ENVIRONMENTAL SOLUTIONS

WSN ENVIRONMENTAL SOLUTIONS

YOUR EASY GUIDE TO WASTE TECHNOLOGIES

VERSION 2

CONTENTS

THE PURPOSE OF THIS GUIDE

Understanding the range of established and developing waste processing technologies can be challenging. So, if you are someone who is either a decision maker, involved, or simply interested in waste management, this "Easy Guide" can help to provide a global overview of the various waste technologies that are available today.

Designed as a simple reference tool, it outlines the categories of waste technologies, the general processes involved, inputs and outputs, and the pros and cons of each method.

No particular technology is recommended in this "Easy Guide" because, at this stage, no single technology offers an all-encompassing solution to waste management. Ultimately it is local considerations such as waste types, environment, community, volume and the available markets for various waste streams that will shape your technology choice.

Originally published in June 2004, *Your Easy Guide to Waste Technologies* has been updated to include the latest information on available technologies. Please replace the original copy with this latest version.

OUR PHILOSOPHY

WSN Environmental Solutions is committed to working with you to find the most effective resource recovery solutions. Our solutions will be tailored to meet your needs and will provide best practice, value for money, sustainable waste management that utilises leading technology.

We are not aligned to any one technology as we believe it is essential to assess each situation on its merits. We have the capability to provide an integrated solution that combines the most appropriate technologies, strategies and services to fit in with your requirements.

Our dedicated team of skilled infrastructure and technology professionals source and assess new technologies from around the world, and ensure that a concept can be adapted to address local needs and developed through to completion.

We operate Australia's largest and most advanced network of landfills, resource recovery centres, and materials recycling facilities.

Our landfills are modern and technically advanced, in fact we were the first in Australia to produce green electricity from landfill in 1994. Today our facilities generate enough green energy to power up to 30,000 homes each year.

Whilst waste disposal will continue to be part of waste management, we are committed to supporting a more sustainable future by making the transition to Alternative Waste Technologies (AWTs) that have the capability to maximise the recovery of resources.

Proof of this commitment can be seen in the opening of Sydney's first AWT facility, the Eastern Creek UR-3R, in partnership with Global Renewables. Each year the UR-3R will divert up to 80% of household waste from landfill, recover 17,000 tonnes of recyclables, reduce gas emissions by the equivalent of taking nearly 50,000 cars off the road and produce enough electricity to power 2,250 homes.

WHAT IS AN AWT?

A new class of waste technology called Alternative Waste Technology (AWT) has emerged in recent years.

Essentially it is a technology that has three key elements:

- Diversion of waste from landfill;
- Recovering more resources from the residual waste that is deemed for landfill after removal of kerbside recyclables; and
- Minimising potential harm to the environment.

Typically AWTs treat waste by fermentation, gasification, percolation and a number of other methods, and are described as “alternative” because they offer a more sustainable solution to traditional methods such as landfill and incineration.

MECHANICAL SEPARATION TECHNOLOGIES

This class of waste technology sorts recyclable waste by material type – typically separating paper, cardboard, glass, metals and plastics. The waste can then be further processed until it is suitable for reuse, recycling or reprocessing.

PROS

- ✓ Good resource recovery
- ✓ Mature technology

CONS

- ✗ Expensive
- ✗ Dependent on the market for outputs

MATERIAL SORTING

Already used commonly in Australia, waste is mechanically separated at a Materials Recycling Facility (MRF).

Suitable for

- Mixed dry recyclables, including: paper, cardboard, packaging plastics, glass, metals; and
- Industrial dry recyclables, including: paper, cardboard metals, plastics, glass, timber, concrete, soil.

Produces

- Re-processable materials by type.

How it works: MRFs perform two functions in waste separation: sorting of mixed waste streams; and consolidation of pre-sorted collected materials for transport to re-processors.

Where it is used: Australia.

HOW IT WORKS – MATERIAL SORTING

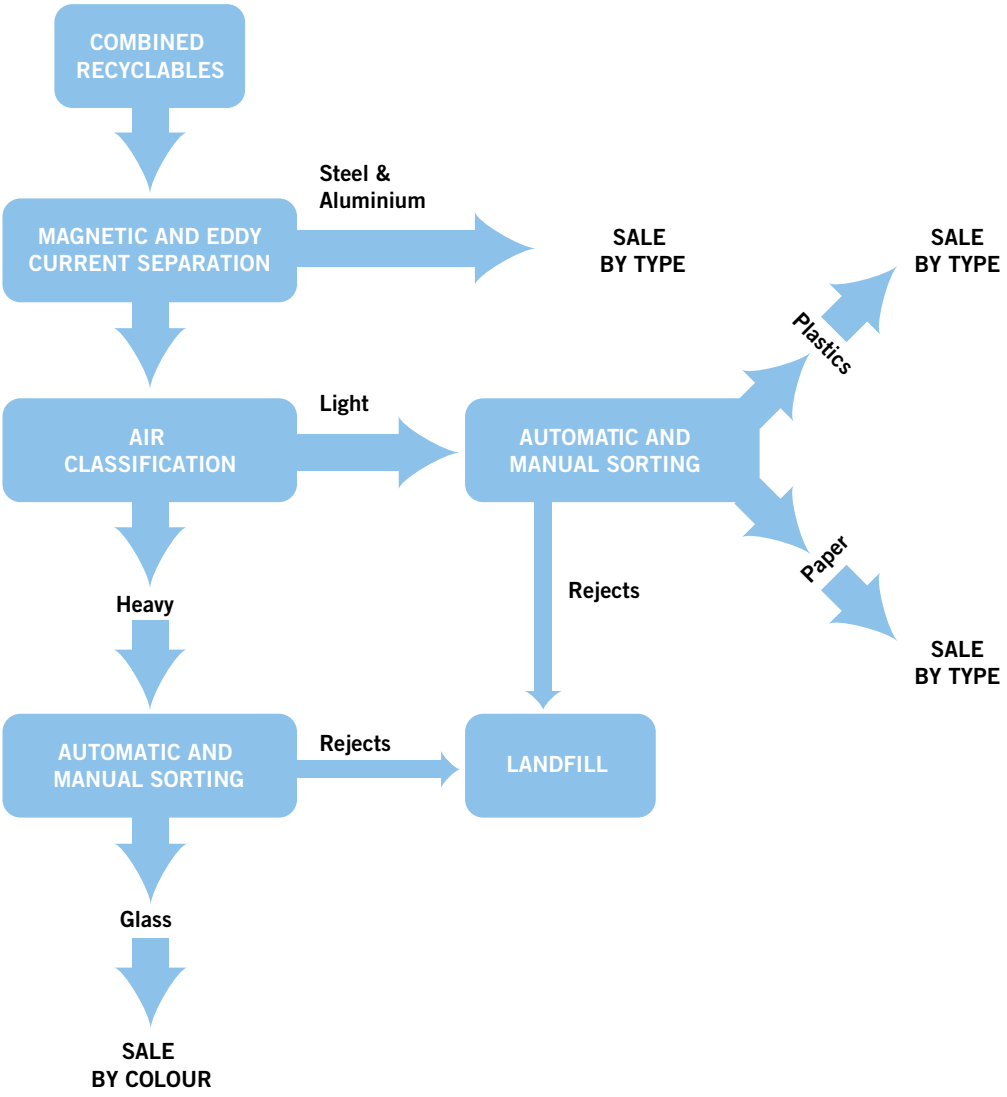


Diagram taken from *Report of the Alternative Waste Management Technologies and Practices Inquiry*, April 2000.

MECHANICAL SEPARATION TECHNOLOGIES

PROS

✓ Particularly useful in conjunction with thermal or biological technologies for ensuring maximum resource recovery

CONS

✗ Not a stand alone system

✗ Waste requires further treatment

WASTE SEPARATION

These technologies use a variety of physical processes, such as shredders, screens, magnetic separators and eddy current separators, to separate mixed municipal wastes. The aim is to recover specific waste streams for further processing and reduce the amount going to landfill. They can be located close to the waste source thereby reducing transportation of waste and recovered materials.

Suitable for

- Municipal waste.

Produces

- Organic mass for biological organic processes (40–50% by mass);
- High calorific material which can be treated by incineration or other thermal treatment, or landfilled (20–30% by mass);
- Inert materials, such as bricks, stones and glass which are landfilled, (about 10% by mass); and
- Metals, (about 5% by mass), which can be recycled.

How it works: Waste separation is usually undertaken in two steps: a processing step where the mixed waste is mechanically worked and heated; and a separation step where the processed waste is segregated using screens, air blowers, magnets and other processes.

Where it is used: Germany, Italy, Spain and other European countries.

HOW IT WORKS – WASTE SEPARATION

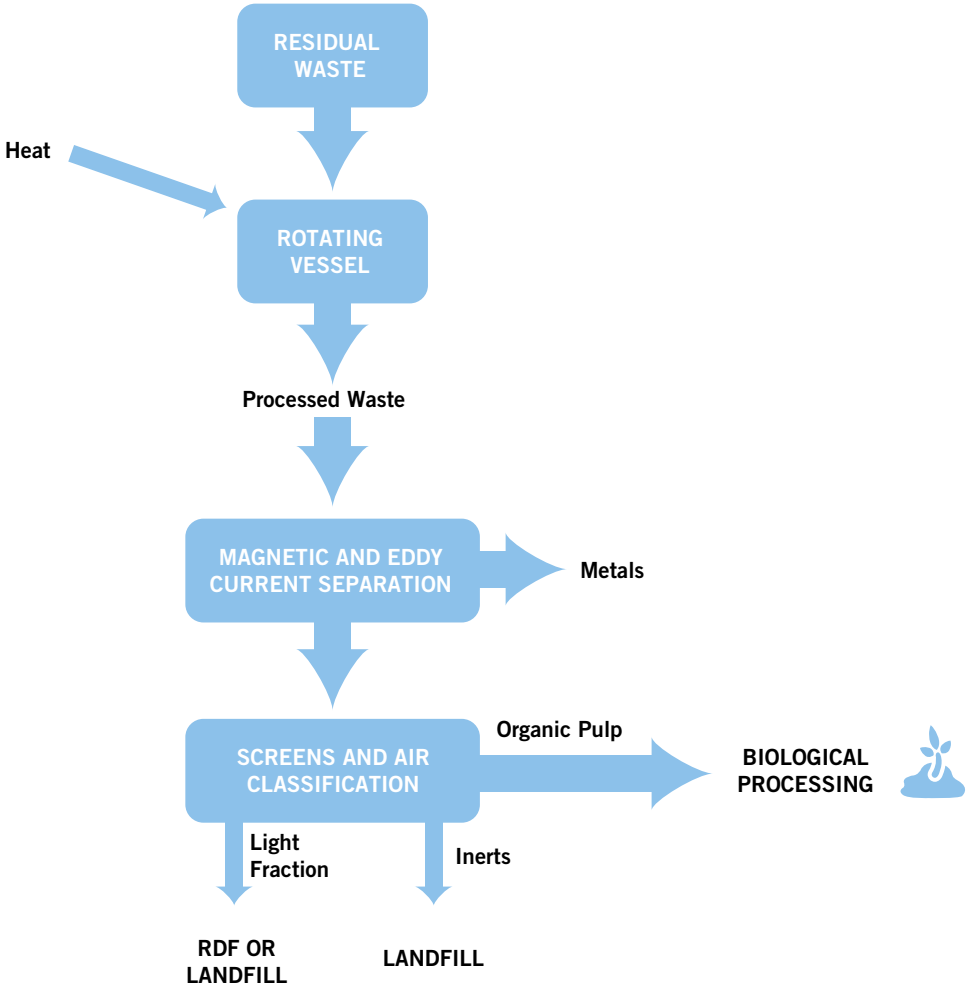


Diagram taken from *Report of the Alternative Waste Management Technologies and Practices Inquiry*, April 2000.

BIOLOGICAL TECHNOLOGIES

Biological technologies all involve the degradation of green organics and bio-solids into products that can be used as garden compost and to improve soil quality, or into biogas to be used as fuel.

There are two main biological approaches: aerobic, where decomposition occurs in the presence of air and heat is produced; and anaerobic, where decomposition occurs in some kind of an air-tight vessel and the gas produced is tapped for fuel.

The technologies are all mature and produce good resource recovery.

PROS

- ✓ Inexpensive
- ✓ Good for the soil

CONS

- ✗ Produces odours, nutrient runoff
- ✗ Limited types of waste can be processed

LAND APPLICATION

As the name implies, land application is simply the application of organic wastes directly to farm soils. This increases soil sustainability and crop yields.

Suitable for

- Agricultural wastes;
- Sewage sludge;
- Gypsum; and
- Specific organic wastes including grease trap wastes.

Produces

- Soil improvement

How it works: Minimal processing

Where it is used: England, Australia.

PROS

- ✓ Low cost
- ✓ High resource recovery
- ✓ Well accepted
- ✓ Simple mature technology that can be scaled up or down

CONS

- ✗ Treats limited types of waste

VERMICOMPOSTING

These technologies use worms to consume organic wastes. Garden organics is sometimes used as a bulking agent. The product is high quality compost suitable for soil conditioning.

Suitable for

- Sewage sludge;
- Food waste; and
- Garden organics.

Produces

- Compost; and
- Soil conditioner.

How it works: Essentially the same technology as a domestic-scale worm farm, the organic matter is applied to a bed of worms. The run off is screened and worm casts collected.

Where it is used: Lismore and Brisbane.

PROS

- ✓ Low cost
- ✓ High resource recovery
- ✓ Well accepted
- ✓ Simple mature technologies

CONS

- ✗ Produces odours
- ✗ Limited types of waste can be treated
- ✗ Quality of the output can vary with the quality of the input

OPEN WINDROW COMPOSTING

These technologies involve decomposition of organic wastes through microbial activity under open, aerobic conditions for a six to twelve week period. The compost product is stable and rich in nutrients and organic matter, and is suitable as a soil conditioner.

Suitable for

- Garden organics and food waste; and
- Sewage sludge.

Produces

- Compost; and
- Soil conditioner.

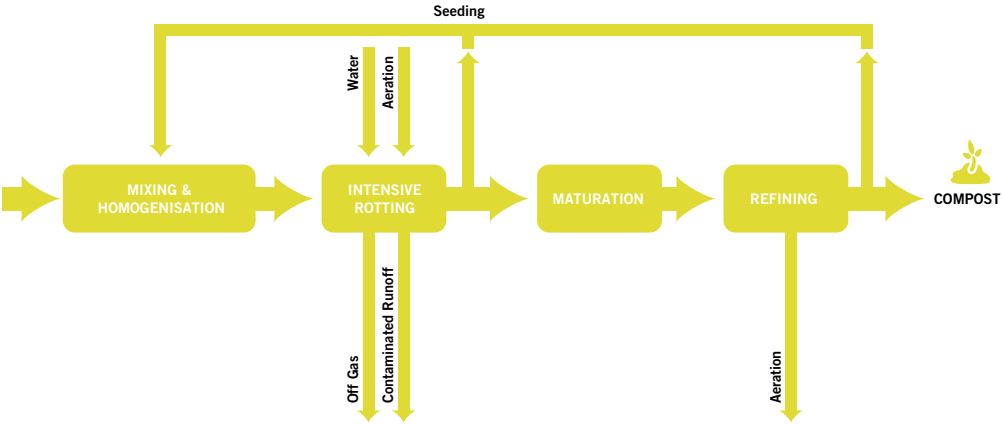
How it works: Organic waste is checked for contaminants, ground and placed into windrows. The windrows are machine-turned to maintain the aerobic conditions.

Water, bio-solids and other nutrient-rich liquids may be added using pumps and irrigation equipment to maintain the moisture level.

The composted material is then screened and blended into a range of horticultural products.

Where it is used: Throughout the world.

HOW IT WORKS – OPEN WINDROW COMPOSTING



PROS

- ✓ Mature
- ✓ Economical technology

CONS

- ✗ Output quality varies with the inputs
- ✗ No energy production

ENCLOSED COMPOSTING

Depending on the scale, containers ranging from small drums to large silos are used to control the atmosphere and moisture and improve the speed and temperature of composting. This technology treats any of the commonly produced organic wastes to produce good quality compost.

Suitable for

- Mixed organic waste, including food and garden organics; and
- Other pre-separated residual waste

Produces

- Compost;
- Soil conditioner; and
- High calorific material for thermal processes or landfill.

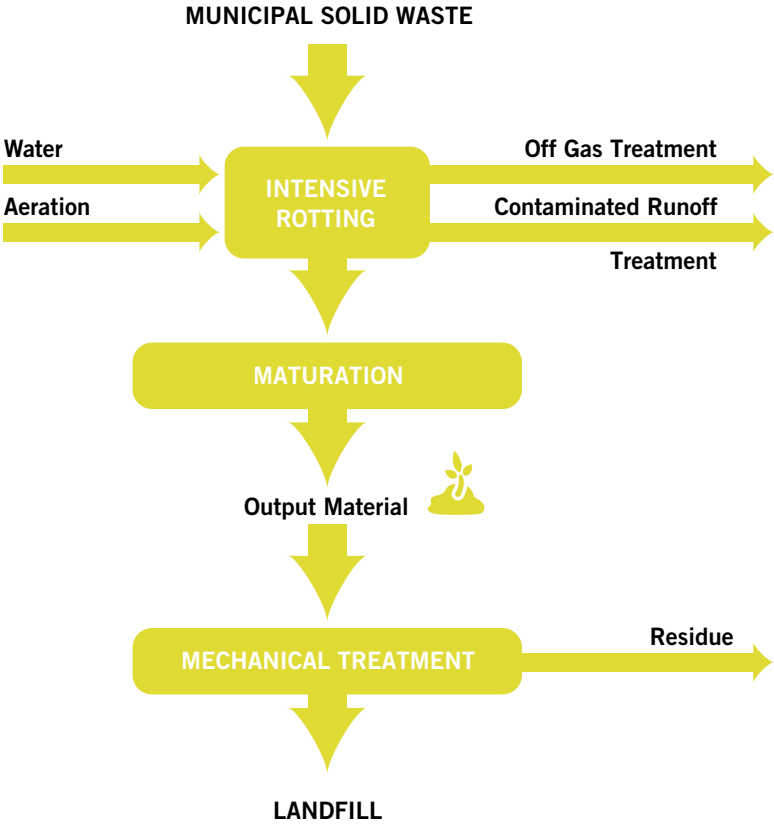
How it works: There are a variety of systems available using this technology. Some use a two-step process. Composting is begun in drums or boxes for one to twelve days after which the material is generally transferred to a containment building to control odours. The composting process is completed over some six to twelve weeks, with turning every few weeks.

A similar enclosed composting scheme is “box composting”, where initial composting occurs in sealed boxes for seven to twelve days. The process includes forced air and water spraying, followed by static pile windrowing for three to four months.

Tunnel composting uses troughs with turning or air-forced disturbance of the bed for around three weeks to produce compost of fairly advanced maturity which needs little further processing.

Where it is used: Europe, increasingly in the US for garden organics.

HOW IT WORKS – ENCLOSED COMPOSTING



PROS

- ✓ Excellent resource recovery
- ✓ Faster processing times

CONS

- ✗ It can not degrade woody waste
- ✗ The output material needs further processing before it can be used as a soil conditioner
- ✗ Process water needs treatment

ANAEROBIC DIGESTION

These technologies break down organic wastes by microbial activity in the absence of oxygen. The methane-rich gas produced is suitable as fuel for energy generation.

A digestate sludge is also produced, which is suitable for enriching compost materials. Input preparation or source separation is required to ensure that waste is free of non organic contamination.

The waste may need further treatment after digestion to further break down the residue.

Suitable for

- Mixed organic waste, including food and garden organics.

Produces

- Biogas fuel/green energy; and
- Organic material for compost.

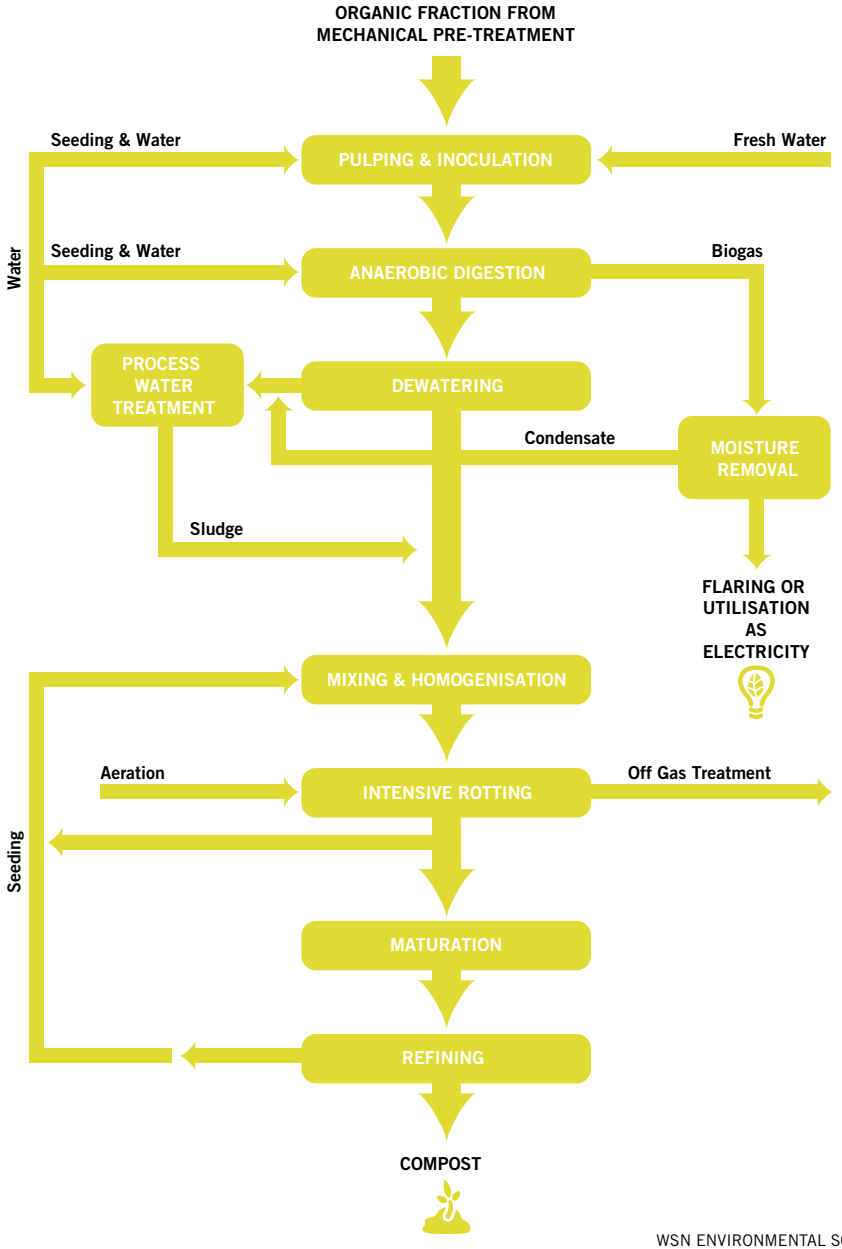
How it works: The overall process requires three to four stages. The first involves mechanical processing to separate recyclables. This is followed by one or two distinct anaerobic decomposition phases.

During digestion, the two different processes of acidification and methanogenisis require different temperatures and pH levels for optimal process control.

Finally an aerobic or other stabilising process is usually required as the anaerobic process does not necessarily destroy all pathogens.

Where it is used: Germany, France, Italy, Switzerland and other European countries.

HOW IT WORKS – ANAEROBIC DIGESTION



MECHANICAL BIOLOGICAL TREATMENT (MBT)

Mechanical Biological Treatment is used to describe any system that combines the mechanical sorting of waste with some kind of biological treatment. This approach offers the most flexibility in types of waste processed, offers the highest resource recovery, and has gained endorsement from Greenpeace UK. These systems are used increasingly throughout the world.

The chief aim of the Mechanical Biological approach is to deal with each type of waste in such a way as to extract the maximum value. All Mechanical Biological systems remove the recyclables for recycling and divert bulky inert material to landfill (some use a shredder so the inert material can be reused).

The remaining organic waste is then treated using a biological treatment to make three products; biogas for electricity generation; compost for soil improvements; and solid recovered fuel, which is the remainder that has calorific value that can be used as fuel instead of coal for power stations. Depending on the system less than 20% of waste is landfilled.

* Note: Some MBT processes use rotating drums to produce compost material only.

PROS

- ✓ Highest resource recovery
- ✓ Faster processing times
- ✓ Easy site selection due to smaller sizes required
- ✓ Handles a variety of input wastes
- ✓ Scales up or down so can be used for large or small volumes
- ✓ Low impact on local environment and high social acceptance

CONS

- ✗ Dependent on a market for outputs
- ✗ Depending on MBT process, process outcomes and economics can vary significantly.

Suitable for

- Municipal solid waste;
- Sewage; and
- Biosolids.

Produces

Depending on the system used, MBT produces:

- Recyclables;
- Compost;
- Electricity;
- Fuel which may be used in conventional coal power plants; and
- Inert material for landfill.

MECHANICAL BIOLOGICAL TREATMENT (MBT)

How it works: Various technologies fit under the MBT umbrella. All involve mechanical waste separation (shredding and fractionation), followed by a biological process (aerobic or anaerobic).

Some systems also incorporate some forms of dry stabilisation techniques to convert residual waste to produce a fuel. Stabilisation involves reduction of water content to less than 15 per cent, thereby suppressing biological activity. The product may be used as a starting material for production of refuse derived fuel (RDF) which may be used to generate electricity.

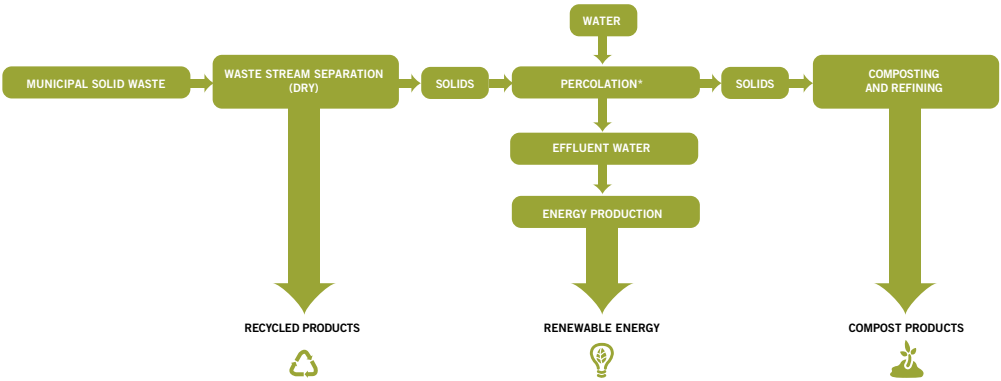
The largest MBT facility in Australia is at Eastern Creek in Sydney. This system uses a four-stage treatment process. Waste is mechanically sorted, rapidly broken down using air and water in an aerobic percolator. The output is then either further treated anaerobically to produce biogas or composted to produce a soil conditioner and refuse derived fuel.

The latest generation MBT process is in Israel. It uses wet reprocessing waste separation and uses the effluent to produce Biogas in a two stage anaerobic process. The solid digestate is used for fertiliser applications. All process water is treated and reused.

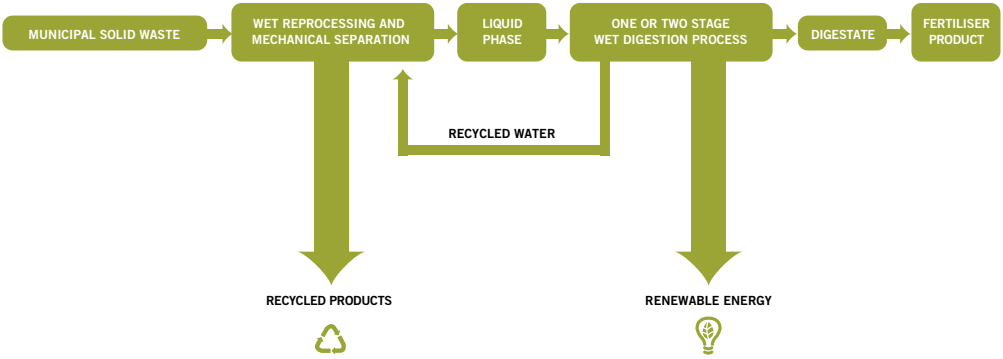
Where it is used: Europe, USA, Australia and Israel.

HOW IT WORKS – MECHANICAL BIOLOGICAL TREATMENT

HOW IT WORKS – MECHANICAL BIOLOGICAL TREATMENT (PERCOLATION)



HOW IT WORKS – MECHANICAL BIOLOGICAL TREATMENT (WET PROCESSING)

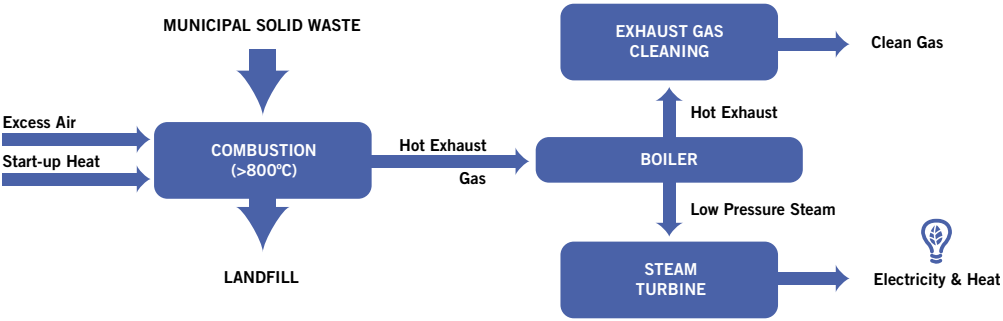


THERMAL TECHNOLOGIES

Thermal technologies use heat to decompose the waste and produce a stable residue for disposal. Municipal solid waste has a calorific value of about 10 GJ/tonne and, using thermal technology, some of this energy may be recovered as heat or electricity.

Conventional incineration, or mass burn combustion, is still the most commonly used thermal process. However, a number of new thermal technologies have been developed that do not involve direct burning or combustion of waste.

HOW IT WORKS – INCINERATION



PROS

✓ Mature technology that can deal with volumes of mixed waste in a small area

CONS

✗ The process is inefficient as little of the available energy is captured for conversion to electricity

✗ Low resource conservation

✗ High cost

✗ Some concerns about air pollution

INCINERATION

One of the more mature technologies for dealing with waste. Heat and steam for electricity generation is produced through mass combustion of the waste, which need not be pre-sorted or separated. The outputs can be used for local heating and as a stable source of electricity for the grid.

Suitable for

- Municipal solid waste;
- High calorific specific wastes;
- Special wastes, including clinical waste; and
- Hazardous waste.

Produces

- Heat;
- Steam; and
- Electricity.

How it works: Waste needs little sorting or pre-treatment. Incineration involves several stages – drying and pre-heating the solid waste, emission and combustion, and a burnout and removal stage. Solid unburnable material is left as a slag which is landfilled or sometimes sorted by grain size for recovery as aggregate.

Ferrous metals may be recovered by magnet and recycled. Wash water is often recycled for flue gas treatment. Flue gas from combustion contains water, combustion gases, oxygen and nitrogen. It may need to be reburned to ensure that any carbon monoxide is converted to carbon dioxide. Steam may be super-heated to drive a turbine to generate electricity.

Pollution control is necessary in incineration because particulates and dust, oxides of nitrogen, acid gases and dioxins, furans, polyaromatic hydrocarbons and heavy metals may be generated and dispersed through the air.

Where it is used: Worldwide.

PYROLYSIS/GASIFICATION

These technologies are not yet fully mature but show promise. They offer less pollution and better resource recovery than conventional incineration.

Gasification offers significantly higher energy production than either incineration or pyrolysis. New combined pyrolysis/gasification systems have yet to be proved.

In this group of technologies, Municipal Solid Waste is sorted into metals, glass and plastics that can be recycled productively in separate processes. The remaining waste materials are heated in the absence of oxygen to produce a liquid fuel (pyrolysis oil), which can then be separately turned into a gas in the presence of oxygen to produce a fuel gas (syngas). The pyrolysis oil or syngas can in turn be used to power industrial engines producing electricity for input to the grid, or as a chemical feedstock.

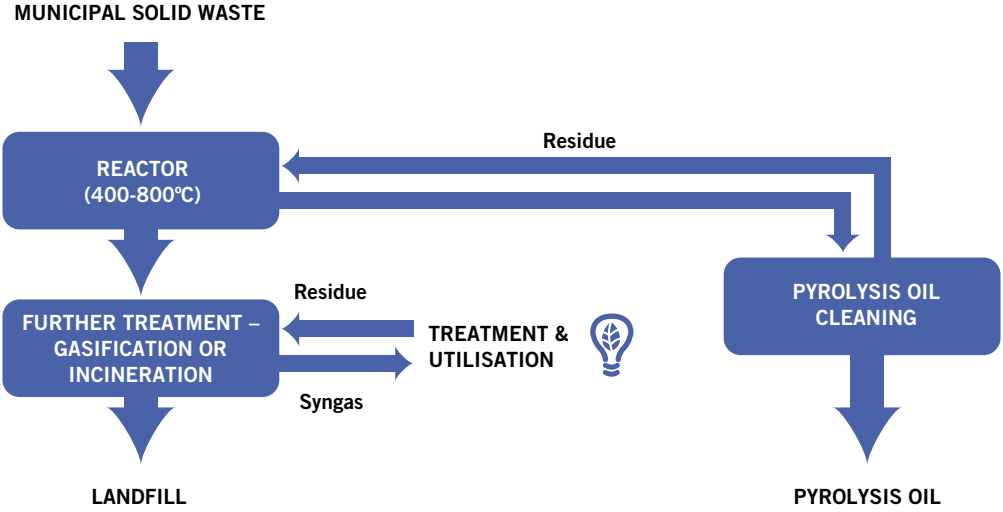
Suitable for

- Sewage sludge;
- Agricultural wastes;
- Mixed organic waste, including food waste, garden organics and paper pulp; and
- Pre-separated municipal waste.

Produces

- Pyrolysis oil or Syngas/green energy.

HOW IT WORKS – GASIFICATION



PYROLYSIS

Involves indirectly heating carbon rich material. Pre-sorted waste is fed into a heated pyrolysis drum or tube. The aim is to achieve thermal degradation of the material at temperatures of 400–800°C in the absence of oxygen and under pressure, resulting in the production of gas, liquid and char.

Less volatile heavy metals remain in char, while volatile metals are captured by gas cleaning systems and treated as hazardous materials. A liquid remainder is produced consisting of a tar or oil stream containing acetic acid, acetone, methanol and complex oxygenated hydrocarbons. This may be used, with additional processing, as a synthetic fuel oil. Useable energy of some 200 to 400 kWh per tonne of waste is generated by pyrolysis.

A number of pyrolysis plants are in operation, mainly concentrating on processing consistent waste streams such as plastics or biosolids.

PROS

- ✓ Pyrolysis/gasification are proven effective treatments for single waste streams
- ✓ Gasification particularly is less polluting and more energy efficient than conventional incineration

CONS

- ✗ Poor resource recovery
- ✗ Less reliably used for mixed municipal waste
- ✗ High cost, some concerns about air pollution

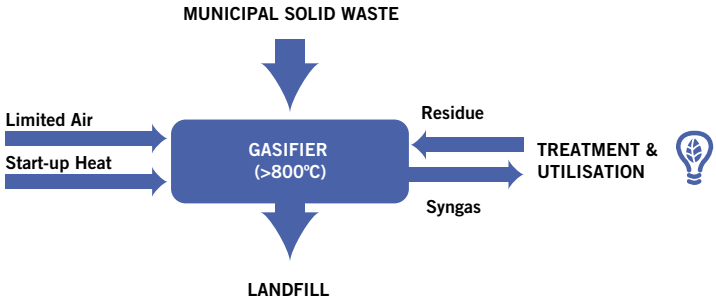
GASIFICATION PROCESS

Descriptions vary for different specific technologies but the basic process involves heating carbon rich waste (bio-solids, agricultural wastes, food waste, garden organics, paper pulp and pre-separated solid waste) in an atmosphere with slightly reduced oxygen concentration to a temperature of around 1,000°C. Most carbon is converted to a gaseous form, Syngas, leaving an inert residue from break down of organic molecules.

Syngas is rich in carbon monoxide, hydrogen and some saturated hydrocarbons (methane) and can be used in internal combustion engines to produce energy; in a steam turbine or boiler; or as a raw material resource to produce methanol, hydrogen or methyl acid.

Where it is used: Pyrolysis and Gasification have been used in Japan, Germany, Switzerland, France and Spain.

HOW IT WORKS – GASIFICATION PROCESS

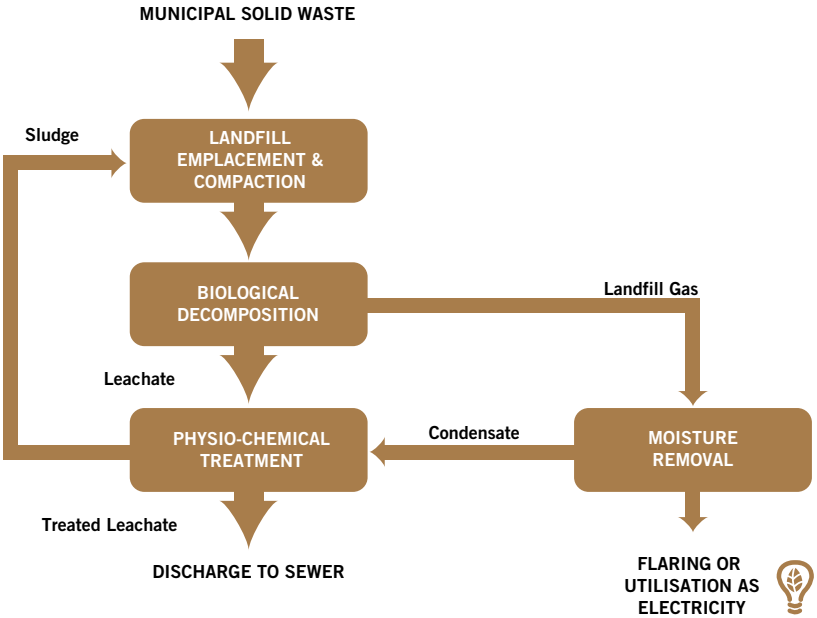


LANDFILL TECHNOLOGIES

This group includes conventional landfills and bioreactor landfills. Wastes are placed in the ground, compacted and then covered. Conventional landfill technology has evolved over time beyond simply filling an excavated hole. Landfills now use a liner or a natural geological barrier beneath the waste, aimed at water protection, and improved local environmental amenity. These barriers must be maintained for a considerable time after the closure of the landfill – perhaps as long as one hundred years.

These mature technologies break down waste in a manner that controls the emission of gas, liquid and odour. As the process of biodegradation takes place methane and carbon dioxide are released, about half of which may be captured and used to generate electricity.

HOW IT WORKS – CONVENTIONAL LANDFILLS



PROS

✓ Landfill is a low-cost, mature technology that is useful for most waste streams

CONS

✗ Poor resource conservation

✗ Environmental risks from gas emission

✗ Long lifetime and high land consumption

CONVENTIONAL LANDFILL

Suitable for

- Municipal solid waste.

Produces

- Methane suitable for electricity production.

How it works: Conventional landfills consist of a bottom liner: one or more layers of clay and/or a synthetic flexible membrane aimed at preventing liquid release to ground water. Pipes are then laid above the bottom liner to capture contaminated water and other liquids (leachate) which is conveyed to a wastewater treatment plant for treatment with any solids removed and landfilled.

When filled a cover is built of several sloped layers including a clay or membrane liner, a permeable layer of sandy or gravely soil, and topsoil in which vegetation can take root to stabilise the underlying layers of the cover. This prevents rain from intruding, promotes runoff, and reduces water and air emissions.

Often the methane and carbon dioxide generated as waste decomposes is collected, usually by a piped collection system. This gas may be burnt either in flares or in engines that recover useable energy. The combustion process can also destroy chlorinated and fluorinated hydrocarbons that are present in landfill gas.

Some landfills differ in that every attempt is made to keep the waste dry so as to inhibit anaerobic decomposition processes. By keeping the waste dry, leachate and gas generation is delayed, reduced or even eliminated. The technology, therefore, is aimed at providing a secure long-term depository for solid waste.

Dry waste landfills can be used for inert waste such as construction and demolition waste and pre-treated waste.

Where it is used: Worldwide.

PROS

- ✓ More rapid stabilisation of waste
- ✓ Controllable and increased short-term gas yields
- ✓ Better leachate control than conventional landfill

CONS

- ✗ Limited potential site selection
- ✗ Requires high standard of design and control
- ✗ Poor resource conservation
- ✗ Environmental risks from gas emission and leachate
- ✗ Environmental risks from gas emission and leachate
- ✗ Long-lifetime and high land consumption
- ✗ Still considered experimental

BIOREACTOR LANDFILL

In these landfills, the rate of decomposition is accelerated by recirculation of leachate and, in some cases, addition of sewage sludge. The process aims to improve gas production and electricity generation, and reduce the decomposition time to 20–30 years.

Suitable for

- Municipal solid waste.

Produces

- Methane suitable for electricity production.

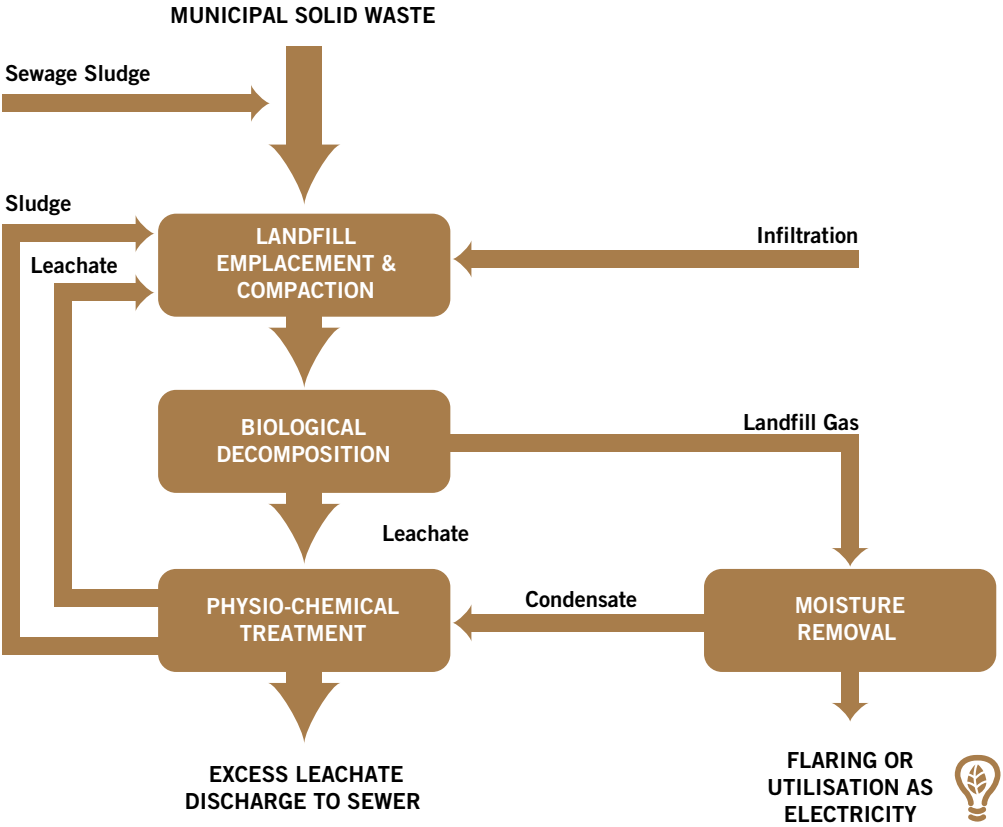
How it works: The process differs from a normal landfill in that the leachate is recycled through the waste to speed up the rate of decomposition. Recirculation rates require careful management as waste changes during initial compaction and subsequent settlement.

Settlement of waste occurs in three stages. First, there is rapid settlement in response to applied load as further waste and capping materials are placed above. As the waste rearranges it continues to settle, and finally there is biodegradation (with mass loss) and the removal of gas and leachate.

Much of the current research and development work is geared to developing cost-effective operating protocols to manage the large quantities of liquids required for recirculation and flushing.

Where it is used: USA and Australia.

HOW IT WORKS – BIOREACTOR LANDFILLS



GLOSSARY

Aerobic
In the presence of oxygen.

Aggregate
A substance formed from different materials.

Anaerobic
In the absence of oxygen.

Biogas
A combustible gas created by anaerobic decomposition of organic material, composed primarily of methane, carbon dioxide, and hydrogen sulfide.

Biosolids
Sewage sludge, a nutrient rich organic product generated during the treatment of domestic sewage in a treatment facility.

Calorific value
The quantity of heat produced by fuel when completely combusted, expressed in joules per kilogram.

Combustion
Burning, when something combines with oxygen to form heat, light and flame.

Compost
As a verb to decay, as a noun, organic matter which has decayed.

Digestion
The process of keeping matter in contact with a liquid to soften or disintegrate it.

Ferrous metal
A metal that contains iron.

Gasification
To convert to a gas.

Incineration
The process of burning something to ashes.

Inert
Not chemically reactive, stable.

Leachate
Liquid moving through a landfill.

Materials Recycling Facility (MRF)
A facility where recyclable items are separated into different streams.

Mechanical Biological
A method of treating waste using both mechanical separation and biological treatment.

Methane
An odourless in flammable gas, formed from decaying organic matter and found in coal mines. It has 21 times the greenhouse effect of carbon dioxide.

Microbial
Bacterial.

Pathogen
An organism that causes disease.

Percolator
A vessel that forces liquid through something, often repetitively.

Putrescible waste
The part of the waste stream that will spoil or decay. Putrescible waste usually breaks down in a landfill to create landfill gases and a liquid by-product called leachate.

Pyrolysis
Decomposition by the action of heat.

Sludge
Can be any matter of muddy consistency that sinks to the bottom of a liquid. In waste it usually refers to the sediment deposited during the treatment of sewage.

Syngas
A synthetic gas produced from
pyrolysis oil.

Thermal
Adjective for heat or temperature.

Windrow
A heaped line or row of organic matter (traditionally hay).

FURTHER INFORMATION

FURTHER INFORMATION

More detailed information on the technologies discussed in this guide is available in the following publications:

- *Report of the Alternative Waste Management Technologies and Practices Inquiry, April 2000* (Published by State Government of New South Wales and known as the Wright Report)

- *Cool Waste Management, A State-of-the-Art Alternative to Incineration for Residual Municipal Waste, 2003* (Published by Greenpeace UK)

WSN Environmental Solutions has staff with extensive technical knowledge who are available to answer any questions you may have about waste processing technologies.

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