

Optimisation of Fuels from MBT Processes

Craig Ibbetson* and Kurt Wengenroth**

*Regen Fuels, London, UK; **B&T Umwelt GmbH, Buseck, Germany

Optimierung von Brennstoffen aus dem MBA Prozess

Abstract

Design and operation of fuel production from MBT processes must be optimised to provide the lowest treatment cost after consideration of capital and operating cost, and income.

This paper illustrates how this approach can be structured to arrive at a design that is significantly lower cost than previous MBT design approaches. A key consideration is the fuel quality that is required.

Keywords

SRF, RDF, MBT, optimization

1 Drivers for the production of Waste Derived Fuels

The EU Landfill Directiveⁱ has forced waste management policy across the member states of the European Union to plan for a reduction of the amount of waste sent for disposal in landfill. The Directive requires that progressively increasing quantities of biologically active waste are diverted away from landfill. Traditionally, incineration has been considered to be the next alternative for disposal; however this approach has encountered high levels of resistance in many countries at the planning and permitting stage. This has opened the possibility of alternative approaches.

Some municipalities have decided to use mechanical biological treatment (MBT) for the treatment of waste. This technology offers a second opportunity to recycle waste as it is processed (in addition to that done by the householder or business). After separating any recyclable materials a “residual” fraction remains, which is then treated aerobically or anaerobically to fulfil the new quality demands to enable it to be landfilled.

Although this approach to waste management is widely practised, it may not represent the best technical, environmental or economic solution; as the landfilled waste can still contain significant quantities of stored energy after treatment. An alternative to landfilling treated waste is the creation of a fuel. This material is often called “refuse derived fuel (RDF) or solid recovered fuel (SRF), the latter being the term that will define compliance with emerging European technical standardsⁱⁱ.

Until recently it has been the fulfilment of the diversion targets of the Landfill Directive that were the main drivers for the production of fuel fraction, and not the demands of the energy market. This results in three important aspects for the usage of SRF:

- a) Usage of SRF is combined with a gate-fee
Production of a high energy fraction is a fundamental part of MBT technology, RDF/SRF is usually delivered with a gate-fee to the user.
- b) Quality of SRF is highly dependent on waste-input and treatment
Compared to the quality demands of an industrial process, unprocessed waste is heterogeneous, and full of disturbing materials which must not enter an industrial thermal process. Therefore the fuel fraction needs further treatment before it can become a solid recovered fuel (SRF) which is fit for purpose. The requested quality is highly dependent on the individual treatment process and technical design of the fuel using plant.
- c) Legal Status
Solid recovered fuels are legally considered to be wastes in Europe. Waste management law and regulation will apply to the user of RDF/SRF.

2 General usage of secondary fuels

RDF/SRF is in wide use across the EU. The rising cost of traditional fossil fuels, the concerns over security of fuel supply and the desire to create more power and heat from renewable sources have combined to increase the usage of fuel derived from waste materials. These substitute fuels find their place in a “merit order” that is determined by individual, project specific requirements.

Generally, the markets for SRF/RDF are a mixture of long-term bi-lateral contracts and spot market trading. The liquidity of individual markets is a function of their maturity, and the incentives and barriers encountered within the waste and energy sectors. These vary significantly across Europe.

The main uses for SRF/RDF are found in:

- Power generation at utility power plant
- Power generation at industrial power plants
- Cement industry

Power generation can be configured as combined heat and power (CHP) resulting in higher efficiency energy recovery than stand-alone electricity generation. Gasification of RDF and SRF is a newly emerging technology that opens the possibility of the production of petrochemicals and transport fuels.

The principal industrial sectors that are using RDF/SRF for power production include:

- Paper industry
- Metals processing industry
- Chemical industry

Studies have indicated that European production of SRF/RDF was estimated at over 3 million tonnes per year in 2003ⁱⁱⁱ. It is known that many plants have been built since then; a more recent study concluded that in Germany in 2005 the production exceeded 6 million tonnes per year.

3 Co-incineration of secondary fuel

Usage of solid recovered fuels (SRF) occurs in co-incineration in industrial processes such as:

1. cement kilns and / or
2. coal fired power plants

SRF used in Co-incineration has not only to fulfil the limitations of the European Waste Incineration Directive (WID), but also be compatible with the technical needs of the plant that was originally designed to use traditional fossil fuels. This causes specific demands for SRF fuel-preparation: the main restrictions occur in particle size, the amount of 3-dimensional plastic particles in the fuel, and chemical parameters such as chlorine content.

The highest demands occur in hard coal fired power-plants designed for usage of pulverised fuel, where the residence time in the combustion zone is limited to 2 – 3 seconds.

Power plants that are purpose designed for SRF have different requirements. For these plants the demands on fuel preparation require only the separation of disturbing materials such as glass and aluminium. Chlorine content is also an important parameter in this case.

3.1 Co-incineration in Cement-kilns

Production of cement is a chemical conversion process, operating at temperatures of 1400 °C, in the presence of other minerals and certain heavy metals. The needed reactivity is formed and fixed in the final product cement^{iv}

For this process a huge quantity of energy is needed. The energy consumption for the whole process is typically about 25% of the total production costs. Emissions of such process are limited to European standards, and in the case of SRF, the WID has to be fulfilled. The amount of SRF usage is limited to 60% of the total energy need; otherwise the emission standards of mass-burning system have to be considered.

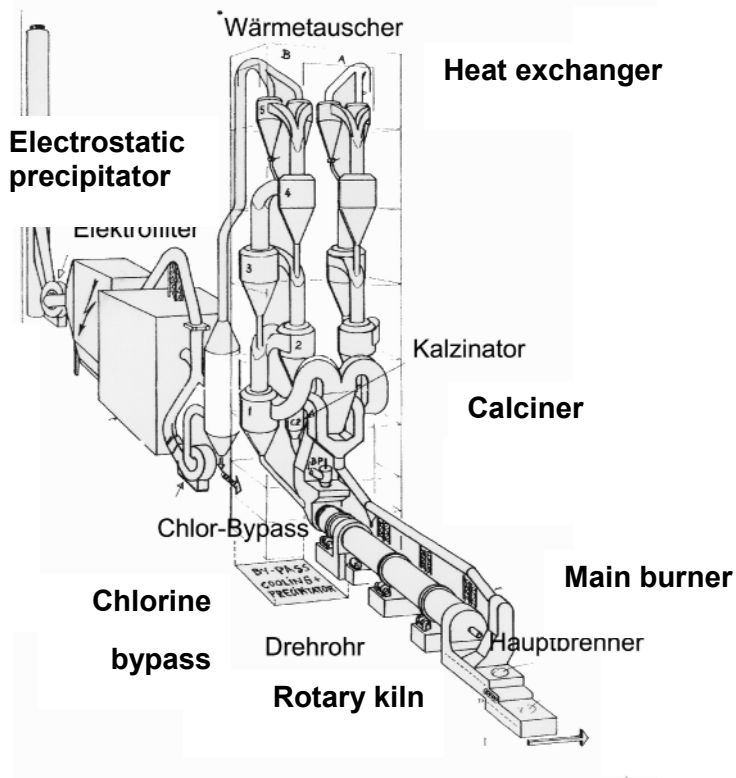


Fig. 1 Scheme of a cement kiln with energy recovery by heat exchanger

The main quality demands are for a high calorific value (CV) and ensuring the fuel is suitable for the fuel feed system. Typical fuel requirements are summarised below:

Table 1 Typical quality parameters for co-firing cement-kilns

Quality parameter	Main-burner feeding	Calciner feeding
Calorific value	min. 20 MJ/kg	min. 15 MJ/kg
Particle size	< 20 mm	< 25 mm as soft-pellet
Ash-content	Low	Can be higher up to 20%
Contrary materials	Free from Fe and Non ferrous metals, no 3-dimensional particles	Free from Fe and Non ferrous metals
Feeding system	Pneumatic	Mechanically by use of a sluice system
Chlorine	depends on the existence of a chlorine by-pass, in general < 1%	depends on the existence of a chlorine by-pass, in general < 1%

As can be seen above the specification demands for main burner fuel are higher than for SRF which is used in the calciner.

3.2 Co-incineration in coal-fired power-plants

Usage of SRF in coal-fired power-plants can have the highest demands on preparation of SRF and is mainly dependent on the type of coal-fired power-plant.

There are a variety of different types of power-plants. The most common are: fluidised bed incinerators, lignite fired power-plants with grate burners as well as dust-fired types, and hard-coal fired power-plants with either molten ash extraction or with dry ash extraction. Fluidised bed incinerators and grate systems have the lowest demands on fuel preparation. The number of such plant-types is generally rather low. Lignite fired power plant are mainly in Germany because of the availability of this type of fuel.

Hard-coal-fired power-plants have the highest demands on fuel-preparation for SRF. The feeding of the secondary fuel is done pneumatically, which requires a particle-size of < 20 mm. Heavy compounds like wood or plastic, which often occur in SRF, have to be separated because the combustion behaviour of these substances at a particle size of 20 mm differs significantly from coal-dust.

Fig. 2 shows the design of a hard-coal fired power plant with molten ash extraction

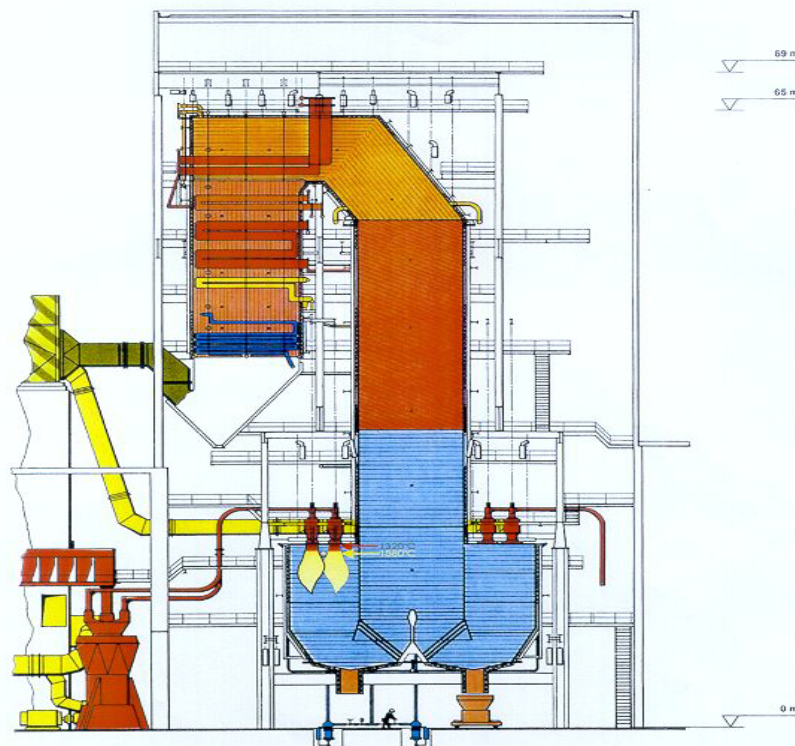


Fig. 2 Hard coal fired power plant with molten ash extraction

The fuel preparation requirements can be summarised as follows:

Table 2 Quality parameters for coal-fired power plants

Quality parameter	Hard-coal power plant	Lignite power-plant
Calorific value	min. 20 MJ/kg	min. 11 MJ/kg
Particle size	< 20 mm	< 25 mm as soft-pellet
Ash-content	Low	Can be high
Contrary materials	Free from Fe and Non ferrous metals, no 3-dimensional particles	Free from Fe and Non ferrous metals
Feeding system	Pneumatic	Mechanically on the conveyor belt
Chlorine	depends on S-content in the used coal in general < 1%	depends on S-content in the used coal in general < 1%

4 Secondary fuel power plants

The implementation of the Landfill Directive in Germany occurred on June 1st 2005; resulting in a large amount of new MBT capacity being brought on-line. Many of these plants did not have contractually secured outlets for the fuel they were about to produce. The result has been an “overhang” of more than 3 million tonnes which has led to secondary fuel being stored.

The market response was that within one year more than 40 projects for the development of secondary power plants are planned, with a combined capacity of more than 7.5 million tonnes per year.

Different technologies are available and in direct competition:

- fluidised bed incinerators
- grate fired systems with the same technology as mass-burn incinerators

All are equipped with flue-gas cleaning systems which totally fulfil the criteria of the WID without restricting the input material.

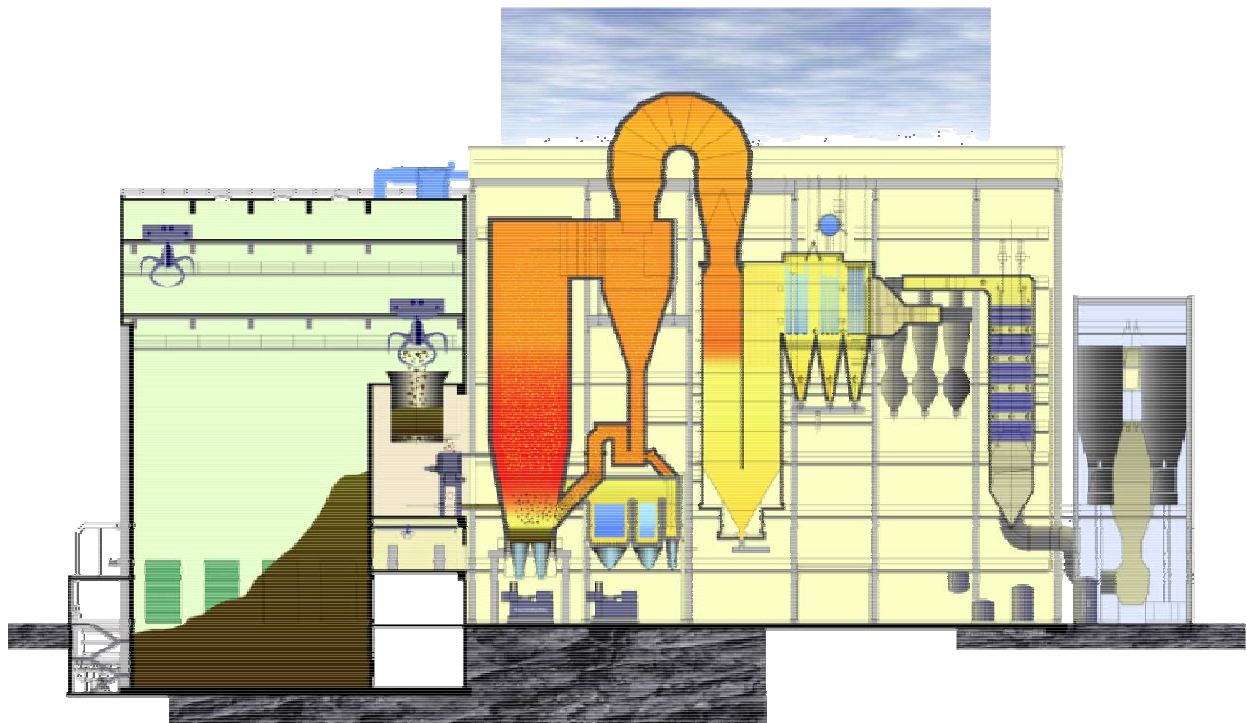
The quality demands of these kinds of power plants shifts from chemical characterisation and calorific value (as needed by co-incineration plants), to those parameters which will influence the performance of the boiler (in terms of steam temperature and plant availability). As most of these power-plants support industrial processes with steam and electricity, reliable performance is essential for the economics of such a project^y.

The following parameters are most important and have to be limited in the fuel input:

Table 3 Quality parameters for an industrial secondary fuel power plant

Particle size	Depending on used technology < 300 mm for grate systems < 80 mm for fluidized bed systems
Metal aluminium	< 5% in the remaining ashes
Alkaline metals (Na, K)	< 5% in the remaining ashes
Glass	
Chlorine	0,85 as median of the samples
Disturbances	Length of longest particles < 300 mm

Note that criteria like calorific value, ash content and particle size distribution are not the principal quality drivers for secondary fuel power-plants.

**Fig. 3** Scheme of a fluidized bed incinerator for secondary fuel

5 Consequences for the design of MBT plants

It is informative to observe the behaviour of markets in order to understand the relationship between cause and effect for a given set of circumstances. The approach taken by designers and operators of MBT plants in Germany offers insight into the changes needed to deal with reduced profitability caused by a shortage of contracted disposal points for MBT outputs.

5.1 General consequences

German MBT plants had mainly concentrated on fulfilment of the landfill disposal criteria of the Landfill Directive. Different types of technologies with aerobic and anaerobic treatment steps were developed. Effort and costs increased because it was found to be impossible to guarantee the landfill target values, especially the $\text{TOC}_{\text{Eluat}}$. Finally, after long discussions the authority adapted the limit from 250 mg/l to 300 mg/l.

MBT plants produce multiple streams of recyclables from the incoming waste stream. Whilst development for compliance with the landfill disposal criteria was happening only limited effort was put into the design of treatment for the production of the high CV fraction. The result was (after coming into force of the landfill directive on June 30, 2005) a short-term market failure; as before the adoption of the new landfill regulations nearly no material was available, and there was not enough market confidence to justify a speculative investment in new power plant for use of the high CV fraction.

However the market has now responded and is moving to correct this position. The difference between supply and demand has increased gate fees causing many established MBT plant operators (who did not have secured fuel supply contracts) to experience financial difficulties.

The longer-term reaction of the market for this kind of secondary fuel, however, has been to specify combustion systems, which are able to take untreated or minimally treated high CV fraction.

As a consequence, it is necessary for MBT designers and operators to consider all output streams and match the design of the plant with the quality requested by the off-takers. (There also might be some synergy effects, i.e. it might be possible for a power plant to burn components which will lead to difficulties in the biological treatment step). The MBT plant designer must understand the balance between investment and operating cost for the production of different fuel qualities; increasing the investment for producing high quality secondary fuel for cement kilns, may not be as attractive as fuel production for secondary fuel power plants. The higher gate-fee for these qualities will increase the operating costs, and must be compensated for by savings made in the design of the facility.

The different qualities and the (relative) related gate fee is illustrated below.

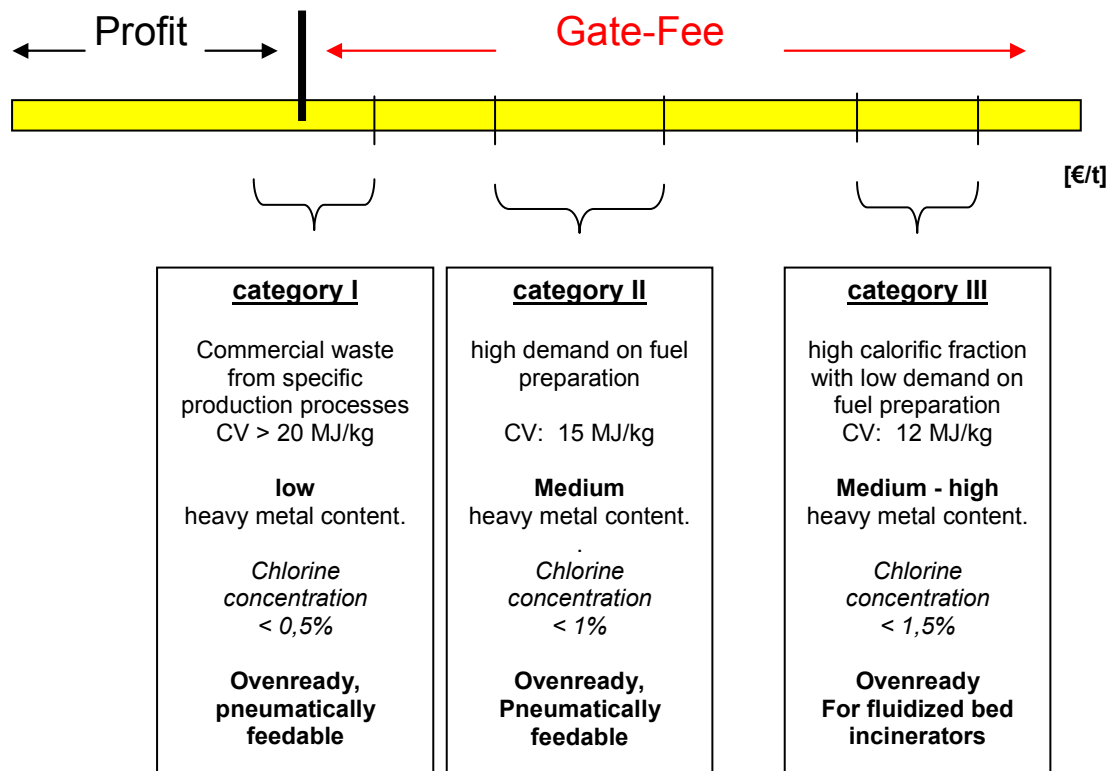


Fig. 4 Relationship between quality and gate fee (typical, simplified)

5.2 Optimisation and redesign of the MBT plants

As a consequence of the above described experiences (both technology and market responses), it is essential to design the process in order to optimise the output streams from economic and quality perspectives.

The high CV fraction and the treated biological fraction represent the biggest output streams of most MBT plants. Both have further cost demands (for recovery or disposal) which have to be considered as they are major cost lines in the operational budget. Therefore an important aspect in optimisation of waste-treatment plants is to consider all output streams for which income can be obtained.

5.2.1 Optimisation of recycling efforts

The increased need for steel in China has had a direct impact on world market prices for steel in the recent past. This leads to the situation that recycled ferrous materials have a market value even when they are contaminated with plastics or other waste fractions. The situation with aluminium and other non-ferrous metals is similar.

Complete separation of ferrous and non ferrous metals from treated waste is state-of-the-art. In the past, this treatment-step was included in the design in order to safeguard the shredder for potentially damaging materials; now it is driven by the economic effects to recycle these metals from waste treatment plants.

Similarly, (driven by the increased costs of crude oil), there is increasing interest in recycled plastics. Income of up to 600 €/tonne have been achieved for the best qualities; lower qualities (which can be achieved more easily and are more realistic for waste treatment plants) have achieved income of between 20 – 80 €/tonne.

Several technologies for separating plastics out of waste are proven and already in routine operation. One of the most sophisticated is from TiTech, a Norwegian company, which recognises and separates different plastic qualities by using infrared light and compressed air.

After detection of the recommended quality the plastic particle is “shot-out” by a jet of compressed air, which is computer controlled. Having more than 3 Million scans/second, a plastic particle with a 10 mm diameter can be recognised and removed from a 2 m wide belt.

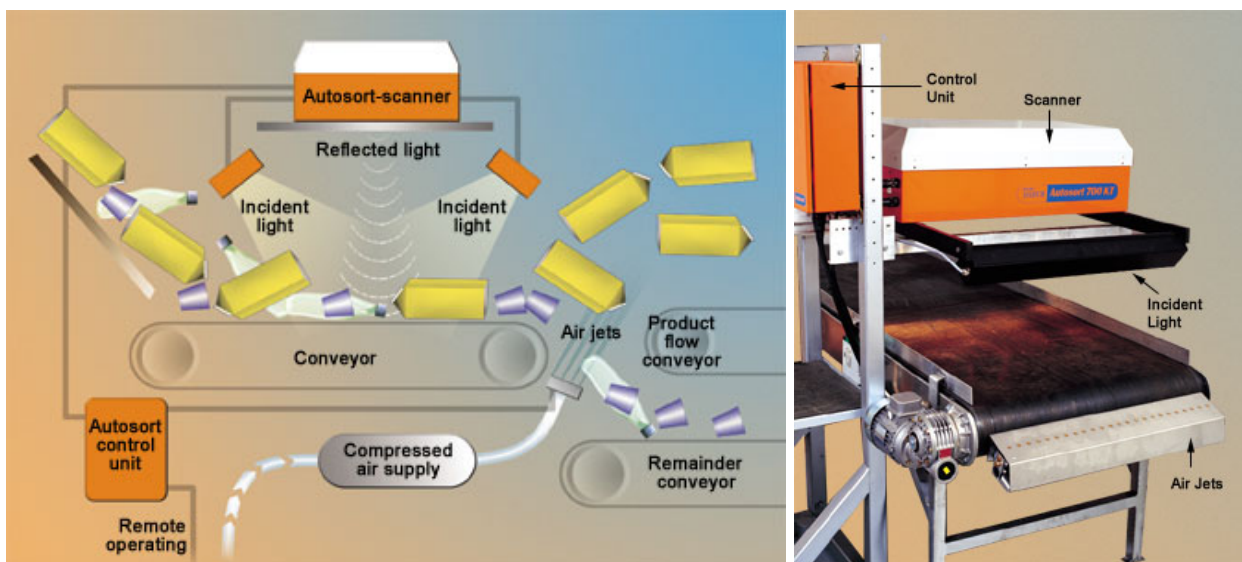


Fig. 5 NIR detection and removal of plastics (source Titech)

The disadvantage of this technology has been the low throughput compared to a waste-treatment plant for household waste, but developments are beginning to address this limitation.

5.2.2 Optimisation of equipment

After optimisation of recyclates has been considered, the design of the plant has to be adapted to reduce the number of different treatment steps that are needed to fulfil the purpose of a treatment plant. A “reduced” plant design is totally independent of any supplier interest; it is an optimisation of effort and benefit for the whole plant.

It is structured in the following steps:

1. *Characterisation of the output-streams*

- a) What is the contracted quantity for the high calorific fraction and
- b) What kind of quality demands exist.
- c) Is there a landfill nearby and/or is it necessary to produce a certain quantity of landfill-fraction ?
- d) What is the number of different recyclable materials that should be produced?

The basis of such a decision is a detailed analysis of the contents and size distribution of waste.

2. *Quality demands for the output-streams*

- a) What are the tolerated disturbing materials in the fuel.
- *direct impact on the design of the wind-sieving or other density separating proceses*
- b) What kind of particle quality is needed.
- *direct impact on the design of the shredding process and the number of shredders which are needed.*
- c) Is there a landfill nearby or is it necessary to produce a certain quantity of landfill-fraction ?

Is there a need for producing a certain quantity of landfill fraction in order to produce the needed income for further activities with the landfill.

- d) What is the number of different recyclables that should be produced?

If the quantity of recyclables justify the use of extended technology, it is necessary to characterise the quality needed to generate income.

If it is realistic to achieve these quality demands the next step is selection of the available technology.

3. *Technical equipment for achieving these quality demands*

In this step technology is requested for the first time:

- a) Which kind of technology is available for fulfilment of the duties, and
- b) Which one has the best effort to benefit ratio.
- c) What is the guaranteed throughput, are there references for the same kind of input
- d) What are the costs for operation and maintenance, how often maintenance has to be done

4. *Influence on variation of operating points on other output-streams*

What will happen to other output streams, when variation in the operating conditions will occur, e.g. if there is abrasion of the cutting equipment of a shredder.

Using this approach can produce a plant design which was never under discussion before. If the main off-taker of the secondary fuels is an industrial power-plant, the effort in separating minerals out of the secondary fuel can be minimised, or even where biological treatment is no longer necessary, because a landfill-fraction can be produced only by mechanical means.

Work done by the authors of the paper has shown that this approach can result in significant savings in treatment cost, created by substantial savings in capital costs and/or lower processing costs.

6 Conclusion

The concept of SRF/RDF can be attractive to both fuel producer and user. For a successful long term solution the fuel producer must be able to meet the needs of the fuel user. This requires the fuel producer to behave as a process operator and not as a disposer of waste.

The main parameters that are sensitive for operators of combustion plant include CV, chlorine, particle size and metal content. All of these parameters can be controlled or modified in the fuel production through the use of mitigation strategies. Many of these strategies are available by investment in separation technology that should be designed in at the initial stages. In order to ensure that only those steps are included that are absolutely necessary (in order to control cost) it is very important for the waste plant to know the long term quality demands of the fuel market. Long term contracts between producer and user are more likely to produce a stable, low cost supply than short-term or spot transactions.

The value of fuel created by this approach is increasing in relation to the increasing cost of fossil fuels. As the price of CO₂ and renewable electricity increase those fuels with higher contents of biomass will increase preferentially in value.

Other streams can be recovered by the MBT process that have a net positive economic benefit. The plant designer and operator should seek to secure these streams in order to optimise the plant design.

Through rationalising and optimising the waste plant design, in combination with using an industrial power plant as off-taker for the high-calorific fraction, shows that the in-

vestment in the waste-treatment plant can be reduced significantly - by more than 50% of those from traditional approaches, resulting in a minimisation of treatment costs.

7 Literature

ⁱ EU Landfill Directive 1991/31/EC. 26th April 1999

ⁱⁱ CEN/TC 343 Solid recovered Fuels

ⁱⁱⁱ Refuse derived fuel, current practice and perspectives (b4-3040/2000/306517/mar/e3). WRC for EU

^{iv} Wolfgang Butz. Vollzug Der Abfallablageungs- Und Der Deponieverordnung Ab 2005

^v SCA. Firmenpräsentation anlässlich des Scopings des Genehmigungsverfahrens zum Kraftwerksneubau, 2003

Authors Addresses

Mr Craig Ibbetson, Mr John Chappell

Regen Fuels Ltd

3 Chisholm Rd

Richmond

Surrey, TW10 6JH, UK

Tel +44 20 8332 9563

Email craig.ibbetson@regenfuels.co.uk

Website: www.regenfuels.co.uk

Dr Kurt Wengenroth

B+T Umwelt GmbH

Marburger Str. 3

35418 Buseck

Germany

Tel: +49 (6408) 5017-20

Fax: +49 (6408) 5017-10

E-Mail: kurt.wengenroth@bt-umwelt.de

Website: www.bt-umwelt.de