BMH TECHNOLOGY

# WASTE REFINING SOLUTIONS

TYRANNOSAURUS MAKES STRONG SENSE

RECOVERING VALUE FROM WASTE

# A NEW APPROACH TO WASTE MANAGEMENT AND ENERGY PRODUCTION

Global population growth, urbanisation and improving quality of living accelerate the production of waste. At the same time, we suffer from lack of raw materials and face an increasing demand for energy. These global environmental challenges force us to adopt new technologies for producing energy and handling waste.

As environmental awareness increases, the related legislation also sets new requirements for societies to support the use of carbon-neutral fuels. All this encourages us to embrace circular economy and recover value from waste.

## LOCAL FUEL IS A GLOBAL SOLUTION

Waste to Energy technology offers an environmentally friendly and economical solution for replacing fossil fuels. It enables obtaining cheaper and locally produced fuel, securing the availability of fuel at a steady price level, and of course, reduction of emissions. BMH Technology offers a comprehensive solution for refining waste into valuable fuel and recycling materials.

## WHY DOES SHREDDING WASTE MAKE SENSE?

In the TYRANNOSAURUS® process waste is shredded into predefined size and refined into high-quality fuel by separating inert and recyclable materials. Pre-processing the waste offers significant benefits compared to simply burning untreated waste.

Shredding the waste homogenises the material stream, which makes conveying easier and combustion much more efficient. Separating inert materials, such as stones, bricks, glass and soil, also adds the fuel's rating by increasing its calorific value. After the waste is shredded into smaller pieces, it can be effectively sorted using mechanical, electrostatic and intelligent sorting equipment. Not only does automatic sorting improve the quality of the fuel but it also produces recyclable raw materials for further use.

## Average waste generation *(1)*


## HOW MUCH WASTE DO WE PRODUCE?

Solid waste management is arguably one of the most important municipal functions. One barely notices it when everything runs smoothly, but it can cause extreme problems when poorly executed.

Average waste generation per person varies a lot depending mainly on socio-economic status and geographical location. Research shows that the world generates 2.01 billion tonnes of municipal solid waste annually. This volume is expected to grow to 3.40 billion tonnes by 2050. In lower income countries, waste generation rates might even more than triple by this time. *(1)*

With waste all around us, and sophisticated technology available to convert that waste into reliable and renewable fuel, energy producers have sustainable, yet profitable choices to choose from.

## IMPORTANT TERMS

**ICW – Industrial and Commercial Waste**

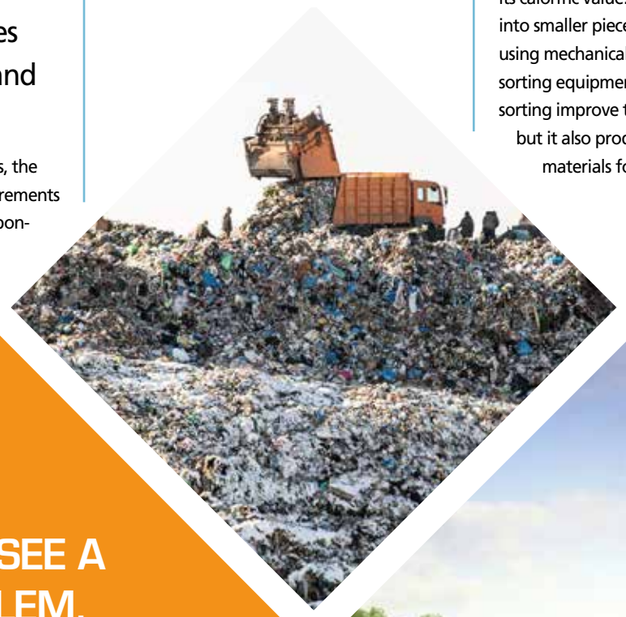
- Typically quite dry and high calorific value waste. Mostly paper, carton, and plastic. Various packaging materials and usually batches of finished or unfinished products, which are for example rejected from the manufacturing process. Density is rather low and material quality relatively consistent.

**MSW – Municipal Solid Waste**

- General household waste of varying quality containing miscellaneous waste types such as food residues, textiles, papers and cardboard, glass, ceramics, bricks, dirt, metals etc. Usually quite humid.

**SRF - Solid Recovered Fuel**
**RDF - Refuse Derived Fuel**

- SRF and RDF are both alternative fuels made of refuse materials such as MSW and ICW, available in surplus all over the world, often in negative cost. The main distiction between the two is in the methods through which their production has been controlled and recorded. SRF is a standardised fuel produced from non-hazardous waste, intentionally prepared with respect to quality criteria (eg. net calorific value, mercury and chlorine content) specified in the European standard EN ISO 21640:2021.



**SOME SEE A PROBLEM, WE SEE AN OPPORTUNITY.**

**USING SRF ENABLES BENEFITING FROM THE MARKETABLE $CO_2$ CREDITS.**

1) Based on the data presented in "What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050", https://openknowledge.worldbank.org/handle/10986/30317, p. 40, 47, 54, 60, 67, 70, 78.

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## THE TYRANNOSAURUS® SYSTEM OFFERS SUSTAINABILITY AND FINANCIAL BENEFITS

# REPLACING FOSSIL FUELS IS THE FUTURE

### HOW MUCH SRF/RDF IS NEEDED TO REPLACE ONE UNIT OF COAL?

Coal has a high calorific value but it releases a lot of fossil $CO_2$ emissions. SRF/RDF on the other hand is significantly lower in fossil $CO_2$ emissions, yet its calorific value is relatively high. The substitution of fossil fuels by sustainable alternatives requires a certain population that produces the required amount of waste. BMH has the methods to assess the optimal size for the population and the yield (Yield = Input - Rejects - Recyclables) that can be achieved with specific types of wastes.

In our calculations we have made the following conclusion: by using SRF instead of coal, the related fossil $CO_2$ emissions could be cut to approximately one third.

### HOW TO ASSESS SRF´S/RDF'S IMPACT ON $CO_2$ EMISSIONS?

SRF and RDF typically contain a large portion of renewable organic materials such as leftover food, cardboard and wood, which are not considered to increase the fossil $CO_2$ emissions. Therefore the fossil $CO_2$ emissions of SRF/RDF are mainly derived from the plastics within the fuel. The impact on fossil $CO_2$ emissions from using SRF/RDF instead of coal can be pre-assessed by BMH. We can provide calculations to support the decision to transfer from fossil fuels to waste based SRF/RDF.

## THE IMPORTANCE OF CALORIFIC VALUE

Calorific value is a vital attribute to any fuel as it defines how valuable the fuel is in terms of its capability to produce energy. When waste is refined into SRF/RDF, the calorific value of the fuel increases significantly as inert materials are removed. Stones, glass, bricks and soil do not produce any heat in combustion, which is why it is worthwhile to remove these materials out of the fuel. In some cases this also applies to wet food residues. In this process recyclable materials also get taken into reuse.

The EN ISO 21640:2021 standard describes the classification of SRF according to the range of its calorific value, chlorine and mercury content.

There is no fixed calorific value for SRF but typically SRF compares well to coal. The calorific value of coal is around 21 to 25 MJ/kg, whereas high quality MSW-based SRF has a calorific value of around 18 MJ/kg. For premium SRF the calorific value can exceed 20 MJ/kg.

High quality SRF is consistent in particle size, free of hazardous components and allows the reduction of fossil $CO_2$ emissions.

| FUEL | HEATING VALUE | Tons of $CO_2$ / ton of fuel |
|---|---|---|
| Coal | 25 MJ/kg | 2.41 |
| Pet coke | 33 MJ/kg | 3.34 |
| Fuel Oil | 42 MJ/kg | 3.16 |
| **SRF*** | **20MJ/kg**** | **0.64**** |

* Class 2 according to EN ISO 21640:2021 ** Based on a reference case.

This calculation does not include the savings in methane emissions, which are achieved by avoiding landfilling. SRF's positive environmental impact is thus greater than what these numbers tell.

| FOSSIL FUEL | | SRF* |
|---|---|---|
| 1 TON OF COAL | CAN BE REPLACED BY | 1.4 TONS OF SRF |
| 1 TON OF PET COKE | | 1.7 TONS OF SRF |
| 1 TON OF FUEL OIL | | 2 TONS OF SRF |

The precise SRF/RDF composition depends on the raw material, so there is no absolute method for determining fossil $CO_2$ emission reduction in a long run. In real life, the fuel is sampled and analysed. Combined with on-line measurements from the plant, the final balance of SRF/RDF-based fossil $CO_2$ reduction can be calculated reliably.

### THE VALUE OF TYRANNOSAURUS® SOLUTIONS

The environmental benefits for converting from fossil fuels to more sustainable solutions are significant. Since 1980, BMH solutions in solid biofuel handling and waste refining have together saved more than 553 million tons of fossil $CO_2$ emissions, and it's a figure that keeps growing. This equals the $CO_2$ emissions for 229 million single flights around the world. In addition to positive environmental impacts, financial benefits to SRF/RDF users are also obvious.

Since1980,

**553**

million tons of fossil $CO_2$ emissions saved by BMH.

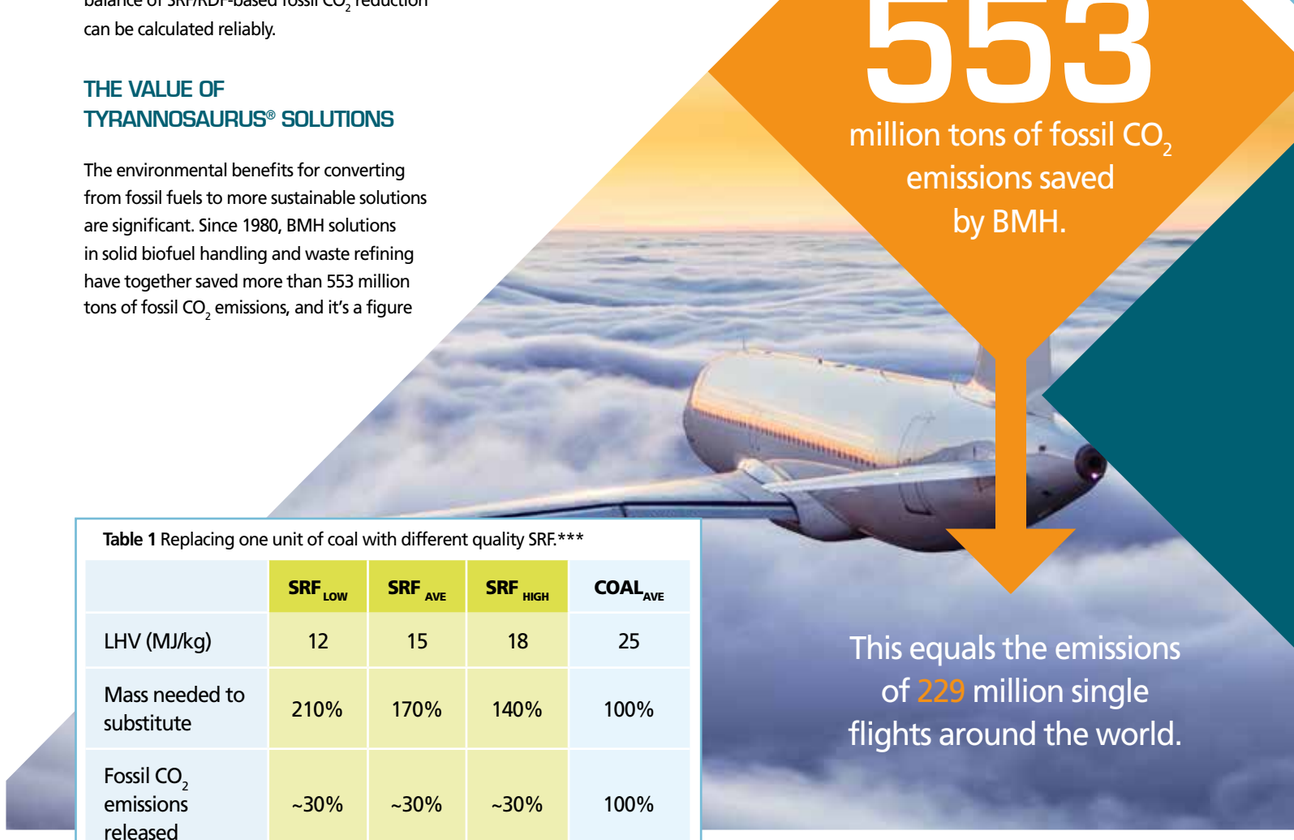


**Table 1** Replacing one unit of coal with different quality SRF.***

| | $SRF_{LOW}$ | $SRF_{AVE}$ | $SRF_{HIGH}$ | $COAL_{AVE}$ |
|---|---|---|---|---|
| LHV (MJ/kg) | 12 | 15 | 18 | 25 |
| Mass needed to substitute | 210% | 170% | 140% | 100% |
| Fossil $CO_2$ emissions released | ~30% | ~30% | ~30% | 100% |

*** It is assumed that for typical SRF the average released fossil $CO_2$ emissions are approximately 30% in the long run, when compared to typical coal.

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## HOW TO TURN WASTE TO FUEL AND PROFIT?

# THE TYRANNOSAURUS® PROCESS

**ONE SUPPLIER FOR ALL**
- TAILOR-MADE SOLUTION
- FROM ANALYSIS & ENGINEERING TO INSTALLATION & COMMISSIONING
- PROCESS GUARANTEE

Fossil $CO_2$ emissions of SRF are significantly less than those of coal. With BMH's advanced waste refining technology, it is possible to economically and efficiently generate huge amounts of sustainable energy.

### TAILOR-MADE SOLUTION

BMH Technology offers a comprehensive solution for refining waste into local, environmentally friendly fuel that can replace coal and other fossil fuels in energy production. The system comes with wide guarantee, one-stop service, fitting interfaces and a compact layout. The TYRANNOSAURUS® waste refining plant, delivered turnkey, produces tailor-made and always optimised fuel. Just one production line can process as much as 1200 tons of MSW (Municipal Solid Waste) or 600 tons of ICW (Industrial and Commercial Waste) per day.

The key features of the TYRANNOSAURUS® system are high availability and capacity, low production cost, low maintenance cost and high level of automation. The process can be adjusted on-line to produce the desired fuel quality for the end user.

### ADAPTIVE FEEDING SYSTEM

The TYRANNOSAURUS® process starts with a feeder, which also serves as a buffer storage. Its moving floor continuously feeds an optimum amount of waste into the process as it communicates with the TYRANNOSAURUS® Shredder. If the shredder has enough waste to process, the feeder slows down, allowing the production line to always work at maximum capacity. Raw material can be fed into the system by crane from a bunker, by front loader or by tipping directly from a truck.

### ROBUST AND INTELLIGENT SHREDDER

Effective shredding is the most important phase in processing waste into SRF/RDF. The TYRANNOSAURUS® Shredder can reduce particles in one single stage to optimised size according to customer requirements. The shredder weighs up to 90 tons and has a rigid steel frame. Not only is it robust, but it is also intelligent. MIPS® (Massive Impact Protection System) means that the shredder will detect and reject any unshreddable items and keep on working. This function is completely automated, which has a significant impact on the availability of the system.

**Scan QR code to see the TYRANNOSAURUS® Process**

### OPTIMAL CUTTING PROFILE

Shredding is a wear-intensive function. ZeroGap® shredding means that the particle size and quality are preserved even with wearing of the knives. This technology, patented by BMH Technology, maintains hydraulically the cutting gap in zero, ensuring an optimal cutting profile. Thanks to ZeroGap®, the TYRANNOSAURUS® Shredder is able to process even the thinnest waste materials, such as plastic films and foils. The shredder's knives are hydraulically adjusted to keep on working optimally and lengthen the service interval.

### SEPARATING RECYCLABLES

Once the waste has been shredded, the process sorts out valuable recyclables and removes other selected fractions. Ferrous metals are separated from the shredded waste by magnets, while eddy current separators take out other conductive metals, such as copper and aluminium.

In some cases where the purity of the fuel needs to be maximised, very fine non-combustible materials such as glass chips, sand, gravel, and soil, are also screened out from the waste with a TYRANNOSAURUS® Fines Screen. This increases the calorific value of the produced fuel while also removing components that might cause problems during combustion.

The final touch is given by TYRANNOSAURUS® Air Classifier, which is the decisive stage concerning the quality of the fuel. This part of the process separates larger inert particles such as pieces of brick, stones, residual metals and other heavy three-dimensional objects.

### OPTIONAL PRETREATMENT PROCESS

Waste qualities and combustion processes vary. The process can be further developed according to customer needs by integrating more specialised recycling stages. These can be, for example, organics removal, additional drying, further refining to biofuel or higher material recovery by intelligent sorting.

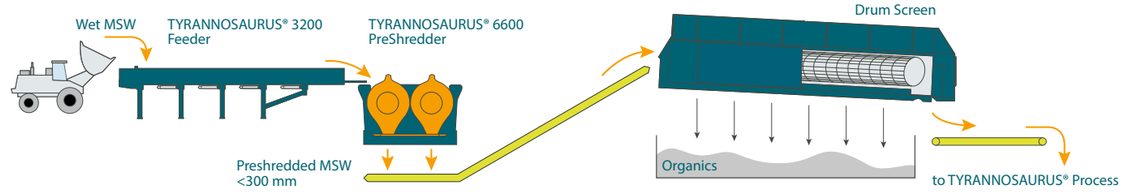
Should the quantities of wet organics in the raw material be high, as usually is the case with MSW, they can be separated before the actual SRF/RDF production process. The TYRANNOSAURUS® Pre-Shredder will produce approximately 250mm particle size, which for grate-fired incinerators would be acceptable as such. In this case the pre-shredder could be the main shredder. A drum screen or a disc screen separates the wet organics and non-recyclable materials. Finally fractions with higher calorific value are conveyed further to the TYRANNOSAURUS® SRF/RDF process.

**Small particle size = Accurate separation**

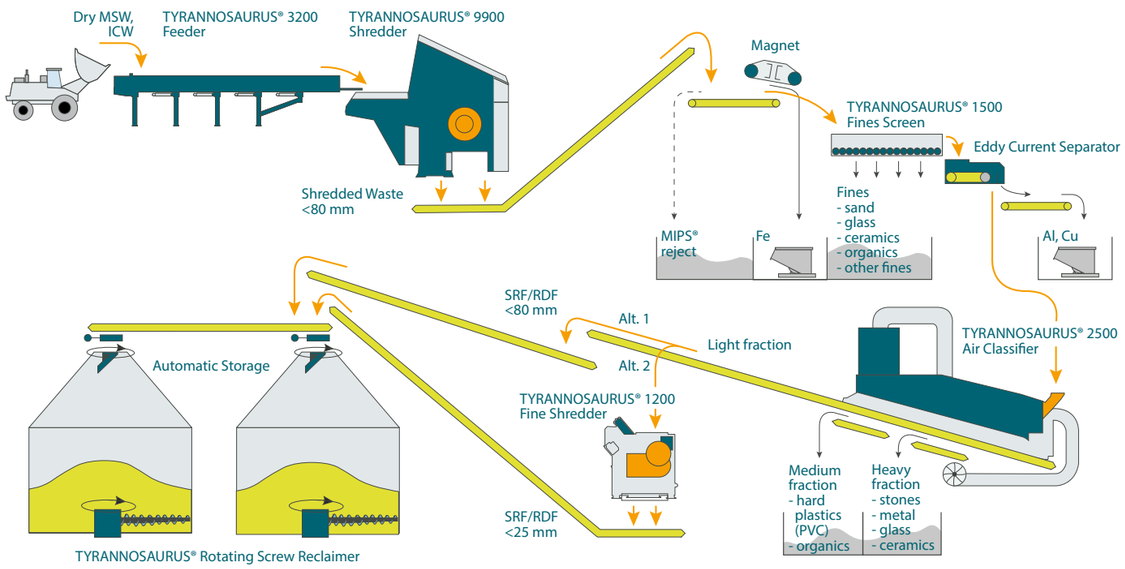
**ZeroGap® = High capacity & Low operational cost**

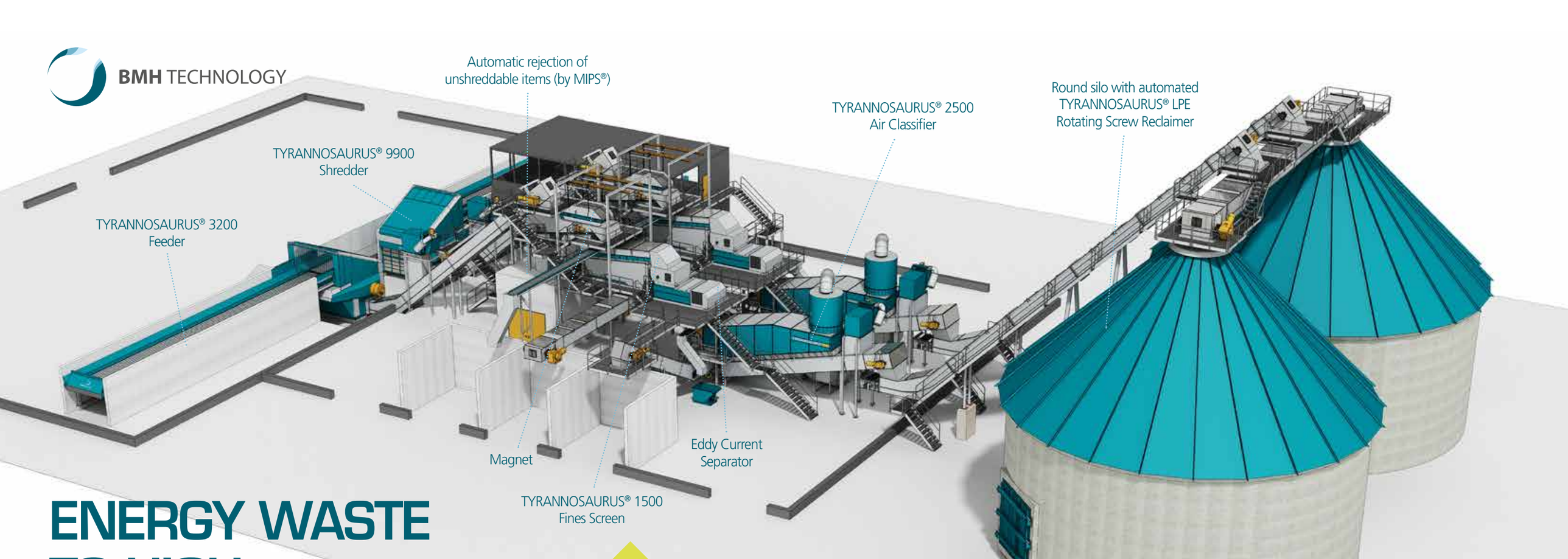
**MIPS® = High availability**

### The TYRANNOSAURUS® Pretreatment Process




### The TYRANNOSAURUS® Process





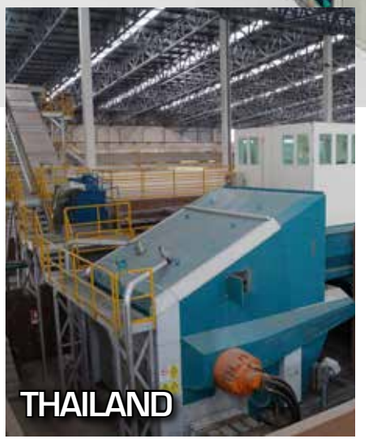

# ENERGY WASTE TO HIGH QUALITY FUEL

DRY
ICW/ MSW
SRF/RDF
< 80mm

This example process is designed to refine dry ICW or MSW into high quality SRF to be used in power plants.

This dual-line processing plant is capable of processing up to 80 tons of dry ICW or MSW per hour, depending on the input quality. The end product is high quality SRF/RDF with yield from 60% up to 95%, depending on separation equipment settings and requirements for fuel characteristics.

With just modest 4 000 h/a, the annual processed input amount would be approx. 320 000 tons. With 75% yield and 15 MJ/kg SRF, the thermal output would be sufficient to run approx. 130 $MW_{thp}$ modern CFB boiler through the year, if the boiler is run 7 800 h/a. This would convert to electricity production of approx. 40-50 MWe or more. In annual production it would correspond to approx. 390 000 MWh. All of these values are subject to change as a function of many variables, such as annual operating hours, ICW characteristics, SRF/RDF requirements and yield, available boiler type and capacity etc.




**Genco** (General Environmental Conservation Public Company Limited) is a significant Thai waste management company that receives industrial waste and refines it to alternative fuel. The fuel can be used in power plants or cement industry. The process also separates recyclables and raw materials.

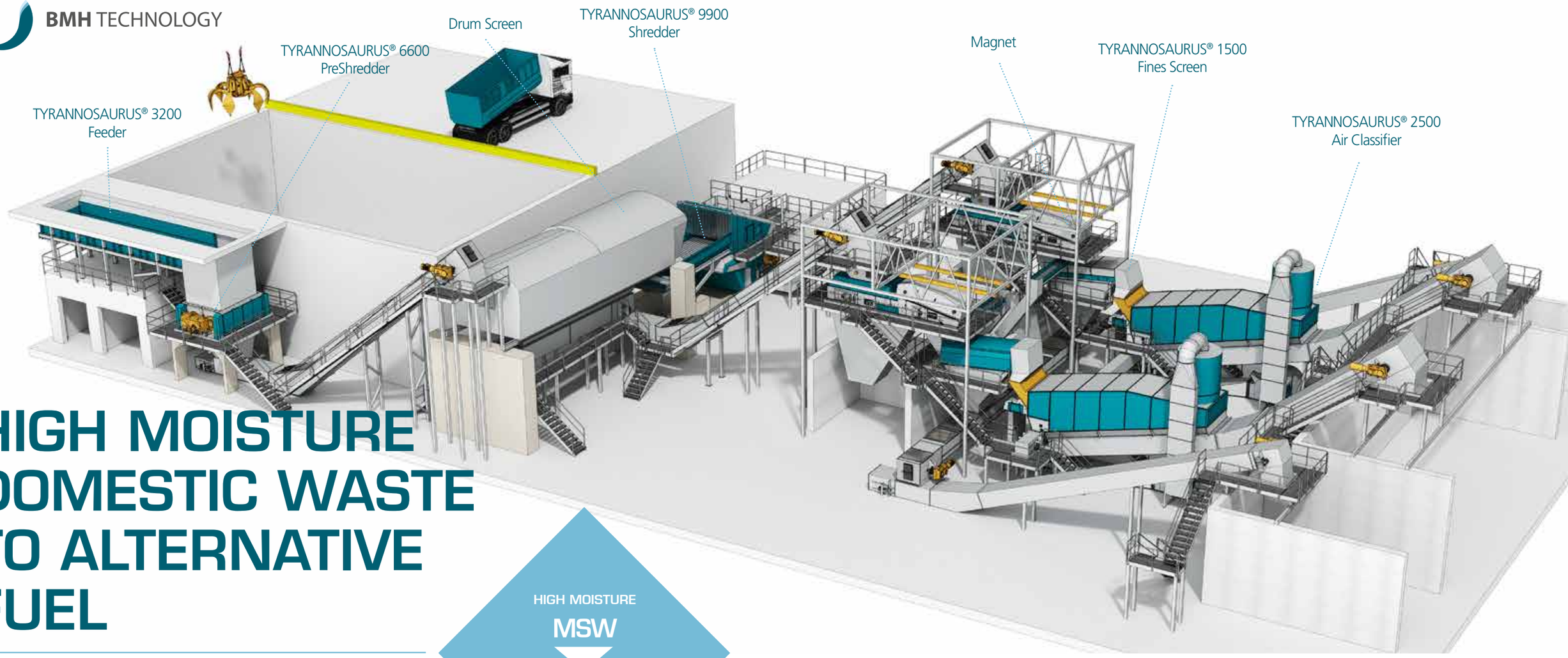
**BMH delivery to Genco**
Waste to Fuel: A shredding platform, metal separation station and a storage system (2017).


**Posco E&C** is a large South-Korean EPC company specialised in major complete plant deliveries. The Pohang plant refines the MSW of the surrounding area into SRF, which is used for an integrated power plant. The plant's single processing line has a big shredding capacity, 40 tons per hour.

**BMH delivery to Posco**
Waste to Electricity: A complete TYRANNOSAURUS® SRF production line (2018).


**Rauman Biovoima** is a combined heat and power plant (CHP) supplying process steam to the local paper industry and district heat to the city of Rauma, as well as electricity. Other fuels besides SRF are bark, forest residues and peat. The power plant complex includes a BFB and a CFB boiler, which use altogether nearly 100 000 tons of SRF annually.

**BMH delivery to Rauman Biovoima**
Waste to Electricity: The TYRANNOSAURUS® SRF production plant is directly integrated to the BFB and CFB boilers and consists of energy waste processing lines, an SRF fuel storage and a dosing and feeding system to the boiler building including necessary auxiliary systems (2014).




# HIGH MOISTURE DOMESTIC WASTE TO ALTERNATIVE FUEL

This example process is designed to refine MSW with high organic content into SRF/RDF. The target is to maximise the amount and the quality of SRF/RDF and at the same time minimise the amount of rejects that require landfilling. The input material is of mixed nature, containing large quantities of organics and inert materials such as stones and soil.

HIGH MOISTURE
**MSW**
**SRF/RDF**
< 80mm

The plant is capable of handling up to approx. 70–80 tons of MSW in one hour, depending on the MSW quality. The end products are SRF/RDF and recovered recyclables. In special applications, the separated inert materials can be used as raw material in cement production.

With typical 4 000 annual operating hours, the capacity is approx. 300 000 tons per year. With an estimated SRF yield of 70% the amount of produced SRF would be approx. 210 000 tons in a year, the remaining 90 000 tons being good quality inert alternative raw materials.
φ
The annual SRF production would be sufficient for a cement plant with approximately 6 000 tons per day clinker production, running at approx. 30-40 overall fuel substitution rate.

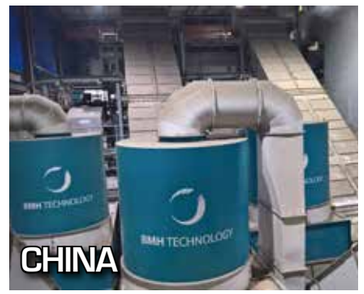
All of these values are subject to change as a function of many variables, such as annual operating hours, MSW characteristics, SRF/RDF requirements and yield etc.


**GPSC's** (Global Power Synergy Public Company Limited) plant in Rayong was built to solve the local waste problems and to produce alternative fuel for energy production. The plant refines extremely high moistur MSW into high quality SRF and separates recyclables and raw materials.

**BMH delivery to GPSC**
Waste to Fuel: A complete TYRANNOSAURUS® SRF production line (2017) including pretreatment.

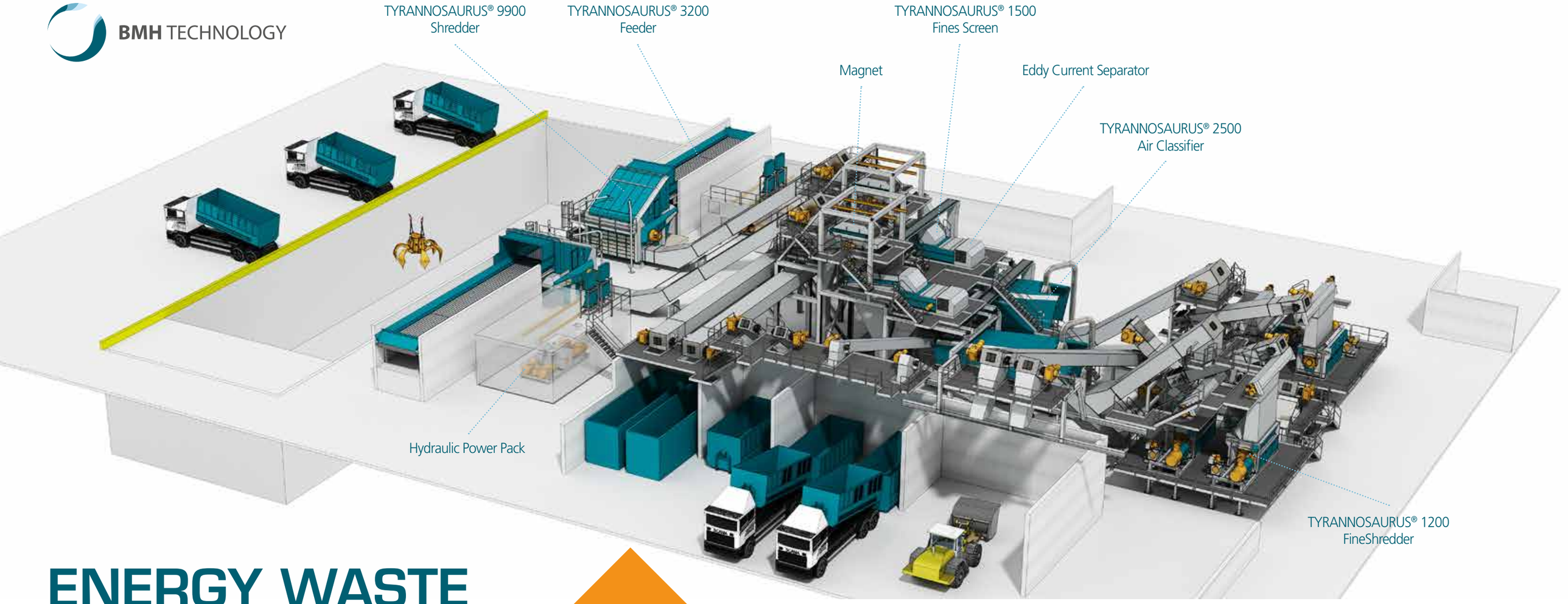

**Estre** is Brazil's largest environmental services company receiving 6 million tons of trash every day. It sees waste as the starting point for a series of opportunities and transforms it into sustainable energy.

**BMH delivery to Estre Ambiental**
Waste to Fuel: A complete TYRANNOSAURUS® RDF production plant with pretreatment process for MSW (2011).




**HJJ** (Hangzhou Jin Jiang Group) is one of the biggest Waste to Energy companies using CFB boiler technology in China. As a part of HJJ´s boiler upgrade program, the waste processing line at Xiaoshan power plant was completely replaced by a high capacity TYRANNOSAURUS® system.

**BMH delivery to HJJ**
Waste to Electricity: A complete TYRANNOSAURUS® plant for SRF production (2016).




# ENERGY WASTE TO SUPERFLUFF

This example process is designed to refine ICW or dry MSW into SRF to be used in cement production or in power plants.

The four fine shredders of the plant reduce the fuel particles into < 25mm size, allowing rapid combustion in any thermal application. This processing plant, equipped with two main shredders and four fine shredders, is capable of handling up to 80 tons of ICW or dry MSW per hour, depending on the waste quality and ratio of fine shredding requirement.

**ICW / DRY MSW**

▼

**SRF**
< 25MM

With typical 4 000 annual operating hours the capacity is approx. 300 000 tons per year.
The end product is high quality SRF in < 25 mm particle size, as well as separated materials to be refined into recyclable raw materials.


**SITA Starol** is a pioneer in alternative fuels production in Poland. It is a part of the global Suez Environnement Group, one of the world leaders in the field of water management and waste handling. One third of Suez Environnement group's shares belongs to ENGIE, the largest independent producer of electricity in the world.

**BMH delivery to SITA**
Waste to Flame: A complete TYRANNOSAURUS® SRF production plant for processing MSW and ICW and special waste fractions to produce SRF (2008).


**Posco E&C** is a large South-Korean EPC company specialised in major complete plant deliveries. The Gwangju plant refines the MSW of the surrounding area into SRF with 50 mm particle size.

**BMH delivery to Posco**
Waste to Fuel: Two complete TYRANNOSAURUS® SRF production lines (2015).


**Langezaal B.V.** is a multifunctional organisation operating in many fields of services for the construction industry and road and water construction. It pays a great deal of attention to environmental issues and strives to reduce $CO_2$ emissions. For them, one way to reduce stress on the environment is using waste-based fuel.

**BMH delivery to Langezaal B.V.**
Waste to Fuel: A complete TYRANNOSAURUS® waste processing plant for preparing SRF and other recyclable materials (2009).

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## FINER FUEL FOR ANY THERMAL APPLICATION

# REFINING WASTE INTO CLEAN ENERGY

Modern society constantly thirsts for more energy in order to keep functioning and growing. Waste-based fuel offers new solutions for producing environmentally friendly electricity at a profit, while simultaneously reducing landfilling.


### GOOD FOR NATURE, GOOD FOR THE COMMUNITY

As power plants are mostly located close to power consumers, they are also located close to sources of waste production. This fact offers new opportunities for electricity production.

Reduction of landfilling by utilising waste-based fuels in power plants benefits both the local community and the power plant. Using waste based fuels in power generation, instead of dumping them, also reduces the negative effects of landfilling, such as methane emissions, sanitary issues and odour problems.

SRF/RDF fuel, produced in the TYRANNOSAURUS® process, has a considerably higher quality compared to raw waste material. Preparing the fuel means better efficiency, less combustion problems and less emissions. The fuel preparation process also recovers recyclable materials, such as metals.

### SOLUTIONS FOR ALL WASTE TO ENERGY APPLICATIONS

Grate firing is the oldest method for burning solid waste. When larger boiler size, higher electricity production capacity or capability to handle different fuel mixes are required, CFB/BFB (Circulating Fluidised-Bed/Bubbling Fluidised-Bed) boiler solutions become more attractive. These boiler technologies have high combustion efficiency and lower emission levels.

BMH Technology offers solutions for all combustion and conversion technologies, such as gasification or pyrolysis for production of chemicals and alternative fuels. In addition to new builds, the existing power plants can be easily modified into using SRF/RDF as their primary fuel.

The supreme fuel flexibility built into BMH's solutions enables combustion of a wide range of fuels. In power plant solutions delivered by BMH, SRF can also be co-fired with biomass, peat, agro-based and fossil fuels in power generation.

Many power plants prefer to produce the fuel at their site and integrate the production into their system. In this case, reliability and availability are essential requirements for the fuel production line.

### THE WASTE TO ELECTRICITY SOLUTION

Requirements for the fuel quality and quantity are investigated together with the customer. Once the waste composition and the fuel requirements have been identified, a suitable design for fuel preparation can be chosen. At this stage the input waste quality and availability are significant factors, as the boiler requires a steady and sufficient fuel flow.


**Mälarenergi AB** is one of Sweden's largest combined power and heating plants. It uses only renewable fuels for energy production and provides both electricity and district heating to the surrounding city of Västerås.

**BMH deliveries to Mälarenergi**

Biomass fuel handling**:** A complete solid biofuel handling system for wood chips, forest residues, bark and peat (2000). A complete solid biofuel handling system for wood, pellets and peat (2002).

Waste to Electricity: A complete TYRANNOSAURUS® RDF production plant for MSW and industrial waste (2014). A complete fuel handling system for recycled wood (2020).


**Lahti Energia** is a big energy company that provides electricity all over Finland and district heating to its nearby area. Its Kymijärvi power plant is Finland's biggest SRF user.

**BMH delivery to Lahti Energia**

Waste to Electricity: A complete SRF receiving and screening system with TYRANNOSAURUS® oversize shredding and sampling system, a large automated silo storage system with reclaiming and feeding to gasification (2012).


**Fortum's** combined heat and power (CHP) plant in Zabrze aims to boost energy efficiency and lower emissions. It provides district heating to some 70.000 households. The plant is adaptable to several fuels and the amount of RDF can be up to 40%.

**BMH delivery to Fortum**

Fuel handling: Complete solid fuel handling system including train unloading and automatic sampling (2018).

BMH has a strong heritage in supplying sustainable system solutions for energy generation. Special attention has been paid to reliability in operation, availability and minimising dusting and other environmental impacts. The consistence of fuel quality is carefully controlled by the automated storages, which create the optimal fuel mix.

Transfers between sub-processes are accomplished with dust-proof, entirely enclosed conveying technology. The design of the layouts is straightforward and compact with a minimum number of conveyors.

The entire fuel storing and handling process up to feeding and dosing into the boiler works automatically. The fuel flow is homogeneous and automatically adjusted to follow the fuel demand in the boiler. The equipment and sub-processes fulfil the regulations of the current ATEX and international design standards.

## IDEAL SOLUTION FOR ALL WASTES

Waste is different across countries and cultures and its characteristics can also vary locally during time. On the other hand, the processes that use waste-based fuel always have their own requirements, which need to be fulfilled consistently and reliably for the whole concept to be a success. This is why choosing the correct process for turning waste into fuel is of such critical importance.

With our experience and comprehensive process, you can customise your own TYRANNOSAURUS® production line for any non-hazardous solid waste material stream to meet your specific fuel needs. We help you to find the right capacity, correct particle size, optimum sorting equipment, and possible additional processes, all in a compact, efficient, and optimised layout.

Whether your goal is to maximise the fuel quality, minimise the process rejects, achieve the highest possible capacity or optimise a specific compound in the fuel or in the rejects, the TYRANNOSAURUS® process, as modular and flexible technology, is the perfect solution.

| | $MSW_1$ | $MSW_1$ | $MSW_2$ | ICW | Mixed Waste |
|---|---|---|---|---|---|
| **Incoming Waste Properties*** | | | | | |
| CV (Calorific Value) | 6 - 8 MJ/kg<br>1 430–1 910 kcal/kg | 6 - 8 MJ/kg<br>1 430–1 910 kcal/kg | 10 - 12 MJ/kg<br>2 390–2 870 kcal/kg | 18 - 21 MJ/kg<br>4 300–5 010 kcal/kg | 15 - 18 MJ/kg<br>3 590–4 300 kcal/kg |
| Moisture | 45%–55% | 45%–55% | 30%–40% | 5%–15% | 25%–35% |
| Typical Input Capacity | 1 000 tpd | 1 000 tpd | 1000 tpd | 800 tpd | 1000 tpd |
| Objective | SRF/RDF Quality | SRF/RDF Yield | SRF/RDF Yield | SRF/RDF Quality | SRF/RDF Yield |
| **Process** | | | | | |
| Pre-Treatment | X | X | | | |
| TYRANNOSAURUS® SRF/RDF Process | X | X | X | X | X |
| Notes | Most organics are separated in order to maximise the SRF quality. This organic stream can be, for example, utilised as raw material in an AD (Anaerobic Digestion) plant. | In order to maximise the SRF yield (recovery rate), most organics are kept as part of SRF at the expense of SRF's CV. | The pre-treatment process is not required due to relatively low organic content. SRF production line is adjusted to optimise the quality and quantity of produced SRF. | Due to very low content of non-combustible materials and high content of plastics, SRF yield and CV are extremely high. | SRF yield and CV can be adjusted by altering the input material mixing rates. The process also allows on-line adjustments for SRF output. |
| **Ready SRF/RDF Properties*** | | | | | |
| CV (Calorific Value) | 11.8 MJ/kg<br>2 820 kcal/kg | 7.4 MJ/kg<br>1 770 kcal/kg | 12.3 MJ/kg<br>2 940 kcal/kg | 22.0 MJ/kg<br>5 260 kcal/kg | 18.3 MJ/kg<br>4 370 kcal/kg |
| Moisture | 47% | 56% | 36% | 15% | 30% |
| SRF/RDF Output | 270 tpd | 760 tpd | 850tpd | 728 tpd | 880 tpd |
| SRF/RDF Yield | 27% | 76% | 85% | 91% | 88% |
| Rejects | 13% | 22% | 11% | 6% | 8% |
| Recyclables and Others | 60% | 2% | 4% | 3% | 4% |
| Fuel Power | 37 $MW_f$ | 65 $MW_f$ | 121 $MW_f$ | 185 $MW_f$ | 186 $MW_f$ |
| Generated Electricity** | 11 $MW_e$ | 20 $MW_e$ | 36 $MW_e$ | 56 $MW_e$ | 56 $MW_e$ |
| **Example layout** | | **See page 10-11** | **See page 8-9** | **See page 8-9** | **See page 8-9** |

**$MSW_1$ =** Typical Asian MSW with high organic, moisture and inerts content. Abrasive for equipment.

**$MSW_2$ =** Typical OECD type MSW, a smaller quantity of organics and inerts and the moisture content is lower compared to $MSW_1$.

**ICW =** Typical Industrial and Commercial Waste, consisting mostly of dry packaging materials.

**Mixed waste =** Typical European type MSW mixed together with ICW. Proportions might fluctuate.

*Properties for incoming waste are based on general data and experience. Properties for ready SRF/RDF are based on specific cases.

**Actual produced electricity depends on chosen power plant technology.



BMH TECHNOLOGY

# WASTE TO FLAME – FUELLING THE CEMENT KILN

Cement production is a very energy intensive process. A typical medium sized cement line can consume over 600 tons of coal every day. The good news is that it can be fully replaced by SRF.

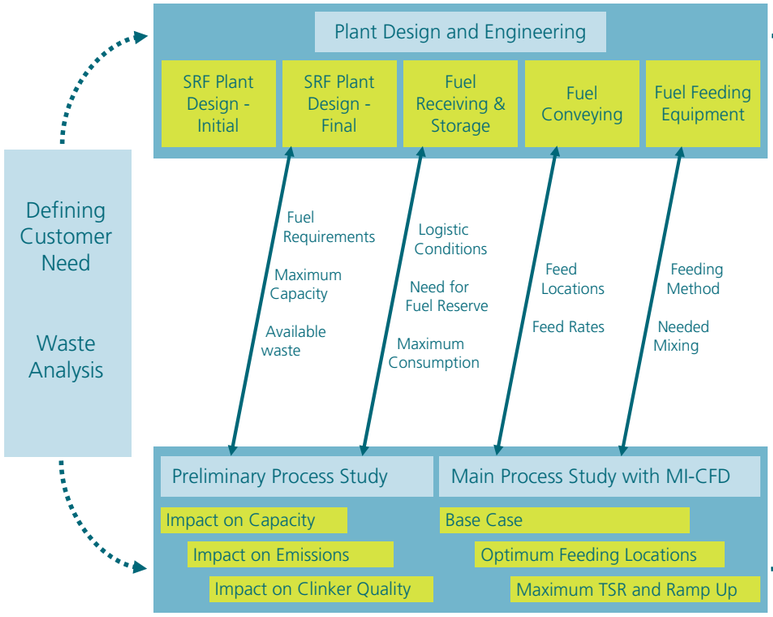
Cement plants can indeed be huge off-takers for SRF, benefitting both the plant and the local community. In co-processing, SRF is used both as energy and as raw material.
With BMH's unique approach in Waste to Flame application, up to 100% Thermal Substitution Rates (TSR) are reachable, using SRF in both calciner and main burner. Simultaneously, the cement process safely binds the ash into cement, reducing the need for mined raw materials and eliminating the need for ash landfilling.

In addition to economic benefits, substituting fossil fuels by SRF will also lead to reduction in $NO_x$ as well as fossil $CO_2$ emissions.

## THE WASTE TO FLAME SOLUTION

BMH solutions customise the SRF process and its implementation to individual cement plant processes and chemical characteristics.
A Waste to Flame project begins with a thorough feasibility analysis, consisting of a waste study, process analysis including CFD (Computational Fluid Dynamics) as needed and plant engineering.
Careful waste analysis is the foundation of all subsequent studies. After the waste analysis, the SRF quality options can be evaluated.

Cement production requires extremely high temperatures and a stable flame. Reaching high temperatures sustainably demands SRF with consistent quality and high calorific value. Optimised mixing and combustion plus retention time (RT), as well as higher temperatures compared to other waste combustion technologies, make co-processing a safer solution for the environment and people.




In order to define the customers' need, their objectives are carefully mapped. Such objectives can be for example annual co-processing capacity, TSR targets or focusing on either calciner or main burner. These customer-specific targets are combined with waste study results and BMH's understanding of global wastes and possible SRF qualities. This sets the scope for the project, which in principle can target up to 90% annual TSR and 10% raw material replacement.

**ALL CEMENT PLANTS ARE DIFFERENT. EACH WASTE TO FLAME SOLUTION IS UNIQUE.**

## THE ENGINEERING AND PROCESS STUDY

The next step, preliminary process study, evaluates the current process and estimates boundaries for SRF quality factors, such as moisture content, chlorine level, alkaline content and particle size distribution. Simultaneously, the impact of local conditions, feed rates, bypass or ID fan capacity, preheating tower cyclones' pressure drop etc. are considered as part of the plant design and engineering.

The main process study with a CFD analysis can be started once the above mentioned boundaries have been determined and agreed.

## OPTIMISATION OF THE PROCESS

The CFD code is customised to find solutions for cement production and emissions related to co-processing, simulating the use of defined AFR (Alternative Fuels and Raw Materials) in the cement process. The goal for the main process study is optimising the co-processing to enable up to 100% TSR to be achieved on a best day basis.

CFD enables optimisation of feeding points and rates, guaranteeing the technical feasibility of the process with SRF in TSRs exceeding 35%. It also allows investigation of ramp-up curve to higher TSRs and problems with mixing. If the plant has some previously unnoticed reserve to increase capacity, this can also be detected with CFD.

After CFD, optimised feed rates and locations are used to finalise the cement plant technical solution, which is then completed with silos and conveyors. Correct feeding and dosing equipment are also chosen according to the process study.

## THE DELIVERY

The TYRANNOSAURUS® Waste to Flame co-processing uses mostly existing cement plant infrastructure. The BMH fuel handling equipment, needed for co-processing, requires only a small layout to integrate into existing processes.

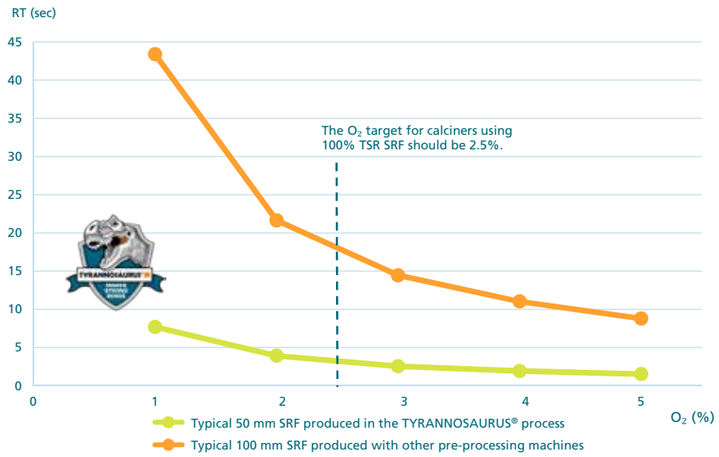
The scope of each project will be determined together with the customer according to their needs. SRF production plant, cement plant fuel handling system, as well as dosing and feeding equipment can be delivered by BMH on a turnkey basis. The suppliers for above mentioned engineering and process study options are also found in our network.



## PARTICLE SIZE – THE SECRET TO SUCCESS

The burnout of 100 mm material, typical of what is produced from other preprocessing machines, compared to the typical TYRANNOSAURUS® product is compared in the below figure, showing its benefits for the cement process.

**Comparison of Burnout Retention Times (RTs) for SRF (50 mm and 100 mm) at 900°C**




The 50 mm particle size is good even for calciners with only 2 seconds' RT (provided that the co-processing installation delivers it to the correct locations and sufficient mixing is guaranteed by, for example, injecting the SRF with high velocity).

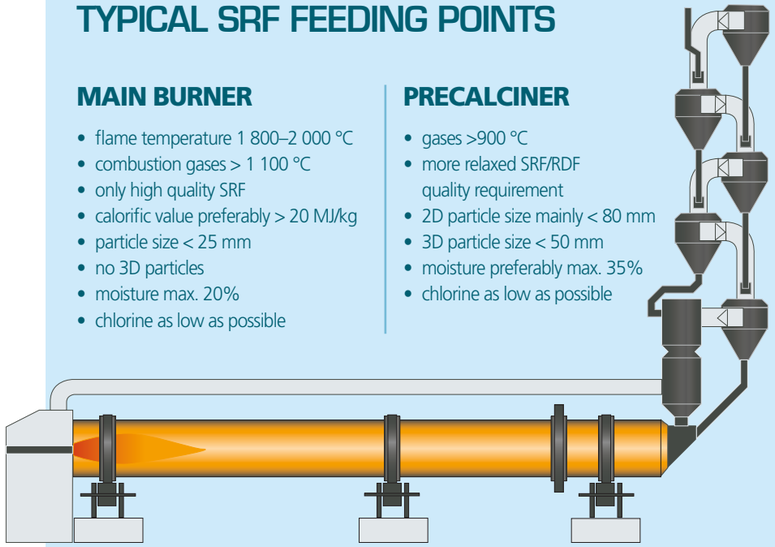
## TYPICAL SRF FEEDING POINTS

### MAIN BURNER

- flame temperature 1 800–2 000 °C
- combustion gases > 1 100 °C
- only high quality SRF
- calorific value preferably > 20 MJ/kg
- particle size < 25 mm
- no 3D particles
- moisture max. 20%
- chlorine as low as possible

### PRECALCINER

- gases >900 °C
- more relaxed SRF/RDF quality requirement
- 2D particle size mainly < 80 mm
- 3D particle size < 50 mm
- moisture preferably max. 35%
- chlorine as low as possible




**CIMPOR's** plant in Souselas (Coimbra) is a major cement factory, part of one of the world's largest cement groups Intercement. It produces 2,40 million tons of cement annually in Portugal. The plant uses waste based SRF in its main burner and precalciner.

**BMH delivery to Cimpor**

Waste to flame: A turnkey solution (2011) for handling alternative fuels at a cement mill, including screening, dosing and feeding as well as storage systems.


**Lassila & Tikanoja** is a Finnish service company focused on environmental care as well as producing support functions for real estates and facilities. It's recycling center in Turku handles ICW as well as construction and demolition waste and produces recyclables, raw materials and alternative fuel.

**BMH delivery to L&T**

Waste to Flame: A complete TYRANNOSAURUS® SRF production plant for preparing high quality fuel for cement kiln main burner (2005).


**BBMG** (Beijing Building Material Group) is the third largest cement producer in northern China and among the 10 biggest producers worldwide. Their plant in Handan produces fuel for the nearby cement plant.

**BMH delivery to BBMG**

Waste to Flame: A complete TYRANNOSAURUS® SRF production plant (2017) for waste refining, producing both alternative fuel (SRF) and raw materials for a zero waste concept.

BMH TECHNOLOGY

# FUELLING A CLEANER FUTURE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