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Dear Readers,

Over the last few weeks, I have had the chance to visit some cement plants in African sub-Saharan countries and in the Middle East, Saudi Arabia in precise, to start projects for the use of alternative fuels.

Yes, you've heard right! Saudi Arabia – the country with the second largest oil reserves in the world and the lowest energy prices.

In the news section of this second edition of the Co-Processing Magazine, you can read more about fuel price subsidies and how to avoid these subsidies.

Not only the omission of the fuel subsidy, but also the set CO_2 reduction targets mean that more and more countries will be switching to the use of alternative fuels.

At our next Alternative Fuel Symposium, which will take place this year from 19 to 21 September, you will also learn – if you register quickly, as there are only a few places left – firsthand about the situation in Saudi Arabia, and about the opportunities for the production of alternatives or refuse derived fuels in North Africa and the Middle East from the point of view of one the major waste management companies.

In the present Co-Processing Magazine, we also report on waste sampling in landfills in order to determine the potential use of the RDF produced from it.

Especially in developing countries, unorganized "dumpsites" are the only source available to sort the waste, to recover the recyclables such as plastics, paper and cardboard from waste and to process the defined high-calorific fractions further into RDF. We are currently working on several such projects in African sub-Saharan countries to implement "true recycling". Certainly there are some obstacles to overcome, but we also see the great support from the respective country governments, who have realized that so many new jobs can be created. In addition to their recognition of the environmental benefits and the reduction of the dependency on fossil fuels.

I wish you an informative "holiday reading" with this booklet, and I would be pleased if we meet again after the summer break at the next symposium.

Have a nice holiday,
With kind regards
Dirk Lechtenberg

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Alternative Fuels for Coal-fired Power Plants

produced in Germany came from coal, 17.2 % of which from hard coal and 23.1 % from lignite coal. The problem with power generation from fossil fuels is their limited availability and the climate damage caused by the emission of fossil-derived CO_2. This also applies to other fuels such as oil or gas. The use of combined heat & power (CHP) can at least improve the efficiency of these power plants by using not only power generation but also heat for district heating.

Due to high CO_2 emissions and the declared aim of the German Federal Government to reduce CO_2 emissions by 40 % until 2030 compared to emission levels of 1990, more and

Alternative Fuels for Coal-fired Power Plants

By Dirk Lechtenberg, MVW Lechtenberg & Partner

Due to the recently launched renunciation of fossil fuels, especially in Europe, modifications of coal-fired power plants towards the use of alternative fuels, e.g. refuse-derived fuels (RDF) have been considered.

In this article, Dirk Lechtenberg gives an account of the potential modifications in coal-fired power plants, as well as previous experiences in the use of RDF in these plants.

In Germany, most of the electrical energy is still generated from coal. Coal is burnt in hard coal or lignite power plants, and the resulting heat causes water to evaporate, by which a turbine is driven. In 2016, more than 40 % of power

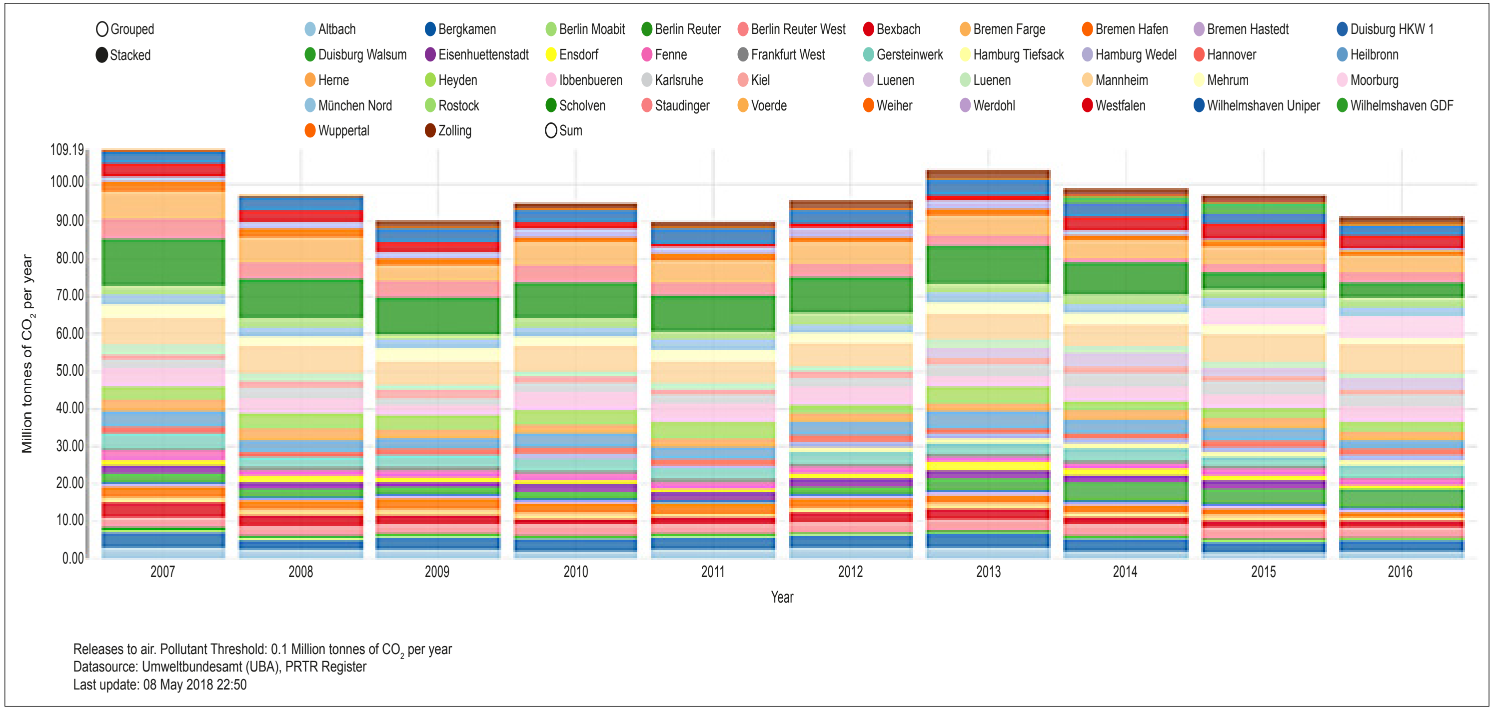

***Figure 1:** CO_2 emissions of hard coal-fired power plants in Germany, source: [7].*

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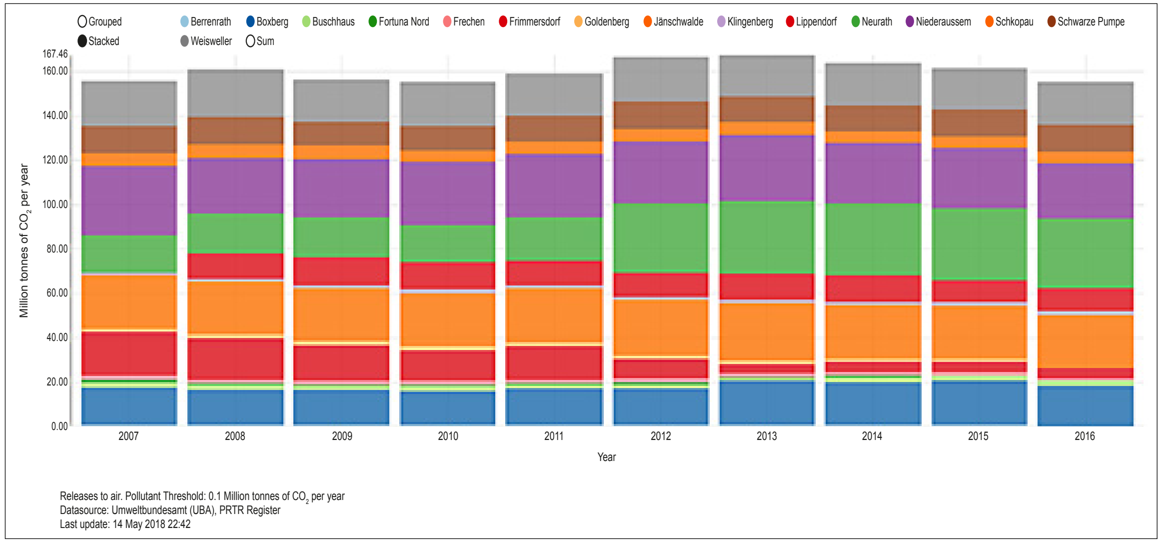

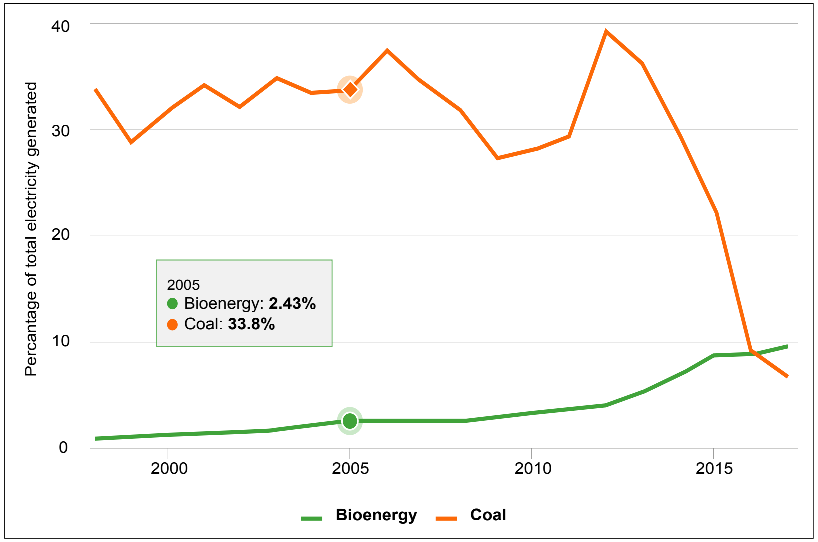

Figure 2: *CO_2 emissions of lignite power plants in Germany, source: [6].*

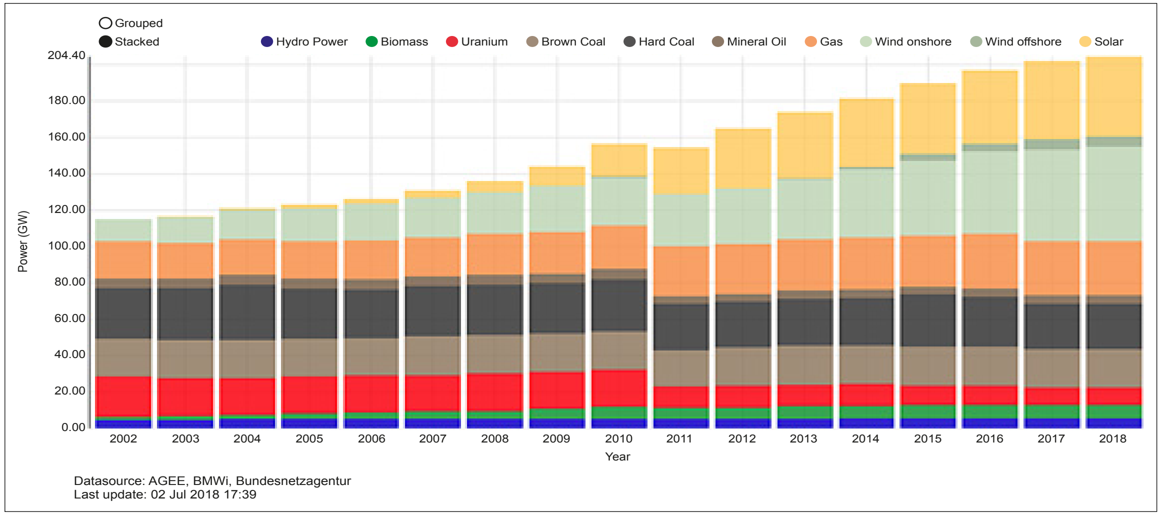

Figure 3: *Installed net capacity for power generation in Germany, source: [5].*

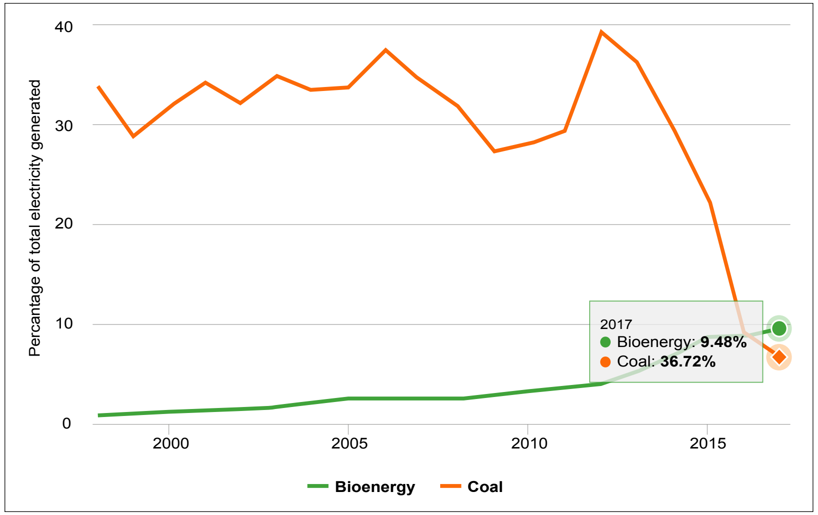

Figure 4: *Percentage of total electricity 2005 und 2017 (for 2017 provisional) in UK, source: [8].*

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more coal-fired power plants (lignite and hard coal) are being decommissioned.

A possible alternative to decommissioning would be the use of CO_2 neutral, or at least CO_2 reducing, alternative fuels from biomass or refuse-derived fuels from waste.

Wood pellets in Europe

A good example of the modification of state-subsidized coal-fired power plants in some European countries would be the use of biomass, such as wood pellets, instead of coal.

The UK for example has immensely promoted the modification of coal-fired power plants into biomass or wood pellet power plants by developing a tailored subsidy system. Out of the global annual production of 26 million tonnes of wood pellets, about 14 million tonnes a year are imported and burnt in the UK.

Since there is no limitation to the maximum size of the subsidized biomass boilers, it is possible to equip former coal-fired power plants with bigger boilers (the biggest boilers in DRAX plant in UK has a capacity of $300MW_{el}$). Subsidization is bound to the tonnage of used biomass, not to the boiler's size (as this is the case in Germany).

Such a subsidy is not possible in Germany due to the limited size of subsidized biomass boilers of $20MW_{el}$, which receive an increased electricity feed-in tariff.

The majority of the wood pellets burnt in the UK originate from USA and Canada. Thus, a final assessment of the total CO_2 footprint is mandatory. Currently, whole forests in USA and Canada are cut down and even high-quality roundwood is transported to the pelletising plants, shredded, dried with fossil fuels, finely ground, pelletised with high (fossil) energy consumption and then shipped to the UK.

Co-incineration of alternative fuels in Germany

Early on, German power-plant operators sought for the co-incineration of refuse-derived fuels. First attempts to use RDF in lignite and hard coal-fired power plants were carried out 20 years ago.

The following refuse derived fuels have been and are still used in German coal-fired power plants, along with the traditional fossil fuels:

	Hard coal	Lignite	Meat-and-bone meal	Sewage sludge	Substitute waste	
					From municipal waste	From commercial waste
Calorific value [MJ/kg] dm	26-31	22	17-18	2.0-3.5	15-18	20-29
Carbon (%)	80-95	40-70	35-45	33-50	30-40	40-50
Ash (%)	5-15	4	10-30	30-50	3-22	2-39
Water (%)	5-20	30-60	3-20	65-75	20	20-29
Sulphur (%)	0.5-1.2	0.35	0.3-0.8	0.5-0.15	0.02-1.2	0.02-0.8
Oxygen (%)	2-10	15-30		10-20	5-10	5-10
Nitrogen (%)	1.3-2	0.7	5-12	2-6	-	-
Chlorine (%)	0.01-1	0.03	0.5-0.7	0.05-0.4	0.04-1.9	0.02-2.2
Hydrogen (%)	3-6	4.3	5-8	3-4	-	-
Arsenic (mg/kg)	1-50	0.3-2.5	0.3	4.5-5	0.3-14	2.6-39
Phosphorus (g/kg)	0.01-0.2		10-30	2-55	-	-
Lead (mg/kg)	10-270	0.07-4	0.4-5	70-100	0.4-7,000	0,5-4,400
Cadmium (mg/kg)	0.1-10	0.01-0.35	0.4-1.0	1.5-4.5	0.08-29	0.05-162
Chrome (mg/kg)	5-80	0.08-15	3-9	50-70	3-2,900	0.7-86
Copper (mg/kg)	0.5-70	1.2-4	12-30	300-350	9-6,900	3-3,600
Nickel (mg/kg)	15-100	3-11	3-5	30-35	1.3-2,500	0.4-1,600
Mercury (mg/kg)	0.03-2	0.05-0.9	< 0.2	0.2-2	0.07-2.0	0.02-1.6
Zinc (mg/kg)	10-300	4-22	100-150	1,000-1,500	-	-

***Table 1:** Comparison of fossil and alternative fuels analysis results; all numbers refer to dry matter; source: [1].*

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MVW Lechtenberg has participated in such co-incineration trials in German-based **Ibbenbüren** power plant, **Gersteinwerk** power plant (Werne), **Hafen** power plant (Hamburg) and **Westfalen** power plant (Hamm) among others. Below, a few examples for co-incineration plants are given:

Hard coal-fired plants:

In the hard coal boilers of **Wedel** power plant (coal-dust firing) and **Werdohl-Elverlingsen / Block E4** power plant (slag-tap boiler) as well as in lignite coal-fired power plant **Buschhaus** (coal-dust firing) trials have been aborted due to *incomplete burnout*. In the hard coal-fired power plant **Ibbenbüren** trial deployment of RDF in the anthracite slag-tap boiler led to *combustion collapse*. During a thirty hours trial of co-incineration of RDF in the CFB-boiler of lignite coal-fired power plant **Wählitz**, a significant chloride corrosion attack has been detected.

In **Hafen/Wedel** power plant in Hamburg the co-incineration has been aborted after only a few days of the trial due to the TOC values being detected in the wastewater from wet bottom ash extraction.

Werne/Gersteinwerk power plant is the only hard coal-fired power plant with coal-dust firing in Germany, which co-incinerates RDF derived from municipal and commercial waste. Nevertheless, there is a huge amount of unburnt RDF which is disposed of along with the slag in a company-owned landfill. In view of the reduced number of operating hours, an increase in the use of alternative fuel in Werne cannot be realized.

Block E3 of the hard coal power plant **Werdohl-Elverlingsen** is designed as a cyclone furnace. In 2001, in both boilers continuous operations with RDF have been commenced, however, the amount of RDF had to be limited to a maximum of 12 % of the rated thermal input due to the heavy boiler pollution. In November 2004, the co-incineration was initially limited to one of the boilers for operational reasons. The co-incineration in both boilers was suspended in the spring of 2006.

Westfalen / Hamm plant is a hard coal slag-tap fired power plant, in which a large number of various types of alternative fuels such as sewage sludge, fibre residues, waste plastics, etc. were used in blocks A and B4. However, since 2010 both blocks A and B have been held off in the sequence of operations; i.e. they became barely operational. Thus, the co-combustion has come to a standstill.

In January 2009, a continuous operation with alternative fuel was commenced in block I of the coal-fired power plant **Duisburg** (CFB boiler). The alternative fuel was characterized with a low chlorine content and a high biogenic carbon content. The authorized capacity was 10,000 tonnes a year. The power plant was shut down in early 2018.

Lignite-fired power plants

The use of RDF is limited in lignite-fired power plants as well. The **Jänschwalde** power plant has an approved co-incineration capacity of 3.6% RDF in eight out of the total twelve lignite-fired boilers which equals 540,000 tonnes per year.

The previous voluntary self-restriction of 400,000 tonnes per year has been exceeded since 2009: Initially, inputs have been increased to 410,000 tonnes (2009) and then further increased to 472,000 tonnes (2010). In the meantime, only one boiler using 200,000 tonnes per year is operationally active.

In general, lignite-fired power plants use almost exclusively sludge-type alternative fuels, such as residues from paper production or sewage sludge. However, due to changes in the legal framework with the aim of recovering phosphate from sewage sludge, the soon abandonment of this procedure is foreseen.

About 65,000 tonnes of RDF are used in both CFB boilers of **Berrenrath/Ville** power plant each year. The plant has the permit to use 80,000 tonnes a year. Furthermore, sewage sludge and waste wood are co-incinerated as well.

Problems in the usage of RDF

Within the last few decades, a variety of solutions have been developed (direct, indirect, parallel co-incineration of RDF), each of which can have different effects (specific advantages and disadvantages) on the efficiency, operation and lifetime of individual aggregates as well as of the entire power plant. The direct co-incineration is the simplest and most cost-effective form of co-incineration. Nevertheless, the heterogeneous composition of the material, adhering fouling, slagging, or corrosion can reduce the co-incineration rate and therefore, shorten the availability of the coal boiler. This applies in particular to the areas of superheater, air preheater and SCR-catalysts.

During co-incineration, the RDF and regular fuel coal are converted thermally in the same reactor. However, depending on the RDF characterization and the used steam boiler type, the treatment and fuel supply can be designed in various ways. In the case of a coal-dust-fired boiler, an additional treatment of the RDF is usually necessary. If this is done together with the coal, the RDF is added to the coal infeed to the mill. Coal and RDF are ground together in the same mill and fed to the combustion as a mixture through joint burners. However, plastic foils, which have a lower melting point, can melt in the coal mill, which leads to technical issues, such as the blockage of coal separators in the mills.

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This resulted in the termination of many trials or in low throughputs in many attempts that it did not portray an economic solution. The use of pelletised alternative fuels did not lead to an improvement in the use of coal mills as well.

If RDF treatment happens in a separated unit (e.g. a hammer mill), the RDF is usually added to the coal only after the coal mill and then passed together with the coal to the combustion through joint burners. The RDF can also be added as a separate single stream either via a separated feeding device at the existing combustion or entirely dedicated RDF burners or lances. If the combustion of RDF happens through separated burners or lances, the stoichiometric combustion conditions of the burner or lance can be adjusted to the specific requirements of the particular fuel.

The corrosion problem

In coal-fired power plants, corrosion processes occur primarily in the area of the steam generator and can be intensified through co-firing of RDF because of their elemental composition. Depending on the reactants, this may be a chemical, electrical or metal-physical process. The risk of corrosion is mainly determined by the combustion conditions, the pipe wall temperature and the content of corrosion-relevant elements.

Corrosion phenomena can take place in different areas of steam generators and are provoked by various mechanisms. These include oxygen deficiency corrosion, molten salt corrosion, high temperature chlorine corrosion and dew point corrosion.

Oxygen-deficient corrosion:

Low-oxygen exhaust gas atmospheres in the form of CO strands may be present above all close to the burner walls of the steam generator. Due to an incomplete oxidation, the protective oxide layer Fe_2O_3 of the steam generator wall can be attacked or its structure impeded. The presence of chlorine can even boost this process.

Molten salt corrosion:

In the area of the furnace walls, alkali chloride and alkali sulphate compounds can be present in an aggressive, molten form, which is caused by reactions between the combustion products SO_2 and SO_3 with the oxides occurring in the ash, such as Na_2O and K_2O. Heavy metal oxides such as CuO, PbO or ZnO can intensify this corrosion process even more.

High-temperature chlorine corrosion:

In the area of superheater heating surfaces, alkali chlorides, in particular NaCl and KCl, can condense, where they can react with SO_2 in an oxidizing atmosphere to form alkali sulphates. Sulphatisation of the alkalis in an oxidising atmosphere within the ash layers releases elemental chlorine, which in turn reacts with the iron of the material surface to form iron chloride which evaporates according to the prevailing wall temperature. A decomposition of the iron chloride by subsequent reactions with oxygen and sulphur oxides leads once again to the release of elemental chlorine, so that an internal corrosion cycle can occur at the superheater heating surfaces within the steam generator.

Dew point corrosion:

The drop of temperature below the dew point can lead to deposit formation, acid condensation (especially H_2SO_4 and HCl), as well as coatings occurrence in the area of the economizer (ECO) and the air preheater. The resulting acid attacks the metal surface of the respective system component.

According to the findings of [2], especially chlorine and its chemical compounds play a vital role: High chlorine levels in the fuel can lead to higher corrosion rates depending on the combustion conditions in the steam generator, which can then cause an early failure of steam and superheater pipes within a few thousand operating hours. Till the moment and after releasing chlorine compounds from different RDF, it is not yet possible to deduce any clear relationships between the chlorine compounds present in the fuel (inorganic or organic). A distinction between organic and inorganic chlorine compounds cannot yet lead to a clear prediction of the corrosion problem. However, from RDF and waste combustion it is known that the different inorganic chlorine compounds enter the vapour phase depending on the combustion temperature. The volatility of various heavy metals for example, such as lead and zinc, would mainly be affected by the amount of chlorine in the fuel. It is also known that organically bound chlorine is already released at temperatures below 400 degrees Celsius in the pyrolysis and degassing zone of combustion. In the case of inorganic

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chlorine (i.e. alkali chlorides), volatilization only occurs at relatively high temperatures. It is known from waste incineration that about 80 % of chlorine is converted to the gas phase as hydrogen chloride HCl and about ten to 15 % as alkali chlorides. For the use of RDF in coal-fired power plants, the behaviour of alkali chlorides should also be considered in case of an excess of sulphur oxides in the exhaust gas, since coal-fired power plants have for some time preferred to use more high-sulphur coal. As a result of an increased proportion of SO_3 in the exhaust gas, alkali chlorides preferably convert to alkali sulphates. An alkaline sulphate layer on the pipe walls of the superheater can potentially act as a protective layer against corrosion.

The issue of retention time

The burning behaviour of fuel particles is largely dependent on the size, density and surface of each particular fuel. This applies especially during the combustion of RDF. From experiences with main burners in rotary kilns in the cement industry it is known that mainly larger fuel particles with higher density and smaller surface area tend to fall out of the burner flame before they burn completely [3]. The following figure illustrates the combustion rates in connection with specific surfaces of different types of fuel:

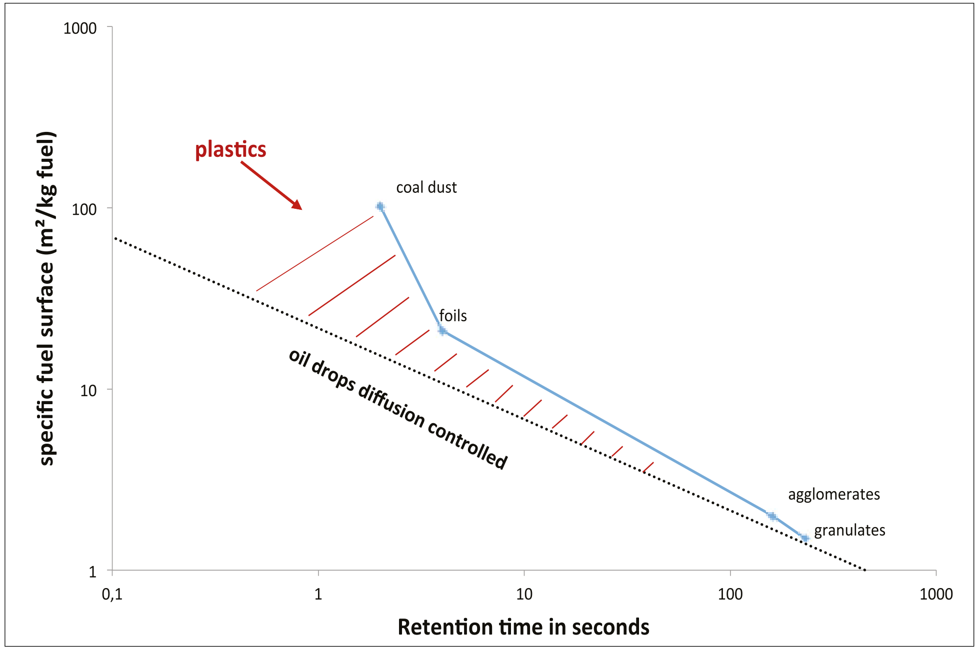

Figure 4: *Rate of combustion and specific fuel surfaces according to numbers by [4].*

It can be clearly seen that coarser particles have a longer trajectory when they leave the burner lances.

Partly unburnt particles can fall into the slag / ash bed of the boiler. This leads to contamination of the combustion ash, partly also the fly ash. As a result, it is no longer possible to market the contaminated ashes, e.g. as a raw material in the cement industry, which will consequently lead to considerable costs for landfilling. This has in many cases led to the termination of alternative fuel use in coal-fired power plants.

In Austria, for example, no animal meal has been used during BSE crisis (2000 – 2004), because the phosphate content of the ashes from co-incineration was so high that it was no longer possible to use such ashes in the cement industry.

Possible final exclusion factors for the use of RDF in coal-fired power plants

Due to massive disruption of plant operation:

- Incomplete burnout
- Collapse of combustion
- Chlorine corrosion

Due to required investments:

- HCl emissions: Necessity to retrofit the exhaust gas purification in CFB plants

Slag discharge system unsuitable for higher volumes (higher ash content in RDF versus coal)

Possible permanent limiting factors

- Contamination and slagging of boiler surfaces
- Increased chloride burden of FDG products

With regard to the **environmental compatibility of co-incineration particularly;**

- the accumulation of heavy metals in side products of the plants and effects on their environmental compatibility and availability as well as
- the emissions, particularly volatile heavy metals into the atmosphere

have to be observed carefully.

Summary

The co-incineration of alternative fuels, such as biomass or RDF in coal-fired power plants or the modification of those plants to RDF-fired power plants is technically possible in some boilers. However, the required modifications for e.g. the corrosion protection of the boilers and the optimization of the flue gas cleaning to avoid possible emissions of volatile pollutants (e.g. Hg) are extensive and costly.

Neither will the increase in the cost of CO_2 emissions by purchasing emission allowances significantly influence the use of RDF in

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coal-fired power plants, since before mentioned technical issues are too expensive.

This makes the co-incineration of RDF, not only in German power plants, a discontinued model, not least because of increased requirements for emission protection.

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Sampling and Characterisation of Municipal Solid Waste for RDF Projects

Sampling and Characterisation of Municipal Solid Waste for RDF Projects*

By Dr. Hansjörg Diller, MVW Lechtenberg & Partner

Summary

Omnipresent municipal solid waste (MSW) is virtually an infinite source of combustible matter which is suitable as raw materials for refuse-derived fuel (RDF) to fire a clinker kiln. In most cases, however, neither the composition of MSW is known, nor the quantity and quality of the potential RDF which can be obtained from an identified waste source. The evaluation of MSW is a key component at the outset of every RDF project, and it features a three-staged manual sorting procedure including sampling of combustible fractions for laboratory analyses. Typically, a sorting campaign lasts for some 4 to 5 days, with approximately up to 40 waste samples being tested for physical composition. Examinations of laboratory samples of combustible components for calorific value and other chemical parameters complement the examination program. The user receives a series of decisive results, such as the yield of RDF, and its potential fuel properties. At the end of the day, the findings enable the user to compute how much fossil fuel can be substituted by the identified tonnage of RDF. Moreover, sound statements can be made about the potential financial benefits of savings on fossil fuel costs.

1. Introduction

In cement manufacturing, the fuel used to fire the clinker kiln is one of the largest costs in the whole production process. Most of the cement plants still rely on fossil fuels, which are subject to increasing prices on the global market, or they are subject to cutting subsidies and supplies, as was the case in Egypt a few years ago. Fuel costs must be carefully monitored, and cement plants seek to diversify the fuels used and find cheaper alternatives. Once such alternative is found, the traditional fuels need to be switched to waste-derived fuels.

In many cases, municipal solid waste (MSW) serves as raw material for waste-derived fuels to fire clinker kilns, for it is available virtually everywhere across the globe. MSW consists of everyday items such as product packaging, grass clippings, furniture, clothing, glass and plastic bottles, food scraps, newspapers, appliances, consumer electronics, and batteries. This waste

* Revised version of lectures given by the author in October 2016 at the "3rd Alternative Fuel Symposium" organized by MVW Lechtenberg & Partner in Duisburg, Germany, as well as on 26 January 2017 at the "Symposium on Business Models of Use of Municipal Solid Waste in the Cement Industry", organized by the Turkish Cement Manufacturer's Association (TÇMB) at Rengum Carya Golf Resort & Spa Belek, Antalya, Turkey.

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comes from homes; institutions such as schools and hospitals; and commercial sources such as restaurants, small businesses, and markets. MSW has plenty of combustible matter like paper, plastics, wood, and textiles, which makes it suitable as a raw material source for refuse-derived fuels (RDF). Since in MSW all of the items listed above are well commingled, the question is what portion of suitable combustible material can be obtained. In most countries across the globe it is convenient to either dump MSW directly in landfills (Fig. 1), or store it intermediately in waste transfer stations (Fig. 2). These are collection centres were trucks from various districts deliver MSW. In some cases a transfer station is equipped with simple machines to extract minute amounts of valuable material or recyclables, but the major waste volume is transferred to a large landfill for final disposal.

Figure 1: *Typical MSW landfills in Europe.*

Figure 2: *Varieties of waste transfer station for MSW in the Middle East.*

Both sites – landfills or waste transfer stations – offer huge quantities of waste, and therefore, they can serve as raw material sources for an envisaged RDF production. There is a vast abundance of MSW, so it is a huge potential source of RDF around the world. The chart shows the figures of annual generation of MSW from a range of various countries (Fig. 3):

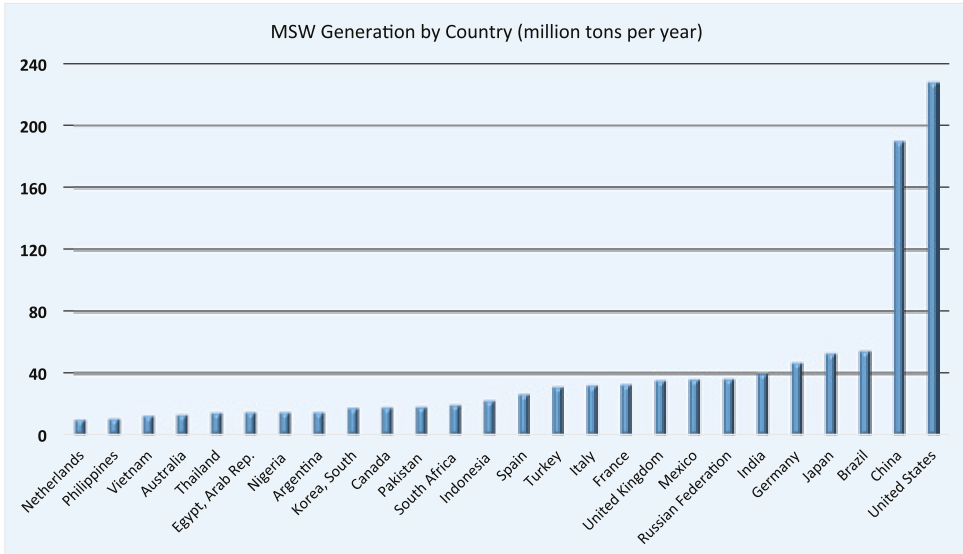

Figure 3: *Annual MSW arisings in selected countries (numbers from [1]).*

The chart covers only the 26 largest numbers from the World Bank report [1], which adds up to 1.045 billion tonnes of MSW per year. If one assumes only a 20 % portion of combustible materials, theoretically 256 million tonnes of RDF could be obtained.

At the outset of an alternative fuel project for co-firing clinker kilns with RDF, it is necessary to gather information on the amounts of locally available waste and its composition, for such information are decisive to calculate the rate of fossil fuel substitution and fossil fuel cost savings. Once a suitable waste source has been identified, the material has to be characterised to assess the potential properties of the RDF produced and its possible impacts on the clinker quality. However, it has to be considered that the MSW composition can vary according to seasons, for example, in a tourist area, as a rule, plastic packaging waste

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increases during the holiday seasons. Another sorting campaign may be introduced to cover all seasonal effects.

The answers to all of the questions can be provided by a special procedure which is the key factor for a successful alternative fuel project. The paper at hand deals with the sorting and sampling process at landfill sites or at waste transfer stations. It describes how to carry out the specific work and what is the outcome.

2. Determination of RDF quality and quantity – the principle

Once a landfill or waste transfer station is identified in the catchment area of the cement plant to serve as a sustainable raw material source for RDF, it is necessary to launch the waste evaluation process. The process is applied to freshly delivered waste by waste vehicles. In general, it follows the procedure as described in ASTM D5231 [2]. The major features of the sorting and sampling procedure are listed below:

Stage 1

- Select waste vehicles from different districts randomly.
- Take a subset of the waste delivery, for example around 100 to 200 kg.
- Separate this waste sample according to predefined waste fractions.
- Determine the net weights of all separated fractions.
- Compute the total waste composition and the composition of RDF only from the combustible fractions.

Stage 2

- Take samples for laboratory analyses from the separated combustible fractions.
- The analyses results in conjunction with the RDF composition provide the answer to the question regarding what fuel properties can be expected.

Stage 3

- The potential tonnage of RDF which can be obtained from MSW will be ascertained by using the weighing records of the landfill or waste transfer station. If this is not available, then data should be taken from environmental reports, if available, and estimate the yield of RDF.

The whole procedure is depicted by Figure 4:

3. Definitions

Waste sample: Part of the waste vehicle load which is sorted manually.

Waste category: Waste materials which are made of the same or similar materials, for example plastics (foils, bottles, blisters, etc.), paper and cardboard (newspapers, paper packaging, boxes), metals (beverage cans, tools, cutlery etc.).

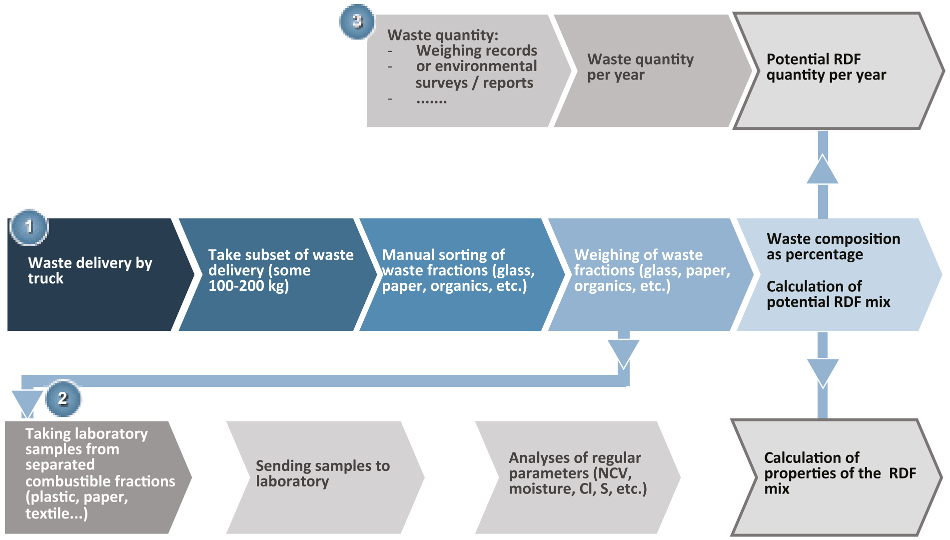

Figure 4: *Scheme of sorting and sampling of MSW.*

Fraction, waste fraction: Material belonging to a waste category (e.g. plastic, cardboard, glass etc.), which is manually taken from a waste sample.

Laboratory sample: It consists of randomly taken materials from each of the waste fractions. It is packaged and sent to the laboratory for analysis.

4. Sorting and sampling plan

At the outset of every waste evaluation project, one of the crucial questions is how many samples have to be sorted to meet the sampling objectives. Since MSW is a heterogeneous mixture of everything conceivable, the sampling approach is very challenging. The intuitive approach "as many samples as possible" might be right because the more samples that are taken and the bigger the samples are, the higher is the probability, that every item has the same chance to be found within the samples.

However, such a strategy quickly reaches its practical and financial limits, for this approach is time-consuming and entails high laboratory costs. There is always a need to optimise the sampling design to control sampling errors within acceptable limits and minimise the costs for sorting efforts, involved staff and eventually laboratory analyses, while continuing to meet the sampling objectives. In many cases sampling and analyses are a compromise of precision and costs.

The usual approach follows statistical considerations. The number (n), required to achieve a desired level of measurement precision, is a function of the waste component under consideration and the confidence level. The governing equation for n is as follows:

$$n = \left(\frac{k * S}{e * x}\right)^2$$

With:

- k Coverage factor corresponding to the desired level of confidence, for example 90 %; assuming the standard normal distribution, k is 1.65;
- S Estimated standard deviation;
- e Desired level of precision;
- X Estimated mean.

Since the required number of samples will vary among the components for a given set of conditions, a compromise will be required in terms of selecting the number of samples that will be sorted. The component chosen to govern the precision of the composition measurement (and therefore the number of samples required for sorting) is termed the “governing component” for the purposes of this method. In the present case, plastics were chosen as the governing component. Considering its corresponding standard deviation “S” and mean “X” from Table 3 of ASTM D5231 [2], which is 0.03, and 0.09 in terms of decimals, respectively, and a level of confidence of 90 % (k = 1.65), the number of waste samples to be taken for sorting is at least 30.

In the projects of MVW Lechtenberg & Partner, usually some 100 to 150 kg of MSW from the waste vehicles are taken as one waste sample. Within one day, it is possible to sort up to around eight waste samples. Over a period of four to five days, up to around 40 waste samples can be sorted.

Only the combustible fractions need to be analysed in the laboratory, for these will be the actual components of the future product, namely RDF. For taking laboratory samples, the strategy of composite random sampling is applied. Random multiple individual or “grab” samples from different heaps of the same material (e.g. plastics are separated onto three different heaps around the waste sample, Fig. 8) are physically combined and mixed into a single sample, so that a physical rather than a mathematical averaging takes place. Collection of multiple composite samples can provide improved sampling precision and reduce the total number of analyses required compared to non-composite sampling. According to statistical considerations, a composite sample of each of a combustible material must consist of at least four random grab samples [3].

Laboratory samples should be taken as a set from the separated combustible fractions of a waste sample. One set consists of one sample of each of the combustible categories, at least of the most abundant fractions, i.e. plastics, paper/ cardboard, and textile. Actually, laboratory samples should cover all the districts from which the waste vehicles carry their loads. If this is not possible, then at least those districts which contribute the highest portion of the entire incoming waste should be sampled. In the projects of MVW Lechtenberg & Partner, the number of individual laboratory samples (plastics, paper/cardboard, textiles) ranges from around 40 up to 160, depending on number of waste vehicles arriving and the budget.

5. Prerequisites

In actual fact, waste sorting is a very simple procedure, however, it needs a careful preparation in terms of providing the right tools, personal protective equipment, pre-requisites on site, and, last but not least, thorough instruction to the people who carry out the sorting. The following list provides the things which need to be organised prior to the waste sorting campaign:

- On site (landfill, waste transfer station, etc.)
  - Concreted or paved area for doing the sorting, ideally weather-protected, and in shadow;
  - Toilet facilities;
  - Front loader for moving waste samples;
- Tools
  - Shovel, rakes, brooms;
  - Buckets or big bags for weighing;
  - Electronic scale (up to 50 kg), either platform or portable scales (Figs. 6 and 7); portable electronic scales are very advantageous as they do not need an external power connection which might not be available on remote landfills. But they do need a suspension arrangement;
  - Desk for taking the notes;
  - Plastic bags for laboratory samples (ca. 30 to 40 L volume);
  - Permanent marker pen;
  - Optional: Screen (simple wire mesh, ca. 50 mm mesh size), size ca. 1 m x 2 m);
- Staff
  - Around 6-8 robust people for manual sorting incl. one supervisor;
  - Well instructed;
- Personal protective equipment
  - Safety shoes or boots;
  - Rubber-coated cotton gloves;
  - Dust masks;
  - First aid equipment.

6. Stage 1 – Selecting waste vehicles

Normally, waste vehicles collect their load from different districts. So, waste supplies will be selected randomly from different districts or towns for sorting. It should be stressed that at least those districts should be covered which contribute the highest portion of the entire incoming waste. Waste vehicles may have loads

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Figure 5: *A waste vehicle is tipping its load onto the concrete sorting place.*

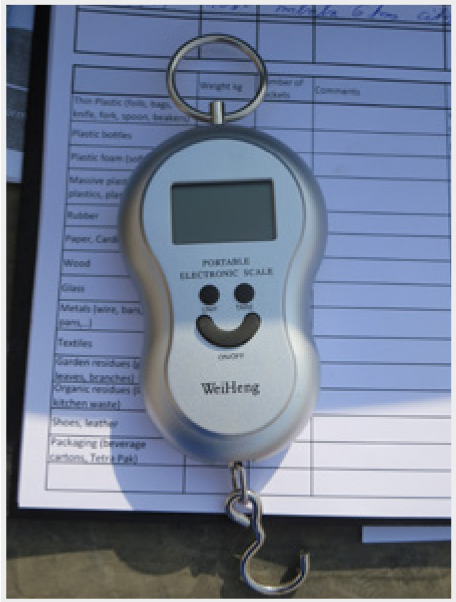

Figure 6: *A handy portable electronic scale.*

Figure 7: *An electronic platform scale.*

of some 4 to around 20 tonnes, depending on the size of the vehicle. Such a load is definitely too much for manual sorting, hence only a fraction of some 100 to 200 kg is taken.

Vehicles discharge parts of the load (approximately 0.2 to 0.5 m^3, up to approximately 100 to 200 kg) onto the dedicated sorting area (Fig. 5).

7. Stage 2 – Layout plan and manual sorting

Waste particles larger than around 100 mm (2D) are manually taken from the waste sample. Typically, pieces of the same type of material are put together on separate heaps around the waste sample (Figs. 8 and 9). The components of the waste sample are separated according to the following waste categories:

1. Plastics (foils, blisters, toys, bottles, etc.)
2. Paper and cardboard
3. Textiles
4. Wood
5. Rubber
6. Shoes
7. Glass
8. Metals (beverage cans, tins, tools, cutlery, iron wire, etc.)
9. Inert waste (stones, bricks, rubble, ceramic, etc.)
10. Nappies
11. Electronics (electronic chargers, cables, radio devices, cell phones, circuit boards, etc.)
12. Organics (i.e. garden residues (e.g. leaves, branches), leftovers, kitchen waste)
13. Screen passing (optional)
14. Screen retention (optional)

From that list, categories 1 to 5 are considered to be useful as raw materials for RDF production. As a rule, plastics and paper/cardboard are the most abundant raw materials, followed by textiles, whilst rubber and wood are comparatively scarce.

The other categories are non-usable fractions. It is always a good idea to also ascertain those fractions to gather as much information as possible on the waste composition, for example, how much recyclables (metals, or glass) are present, how much is the portion of non-usable garbage, or how much organics could be used in a biological treatment plant if the user contemplates such an option for further purposes.

In general, larger sized pieces (of about 100 mm) of categories 1 to 12 are separated manually onto heaps around the original waste sample. The remainder of the handpicking consists mainly of small pieces and some large-sized pieces chiefly of organic origin, actually belonging to category 12. However, coarse organics like fruit waste as well as fine grain-sized matter like street sweepings, sand, soil and similar material are included.

In the company's projects, the use of a simple wire mesh from construction markets to sieve the remaining garbage after manual sorting is an option. The standard mesh size is some 5 to 6 cm. The sieve dimensions are some 1 by 2 m, so it can be handled easily by two people. Sieving is very simple: Two people shake the mesh, another person scoops material (Figs. 10 and 11).

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Figure 8: *Typical arrangement of manually sorted waste components around the waste sample.*

Figure 9: *Typical waste sorting.*

This screen is used to sieve the residual waste fraction after the manual sorting. The residual fraction usually consists of organic matter which is commingled with small plastic and paper particles as well as inorganic matter like soil, or sand. The resulting fractions are category 13 and category 14, i.e. screen passing and screen retention. The sieving provides information about the proportion of organic contaminants which can be expected in the overflow of a drum screen in the future waste treatment facility to produce RDF. These organics would pass a drum screen along with combustible materials.

Figure 10: *Sieving of the residues from handpicking: Sieve retention 5.5 cm, mostly consisting of fruit, and leftovers.*

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Figure 11: *Passing 5.5 cm: Mainly organics, soil and small plastic and paper particles.*

Figure 12: *Buckets filled with plastics ready for weighing.*

Figure 13: *Buckets filled with plastics on a platform scale.*

After the separation and sieving, all fractions are put into buckets of around 20 L in volume (Figs. 12 and 13) or into large big bags in case of voluminous matter like large foils or foam pieces. The containers are weighed. The gross weights of the buckets are determined by an electronic scale, whilst the net weights of the contents are ascertained under consideration of the tare weight of the containers. Bulky items may be weighed directly without requiring a container.

All separated waste fractions are weighed. The weights are manually recorded preferably in a template form which has predefined cells for the waste categories. Additional information on waste origin, vehicle plate number, date and time of delivery must also be recorded.

8. Stage 3 – Laboratory samples and analyses

Spot samples of high calorific waste fractions suitable for RDF; i.e. plastics, paper/cardboard, and textiles are manually taken randomly from the separated heaps. In practice, there are several heaps of the same material around the original raw waste pile (see Fig. 8). Therefore, materials are randomly taken from all those separated heaps. Such laboratory samples would be considered as characteristic for this particular waste sample. Most frequently, wood is scarce, also rubber. Therefore, sampling of such materials can be omitted in some cases in favour of the abundant fractions plastics, paper/cardboard, and textiles.

The size of each composite sample should be around 20 to 30 litres in volume. Robust plastic bags of some 50 litres should be used. To prevent losses of moisture, bags must be knotted and sealed. For safely labelling the bags, a permanent marker pen has proved satisfactory. All data of the samples must be recorded, e.g. kind of material, sample weight, the source (this is the district or town), as well as date and time of the waste delivery.

The samples will be sent to a laboratory for chemical and physical analyses according to the relevant standards. The extent of the analysis parameters depends on the requirements of the user and his environmental permit. In most cases the laboratory programme covers the following parameters:

- Moisture
- Net calorific value (NCV)
- Ash content
- Chlorine and sulphur content
- Minor elements (e.g. Cd, Hg, Tl, etc. according to the user's environmental permit)

Once the composition of MSW has been determined, the fuel properties of RDF can be calculated by applying the calculation procedure as described in [4].

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9. Results from exemplary sorting campaigns

The following charts show some examples from various waste sorting campaigns that have been accomplished by MVW Lechtenberg & Partner.

Fig. 14 shows the waste fractions which are suitable for use as RDF. From 1 tonne of MSW around 320 kg of RDF (32 mass % of the entire garbage) could be obtained. The rest consists chiefly of "fine material" which is mainly of organic nature (leftovers, vegetables etc.) as well as inorganic matter such as soil, sand, fines, and rubble, in addition to some metals, glass, and shoes. Laboratory analyses of the combustible components revealed that RDF would have a moisture content of some 23 %, whilst its net calorific value (NCV) is 3880 kcal/kg (ar = as received), and chlorine is quite low, namely approx. 0.5 % (dm = dry matter). One tonne of such RDF enables substitution of around 600 kg of a typical coal with an NCV of 6400 kcal/kg

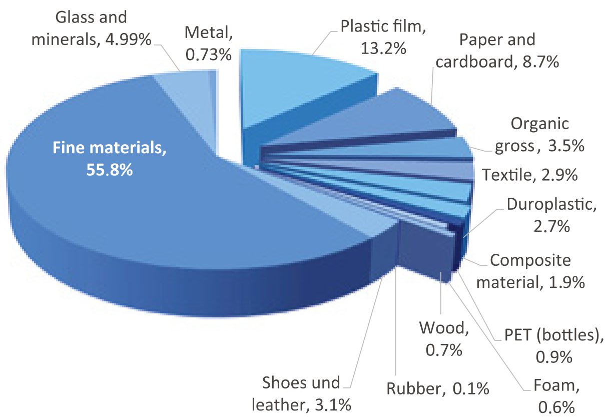

Figure 14: *Results of a waste examination in Turkey 2008.*

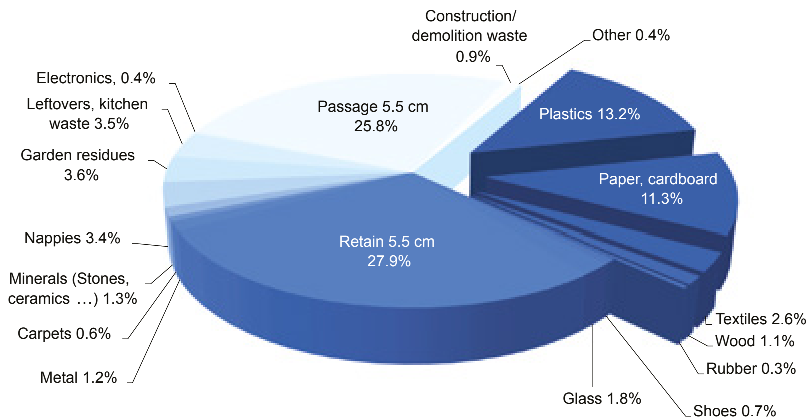

Figure 15: *Results of a waste examination in Egypt 2014.*

Another sorting campaign in Egypt (Fig.15) showed that some 20.8 % or 208 kg of RDF could be obtained from one tonne of MSW. The potential NCV would be approx. 3900 kcal/kg (ar) at 23 % moisture. One tonne of this RDF would enable substitution of roughly the same amount of typical coal as described in the case above. The fractions "retain" and "passage" represent the residues after manual separation of larger items. The fractions are comprised of mostly organic matter like leftovers, coarse fruit and vegetable remnants, as well as fine-grained rubble and minor amounts of small pieces of plastics and paper.

10. Final remarks

Omnipresent MSW is a huge source of combustible matter suitable as raw materials for RDF production to fire a kiln for clinker production. Since the composition of MSW is widely unknown, it is a must to investigate the yield and the quality of the potential RDF. The sorting procedure provides the user with a series of decisive information. Firstly, the percentage of combustible fractions in MSW can be ascertained. Based on the MSW arisings the yield of RDF in terms of tonnes per year can be appraised. Secondly, the chemical and physical analyses of samples from combustible matter will provide the information regarding what quality of RDF can be expected. Eventually, the user would be able to calculate how much fossil fuel can be substituted by the identified tonnage of RDF in connection with its calorific value. Furthermore, it is possible to gain the potential financial benefits by savings on fossil fuel expenses.

Although the whole procedure of waste sorting and laboratory analyses appears to be laborious, it delivers fundamental and reliable information for assessing the profitability of an RDF project. So, this makes the evaluation of waste a key component at the outset of every RDF project.

11. Literature

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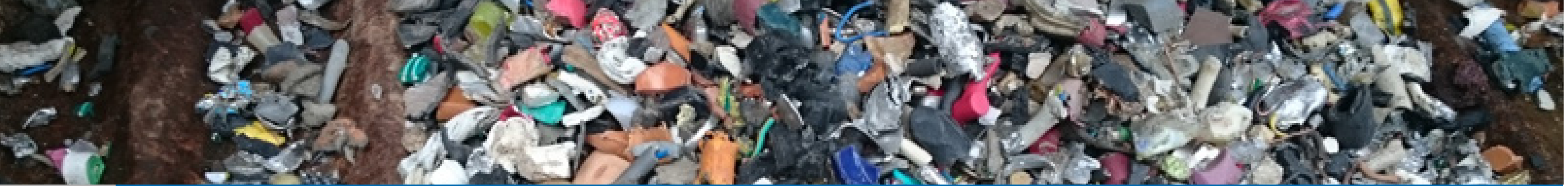

A Technological Revolution

A Technological Revolution

By Dirk Lechtenberg, MVW Lechtenberg & Partner

Introduction

Processing waste is always a challenge. When processing municipal solid waste into alternative fuels (AFs) or refuse-derived fuel (RDF), the energy consumption and wear causes high costs, and the fact that the fuel contains foreign particles, such as metals and stones, means that there is limited availability of the processing equipment needed to manage it.

Shredding waste-derived fuel

Some 30 years ago, when the first waste-derived fuel was produced in the Wittekind cement plant in Erwitte, Germany, there was no specialised shredding equipment available in the market. The only existing recycling equipment for shredding and milling was designed for defined plastics or wood without foreign particles. The fast rotating milling equipment that was being used was not able to cope with such foreign particles: the blades, screens, and even the entire rotors were damaged on a regular base.

In the 1990s, equipment suppliers, such as Vecoplan or Lindner Recyclingtech, began to develop shredders designed specifically for waste.

Typically, in an RDF production facility, the municipal solid waste, or commercial and

industrial waste, is shredded in two steps: first using a pre-shredder to reduce the waste to a grain size of between 300 – 500 mm. To remove the foreign particles, ballistic separation, sieving or air classification is applied before the final shredders cut the RDF down to grain sizes of 30-50 mm.

In the sphere of waste-derived AF production, single-shaft shredders have become accepted, although some producers have also achieved good to very good results with household waste by using a twin-shaft shredder, combined with a defined screen basket.

Throughput volumes with twin-shaft shredders are, as a rule, higher than with single-shaft shredders. The disadvantage is that the shredded material frequently consists of undefined particle size and of long foreign matter, including threads and tapes. Single-shaft shredders produce more homogeneous grain sizes. However, they are frequently more prone to impurities, so attention must be paid to safety systems such as belt drive and pneumatic air-cushion safety devices. Additionally, the extraction of foreign matter, if damage occurs, must be handled to prevent considerable plant stoppages. Contaminant extraction flaps, which allow contaminant removal, have proved to allow for this without having to clear the shredder's filling chute.

The rotation speed of pre-shredders is critical in regard to the lifetime of the machine. It has been shown that, at rotation speeds of around 250 rpm, contaminants can cause considerable damage to blades, the shaft, or to the screen basket. Final shredders, which shred waste into grain sizes of less than 30 mm, are usually single shaft shredders, and use blades on a heavy-duty rotor to cut the waste into a grain size that is controlled using screen baskets. Final shredders usually have a high rotating speed and, as such, a very high energy consumption of up to 50 kW/t of shredded material (such machines have often drives with 200 kW or more), causing high costs.

When feeding RDF to the kiln, it is not only a defined grain size that is important, but also having a grain without three dimensions, to avoid RDF particles falling out of the flame into the sintering zone, which can lead to coloured clinker. A defined, small grain size is therefore very important to achieve high substitution rates. Furthermore, having a low moisture content in the RDF is important, meaning that drying equipment is being used in an increasing number of cement plants to dry the RDF before feeding into the kiln.

Grain size and low moisture content are very important to maintain stable kiln operation in Germany especially, where high substitution rates of up to 80% are achieved. This requires more effort and increases costs for the RDF producers.

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A Technological Revolution

Revolutionising the process

In 2016, Voges Maschinenbau, an equipment manufacturer from Beckum, Germany, contacted MVW Lechtenberg to present a new approach to process waste: the V-Mill. The V-Mill not only shreds the RDF to a grain size of less than 10 mm, it also dries it and separates foreign 3D parts in one step.

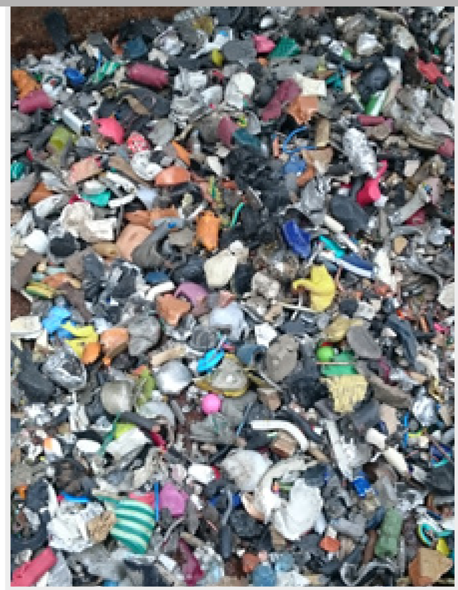
Dyckerhoff cement in Geseke, Germany, installed the first V-Mill, which has been processing shredded RDF in one step since March 2016.

Arriving by walking-floor trailer, the RDF is fed continuously to a receiving and dosing station, where the AF is de-compacted. Using a conveyor, the RDF is transported to a weighing belt, and then pneumatically transferred to the V-Mill.

In the mill, hot gases from the clinker cooler with a temperature of 120°C are used to dry the RDF. Tests have shown that the moisture content of the RDF, which can be up to 25%, is reduced to around 10% in the final shredded RDF.

Contaminants, such as glass, stones, and metals etc., are separated inside the mill by an air separation system, so that only the contaminant free fraction is milled to grain size of around less than 10 mm.

The AF can be pneumatically or mechanically injected onto the rotating dispenser below the



rotor. The flow of material accelerates both radially and tangentially as it sprays out in all directions from the dispenser.

In the sorting zone, the drying and control airstream separates the light material from the contaminants. The light material is blown up into the shredding zone, where its size is further reduced with the aid of high circumferential velocity and, at the same time, dried to the targeted residual moisture level. Separated out by force of gravity, the contaminants drop toward the bottom of the sorting zone, where they are collected and removed via conveyor. Finally, a cyclone separator removes the finished, post-dried RDF from the recirculating clinker-cooler air for pneumatic injection into the kiln.

This separation of foreign particles has a huge advantage, as there is little wear and tear on the cutting blades.

The chopping elements and impact plates are readily accessible for inspection and, if necessary, can be accessed through the service openings, meaning a replacement can be completed within a few hours.

As the initial RDF has a grain size of up to around 50 mm, such a system produces significant savings.

At the same time, the efficiency of RDF feeding increases, as the pneumatic feeding systems are subject to less frictional wear.

The pilot plant achieved processing capacities of up to 6 tph, with an extremely low energy consumption of only 31 kW/t of infeed. The V-Mill has a 110 kW drive, plus the additional fans for the cooler exhaust gases.

This is possible due to the separation of the 3D parts and foreign particles, which typically cause high energy consumption and wearing.

The final milled RDF is separated from the cooler gases in a cyclone and then pneumatically fed into the kiln burner.

Technical data

Dimensions:

- Length: 3600 mm.
- Width: 3200 mm.
- Height: 3370 mm.
- Rotor dia.: 1500 mm.
- Weight: 17 t.

Performance data:

- Power requirement: 110 kW.
- Throughput: around 6 tph.
- Speed: variable.

Conclusion

The V-Mill has significant advantages over the standard final shredders available. It dries and mills the RDF efficiently, with very low energy consumption. Wearing costs are less than €0.5/t. Further testing at two other cement plants will be undertaken by MVW Lechtenberg to evaluate the efficiency of the mill for higher capacities, bigger grain sizes, and higher moisture contents of the material to be milled.

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NEWS

India

- Gujarat Pollution Control Board supports co-processing

Sri Lanka

- INSEE Cement, together with its sustainable waste management arm INSEE Ecocycle, joined hands with Biodiversity Sri Lanka (BSL)
- Chicken litter as fuel source

Thailand

- Community wastes to be turned into refuse derived fuel

South Africa

- 1.144 million tonnes of recyclable plastic dumped in landfills
- AFRISAM committed to reduce fossil CO_2 emissions

Egypt

- Government hikes fuel prices by up to 66.7 %
- Fuel price subventions in other countries:

Technology

- Second UNTHA Shredder for French Waste Derived Fuel Manufacturer
- Lindner-Recyclingtech GmbH

Europe RDF Market

- RDF exports slightly fall: DEFRA published new export data
- More than 20 million tonnes RDF used in the worldwide cement industry
- Pyrolysis

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India

Gujarat Pollution Control Board supports co-processing

Gujarat, India's westernmost state, is quickly becoming an industrial powerhouse. Companies that produce petro-chemicals, fertilizers and pharmaceutical products dominate the state's economic landscape, providing jobs for many of its 62 million residents. But with the increased industrialization comes a massive flow of waste. Gujarat has 7,751 hazardous waste generating units that generate more than a quarter of India's total hazardous waste – the highest in the country. But lately a new idea has come along: The state government, with assistance from the Gujarat Pollution Control Board, began to work closely with industries that generated large amounts of plastic waste, and introduced them to the concept of "co-processing of waste".

Co-processing refers to the use of waste materials in industrial processes or the use of waste as a substitute for primary fuel or raw material. As a result to the introduction of "waste co-processing" concept, paper mills in the industrial town of Vapi are now collecting their plastic byproducts, then using them to fire cement plants instead of directing them to landfills.

Source: UN environment (2018, June 04). How the Indian state of Gujarat is taking on plastic pollution.

Sri Lanka

INSEE Cement, together with its sustainable waste management arm INSEE Ecocycle, joined hands with Biodiversity Sri Lanka (BSL)

INSEE Cement, together with its sustainable waste management arm INSEE Ecocycle, joined hands with Biodiversity Sri Lanka (BSL), a network of private sector companies working together on conservation issues and the Base for Enthusiasts for Environmental Science and Zoology (BEEZ) of the University of Colombo, to commemorate World Environment Day celebrated on June 05 every year. INSEE has heavily invested in reducing CO_2 emission in the manufacturing process while investing in recycling water, recycling paper, harvesting rainwater, using less water and energy in its manufacturing and kiln processes and promoting natural light and ventilation, while it has also placed more focus on innovation to create environmentally friendly raw materials.

Source: The Sunday Leader (2018, June 22). INSEE Cement joins Biodiversity SL and Colombo University to promote green practices on World Environment Day.

Chicken litter as fuel source

Endeavour Energy Corporation Ltd (EECL), an Australian based international corporate entity, floated a limited liability company in Sri Lanka to convert municipal waste and chicken litter into energy and fertiliser.

According to a study of EECL, there are 698 large scale poultry farms in Sri Lanka which produce 130 million broilers annually, and their droppings are around 130,000 tonnes. Together with Ductor Pte Ltd of Finland located in Helsinki, EECL processes chicken litter into up to 10 MW electricity and fertilizer from organic waste and chicken litter.

Source: The Sunday Times (2018, June 24). Transforming chicken droppings into 'gold' energy.

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Thailand

Community wastes to be turned into refuse derived fuel

Bangkok – Thailand's Pollution Control Department is set to turn community waste into refuse derived fuel (RDF) to make energy provision more sustainable.

The PCD held a strategic meeting last June on waste management with representatives from related agencies. The meeting discussed the production of RDF and drafted criteria for identifying fuel worthy materials from community waste.

They are also planning to ask the natural environment committee to lay down waste sorting standards for communities to follow and develop a waste purchase contract between RDF suppliers and buyers to prevent purchase irregularities.

In addition, they will urge the government to set up a supply chain network between cement factories and waste treatment plants, provide them with financial support in the event of declining fuel prices and prevent illegal waste disposal.

Source: Pattaya Mail (2018, June 13). Community wastes to be turned into refuse-derived fuel.

South Africa

1.144 million tonnes of recyclable plastic dumped in landfills

According to a press release of INTERWASTE, one of this year's Alternative Fuel Award winning companies, more than 1.1 m tonnes of recyclable plastic waste is landfilled in South Africa. Kate Stubbs, Director Business Development and Marketing at Interwaste explained further, that Interwaste recently launched a refuse derived fuel (RDF) plant with the aim to reduce waste-to-landfill and directly contribute towards government's efforts to reduce the country's carbon footprint.

Source: ESI Africa (2018, June 05). S.Africa | 1.144m tonnes of recyclable plastic dumped in landfills

AFRISAM committed to reduce fossil CO_2 emissions

AfriSam, the South African cement producer has established its own environmental department as early as 1992, and developed an environmental policy just two years later, has gone on to innovate a number of air quality management improvements. Upgrades in cement kilns and emission filters have led to the lowest dust emissions in Africa. "Our ongoing focus on alternative fuels and resources (AFRs) has allowed us to steadily reduce the amount of coal burnt in our cement kilns, which in turn contributes to lower CO_2 emissions," says Nivashni Govender, an environmental specialist at AfriSam. "For instance, we have developed a way of burning old tyres in our Dudfield plant – a strategy that also contributes significantly to addressing the environmental hazards posed by tyres when they are disposed of in landfill."

Energy conservation is an ongoing programme, which has included the progressive installation of energy efficient lighting across the company's range of cement, readymix and aggregate quarry facilities. As water scarcity becomes a more pressing issue for countries like South Africa, water conservation has also featured high on AfriSam's environmental agenda, says Govender.

Source: Creamer Media (2018, May 03). Cleaner, Greener The Afrisam Way.

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Egypt

Government hikes fuel prices by up to 66.7 %

The government raised fuel prices by as much as 66.67 %, according to the Official Gazette. The move comes as part of the 2016 structural readjustment programme, which was agreed on with the International Monetary Fund (IMF) which amid to increase international oil prices. The government also raised mazut prices to around 196 USD per tonne for industrial users except those in the food, cement and electricity sectors. The price of mazut, a heavy, low-quality fuel oil used to generate electricity in power stations and for other industrial purposes, had increased last year, but only for the cement industry. At the moment, the food industry pays around 84 USD per tonne, the cement pays around 196 USD per tonne and the electricity sector pays some 140 USD per tonne, according to the Official Gazette.

Fuel price subventions in other countries:

Tunisia, which had budgeted 1.5 billion dinars in subsidies, would have had to spend a further four billion to avoid a rise in pump prices due to increases in global oil prices. It raised fuel prices twice in three months, but by a meagre three per cent each time, and it is now expected to do so again in line with recommendations from the IMF after a $2.8 billion loan.

Jordan has been witnessing monthly hikes in fuel prices since the beginning of 2018, a trend halted in May on the back of protests against increased fuel and electricity prices together with other austerity measures.

However, the May decision was not to freeze the increases, but to postpone them for a month. The new increases in fuel prices will be the fifth since the beginning of 2018.

Oil-rich Saudi Arabia and the United Arab Emirates have taken more aggressive steps on fuel subsidies. The UAE became the first country in the Gulf to remove subsidies on transport fuel when it began linking petrol and diesel prices to global oil markets in August 2015.

Saudi Arabia, which increased fuel prices by 127 per cent in January, has adopted an energy subsidy phase-out programme that ends petrol and diesel subsidies in 2025.

Other countries have opted to shoulder the burden instead of passing it onto consumers. Thailand is using a state oil fund to support domestic retail fuel prices to help consumers cope with rising global oil prices, for example. The fund, of about 30 billion baht ($936.9 million), will absorb 50 per cent of any increase in retail prices.

Neighboring Malaysia has an even better strategy: the government has allocated three billion ringgit ($760 million) to subsidising petrol pump prices until the end of 2018 in spite of current plans to deal with escalating debt levels.

Sources:

Mada Masr (2018, June 16). Government hikes fuel prices by up to 66.7%.
Ahram Online (2018, June 22). Egypt continues economic reforms with cuts to fuel subsidies.

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Technology

Second UNTHA Shredder for French Waste Derived Fuel Manufacturer

In France, solid recovered fuel (SRF) manufacturer, Environnement 48, has increased the capacity of its waste processing facility in the south west of the country with an investment in its second UNTHA shredder.

Environnement 48's alternative fuel production plant first became operational back in early 2016. At the heart of the site was an UNTHA XR Ripper waste shredder, transforming C&I and bulky wastes into a homogenous fraction of 80% <300mm. This was then further refined to produce SRF.

Source: WASTE MANAGEMENT WORLD (2018, June 07). Second UNTHA Shredder for French Waste Derived Fuel Manufacturer.

Lindner-Recyclingtech GmbH

Lindner-Recyclingtech GmbH made several key new product introductions at this year's IFAT, held in May, in Munich, Germany, including the Polaris 1800 model, a specialized shredder designed for SRF (solid recovered fuel) applications, the Zeta Star 95 F2 starscreen for processing waste wood fuel, and the Atlas 5500, a new twin-shaft primary shredder with an innovative electric drive.

Europe RDF Market

RDF exports slightly fall: DEFRA published new export data

As expected, the Defra compendium confirms that in 2017 the export of refuse derived fuel stabilised and in fact fell marginally by 12,000 tonnes.

It is reported that the majority of refuse-derived fuel exported from England in 2017 was sent to The Netherlands (48%), Germany (20%) and Sweden (16.5%).

Thousand tonnes

	2010	2011	2012	2013	2014	2015	2016	2017
Export of refused – derived fuel	9	250	961	1,799	2,347	2,819	3,213	3,201

RDF export figures: *source Defra compendium*

https://www.letsrecycle.com/news/latest-news/defra-compendium-reveals-rdf-exports-fall/

Source: Letsrecycle.com (2018, May 25). Defra compendium reveals RDF exports fall.

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More than 20 million tonnes RDF used in the worldwide cement industry

According to EUWID, more than 20 million tonnes of RDF were used in 2017 by the 10 biggest cement producers worldwide.

Cement groups putting the use of alternative fuels as strategic goal to meet CO_2 reduction targets and to save fossil fuels.

Co-incineration in large* global cement companies 2017			
Company	**Sales [2] (bln. €)**	**Co-incinration of alternative fuels (t)**	**Thermal subsititution rate (%)**
CRH	27.6	2 m	38.6
LafargeHolcim	22.3	about 10 m	16.5
HeidelbergCement	17.3	3.3 m [3]	20.8
Cemex	10.9	about 3 m	26.2
Anhui Conch Cement	9.7	850,000 [4]	N/A
Taiheiyo Cement [1]	6.7	481,000	31.1
Buzzi Unicem	2.8	N/A	26
Votorantim Cimentos	2.8	N/A	14.6
Vicat Group	2.6	N/A	25.2
Titan Cement	1.5	203,000	9.1

* The list is missing, among others, China National Building Material Company (CNBM) – one of the world's largest cement producers (Sales of 2017: approximately € 16.4 billion). In its Sustainability Report, CNBM makes no specific mention of the co-combustion of alternative fuels

1) Financial year: 01.04.2016 – 31.03.2017

2) The turnover was in local currency when published , it was converted into euros according to the exchange rate int the balance sheet date

3) Company's information for 2016

4) Treatment of household waste, in addition to treatment of 30,000 t of sewage sludge and 66,000 t of wastewater

Sources: Sustainability and business reports and other published or requested data from CRH, LafargeHolcim, HeidelbergCement, Cemex, Anhui Conch Cement, Taiheiyo Cement, Buzzi Unicem, Votorantim Cimentos, Vicat Group, Titan Cement and China National Building Material Company.

The French-Swiss industry leader LafargeHolcim recently announced that it had used around 10 million tonnes of waste by means of co-processing in the rotary kilns of its cement plants in 2017, with the aim of doubling this amount by 2030. The Mexican construction materials company Cemex reports that more than 3 million tonnes of alternative fuels, such as processed municipal waste, used tyers and organic residues have been used in the clinker burning process in its cement plants in 2017 worldwide. This corresponds to a thermal substitution rate (TSR) of 26.2 %. By 2020, this rate is to be increased to 35 %.

The Irish cement company CRH also uses more and more waste in the clinker burning process. According to the company's new sustainability report published at the end of April, around 2.0 million tonnes of alternative fuels, such as high-quality RDF, scrap tyers, solvents and biomass were co-incinerated throughout the Group in 2017. 1.9 million tonnes were co-incinerated in the previous year, in 2015 about 1.6 million tonnes. CRH's TSR ratio is the highest in the industry at 38.6 %. The ten corporations considered by EUWID alone, together, they have a co-incineration rate of at least 20 million tonnes per year. In view of the limited sectoral breakdown made here, the volume of waste used in the global cement industry for co-incineration is likely to be significantly higher.

Source: EUWID (2018, May 14). Weit über 20 Mio Tonnen Abfall weltweit in Zementwerken mitverbrannt.

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Pyrolysis

Trouble in another pyrolysis plant for refuse derived fuels:

Avonmouth gasification plant closed until 2020. The plant was established in 2013 to process refuse derived fuel (RDF) from the adjacent mechanical and biological treatment works formerly run by New Earth Solutions Group.

But although the plant could handle 120,000 tonnes a year of RDF using pyrolysis and gasification and producing 14.8 MW of power, it "always operated at below its design point. The lack of performance and hence lack of revenue generation resulted in a decision to suspend operations at the plant with a view to implementing major redevelopment programme", as per the report by director Ian Brooking.

Source: MRW (2018, June 04). Avonmouth plant closed until 2020.

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5th Alternative Fuel Symposium
19 – 21 September

Just a few weeks to go for our next Alternative Fuel Symposium on 19 – 21 September, which will again draw alternative fuel experts from cement, lime and power generating groups, waste management companies from all over the world together.

We are delighted to announce that this year's event will include exclusive insights from top cement producers such as City Cement Group, waste management companies and cement associations explaining case studies and their first-hand experience on how to develop and run a successful waste to fuel project.

In this year's symposium you can look forward to hearing from the following speakers among others:

- **Rick Bohan**, Director of Manufacturing Technology, Portland Cement Association, USA: "Development of Alternative Fuels in the United States of America"
- **Saleh Al Shabnan**, CEO of City Cement, Kingdom of Saudi Arabia: "The Role of the Cement Industry in a Sustainable Waste Management in the Kingdom of Saudi Arabia – Constraints and Opportunities"
- **Berthold Kren**, Region Head of Geocycle Asia, GM – Geocycle India: "Development of Alternative Fuels in the APAC Region – Case Studies of Geocycle"
- **Bassam Moumneh**, CCO of AVERDA International, United Arab Emirates: "Waste Management in Selected Countries in Middle East and Africa – Opportunities and Business Models for Alternative Fuels"
- **Dr. Rainer Bertling**, Sales Director Metallurgy, Power & Alternative Fuels, Aumund Fördertechnik, Germany: "Aumund Integrated Solution for Optimization of Alternative Fuels Application in Cement Plants"
- **Konstantinos Papadimas**, Managing Director of Herhof, Germany: "From Municipal Solid Waste to an Alternative Fuel Resource by Herhof "Stabilat©" Technology"
- **Tania Godinho**, SGR Ambiente, Portugal: "Production and Use of Refuse Drived Fuels in the Portuguese Cement Industry"
- **Leos Volesky**, Schenck Process, Czech Republic: "Progress in Alternative Fuels Feeding Systems"
- **Tim Hamer**, Vecoplan, Germany: "Innovative Technologies for RDF Production & Handling"
- **Dr. Luigi Di Matteo**, DI MATTEO Förderanlagen, Germany: "Transitioning to a Zero Waste Future – International Best Practices for Co-processing of Alternative Fuels"
- **Thomas Jennewein**, FLSmidth Pfister, Germany, "Case Studies on Feeding and Dosing of Alternative Fuels in Different Countries"
- **Boris Hille**, PROCESS SENSORS Europe, Germany: "Automatic Quality and Moisture Control for Refuse Derived Fuels"
- **Jan Gressmann**, Eggersmann Anlagenbau Concept, Germany: "Case Study Cilacap, Indonesia: MSW to RDF in Developing Countries Where Dumpsites are the Standard"
- **Marco Egger**, Linder-Recyclingtech, Austria: "Case Study for the Production of Alternative Fuel from Solid Waste for the Cement Industry"

Furthermore, the committee has reviewed all applications for the "Alternative Fuel Award". We have received almost 20 applications from cement plants and RDF producers from all over the world, in which particularly interesting alternative fuel projects are described.

These winners of the competition will present their case studies at the Symposium:

- **Intercement**, Portugal: "Alternative Fuel Dryer Project at Souselas Plant"
- **Interwaste**, South Africa: "Case Study from South Africa - Producing Alternative Fuels for the Cement Industry"
- **BioEnergy**, Egypt "Waste Fueling the Future of Pyroprocess"
- **Qena Cement**, Egypt: "Multifuel Handling of Fossil and Alternative Fuels from the Sugar Industry"

Besides this, equipment suppliers and service providers will present case studies from their projects and demonstrate new developments.

Register without delay to guarantee your place

Places are strictly limited and in previous years have sold out early, to ensure your participation, we advise you to register without delay. The delegate rate is just 940 euros (+19% VAT) including the dinner on the first night, and social programme (a Rhine river boat tour through the port of Duisburg).

This year we will also have a field trip to Dyckerhoff cement plant in Geseke.

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Alternative Fuel Award

The Alternative Fuel Award is established by MVW Lechtenberg & Partner to encourage the acceptance of the ecological responsibility on both social and individual levels, and to identify role models in the field of alternative fuels, a field which, aside from its contribution to the economic development, has the greatest contribution to the protection of our environment. The award is to be presented to cities, companies and individuals promoting the idea of sustainable alternative fuel's production and use.

This year's awards' ceremony will take place in the next Alternative Fuel Symposium of MVW Lechtenberg & Partner in September 2018 in Duisburg, Germany.

Over 20 applications and project descriptions were received from cement producers, RDF producers and waste management companies from all over the world.

All submitted project descriptions were thoroughly reviewed by MVW Lechtenberg`s expert team, and the award winning projects were selected after many long discussions, as almost every single submitted project deserves to be a winner.

In the next editions of "Co-Processing Magazine" we will publish excerpts of the received project descriptions, which can be also used by other cement plants and waste management companies as "Case Studies" on how to develop a sustainable production and use of refuse derived fuels.

These winners of the competition will present their case studies at the symposium:

Intercement, Portugal: "Alternative Fuel Dryer Project at Souselas Plant"

Cimpor Souselas plant decided to install an RDF dryer that could use the excess hot air from the clinker cooler to dry the waste, sending the cooled air to the existing cooler chimney. After drying, the RDF can be fed into the kiln through conveying systems. This allows the co-processing of the RDF which was previously not suitable for feeding due to its high content of moisture.

Interwaste, South Africa: "Blending Platform Facility for Hazardous Waste"

Interwaste is one of the pioneer companies to introduce the production of liquid fuels for co-processing in South Africa. The company has proven experience in blending hydrocarbons and chemical hazardous waste and has now commenced a blending platform facility at one of its sites in Germiston, South Africa. A total of 6 – 7 million Rand was invested in the project and the facility is 100% solely owned by Interwaste Pty Ltd.

BioEnergy, Egypt "RDF Production and Operation at Suez Cement, Egypt"

The team members of BioEnergy are young entrepreneurs who have identified "refuse derived fuels" as a business opportunity, they have formerly worked in cement plants, but quit their secured jobs in order to build and operate RDF production plants. This is a good example of the promotion and support of alternative fuel's sustainability, as the use of refuse derived fuels in the cement industry supports the development of a sustainable waste management system. Furthermore, by creating numerous of jobs and business opportunities in this field for young people in developing countries, BioEnergy contributes to the local economic development.

Qena Cement, Egypt: "Multifuel Handling of Fossil and Alternative Fuels from the Sugar Industry"

Suffering from high fossil fuel prices and difficulties in receiving sufficient quantities of refuse derived fuels in Egypt, Qena Cement has built a "multifuel handling facility", which is able to process and blend various types of alternative fuels such as bagasse, residues from the sugar production, biomass, refuse derived fuels, sewage sludges together with conventional fuels (coal).

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