Directional Compass:

Alternative Fuels

Pre-processing of non-hazardous solid waste
to customized alternative fuels and
its thermal use

WhiteLabel-TandemProjects UG
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“Waste is a resource in the wrong place”

Adopted wording from Sir Edward Salisbury’s “Weeds and Aliens” (A weed is a plant in the wrong place)

I. List of figures:

Abbreviations

ASTM	American Society for Testing and Materials
AF(s)	Alternative Fuel(s), including:
HCF	High Calorific Fraction
RDF	Residue Derived Fuel
SRF	Solid Recovered Fuel
AFR	Alternative Fuel(s) and Raw Material
BAT	Best Available Technology
BGS	Bundesgütegemeinschaft Sekundärbrennstoffe e.V. (EN: Registered Federal Quality Association Secondary Fuels)
BMT	Biological-Mechanical Treatment plant (note the sequence of the process steps)
BREF	Best Available Techniques Reference
C+IW	Commercial and Industrial waste
CEN	Comité Européen de Normalisation (EN: European Committee for Standardization)
CFBC	Circulating Fluidized Bed Combustion
CV	calorific value
DEHSt	Deutsche Emissionshandelsstelle (EN: German GHG-Emission Trading Office)
DIN	Deutsches Institut für Normung (EN: German Institute for Standardization)
DM	Dry mass
EIA	Environmental Impact Assessment
EN	European Norm
FBC	(stationary) Fluidized Bed Combustion
FGD	Flue Gas Desulphurization
GB_{21}	Gasbildungsrate nach 21 Tagen (EN: Gas formation rate after 21 days)
GHG	Greenhouse gas
H_i	inferior heat value (formerly known as lower calorific value Hu)
ITAD	Interessengemeinschaft Thermischer Anlagenbetreiber Deutschlands (EN: Interest community of thermal plant operators in Germany)
MBT	Mechanical-Biological Treating plant (note the sequence of the process steps)
MSW	Municipal Solid Waste
MWI	Municipal Waste Incinerator (to burn commingled untreated solid wastes - note the difference to WtE)
NIR	Near-Infrared (Detection system)

OPC	Ordinary Portland Cement
PVC	Polyvinyl Chloride
QA/ QM/ QS	Quality assurance/ quality management/ quality surveillance
RAL GZ	RAL-Gütezeichen (Quality seal in accordance to the Committee for Supplying Conditions)
SWA	Solid Waste Assessment
TDF	Tire Derived Fuel (shred tires)
TSR	Thermal Substitution Rate
VDZ	Verein der Deutschen Zementindustrie e.V. (registered Association of the German Cement Industry)
WtE	Waste-to-Energy plant (to produce steam and additionally power from pre-processed HCF and biomass - note the difference to the MWI)

The colour code used here is related to	**waste**	**technic**	**invest + use**

II. Terms, Definitions and Remarks

Definitions	Remarks
Alternative Fuels (AF): general term used for all types of energy resources which are waste derived, without any prediction for consistence or its point of feeding **Alternative Raw materials (ARM):** mineral based waste like foundry sand, precipitation sludge, moulds etc. which will replace natural raw material compounds **Alternative Fuels and Raw Materials (AFR):** **Co-processing:** term for using energy and its remaining ash as a compound in the clinker formation of the pyro process in a rotary kiln. **Co-incineration:** term for using energy as a minor matter in the thermal process of a fossil fired power plant **Pre-processing:** customer-specific pre-treatment of waste for the production of process-, product- and emission-neutral alternative fuels and raw materials	The topics of “AFR”, “co-processing” and “alternative fuels” in the cement manufacturing process have been characterized by the cement industry since the 1980th when they became pioneers after the 2nd oil price shock by replacing primary energy carriers against alternatives (used oil and whole tires). After long lasting discussions with the Environmental Ministries on the state and the federal level as well as NGO’s, the waste management companies selected specific Commercial + Industrial Waste streams to start testing further pre- and co-processing. With this trails a lot of analysis from the fuels input and output, as there are exhaust gas and product, were done to find out, which influences may become aware. In the 1998th the German registered Federal Association for Quality Assurance (BGS e.V.) started its work and was finally the nucleus for the European standardization CEN TC 343, which is in the meantime the European-wide standard for country wide waste management systems and quality surveillance. Therefor all the wording and terms were defined and shall be used here in accordance to the German cement sector and it’s Association of German Cement Manufacturers – VDZ.
High Calorific Fraction (HCF) combustible fraction separated from MSW on the first level, feedstock for WtE-plants, FBC or pre-combustion chamber or furtherly processed to customized calciner fuel (RDF) or main burner fuel (SRF)	High Calorific Fraction (HCF): combustible fraction from splitting MSW into its fractions on the 1. level for splitting and removal of all impurities which will contaminate the fuel quality or which will disturb the combustion process such as e-scrap by heavy metals, biomass or organics by moisture, undefined debris of demolition waste, glass, soil etc., grainsize <300 mm, net CV ~14-17 MJ/kg. When directly used as an AF its retention time is 30 – 1.200 s and requires a special device for combustion like an additionally installed pre-combustion chamber such as Hot Disc™ or PREPOL SC™. HCF will also be used directly in WtE-plants, FBC or shall be blend with C+IW to be furtherly processed to higher grade fuels.

Definitions	Remarks
Residue Derived Fuel (RDF)	Residue Derived Fuel (RDF), which is poorly processed and cleaned on second level (coarse cleaning and comminution from HCF), grain size 60-120 mm, CV ~15-19 MJ/kg, retention time to burn out 5-8 s. RDF requires better processing equipment than HCF production. ***NOTE: RDF is not a synonym term for "Alternative Fuel (AF)"! RDF is defined by its efforts of pre-processing and its quality to suit the customer's thermal process. On the (wet kiln) process or in old cement kilns RDF cannot be used due to its absence of calciners. RDF requires a sufficiently designed calciner for its longer burn out.*** When the thermal potential of MSW respectively its HCF is high enough, RDF will be processed directly or, if net CV is too less, it shall be blend with C+IW and finally processed to the highest grade SRF.
Solid Recovered Fuel (SRF)	Solid Recovered Fuel (SRF) on a three step process from MSW, comminuted down typically to 25 or 30mm, and mandatorily classified to a sufficient SRF which will not land unburnt in the power plants' de-slagger or will cause reductive burning conditions in the clinker bed of the kiln. Only 2D-flakes will guarantee the best burn out and result in the shortest retention time in the flame shape. Due to its individual portions of components its net CV can range from similar lignite to significant highest values close to oil caused by pure plastic foils.
Quality surveillance (QS)/ Quality assurance (QA): quality control during pre-processing and co-processing of <u>all</u> types of waste derived fuels is imposed by the approval authorities as well as to the billing basis and input criteria regarding thermal process, product quality, air pollution control or GHG-emission allowances; only useful with existing and really applicable analysis methods.	QA during pre-processing, co-incineration and co-processing of **all types of waste derived fuels** is claimed by the authorities. Of course, QA is also required with regard to the contractual accounting basis and the input criteria for the manufacturing processes, their products and the GHG emissions trading. Parameters are imaginative if they are not seriously linked to analysis methods and quoted in the supply contract. In the EU, analytical methods based on CEN TC 343 are therefore used.

Definitions	Remarks
Municipal Solid Waste (MSW)	Residual household waste which may be described as commingled solid waste from households, which is collected, transported, and disposed of, either by the household, the municipality or by any other third party in any kind of containers, bins or plastic bags
Commercial and Industrial Waste (C+IW)	Residual co-collected commercial and industrial waste which may be described as mixed solid waste from commerce, craft and small industrial production, which is co-collected, transported, and co-disposed of, either by the polluter, the municipality or by any other third party in any kind of containers, bins or plastic bags. The composition of this waste is comparable with the composition of residual waste from households, but its amount and composition arise in spatial clusters and depends on the business sector.

Not included in this kind of definition are:

- Separately collected kerbside, household and commercial waste materials such as furniture, glass, paper, plastics
- Separately collected municipal waste which may include hazardous waste, electrical + electronic waste, street cleanings, garden + park waste as in minor matters
- Any other waste, which is not produced from routine activities such as bulky waste.

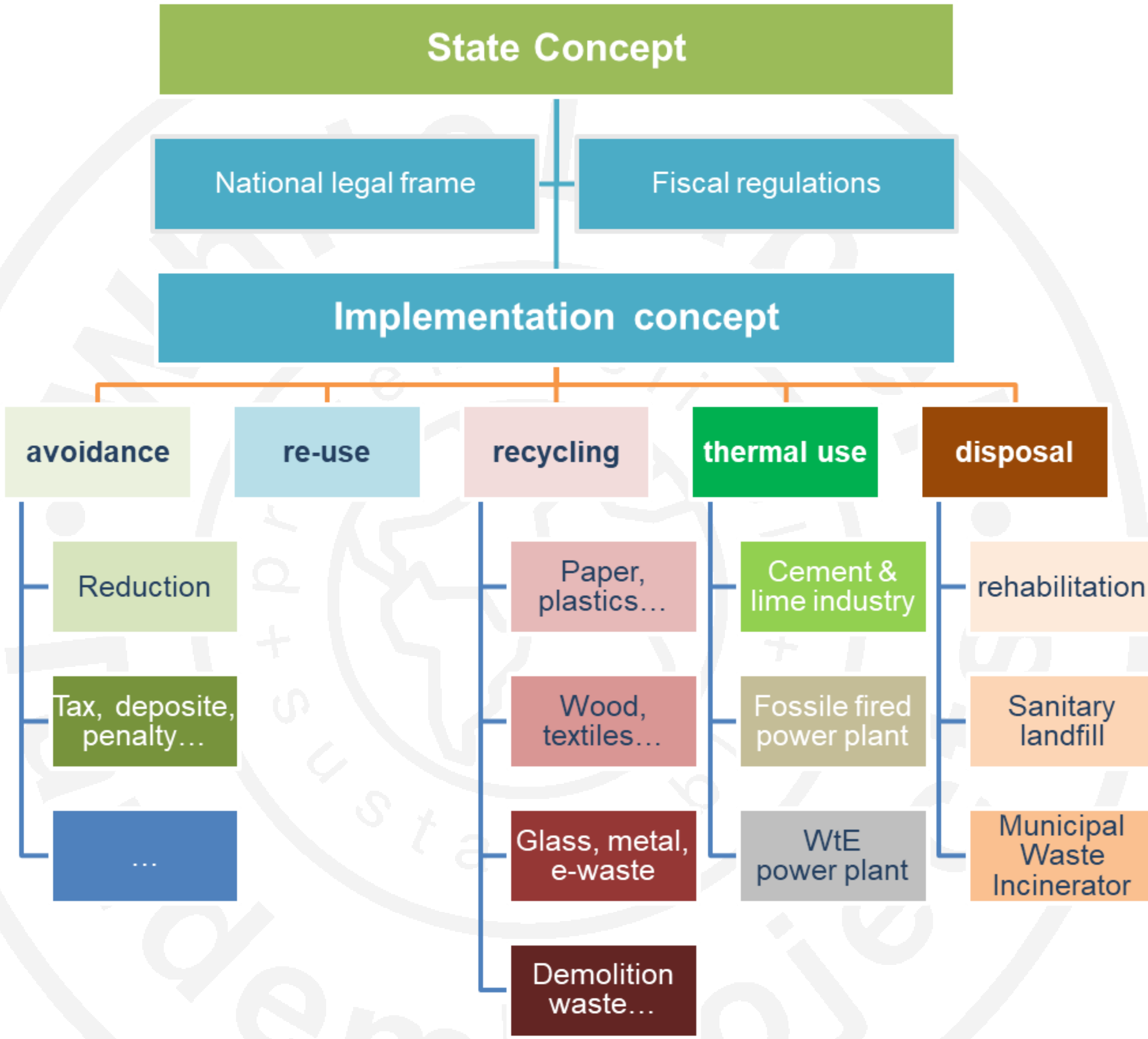

Fig. 1: A regional waste–to-energy concept is an integral part of a state concept

The identification of potentials for materials recycling and thermal use of waste introduces the issue of waste management, and induces strategies which are focused on purposive best available solution.

Therefore, knowledge of the composition of solid wastes and the understanding of the thermal valorisation processes are essential for designing the required pre-treating facility right. Measures have to be taken with the waste from its collection to its final destination, in a correct sanitary way, economically feasible, and considering the type of waste and always having in view of environmental sustainability and waste resource market trends.

Within the scope of the characterization, the depth, and the kind and sequence of treatment can be derived as well as its potentials the thermal use of alternative fuels and its need of disposal of unsuitable fractions. Whether the resulting solid alternative fuel will suit for the envisaged process, it will depend on the waste derived thermal potential, its organics to be reduced, and it’s content of impurities which have to be disposed in a safe manner.

The lack of knowledge has a fundamental impact on the waste management chain until feeding AF to thermal processes. Thus all parties involved are forced to close gaps in the chain of pre- and co-processing by control and quality assurance of input and output, and to claim a sufficiently high lead factor, e.g. in compliance with the legally required environmental standards.

Irrespectively, the potentials of the envisaged waste must meet the process and production-specific target of the respective recovery process after pre-processing and quality surveillance.

These properties have to be agreed individually and after the assessments in advance.

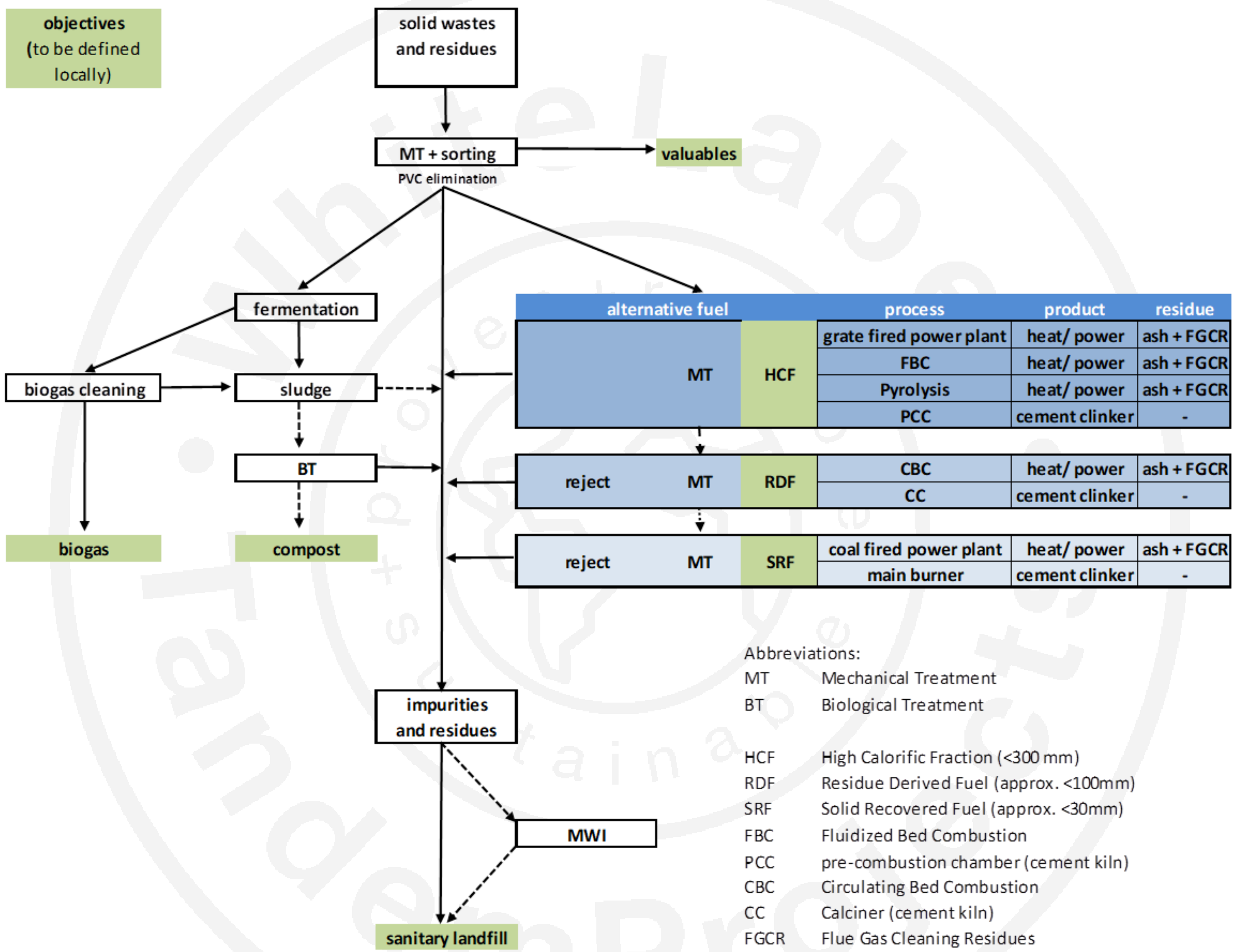

Fig. 2: Objectives and tasks for a reliable project of waste pre-processing and sustainable use

1. Waste sourcing and assessment

A main pillar of waste management in the EU is the waste hierarchy. According to the hierarchy, generation of waste must be prevented, otherwise waste should be reused, recycled, recovered or disposed of in that sequence. Despite high recycling potentials, not all waste can be turned into secondary materials.

With the introduction of the European technical guidance in 2000 and its latest revisions (2018/C 124/01) the identification of the waste sources and its classification as hazardous or non-hazardous and the application of the relevant EU legislation are established. This guidance is provided to the waste producer, waste conditioner, to the national and to the local authorities for sourcing, tracking and permitting issues.

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Since the waste remains a waste even after it has been processed, the recyclers and users requires a permit with the same waste code catalogue to prove the origin of waste derived alternative materials.

1.1. Commercial and industrial waste (C+IW)

Furtherly, hazardous wastes can also be included into this list if they have individually and previously proven that they are not contaminated by heavy metals which may affect the emissions of the exhaust gas of the thermal process negatively.

1.2. Municipal Solid Waste (MSW)

Municipal solid waste and bulky kerbside waste from private households form a complex mixture that can be contaminated by heavy metals, moisture carrying organics, food, green cut etc., and hazardous or medical waste as well. Its composition will differ with regard to the type of collection and its frequency, on the kind of region (rural, urban) or the consumer habits and his environmental awareness.

After comprehensive analyses and its proven harmlessness authorities and the cement industry drew up a list of wastes which demonstrably suit with regard to the air pollution criteria for the production of solid alternative fuels (EWC 19 12 10) without any further preliminary certification procedures:

1.3. Positive list of permissionable waste sources for AF-processing and thermal use

Table 1: Permissionable waste feedstock for a sustainable AF-production

EWC	Description
01 03 01	Residues from coal flotation
02 01 03	plant–tissue waste
02 01 04	waste plastics (except packaging)
03 01 01	waste bark and cork
03 01 02	sawdust
03 01 03	splinters, cuts off, blended from wood, chip boards and veneers
03 03 01	waste bark and wood
03 03 02	green liquor sludge (from recovery of cooking liquor)
03 03 06	fibre mud, paper mud
03 03 07	mechanically separated rejects from pulping of waste paper and cardboard
04 02 01	wastes from untreated textile fibres and other natural fibres, mostly vegetable origin
04 02 02	wastes from untreated textile fibres, mostly animal origin
04 02 03	wastes from untreated textile fibres and mostly artificial and synthetic origin
04 02 04	wastes from untreated and mixed textile fibres before spinning
04 02 05	wastes from finished textile fibres mostly vege-table origin
04 02 06	wastes from finished textile fibres mostly ani-mal origin
04 02 07	wastes from finished textile fibres mostly artifi-cial and synthetic origin
04 02 08	wastes from finished and mixed textile fibres
04 02 09	wastes from composite materials (impregnated textile, elastomer, plastomer)
04 02 10	organic matter from natural products (wax etc.)
04 02 99	wastes not otherwise specified
07 02 99	wastes not otherwise specified
08 01 03	wastes of colours and lacquers on water basis
08 01 04	colours in powder form
08 01 05	hardened colours and lacquers
08 03 03	wastes of water-mixable printing inks
08 03 09	used up toner, incl. cartouches
08 04 03	wastes of water-mixable adhesives and sealant
08 04 04	hardened adhesives and sealant
08 04 07	aqueous dredges, containing adhesive + sealant
09 01 07	photographic film and paper containing silver or silver compounds
09 01 08	photographic film and paper free of silver or silver compounds
10 01 02	coal fly ash
10 01 05	calcium-based reaction wastes from flue-gas desulphurisation in solid form
10 03 10	wastes from treating salt slag and black itch
10 12 06	discarded moulds
12 01 02	ferrous metal dust and particles
12 01 05	plastics shavings and turnings
12 01 13	welding wastes
13 01 02	other chlorinated hydraulic oils (no emulsion)
13 01 03	no chlorinated hydraulic oils (no emulsion)
13 01 06	excluding mineral hydraulic oils
13 02 01	chlorinated engines-, transmissions- and lubri-cation oils
13 02 02	not chlorinated engines-, transmissions- and lubrication oils
13 03 01	insulating or heat transmission oils cont. PCBs
13 03 02	other chlorinated insulating oil, warm-transmission oil or liquids
13 03 03	other not-chlorinated insulating oil, warm-transmission oil or -liquids
13 03 04	synthetic insulating oil, warm-transmission oil or -liquids
13 03 05	mineral insulating- and warm transmission oil
13 06 01	oil mixtures not mentioned
15 01 01	paper and cardboard packaging
15 01 02	plastic packaging
15 01 03	wooden packaging
15 01 05	composite packaging
15 01 06	mixed packaging
15 02 01	absorb- and filter material, cloths and protec-tive clothing
16 01 03	end-of-life tyres
16 02 07	wastes from synthetic material processing in-dustrial
16 03 02	organic miss charge (lack load)
17 02 01	wood
17 02 03	plastic
17 06 02	other isolate material
17 07 01	mixed building break and dolomite waste
19 09 04	spent activated carbon
19 09 05	saturated or spent ion exchange resins
20 01 01	paper and cardboard
20 01 03	small partial of plastic
20 01 06	other plastics
20 01 07	wood
20 01 10	clothes
20 01 11	textiles

2. Collection

2.1. Separate Collection

Where a reliable waste management system is developed, bringing and fetching systems are established which are served by private and public disposal companies as well as by the people.

Additionally, waste such as production residues, wrapping or recyclables like paper, plastic, metal, clothes, glass, e-scrap etc. are separately collected from hazardous waste which will hinder a proper sorting and further recycling.

Alternative fuels from C+IW will be purchased selectively and directly from the waste producer, while unsuitable waste is rejected. The efforts for acquisition, transport and analytical testing are higher, but they are compensated by a reduced amount of impurities and its disposal costs, a lower gate fee to or even by revenues for an excellent AF-quality from the customer.

In general, the sense of disposal taxes is to force the waste producer to avoid and to pay for an environmentally sound disposal of his unavoidable waste according to the polluter-pays-principle. The waste volume shall be reduced or at least a better recycling potential shall be achieved by separation.

2.2. Commingled Collection

Worldwide, collection systems range from no system which is only organised by the informal sector to a "one-ton system", or as a separate "dry-wet system" to a sophisticated "multi-ton system".

But in most cases, you will find a simple one-ton system, where all wastes, which are unsuitable for hand pickers shall be disposed in a commingled manner incl. hazardous and medical waste or other impurities.

Alternative Fuels produced from such a commingled waste source must therefore be processed at a significantly higher level than suitable commercial and industrial waste, which can be selectively sourced from a well-established waste market (“cherry picking”).

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3. Solid Waste Assessment (SWA)

In the EU the characterization of waste which shall be pre-processed starts with the assignment to the waste catalogue code.

In countries without regulated waste management system all fractions from households, and commerce and industry will be collected and dumped in a mixed manner.

The objective of the SWA is to classify suitable and unsuitable components and to evaluate its potentials for valuable such as customized solid alternative fuels (AF), compost, biogas, paper, cardboard, polymers and metals, or to define the need for dispose of impurities on a sanitary landfill or in a waste incinerator.

Therefore the manual classification by a SWA is to identify and determine the waste composition and the portion of each fraction, whereby the waste is differentiated according to 16 classes (conf. 3.1.).

As a side effect, it should be noted that these data can be used to draw up a compulsory waste management plan for each portion.

The knowledge of the waste composition is of fundamental importance for the design of treatment plant and the further properties, which have to match the requirements of the envisaged valorisation process as a solid alternative fuel:

1) That includes the initial components for the resulting solid alternative fuel,

2) The quantity and quality of recyclable, non-recyclable fractions or pollutant carriers shall be identified,

3) Important data shall be obtained for the design of treatment plants and their material flows, and consequently its performance, respectively its economy

4) CO_2-neutral components relevant for GHG-emission-trading will be identified

The visual classification does not replace the chemical analysis of the waste. It is only suitable to determine the components and their amount in the MSW.

The preliminary analysis is concerned with the provision of necessary background information such as:

- General description of the region and seasonality

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- General population information and its social strata regarding residential structure, collection system, bin size, source of waste (household, craft, services etc.), socioeconomic influences, collection day, and among others such as levels of public education or environmental awareness etc.
- Creating a selection basis adopted to the envisaged region
- Planning the days and number of sampling units for each stratum and to ensure a representative measure period (at least two analyses per year in accordance to the standards that characterize the communities, regardless of the development level and social habits)

3.1. Execution:

Based on the preliminary analysis regarding collection system, geographical and topographical aspects the amount of the increments shall represent 1 - 2% of each garbage truck in order to equalize uncertainties of the waste analyses.

Fig. 3: Example of a waste assessment by manual classification executed in Morocco 2013 (WLTP)

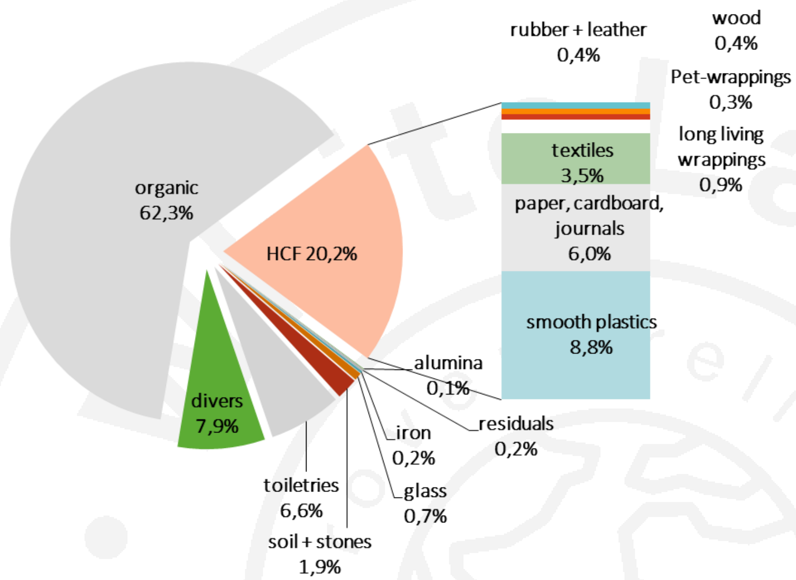

Fig. 4: A meaningful waste assessment shall reveal the composition of the commingled waste and its potentials for recycling, thermal use and its portion of disruptives to be disposed

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The visual classification should be repeated at least over a period of one week and, depending on the different seasons, even several times a year directly when the waste in question shall be disposed.

- a sound flat surface is first to be prepared on which the tarpaulin can be spread out, secured with earth spikes and on which the sorting table can be placed
- Max. 10 m^3 of the collection truck content shall unload next to the tarpaulin, so the liquid can drain off and will be determined later by back weighing of the truck and recalculating the mass balance
- the whole trash shall be screened <40mm by the sorting table and will be divided into the following fractions manually and finally weighed:

1. fine fraction smaller than hole size (drop through of the screening table <40 mm), and the coarse fraction larger than hole size, is
2. Paper, cardboard, cartons

3. Textiles
4. Wood
5. Glass
6. PET
7. 3-D plastics (thick-walled hollow bodies, e.g. for flushing agents or engine oil, etc.)
8. PVC (tested by BEILSTEIN in case of uncertainty)GHG
9. Composite material (e.g. tetrapak, GRP[1], etc.)
10. 2-D and plastic films (exclude PVC)
11. Cumulated or separately specified metals such as iron, aluminium or other non-ferrous metals, alloys etc.
12. Electronic scrap, batteries and bulbs
13. Construction waste, mortar, ceramics (mineral)
14. Organic/ bio-waste/ green cut
15. toilet/ hygiene articles
16. Remaining portion (indefinable > 40 mm)

The educated collections team should collect the sampling units from the predetermined properties by emptying or exchanging the selected container on the day of the regular collection interval.

Components which are relevant for the “greenhouse gas” or “CO_2“-emission trading system are organics, paper, cardboard, journals, wood, a certain portion from textiles as well as rubber. Its portion in the waste in question should therefore be determined carefully.

The relevant analyses for the use as an alternative fuel from the larger fractions (>40 mm) are carried out, while the fine fractions <40 mm will be evaluated on their suitability for the biological treatment such as composting or fermentation for methane generation.

personal notes:

[1] Glassfibre Reinforcement Plastics

For the further use as an AF it is mandatory to know the calorific value by modelling by simulating pre-processing or by analysis. Usually, the AF shall obtain properties which are close to the primary fuels used in the envisaged thermal process such as power plant or cement kiln.

To receive later best thermal substitution rates without any impact on the process, the product or the emission, volatile elements such as Hg, Tl, Cd, As and Pb have to be determined as well as to reduce the product-effecting ash composition.

These elements are characterized by their level of evaporation and escape from the thermal process.

The equipment of the pre-process has to be designed in advance to the properties of the waste to be pre-processed, and after the technical assessment the tolerable concentrations such as of moisture, sulphur, chlorine or heavy metals etc. have to be adjusted also in accordance to the envisaged exploitation processes.

In order to evaluate the biological treatment to produce biogas or compost, methanogenic activity, respirometry (oxygen consumption in an aerobic degradation process) and heavy metals (As, Cu, Pb, Ni, Cr, Zn, Cd, Hg) have to be analysed in the fraction <40 mm as well.

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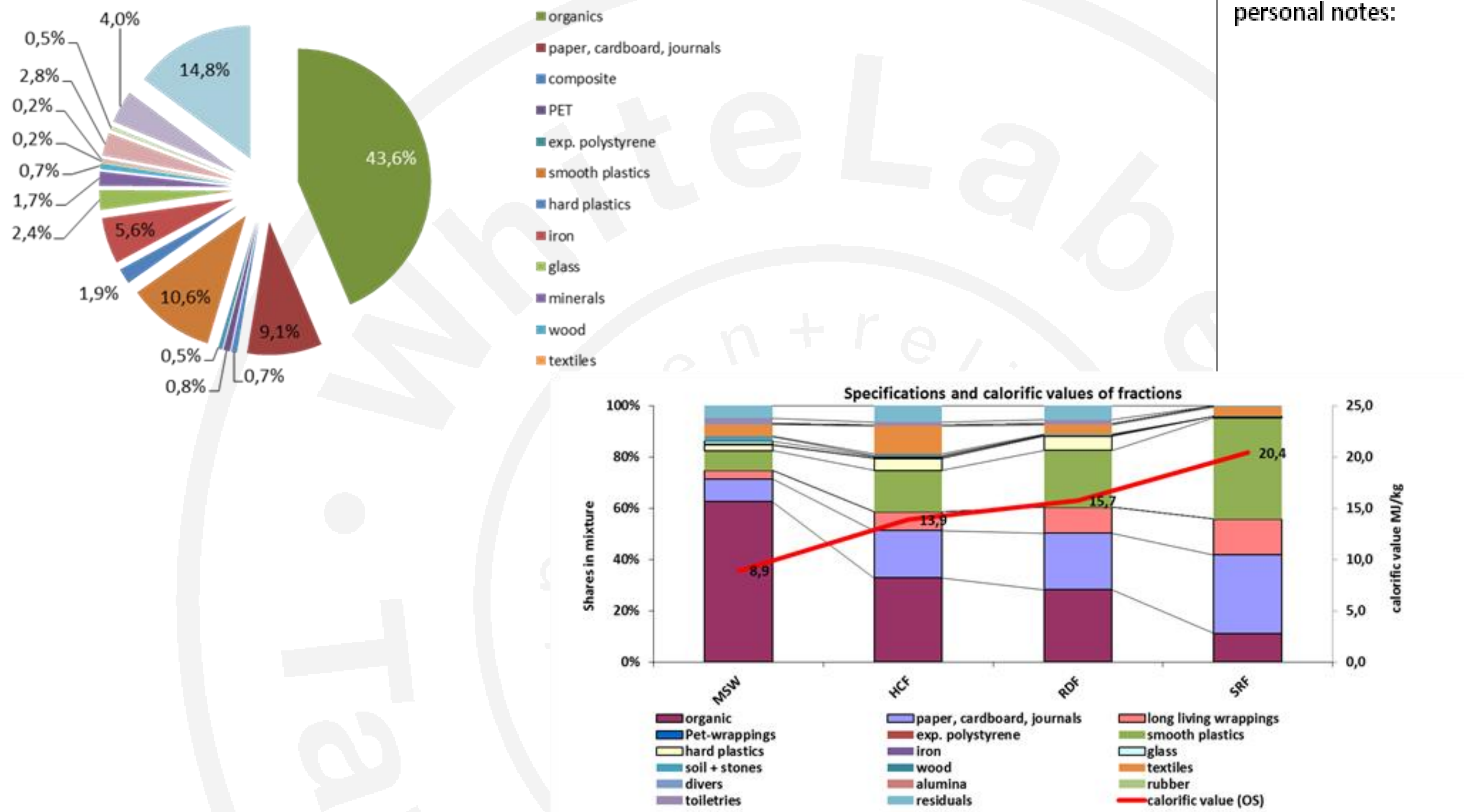

Fig. 5: After simulation of a RAL-awarded MBT the quantity and quality of recycling materials and the efforts to produce suitable fuels can be simulated and matched with the assessed thermal process.

Property		Detection methods
Water content	wt.-% DM	RAL-GZ 724 or CEN/ TC 15414
Sulphur	wt.-% DM	CEN/ TC 15408
Chlorine	wt.-% DM	RAL-GZ 724 or CEN/TC 15408
Ash content/ Loss of ignition	wt.-% DM	RAL-GZ 724 or CEN/ TC 15403
metallic aluminum	wt.-% DM	CEN/ TC 343/ WG 5 N 69 or CEN/TC 15401
Calorific value	kJ/ kg	DIN 51900 or CEN/ TC 15400
Gas forming potential (GB_{21})	NL[2]/kg DM	In accordance to the German Waste Deposition Ordinance (AbfAblVO)
Heavy metal content		
Mercury	mg/MJ DM (older version mg/kg DM)	RAL-GZ 724 or CEN/ TC 15411
Cadmium		
Thallium		
Arsenic		
Lead		
Chlorinated organics		
PCP	mg/kg DM	DIN EN ISO 15320
PCB	mg/kg DM	DIN 51 527-T 1
Chlorobenzene	mg/kg DM	NATO

Table 2: Methods and standards for chemical waste and fuel analysis in accordance to the standards (WLTP 2010, Terra Melhor Ltda 2015)

The objective of a characterization of commingled solid waste is generally common, meanwhile the development of methodologies and their specifications are a consequence of management policies and regulations. Thus, the methodologies are adaptable according to the objectives for measurements and must be clearly defined by the operator who initiates the characterization campaigns.

[2] Norm liter per kilogram input after 21 days

The currently applied characterization of commingled solid waste distinguishes dry and wet material, not humid. Other analysis focuses on the quantity of recyclable materials, such as metals, paper, cardboard, glass and plastics, and organics.

Here, the waste management strategy shall focus only on separation of recyclables, combustion and landfilling of the rests. Due to the lack of detailed information on the quality of generated waste, other supplementary treatment and revenue options cannot be derived.

Specific challenges of waste assessment:

- Guarantee the personal protection for the people respectively of hands and feet.
- Cover the discharge area with foils to avoid material contamination.
- Identify each polymer separately when materials recycling is envisaged
- Efficient weight control – only the same person is responsible for the registration.
- Use always the same standards for chemical analysis.

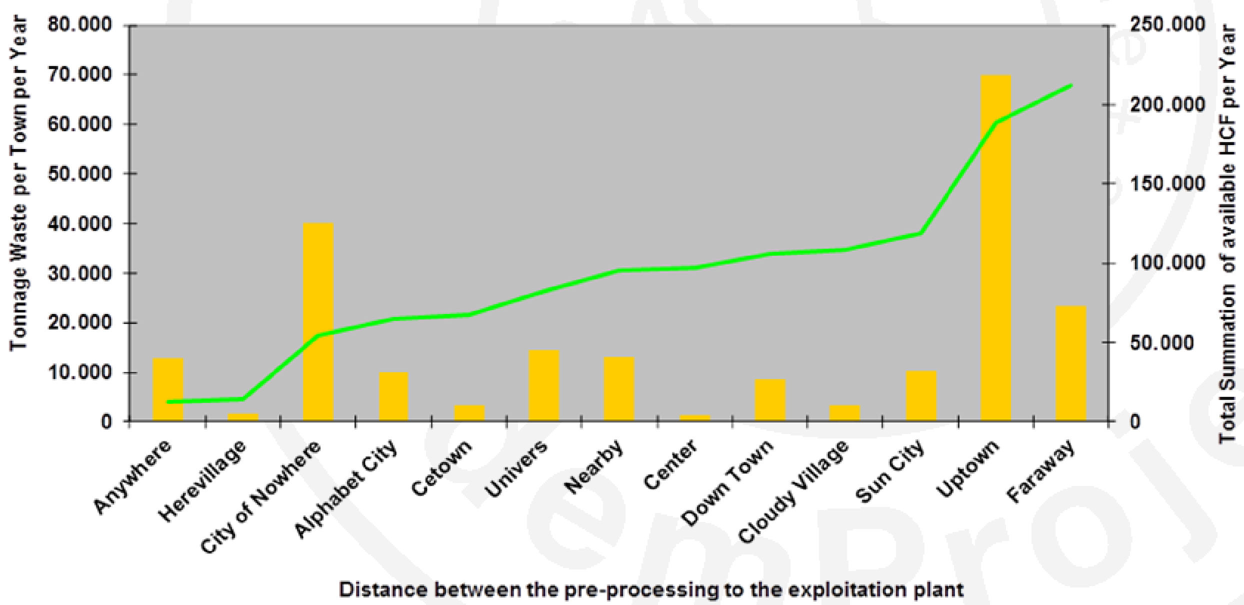

Fig. 6: Exemplary display of distances from a local point and the accessible amount of HCF (green) and its demand of waste to be collected (yellow bars).

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Thereby, accurate data on waste composition and quality is an indispensable basis for further and long-term planning for a sound resource management and its implementation with the required suitable technologies.

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Potentials and targets for recycling, fermentation and composting, and the generation of alternative fuels (AF) must be determined before the erection of a pre-processing facility in order to performance and to prevent losses of investment.

4. Technical Assessment

Both, the assessment of already existing thermal facilities such as a district heating, pyro process of a cement work or a fossil fired power plant, as well as the previous waste assessment will form the foundation for the design of the required pre-treating plant. Therefore, a careful coordination with the later user of the alternative fuel is of enormous importance for a long-term and reliable cooperation. Even if the processes may look the same from the outside, each production facility is individually designed for its local conditions, products and market.

The technical assessment of the recovery process defines the specifications of the alternative fuels that are ultimately to be achieved by the waste conditioning. This clearly defines the need for suitable technical equipment and its design and optimises the effects on approval capability and operation:

• Type and composition of coal which has to be substituted

• Type of combustion technology, availability and forecast

• Specification of the AF such as particle size and form, retention time particular its burn out, quality parameters like calorific value, chlorine (causing corrosion), ash content and its composition, remaining unburnt carbon which may hinder a later use of the slag and fly ash, heavy metal loads (air pollution control and its potential need of a separate disposal of fly ash as hazardous waste etc.)

• Quality monitoring, automatic sampling and agreed chemical standards

• Logistics and necessary modifications such as reception, materials handling, feeding and dosing

• Future demand of GHG-allowances

• Approvals and public acceptance

4.1. Fossil-fired power plant

Depending on the purchase or local deposit, different fuels can be used for heating and power plants. Typical power plants for direct co-incineration of waste derived alternative fuels are fed with peat, lignite, hard coal or anthracite. Gas- and oil-fired power plants must be modified or replaced wherever possible first, which also results from the technical evaluation.

In the past, peat extracted from open deposit was usually burned in form of sods on a grate, and with a capacity of a few megawatts. Modern large power plants (i.e. Ireland, Finland, Sweden or Belarus) have firing capacities of several hundred megawatts. They operate fluidized bed combustion technology which suits due to the high moisture entrance and ash content and the low softening temperature of those ashes.

If the deposits weren't exposed by erosion hard coal is normally mined from the underground, and lignite is extracted from open mines. Due to the mountain humidity lignite is coked first and then ground and burnt or it can pass a direct grinding drying for feeding the combustion vessel.

Coal fired power plants are using pre-processed coal, which are “washed” (flotated) to reduce and to segregate minerals generating fly ash and slag from the carbon content, after that the coal will be blend and also ground very fine (<100µm) in a mill and directly fed to the boiler.

Power plants fueled by lignite generate electricity for the base load (constant operation) and hard coal fired power plants are mainly for the medium load which influences its availability and consequently its supply with AF.

Gas-fired power plants cover the peak load because they can be started and shut down quickly. Therefore they are not suitable for using waste derived AFs.

In addition to fossil-fired power plants and combined heat-power (CHP) plants, biomass power plants and waste-to-energy plants (WtE) are also been designed with increasing capacities, recently.

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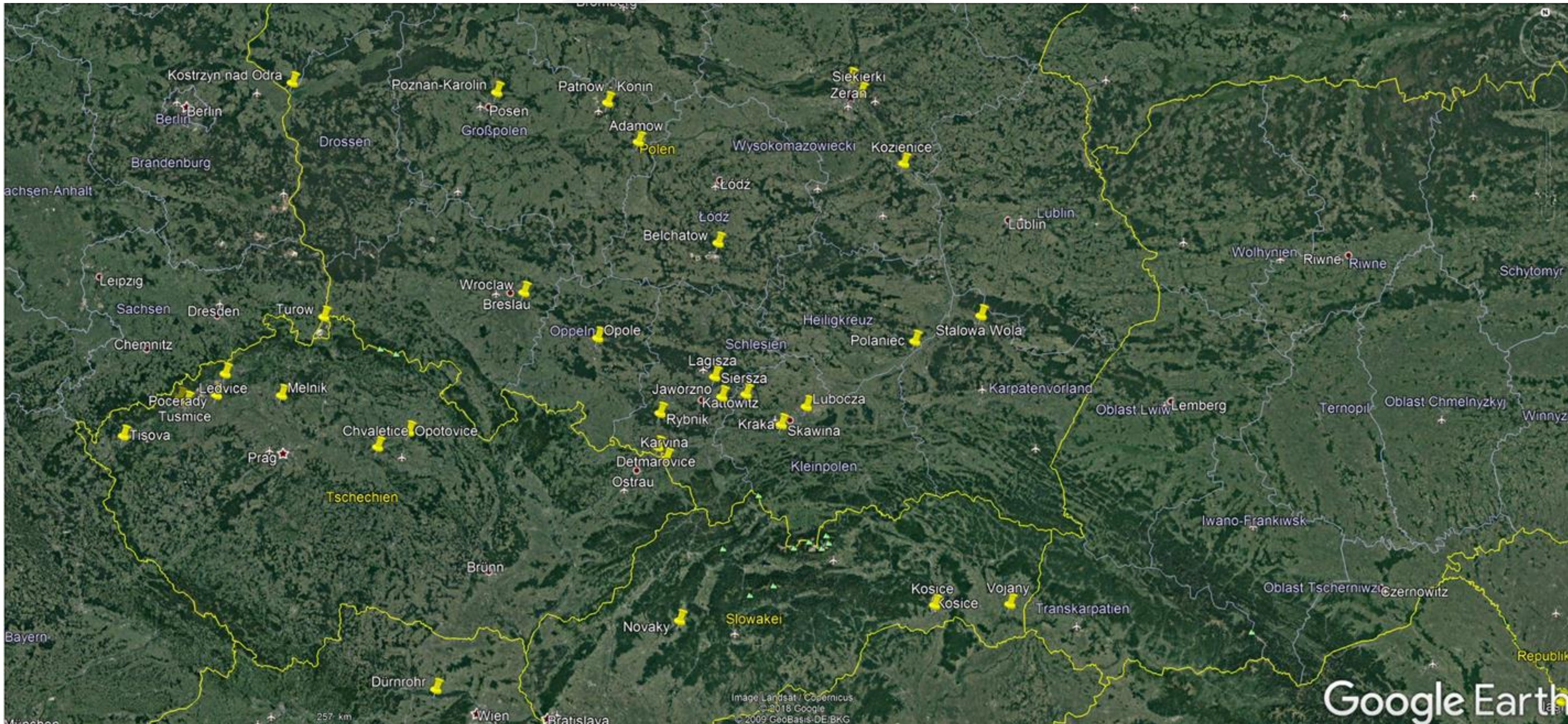

Fig. 7: A map of a region where coal fired power plants are operating that may suit for co-incineration of waste derived solid alternative fuels

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4.1.1. Direct feeding

For a direct injection the solid waste has sufficiently to be segregated from impurities that may disturb the feeding, grinding and the thermal process. This means that the particles must mandatorily and completely burnt out after leaving the burners mouth, i.e. before sinking into the de-slagger or entering the heat exchanger.

The waste pre-treating process requires a high level of quality, as the SRF particles only have a short residence time within the geometry of the combustion boiler to burn out. This means that no unburned particles are acceptable to enter the electrostatic precipitator or falling into the de-slagger. Consequently, SRF must be air classified during the conditioning process to exclude heavy, wet or compact 3D particles of polymers, rubber, wood etc.

4.1.2. Co-grinding

In the case, the feedstock waste source consist of a lot of wet or unavoidable 3D-materials, the SRF has to be ground on the coal mill afterwards. Co-grinding is done either by dosing the SRF as a fully pre-processed loose material stream not directly fed onto the burner but add to the coal stream to the coal mill or, still better, separately dosed into the coal mill.

The SRF shows a light bulk density and must nevertheless be prepared very carefully, because otherwise remaining impurities may lead to enormous wear and even metals (especially aluminium) can even be forged into ingots, which will destroy the grinding process.

In order to make milling more efficient, the hardness of the material shall be increased by pelletizing before grinding. The soft components of the alternative fuel that absorb the impact energy are supposed to become more brittle that they are pulverized with the coal as far as possible and burned optimally. However, the proof of the supposed effect and its energy efficiency of this so-called "sub-coal process" is still pending.

4.2. Waste-to-Energy

In the case no classical thermal process such as cement kilns or power plants are available or all the thermal capacities are saturated, it might become interesting to replace old district-heating plants (DHP) and install new so-called Waste-to-Energy power plants, which are designed for pre-processed HCF.

Contrary to the popular delusion that this is only another type of waste incinerator, it is in fact a modern technology which bases on the development of the proven grate firing system. The grate can be air or water cooled, but the pre-processed and specified alternative fuel can be used to generate steam for industrial purposes for the manufacturers of paper, food, medicine, textiles etc. or to generate district heat or electricity which will be fed into the public grid.

With regard to each individual target the solid waste has to be pre-treated into the specified AF to match the operational needs.

In this constellation, the required waste pre-processing facility and the final thermal technology can be adjusted and designed in a cheap and optimal manner.

MSW shall be segregated on a simple level into recyclables, organics, impurities, and the combustible portion which is called High Calorific Fraction (HCF) with a diameter <300mm and a CV of ~12-16 MJ/kg which suits best to a grate firing or a robust CFBC.

When a combustion technology is installed and is sensitive like a stationary Fluidized Bed Combustion, more homogeneous properties and small range of particle sizes are required. Meaning, on a second level of pre-processing Residue Derived Fuels (RDF) with a diameter less than 120 mm and a CV between 15 and 18 MJ/kg are to be produced.

4.2.1. Fluidized-Bed Combustion - FBC

Stationary Fluidized-Bed combustion operates a sand-filled bubbling bed, which is first heated up separately. The AF in RDF quality is burnt in a stationary bed, where the compressed air keeps the sand bed bubbling and ensures a uniform combustion.

However, here RDF has to be pre-processed sufficiently in a two stage process to get a common and stable bubbling point by air pressure for the fluidized bed.

If the proportion of light airborne fuel is too high, the temperature profile will shift from the combustion chamber to the heat exchange area, leading to thermal overheating.

Poor qualities can lead to clogging and to dropping out of impurities falling through the nozzle bottom of the stationary bubbling bed, whereby ashes with alkali content lowering the melting

personal notes:

point will also lead to chemical reaction and reduction of the melting point in the sand bed (enamel formation), and will form blocking aggregates.

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In consultation with the FBC supplier, the waste conditioning of alternative fuels has to run through two levels and shall concentrate on the flyable particles to be minimised, and in particular on the screening of the ashes, which must be carried out very carefully if they contain, for example, alkali-containing residues of wood ash, glass or ceramics.

4.2.2. Circulating Fluidized-Bed Combustion - CFBC

A Circulating Fluidized-Bed Combustion operates a sand-filled loop, which is directly fed by AF in HCF quality. The process is more robust and the 300 mm HCF can be pre-processed simpler in a one-level process.

The combustion profile is evenly distributed over the whole loop, where the sand ensures a uniform heat transfer. The received hot air is separated and sent to the heat exchanger. So, no local thermal overheating will occur.

Although the CFBC is more robust than its FBC sister process, the HCF must also be pre-processed in a sufficient manner in order to avoid the entrance of disruptive materials and clogging in the loop.

Each fuel particle can burn with respect to its particular combustion behaviour: i.e. the retention time it will take to pass through the sequence of drying, pyrolysis, ignition and burnout does not have a significant effect on the circulation or its place of combustion.

4.2.3. Grate fired

Indeed, the combustion of untreated solid waste on a grate is well-known from common waste incinerators, but here the focus lays not on volume reduction and ash disposal, the technology is more dedicated to produce heat and power in a robust WtE-plant with a simply pre-processed HCF. The thermal window of this combustion is more open to higher calorific values and a grainsize of about 300 mm.

The crucial difference is to reduce the occurrence of all combustion-disturbing components such as organic matter, minerals and metals before and to convert the pre-treated HCF to steam for industrial processes or district heating, or to generate electricity for own use or for the public grid.

With regard to the slowly moving grate the HCF particles can burn out individually. Only really hard to burn stuff will leave the grate in unburnt condition.

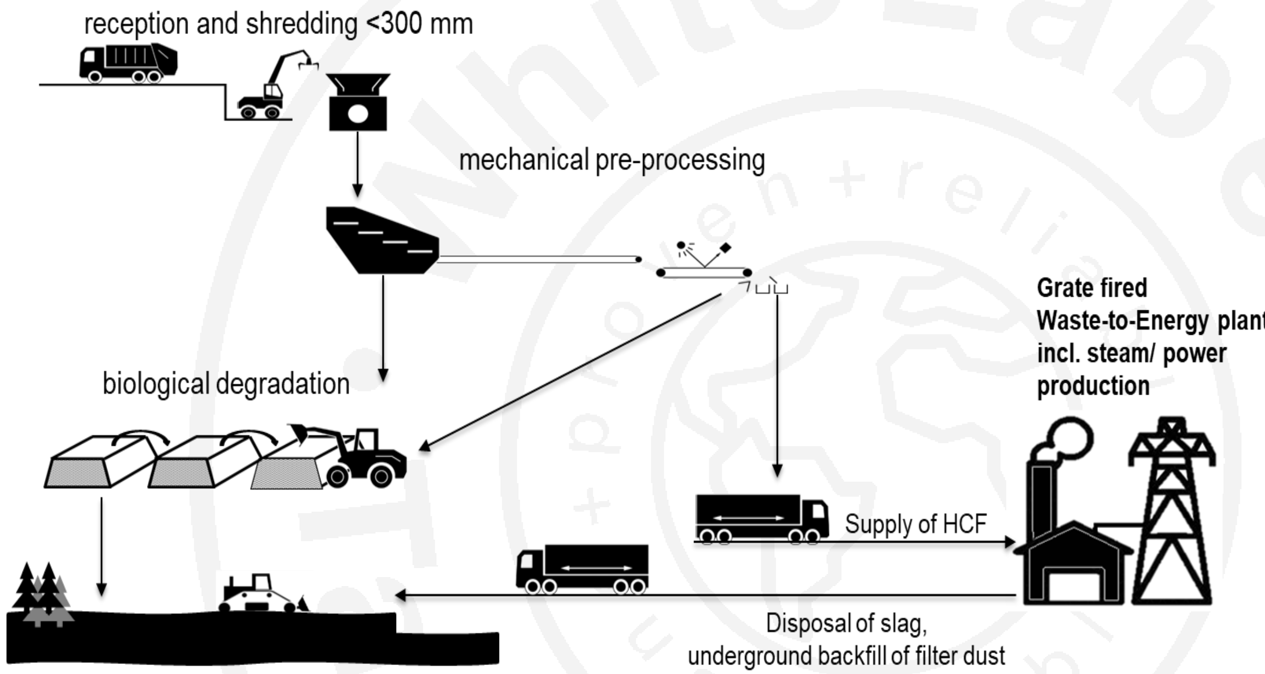

Fig. 8: Exemplary mass flow of processing MSW in a MBT that shall fuel a Waste-to-Energy power plant with customized HCF and will serve a safe disposal of slag and filter dust

The capacity of the currently operated grate fired WtE-plants in Germany (22) range between 35.000 to 400.000 tpy (110.000 tpy in median) and is operated very close to the clients to keep the steam pipes as short as possible.

4.3. Cement work

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Cement is an artificial building material that binds under water, and which is used in concrete to erect infrastructures all over the world. This is why most cement plants are located in the vicinity of cities, where the waste comes from, too.

With regard to the mass balance, cement is produced where limestone deposits are available. That means the modern cement manufacturing process is 90% of mineral raw material such a fine ground blend of limestone, sand, clay and iron in a specific ratio, whilst 10% of the input mass is fuel to burn the clinker, which is an intermediate product on the track to the cement product.

Roughly 85-90% of these 10% of fuel can be replaced by suitable alternative fuels.

So, when we talk about the use of waste derived alternative fuels in the cement manufacturing process, we actually mean the energy consuming, clinker burning process in the rotary kiln and not the (cold) cement grinding in the mill.

This now requires a more detailed explanation: Limestone ($CaCO_3$) is quarried, crushed and mixed with sand (SiO_2), ore (Fe_2O_3) and clay (Al_2O_3) to achieve the correct chemical ratio of the composition of the later clinker mineral composition.

The homogenized raw material is ground to a meal with a diameter of less than 100 µm, fed to the preheating process at approx. 300°C and heated up, while water evaporates and at a temperature of approx. 900°C CO_2 is expelled from the limestone. After leaving the preheater, iron and aluminium starts melting from 1000°C and incorporates the free lime (CaO) and silica in order to obtain the desired clinker mineral reaction.

The final cooking process starts at approx. 1450°C in the direct contact to the main burners flame. The ashes will also become part of the clinker formation process, which is therefore been called “co-processing”.

Finally, the clinker is leaving the rotary kiln and has to be cooled down rapidly in the clinker cooler. This cooled clinker is the feedstock to grind an so called Ordinary Portland Cement (OPC) in the presents of sulphates such as gypsum (natural or from flue gas desulphurisation of power plants) and anhydride (natural or from chemical processes) and further admixtures such as slag, fly ashes, lime etc. to get binders in accordance to the international cement standards.

This OPC is the binding material which is mixed with water, admixtures and aggregates to formulate the concrete right for its specific properties like cast-in-place-concrete until shotcrete.

The worldwide capacity (2018) is roughly 3.799 mio. tons of cement distributed on 4.707 kilns. 77% of this production capacity is operated by so-called dry process technology and only 3% are operated by wet kiln process. The rest are old semi-wet and shaft kilns, whilst data of the rest 10% of the worldwide capacity are not clearly listed.

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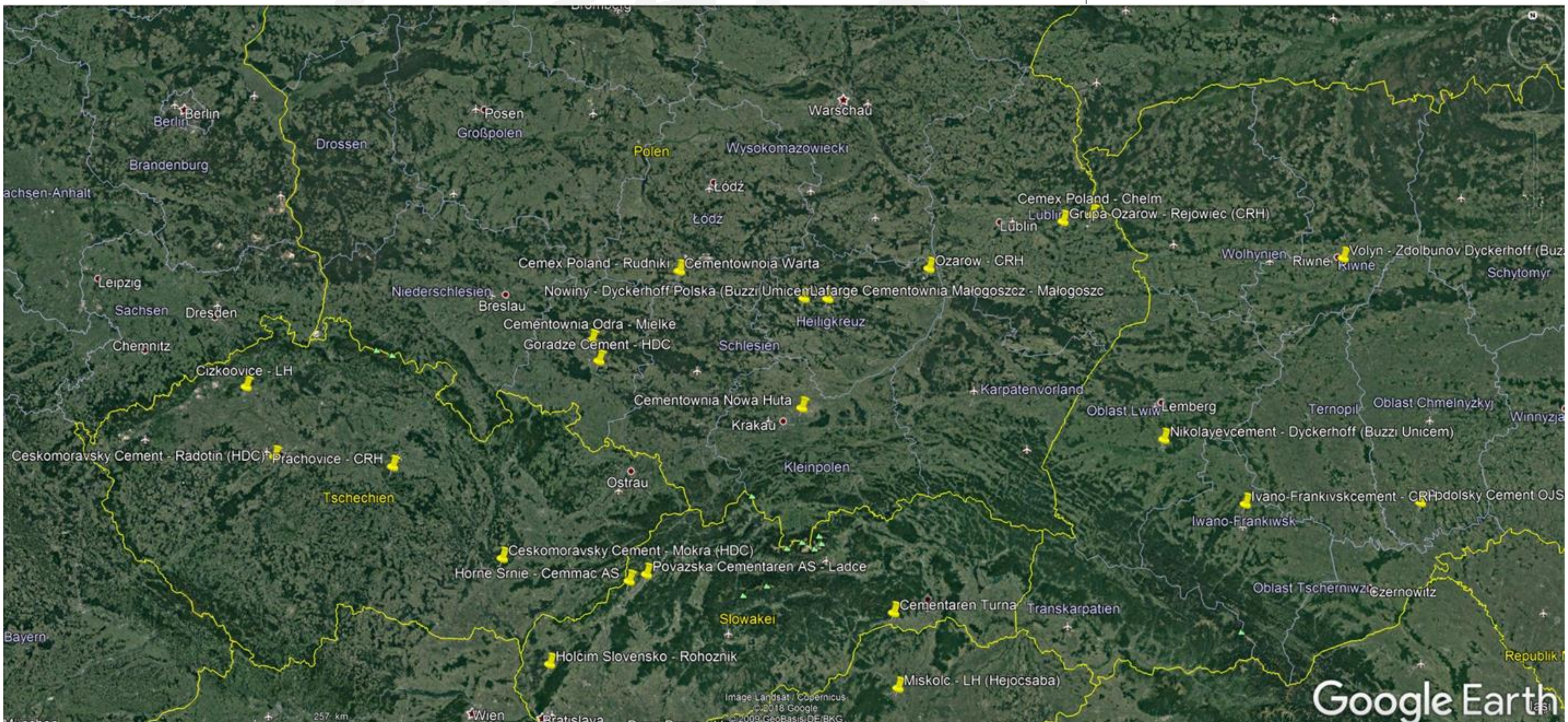

Fig. 9: A map of a region where cement works are operating that may suit for co-processing. Which type and how customized AF will be produced individually depends on the clients process, product and permission

The production of clinker is energy-intensive. Theoretically an average of 1.75 MJ of thermal energy is needed to burn 1kg clinker. The actual requirement for thermal energy in modern plants is approximately 2,9 to 3,2 MJ/kg (BREF 2001) depending on the process, up to 4 MJ/kg in semi-dry processes. Most installations use the dry process, which is the most economical in terms of energy consumption.

In practice, SRF with an average net calorific value of at least >20 MJ/kg are normally used in a main burner system.

RDF with a lower calorific value of 18 – 20 MJ/kg can be used at the calciner of a semi dry or dry process.

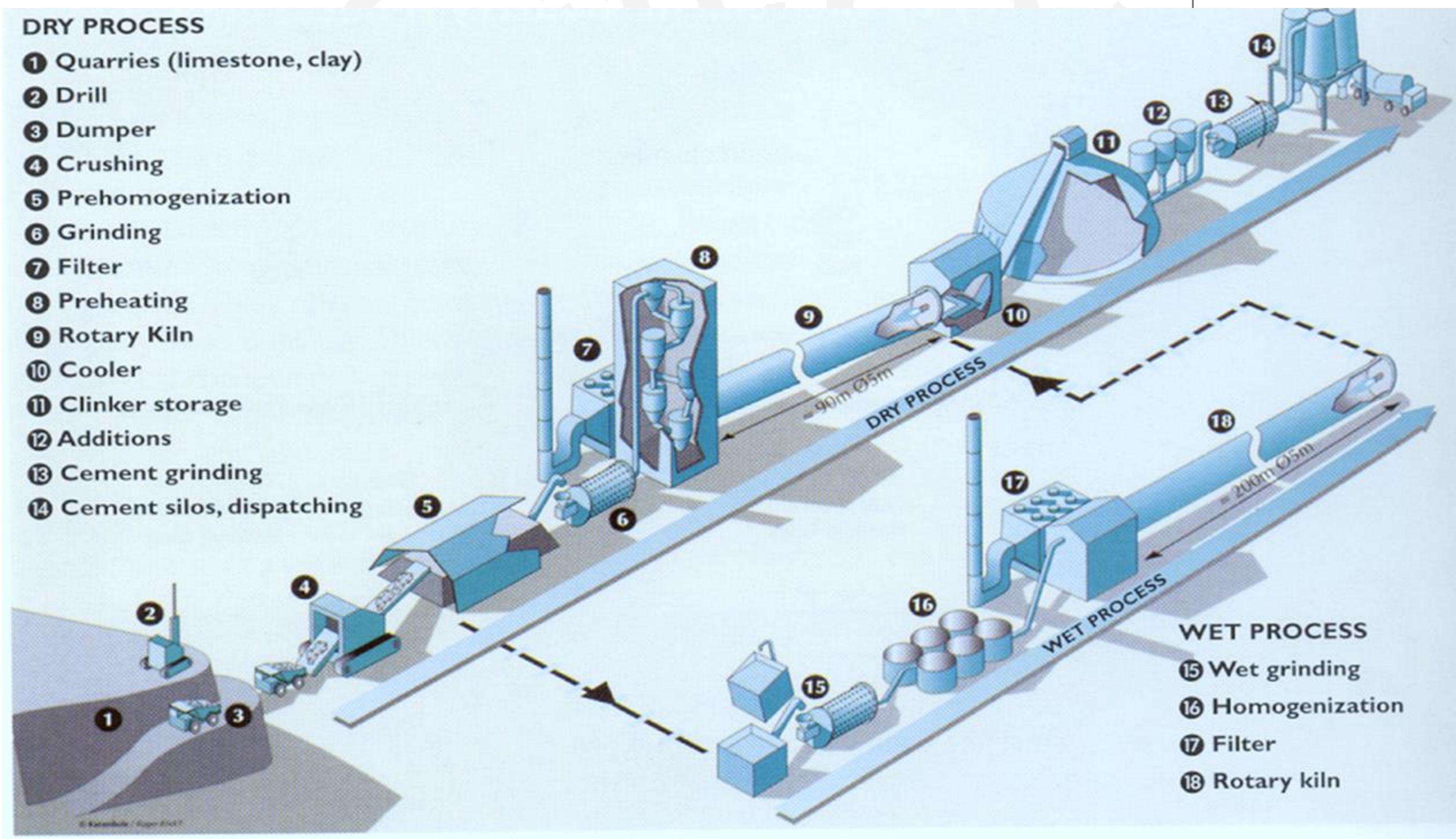

Fig. 10: The manufacturing scheme of cement in a dry process and in a wet process (CEMBUREAU)

4.3.1. Wet process

This Russian process technology, which is still common in the CIS or former USSR-states, is developed to handle raw materials with high moisture content. The raw material were wet ground, homogenized in vats and fed raw material sludge into approx. 200 m long rotary kiln. The sequence of drying, decarbonisation, melting phase and clinker mineral formation is passed slowly to the direction of the oil or gas-fuelled main burner. The energy demand is roughly twice as high as of modern dry kilns.

In the case of co-processing, the alternative fuels traditionally are produced by blending pasty hazardous waste with saw dust to make it solid and dosable. Or hydrocarbon containing oil, paints and solvents etc. are also blend and filtered to get a safe and pumpable liquid for feeding the main burner.

Solid SRF can be pre-processed as well from non-hazardous HCF and C+IW and blend afterwards with the fuel mentioned above to get a sufficient burn out in the flame of the main burner.

There are several options of co-processing in a wet kiln, where the energy demand is covered 100% only by fuelling the main burner:

1) Liquid hazardous waste, which will be blend to a homogeneous liquid or pumpable sludge
2) Solid hazardous waste, which consists of a blend of saw dust with hydrocarbons
3) Solid non-hazardous waste, which consist of 2D-flakes with a short trajectory (SRF) and a sufficient combustion

4.3.2. Dry process

The dry process technology currently is the most energy effective process due to the distribution of 60% of the required energy to the calciner and 40% to the burner at the kilns end. Calciners were introduced into the pyro process lines in the second half of the last century and have brought a substantial advance to the technology of cement manufacturing and its performance. As described above, all cement processes are designed according the counter current principle to guaranty a high efficient energy transfer from the gas to the fine ground raw meal to start the clinker formation.

The dry process offers several points for feeding energy:

1) Pre-calciner in the preheater, where RDF as a low grade fuel can be supplied to extended calciner loops

personal notes:

2) Kiln inlet, where even coarse fuels (such as whole tires) can be fed via pendulum flap or slide valve

3) Kiln end burner (also called “main burner” or “sinter zone burner”), where a 2000°C and stable flame guaranties the proper clinker formation and the high grade fuel SRF will replace coal, and

4) increasingly, a new option of feeding coarse HCF is characterized by a pre-combustion chamber which is added on the calciner

Therefore, solid waste has to be pre-processed to several customized qualities and can be supplied to the rotary kiln depending on the strategy and point of feeding at the individual kiln process.

In this context, it has to be noted that all types of waste derived fuels must be sampled and analysed in accordance to the permit (compere "10 Legal Aspects"). And, additional quality monitoring of the input criteria related to the process and the product, which have also become part of the agreed delivery contract (cf. chapter 13), must be monitored as well.

It is recommended to equip the facility to pre-process solid waste in a three-stage pre-processing to extract customized:

1) HCF for the pre-combustion chamber

2) RDF for the calciner

3) SRF for feeding the main burner directly

In addition, a uniform quality assurance system along the entire pre-treating chain is required between the conditioner and the customer in order to monitor the proper operation of the pre-treating plant and to prove compliance with the contractually agreed delivery specification during the final recycling process.

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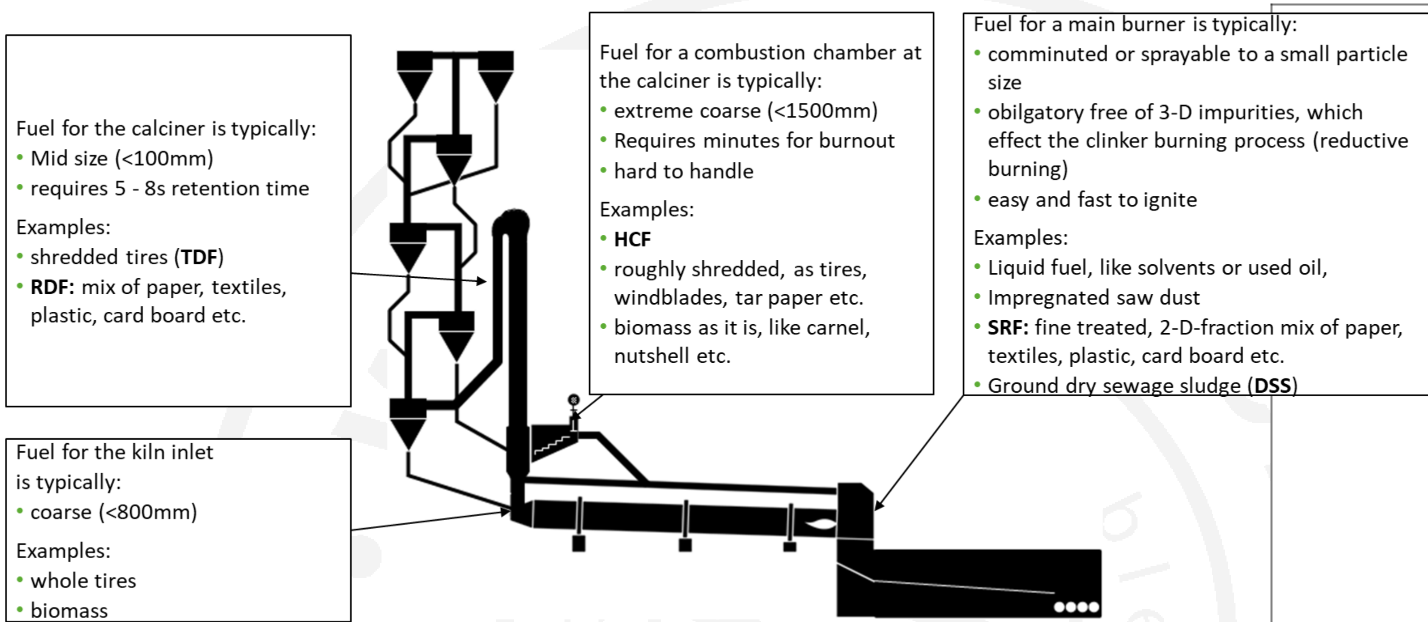

Fig. 11: Points of feeding different types of alternative fuels to a kiln of a modern dry process

4.4. Lime production

In principal the production of quicklime (calcium oxide) is based on deacification of chalk or limestone.

Burnt lime or quicklime is produced in larger quantities by burning limestone (calcination) in a rotary or a shaft kiln. Calcium carbonate (chalk or limestone) is deacidified at a temperature of around 800°C, i.e. carbon dioxide is expelled and calcium oxide is leaving the thermal process. Due to the further use, the qualities will be produced in different types of kilns.

Such as lime qualities are produced, e.g. for mortar, as filler in paper, paints or in food, as filter media and other applications.

Based on the quality of the deposits and the subsequent application, the lime-stone is burnt in various types of kilns.

4.4.1. Rotary kiln

personal notes:

Quicklime burnt in a rotary kiln is often used as a filter medium for water cleaning or exhaust gas purification.

In contrast to the already known pre-calciner at the cement pyro process, the rotary kilns here only work with the hot exhaust gas of the main burner during lime burning. Common fuels such as lignite or hard coal can also be substituted by SRF, but the main burner flame is also in direct contact with the product. However, the SRF quality is very demanding due to the subsequent application of the lime. The concentration of chlorine and ash, and in particular, aluminium (e.g. from beverage cartons) are limiting the entrance.

The concentration of chlorine and ash, and in particular, aluminium (e.g. from beverage cartons) are limiting the entrance, and can only be guaranteed by a selective collection of high-grade and suitable waste

In the case the pre-processing facility will only consist of a pre-shredder, magnet separation, eddy-current and a NIR system are mandatory to control the entrance of chlorine and aluminium and a fine shredder to comminute down the SRF to ~25 mm..

To avoid reductive burning and encapsulation of unburnt particles, SRF has to be air classified as usual for being fed to a horizontal flame.

Impurities will occur negligible, when the C+IW acquisition and its quality surveillance in front of the shipment to the AF-production will work highly efficient.

4.4.2. Shaft

Shaft kilns are even more efficient for lime burning than rotary kilns because they burn the lime in smaller batches. The coal burns continuously in a separate combustion chamber or gas is burnt directly injected by lances. The hot gas is blown alternately through one shaft at a time, while the other shaft is cooled, emptied and refilled again.

Currently (2019), attempts are being made to further comminute alternative fuels with special mills and to feed it pneumatically, or further approaches are also being made with co-grinding pellets in the coal mill.

Please note that co-grinding requires a prior pelletizing, that again needs a sufficient three-stage pre-processing to avoid the entrance of impurities which are blocking the pan grinder matrix respectively the energy intensive pelletizing process.

The total demand of pulverised SRF for a lime shaft kiln is very small in comparison with a cement kiln, so the economy as a well as the energy balance so far is not given due to the low world energy price and the required high investment.

5. Requirements and Specifications

5.1. General Remark

In general, the use of alternative fuels requires a comprehensive monitoring of the combustion which is the core of all the thermal production process, and which will define the efforts of pre-processing.

It is mandatory to control the processes continuously by using modern measurement technology. A constantly fixed inspection inclusive sampling and analysis on reception of AF, before shipment and at its arrival on the works in highly recommended.

Ultimately, it is simpler and more cost-effective to rebuild the pre-processing facility than the thermal production process.

Unfortunately, it happened several times in the past that unspecified waste, which originally had to be disposed of separately and safely, and therefore expensively, was mixed with suitable materials intended for other (cheaper) recycling.

Although, there is now a general acceptance of the waste industry, these incidents have led to the legislator introducing the precautionary principle in waste management. Consequently, it is requiring proof by means of quality assurance that the recycled products can be used and have been used without any environmental impacts and damages. For this reason, the definition of waste has been broadened so that such incidents from the past are not repeated.

A transformation from waste to product is therefore not planned from the legal side, even if some countries (mostly those without sustainable waste management concepts) try to relabel their waste as a product in order to export it and to passing by the customs.

personal notes:

The standard EN 15359 on quality classification is frequently cited in this context and often misused for relabelling waste to a product. The original intention of the standard 15359 is only to serve the final user to decide which qualities seem suitable for his process and what efforts will become crucial to install additional equipment. Individual contract agreements are not affected by this.

5.2. Waste tracking

Consequently, by legal requirements any party involved or likely to be involved in waste management shall prove the path from waste origin to its final destiny. In other words, depending on the specific requirements of each country, everyone must carry out the necessary administrative work from the acquisition, collection, processing, transport and pre-processing of the waste to the recycler or the disposing landfill or waste incineration plant.

Each party shall get the same identical list of permitted waste catalogue numbers or specifications (compere Table 1).

If there is no such administration in a country, it is strongly recommended that the companies involved commit themselves to conduct themselves vis-à-vis to the supervisory authorities in such a way as to ensure a reliable waste management.

5.3. Air pollution control

AF can be used in thermal manufacturing processes, which were originally not designed for burning waste derived fuels. Therefore, a more restrictive air pollution control is applied.

To avoid revolving repetitions of complex approval procedures, in the 1999 the Federal Quality Association for Secondary Fuels was registered (BGS e.V.) in Germany. It developed under the umbrella of the environmental ministry and its licensing bodies, and in cooperation with waste processors, recyclers, critics and NGOs, methodes for sampling and analysis and agreed input criteria on the basis of dry mass (mg/kg or ppm), which in the meantime became European standard. In 2012 these criteria become more practical by introducing energy related values as mg/ MJ dry mass.

With regard to the precautionary principle for air pollution control input criteria are agreed as a specification for all types of waste derived fuels during its whole fate.

The most volatile and emission relevant heavy metals are mercury (Hg), cadmium (Cd) and Thallium (Tl).

To compare scenarios between “with and without use of AF” it is advisable to define an average content of heavy metals in fossil fuels for benchmarking. It is used for direct comparison of different types of AF qualities or even serves as the basis for developing material specifications.

The standard is defined as an average content (median) and maximum (80%-percentile) of heavy metals. The reference calorific value in solid AF derived from C+IW ready to use is 20 ± 2 MJ/kg, while the calorific value content for the high calorific fraction of municipal waste has initially been fixed at 16 MJ/kg.

5.4. Combustion properties of SRF

In general, it is always assumed when AF particle is as small as possible, the surface is as large as possible and the fuel particle burns out completely. This is acceptable for HCF and RDF, but it is a misconception for SRF!

Combustion is a diffusion-controlled reaction, whereby the offered oxygen oxidizes the reaction partner such as hydrogen or carbon. The time for combustion is therefore determined by the time for passing the sequence of water evaporation (drying), pyrolysis, ignition of the pyrolysis gas and the carbon burn out on the available surface of the individual fuel particle.

However, in a heterogeneous SRF mixture, as it is produced from a wide variety of waste by pre-processing, there are also 3-dimensional pieces of wood and rubber, as well as thick-walled pieces of plastic, which do not burn completely during their short passage through the flame.

For this reason, additionally SRF has mandatorily to be quality monitored by analytical air classification and specified by its rate of sinking which is correlated with the kiln end burner.

HCF <300 mm processed from MSW and presorted C+IW			number of analysis	minimum	average	**median**	**80. percentile**	maximum
physical properties	grain size	mm	83			**300**		
	calorific value	kJ/kg OS	83	5.800	12.652	**11.900**	**15.380**	24.400
composition	dry substance	wt.-% DM	83	52,90	71,19	**70,70**	**80,26**	91,00
	moisture	wt.-% OS	83	9,00	28,81	**29,30**	**35,70**	47,10
	ash	wt.-% DM	83	2,80	24,64	**24,60**	**29,46**	60,70
	chlorine	wt.-% OS	80	0,20	0,90	**0,50**	**1,30**	4,70
	fluorine	wt.-% OS	16	0,04	0,04	**0,04**	**0,04**	0,04
	sulphur	wt.-% OS	16	0,10	0,16	**0,10**	**0,10**	1,00
trace element content	antimony	mg/kg DM	16	3,00	16,13	**11,50**	**25,00**	42,00
	arsenic	mg/kg DM	16	1,00	1,98	**1,00**	**2,70**	5,50
	beryllium	mg/kg DM	16	0,20	0,21	**0,20**	**0,20**	0,30
	lead	mg/kg DM	16	17,00	146,50	**79,00**	**320,00**	380,00
	cadmium	mg/kg DM	16	0,20	9,35	**0,20**	**1,80**	76,00
	chromium	mg/kg DM	16	12,00	62,69	**44,50**	**81,00**	200,00
	cobalt	mg/kg DM	16	1,20	7,96	**5,15**	**5,80**	61,00
	copper	mg/kg DM	16	41,00	348,31	**135,00**	**640,00**	1.400,00
	manganese	mg/kg DM	16	68,00	113,81	**93,00**	**130,00**	270,00
	nickel	mg/kg DM	16	10,00	23,81	**15,50**	**32,00**	73,00
	mercury	mg/kg DM	16	0,20	0,27	**0,24**	**0,30**	0,54
	selenic	mg/kg DM	16	1,00	1,00	**1,00**	**1,00**	1,00
	tellurium	mg/kg DM	16	0,40	0,51	**0,40**	**0,50**	1,20
	thallium	mg/kg DM	16	0,40	0,44	**0,40**	**0,40**	1,00
	vanadium	mg/kg DM	16	1,90	9,53	**6,50**	**8,10**	59,00
	tin	mg/kg DM	16	4,00	32,25	**11,50**	**28,00**	170,00
ash composition	phosphate (P2O5)	wt.-% DM	6	0,66	1,02	**0,85**	**1,37**	1,65
	aluminum oxide (Al2O3)	wt.-% DM	6	5,90	8,48	**8,11**	**9,81**	11,80
	calcium oxide (CaO)	wt.-% DM	6	13,90	18,33	**17,65**	**19,60**	26,00
	iron oxide (Fe2O3)	wt.-% DM	6	2,22	2,96	**2,77**	**2,93**	4,82
	potassium oxide (K2O)	wt.-% DM	6	1,28	2,40	**2,35**	**2,82**	3,60
	magnesium oxide (MgO)	wt.-% DM	6	1,26	1,79	**1,91**	**1,99**	2,27
	sodium oxide (Na2O	wt.-% DM	6	2,56	4,22	**3,63**	**4,27**	8,47
	silicium oxide (SiO2)	wt.-% DM	6	37,70	48,03	**49,15**	**51,60**	53,90

Table 3: Exemplary sample analysis of **HCF <300 mm** processed from 60% MSW and 40% non-recyclable and pre-sorted C+IW in a MBT (Note: This data comes from a MBT sufficiently equipped with the corresponding technology and certified according to RAL)

RDF <80 mm processed from MSW and presorted C+IW			number of analysis	minimum	average	median	80. percentile	maximum
physical properties	grain size	mm	165			**80**		
	calorific value	kJ/kg OS	165	4.400	12.575	**11.800**	**14.820**	25.300
composition	dry substance	wt.-% DM	165	58,70	70,71	**68,40**	**76,00**	96,70
	moisture	wt.-% OS	165	3,30	29,29	**31,60**	**35,42**	41,30
	ash	wt.-% DM	164	8,30	21,29	**20,70**	**25,74**	35,00
	chlorine	wt.-% OS	165	0,20	0,85	**0,70**	**1,10**	3,40
	fluorine	wt.-% OS	30	0,04	0,04	**0,04**	**0,04**	0,09
	sulphur	wt.-% OS	30	0,10	0,15	**0,10**	**0,20**	1,00
trace element content	antimony	mg/kg DM	50	3,00	23,60	**11,50**	**29,00**	190,00
	arsenic	mg/kg DM	50	1,00	1,34	**1,00**	**1,72**	3,20
	beryllium	mg/kg DM	30	0,20	0,20	**0,20**	**0,20**	0,25
	lead	mg/kg DM	50	31,00	143,82	**92,00**	**220,00**	1.000,00
	cadmium	mg/kg DM	50	0,20	2,13	**0,55**	**2,06**	22,00
	chromium	mg/kg DM	50	8,30	105,97	**57,00**	**100,00**	820,00
	cobalt	mg/kg DM	50	2,70	9,61	**6,70**	**9,42**	52,00
	copper	mg/kg DM	50	26,00	2.564,20	**160,00**	**1.680,00**	36.000,00
	manganese	mg/kg DM	50	15,00	128,78	**120,00**	**150,00**	360,00
	nickel	mg/kg DM	50	3,80	29,02	**16,50**	**26,00**	270,00
	mercury	mg/kg DM	50	0,20	0,56	**0,31**	**0,73**	3,30
	selenic	mg/kg DM	30	0,10	0,97	**1,00**	**1,00**	1,00
	tellurium	mg/kg DM	30	0,04	0,42	**0,40**	**0,40**	0,70
	thallium	mg/kg DM	36	0,04	0,39	**0,40**	**0,40**	0,40
	vanadium	mg/kg DM	50	1,30	7,78	**6,40**	**9,58**	31,00
	tin	mg/kg DM	50	5,00	24,28	**15,00**	**27,00**	240,00
ash composition	phosphate (P2O5)	wt.-% DM	15	0,76	1,24	**1,13**	**1,43**	2,40
	aluminum oxide (Al2O3)	wt.-% DM	15	5,75	12,37	**9,94**	**17,90**	24,90
	calcium oxide (CaO)	wt.-% DM	15	13,20	19,67	**18,20**	**23,20**	29,80
	iron oxide (Fe2O3)	wt.-% DM	15	1,40	2,47	**2,32**	**3,01**	4,00
	potassium oxide (K2O)	wt.-% DM	15	1,00	1,84	**1,80**	**2,40**	3,05
	magnesium oxide (MgO)	wt.-% DM	15	1,17	1,66	**1,70**	**1,85**	2,40
	sodium oxide (Na2O	wt.-% DM	15	2,20	3,61	**3,20**	**4,42**	6,77
	silicium oxide (SiO2)	wt.-% DM	15	37,50	43,89	**43,80**	**48,82**	51,10

Table 4: Exemplary sample analysis of **RDF <80 mm** processed from 60% MSW and 40% non-recyclable and pre-sorted C+IW in a MBT (Note: This data comes from a MBT sufficiently equipped with the corresponding technology and certified according to RAL)

SRF <30 mm processed from MSW and presorted C+IW			number of analysis	minimum	average	**median**	**80. percentile**	maximum
physical properties	grain size	mm	176		30			
	calorific value	kJ/kg OS	176	7.400	17.594	**17.950**	**19.900**	25.100
composition	dry substance	wt.-% DM	176	71,80	92,33	**93,00**	**95,00**	98,50
	moisture	wt.-% OS	176	1,50	7,67	**7,00**	**9,60**	28,20
	ash	wt.-% DM	171	7,30	16,67	**15,60**	**20,70**	53,30
	chlorine	wt.-% OS	174	0,30	0,88	**0,80**	**1,10**	2,31
	fluorine	wt.-% OS	40	0,04	0,04	**0,04**	**0,04**	0,04
	sulphur	wt.-% OS	40	0,10	0,12	**0,10**	**0,12**	0,20
trace element content	antimony	mg/kg DM	104	1,20	69,04	**32,50**	**80,40**	890,00
	arsenic	mg/kg DM	104	1,00	1,31	**1,00**	**1,40**	4,00
	beryllium	mg/kg DM	39	0,20	0,21	**0,20**	**0,20**	0,33
	lead	mg/kg DM	104	1,00	182,94	**140,00**	**274,00**	790,00
	cadmium	mg/kg DM	104	0,20	3,68	**2,35**	**5,12**	34,00
	chromium	mg/kg DM	104	3,60	154,43	**105,00**	**244,00**	770,00
	cobalt	mg/kg DM	104	1,00	6,10	**4,40**	**6,94**	52,00
	copper	mg/kg DM	104	12,00	2.217,42	**810,00**	**2.920,00**	25.000,00
	manganese	mg/kg DM	104	40,00	111,97	**100,00**	**140,00**	530,00
	nickel	mg/kg DM	104	1,00	37,05	**16,50**	**35,40**	320,00
	mercury	mg/kg DM	104	0,20	0,34	**0,26**	**0,37**	2,30
	selenic	mg/kg DM	39	0,40	0,98	**1,00**	**1,00**	1,00
	tellurium	mg/kg DM	39	0,40	0,49	**0,40**	**0,40**	3,60
	thallium	mg/kg DM	79	0,40	0,47	**0,40**	**0,40**	6,30
	vanadium	mg/kg DM	103	1,60	6,32	**5,70**	**7,52**	29,00
	tin	mg/kg DM	104	3,00	38,57	**21,00**	**38,00**	660,00
ash composition	phosphate (P2O5)	wt.-% DM	50	0,13	1,44	**1,30**	**1,64**	4,28
	aluminum oxide (Al2O3)	wt.-% DM	50	1,75	12,86	**11,45**	**16,48**	27,50
	calcium oxide (CaO)	wt.-% DM	50	3,87	22,76	**23,60**	**25,76**	30,60
	iron oxide (Fe2O3)	wt.-% DM	50	1,58	3,77	**3,09**	**4,23**	14,70
	potassium oxide (K2O)	wt.-% DM	50	0,13	1,59	**1,54**	**2,05**	2,67
	magnesium oxide (MgO)	wt.-% DM	50	0,63	1,96	**1,97**	**2,20**	2,52
	sodium oxide (Na2O	wt.-% DM	50	0,37	3,26	**3,16**	**3,88**	6,12
	silicium oxide (SiO2)	wt.-% DM	50	5,56	36,36	**36,25**	**42,96**	53,80

Table 5: Exemplary sample analysis of **SRF <30 mm** processed from 60% MSW and 40% non-recyclable and pre-sorted C+IW in a MBT (Note: This data comes from a MBT sufficiently equipped with the corresponding technology and certified according to RAL)

RAL GZ 724 (1999)						
		reference calorific value:	H_i: 20 MJ/kg	H_i: 20 MJ/kg	H_i: 16 MJ/kg	H_i: 16 MJ/kg
Parameter		**source:**	**Commercial + industrial waste**		**household waste**	
			Median	**80%-percentile**	**median**	**80%-percentile**
Cadmium	Cd	mg/kg DM	4	9	4	9
Mercury	Hg	mg/kg DM	0,6	1,2	0,6	1,2
Thallium	Tl	mg/kg DM	1	2	1	2
arsenic	As	mg/kg DM	5	13	5	13
cobalt	Co	mg/kg DM	6	12	6	12
nickel	Ni	mg/kg DM	80	160	80	160
antimony	Sb	mg/kg DM	60	120	60	120
lead	Pb	mg/kg DM	70	200	190	-
chrome	Cr	mg/kg DM	40	120	125	250
copper	Cu	mg/kg DM	100	-	350	-
manganese	Mn	mg/kg DM	50	100	250	500
Vanadium	V	mg/kg DM	10	25	10	25
Tin	Sn	mg/kg DM	30	70	30	70

Table 6: Old input criteria established by BGS e.V. in 1999. These data were source-related to the calorific value of municipal solid waste and to sorting residues and commercial and industrial wastes. For a better statistical evaluation, the 8 of 10-rule, as well as the introduction of a median value as “practical value” and the 80th resp. 90th percentile as the “expectable maximum value” have proved their practical worth. Due to the customized blend of AFs these input criteria were changed to energy-related data in 2012 (see Table 9).

Additionally, process individual parameters shall be agreed between supplier and user, such as:

chlorine	Cl	wt.-%
sulphur	S	wt.-%
ash	ash content @ 850°C	wt.-%
moisture	dry mass @ 105°C	wt.-%

Note that **all types of alternative waste derived fuels** must be sampled and analysed in accordance to the permit (cf. chapter 10). And additionally, quality monitoring of the input criteria related to the thermal valorisation process and its product will become part of the agreed delivery contract (cf. chapter 13), too.

5.5. Residues ending in the product

personal notes:

5.5.1. Fly ash from fossil fired power plants

The mineral residue from coal or lignite is fly ash, which shall be used as a concrete admixture, and must prove their suitability by a European Technical Approval or shall be certified and monitored according to DIN EN 450-1, DIN 1045-2 and EN 197-1.

Fly ash can be used in accordance with the following regulations:

- Concrete, steel and pre-stressed concrete according to DIN EN 206-1 and DIN 1045-2
- Concrete according to the guidelines of the Committee for Structural Concrete
- Bored pile concrete according to DIN 1536
- In-situ concrete diaphragm wall according to DIN EN 1538

When using AFs, the mineral residue which becomes fly ash and shall be used as a concrete admixture has to fulfil the application standards.

Fly ash, which exceeds the above mentioned norm due to an increased proportion of unburnt coke, may be used as a raw material component in a brick production or clinker burning process.

Otherwise these ashes can only be disposed.

5.5.2. Bottom slag

Bottom slag or with regard to the burning temperature is also known as bottom ash cannot be used as a concrete admixture within the standards.

After a successful leaching test, bottom ash can be used in unpaved road and path construction outside the standards.

5.5.3. Clinker

personal notes:

Clinker is the intermediate product from which cement will be produced by grinding in a mill in accordance to the binders standards.

Due to the potential use of cement in water sensitive sectors, the leachable heavy metal content shall not exceed the natural heavy metal content which is already present by background.

During the clinker burning process semi- and non-volatile heavy metals such as magnesia (Mg), iron (Fe), nickel (Ni), chromium (Cr), vanadium (V), titan (Ti), copper (Cu), zinc (Zn), lead (Pb), arsenic (As) or manganese (Mn) will be absorbed by the presence of the de-acidified lime dust. These elements will later be incorporated to the clinker formation, and consequently they will become product relevant.

5.5.4. Binder system

The product relevant heavy metal balance will be pre-conditioned by the individual raw material from the deposit. To avoid an additional negative quality impact on the final product, the relevant elements will be detected by the proper waste assessment and will rejected during AF production by suitable devices.

Product and process relevant parameters have to be determined prior by a balance and assessment at the envisaged client.

The performance of cement has to follow the requirements of the international standards for inorganic binders in accordance to DIN EN 197-1 or ASTM C150.

personal notes:

6. How to design a reliable pre-processing

Against the common practise, the mechanical treatment plant can only be planned and designed after the determination of the waste composition and after the technical and chemical assessment done in the envisaged thermal process.

Pre-processing plants should be regularly inspected regarding fire protection and if relevant, regarding its emissions. The coverage of the inspection and emission testing shall be written in the permit of the treatment facility. The testing company must comply with the requirements of local regulations, both with regards to competence and reporting.

6.1. C+IW processing

As suitable waste has already been identified and separated in the commercial and industrial sectors, only a little specific equipment and a professional material flow management including quality monitoring are required.

The pre-processing line is characterized by a pre-shredder, magnet and a sufficient fine shredder, and if necessary a wind sifter to reject 3D-particles from SRF, as well as a NIR-control device to stop the process when PVC is appearing.

The amount of impurities and foreign substances is very low, which requires a minimum of fees for its disposing of.

The OPEX is significantly lower than of a MBT/ BMT.

The capacity of one single line is ~100.000 tpy for a three shift operation. The reception area and the storage capacity should be designed sufficiently.

The focus of C+IW derived AF lays on stuff management and quality assurance.

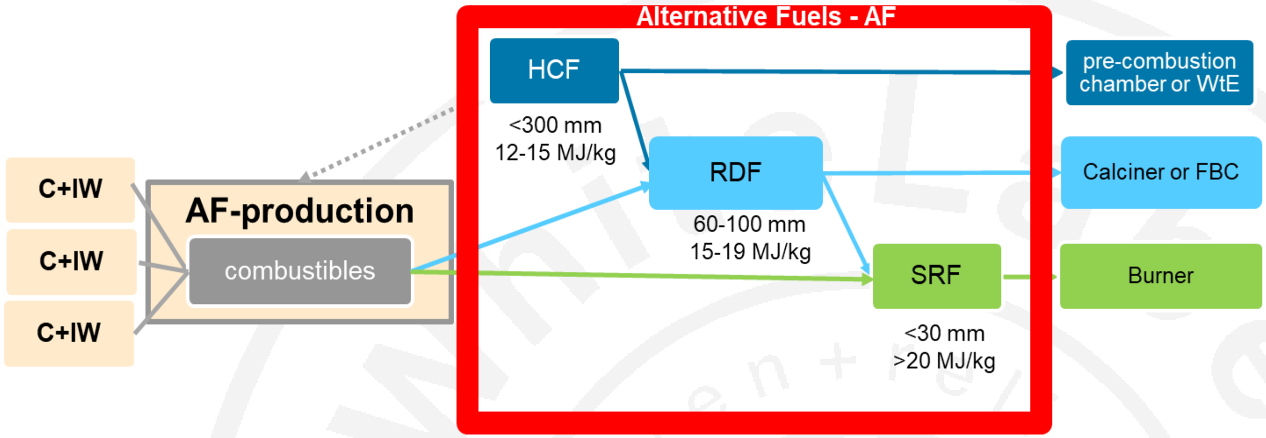

Fig. 12: Solid Alternative Fuels (AF) derived from commercial and industrial waste (C+IW). It is important to differ the quality and its names independently from its waste source when pre-processing and its envisaged point of feeding are clearly defined.

personal notes:

6.2. Commingled collected waste

In most of the cases, waste will be collected in a commingled manner, and it has to be disposed after the informal sector had picked out its valuables. This waste is normally not recognized as a feedstock for further processes such as compost, recycling or fuels.

After a robust and meaningful assessment of the waste composition, the quantities for recycling and disposal are identified. The requirements for recyclers are also known so that the pre-processing plant can be designed accordingly.

personal notes:

6.2.1. MBT

As a rough rule, in the case the initial waste contains less than approx. 40% organic matter, pre-processing can begin with a mechanical process whilst the biological process will run parallel. The process sequence is called Mechanical-Biological Treating (MBT).

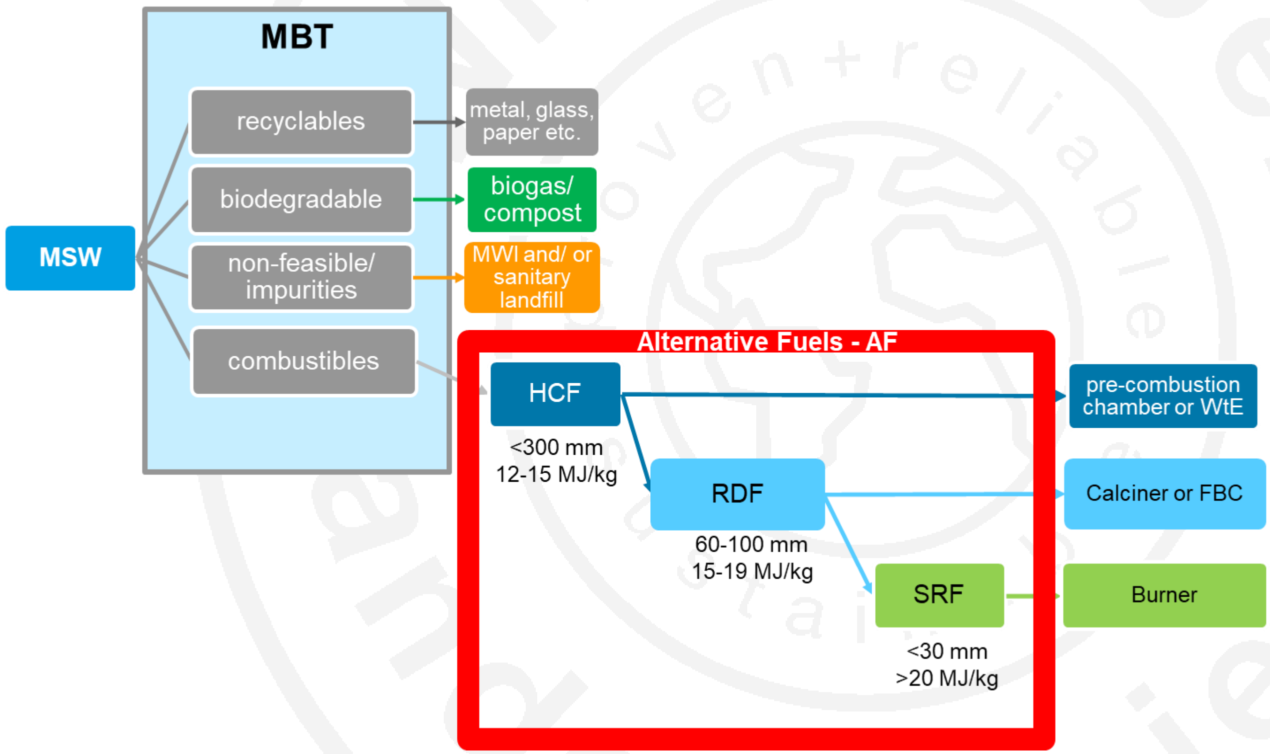

Fig. 13: Solid Alternative Fuels (AF) and its designations from MBT-processing of municipal solid waste (MSW).

Due to the unexpected and interfering impurities the according facility has to be designed robust with a heavy duty shredder, a proper splitter or flat screen and a classifier with a sufficient large soothing chamber. In most of the cases, the main material streams leaving a MBT are in the sequence of its amount organic matter, non-recyclables and impurities. The minor portions are AFs, and valuables like polymers or metals.

The quantity of each respective material flow depends on the one hand on the respective composition of the feed waste and on the other hand on the quality requirements of the customer.

If a MBT does not meet these requirements, either expensive improvements must be made or there is even a risk that it will not be able to start the planned operation.

First, all the solid waste have to be shred down to <300mm to open all for splitting. It shall be screened on a vibration screen sufficiently to segregate the unwanted minerals and the moisture containing organic material due to its sticky effects and to avoid wear and tear and corrosion in the downstream process. In a wind sifter with a properly large settling chamber heavy unsuitable material will be separated from the light mostly combustible portion, which is then called High Calorific Fraction (HCF).

According to the specifications which are previously defined by the thermal process assessment, HCF has to be refined to a customized calciner fuel, which is known as RDF or has furtherly cleaned and processed in a third step down to get main burner fuel (SRF) for the rotary kiln or the power plant boiler.

The SRF has mandatorily to be separated from PVC and from compact 3D-particles and in some cases dried to approach the needed high calorific value.

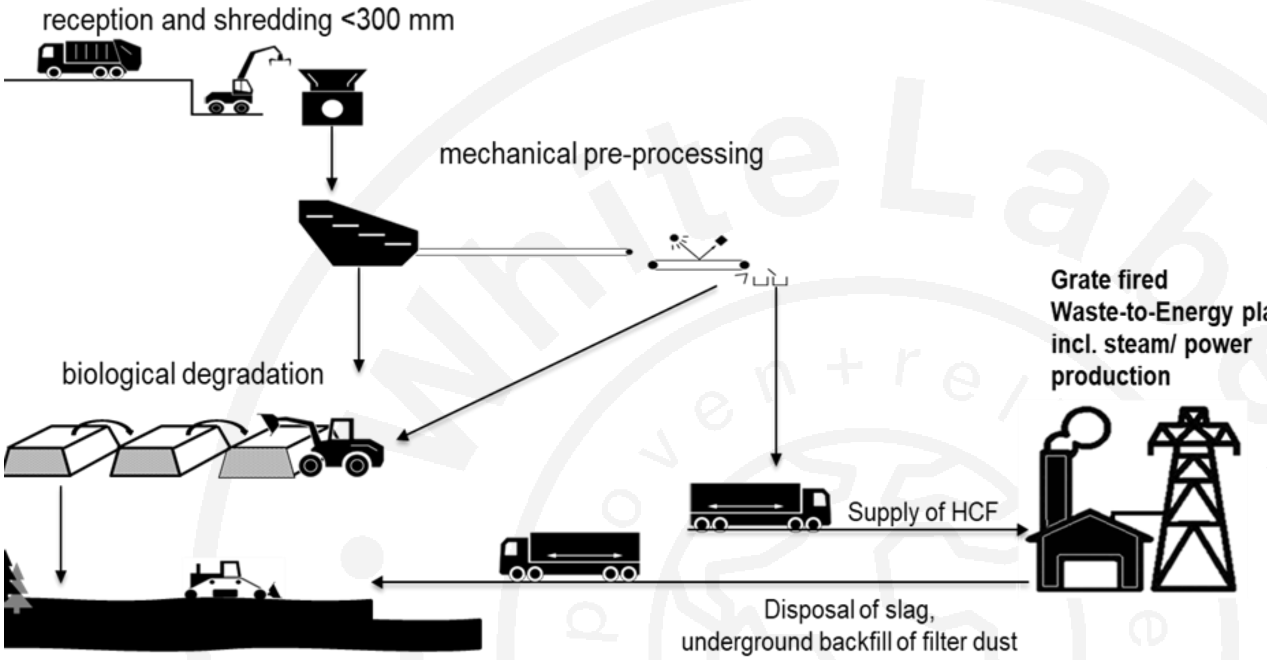

Fig. 14: A Mechanical-Biological Treating (MBT) starts first to shred the commingled waste for a sufficient separation of organics and NIR-discharge of PVC. The efforts of segregation are defined by the targeted process (here a WtE- power plant with a robust combustion technology).

personal notes:

The remaining substances obtained from the processes are either biodegradable organic or interfering substances that are subject to a controlled disposal. They shall either be disposed of on a sanitary landfill or burnt in a municipal waste incinerator (MWI).

Depending on its heavy metal content the organically fraction can be converted to a fertilizing compost or to a technical compost e.g. to close and cover old dump sides.

Mechanical fine treating to RDF or SRF can also be done separately such as close to the cement work, to process suitable portions of HCF coming from an MBT or to blend it with suitable C+IW.

personal notes:

6.2.2. BMT

In the case the commingled waste contains more than ~50% organics, the pre-processing should better start with a biological process for drying. This process sequence is called Biologically-Mechanical Treating (BMT).

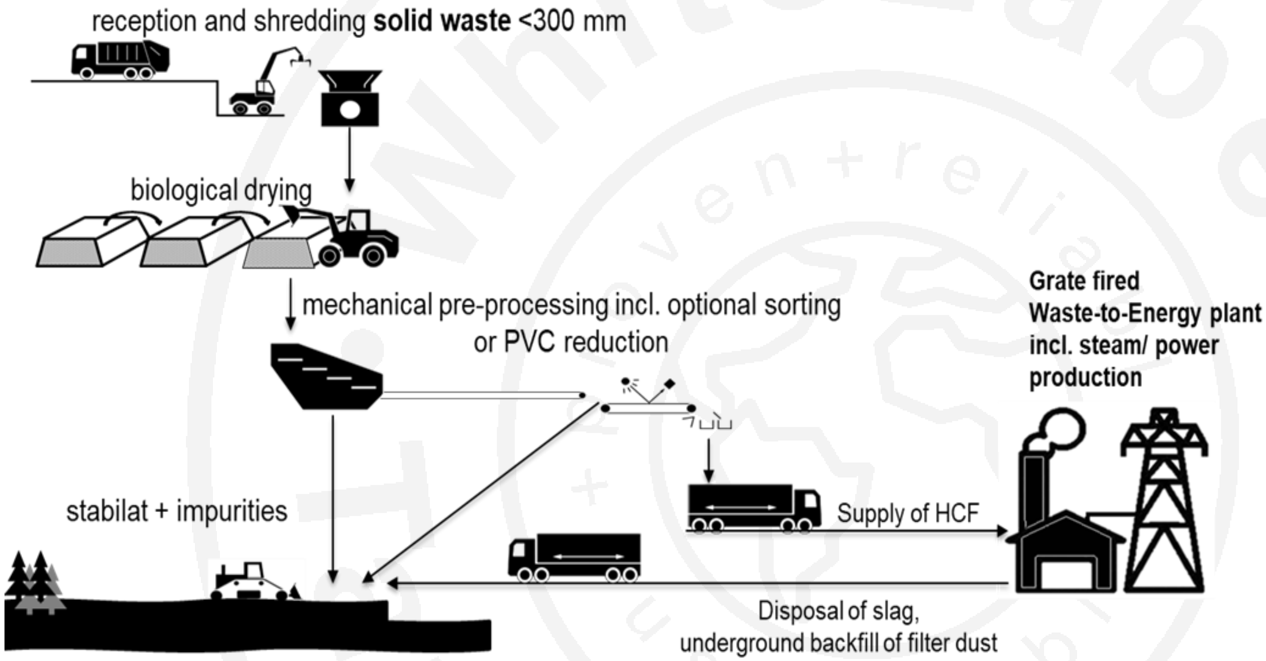

Fig. 15: A Biological-Mechanically Treating (BMT) starts with comminution, too, and the organics will be degraded first by bio drying for a sufficient segregation without sticky moisture.

A biological pre-process is based on the identical biological processes known from composting. But, here the whole amount of waste shall be processed after shredding down to approximately 200 mm. The involved bacteria require specific conditions and more time, which results in a higher demand of space. The advantage is the following mechanical process can work more efficient due to the missing stickiness by water, and results in a better quality of screening, wind sifting and handling. Sticky and abrasive ashes, clogging, moisture as well as wear and tear will be reduced.

7. Logistics

personal notes:

A pre-treatment plant should be planned where the largest mass flow will be send ultimately.

A pre-treating facility of commingled waste is better located on a sanitary landfill, while a commercial and industrial waste treatment plant can also be placed directly at the power plant or cement work.

For the development of a reliable AF-concept, logistics is one of important factor influencing operational costs.

The supply with suitable waste, as well as the materials management of rejects and impurities and of customized AFs shall be assessed before with regard to the properties and qualities of each stream.

During the waste assessment the sources as well as the logistical distances to the supply and the required disposal have to be analysed in-depth.

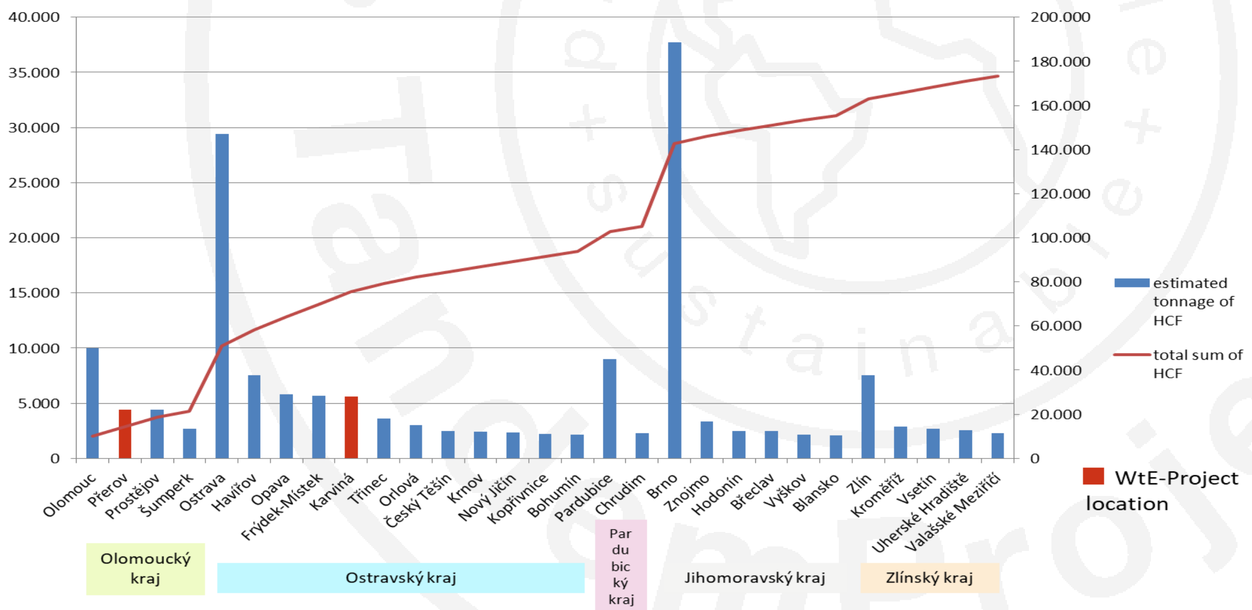

Fig. 16: Waste assessment respectively its results will give the indication for the waste collection and its resulting pre-processed HCF

For example for a WtE plant, which needs annually 42.000 t of HCF: When the annual waste amount per capita is 360 kg and the determined of combustible portion of HCF will be 120 kg/t, consequently 350.000 people have to be connected to the collection system and pre-treating concept. As the stratum (urban or rural) is determined as well, the efforts for collection and its costs can be calculated.

personal notes:

A rough re-calculation of the portion and its thermal potential of the waste per capita will also show how large the access area for the collection will become.

After the pre-processing, the customized AFs have to be stored and homogenized in a proper hall and shall serve the final quality control and the loading of the trucks.

Additionally, the storage concept has to respect the logistics during unplanned breakdown or planned revisions.

The logistical factors will define the size of the required land plot needed for operation, quality control and stuff management.

8. Occupational Health and Safety (OH&S)

Also with regard to OH&S, wastes not listed under chapter 1 and wastes with insufficient, doubtful or unreliable information will not be accepted.

Proper location (environmental, proximity to populations of concern, impact of logistics/ transport); good infrastructure (technical solutions for vapours, odour, dust, infiltration into ground or surface waters, fire protection etc.) and properly trained management and employees with regard to the handling and processing of AF will all minimize risks.

A risk manager is responsible for the arrangement, education of the employees and the performance of the facility. His documentation and information is a must to be respected. Management should be trained before starting with processing at a new facility or site.

Good, regular emergency response and fire-fighting simulations, including the neighbourhood and the authorities, contribute to the safe production and use of AF.

9. Quality Surveillance

With regard to the precautionary principle all involved parties, which are dealing with waste, have to ensure, that neither during collection, handling, pre-processing, recycling and use nor at the final point of disposal people, employees or the environment will be affected.

Sufficient quality systems are relevant for:

- Avoiding any impacts on the AFs
- Minimizes effects on the valorising manufacturing process and all involved co-workers
- Avoidance of loss on the production performances
- Greenhouse gas emission trading
- Emission and pollution control

Each party must establish a comprehensive quality control system from the waste source qualification, routine deliveries, AF product shipments, and the valorisation process for its products such as clinker or cement, fly ash, slag, FGD-gypsum or a reliable power or heat supply.

Normally, in most of the permissions, a delivery control mechanism is implemented to the routines of operation which will be controlled by the authorized bodies as well. Delivery control has an administrative part (document control, waste, AF certificate identification, transport certificate control etc.) and an analytical part (sampling, tests, analysis, and comparison against contracted specification).

Based on the experiences made by the BGS e.V. the CEN was mandated by the EU commission to develop international standards for AF production and its environmental safe use. The use of AF requires a supply of pre-treated and stable waste derived fuel quality that suits to the users' requirement of production, product and permission.

Several technical standards were developed by CEN/TC 343 to provide a system of specification and control of AF. It also provides for a set of compliance rules that points out how AF can be specified in a reliable way.

The quoted standards can be found in chapter 15, and further information is available from the Technical Report (CEN/TR 15508) which gives deeper explanations.

personal notes:

The standards prescribe the procedures and the specification of certain physical and chemical properties. The properties obligatory to specify include particle form and size, moisture content, ash content, net calorific value, chlorine content and each heavy metal mentioned in the Waste Incineration Directive. Also the waste sources are obligatory to be specified or can include for instance biomass content (relevant for GHG-trading) and ash melting behaviour as well.

As the method of specification already provides for the full information of the AF, classification only aims to assign it to a class so that both producer and user understand the type of AF they are dealing with. This classification does not differ between "waste and product" or "good and poor quality". It is an error to think that this discrimination is a goal and for relabelling. Each AF can be classified with regard to its environmental impact at a glance, and it becomes obvious whether additional investment may be needed for exhaust gas cleaning technologies.

For further information confer the directory of pre-references of CEN/ TC 343 without guarantee of completeness and actuality in chapter 15.

Due to the CO_2-emission trading system several methodes are under development or had already been established to determine relevant carbon contents, respectively to adjust the emission factor:

Several methods to determine CO_2-neutral waste compounds are available:

1) Morphological analysis for a rough overview

2) Chemical selective analysis of the AF

3) C_{14}-methode during combustion

4) Legal list (agreement) and

5) Praxis list which both the country government has to commit

personal notes:

1) Sorting method is based on the morphological analysis of the waste composition and its CO_2-neutral proportions of biomasses like paper, cardboard, wood etc. are determined by enumeration. This method hasn't been established due to various ranges of compounds and components like textiles, viscose or biodegradable plastics etc. It will only give a rough overview but no reliable data for trading allowances.

2) Selective digestion works as a digestion process with concentrated sulphuric acid. It is assumed that young carbon carriers such as paper or wood dissolve faster than fossil carbon carriers such as coal. This method is also used only for a screening of the AF, but cannot be used in AF containing natural rubber, wool, viscose or biodegradable plastics.

3) CEN/ TR 15591:2007 describe a method known to determine the age of organic materials. It is based on the ratio between the carbon isotopes C_{12} and C_{14}, where it is assumed that "young", regenerative carbon contains the C_{14}-isotope and is no longer present in fossil fuels because of its half-life period of 5730 years. This methode is based on combustion and to precipitate carbon as barium carbonate directly from the exhaust gas. In a mass spectrometer, later all the C-isotopes will be separated and qualitatively detected. This method enables to determine fuel-related biogenic CO_2 from all types of fuels, regardless of their composition and consistence.

4) Agreement on emission factors: Emission factors have been agreed by the Governmental Organisation in countries where the corresponding regulations are enforced. The relevant factors are evaluated and validated in a regular manner such as from DEHSt in 11/2006:

Energy resource:	emission factor t CO_2/GJ
Lignite from Rhineland	0,114
Anthracite	0,098
Lignite dust Central Germany	0,098
scrap tyres	0,088
erived AF	0,082
MSW derived AF	0,080
Gasoline	0,072
Plastic	0,061
natural gas	0,056
Garbage (household)	0,045
vegetable oils	0,023
impregnated saw dust	0,022
Biogas	0,020
solid biomass	0,004
sewage sludge	0,003
landfill gas	0,000
…	…

Table 7: List of energy resource and its emission factors in accordance to the EU trading system

5) The German association of waste incinerators (ITAD) developed a procedure based on the European Waste Code numbers and its individual emission factors. This method is used for the monthly report in accordance to the R1 energy efficiency formula in Annex II of Directive 2008/98/EC. The following table quotes an excerpt from a monthly report of a WtE plant:

personal notes:

Group	EWC		biogenic portion (energy-related)	gross CV [MJ/kg OS]
1	150105	Composite packaging – MRF	32,0%	18,1
2	150106	mixed packaging	48,9%	13,3
	150202	Absorbent and filtering materials (including oil filters n.e.m.), wiping cloths and protective clothing contaminated with dangerous substances		
	170903	other construction and demolition wastes (including mixed wastes) containing dangerous substances		
	170904	mixed construction and demolition waste other than those mentioned in 17 09 01, 17 09 02 and 17 09 03		
	180104	Waste whose collection and disposal is not subject to special requirements from the point of view of infection prevention (e.g. wound and plaster dressings, laundry, disposable clothing, diapers)		
	191208	Textiles		
	200132	Medicinal products other than those listed under 20 01 31		
3	191210	combustible wastes (fuels from wastes)	50,0%	10,0
	191212	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11		
4	020203	substances unsuitable for consumption or processing	53,5%	8,8
	020304	substances unsuitable for consumption or processing		
	150101	Paper and cardboard packaging		
	190599	Waste n.e.m.		
	190801	Screen and rake residues		
	200108	Biodegradable kitchen and canteen waste		
	200201	biodegradable waste		
	200203	other non-biodegradable waste		
	200301	mixed municipal waste		
	200302	market drops		
	200303	street sweepings		
	200306	Waste from sewage cleaning		
	200399	Municipal waste n.e.m.		
5	200307	Bulky waste	60,3%	16,0
6	xx xx xx	other, not mentioned above (with individual verification of biogenic share and calorific value)		

Table 8: Example of an ITAD conform reporting sheet from a WtE plant

10. Legal Aspects

National laws should define the basic principles under which the thermal use of waste derived alternative fuels shall take place. They should define sound requirements and standards. Without any legal binding frame and its enforcement, the authorities will not be able to control compliance or to sanction.

personal notes:

> If no specific legislative framework covers the use of AF, the clients interested in the use of AF should prepare all the necessary documentation before starting any activities, and apply for a permit under the general environmental law in force, in close cooperation with the authorities, basing the application on existing good practices. International and regional experiences and information exchange about best practices should be considered.

An appropriate legislative and regulatory framework shall be set up:

- Thermal use shall be integrated into the overall legislation concerning environmental protection and waste management.
- Legally-binding regulations and standards are necessary to guarantee legal security and to assure a high level of environmental protection.
- Law enforcement is the key to a successful AF implementation.

Baselines for traditional fuels and raw materials shall be defined:

- Control and monitor inputs, outputs, and emissions during the operation of the production processes.
- Evaluate the given environmental situation prior to starting waste processing and use.
- The client will be getting an overview on his baseline data to define potential impacts of AF usage based on standardized international EIA.

All relevant authorities should be involved during the permitting process:

- Build credibility with open, consistent, and continuous communications with the authorities.
- Consider and strive to apply BAT.

The regulatory framework must provide rules that are easy to enforce. National emissions standards must be applied by the concerned authorities and implemented by permits in each case. Within the given standards, the technical specifications for usage and the waste to be used may vary from country to country.

personal notes:

Special attention must be given to reliable emissions control and combustion monitoring, as this is one of the most sensitive areas of the use of processed waste derived alternative fuels. In many countries, industrial emissions standards already exist but do not cover emissions from cement factories or power plants using AF.

The EU Directive 2000/76/ EC, for example, provides explicitly in Art. 4, paragraph 4 that the permit granted by the competent authority for a co-incineration/ co-processing plant shall list explicitly the categories of waste which may be treated.

Derived from the EU waste catalogue (EWC), a list of wastes which suit for thermal use has been prepared (see Table 1). This list indicates that co-processing and co-incineration is applicable for a wide range of waste and is not limited to a certain type of waste.

However, the decision on what type of waste can be finally used in a certain plant cannot be answered uniformly; it must be based on each individual production process which has to be assessed before as well as the intended waste to be pre-processed.

In some cases kilns and boilers can be used for the safe disposal of special wastes such as obsolete pesticides, PCBs, or outdated pharmaceutical products. However, for this type of treatment, regulatory authorities and plant operators must come to individual agreements and standards on a case-by-case basis. Such disposal activity should be done as a joint effort between the public and the private sector.

As documented the most pre-processed solid wastes are unrecyclable and commingled wastes such as paper, cartons, plastics, composite, textiles, carpets, packaging material, tires, wood, HCF, rejects from sorting or end-of-life products (see Table 1).

Regular quality control of the collected and delivered waste will help to ensure a smooth use of the AF in the processes.

The quality of what shall be fed to the process determines the quality of what comes out in form of emission or in form of product. Therefore attention must be paid to the pre-processing of waste and its supplier.

All natural resources used in the production contain pollutants such as heavy metals, so the zero baselines and the acceptable HCF have to be assessed beforehand. Data from this study helps operators to understand the pollution content of traditional inputs and to demonstrate later whether the use of AF offers environmental improvements.

Due to the huge absorption effect of the clinker burning process by the lime, it has been shown that a maximum load of 2 ppm DM of mercury, 45 ppm DM of thallium and 50 ppm DM of cadmium will not exceed the EU Directive 2000/76/ EC or even its more restrictive derived 17th Federal Emission Control Act (17. BImSchV). The other heavy metals are dust bound and consequently they will be incorporated in the clinker forming process and become product relevant (see above).

The situation is different for power plants which intend to use AF. They have to ensure more restrictive input criteria of the heavy metal content of the AF than the cement kiln.

In a hard-coal fired combustion additionally arsenic (As), lead (Pb) and antimony (Sb) will become high volatile due to the silica based ash conditions in the boiler which do not absorb heavy metals like a lime based milieu does. In a lignite-fired combustion which is more similar to lime based ashes the heavy metals become semi-volatile, which consequently have to be monitored as well. Individual loads of heavy metals have to be assessed regarding its retentions effects.

To verify safe input criteria the limited input values have to be verified by a proper quality assurance system, which shall be implemented in accordance to the precautionary principal.

Process requirements, product quality targets, and emissions regulations all have a bearing on the choice of the potential waste material considered for use.

The customized pre-processing in a sufficiently designed MBT and the selecting of suitable C+IW for a customized AF-production will minimize the net financial and economic costs of operation on all sides.

In all countries where co-processing and co-incineration shall be used, such measures should be prepared and regularly reviewed by national or local authorities in cooperation with the relevant associations. The aim is to define standard values appropriate for the local circumstances and requirements (on a country-wide basis or on a plant-by-plant approach). This sensitive task should be given special attention during any capacity development activity.

personal notes:

The EU Directive 2000/76/ EC, for example, provides explicitly in Art. 4, paragraph 4 that „the permit granted by the competent authority for a co-incineration/ co-processing plant shall ... list explicitly the categories of waste which may be treated“.

The main objective of the permission and controlling process is to assure that only suitable wastes will be used and the AF operations run properly. Regulators and operators should be able to track the progress of the waste through the waste treatment path, either directly from a waste generator or through collecting/ pre-treating companies. The quality of the material designated for co-processing is crucial. Quality data and emissions monitoring data form the basis for scientific discussions with external stakeholders (NGOs). They are also helpful tools for reducing local concern and the notion that cement and power plants are misused as trash bins for uncontrolled disposal of wastes.

personal notes:

The mental mind set and a consistent wording is the key for acceptance and success.

Co-processing should only be applied if not just one but all tangible pre-conditions and requirements of environmental, health and safety, socio-economic and operational criteria are fulfilled. As a consequence, not all waste materials are suitable.

Operators of the pre-conditioning as well as the operator of the thermal exploitation process must know the quantity and characteristics of the available wastes before applying for a permit for thermal usage. However, an open communication channel and regular consultations between the public and the private sector will help to reduce possible friction and misunderstandings and to develop a permit process most suitable for all parties involved.

personal notes:

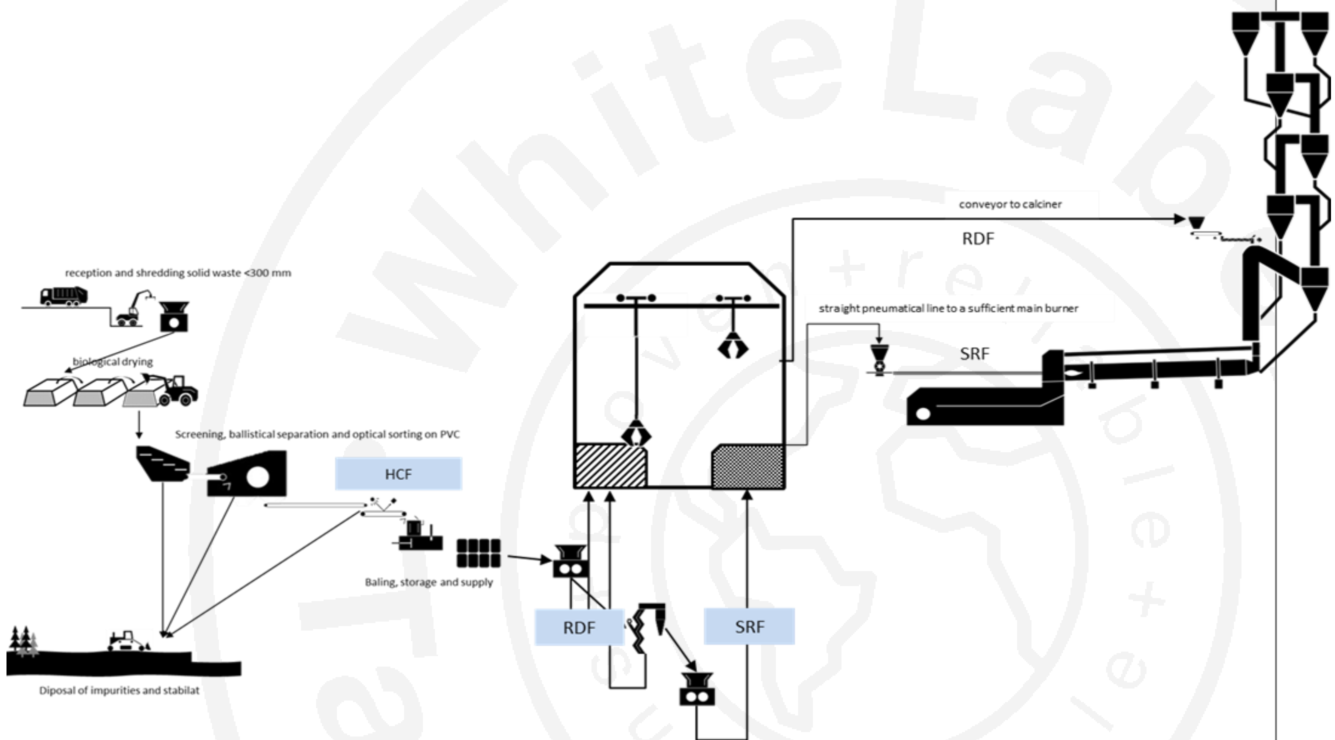

Fig. 17: Here, the classical BMT-process scheme is principally shown from waste to a customized co-processing (conf. MBT on video)

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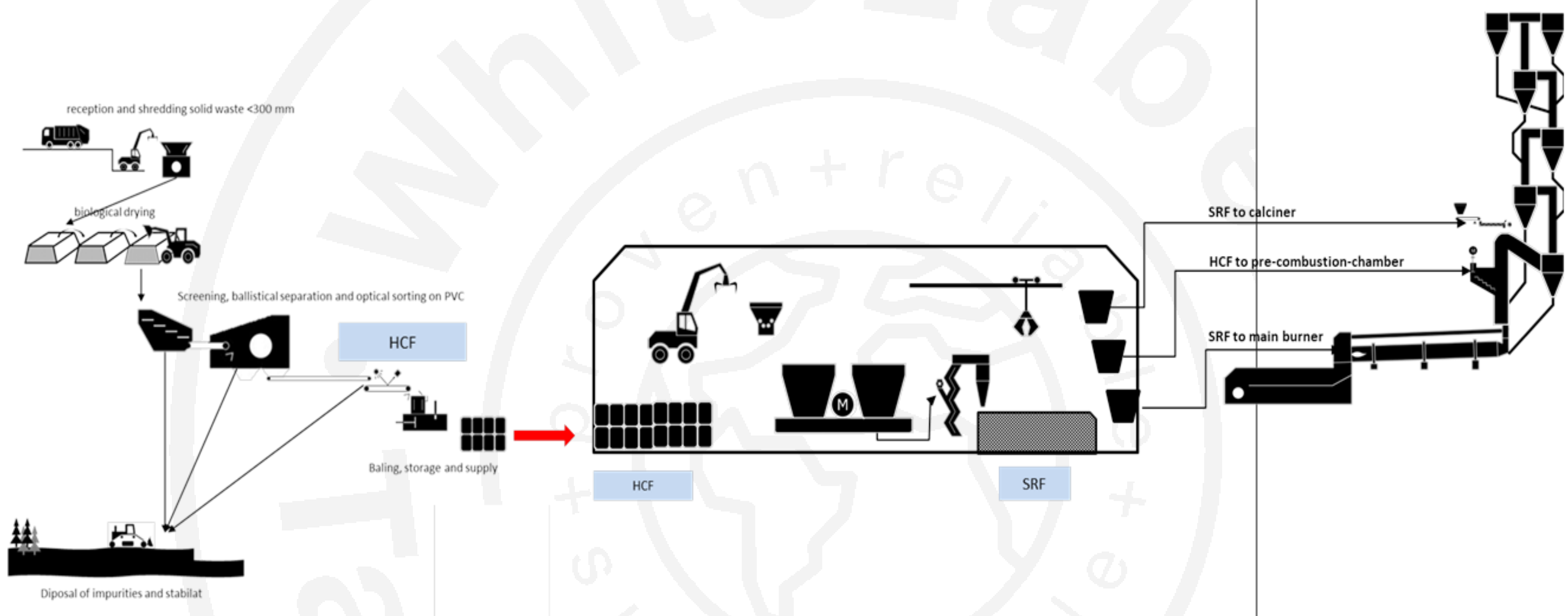

Fig. 18: In the future, conditioning and exploitation processes will grow together to form one logical line where alternative fuels will have best burning properties at their point of feeding.

personal notes:

11. Permission for trial burn testing

With the exception of NO_x and some heavy metals the emissions of a power plant are dominated by the combustion properties of the main fuel stream, which is still the primary fossil fuel – coal or lignite.

The emissions of a clinker kiln are characterized by 90% of the input which still is the quarried raw material that volatilize during preheating and calcination.

WtE power plants are excluded from this possibility, as they are 100% fuelled with pre-processed waste derived HCF and therefore they are subject to the emission protection regulation for licensing waste incineration plants.

Volatile components are hardly ever homogeneously distributed in the deposit of coal or the quarry and thus their amounts fluctuate over days and years depending on the part of the quarry being exploited. Dynamic processes of formation and reduction during internal circulation, as well as the operation modes, also affect emissions.

An emission change forecast based on expert know-how and, if required, expulsion testing and chemical analyses would provide good information. However, many authorities and external stakeholders prefer emissions measurements.

Therefore a trial burn testing is required. The following simple rules and regulations should be applied for the testing procedures:

- The baseline test shall take place over a week during operation with primary fuels
- dust, SO_2, NO_x, and VOC are shall be measured continuously
- HCl, NH_3, benzene, PCDDs/PCDFs and heavy metals are measured
- The trial burn test shall be identically repeated inclusive the AFs

The trial burn test is normally used to test the effects on the individual kiln or boiler in operation and the performance of different suppliers.

Due to the relatively small investment, such pilot plants are also used to build up the missing structures for a local supply including pre-treating plant and its AF qualities.

It is unlikely that normal emissions to air, soil, and water from AF pre-processing plants would reach threshold limit values for any of the pollutants. Nevertheless, emission monitoring and reporting must be performed according to locally applicable regulations.

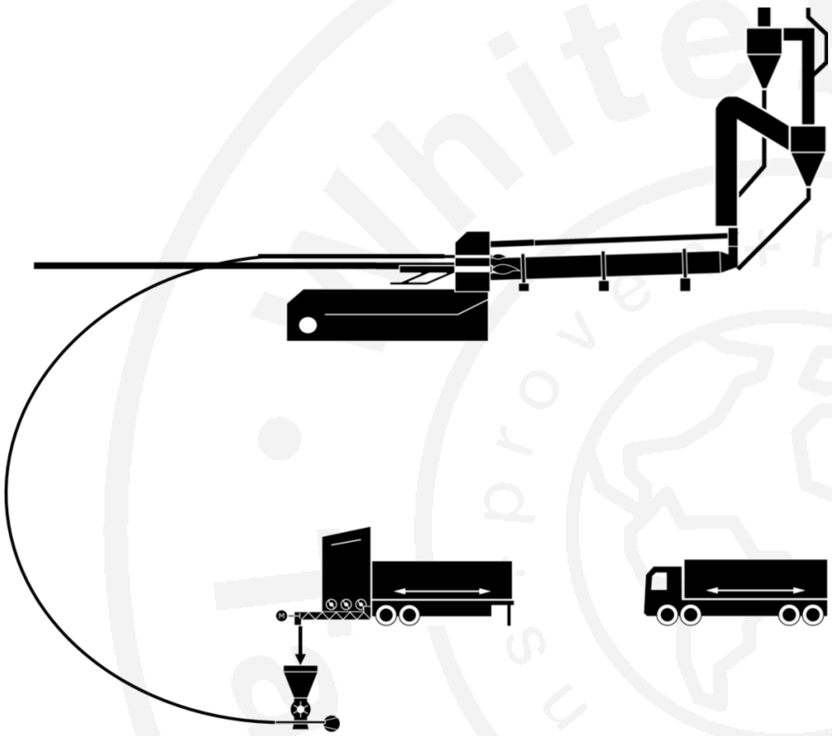

Fig. 19: If the AF- market is not well developed, small mobile test plants with low throughput rates of up to approx. 5t/h, so-called docking stations with frequency-controlled dosing, have proven themselves in practice.

12. Permanent Permission

Generic permits for heterogeneous waste groups should not be issued because it is hard to track these wastes from the generator to the boiler or kiln. And it is difficult to assess their environmental impact. It is important to know the origin of each type of waste and its composition in order to ensure safe co-processing. Agreements must be signed with the collectors or haulage companies in order to ensure these requirements. Pre-processing facilities accept different

personal notes:

waste materials suitable for processing that due to their physical states cannot always be fed directly to the plant.

personal notes:

It is necessary to prepare a single and homogenized stream in the form of a solid alternative fuel that complies with the administrative and technical specifications of the envisaged plants. In this case the traceability is ensured.

All plant operators who are dealing with AFs have the main responsibility for the whole procedure, including permitting and quality assurance. Their applications must include detailed descriptions of all relevant processes within the plant, comprehensive data about all materials designated for usage and a detailed self-monitoring plan. These documents give the authorities an overview of the quality of the AF and the expected emissions. The authorities will not accept incomplete application documents.

A well-documented permitting process will provide detailed information on the plant specifications and will give information on:

- Source or feedstock materials, pre-processing, primary fuels, alternative fuels and handling
- expected volumes per input and output stream
- feeding points into the processes of each waste in and fuel out
- chemical and physical criteria of each stream
- main items of equipment including plant capacity and operating conditions relevant to pollution potential
- pollutant abatement equipment such as scrubbers, filters, absorbers, precipitators, etc.
- release points
- intermediary products of waste processing, envisaged target and disposal
- description of alternative fuels, generation, processing, using installation, supply and quality assurance system
- inspection plan for incoming waste and pre-processed AF
- sources of water and treatment used for process cooling water, effluent water etc., where relevant to pollution potential or release
- description of the emission situation (applies for both to the operating of the pre-treating plant as well as to the use of AFs)
- Environmental Impact Assessment (EIA) incl. investigation regarding effects of pollutants in the plant's sphere of influence (area within a radius of 50 times the stack height)

- And information regarding chemical/ physical reactions of emitted substances, potential of dangers, toxicological and environmental relevance, loads and protection factors in the plant's sphere of influence, emission load of relevant components, pathways, periods of time, and circumferences of effects that require protection, suitable measures for avoiding pollutants' environmental effects, the emission values ascertained in the assessment areas are compared with various references, limiting values, and guide numbers for the background, pollutants to be considered in relation to the production of power and cement are dust, NOx, SO2, VOC, heavy metals, and PCDDs/PCDFs
- maintenance of industrial and occupational health and safety standards, description of methods of informing the public.

The roles and responsibilities of the permit issuing authority are:

- considering the application and all the forms
- involving other authorities in the consultation process (health, transportation, economy)
- public participation: public information, public inspection of an application, public hearing
- environmental assessment
- risk assessment evaluation with interdisciplinary teams
- final decision on approval by the competent authority (with additional stipulations i.e. imposition, condition, time limitation, reservation as to revocation).

personal notes:

Each site, pre-processing or AF user must establish a comprehensive quality control system for waste derived fuels, routine deliveries, shipment, and on the client's site for its end product such as power production, FGD-gypsum, clinker or cement.

Each party had to be committed to the sampling, the analysis and the interpretation of data.

Delivery controls in routine operations must be carried out for each individual shipment.

Delivery control has an administrative part (document control, waste/AFR certificate identification, transport certificate control etc.) and an analytical part (sampling, tests/analysis, comparison against specifications).

As already mentioned in chapter 5.3 the limited input values published in 1999 were first agreed on material specific heavy metal content and added with a footnote regarding its source specific calorific value. But, in the daily work of keeping the thermal production running AF-qualities become increasingly more tailor-made by proper pre-processing and blending.

It could be shown and agreed with the responsible monitoring authorities that energy-related entrance criteria make more sense, also with regard to the increasing TSR, the operational aspects and with the view of minimizing the load of the exhaust gas.

Therefore, BGS published in 2012 its standardized energy related input criteria for the quality seal in accordance to RAL GZ 724:

personal notes:

RAL GZ 724 (2012)				
Parameter in mg/MJ				
		reference calorific value:	No longer relevant	No longer relevant
energy-related input criteria of AF		source:		
			Median	80%-percentile
Cadmium	Cd	mg/MJ DM	0,250	0,560
Mercury	Hg	mg/MJ DM	0,038	0,075
Thallium	Tl	mg/MJ DM	0,063	0,130
Arsenic	As	mg/MJ DM	0,310	0,810
Cobalt	Co	mg/MJ DM	0,380	0,750
Nickel	Ni	mg/MJ DM	5,000	10,000
Antimony	Sb	mg/MJ DM	3,100	7,500
Lead	Pb	mg/MJ DM	12,000	25,000
Chrome	Cr	mg/MJ DM	7,800	16,000
Copper	Cu	mg/MJ DM	abolished due to lack of reproducibility	
Manganese	Mn	mg/MJ DM	16,000	31,000
Vanadium	V	mg/MJ DM	0,630	1,600
Tin	Sn	mg/MJ DM	1,900	4,400

Table 9: Input criteria of AF modified by BGS e.V. in the 2012 to a more practical monitoring related to the energy content

Additionally, individual further parameters have to be agreed too between AF-supplier and AF-user with reference to the respective analysis methods.

13. Working Plan:

personal notes:

Position	Description	Person in charge (contact data)	Current status on date (mark date, and with one keyword why)			remark	Additionally for-warded to
			red	yellow	Green		
1	Waste access and assessment						
2	Identification of potentials for recycling						
3	Market assessment						
4	Identification of disturbances						
5	Technical assessment + requirements of the future customer(s)						
6	Mass stream management and costs						
7	Logistics						
8	Plot + premises assessment						
9	Legal assessment						
10	Pre-engineering for tendering						
11	Tendering for budgeting						
12	Request for approval						
13	Business plan						
14	Internal approval						
15	Detailed engineering						

14. Draft of a delivery contract

§1 Subject matter of contract

§2 Obligations of delivery and acceptance

§3 Delivery

§4 Quality

§5 Fees/ payment/ invoicing

§6 Transfer of ownership / right of rejection

§7 Liability

§8 Disruption of performance

§9 Contract processing

§10 Enforcement/ term/ termination

§11 Severability Clause

§12 Final provisions

personal notes:

DRAFT

Supply of solid alternative fuels

(Contract)

Between the

(supplier, address) represented by

- hereinafter referred to as "Supplier" –

And

(customer, address) represented by

- hereafter referred to as “Customer” –

§1

Subject matter of contract

The subject matter of the contract is the supply of solid, non-hazardous alternative fuels of the specifications and quality set in **Annex 1.**

§2

Obligations of delivery and acceptance

(1) The supplier commits itself to supply ……….t/a solid alternative fuels in the quality specified in **Annex 1** (free deliverance to installation/ex works). The delivery obligation for the year shall be reduced pro rata in proportion to the time at which this agreement comes into force.

(2) The customer shall be obliged to take delivery of the fuels referred to in section 1 above and to use the accepted fuels properly and without damage in accordance with the Waste Directives and Emission Protection Act (if applicable state additional paragraphs).

(3) The parties shall inform each other right in time, at the latest by the end of the calendar year, on operating times, planned shutdowns and inspection times of its plant for the following year in order to take these times into account for deliveries in time.

(4) Should there be a permanent increase on demand above the capacity specified in section 1; the parties will negotiate the option of increasing the envisaged quantities, first.

personal notes:

§3

Delivery

(1) In consultation with the customer, the supplier shall deliver the AFs to the plant as evenly as possible during the agreed period, i.e. the supplier shall deliver approx. **………** tons per week/ month.

(2) The supplier as well as a commissioned third party for transport is entitled to deliver (passage only if transport is carried out by third parties).

(3) In order to specify the delivery obligation agreed in accordance with section 2 (1) of this agreement, the contracting parties shall agree a delivery plan by the end of each year at the latest, stating the expected fuel quantities for each month of the following year. The delivery plan shall be continuously adapted to actual developments. The aim is to deliver as continuously as possible.

§4

Quality

(1) The operation of the customer's plant shall be subject to authorized requirements which require compliance with the quality parameters for the alternative fuels specified in Annex 1. Deliveries shall be made within the conditions recorded in Annex 1 for each individual parameter.

(2) If sampling and analysis at the supplier's premises show that the specified parameters have been significantly exceeded, the customer may refuse acceptance of the delivery. If the parties are unable to agree on the acceptability of the fuel, an independent laboratory shall decide on compliance with the parameters. The costs of re-sampling shall be borne by the party whose opinion is contradicted by the result of the re-sampling.

§5

Fees/ payment/ invoicing

(1) The customer/supplier shall pay the supplier/customer a price of .... per ton based on a calorific value of GJ/t for the acceptance and utilisation of the delivered fuel.

(2) Customer and supplier reserve the right to assert a bonus/malus regulation in the event of improvement or deterioration of the agreed fuel specification in accordance with Annex 4. This regulation applies in particular to the agreed lower calorific value and tolerances in the

personal notes:

chlorine content and is regulated by mutual agreement in the Annex to this contract.

(3) If this contract is extended, the parties undertake to check annually whether the price stipulated above in paragraph 1 is still in line with the market or whether the price is to be updated if necessary.

(4) The customer/supplier shall provide the supplier/customer with a monthly report of the quantities delivered for the previous month, in each case on the 15th of the following month. The invoices are due and payable within 30 days of receipt.

§6

Transfer of ownership / right of rejection

(1) The ownership of the AFs shall pass to the customer after acceptance at the customer's plant.

(2) The customer shall be entitled to reject the acceptance of AFs if the incoming inspection reveals a clear deviation from the specifications permitted under § 4 and if, as a result of this deviation, the use of the fuel in the plant after approval is not permissible.

§7

Liability

The parties agree on the validity of the legal liability regulations.

§8

Disruption of performance

(1) If the customer or the supplier cannot fulfil their obligations under this contract due to force majeure, they shall be released from all obligations.

(2) If, for reasons for which the supplier is not responsible, the supplier is unable to deliver the fuels during four consecutive days, he shall be released from his delivery obligation.

(3) Compensation claims of the buyer are excluded in case of non-delivery in accordance with paragraph 2 above.

§9

Contract processing

(1) The delivered quantities shall be determined by using a calibrated balance of the customer/

personal notes:

supplier. In exceptional cases (failure, maintenance of the balance), weighing may also be carried out on another calibrated scale.

(2) The operating regulations for the Customer's plant have to be noted in their current valid version. Amendments to the operating rules, in particular the opening hours of the plant, the supplier has to be informed in time. The supplier supports as far as possible to cooperate in ensuring a uniform load of the production capacity of the plant. For this purpose, the supplier shall take the requirements of the customer into account in his deliveries.

(3) The Buyer shall issue the Supplier with a monthly invoice for the quantities and qualities delivered.

§10

Enforcement/ term/ termination

(1) The contract shall enter into force upon signature and has a term of one year.

(2) In the case the contract is not terminated at the end of its term by a notice period of three months, it shall be extended by a further year. Termination must be effected by registered delivery with acknowledgement of receipt.

(3) The supplier shall be entitled to terminate this contract in time if the customer fails to comply with the performance obligations transferred under this treaty despite two written reminders.

(4) Each party shall be entitled to terminate this agreement without notice if the other party ceases payments, insolvency proceedings are instituted against its assets or the opening is rejected for lack of assets covering the costs. Termination may be effected without notice at the time at which the circumstance giving rise to the right of termination occurs. Notice of termination must be given in writing. Paragraph 2 sentence 2 shall apply mutatis mutandis.

§11

Severability Clause

(1) Should a provision of this contract be or become invalid or unenforceable for legal reasons, without thereby making it impossible to achieve the aim and purpose of the entire contract, the validity of the remaining provisions shall not be affected. The same shall apply if, after conclusion of the contract, it should turn out that the contract contains a regulation gap requiring amendment.

personal notes:

(2) The contracting parties commit themselves to replace the invalid or unenforceable provision by a provision which fulfils the purpose and economic objective of the entire contract as intended by the invalid or unenforceable provision.

(3) In the case the contract contains a regulation gap which needs to be closed, the parties commit themselves to fill the gap by a regulation which economically comes closest to what the contracting parties have intended according to the purpose and the economic objective of the contract, if they had considered the regulation-needy point.

§12

Final provisions

(1) This contract shall be concluded in writing. Changes and additions to this contract must also be made in writing. This also applies to the amendment of this clause. Verbal collateral agreements do not exist and are ineffective.

(2) Court of jurisdiction for disputes arising from this agreement is….

Place, date….

Signs

personal notes:

Annex 1:

Quality features and specifications of solid alternative fuels to be delivered

According to the operational licence of the plant operator…………., at the plant………, file number……………………...dated……………………by the authorities of…………., solid alternative fuels may be used if:

(1) The fuel to be delivered are kiln ready/ specified as

(2) The AF are analysed before delivery and the results are attached to the respective loading documents as single analysis.

(3) The fuels shall be deemed to have quality assurance if, when delivered, they comply with the following specification set out in Table 1:

Parameter	Unit	Norm	median	80%. Percentile
Inferior calorific value (Hi)	MJ/kg	**For example** 15400		
Ash	wt.-%	15403		
Moisture	wt.-%	15414		
Sulphur	wt.-%	15408		
Chlorine	wt.-%	15408		
Mercury	mg/MJ (DS)	15411		
Cadmium	mg/MJ (DS)	15411		
Thallium	mg/MJ (DS)	15411		
Arsenic	mg/MJ (DS)	15411		
Lead	mg/MJ (DS)	15411		
n.a.	…	…		

An addition, following specifications apply:

(1) **HCF, resp. RDF** has an average dimension (d_{50}) of ……x…….x……..mm

(2) The grain size of the **HCF/ RDF** is checked by the customer on random samples of the as-

personal notes:

sumed fuel. It is agreed to use the sieve trays of the concrete laboratory.

(3) The physical properties of **SRF** shall be specified by its sink rate (v_{50}) in air classification

(4) The average (median) inferior calorific value Hi of the alternative fuel shall be ....kJ/kg.

(5) The median bulk density is ....kg/m³

(6) As described in Annex 2, the European standards shall apply for sampling and analysis according to CEN-TC 343.

(7) The agreed specification is considered to be met if 4 out of 5 analytical values (80% percentile) meet the specification.

(8) A rejection is made if the floating mean of the individual values permanently exceeds the 80% percentile or falls below the minimum for the calorific value.

(9) In case of dispute, the analytical values of an independent laboratory apply.

Annex 2:

Description of the sampling procedure

The sampling for the preparatory analysis in accordance with Annex 1 has to be carried out by well instructed and trained personnel when the fuel is taken over in the reception area of the plant. This can be done at the scale, when the fuel is dumped into the bunker, or automatically from the flowing fuel stream. It should be carried out as representatively as possible according to objective evaluation standards.

The contracting parties agree that the representation of the sampling in this procedure cannot be guaranteed in every case. It is therefore agreed that the sampling volume can be increased and that one-off "outliers" (i.e. the analysis result is above the agreed 80% percentile) are not included in the calculation of the percentile.

The sample material is temporarily stored in a special container (airtight, lockable) for each supplier. This container contains ID which is a unique and is assigned to this individual container. An exact sampling protocol is kept for each container, from which the following can be seen:

- who carried out the sampling and when,
- the inbound deliveries from which the reserved samples result such as material description, EWC code, date, time, truck sign,
- when the taken sample material was sent to the commissioned analysis institute,

personal notes:

- and, by whom and when was the container cleaned before reuse.

Each bucket contains a 20L-sample per delivery from a quantity batch by truck load.

The individual deliveries per day are collected for each vendor.

As long as there is no comparable and mutually recognized alternative to taking samples, the supplier-specific daily samples shall be carried out professionally in accordance to the analysis regulations of CEN/TC 343 in or by the commissioned laboratory.

The sample is reduced to approx. 10L each (cone-quarter-method). Half of the daily sample remains with the customer as a reference sample.

This is stored in a closed and sealed bucket, which is clearly marked accordingly, while the other half of the samples (seven per week) are combined to a weekly mixed sample per supplier and again reduced to approx. 10L laboratory sample.

This weekly composite sample is handed over to the agreed laboratory for analysis.

Further sample preparation is also carried out in the laboratory in accordance with the analysis regulations of CEN/TC 343. Size reduction to < 1 mm is carried out by means of a cutting mill after becoming embrittled with liquid nitrogen.

The destruction of the reference sample is only carried out after presentation and release of the analysis values by the supplier. In the case of necessary control tests, the retained quantities remain until clarification or until the final, possibly third control analysis has been carried out.

Annex 3:

Description of the quality control procedure

Quality control is essentially carried out through the sampling and analytical procedures described above. These continue to apply unchanged.

An essential element of price determination is the determination of the inferior calorific value Hi. It shall be specified in greater detail in accordance with Annex 4.

This is done continuously through analysis and measurements by the thermal process. These data shall be valid as accompanying control measurements. Especially for the supplier concerned, the determination of the calorific value is carried out by the laboratory test of the commissioned institute in accordance to the annexes.

If several values are available for the delivery month, the statistical mean value is calculated

personal notes:

from all of these values. This is decisive for the classification of the alternative fuel.

All contract-relevant procedures for sampling and analysis shall be properly documented and checked annually for reliability and practicability within the framework of appropriate audits.

The customer reserves the right to carry out an annual audit in the supplier's plants concerned after prior agreement on a date. As part of this audit, the supplier shall keep available the current operating permit, his operating log and beside others the plant documents, such as flow diagrams, process organisation, results of self-monitoring.

Annex 4: Example for a billing basis for supply of solid calciner fuel (RDF).

Due to the different framework conditions (raw materials, fuels, technology, product, etc.), such an allocation scheme must be agreed individually in each plant, i.e. the basis of calculation (basic data) may differ considerably from this example.

Base price: 18 €/t; purchase price for customer (CIF)

		Inferior calorific value		**Max**
	< 16 MJ/kg	16 MJ/kg	> 16 MJ/kg	20 MJ/kg
Correction factor	-2,0 €/t per MJ/kg	0 €	1,0 €/t per MJ/kg	6,0 €/t

		Chlorine content		**Max**
Concentration	< 0,9%	0,9%	> 0,9%	1,50%
Correction factor	1,5 €/t per 0,1%	0 €	-1,5 €/t per 0,1%	-4,5 €/t

		Water content		**Max**
Concentration	< 20%	20%	> 20%	30%
Correction factor	1,5 €/t per %	0 €	-1,5 €/t per %	-4,5 €/t

personal notes:

Example calculations for a monthly settlement

Analyzed parameters in the monthly median

Example 1:

H_i: 18 MJ/kg

Cl: 1,1 %

Water content: 18%

Calorific value			+	Chlorine		+	Water content		=	Transfer price
16 MJ/kg	+	2 MJ/kg		0,9%	+ 0,2%		20%	- 2%		
(18 €/t	+	(2*1€/t))	+	(0 €/t	+ (2*-1,5€/t))	+	(0 €/t	+ (2*1,5€/t))	=	20,00 €/t

Example 2:

H_i: 14 MJ/kg

Cl: 0,8 %

Water content: 28%

Calorific value			+	Chlorine		+	Water content		=	Transfer price
16 MJ/kg	-	2 MJ/kg		0,9%	- 0,1%		20%	+ 8%		
(18 €/t	+	(2*-2€/t))	+	(0 €/t	+ (1*1,5€/t))	+	(0 €/t	+ (8*-1,5€/t))	=	3,50 €/t

personal notes:

15. Directory of pre-references of CEN/ TC 343 (without guarantee of completeness)

Reference pre EU-norm	Titel
15357	Solid recovered fuels – Terminology, definitions and descriptions
15358	Solid recovered fuels – Quality management systems - Particular requirements for their application to the production of solid recovered fuels
15440	Solid recovered fuels - Method for the determination of biomass content
14980	Solid recovered fuels – Report on relative difference between biodegradable and biogenic fractions of SRF (TR)
15441	Solid recovered fuels - Guidelines on occupational health aspects (TR)
15400	Solid recovered fuels - Methods for the determination of calorific value
15401	Solid recovered fuels - Methods for the determination of bulk density
15402	Solid recovered fuels - Methods for the determination of the content of volatile matter
15403	Solid recovered fuels - Methods for the determination of ash content
15404	Solid recovered fuels - Methods for the determination of ash melting behavior
15405	Solid recovered fuels - Methods for the determination of the density of pellets and briquettes
15406	Solid recovered fuels - Methods for the determination of bridging properties of particulate solid recovered fuels
15407	Solid recovered fuels - Methods for the determination of carbon (C), hydrogen (H) and nitrogen (N) content
15408	Solid recovered fuels - Methods for the determination of sulphur (S), chlorine (Cl), fluorine (F) and bromine (Br) content

personal notes:

Reference pre EU-norm	Titel
15410	Solid recovered fuels - Method for the determination of the content of major elements (Al, Ca, Fe, K, Mg, Na, P, Si, Ti)
15411	Solid recovered fuels - Methods for the determination of the content of trace elements (As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, Se, Tl, V and Zn)

Standard reference	Title
CEN/TR 14980:2004	Solid recovered fuels - Report on relative difference between biode-gradable and biogenic fractions of SRF
CEN/TR 15404:2010	Solid recovered fuels - Methods for the determination of ash melting be-havior by using characteristic temperatures
CEN/TR 15441:2006	Solid recovered fuels - Guidelines on occupational health aspects
CEN/TR 15591:2007	Solid recovered fuels - Determination of the biomass content based on the 14C method
CEN/TR 15716:2008	Solid recovered fuels - Determination of combustion behavior
CEN/TS 15401:2010	Solid recovered fuels - Determination of bulk density
CEN/TS 15405:2010	Solid recovered fuels - Determination of density of pellets and briquettes
CEN/TS 15406:2010	Solid recovered fuels - Determination of bridging properties of bulk mate-rial
CEN/TS 15412:2010	Solid recovered fuels - Methods for the determination of metallic alumin-ium
CEN/TS 15414-1:2010	Solid recovered fuels - Determination of moisture content using the oven dry method - 1: Determination of total moisture by a reference method

personal notes:

Standard reference	Title
CEN/TS 15414-2:2010	Solid recovered fuels - Determination of moisture content using the oven dry method - 2: Determination of total moisture content by a simplified method
CEN/TS 15639:2010	Solid recovered fuels - Determination of mechanical durability of pellets
EN 15357:2011	Solid recovered fuels - Terminology, definitions and descriptions
EN 15358:2011	Solid recovered fuels - Quality management systems - Particular requirements for their application to the production of solid recovered fuels
EN 15400:2011	Solid recovered fuels - Determination of calorific value
EN 15402:2011	Solid recovered fuels - Determination of the content of volatile matter
EN 15403:2011	Solid recovered fuels - Determination of ash content
EN 15407:2011	Solid recovered fuels - Methods for the determination of carbon (C), hydrogen (H) and nitrogen (N) content
EN 15408:2011	Solid recovered fuels - Methods for the determination of sulphur (S), chlorine (Cl), fluorine (F) and bromine (Br) content
EN 15410:2011	Solid recovered fuels - Methods for the determination of the content of major elements (Al, Ca, Fe, K, Mg, Na, P, Si, Ti)
EN 15411:2011	Solid recovered fuels - Methods for the determination of the content of trace elements (As, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Mn, Ni, Pb, Sb, Se, Tl, V and Zn)
EN 15413:2011	Solid recovered fuels - Methods for the preparation of the test sample from the laboratory sample
EN 15414-3:2011	Solid recovered fuels - Determination of moisture content using the oven dry method - Part 3: Moisture in general analysis sample
EN 15415-1:2011	Solid recovered fuels - Determination of particle size distribution - Part 1:

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Standard reference	Title
	Screen method for small dimension particles
EN 15440:2011	Solid recovered fuels - Methods for the determination of biomass content
EN 15442:2011	Solid recovered fuels - Methods for sampling
EN 15443:2011	Solid recovered fuels - Methods for the preparation of the laboratory sample
EN 15590:2011	Solid recovered fuels - Determination of the current rate of aerobic microbial activity using the real dynamic respiration index

See also: https://www.beuth.de/en/erweiterte-suche/272130!search?alx.searchType=complex&searchAreaId=1&query=Solid+recovered+fuels&facets%5B276624%5D=&hitsPerPage=10

personal notes:

16. Check lists

personal notes:

Chapter	Prefeasibility Study			Approval			Conceptual development		
Economy	world energy price			competition			quality parameter		
	local energy price			competition			quality parameter		
	polluter-pay-principle			legal enforcement			quality parameter		
	disposal fee			legal enforcement			quality parameter		
	penalty			legal enforcement			quality parameter		
	revenues/ gate fee			local market			quality parameter		
	GHG-ETS			international commitment			quality parameter		

Notes:

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Chapter	Prefeasibility Study			Approval			Conceptual development		
Realization/ Waste management	access	owner					quality parameter		
		municipal collection		composition			design parameter		
	amount	population growth					design parameter		
	disposal	wild dumping		to be closed			rehabilitation needs		
		sanitary landfill			parameter		quality parameter		
	recycling	type of recycables		wood chipboard	parameter		quality parameter		
		private collection		EWC			design parameter		
		portion of recycables		paper mill	parameter		quality parameter		
				glass smelter	parameter		quality parameter		
				scrap smelter	parameter		quality parameter		
	thermal capacity	existing		cement/ lime	technical assessment		quality parameter		
				power plants	technical assessment		quality parameter		
				paper mill	technical assessment		quality parameter		
				MWI			quality parameter		
				MBT/ BMT	technical assessment		design parameter		
		new		WtE			design parameter		
				MBT/ BMT			design parameter		

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Chapter	Prefeasibility Study			Approval			Conceptual development		
legal/ political frame	country strategy	legal enforcement		EU-directives			quality parameter		
				waste hierarchy			quality parameter		
				Kyoto/ Paris			quality parameter		

Notes:

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WhiteLabel

18. Topics of the WLTP-inhouse-seminar:

1. Preliminary work	2. Pre-treatment	3. Materials Handling	4. Co-processing
1.1 Definition 1.2 Waste assessment 1.3 Technical process assessment 1.4 Economical frame 1.5 Permission 1.6 Designing the pre-treating process	2.1 Source & Composition 2.2 Treating haz./non-hazardous waste 2.3 Equipment: 2.3.1 Shredding 2.3.2 Screening 2.3.3 Sifting 2.3.4 Classify 2.3.5 Metal Separation 2.4 Quality assurance 2.5 Logistics	3.1 AFR System Definition 3.2 Truck unloading 3.3 Mechanical conveying and screening 3.4 AFR storage 3.5 Weighing and feeding 3.6 Pneumatic conveying 3.7 ATEX directive	4.1 Kiln process 4.2 Feeding points 4.3 Co-processing 4.3.1 Traditional 4.3.2 Modern 4.3.3 Future 4.4 Awareness and Impacts 4.5 Faulty operation

personal notes:

- Arrange a meeting
- Contact info@wltp.eu for proposal

www.wltp.eu

info@wltp.eu

Legal note:

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Münster, 05.03.2020