Chapter 6

POTENTIAL TECHNOLOGIES LONG TERM

6.1 Overview

The technologies with long term potential to help divert waste from landfill in South Africa are described in[8] this section. Barriers to the short term establishment of these technologies include high capital costs and limited international experience of their operation. They are as follows, and discussed in this chapter:

- Gasification
- Plasma gasification
- Pyrolysis
- Mechanical heat treatment

6.2 Gasification

Thermal treatment involves the degradation of waste by heat and includes incineration (previously discussed in Chapter 5.2). **Advanced thermal treatments, such as pyrolysis and gasification, are well proven for treatment of certain solid materials and in recent years have been commercially applied to solid waste streams.**

Typically, advanced thermal treatment processes will treat **prepared fuels (e.g. RDF) derived from municipal (or other) waste streams.** Therefore they are commonly part of an integrated waste management system. For example, they may be used in conjunction with mechanical sorting technologies, Mechanical Biological Treatment, or Mechanical Heat Treatment processes that produce a fuel stream which is more amenable to treatment than mixed residual municipal-type waste. This Refuse Derived Fuel (RDF) or Solid Recovered Fuel (SRF) comprises the energy-rich elements of the waste stream, typically paper, card and plastics.

Thermal treatment facilities for waste must hold the relevant Air Emissions and Waste Management Licences for operation. The National Policy on Thermal Treatment of General and Hazardous Waste (2009) sets out guidelines on operations, monitoring and pollution control, while the National Environmental Management: Air Quality Act (Act 39 of 2004) sets out the minimum standards for emissions from such facilities.

6.2.1 Advanced thermal treatment process

Gasification and pyrolysis processes have been used extensively to produce fuels such as charcoal, coke and town gas. In recent years, the processes have been commercially used for the treatment of municipal and other solid waste streams. There remains a limited track record of commercial plant treating municipal derived wastes, although large scale waste gasification and pyrolysis plants are in operation in Europe, North America and Japan, with recent pyrolysis developments in Moscow and Bristol (UK) in early operational stages. There is a much longer track record for pyrolysis in treating waste tyres and mixed plastics, where the char produced is in liquid form and can be used as a substitute fuel to diesel.

In general, the configuration and main components of the two processes are similar, which is why gasification and pyrolysis have been grouped together in this publication.

The technology can be employed at small scales[11] (10k tonnes per annum) through to large scale merchant plants either as a modular system of numerous small scale chambers or a singular large scale chamber depending on the technology provider chosen.

Raw MSW is usually not appropriate for gasification or pyrolysis, which prefer consistent feedstock. The separation of glass, metals and inert materials (for example rubble) is necessary prior to the thermal processing stage.

6.2.1.2 The process

Both gasification and pyrolysis processes involve the thermal treatment of waste to produce a solid residue, known as slag or char respectively, and a synthesis gas, or 'syngas'. The process is carried out either in complete absence of oxygen (pyrolysis) or in a low oxygen environment (gasification). **Key process differences between gasification and pyrolysis are the level of oxygen required, the operating temperatures and the outputs from the processes**. These aspects are summarised in the Technical Glossary, Table 22.

Thermal treatment reactors are well-established technologies to maximise heat transfer and mixing; the technology being similar to that used in standard combustion (waste and non-waste) processes. Pyrolysis processes tend to use rotating kilns, heated tube or surface contact reactors; gasification processes use either fluidised or fixed bed reactors. These are summarised in and of the Technical Glossary.

6.2.1.3 Synthesis gas output

Synthesis gas, or 'syngas', generated by pyrolysis and gasification processes may be used to generate electricity and / or heat through combustion in a gas engine or through a steam circuit. Syngas comprises carbon monoxide, methane and hydrogen. Some gasification and pyrolysis processes export the syngas off-site for use as a fuel, for example in a power station. The combustion of the syngas would be subject to the emissions limits set out in the National Environmental Management: Air Quality Act (Act 39 of 2004).

One key issue for use of syngas in energy recovery is the problem of tarring which can cause blockages and other operational challenges and has been associated with plant failures and inefficiencies at a number of pilot and commercial scale facilities. As described under Plasma Gasification, tarring issues may be overcome by higher temperature thermal processing.

[11] There are likely to be some economies of scale and very small scale plant will tend to be more costly 'per tonne of throughput'.

6.2.2 Gasification plant configurations

Gasification is a thermal waste treatment technology which processes waste in a limited oxygen environment to produce a syngas which can be used to generate heat and electricity. Here, the gasification process is summarised by way of example configurations of the various technology components.

Table 12: Key characteristics of gasification

Waste streams accepted	RDF (Treated residual waste, C&I waste or selected C&D waste)
Input capacity ranges	10k – 100k tonnes per annum
Typical outputs	Electricity, heat, ash
Purpose	To recover energy from non-recyclable mixed waste streams
Indicative capital cost	c. R 387.5m – R 620m for a 60ktpa facility

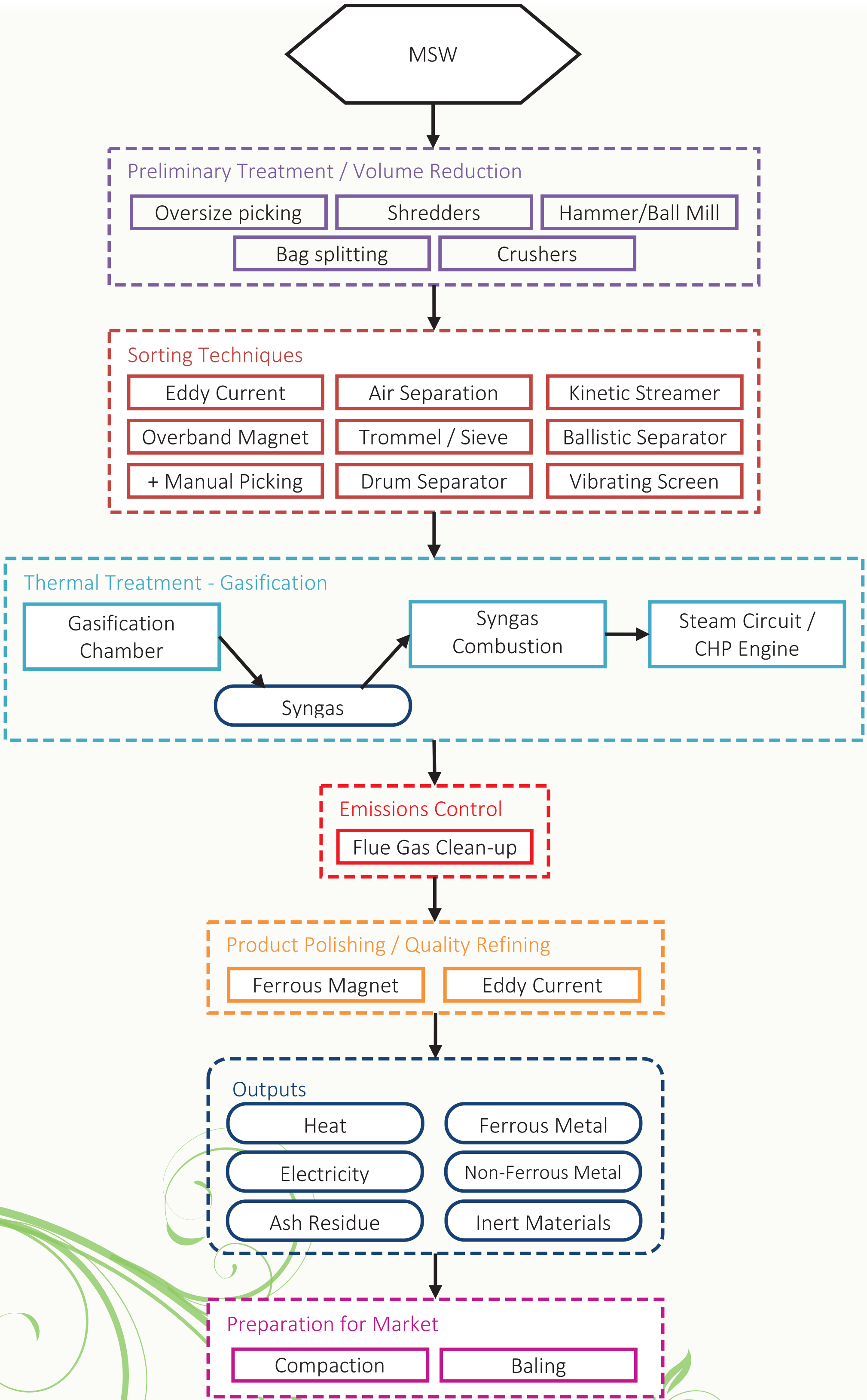
Figure 21: Refuse derived fuel bales ready for gasification; gasification ash residues used as aggregate for road building (image courtesy of Ballast Phoenix)

A typical process flow diagram for waste gasification is shown in Figure 22 .

6.2.3 Preliminary treatment / volume reduction stage

The gasifier requires a homogenised waste stream or RDF. If the facility is planned to accept untreated waste it is essential that some waste preparation activities are carried out. This will remove unwanted items (usually inert materials like glass) from the waste feedstock and also allows the recovery of valuable materials (for example, ferrous and non-ferrous metals) through preparing the waste into a form acceptable for both the gasifier and potential mechanical separation technologies. Typically, a bag splitter will be used to split bagged waste and a simple form of treatment (hammer/ball mill, crushers and/or shredders) will be utilised in order to prepare the waste into a treatable form.

Figure 22: Typical gasification process flow diagram



6.2.4 Mechanical sorting stage

A variety of mechanical treatments exist suitable for MSW pre-treatment prior to gasification. These are designed to extract recyclable fractions from a mixed waste stream. **Most commonly ferrous and non-ferrous metals will be recovered for recycling** using magnets and eddy current respectively. Additionally an assortment of screens will be used to extract a glass and aggregate fraction which is not suitable for the gasifier. It is possible, although not widely practised, that a more advanced pre-treatment process can be designed to remove other valuable target materials. **This should be done with care so that the waste CV is maintained above a threshold suitable for the gasification technology chosen.**

6.2.5 Thermal treatment stage

The treated waste or RDF will be fed into the gasification chamber(s) on a continuous basis where it will be heated above 650^{0}C in a limited oxygen controlled environment. The waste will not combust, but will transform into an ash and syngas, with the syngas rising and ash falling though grates at the bottom of the gasification chamber. The syngas will flow into a second chamber where it may be combusted with the application of heat producing steam which can be fed through a steam circuit (and CHP engine) to produce heat and electricity. This is the most common configuration for processing municipal type wastes. Part of the generated heat and electricity will be used to power the facility, with the rest available for export. Other configurations may seek to utilise the syngas in higher efficiency energy recovery or exported as a fuel for an adjacent industrial process (co-firing).

6.2.6 Emissions control stage

The major emission from a plant with energy recovery is the release of flue gases from the combustion of the syngas (and in some instances also the residual solid if also burnt, if it has high carbon content). For conventional gasification, entrained (fine) particles in the syngas are removed after combustion as part of the flue gas clean-up process.

One of the main benefits claimed by manufacturers of gasification plant is that emissions of pollutants are lower than those from conventional incineration. The flue gases are maintained at high temperatures for a specified minimum time, before being rapidly cooled. These stages minimise the formation of potentially harmful substances. Following the thermal stage, the flue gases are normally treated to remove oxides of nitrogen, mercury, dioxins and furans, and acid gases, although specific treatment may not be needed if the in-process controls give the required performance. The air stream is then passed through a bag filter to remove particulate matter. The residual emissions to air from waste thermal treatment processes are discharged from a stack which is designed to provide sufficient dispersion of the low levels of remaining air pollutants.

The use of an air filtration system to remove particulate matter from the flue gases results in a fine, dusty waste stream referred to as air pollution control residues (APCr) (or in some cases Flue Gas Treatment residues). This waste stream must be disposed of appropriately to a controlled landfill. Emissions of many parameters need to be monitored continuously to comply with operation permits. Some substances, including dioxins, furans and some metals, cannot be measured continuously or it may be prohibitively expensive to do so. Some substances such as dioxins and furans can be continuously sampled, with analysis carried out periodically to give the average amount emitted over a longer period. Emissions of substances which cannot be measured continuously are normally measured periodically. Routine day-to-day control is achieved by ensuring that surrogate indicators such as combustion temperature, particulate emissions and hydrogen chloride emissions are within the permitted limits.

6.2.7 Product polishing / quality refining stage

The ash produced by gasification and gas combustion will likely contain ferrous and non-ferrous metals which can be extracted in a similar way to post incineration metal extraction. **The metals recovered will be of a lower quality than source separated materials of MRF outputs,** however will still be of financial benefit.

6.2.8 Process outputs

Heat and electricity derived from the combustion of syngas can be exported to the local grid or nearby users as the market dictates. Metals (and other recyclate) extracted at the front and back ends of the gasification process are suitable for sale into the relevant local commodities market. Inert material from the front end of the process, and ash (non-APCr) from the back end of the gasification process can be used as aggregate materials. A common use for ash from gasification processes is as a component of cement as a substitute for natural aggregate. APC residues will need to be disposed of in controlled landfill sites as a hazardous waste.

6.2.9 Preparation for market

Aggregates and ash will require bulking ready for onward transportation. Any raw recyclate which is recovered will similarly require baling in preparation for its end market.

6.2.10 Concluding comments

Gasification technologies have a variable track record for processing municipal type wastes, partly due to the variability of the feedstock, the sensitivity of the systems and also due to the significant capital outlay for these facilities. In the light of these factors **it is often the more simple designs, closer in nature and efficiency to incinerators that have been the most successful in terms of municipal waste treatment.**

There may be emissions improvements over incineration technologies and smaller scale solutions are often promoted by manufacturers. As an advanced process it requires highly skilled operators and appropriate feedstock to gain the full potential that gasification technologies can offer.

The **high capital costs involved**, the shortage of suitably qualified and experienced personnel needed to operate thermal treatment plants as well as the environmental concern for properly managing flue emissions, has resulted in South African companies and municipalities considering lower-technology waste treatment solutions instead of gasification. Advanced thermal treatment solutions may potentially become viable for niche waste streams or as municipalities, after having dealt with the less costly treatment and disposal of waste streams such as builders' wastes, recyclables and garden wastes, focus more on diverting residual wastes (such as mixed organic wastes) from landfills.

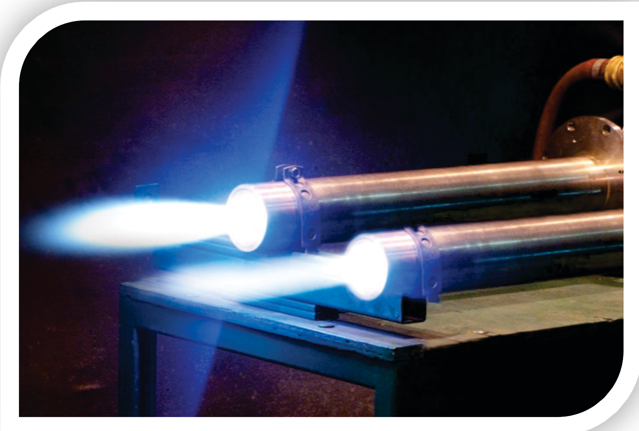
6.3 Plasma gasification

Plasma gasification is a variation on gasification which uses a plasma torch / arc to ionise waste feedstock and is optimised to produce a clean syngas suitable for use in gas engines. The plasma application allows waste treatment at higher temperatures than conventional. Details on the plasma process are explained further in subchapter 6.3.3. Below, the plasma gasification process is summarised by way of example configurations of the various technology components.

Table 13: Key characteristics of plasma gasification

Waste streams accepted	RDF (Treated residual waste, C&I waste or C&D waste)
Input capacity ranges	10k – 500k tonnes per annum
Typical outputs	Electricity, heat, slag
Purpose	To recover energy from non-recyclable mixed waste streams
Indicative capital cost	Too limited examples to provide indicative Capex range

Figure 23: Demonstration plasma torches (image courtesy of AlterNRG); delivery of large (350k tonnes per annum) plasma gasifier in NE England (image

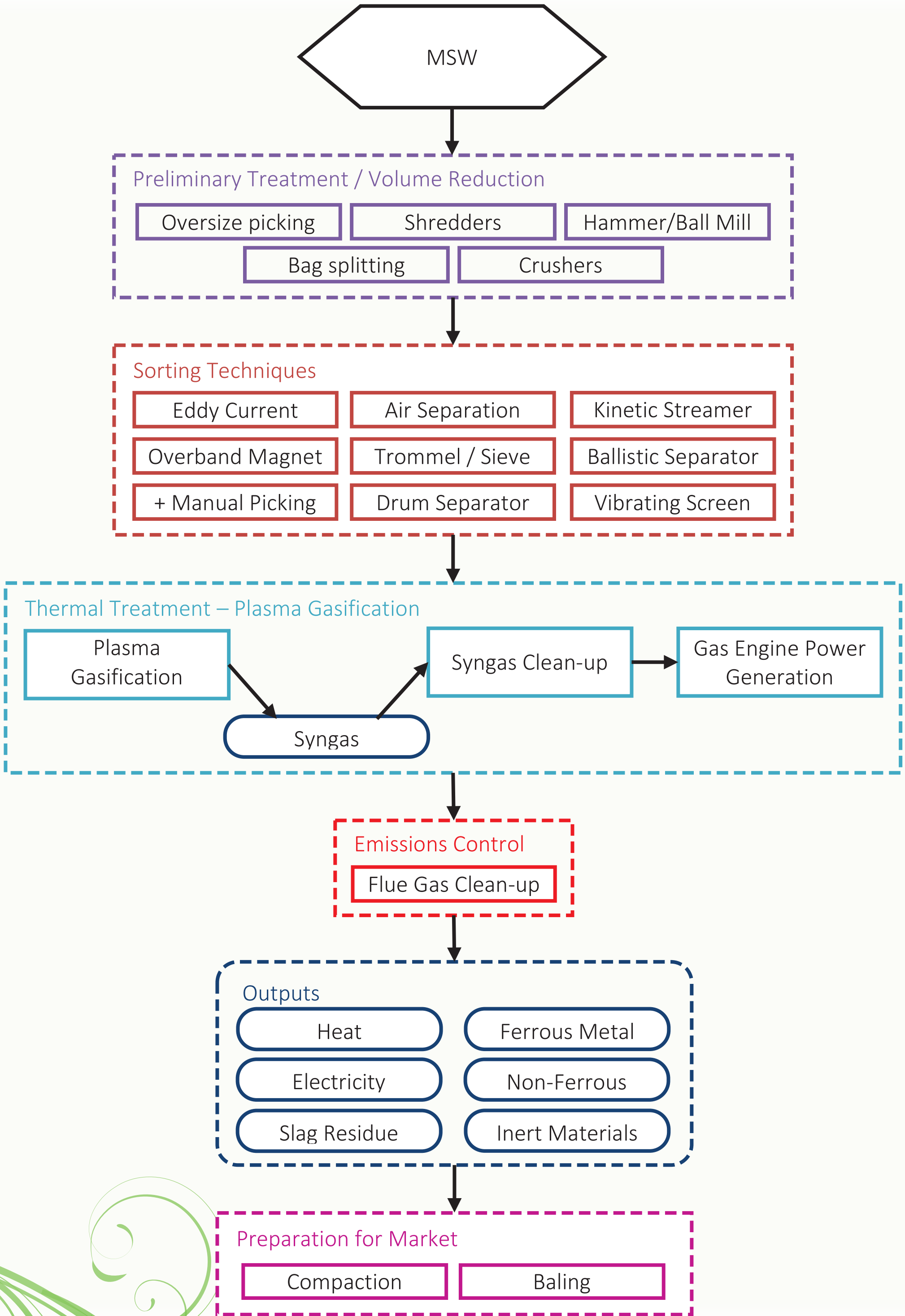


A typical plasma gasification process flow diagram is shown in Figure 24.

6.3.1 Preliminary treatment / volume reduction stage

Similar to a conventional gasifier a plasma gasifier requires a homogenised waste stream or RDF. If the facility is planned to accept untreated waste it is essential that some waste preparation activities are carried out. This will remove unwanted items (usually inert materials like glass) from the waste feedstock and also allows the recovery of valuable materials (for example, ferrous and non-ferrous metals) through preparing the waste into a form acceptable for both the gasifier and potential mechanical separation technologies. Typically, a bag splitter will be used to split bagged waste and a simple form of treatment (hammer/ball mill, crushers and/or shredders) will be utilised in order to prepare the waste into a treatable form.

Figure 24: Typical plasma gasification process flow diagram



6.3.2 Mechanical sorting stage

A variety of mechanical treatments exist suitable for MSW pre-treatment prior to gasification. These are designed to extract recyclable fractions from a mixed waste stream. **Most commonly ferrous and non-ferrous metals will be recovered for recycling** using magnets and eddy current respectively. Additionally an assortment of screens will be used to extract a glass and aggregate fraction which is not suitable for the gasifier. It is possible, although not widely practised, that a more advanced pre-treatment process can be designed to remove other valuable target materials. This should be done with care so that the **waste composition is maintained to a level suitable for the gasification technology chosen.**

6.3.3 Thermal treatment stage

The treated waste or RDF will be fed into the gasification chamber(s) on a continuous basis where it will be heated, with the aid of plasma torches, in a limited oxygen controlled environment.

Plasma technologies are based on high temperature (typically in excess of 1200˚C) reaction achieved by an electric arc. Inert gas passes through the arc, producing a 'plasma'. Lightning is a naturally occurring example of plasma. Plasma technologies are a 'family' of thermal processes that can use plasma at different stages of their particular process.

The waste will be broken down into molecules which will then form into syngas and molten slag, with the syngas rising and slag falling though drains at the bottom of the gasification chamber. The syngas will then flow through a series of further treatments in order to make it suitable for use in a gas engine. Rapid cooling and use of scrubbing technologies on the syngas will allow removal of particulates, ammonia, hydrogen fluoride and hydrogen chloride; whilst hydrolysis and absorption units will allow for the removal of sulphurs. Quenching will prevent the reforming of organic compounds into dioxins and furans.

The cleaned syngas is then designed to be burnt in gas turbines where it is used to generate power. Part of the generated heat and electricity will be used to power the facility, with the rest available for export.

The plasma may be used to heat the process to achieve the decomposition of the waste into syngas and residue as for gasification or pyrolysis. Alternatively, plasma may be directed solely at the syngas generated by conventional gasification in order to break down tars which would otherwise cause blockages and damage to gas engines (also known as 'plasma polishing'). Some incinerators (particularly in Japan) apply plasma to convert solid residues (ash / fly-ash) into vitreous ('inert') residues exhibiting low environmental impacts and therefore appropriate for a wider range of potential recycling applications.

The syngas produced by plasma gasifiers should be cleaner than that produced in conventional gasifiers due to the elimination of tars through the high temperature process.

The technology has been utilised with difficult wastes, such as hazardous waste, but remains **relatively unproven at commercial scale on municipal waste.** There are a number of small or demonstration plants in operation (Japan and UK) and one large scale plant in construction for municipal waste in the UK; several more are planned.

6.3.4 Emissions control stage

Similar to gasification the exhaust fumes from the gas turbines will require clean-up in order to reduce pollution from a plasma gasification facility. This will include a catalytic convertor to limit the emissions of Nitrogen Oxides (NOx). For plasma gasifiers the majority of other pollutants are removed in the gas clean up stage prior to use in the gas engines. These pollutants should be disposed of responsibly to hazardous waste landfill sites in order to protect the environment.

6.3.5 Process outputs

Heat and electricity derived from the gas engine can be exported to the local grid or nearby users as the market dictates. Metals (and other recyclate) extracted at the front end of the process are suitable for sale into the relevant local commodities market. Inert material from the front end of the process, and slag from the back end of the gasification process can be used as aggregate materials. **A common use for slag is aggregate for road construction.** Plasma gasification technology providers claim that the slag is suitable for other construction purposes due to its non-leaching and hard wearing properties. APC residues will need to be disposed of in controlled landfill sites as a hazardous waste.

6.3.6 Preparation for market

Aggregates and slag will require bulking ready for onward transportation. Any raw recyclate which is recovered will similarly require baling in preparation for its end market.

6.3.7 Concluding comments

The **high capital costs** involved, the shortage of suitably qualified and experienced personnel needed to operate thermal treatment plants as well as the environmental concern for properly managing flue emissions, has resulted in South African companies and municipalities considering lower-technology waste treatment solutions instead of plasma gasification. Advanced thermal treatment solutions may potentially become viable for niche waste streams or as municipalities, after having dealt with the less costly treatment and disposal of waste streams such as builders' wastes, recyclables and garden wastes, focus more on diverting residual wastes (such as mixed organic wastes) from landfills.

Plasma gasification does have **the potential to utilise higher efficiency energy recovery systems** due to the potential for cleaner syngas, however this needs to be considered in the context of the additional energy input required to generate the plasma. **International developments in this field will provide further intelligence on the future applicability** of this technology to municipal type wastes.

6.4 Pyrolysis

In contrast to combustion, **pyrolysis is the thermal degradation of a substance in the absence of oxygen.** Here, the process is summarised by way of example configurations of the various technology components.

Table 14: Key characteristics of pyrolysis

Waste streams accepted	RDF (Treated residual waste or C&I waste)
Input capacity ranges	8k – 150k tonnes per annum
Typical outputs	Electricity, heat, char
Purpose	To recover energy from non-recyclable mixed waste streams
Indicative capital cost	c. R 387.5m – R 620m for a 60ktpa facility

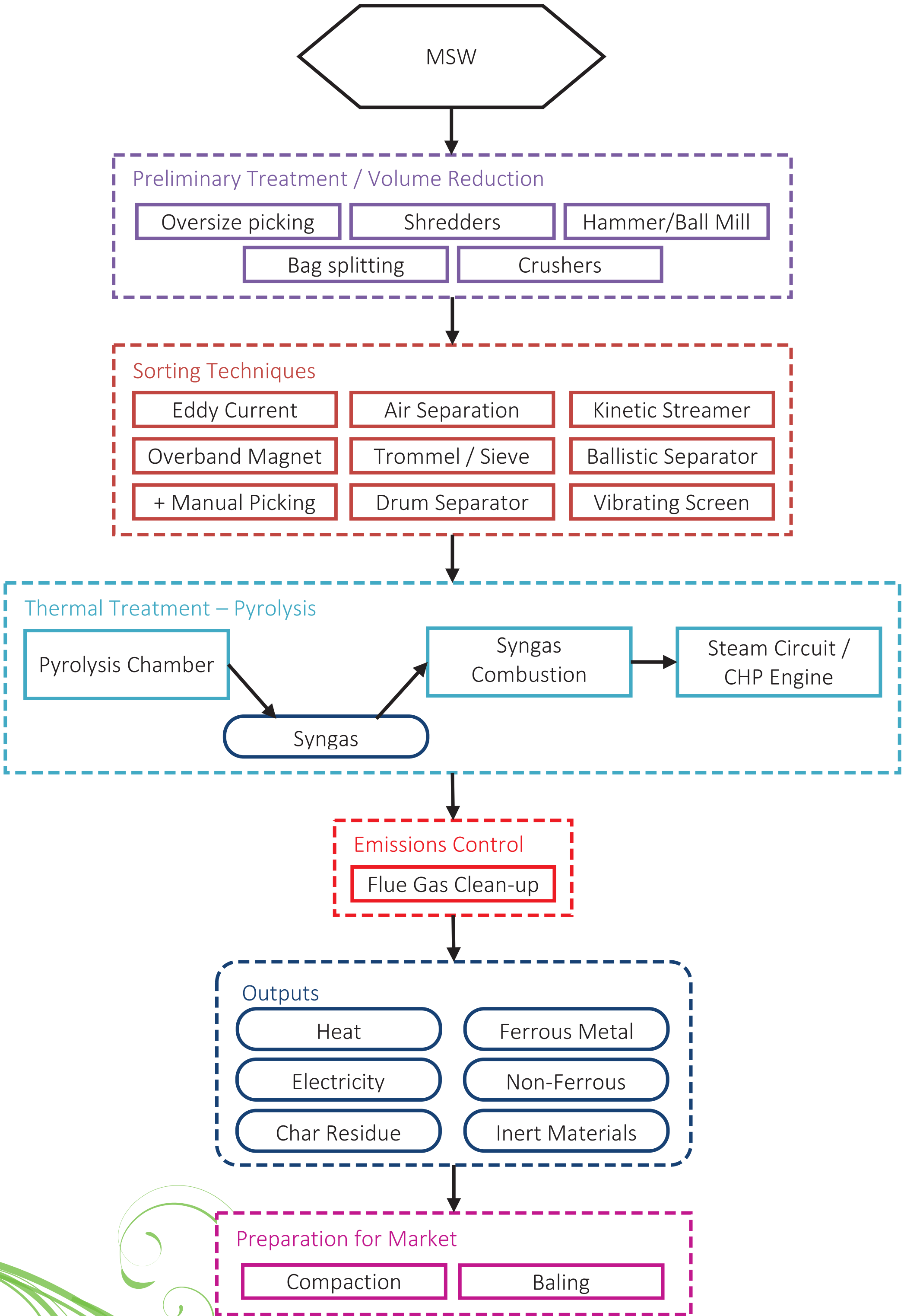
Figure 25: Modular pyrolysis units at Avonmouth, Bristol, UK (image courtesy of New Earth Advanced Technology); char from pyrolysis of mixed feedstocks (image courtesy of Pacific Pyrolysis)

A typical waste pyrolysis process flow diagram is shown in Figure 26.

6.4.1 Preliminary treatment / volume reduction stage

Similar to gasification **a pyrolysis process requires a relatively consistent waste stream.** Therefore, a pyrolysis unit for waste treatment would process either an RDF or pre-treat and sort a more mixed waste feedstock prior to thermal treatment. Unwanted items in the feedstock would include inert materials (for example glass and rubble), and it is similarly advantageous to extract recyclates including ferrous and non-ferrous metals. Typically, a bag splitter will be used to split bagged waste and a simple form of treatment (hammer/ball mill, crushers and/or shredders) will be utilised in order to prepare the waste into a treatable form.

Figure 26: Typical pyrolysis process flow diagram



6.4.2 Mechanical sorting stage

A variety of mechanical treatments exist suitable for MSW pre-treatment prior to pyrolysis. These are designed to extract recyclable fractions from a mixed waste stream. **Most commonly ferrous and non-ferrous metals will be recovered for recycling** using magnets and eddy current respectively. Additionally an assortment of screens will be used to extract a glass and aggregate fraction which is not suitable for the thermal treatment unit. It is possible, although not widely practised, that a more advanced pre-treatment process can be designed to remove other valuable target materials. This should be done with care so that the waste CV is maintained above a threshold suitable for the pyrolysis technology chosen. The anaerobic nature of pyrolysis systems means that waste may be fed into the process using a sealed means, such as a mechanical screw feed process.

6.4.3 Thermal treatment stage

The treated waste or RDF will usually be fed into the pyrolysis chamber(s) on a continuous basis where **it will be heated to between 300˚C and 800˚C in an oxygen-free environment.** Typical temperatures are around 350^{o}C, with the higher end of the range used in 'flash pyrolysis' technology. The waste will be broken down into syngas and molten char, with the syngas rising out of the vessel and char being extracted at the bottom of the vessel. Pyrolysis vessels vary in size dependent upon the specific technology chosen. Large scale units exist which are reportedly able to treat 110,000 tonnes per annum of feedstock. Smaller scale units also exist, often with annual capacities below 10,000 tonnes, which can be scaled in a modular arrangement with the combustion and steam circuits sized accordingly. Following the pyrolysis process the syngas produced may be fed into a secondary chamber where it will be combusted and fed through a steam circuit in a similar fashion to that described for conventional gasification technologies.

Part of the generated heat and electricity will be used to power the facility, with the rest available for export.

6.4.4 Emissions control stage

The emissions from a pyrolysis facility may be similar to those of a conventional gasifier, resulting from the combustion of the syngas produced. For pyrolysis entrained (fine) particles in the syngas are removed after combustion as part of the flue gas clean-up process. One of the main benefits claimed by manufacturers of pyrolysis plant is that emissions of pollutants are lower than those from conventional incineration. The flue gases are maintained at high temperatures for a specified minimum time, before being rapidly cooled. These stages minimise the formation of potentially harmful substances. Following the thermal stage, the flue gases are normally treated to remove oxides of nitrogen, mercury, dioxins and furans, and acid gases, although specific treatment may not be needed if the in-process controls give the required performance. The air stream is then passed through a bag filter to remove particulate matter. The residual emissions to air from waste thermal treatment processes are discharged from a stack which is designed to provide sufficient dispersion of the low levels of remaining air pollutants.

The use of an air filtration system to remove particulate matter from the flue gases results in a fine, dusty waste stream referred to as air pollution control residues (APCr, or in some cases Flue Gas Treatment residues). This waste stream must be disposed of appropriately to a controlled landfill. Emissions of many parameters need to be monitored continuously to comply with operation permits. Some substances, including dioxins, furans and some metals, cannot be measured continuously or it may be prohibitively expensive to do so. Some substances such as dioxins and furans can be continuously sampled, with analysis carried out periodically to give the average amount emitted over a longer period. Emissions of substances which cannot be measured continuously are normally measured periodically. Routine day-to-day control is achieved by ensuring that surrogate indicators such as combustion temperature, particulate emissions and hydrogen chloride emissions are within the permitted limits.

6.4.5 Process outputs

Outputs from a pyrolysis plant will consist of heat and electricity from the combustion of syngas, alongside APC residues which should be disposed of to a controlled hazardous landfill site. **A liquid petrochemical output may be derived instead of direct energy recovery,** and some plastic fuelled plant are designed to generate a fuel fraction using the liquid output. The pyrolysis process will also produce a stabilised char which may be suitable for use as aggregate depending on its nature and the availability of appropriate outlets.

Pre-treatment of wastes, where applicable, will result in a reject fraction which requires either treatment by conventional incineration or disposal to land as well as the recovery of valuable recyclable materials usually consisting of ferrous and non-ferrous metals. Pre-treatment will also remove inert materials which can be suitable for use as an aggregate substitute.

6.4.6 Preparation for market

Aggregates and char will require bulking ready for onward transportation. Any raw recyclate which is recovered will similarly require baling in preparation for its end market. Both syngas and pyrolysis liquid fuels are likely to require clean up prior to most forms of energy recovery.

6.4.7 Concluding comments

The **high capital costs** involved, the shortage of suitably qualified and experienced personnel needed to operate thermal treatment plants as well as the environmental concern for properly managing flue emissions, has resulted in South African companies and municipalities considering lower-technology waste treatment solutions instead of pyrolysis. Advanced thermal treatment solutions may potentially become viable for niche waste streams or as municipalities, after having dealt with the less costly treatment and disposal of waste streams such as builders' wastes, recyclables and garden wastes, focus more on diverting residual wastes (such as mixed organic wastes) from landfills.

Pyrolysis technologies have a limited track record on municipal type wastes and are most suited to more consistent, single material feedstock (e.g. waste plastics) where a more reliable process output can be derived.

6.5 Mechanical heat treatment

Mechanical heat treatment (MHT) combines both mechanical and thermal treatment methods. Mechanical treatment methods were previously discussed in Chapter 4.3 and are similar to those treatments used in MBT processes (see Chapter 5.5). Heat treatment methods include autoclaving and thermal drying, as described in the following pages. These will be supported by a combination of pre-treatment and sorting techniques at the front-end of the process, and a selection of emissions control and quality control techniques at the back-end of the process.

6.5.1 Heat treatment process

There are two main heat treatment processes, as discussed here:

- Autoclaving
- Thermal drying

Autoclaving is a pressurised process, and thermal drying non-pressurised process. Both are designed to sanitise and stabilise a general non-hazardous waste feedstock.

6.5.1.2 Autoclaving

Autoclaving is a well-established process for sterilising equipment using high pressure saturated steam at temperatures around 150oC. Autoclaves also have a growing number of industrial applications within the manufacturing industries.

For municipal waste management, autoclaving remains a relatively new process, with few commercial plants in operation and several failed projects on public record. Combined with mechanical pre-treatment as part of a Mechanical Heat Treatment system, autoclaving is potentially suitable for municipal residual wastes and co-treatment with municipal-type waste streams.

Autoclave treatment of waste uses saturated (wet) steam under pressure to clean 'hard' type recyclables (e.g. glass and metals), soften plastics and reduce biodegradable material into a mass often referred to as 'fibre'. **The process is a batch operation using a sealed pressure vessel injected with steam at around 5bar pressure for up to 45 minutes – 1 hour.** Following the autoclaving, recyclable materials can be more easily separated by mechanical means using screens and separation equipment.

The outputs from MHT are typically: mixed plastics; a glass and aggregate stream; an organic pulp or fibre fraction and; and separate ferrous and non-ferrous metals. The outputs have effectively been steam cleaned and can be exceptionally clean considering their origins. However, the mixed plastics stream has little or no market value as a recyclate, and is usually used as a fuel, for example within a gasification, pyrolysis or industrial process.

6.5.1.3 Thermal drying

Thermal drying is a simple process that uses the application of heat to dry the waste, not under pressure, for example by drying the waste in a continuously fed, heated drum. The concept is that the waste is more easily separated into recyclate after it has been dried, leaving a fraction suitable for use as a high calorific value fuel. Again, combined with mechanical elements within a Mechanical Heat Treatment process with pre- and post-mechanical treatment, thermal drying is suitable for municipal residual waste and municipal-type wastes, although again it has a limited commercial track record at present.

6.5.2 Summary of thermal treatment systems

The heat treatment systems considered here, and advanced thermal treatment systems considered previously (gasification, plasma gasification and pyrolysis) are summarised in the Technical Glossary, Table 25.

6.5.3 Mechanical heat treatment plant configurations

The MHT process is summarised below using example configurations of the various technology components.

Table 15: Key characteristics of mechanical heat treatment

Waste streams accepted	MSW, C&I, certain C&D, Clinical / Hazardous wastes
Input capacity ranges	50k – 500k tonnes per annum
Typical outputs	Recyclate, fines, stabilised material, RDF
Purpose	To stabilise waste, producing useable recyclable and organic products in the process. Potential to produce energy either through AD or production of RDF
Indicative capital cost	c. R 186m – R 542.5m for a 100ktpa facility

The mechanical and heat processes can be arranged in either order, with mechanical treatment preceding heat treatment or vice versa. Typical mechanical treatments will include a range of sorting technologies; from simple sieve / trommel separation techniques through to more advanced positive selection techniques like near infrared segregation. Heat treatment will predominantly be in the form of autoclaving (high pressure batch system steam treatment); however an alternative non-pressurised rotating kiln drying treatment is available where waste is treated prior to separation.

A process flow of typical MHT arrangements in Europe is illustrated in Figure 27.

6.5.4 Preliminary treatment / volume reduction stage

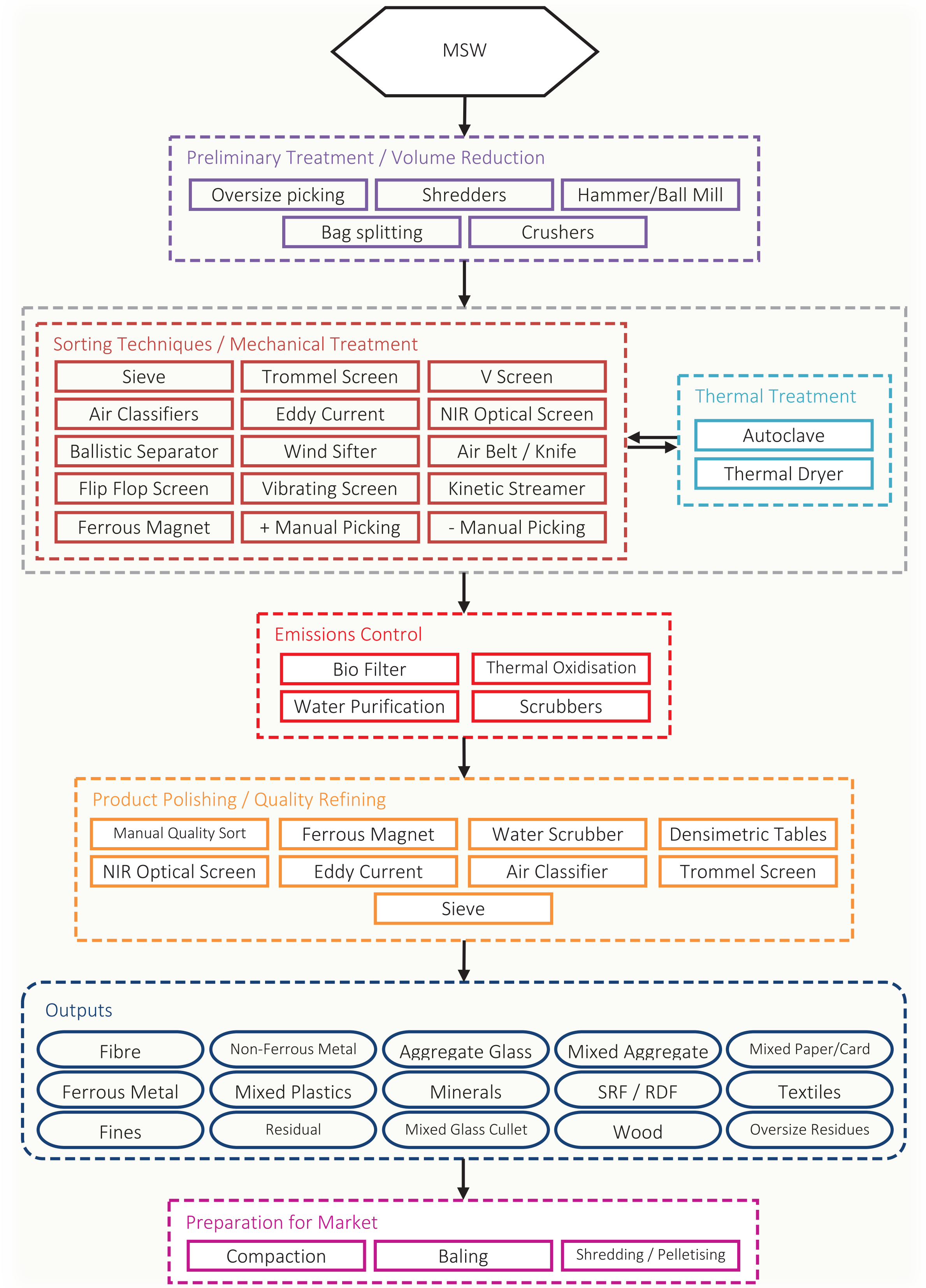
Waste is fed into the process in an untreated form. A series of processes can be undertaken to either remove waste which cannot be treated (oversized items) or to prepare waste so that it can be accepted by the mechanical and thermal processes at the next stage of the MHT process. Typically, a bag splitter will be used to split bagged waste and a simple form of treatment (hammer/ball mill, crushers and/or shredders) will be utilised in order to prepare the waste into a treatable form.

6.5.5 Termal treatment stage / mechanical sorting tretment

6.5.5.1 Thermal treatment

MHT facilities will usually apply heat treatment before mechanical separation as the treatment will sterilise and clean waste leaving a 'flock' or mass of fibre derived from the paper and organics, mixed with dry recyclables. Autoclaving is a batch process in a sealed vessel. Steam is injected into the vessel, wetting the waste. Pressure is applied in the range of 5-7 bar, and the vessel is rotated to mix the waste. These conditions are maintained for up to one hour, after which the pressure is released, and the contents emptied from the vessel.

Figure 27: Typical MHT process flow diagram



Alternative heat treatment processes, which usually accept shredded waste, operate on a continuous cycle with waste constantly passing through the vessel at a steady rate. Water is added to the waste to give it a pre-determined moisture content. The vessel is under atmospheric pressure, and the waste is rotated as a hot air stream passes through the vessel. The residence time of the waste in the vessel is generally up to 45 minutes, after which the treated waste is removed for mechanical separation.

An aspect common to both processes is that biodegradable materials (including paper) will break down into a fibre, glass and metals will be cleaned, and plastic softened (sometimes certain polymers will melt and form dense balls of plastic). **There is a notable volume reduction in waste after the thermal treatment process stage due to the reduction in moisture content.**

6.5.5.2 Mechanical treatment

A variety of mechanical treatments exist suitable for an MHT process. These are designed to extract recyclable fractions from a mixed waste stream. The qualities of materials recovered from MHT can often be of a higher quality than those derived from MBT processes.

Figure 28: (clockwise from top left) Non-pressurised heat vessels (Orchid Environmental); end of process / emptying of an autoclave vessel; autoclaved waste; pelletised RDF from heat non-pressurised heat vessels (Orchid Environmental)

A high-quality ferrous and non-ferrous metal stream, cleaned of labels and foodstuffs is always extracted for recycling. Some systems may also extract a glass / aggregate fraction, and a plastics stream for recycling. There may be small amounts of fibre / contrary material trapped within containers destined for recycling, and so whilst the recyclate is likely to be considerably cleaner than materials extracted for example from an MBT process, there may still be some quality issues for some reprocessors.

As with any waste treatment process there will be a reject fraction which must be disposed of. The fibre comprises the biodegradable elements of the waste stream (predominantly green waste, kitchen waste, paper, and card). There are a number of potential options available for the remaining fibre after removal of recyclables including plastics and glass, although the predominant use is as an RDF sent for energy recovery. Some MHT systems undertake further processing of the fibre properties in order to tailor to a fuel specification appropriate for the end user. Alternatively the fibre can be composted and then spread to (non-agricultural) land in appropriate circumstances and subject to environmental controls.

6.5.6 Emissions control stage

During the heat treatment stage there is a requirement of emissions control for the steam produced by thermal treatment. **MHT processes will often occur in enclosed buildings.** Applying negative air pressure to these buildings will reduce the prevalence of environmental effects on the facilities' surroundings.

6.5.7 Product refining / quality control stage

Material separated by either thermal or mechanical treatment will require refining and quality assessment before it can be classed as an output. Often the separated waste streams at this stage will still be composed of several component materials, and therefore further separation will enable the production of marketable and higher value products. It is likely that the technologies used at this stage of the MHT process are more advanced than those used earlier in the process and capable of separating waste stream by specific polymers or precise properties. Technologies could include near infra-red and positive picking to separate paper or plastics by type (e.g. PET bottles), and will include eddy currents to separate aluminium and magnets to separate steel. Manual separation could also be used with appropriate controls and consideration of occupational health.

6.5.8 Process outputs

Typically **an MHT process will produce recyclables, rejects and a sterilised fibre** (sometimes referred to as flock). The recyclables will consist of segregated aluminium and steel, and may also include plastics and glass / aggregates. If materials are separated before the thermal treatment stage it is possible to extract relatively low quality paper, textiles and wood for recycling. Some MHT processes may be configured to separate mixed plastics. Depending on the process, the quality of the material is unlikely to be sufficient for the reprocessing industry. As such, the market value will be low (or negative) and may end up as a refuse derived fuel stream.

The fibre is suitable to be used as an RDF of further composted in order to be used for land spreading. Stabilised biowaste from the treatment of mixed residual waste is not suitable for use on agricultural land and may entail a cost rather than deliver a revenue stream for any outlets applied. Rejects can either be used in energy recovery facilities or disposed of depending on physical characteristics, for example size and material properties.

6.5.9 Preparation for market

The final stage of an MHT process is preparation for market of the segregated materials. For recyclate this could involve baling and wrapping for onward transportation to reprocessor. Waste streams which are intended for RDF could be pelletised or compacted, baled, wrapped and bulked for transportation to an energy recovery facility. Waste streams intended for land spreading will require further maturation (usually seeding of microbes will be required to replace bacteria which has been destroyed by the heat treatment) prior to application to land.

6.5.10 Concluding comments

The use of mechanical heat treatment technologies in South Africa has centred mainly around healthcare and hazardous waste treatment, with some examples of autoclave and hydroclave technologies. Medical/healthcare waste facilities are generally owned and operated by private contractors.

The application of MHT to municipal wastes has a limited track record internationally and its viability is likely to be determined by the potential markets and outlets for the fibre / fuel fractions derived from the process. There have been some health and safety incidents concerning autoclave technology and pressurised vessels require appropriate handling and management.