can lead into a better cost effectiveness. There are much more starting points to increase the cost effectiveness for example by using synergistic effects by integrated solutions beyond the MBT-plants boarders. In Lübeck for example the minor contaminated leakage water of the neighboured landfill will be integrated into the process water circulation [2]. This makes it possible that the landfill must not operate an own leakage water treatment facility [2].

3. Processing, energy recovery and quality management of Solid Recovered Fuels

3.1. Essential remarks

The previous explanations show, that the frameworks of the MBT-technology have dramatically changed. The significant value of production and energy recovery of Solid Recovered Fuels has increased due to ecological and economical reasons. The energy resource waste will face a higher demand, because of the expected price increases of primary energy sources like crude oil, natural gas and coal. The energy recovery of high calorific fractions from MBT-plants and commercial waste sorting facilities will take more and more part in SRF power plants. Energy intensive companies have early identified waste as energy resource and realized many SRF-projects. Furthermore high calorific Solid Recovered Fuels with high energy efficiency are used as a quality secured material in the combustion of coal fired power plants and cement plants. The ecological aims of climate protection can be properly combined with the aims of the business-management. By the assignment of SRF primary energy sources like coal, crude oil and natural gas can be replaced. This can pay contribution to the disposal security and to the conservation of natural resources. Solid Recovered Fuels from municipal wastes possess biogenic parts of up to 50 percent. Their combustion is carbon dioxide neutral and a sustainable contribution for environmental protection.

It has to be mentioned that the available SRF potential is limited and as described before, in Germany were created serious overcapacities with respective consequences (price decline etc.). In addition the amount of municipal waste is considerably declining due to the demographic change in many regions. Effected by the economical situation during the market crisis the commercial waste amount also declined until mid 2010. Also there are serious risks on the recycling market, because of the declining substantial exploitation due to the depressed combustion prices, which also effected the shutdown of some conditioning facilities.

3.2. Terminology and options of the processing and energy recovery

The terminology for treated wastes used either in SRF power plants or co-incineration plants varies. In Germany, waste for energy recovery is generally subdivided into Solid Recovered Fuels and high-calorific fractions. A Solid Recovered Fuel is a specially prepared fuel made of production-specific or municipal waste that has been treated adequately for co-incineration. Solid Recovered Fuels that comply with a defined quality standard according to the German quality assurance *RAL-GZ 724* are known by the protected brand name SBS. By contrast, high calorific fractions have undergone a lesser degree of treatment and consist simply of selectively separated portions or fractions of waste whose calorific value is significantly higher, due to their composition and characteristics, than that of a normal waste mixture. As SBS and other Solid Recovered Fuels are an input material for co-incineration plants, for instance cement and coal-fired power plants, the quality requirements the fuel needs to satisfy are stricter. The German Gütegemeinschaft Sekundärbrennstoffe und Recyclingholz BGS e.V. (association for the quality assurance of SRF) characterizes **high calorific fractions** by the following notes:

- from waste separated parts or fractions, which due to their composition possess significantly higher calorific values than the waste mixture,
- lower conditioning depth, like rougher grain size,
- for example high caloric fractions from MBT-plants or commercial waste sorting facilities.

Solid Recovered Fuels are defined according to the BGS e.V. as ready-for-use combustible from production specific waste or municipal waste after an extensive conditioning. This conditioning can be realized by near-infrared technology or additional ballistic separation. Aim of the conditioning is to produce a combustible with a defined quality, which is suitable for the co-incineration in cement-, chalk- or power plants. Solid Recovered Fuels in common possess grain sizes under 20 mm with a caloric values between 20 up to 25 MJ per kg and a specific humidity of 10 up to 15 percent. SRF for co-incineration is produced predominantly in a blowable form (fluff), which enables the combustion during the flight phase of the material after the entry into the combustion chamber.

According to current data of the BGS e. V. an amount between 1.8 and 2.5 billion euro had been invested into the conditioning technology in over 140 facilities in Germany. Those facilities, which created several thousands jobs produce a total amount of 7 million tons Solid Recovered Fuels per year.

The **production of SRF** depends significant on the specific location and application. Independent to that there are generally defined guidelines for physical and chemical parameters like grain size, bulk density, calorific value, chlorine- and heavy metal content. For industrial combustion plants it's important that the specific Solid Recovered Fuel is available in a constant amount and quality. To match the requirements of an user the combustible producers should adjust their conditioning correspondingly.

High caloric fractions can be used energetically in suitable mono-combustion-facilities (SRF-power plants). They perform as basic raw material for the further conditioning of Solid Recovered Fuels or high caloric fractions.

Even if the extension of material specific conditioning facilities is nearly finished in Germany, a strengthening of this conditioning of the waste characteristics and delivers corresponding precursors for ongoing procedural steps. The question what amount of waste still has to be disposal is negligible, because the aim of all these upstream facilities (MBT, MBS, MPS) is to exploit the high calorific waste materials energetically. The 46 German MBT-plants are running with a total combustible production of 2 up to 3 million tons per year. These constructions are running totally different process concepts, but do all finally conditioning an appreciable mass flow of high caloric waste flows for the energy recovery (depending on the waste characteristic and process concept up to 70 %). Besides there exist 91 SRF-facilities with a total combustible production about 4.7 million tons a year.

The most facilities running the MBT-technology produce Solid Recovered Fuels from high caloric fractions. These are used in energy efficient SRF-power plants to produce energy and steam. This will be shown on the example of the MBT-Neumünster.

Figure 3:

MBT Neumünster

The MBT-Neumünster has a treatment capacity of 200,000 tons of domestic waste a year. The facility is designed for the conditioning of 150,000 tons domestic waste and 50,000 tons commercial waste a year. After the pre-treatment the waste is biological dried. In that way a yearly amount of 160.000 tons of high caloric fraction is obtained. These are recovered energetically in the thermal SRF exploitation facility of the *Stadtwerke Neumünster GmbH (TEV)*, which operates a yearly capacity of 190,000 tons (with a caloric value 12 MJ/kg). Besides the high caloric fractions from the MBT-Neumünster an additional amount is used from the MBT-Lüneburg. The facility has a combustion line with a circulating fluidised bed. The boiler output amounts 75 $MW_{electric}$. During the year 2009 the *TEV Neumünster* produced over 1.1 million tons of steam and about 183 million kW electricity.

Figure 4:

TEV Neumünster

During the last years the production of **Solid Recovered Fuels** for co-incineration in industrial combustion facilities has more and more established. The total amount of co-incinerated Solid Recovered Fuels accounts to currently 2 million tons per year. 15 % of this amount comes under quality assurance according to the German RAL-GZ 724.

In the face of the global economic situation the deployment of Solid Recovered Fuels is of vital importance for many branches. For the German cement industry the utilization of SRF is the one and only alternative. The cement industry is a highly energy intensive process. In order to cut down the costs to remain capable of acting on the global market, the cement facilities replace their primal combustibles more and more by refuse derived fuels (up to 100 % of their firing heat capacity).

3.3. Motivation for quality assurance of Solid Recovered Fuels

In recent years, many new SRF power plants were commissioned. Consequently, the relevance of usable quality assurance concepts for high calorific fractions and Solid Recovered

Fuels are also increasing. The main motivation for the operation of an SRF power plant is to generate useful energy. As a result, power plant projects are implemented primarily in co-operation with energy-intensive enterprises. A SRF power plant provides these enterprises with the process energy they need for production. Especially for manufacturing enterprises, the technical availability is fundamental for their operations. This also means that the availability of the SRF power plants is highly important.

A trouble-free operation of an SRF power plant can only be achieved, if the energy source is permanently available. Therefore, the power plant depends on the supply of a fuel of constant quality that is appropriately matched with the combustion technology. In addition to predefined requirements in terms of the physical and chemical properties of the fuel, requirements concerning the limitation of foreign matter must also be satisfied. For this reason, fuel agreements between SRF incineration plant operators and fuel producers usually impose penalties if quality parameters relevant to the process are not satisfied. Chlorine is an example for such a parameter, because a high chlorine content can cause high-temperature chlorine corrosion. Furthermore, operating permits and regulations force the power plant operators to fulfil certain boundary conditions regarding fuel quality.

Only a consistent sampling, analysis and assessment procedure – for instance as described in the Guidelines of the BGS e.V. – can ensure that all contracting parties apply the same definition to the applicable quality parameters [6]. The following boundary conditions must always be observed, regardless of whether the fuels are used in a co-combustion or mono-combustion:

- defined caloric value – low chlorine content,
- defined particle size and bulk density,
- low foreign matter content,
- low heavy metall content (in co-incineration),
- available in sufficient quantity and constant quality.

A consistent quality in the production of Solid Recovered Fuels is only achievable if continuous quality assurance measures are implemented. For this purpose, it is indispensable to apply a consistent procedure to the taking of samples, their analysis and also the assessment of the results.

For the quality assurance of Solid Recovered Fuels, it is fundamental that the retrieved samples are representative. In many cases, sample taking is not considered when the plant is planned. However, detailed planning and the taking of samples are a prerequisite for meaningful analysis results. The staff on site should be trained, and their awareness of the issue of *quality assurance* should be raised accordingly.

Due to the different separation requirements and in particular also because of the considerably larger piece sizes, the rules of RAL-GZ 724 do not apply to the calorific fractions for mono-combustion and must be modified. In these cases, the quality parameters to be applied – in addition to the parameters defined in the permit – are negotiated bilaterally between the SRF power plant operator and the SRF producer. Here too, it is necessary that the procedure to determine the applicable values, the corresponding methods and the assessment are all appropriately defined. The *Guidelines – Quality Assurance of High Calorific Fractions* [5] of BGS e.V. describe the relevant requirements.

Because of the grain size, the procedure of sampling the calorific fraction and its further treatment to create the laboratory sample is highly complex. Therefore, it is planned to optimise this procedure by introducing new possibilities, for instance automatic sampling and appropriate further treatment. For this purpose, a research application was submitted by the University of Applied Sciences Münster. The objective of the project is to compare and optimise existing and already implemented methods. Representatives of some SRF power plants and manufacturers of automatic sampling systems were involved in the successful formulation of the application. The research project will take duration of 3 years and started in the beginning of 2011.

4. Outlook on M(B)T-concepts and energy recovery of Solid Recovered Fuels in national and international dimension

The waste management must increasingly be adjusted to the guidelines of sustainable resource- and climate protection. Current studies show that the waste management can still make significant contributions for the energetic and material exploitation of wastes by energy efficient optimisation of conditioning facilities. In Europe the practical implementation of the waste framework directive in the states of the EU will lead into a difficult predictable change of waste accumulation in regard to its amount, quality and its dispositions. The MBT must face with this competition about mass flows and qualities. The technical preconditions and development potentials for that are available. The material specific waste treatment in a plant with MBT-technology as a corridor of power that separates the material mass flow under energy efficient treatment and exploitation of the partial flows does not only provide an initial position for Europe. The technical construction of a MBT-technology can be flexible adjusted on to specific requirements or basic frameworks.

Within a few years the MBT-technology has achieved a high development level in Germany. These experiences have to be established in an adapted form in foreign countries in the next years. To simplify the consideration two different country groups have to be divided.

On the one hand there are countries, which rule a well working waste management. These are especially countries of the European Union, which already implemented similar MBT-standards on the waste treatment area (for example Austria). There are also the *new* and partly *old* countries of the EU, where the waste management is still in the build-up process. That's the point were energy specific optimised waste treatment concepts with integrative MBT-solutions can afford a substantial contribution for a sustainable development. The focus thereby is always standing on the production and environmental-friendly energy recovery of Solid Recovered Fuels.

On the other hand there are the developing countries and emerging markets with a mostly rudimentarily waste management, which are responsible for about 10 up to 15 percent of the climate relevant emissions. Due to the high disposal standards in Germany meanwhile the net discharge has been realized. Over 5 billion people in the world have to suffer under the hygienic follow-up of a missing or underdeveloped waste management. On this sector simple and adapted MBT-solutions can afford large effects for the climate protection. The exchange of technology and knowledge on this sector is economical interesting for all actors. The production and energy recovery of Solid Recovered Fuels is a particular significant value.

The current situation of the production an energy recovery of Solid Recovered Fuels in Germany is deeply effected by the mentioned overcapacities on the thermal waste treatment sector. At present a high valuable conditioning of quality secured Solid Recovered Fuels cannot be produced economically. Thereby temporary close-downs of conditioning facilities were effected. Aim of all involved market parties should be a sustainable waste management and according to this a sensible price for Solid Recovered Fuels, which is oriented on its energy value.

Besides the economical view the climate- and resource protection should be integrated into the considerations. On the area of energy recovery the most energy effective design should be the achievable aim. Thereby the degree of efficiency of a combustion facility is an essential part, because a higher effectiveness can use the included waste energy more efficiently. The efficiency factor of industrial combustion plants or large power plants are usually higher than the efficiency of waste incineration plants. That's why the co-incineration of Solid Recovered Fuels should be further developed. The present ecological balance studies also come to the conclusion that the carbon dioxide reduction is increasing when the inserted energy is used more efficiently.

Finally it must be stated that the mono-combustion in the course of *combinatory processes* (high caloric fractions from facilities with MBT-technologies and energy recovery in SRF-plants) and the co-incineration of quality assured Solid Recovered Fuels are one of the most efficient recycling forms for energy rich wastes and a serious contribution for climate- and resource protection. A modern and sustainable closed loop recycling management can not dispense on the production and energy recovery of Solid Recovered Fuels in future. This is relevant for Germany and on the international area. Germanys waste management concepts and realized system engineering's are highly regarded in any countries (for example Arabic States, China, India) and are seen as a waste management role model. This has to be used when considering the global development of the waste management for future tasks.

5. Abstract

In Germany, there are currently existing 46 Mechanical-Biological waste Treatment plants (MBT-plants) operating with a total capacity of around 6 million tons. Most of the plants meanwhile possess about almost 6 years operating experience and have become an important part of Germany's waste industry. But there is still a great range of possibilities to optimise the MBT-technology. This review describes the current developments in the areas of system inputs, mechanical treatment, biological treatment, air purification, waste materials, as well as the aspects of energy efficiency, climate protection and economic efficiency. Afterwards the energetic recyclable waste materials are assumed in detail, whereat the possibilities of the conditioning and utilization are described and the status of the quality management of waste for energy recovery will be discussed. On this technological basis the MBT-Technology as an environmentally-friendly integrating option of the waste treatment will gain in importance, especially in the international area.

6. References

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