Chapter 7

CONCLUSION

Conclusion

This series aims to provide clear, concise and factual information to support decision-making on advanced waste treatment, so that municipalities and their partners can plan and implement the next generation of advanced waste treatment facilities.

By using the term 'advanced waste treatment (AWT)' we are specifically referring to technologies and facilities that alter the characteristics of waste through physical, thermal, chemical and/or biological processes either prior to, or in place of, landfill. We specifically do not mean 'expensive or sophisticated' technology that is not sustainable for implementation in South African Municipalities!

This document advocates care in technology selection to ensuring that whatever facility is implemented will work well in the local context, and lead to the sustainable diversion of materials away from landfill.

The technology types explained in this document cover the principal technical options applied for the management of municipal wastes, or sub fractions thereof, in varying circumstances around the world. Not all will be appropriate for South Africa in either the short or the medium term, and the report has been structured so that those that are 'near field' or more likely to be viable, are explained first (section 4) and those that are either niche or longer term possibilities are addressed in later sections (5 and 6).

But equally, the diversity of South African municipalities' waste management needs is so large, that it has been essential to profile all of the main advanced waste treatment technologies either in common use, or gaining some sort of foothold, in the waste management systems of the world.

It is clear that the most appropriate technologies at the time of writing will be Materials Recycling Facilities (MRF), with a focus on manual sorting to maximise jobs and training opportunities, in combination with some mechanical separation methods such as overband magnets for ferrous metals extraction or screens for sorting by size. The purpose of these facilities is to separate recyclables into individual material types for reprocessing and also, in some cases, to separate a fuel fraction from mixed waste. Both approaches reduce the amount of waste remaining for disposal and provide useful resources (materials or energy) back into the economy.

For separated green or garden type wastes, 'open windrow composting' is a robust and available approach for treating the waste in order to generate a usable compost which may return important structure and nutrients to soils and also help prevent open burning or disposal of materials.

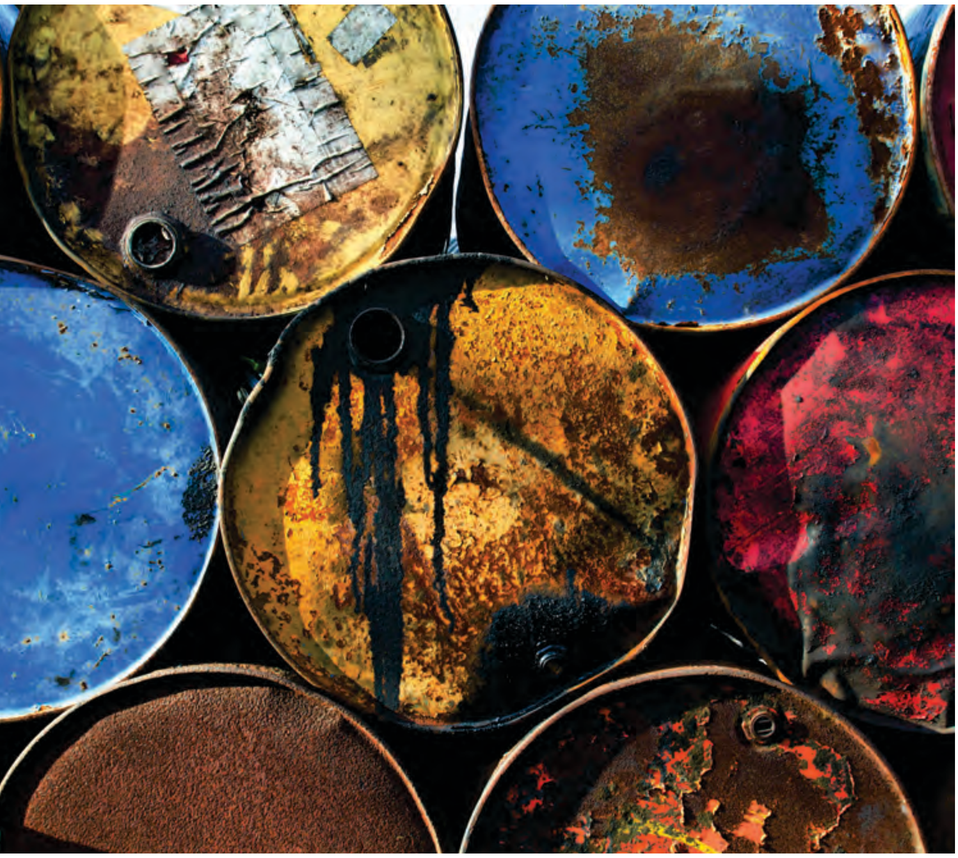
The examples of sorting recyclables in an MRF and composting of garden waste both usually have a requirement to separately collect these waste streams in the first instance. Therefore in consideration of these options it is necessary to assess all the costs and benefits involved in establishing separate collections, including educating the population to utilise the collections appropriately, in addition to the costs and benefits associated with the treatment solution in question. These important issues will be picked up and further explored in later volumes of this AWT series.

Other technologies discussed in this document may only be appropriate in very specific circumstances in South Africa at present (or indeed not at all in the short term). Each example should be carefully considered in the context or municipality in which it has been proposed.

Conclusion

As discussed in this document not all technologies are suitable for all municipal type waste streams and it is important when any new or alternative technology is proposed that appropriate market research and references are obtained. There are many examples around the world where 'new technology' has been invested in, and the plant has not been robust enough to process the feedstock coming into it, resulting in a failed project. Conversely there are other countries that have invested in collection systems and treatment technologies and now send less than a quarter of their waste to landfill sites and recover valuable materials and energy from all of the rest.

Technology is certainly a part of the 'solution', but it is not all of it! This document is designed to raise awareness of both the technical solutions available for municipal waste management and also raise some limitations and issues to consider when exploring the implementation of a technology. It is imperative that a rigorous investigation of any proposed approach or technology takes place as part of decision making for any advanced waste treatment project.



Annexure A

TECHNICAL GLOSSARY




Technical glossary

This section includes tables referenced in the body of this publication, addressing the technical components[8] and systems used in Advanced Waste Treatment.

Table 16: Typical mechanical preparation technologies

Technology component	Prime function	Operational considerations
Hammer mill	To significantly reduce the size of material by means of swinging steel hammers. This can render the waste more appropriate for separation processes.	Noise; wear on hammers (life cycle costs); pulverising and potential 'loss' of glass / aggregates; exclusion of pressurised containers. Limited track record on municipal waste treatment.
Shredder	Knives or hooks rotate at a low speed with high torque to produce a shearing action which tears or cuts most materials.	Large, strong items can physically damage the shredder (life cycle costs); exclusion of pressurised containers.
Rotating drum / Trommel	Material is lifted up the sides of a rotating drum, and dropped back to the centre. The waste is tumbled, mixed and homogenised through this method. Dense, abrasive materials (e.g. glass, metal) will help break down the softer materials to reduce the size of paper and other biodegradable materials. There may be holes in the side of the drum to allow the smaller fraction (predominantly organics, broken glass and fines) to fall through, facilitating separation of the waste as discussed in the next table.	Feedstock with high moisture content may not break up under the gentle action. Drum will require removal of wastes that become entangled in the drum / block apertures from time to time.
Ball mill	Rotating drum using heavy balls to break up or pulverise the waste. This may also be used to facilitate separation of the waste as holes (smaller in aperture than the balls within the mill) allow the finer fraction of the waste to fall through.	Wear on balls (life cycle costs); pulverising or 'loss' of glass / aggregates. Limited track record on municipal waste treatment.
Wet rotating drum with knives	Waste is wetted to form heavy lumps which break against the knives when tumbled in the rotating drum.	Potential for damage from large items (life cycle costs); gives relatively low size reduction.
Bag splitter	Plastic or paper bags are split using a gentle shredder, leaving the majority of the waste intact, but facilitating later separation techniques	Does not reduce size; may be damaged by large strong items.

Table 17: Typical mechanical separation technologies

Technology component	Prime function	Target materials	Operational considerations
Manual separation	Visual examination	Contaminants, oversize, certain plastics, improving quality Not normally used for mixed municipal waste	Health & safety issues; relies on effective training of staff; operatives need safe working conditions and protective equipment. Need to operate in a well-ventilated area. Very flexible to changing commodities markets.
Trommels	Size, density	Oversize – paper, plastic Undersize – organics, glass, fines	Regular cleaning is required; containment of air.
Vibrating screens	Size / 3D properties	Oversize – paper, plastic Undersize – organics, glass, fines	Noise, regular cleaning is required; high throughput; appropriate shielding required
Star / disc screens	Shape, rigidity	Card, paper, plastics	Wear on moving parts, regular cleaning is required
Magnetic separation	Magnetic properties	Ferrous metals	High efficiency of separation
Eddy current separation	Electrical conductivity	Non-ferrous metals	High efficiency of separation
Wet separation	Differential density	Floats – plastics, organics Sinks – stones, glass	Produces wet waste streams. Limited applications for MSW in practice, although some systems use 'washing' techniques (see below) for refining organic outputs.
Air classification	Weight	Light – plastic film, paper Heavy – stones, glass	Air cleaning
Ballistic separation	Density, elasticity	Light – plastics, paper Heavy – stones, glass	Appropriate shielding required
Optical separation	Optical properties, NIR diffraction	Specific plastic polymers, colours	Low rate of throughput, high capital costs, wide variety of applications

Table 18: Typical mechanical polishing technologies

Technology component	Prime function	Operational considerations
Manual sorting	To visually remove contaminants.	Health & safety issues; relies on effective training of staff, very flexible sorting method.
Glass screen / sieve	Sorts glass by size to separate glass for reprocessing or for use as aggregate.	Requires subsequent reprocessing in a glass colour separation plant to enable use of the cullet into remelt applications.
Shredder / pelletiser	For the production of secondary recovered fuel from fibrous materials (e.g. paper, plastics, and textiles).	Different markets may prefer refuse derived fuel to be presented in a particular manner to complement their operation.
Densimetric tables	Separation by density using a vibrating plate with upward air flow. Used for grading and refining products from organic waste treatment.	
Washing	For washing organics to achieve final quality standards	Product retains some water after washing
Piercer	To puncture plastic bottles to allow more effective compaction.	Effectiveness also linked to the compaction ability of the baler used.
Compaction	Compression of the material reduces the volume of the waste for onward transit.	Not suitable for fragile or friable materials, e.g. glass
Baling	Material is usually compressed into standard sized blocks and bound with wire for onward transit.	Not suitable for fragile or friable materials, e.g. glass Certain materials may need to be wrapped in film to prevent loss, e.g. organics, RDF
Dewatering	Volume reduction of organic materials to optimise process or output.	Determined by the technology chosen and the end-market for useable products, e.g. digestate as fertiliser
Crushing / Screening	For application to aggregates in order to refine outputs, for example bottom ash from thermal processes.	

Table 19: Overview of combustion technology options

Technology	Description
Moving grate	The moving grate furnace system is the most commonly used combustion system for high through-put MSW processing. The waste is slowly propelled through the combustion chamber (furnace) by a mechanically actuated grate. Waste continuously enters one end of the furnace and ash is continuously discharged at the other. The plant is configured to enable complete combustion as the waste moves through the furnace. Process conditions are controlled to optimise the waste combustion, to ensure complete combustion of the feed. The end of the grate normally passes the hot ash to a quench to rapidly cool the remaining non-combustibles. There are three main sub categories of moving grate combustion systems used for MSW. These are as follows: **The Roller Grate** – this consists of adjacent drum or rollers located in a stepped formation, with the drums rotating in the direction of the waste movement **The Stepped Inclined Grate** – this system uses bars, rockers or vibration to move the waste down each of the grates (typically three) **Inclined Counter-Rotating Grates** – grate bars rotate backwards to agitate the waste and prevent it tumbling down the forward inclined grate until burn out is complete.
Fixed grate	These are typically a series of steps (normally 3) with the waste being moved by a series of rams. The first step is a drying stage and initial combustion phase, the second is where the remaining combustion takes place and the third grate is for final carbon burn-out.
Fluidised bed	The combustion of MSW using a fluidised bed (FB) technique requires pre-sorting of MSW material to remove heavy and inert objects, such as metals, prior to mechanical processing to reduce particle size. The combustion is normally a single stage process and consists of a lined chamber with a granular bubbling bed of an inert material such as coarse sand/silica. The bed is 'fluidised' by air (which may be diluted with recycled flue gas) being blown vertically through the material at a high flow rate. Wastes are mobilised by the action of this fluidised particle bed. There are two main sub-categories of fluidised bed combustors: **Bubbling FB** – the airflow is sufficient to mobilise the bed and provide good contact with the waste. The airflow is not high enough to allow large amounts of solids to be carried out of the combustion chamber. **Circulating FB** – the airflow for this type of unit is higher and therefore particles are carried out of the combustion chamber by the flue gas. The solids are removed and returned to the bed.
Rotary kiln	Rotary kilns have wide application and can be a complete rotation vessel or partial rotation vessel. Incineration in a rotary kiln is normally a two stage process consisting of a kiln and separate secondary combustion chamber. The kiln is the primary combustion chamber and is inclined downwards from the feed entry point. The rotation moves the waste through the kiln with a tumbling action which exposes the waste to heat and oxygen. There is also a proprietary system which oscillates a rotating kiln for smaller scale incineration of MSW with energy recovery.

Table 20: Summary of in-vessel composting technologies

System	Basis	Material flow	Loading	Aeration / mixing
Tunnels	Large-scale rectangular concrete or steel structure	Batch / continuous	Loading vehicle or conveyor at end or via roof	Forced aeration through floor, pipework or aeration channels
Vertical towers and silos	Sealed tower	Continuous	Through top of vessel	Moves under gravity; Mechanical mixing; Passive or forced aeration
Rotating drums	Rotating drum with baffles for mixing	Continuous	Loading vehicle or conveyor	Forced aeration; Mixing through movement and design of drum
Agitated bays / extended beds	Enclosed building	Continuous	Loading vehicle at one end	Turning machine; forced aeration

Table 21: Summary and comparison of biological treatment system classifications

Treatment system	Suitable waste feedstocks	Operational considerations	Key components
Anaerobic digestion	Source-separated municipal and non-municipal organics; Mixed residual waste as part of MBT system	Sensitive process; may require 'balancing' with other feedstocks to achieve optimum performance	De-packaging unit; maceration unit; digestion vessel(s); sanitisation / pasteurisation vessel (depending on process); separate hydrolysis vessel (depending on process); dewatering equipment; biogas storage tanks; biogas clean-up equipment; Gas engine / CHP unit; odour control. Depending on the nature of the waste feedstock, mechanical pre- or post-treatment may be required (see section 4.3)
Open windrow	Source-separated green garden waste	Not usually suitable for the treatment of food waste	Mechanical shredder; loading vehicles; windrow turner; tractor; screens; non-permeable composting pad
In-vessel composting	Source-separated municipal organics; Mechanically segregated organics as part of MBT system.	A further sanitisation stage may be required where meat waste may be present	Mechanical shredder; loading vehicles; composting vessels / buildings; turning vehicle / mixing equipment; aeration system; moisture control; temperature control; screens; maturation pad; odour control.
Bio-drying	Mechanically segregated municipal and non-municipal organics as part of MBT system; Mixed residual waste as part of MBT system.	Only partially bio-stabilises, further treatment is usually necessary	Mechanical shredder; loading vehicles; composting vessels / buildings; turning vehicle / mixing equipment; aeration system; moisture control; temperature control; odour control

Table 22: Summary of predominant thermal technologies

Technology	Oxygen requirements	Temperature	Principal outputs
Incineration	Full combustion in the presence of oxygen	> 850 C	Carbon dioxide, water. Heat from combustion (typically used in steam circuit) Non-combustibles remain as bottom ash.
Pyrolysis	Thermal degradation in the absence of oxygen	Relatively low temperature: 300-800 C (typically c350 C)	Solid residue (char) from non-combustibles and carbon. Synthesis gas (syngas) comprising predominantly CO, H_2, CH_4. Liquid / condensate oils & tars
Gasification	Partial (or 'starved') oxidation - in a low O_2 environment – insufficient oxygen for full combustion	Typically above 650 C	Solid residue from non-combustibles remains as ash / slag. Synthesis gas (syngas) comprising predominantly CO, H_2, CH_4

Table 23: Gasification treatment options

Reactor type	Key characteristics
Fluidised bed	Bed is a mass of particles (typically alumina) that has similar properties to a moving fluid achieved by blowing hot gases through the bed. Provides good mixing and heat transfer. Waste feedstock is pre-treated to remove large-sized material.
Fixed bed	Covers a range of reactor types. Typical example is a grate system where feed passes along grate and hot gases heat the waste as it passes through the bed.

Table 24: Pyrolysis treatment options

Reactor type	Key characteristics
Rotating kiln	Feedstock fed into one end of kiln which slowly rotates to give a tumbling action to mix the waste and ensure contact with heating surface and gases. Externally heated, for low temperature operation around 400-600 C. Can accommodate large size feed material (200mm).
Heated tube	Feedstock passes through tube at a set speed to ensure complete reaction. Externally heated, for high temperatures of up to 800 C. Can accommodate large size feed material.
Surface contact	Maximises the rate of pyrolysis. Significant pre-treatment is needed to achieve small size feed material required. Operates at high temperatures, small size of feed gives high heating rates.

Table 25: Summary of advanced thermal treatment options and key characteristics

Treatment system	Suitable waste feedstocks	Operational considerations	Key components
Gasification	Pre-treated residual municipal and co-treatment with municipal-type waste (e.g. tyres, plastic rich wastes, biomass)	Pre-treatment required; Used as part of, or processing outputs from, MHT / MBT / Dirty MRF system; several operating plant, predominantly based on 'steam circuit energy recovery (lower efficiency)	Waste handling equipment; Thermal reactor Energy recovery plant; Gas & residue treatment; Air pollution abatement equipment
Pyrolysis	Pre-treated residual municipal and co-treatment with municipal-type waste (e.g. tyres, plastic rich wastes)	Pre-treatment required; Used as part of, or processing outputs from, MHT / MBT / Dirty MRF system; Limited commercial track record	Waste handling equipment; Thermal reactor Energy recovery plant; Gas & residue treatment; Air pollution abatement equipment
Plasma	Pre-treated residual municipal and co-treatment with municipal-type waste (e.g. commercial wastes, certain industrial wastes).	Plasma may be used on part of the process (e.g. applied to syngas) or as part of a gasification or pyrolysis process (i.e. applied directly to the waste feedstock) Limited commercial track record, although some large facilities under development	Waste handling equipment; Thermal reactor Energy recovery plant; Gas & residue treatment; Air pollution abatement equipment
Torrefaction	Biomass	Unsuited to residual waste	Waste handling equipment; Thermal reactor; Densification equipment for briquettes / pellets
Autoclaving	Residual / raw municipal waste and co-treatment with municipal-type waste	Used as part of MHT system; Limited commercial track record; Pressured system requires appropriate H&S management. Produces fuel output for further treatment	Waste handling equipment; Steam pressure vessel; Mechanical sorting
Thermal drying	Residual / raw municipal waste and co-treatment with municipal-type waste	Used as part of MHT system; Limited commercial track record; Produces fuel output for further treatment	Waste handling equipment; Heating vessel; Mechanical sorting