Advanced Integrated Solid Waste Management - South Africa

Series Overview

Knowledge Products: 1 - 5

Government of the Republic of South Africa
Department of Environmental Affairs

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Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

NATIONAL GREENING

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We apologise if we have excluded an individual or organisation.

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Acronyms and Abbreviations

AD	Anaerobic Digestion
AISWM	Advanced Integrated Solid Waste Management
ASD	Alternative Service Delivery
ATT	Advanced Thermal Treatment
AWT	Advanced Waste Treatment
BAU	Business As Usual
BFOT	Build Finance Operate Transfer
C&D	Construction and Demolition
CAPEX	Capital Expenditure
CBO	Community-based Organisation
CCT	City of Cape Town
CDM	Clean Development Mechanism
CFC	Chlorofluro carbon
CH4	Methane
CHP	Combined Heat and Power
CIISC	Brazilian Inter-Ministerial Committee for Social Inclusion of Waste Reclaimers (translated from Portuguese)
CMIP	Consolidated Municipal Infrastructure Programme
CO2	Carbon Dioxide
CPI	Consumer Price Index
CSIR	Council for Scientific and Industrial Research, South Africa
CV	Calorific Value
DBFO	Design Build Finance Operate
DBO	Design Build Operate
DBOFT	Design Build Operate Finance Transfer
DBOT	Design Build Operate Transfer
DEA	Department of Environmental Affairs
DEFRA	Department for Environmental, Food & Rural Affairs, United Kingdom
EHS	Environmental and Health and Safety
EIA	Environmental Impact Assessment
EM	Environmental Managers
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
EPWP	Extended Public Works Programme
ESLA	Extended Service Level Agreement
FGT	Flue Gas Treatment

FNLC	National Waste and Citizenship Forum (Brazil)
FX	Foreign Exchange
GCF	Green Climate Fund
GHG	Greenhouse Gas
GIB	Green Investment Bank
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GN	Government Notice
HCFC	Hydrochlorofluourcarbon
HDPE	High Density Polyethylene
HFC	Hydrofluorocarbon
HM	Her Majesty's
HSE	Health, safety, and environment
IBA	Incinerator Bottom Ash
IDP	Integrated Development Plan
IFI	International Financial Institutions
IRS	Informal Recycling Sector
ISWA	International Solid Waste Association
ISWM	Integrated (Sustainable) Solid Waste Management
IVC	In Vessel Composting
IWB	Itinerant Waste Buyer
IWMP	Integrated Waste Management Plan
IWS	Informal Waste Sector
KfW	KfW Development Bank
KP	Knowledge Product
LFG	Landfill Gas
LM	Local Municipality
LPG	Liquefied Petroleum Gas
MAP	Mean Annual Precipitation
MBT	Mechanical Biological Treatment
MFMA	Municipal Finance Management Act
MHT	Mechanical Heat Treatment
MIG	Municipal Infrastructure Grant
MRF	Material Recovery Facility
MSA	Municipal System Act
MSP	Micro Service Provider
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NAMA	Nationally Appropriate Mitigation Actions
NEMA	National Environmental Management Act (Act 107 of 1998)
NEMWA	National Environmental Management Waste Act (Act 59 of 2008)

NGO	Non-Governmental Organization
NO2	Nitrogen Dioxide
NPV	Net Present Value
NWMS	National Waste Management Strategy
O&M	Operational and Maintenance
O3	Ozone
OCC	Old Corrugated Containers
ODA	Official Development Aid
OPEX	Operational Expenditure
OWC	Open Windrow Composting
PDI	Previously Disadvantaged Individual
PET	Polyethylene terephthalate
PFC	Perfluorocarbons
PFI	Private Finance Initiative
PFMA	Public Finance Management Act
PPE	Personal Protective Equipment
PPP	Public Private Partnerships
PPPFA	Preferential Procurement Policy Framework Act
PRC	Private Recycling Cooperatives
PSP	Private Sector Participation/Private Service Provider
RDF	Refuse Derived Fuel
RLM	Rustenburg Local Municipality
RSA	Republic of South Africa
S@S	Separation at source
SAWIS	South African Waste Information System
SCM	Supply Chain Management
SEIA	Strategic Environmental Assessment
SF6	Sulphur hexafluoride
SHEQ	Safety Heath Environment and Quality
SLA	Service Level Agreement
SMME	Small, Medium and Micro Enterprises
SRF	Solid Recovered Fuel
SWM	Solid Waste Management
UCLA	Uswag Calahunan Livelihood Association, Iloilo
UEL	Useful Economic Life
UK	United Kingdom
UMDM	uMgungundlovu District Municipality
UNICEF	United National Children's Fund
WC	Windrow Composting
WtE	Waste to Energy
ZAR	South African Rand

Glossary

Advanced Integrated Solid Waste Management (AISWM): AISWM describes the next natural developmental step for waste management in South Africa. Implementing the concept will present significant challenges, and solutions will need to be found that work in many different socio-economic contexts.

Action Plan: A document arrived at through a strategic and tactical decision-making process committing competent authorities and/or other stakeholders to the implementation of certain measures necessary to achieve a defined SWM goal.

Advanced Waste Treatment (AWT): A specific technology or facility that alters the characteristics of waste through physical, thermal, chemical, and/or biological processes either prior to, or in place of, landfill. AWT broadly includes the recycling and/or recovery elements of the waste hierarchy.

Alternative Waste Treatment: Alternative waste treatment technologies transform waste into a valuable resource. Alternative waste treatment technologies use one, or a combination, of the following processes: mechanical treatment, biological treatment, and thermal treatment.

Biodegradable municipal waste: A type of waste, which can be degraded in a reasonable amount of time into its base compounds through biological processes, microorganisms and other living things, regardless of what those compounds may be.

Business-to-Business Value Chain Interventions: Supporting value-adding activities such as the production of final goods from recycled waste.

By-product: A secondary product derived from a process, which has similar characteristics as the virgin or raw materials.

Cherry Picking: Selective picking of the most valuable recyclable materials.

Circular Economy: An economy where solid waste is valued as inputs into the economy without exiting the economic flow of goods after initial use.

Collection: The collation, loading and subsequent movement of materials considered by the generator as waste, from the point of generation to the point of recycling, treatment or disposal.

Competent Authority: Any person or organization that has the legally delegated or invested authority, capacity, or power to perform (or delegate the performance of) a designated function.

Contaminated Recyclables: Recyclable materials mixed with, or ‘contaminated’ by, other types of waste.

Contract: An agreement between two or more parties regarding the delivery of works, supplies or services related to SWM that is written and enforceable by law.

Corporate Social Investment: Proportion of companies’ profits injected into poor communities.

Corporate Social Responsibility: The continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large

Cost of financing (Cost of capital): Interest on loan and other charges (front-end fee, commitment fee) involved in borrowing of money for investment.

Domestic Waste: Waste generated from households.

Economic analysis: The analysis of the economic performance of an investment, taking into account the welfare effects of the investment, results in economic indicators. This type of analysis is usually used by government agencies when spending public funds in choosing among various investment projects.

Energy from waste: The recovery of energy from waste typically by direct combustion and mass incineration. More broad energy recovery technologies are mentioned in the “waste to energy” definition.

Environmental costs: Costs connected with the actual or potential deterioration of natural assets due to economic activities. In case of AWT, environmental costs may include the costs of pollution prevention (e.g. filters, odour control measures), pollution remediation measures, etc.

Externality: Effects/impacts cost and benefits of production that are external to the buyer and provider of a service or good and are not included in the price of the service/goods.

Extended producer responsibility: Producers or manufacturers of products which subsequently become waste, having a responsibility to put measures in place for the collection and management of such waste materials for the post-consumer stage.

Feasibility Study: A study designed to determine the practicability of a plan, system or technological application.

Financial analysis: Assessment of financial (monetary) viability, stability and profitability of a project or business.

Food Waste: Food losses occurring at the end of the food chain (retail and final consumption) are rather called “food waste”, which relates to retailers’ and consumers’ behaviour. There are different food waste streams and therefore different approaches in terms of management may need to be considered.

Formal Sector: All jobs with normal hours and regular wage, and are recognised as income sources on which income taxes must be paid.

Formal Sector: An economic sector, which encompasses all jobs with regular, structured, working hours and regular wage, and are recognised as income sources, on which income taxes must be paid. The formal waste sector is defined as including: waste handlers (private and municipalities), waste equipment providers, waste consulting/engineering companies, waste research and development organisations, as well as waste and resources sector associations.

Formalisation: Legalising and ensuring compliance with business regulations, tax laws, etc.

Full cost: Total costs including the investment cost and the operating cost. Investment cost allocation within an accounting period is presented by the depreciation expenses and interest on loan (if funded by loan).

General Waste: Refers to waste that does not pose an immediate hazard or threat to health or to the environment, and includes (a) domestic waste; (b) building and demolition waste; (c) business waste; (d) inert waste; or (e) any waste classified as non-hazardous waste in terms of the regulations made under section 69 of the waste amendment Act (2008), and includes non-hazardous substances, materials or objects within the business, domestic, inert or building and demolition wastes.

Greenhouse Gas: Any gas that absorbs infrared radiation in the atmosphere, including gases such as: carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (NO_2), ozone (O_3), chlorofluorocarbons (CFC), hydro chlorofluoro-

carbons (HCFC), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF6). These gases affect the overall heat-retaining properties of the Earth's atmosphere and create a temperature increase of the Earth's atmosphere when they build-up, affecting and changing the global climate.
Greens and Garden Waste: Organic biodegradable waste material generated from a typical garden such as grass clippings, leaves, branches etc.

Guideline: A document or set of materials that provides direction or advice as to a decision or course of action in improving SWM systems.

Hazardous waste: Means any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

Household: A household is a group of persons who live together and provide themselves jointly with food and/or other essentials for living, or a single person who lives alone. Note: The persons basically occupy a common dwelling unit (or part of it) for at least four nights in a week on average during the past four weeks prior to the survey interview, sharing resources as a unit.

Human Rights Interventions: Aimed at addressing the most basic human rights
(right to work in a safe environment).

Informal Recycling Sector: Individuals, families or [informal] small private sector entities whose activities are neither organised, sponsored, financed, contracted, recognised, managed, taxed nor reported upon by the formal solid waste authorities.

Informal Sector: The nature of employment in addition to the characteristics of enterprises and includes all types of informal employment both inside and outside informal enterprises. It extends the focus from enterprises that are not legally regulated to include employment relationships that are not legally regulated or socially protected.

Informal Sector Integration: Methods to organise or formalise the informal recycling sector as part of official waste management strategies.

Informal Service Sector: Entrepreneurs providing small-scale waste collection and cleaning services in rural and poor areas.

Informal Valorisation Sector: Recovery of recyclables and small scale manufacturing by the informal sector.

Informal Waste Sector: An all-encompassing term that captures the totality of informal economic activity in the cleaning, waste management services, and recycling sector.

Integrated Solid Waste Management: Integrated Solid Waste Management (ISWM) is a comprehensive waste prevention, recycling, composting, and disposal program. An effective ISWM system considers how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions.

Investment cost (Capital cost) also called 'Capex': Fixed, one-time expenses incurred for the purchase of land, buildings, construction, and equipment (includes cost of dismantling, removal and restoration). Total cost needed to bring a project to a commercially operable status.

Integrated Waste Management Plans: Plans which outline how competent authorities are going to deal with waste that also identified required resources.

Itinerant Waste Buyers: Recyclers who go door-to-door, collecting, buying or bartering for materials, before they have entered the official waste stream.

Labour Force: Those people who are able and willing to work.

Landfill airspace (Void space): The volume of space on a landfill which is permitted for the disposal of waste.

Linear Resource Economy: Refers to an economy where solid waste exits the economic flow of goods once generated.

Materials Recovery Facility (MRF): A specialised plant for material recovery reclamation where recyclable materials are received, separated into fractions through manual and mechanical methods and prepared for marketing to end-user manufacturers There are two types of MRFs: clean and dirty. A clean MRF utilises mechanical separation techniques to further sort a partially segregated waste stream into fractions, while a dirty MRF may accept mixed solid waste, mixed commercial waste, or construction and demolition (C&D) waste.

Mechanical Biological Treatment: A combination of mechanical and biological processes used to pre-treat the input feedstock, and produce outputs including recyclables, refuse derived fuel, and/or biologically stable compost.

Mechanical Biological Treatment (MBT): MBT combines both mechanical and biological treatment methods, i.e. open windrow composting, materials recycling facilities, anaerobic digestion, and in-vessel composting. 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 end of the process.

Municipal solid waste: Waste generated by households or by legal entities of a similar nature to household waste.

National Waste Management Strategy: A document which outlines the priorities of the country in terms of ensuring that waste is minimised and managed in a sound manner.

Net Present Value: The difference between the present value of cash inflows and the present value of cash outflows, used in capital budgeting to analyse the profitability of a projected investment or project.

Operating Cost: Running costs, fixed and variable, involved in the daily production/service provision, including costs for maintenance and repair, labour, utilities, consumables, etc. Also called 'Opex'.

Organic Waste: Waste of biological origin which can be broken down, in a reasonable amount of time, into its base compounds by micro-organisms and other forms of treatment, regardless of what those compounds may be, they have also been considered as "organic waste" and are referenced in this study.

Policy: A plan or course of action set by government intended to influence and determine decisions, actions, and practices in the SWM sector.

Primary collection: The collation, loading and subsequent movement of materials considered by the generator as waste, from the point of generation to a point of intermediate transfer, either to secondary collection or transfer. (see also Secondary collection)

Professionalisation: The process of imparting professional skills and capacities.

Promising technologies – short term: Including Windrow Composting, Construction and Demolition (C&D) Reuse, Waste Recycling and Materials Recovery Facilities (MRF).

Potential technologies – medium term: Including Mechanical Biological Treatment (MBT), Anaerobic Digestion (AD) and In-Vessel Composting (IVC).

Potential technologies – long term: Including Incineration with Energy Recovery, Mechanical Heat Treatment (MHT), and Advanced Thermal Treatment (ATT) technologies such as Gasification and Pyrolysis.

Recovery: A practice whereby waste is reclaimed for further use in a process which involves the separation of waste from a waste stream and the processing of that separated material as a product or raw material.

Recyclate: Material separated or recovered from waste for recycling.

Recycling: The process of collecting, separating, classifying, transforming (through physical, mechanical or chemical processes), and returning to productive use, materials originally discarded by the generator as waste.

Refuse Derived Fuel: Waste fraction with good combustion properties that can be used as fuel.

Regulation: A governmental order having the force of law.

Re-use: To utilise components of the waste stream again for a similar or different purpose without changing the form or properties of that component.

Revenues: Income from sales of services or goods, sourced from gate fees, sale of recovered materials, energy, tariffs or other income.

Ring-Fencing: Financial separation of a portion of a municipality's assets or budget in order to safeguard use for the intended purpose.

Sanitary landfill: Sites where waste is isolated from the environment and its subsequent in situ degradation is managed under a controlled physical, biological and chemical process until it is rendered safe.

Secondary Collection: The collection of waste from a place of temporary storage that is distant from the point of generation (e.g. community container or other location) and transported to transfer station, treatment or landfill.

Secondary cities: The secondary cities are geographically defined urban jurisdictions or centers performing vital governance, logistical, and production functions at a sub-national or sub-metropolitan region level within a system of cities in a country. Secondary cities have between "500,000 to 3 million inhabitants on average.

Separation at Source: Sorting of different materials at the source of generation (households, businesses etc.), before collection.

Specific cost (Unit cost): A cost per unit, e.g. cost per tonne of waste handled (ZAR/tonne). Throughout this document, the following exchange rate is used: 1 EUR = 13 ZAR (corresponding to European Central Bank exchange rate April 20th, 2015).

Specification: A detailed, exact statement of particulars, especially a statement prescribing materials, dimensions, and quality of work for something to be built, installed, or manufactured.

Standard: An acknowledged measure of comparison of quantitative or qualitative value; a criterion against which to enforce and/or benchmark the performance of SWM systems.

Traders: Formal or informal entrepreneurs and companies buying recyclables from individual waste reclaimers or companies and reselling them into the recycling value chain.

Transfer Station: A building or processing site for the temporary deposition of waste where local waste collection vehicles deposit their waste cargo prior to loading into larger vehicles. These larger vehicles will transport the waste to the end point of recycling, treatment or disposal.

Treatment: The National Environmental Waste Management Act No. 59 (2008) defines treatment as any method, technique or process that is designed to:

a) Change the physical, biological or chemical character or composition of a waste; or

b) Remove, separate, concentrate or recover a hazardous or toxic component of a waste; or

c) Destroy or reduce the toxicity of a waste, in order to minimise the impact of the waste on the environment prior to further use or disposal.

Waste Management Hierarchy: The waste management hierarchy provides a systematic and hierarchical approach to integrated waste management, addressing in turn waste avoidance, reduction, re-use, recycling, recovery, treatment, and disposal as a last resort.

Waste to Energy (WtE): The conversion of waste materials into useable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolysis, anaerobic digestion, and landfill gas (LFG) recovery.

1 Introduction

1.1 The Programme

The South African Government in partnership with the German Development Cooperation has embarked upon the implementation of an **ADVANCED INTEGRATED SOLID WASTE MANAGEMENT (AISWM) Programme** for the Republic of South Africa.

The Programme prepares pilot projects in municipalities and disseminates knowledge, experience and practical application of Advanced Waste Treatment (AWT) and broader AISWM systems in the context of South African municipalities.

AISWM is the term used to describe Integrated Solid Waste Management (ISWM) making use of systems and technologies, within a framework of policies, legislation and practices, that reduce dependency on landfill for disposal of waste. The Programme defines AISWM as the coherent and sustainable application of approaches and solutions that have the effect of reducing the amount of waste that needs to be landfilled.

AISWM is the process of advancing waste management practices up the hierarchy away from landfill and towards creating energy, recycling, composting, reuse and reduction. In contrast, AISWM does not necessarily require the use of sophisticated and expensive technology; rather it involves a blend of management systems and appropriate technologies that succeed in sustainably diverting waste away from landfill.

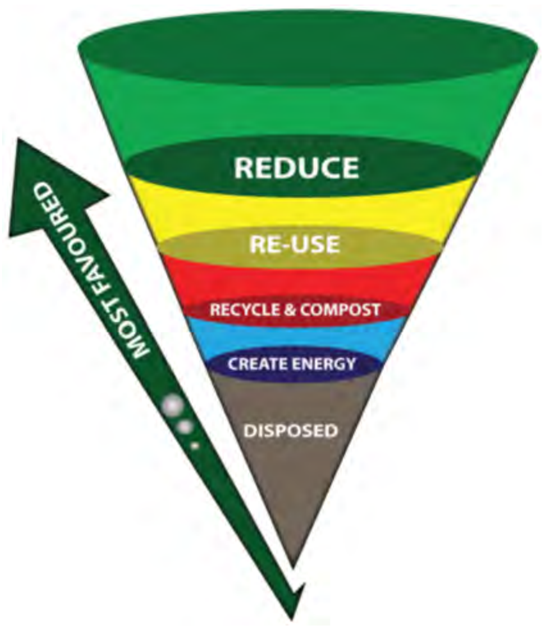

Figure 1.1: The waste hierarchy

AWT is a specific technology or facility that alters the characteristics of waste through physical, thermal, chemical, and/or biological processes either prior to, or in place of, landfill. Moreover, AWT broadly includes the recycling and/or recovery elements of the waste hierarchy.

The National Department of Environmental Affairs (DEA) coordinates the Programme at national level, with Rustenburg Local Municipality (RLM) and uMgungundlovu District Municipality (UMDM) partnering at a local level. Each of the partner municipalities has received tailored consultancy support for the preparation of AISWM projects that may be integrated into, and be sustainable within, their local situation. The intended results of the Programme are to support implementation of AISWM systems in municipalities across the country and undertake knowledge dissemination and training on best practices, and lessons learned.

A series of five publications - called Knowledge Products (KPs) - has been prepared to support capacity building on the subject of AISWM across South Africa. The KPs provide clear, concise and factual information to support decision-making on AISWM and AWT to enable municipalities and their partners to plan and implement future waste facilities.

1.2 The Advanced Waste Treatment Knowledge Product Series

This KP1 is the primary KP document in a series of five publications – known as Knowledge Products (KPs) - comprising of different aspects of Advanced Waste Treatment (AWT) in South Africa. KP1 serves as an introduction and overview to the rest of the KPs, whereas each of the remaining KPs focuses on specific factors associated with AWT technologies, and their potential applicability within the South African context *(see Figure 1.2 and Table 1.1).*

The KPs present technical, social and financial aspects of AWT, and the operator models and business opportunities associated with AWT. The aim is to provide a comprehensive understanding of the range of AWT technologies, as well as the implications associated with the uptake of such technologies in South Africa.

Figure 1.2: Overview of the Knowledge Products in this Series

Table 1 1. Summary of Knowledge Products

Knowledge Product	Scope of the publication
AWT Series Overview (KP1)	KP1 provides highlights of the KP series with onward links on the electronic versions to help the reader navigate through the series by following the hyperlinks for each KP.
Appropriate Technology for AWT (KP2)	KP2 concentrates on the technical aspects of AWT. It identifies and classifies the technology options, identifies technology potential and technical constraints, outputs and markets.
Recognising the IWS in AWT (KP3)	KP3 discusses the role of the informal sector in waste management (IWS). Drawing upon local and international experience it presents benefits and challenges of inclusion and gives practical guidance on methods that can be used and steps to be taken for inclusion.
Financial Implications of AWT (KP4)	KP4 introduces key budgeting and accounting principles for waste management investment planning and operation. It highlights the economic benefits of AWT and gives benchmark costs and revenues, together with influencing factors for each of the AWT technologies introduced in KP2.
Operator Models and Business Opportunities for AWT (KP5)	KP5 provides guidance on the management and contracting arrangements for AWT facilities and services. It classifies the operator models relevant for different AWT technologies, and forecasts the potential business opportunities for AWT in South Africa.

A suite of e-learning modules has been prepared to accompany the KPs in the series.

E-learning Modules for the AWT series

Module 1: Concepts for AISWM
Module 2: Appropriate technologies for advanced waste treatment
Module 3: Recognising the role of the IWS in AWT
Module 4: Financial implications of advanced waste treatment
Module 5: Operator models and business opportunities in advanced waste treatment

1.3 Scope of KP 1 - Series Overview

The objective of KP1 is to provide an overview of the KP series, with hyperlinks (on the electronic version) to enable the reader to navigate through and source information, analyses and case studies from the entire series. The aim is to provide an impartial perspective on relevant information and analysis, supported by case studies, to ensure that readers understand the strengths and weaknesses of different AWT options and to use such information as a basis to take informed decisions.

Knowledge Product 1 is structured in relation to the technology options that have been profiled in the series. Available technologies have been categorised into three groups:

- Promising technologies in the short term;
- Potential technologies for the medium term; and
- Potential technologies for the long term.

Promising technologies – short term: including Windrow Composting, Construction and Demolition (C&D) Reuse, Waste Recycling and Materials Recovery Facilities (MRF).
(Fig 3.1-3.3)

Potential technologies – medium term: including Mechanical Biological Treatment (MBT), Anaerobic Digestion (AD) and In-Vessel Composting (IVC).
(Fig 3.4-3.6)

Potential technologies – long term: including Incineration with Energy Recovery, Mechanical Heat Treatment (MHT), and Advanced Thermal Treatment (ATT) technologies such as Gasification and Pyrolysis.
(Fig 3.7 -3.8)

1.4 Scope of KP2 – Appropriate technologies for advanced waste treatment

KP2 aims to provide clear, concise and factual information to support decision-making on AWT, so that municipalities and their partners can plan and implement their next generation of AWT facilities. The term ‘AWT’ specifically refers 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. The term does not mean ‘expensive or sophisticated’ technology that is not sustainable for implementation in South African municipalities.

KP2 cautions the need for care in technology selection to ensure 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 waste, or sub fractions thereof, on varying circumstances around the world.

1.5 Scope of KP3 - Recognising the IWS in AWT

KP3 takes into consideration: recognition, organisation, or formalisation of the informal waste recycling sector in AWT, currently functioning without proper structure, and suggestions for undertaking this successfully. Since the options for moving up the waste hierarchy away from landfill differ depending on the local context of the municipality, this KP covers a range of general decision support mechanisms to be considered by municipal waste service managers and operators for including the informal recycling sector in the design and implementation of AISWM systems. It covers a wide range of social factors from understanding the working conditions of informal waste reclaimers, to recognising their benefits, and possible suggestions for municipalities to include in their processes of dealing with solid waste management and reducing dependency on landfill.

It should be noted that exploring the possible contribution of the informal recycling sector in modern waste management systems is a challenging undertaking. Whilst there is increasing recognition globally of the importance of the informal recycling sector, and the need to design new solid waste management systems instead of replacement of such systems, it is an emotive subject on which there has been very little substantive research and which is lacking quantitative data.

1.6 Scope of KP 4 - Financial Implications of AWT

There are a number of options available to municipalities when deciding on whether or not to move from business as usual (BAU) scenario (i.e. landfill) to implementation of AWT technologies. Relevant cost implications are key decision-making factor. Introducing AWT will usually entail an increase in cost to the municipality. The scale of that increase will depend on the specifics of the AWT project. The relative cost component for investment in the full specific costs increases, with the complexity of the technology options. KP4 considers the financial implications of AWT by attempting to answer the following questions:

- What is the economic rationale for a municipality to invest in AWT?
- What should municipalities take into consideration whilst preparing a business case for AWT?
- What are good practices for financial analysis and prioritizing investments?
- What are the typical cost structures for different AWT technologies? And what are the cost implications for collection and transportation of various AWT technologies?
- What degree of cost-increase (from the business as usual scenario) should municipalities expect when implementing different AWT facilities?

The business case for an AWT project may become compelling when the social and economic benefits are factored in. Labour intensity, and cost of technology uptake are important decision-making factors when selecting waste treatment options, implying that those technologies which create sustainable employment opportunities are the most attractive options for implementation in South Africa. Multi-dimensional AISWM systems have the potential to generate significantly greater business and employment opportunities compared to one-dimensional systems that depend solely on landfill.

1.7 Scope of KP5 - Operator Models and Business Opportunities for AWT

The objective of KP5 is to provide guidance on, and assist decision-makers at the municipal level, with management and contracting arrangements for appropriate AWT facilities within a South African AISWM context. Operator models applied internationally are presented in this KP, depending on the AWT facilities. A comparison between public and private models is made and the eligible suggested models for South

Africa are presented, commencing with an introductory overview of this study, which briefly introduces the waste management hierarchy, the position of AWT technologies within the hierarchy, and identifies the most appropriate examples of AWT technologies, for which operator models will need to be developed to facilitate their short to medium-term implementation in South Africa.

KP5 further defines an “operator model”, and its position within the wider institutional framework for supporting ISWM systems. It presents the basis for identifying, and subsequently developing, the most promising arrangements operator models for South Africa by presenting the main lessons learnt from other developing countries in the development of such operator models to facilitate AISWM systems. The principle generic management arrangements under which service delivery is organised, managed, and financed, is presented. The KP further links context and conditions for selecting an operator model, and proposed several objectives, which may shape decision making on operator models.

KP5 transposes the theory at global context into a South African context, through the development of bespoke operator models for each of the main “quick win”/ “special case”, short/medium-term technology types hitherto identified. As a prelude, this KP presents the main elements of the country’s prevailing policy/planning and legislative frameworks and continues to present a screening of the potential “generic” models to identify those which will work best in South Africa – the screening being undertaken against a set of sustainability criteria based on a desk-based review of policy/legislative drivers and augmented by stakeholder interviews with a number of representatives from the waste management industry in Cape Town, Johannesburg, and Pretoria, respectively.

2 Planning Considerations

Alternative Waste Treatment options are only, but, one part of an AISWM system. Technologies must function within the national framework, and work well within the local context. The following planning considerations need to be taken into account before a detailed discussion on various technology options can be entered into:

- Making decisions on AWT is a complex task due to the diversity thereof,
- Variety in composition of waste,
- Large number of different technologies available,
- Levels of cost and revenues associated and
- Variety of operator/contractual models in the market.

The system, in managing waste at a local level is unique and context adaptation is essential to achieve functionality. The context varies between provinces, municipalities, cities and communities. In planning the next generation of waste management facilities, some of the questions waste management authorities need to find solutions to include the following:

- What are the different AWT options, and how to distinguish between them?
- How technologically sophisticated are the AWT options?
- What skills and resources are needed to construct, operate and maintain these facilities?
- What are the outputs from the different AWT processes, and the potential markets for these outputs?
- How will the choice of AWT technology influence the upstream collection system, and the downstream demand for landfill?
- Will implementation of an AWT facility displace existing IWS activities?
- How can the informal sector be considered and build upon the existing activities within the sector?
- What are the costs and revenues associated with the different AWT options, are these costs realistic and affordable?
- What operator models and contractual options are most favourable for the different AWT facilities?
- What is the likely market demand for investing in AWT technologies?
- What business and employment opportunities would be created by their implementation?

It is important to understand how the business case for AWT (multi-dimensional) compares against a one-dimensional 'collect and dispose' waste management system. The case for AWT depends on many factors. However, the most important factor is the availability and baseline cost of landfilling. Current costs of disposing waste vary from close to zero up to about ZAR 400/tonne for municipal solid waste (MSW). The first essential step in evaluating the potential applicability of AWT is for legally compliant landfill to be in place, and for the associated costs of landfill to be known and reflected in the municipal budget.

Given the current trends and related climate change mitigation implications, the cost of landfill can be expected to increase in the medium to long term. In planning AWT reasonable assumptions need to be made about the future availability and cost of landfill. Coupled with this, increased costs to transporting waste over longer distances to more remote 'regional' landfill sites can be anticipated.

The National Waste Management Strategy (NWMS) contains targets intended to drive waste management practices up the hierarchy and away from landfill. New market-based mechanisms in the future will have an effect of stimulating recycling systems, increasing the effective cost/price of landfill, and driving diversion of waste from landfill in order to meet targets set in the NWMS.

The introduction of Extended Producer Responsibility (EPR) for different waste streams, including packaging, is expected in the future. Other economic instruments being explored include the deposit refund system, waste disposal taxes, product taxes, tax interventions for hazardous waste disposal, and tax rebates and benefits.

Out of the potential instruments, the EPR and a landfill tax/levy seem to be the most effective mechanisms for stimulating introduction of AISWM/AWT systems. These mechanisms may have a profound effect on the market demand, business opportunities and employment contribution of the waste sector in South Africa.

An AWT project needs to be justified in terms of its technical and financial feasibility. Wider social and economic effects are also important. These include social, economic and environmental effects such as the reduction in greenhouse gas emissions, reduction in pollution to air, soil and water, and the social, economic and employment benefits.

Conditions in South Africa enable certain technologies and raise barriers to others. As such, waste quantity and quality, infrastructure, income level, availability of technical capacity, monitoring and management skills, the social and cultural context, the policy environment are just a few of all the factors that will influence the suitability of the technologies.

Specific conditions in South Africa that municipalities may need to consider when designing and implementing advanced waste treatment include:

- Varying population density and road conditions.
- Discrepancies in housing types and intensity of commercial activity.
- Varying quantity and composition of major waste streams.
- Rights for equity of service provision regardless of income.
- Involvement of the IWS.
- Availability of land close to population centres for waste management facilities.
- Availability of permitted landfill capacity
- Incidence of illegal dumping and costs of clean-up.
- Financial standing of the municipality.
- Ability to attract investment through grants or commercial loans.
- Planning requirements (e.g. public consultation, environmental assessment, permitting).
- Drive for economic development and employment creation.

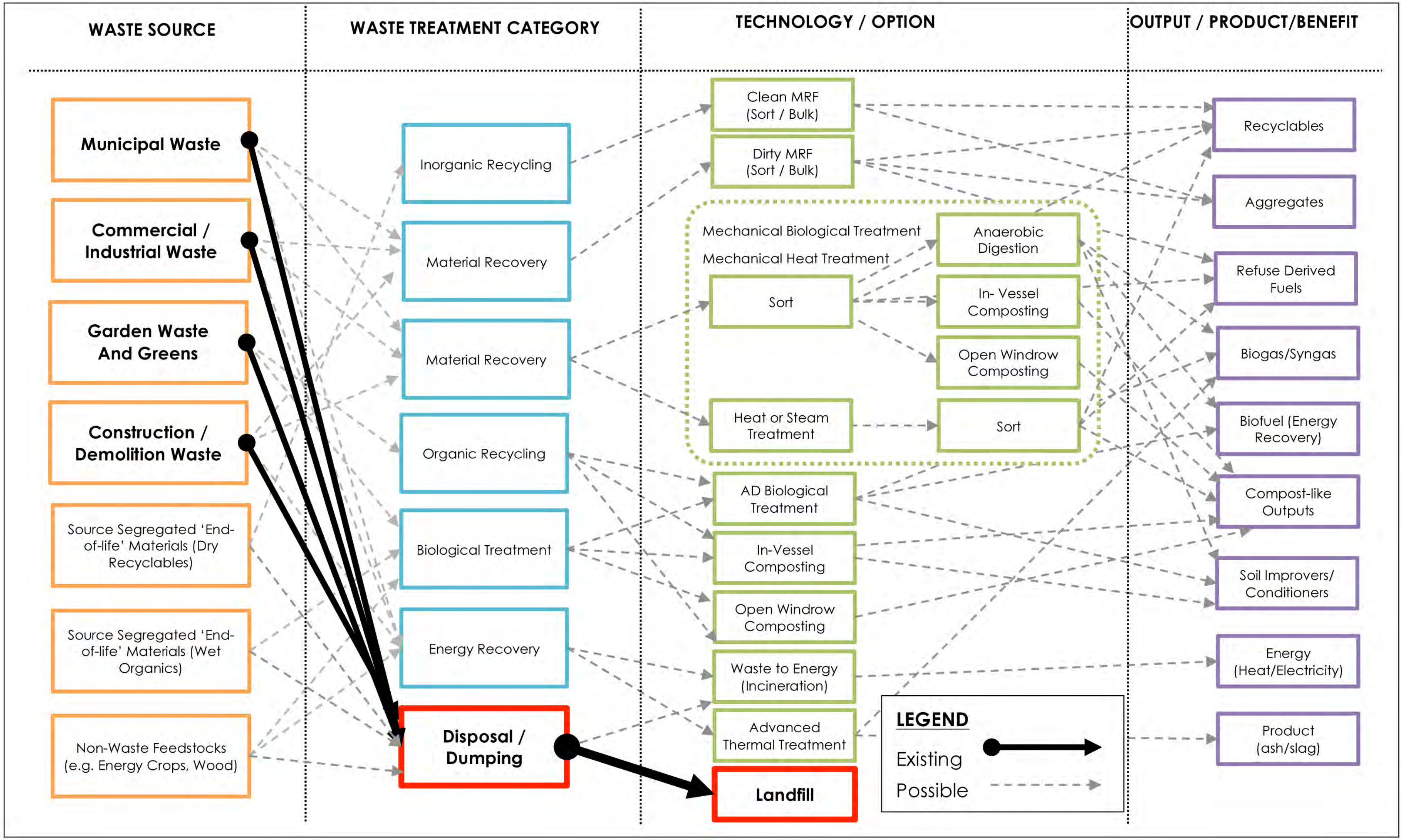

Figure 2 .1: Business-As-Usual approach to SWM in South Africa, reflecting possible AWT business opportunities.

Notes for flow diagram:

1. All treatment options will typically also have non-recyclable materials which is subsequently destined for **disposal,** usually items that are inappropriate for treatment because of their size or other characteristics. This is not illustrated on the diagram to avoid over complicating the illustration. However, it is an important aspect to consider, and overall mass balances should be considered in the context of the technology, its performance limitations & track record and the waste stream in question.

2. Whilst there are a range of outputs indicated on the diagram (**purple** boxes), these are reliant on the respective market for that output. Where markets are not available the output may have to be disposed of. For example, if the quality of compost produced is insufficient for the available market it might be disposed of in landfill. Or, if the quality of a gas generated is insufficient to meet energy recovery system requirements it may be flared off. In such circumstances the environmental merit of the system and its business case may be jeopardised.

3. The diagram is focussed on the **waste sources** from municipal, commercial and industrial and construction and demolition sectors. There will be individual components within each of these categories that may require specialist treatment, such as asbestos in construction waste for example, which are not covered within this publication.

4. The diagram is a generic illustration of the main technology types and is not intended to be exhaustive in terms of all technology combinations and configurations. For example, there are technologies which may be used for specific waste streams (e.g. tyre crumbing or waste electrical goods treatment systems).

5. Some outputs in the diagram may be used as feedstock of other treatment options within the diagram, for example refuse-derived fuel, which could be used as a feedstock for some incineration processes or an advanced thermal treatment (e.g. gasification or pyrolysis) process.

Some technologies will also generate residues from the clean-up of emissions from the treatment process which may require specialist disposal. These are not shown on the diagram, but are referred to in the text of this document as each technology is described. An example is the flue gas treatment (FGT) residue produced during the clean-up of incineration emissions, which typically comprises of approximately between 3-5% of the throughput of the facility and would require specialist **disposal**.

3 Appropriate Technologies for AWT

This chapter provides a summary on AWT technologies that are assessed as being strongly applicable in the short term, potential medium and long term, respectively.

In broad terms, the technology options for the treatment of municipal solid waste include the following three types of processes:

- **Mechanical**
- **Biological**
- **Thermal.**

Most treatment technologies involve a combination of more than one of such processes. For example, composting of green garden waste will involve mechanical shredding as well as biological composting; the pyrolysis of mixed waste will involve mechanical pre-treatment as well as thermal degradation.

While there are many configurations of AWT plants, in general the suite of technologies included in this document are outlined in Table 2:

Table 2.1: Typical AWT plant configurations

Technology	Purpose of technology	Outline description
Biological treatment	To reduce the biodegradability of the waste and its volume. Typically produces a soil improver / conditioner material which may generate income / agricultural benefit. Some technologies (anaerobic digestion) are also designed to recover energy from the waste.	Processes involving biological breakdown of the waste under controlled conditions. Includes anaerobic digestion (AD), in-vessel composting (IVC) and open windrow composting (OWC).
Materials Recovery Facilities (MRF) - clean	To extract recyclable material from source-separated waste in order to recover value as marketable products.	Combination of various mechanical processes to separate materials, e.g. sieving, sorting, magnets. Usually also includes some manual sorting.
Materials Recovery Facilities (MRF) – dirty / residual waste	To extract recyclable material from mixed waste streams in order to recover value as low grade recyclates. To produce a fraction with good combustion properties which may be appropriate for use as a fuel (refuse derived fuel (RDF)).	Combination of various mechanical processes to separate materials, e.g. shredding, sorting, magnets.
Incineration	To reduce both volume and biodegradability of the waste, usually also deriving energy in the form of electricity and/ or heat. Bottom ash from the process may be recycled in some circumstances but the fly ash and air pollution control residues require specialist disposal.	Waste treatment method using mechanical grates to move waste through a combustion chamber. The temperatures are maintained at high levels through the addition of air and the waste is burnt to an ash. The temperature from the combustion process is used in a steam circuit to recover energy.
Mechanical Biological Treatment (MBT)	Whilst there are a wide variety of different purposes of MBT, all configurations extract some recyclables. In addition, there will always be at least one of the following other functions of the plant: to recover a fuel fraction from the waste (refuse derived fuel); to derive biogas (for AD systems) for energy recovery; to generate a compost like output; to stabilise (or partially stabilise) the waste, and reduce its volume.	Processes combine mechanical and biological elements in a range of different configurations.
Advanced Thermal Treatment (ATT)	To derive energy from the waste and to reduce both volume and its biodegradability, higher temperature processes may derive a usable aggregate or slag.	Processes involving heat to degrade the waste, recovering some value from its energy content. Includes gasification, pyrolysis and plasma gasification.
Mechanical Heat Treatment (MHT)	MHT plants often have the prime aim of extracting either relatively high quality recyclables or fuel fractions (refuse derived fuel) from the waste. In addition, and dependent on the technology employed, they may: reduce the volume of the waste; derive an organic fibre for use as a raw material / substitute fuel.	Processes combine mechanical and thermal elements in a range of different configurations.

Most technologies are suitable for the treatment of other waste streams in addition to municipal solid waste.
From comparing various technologies for uptake, the 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 over-band magnets for ferrous metals extraction or screens for sorting by size, seems to be a preferred option. 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' (OWC) 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. Therefore, in consideration of suchoptions it is necessary to assess all the costs and benefits involved in establishing separate collections, including educating society to utilise the collections appropriately, in addition to the costs and benefits associated with the treatment solution in question. Such significant issues are further discussed in the AWT series.

Not all technologies are suitable for all municipal type waste streams and it is important when any n**ew or alternative technology is proposed, that appropriate market research and references are obtained.** There are many examples around the world whereny a 'new technology' has been invested into. The plant is subsequently not robust enough to process the feedstock coming into it, which invariably resulting in a failed project. Conversely, there are other cases whereby investments in collection systems and treatment technologies were made and where approximately 75% of the material could have been diverted from landfill, to recover valuable materials and energy.

Technology is certainly a part of the 'solution', but it is not all of it! Therefore, KP2 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.

A snapshot of AWT technologies are summarized in figures 3.1- 3.9:

3.1 Windrow Composting
3.2 Construction and Demolition Waste Recycling
3.3 Material Recovery Facilities
3.4 Mechanical Biological Treatment
3.5 Anaerobic Digestion
3.6 In-Vessel Composting
3.7 Incineration with Energy Recovery
3.8 Mechanical Heat Treatment

3.1 Windrow Composting: Technology Profile

Table 3-2: Key characteristics of windrow composting

Characteristic	Description
Waste stream	Putrescible/organic waste, garden/food waste
Typical capacity	5k – 500k tonnes per annum
Typical output	Compost
Indicative capital cost	A range of 6 to 10 m ZAR for small scale, simple windrow systems
Equipment	Tractors, compost turners, excavators, shredders, sieves, loaders and dumper trucks
Technology restrictions	Long process time (c. 12 weeks) Requires low level of contamination, or some mechanical treatment to remove contaminants Compost turned by mechanical means Should not be practiced in close proximity to sensitive receptors in case of odours/ bioaerosol issues
Range of full specific cost	300 – 400 ZAR/t
Investment cost (percentage of full cost)	40%
O&M cost (percentage of full cost)	60%
Human resource requirement	Mostly unskilled workers, drivers and mechanics
Factors influencing revenue	Revenue/ price of compost product in market Distance to outlet for compost Quality requirements/bagging of compost Quantity of contaminants and subsequent screening costs Disposal costs for contaminants

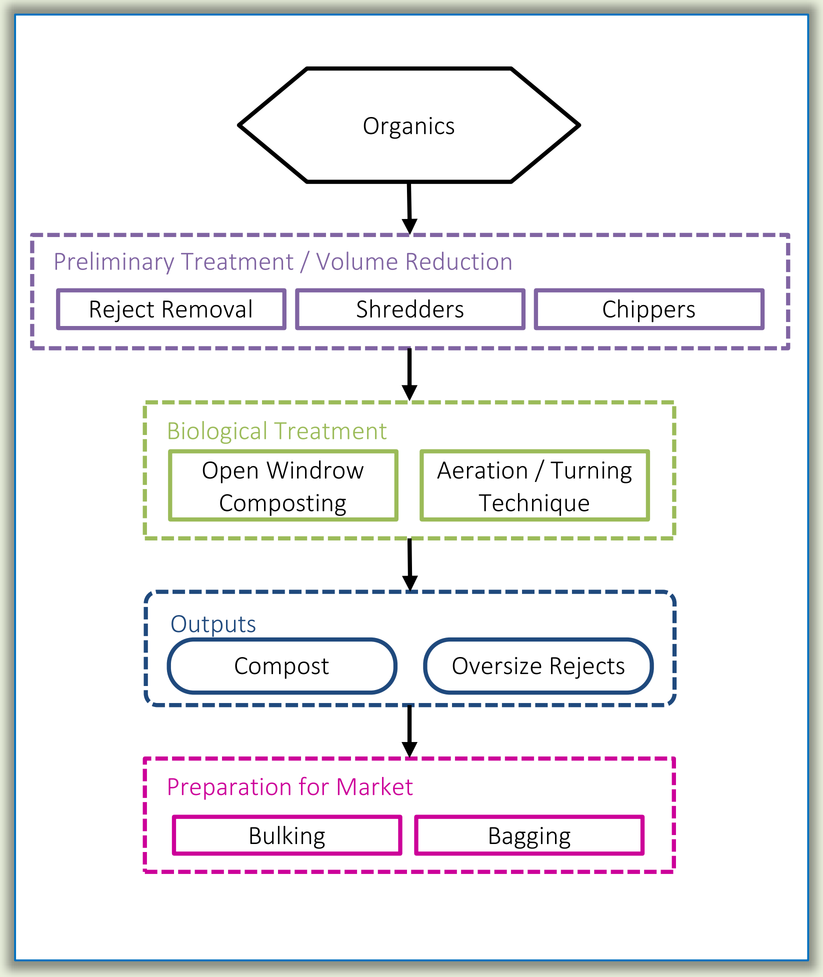

Figure 3-1: Typical composting process flow diagram

Figure 3-3: Compost windrows (image courtesy of Blue Group)

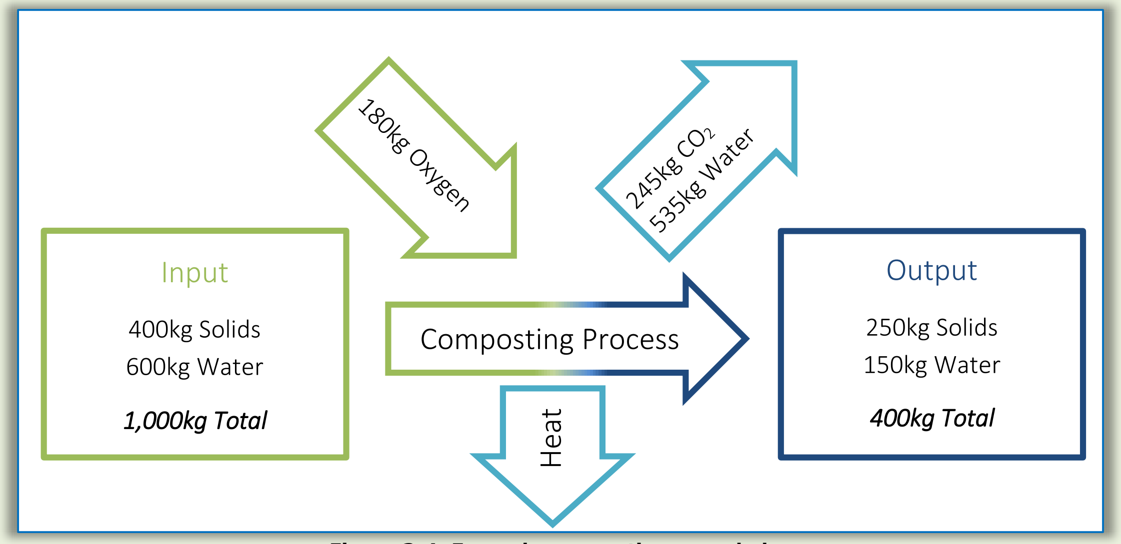

Figure 3-4: Example composting mass balance

Table 3-5: Public and PSP Operator Model Options for Supporting OWC (Soos, Whiteman, Wilson, Briciu, & Schwehn, 2012).

Type	Description
Public Model composting *Composting established and managed by the public authority*	The public authority develops and operates the composting plant.
PSP service: composting *Composting facilities leased for operation to PSP*	Composting facilities are established by public authorities but operated under service contract by PSP
PSP concession: composting *Composting facilities established and managed by PSP*	The private sector finances and operates composting plant independently, and secures contracts from the public authority for the input material. These types of arrangements are more frequent for commercial scale composting
Micro PSP: composting *Small-scale community composting by micro-service providers*	Micro-service providers establish and operate small scale decentralised composting facilities. All costs and revenues accrue to the PSP, but may be supplemented by payment of avoided costs of collection and disposal.

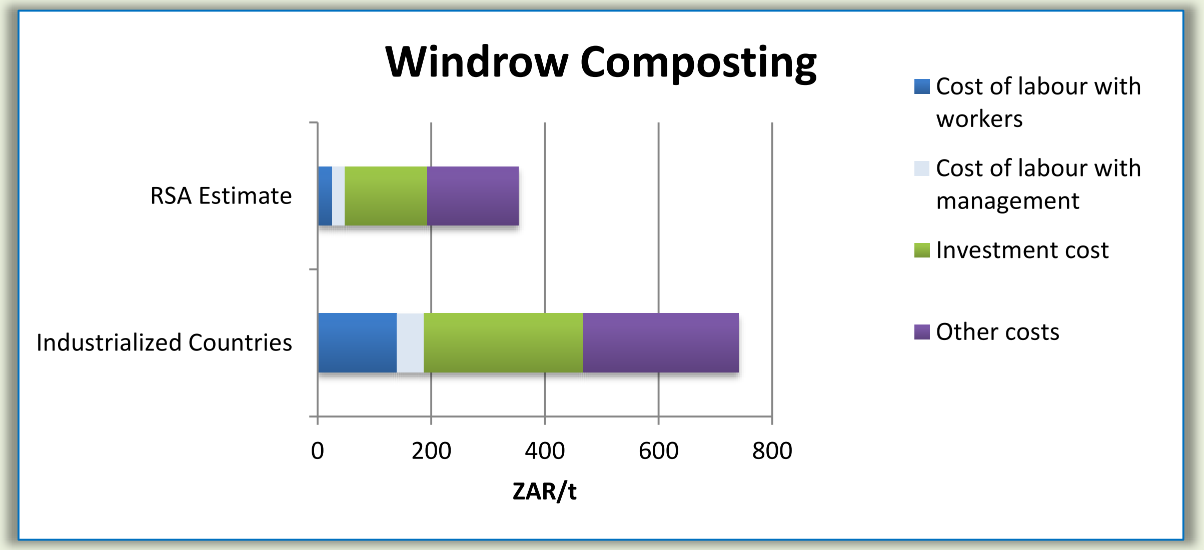

Figure 3-2: Full cost breakdown for windrow composting (Cost information for industrialized countries derived from, and cost ranges for South Africa adapted from, Pfaff-Simoneit, 2013)

1.2 Construction and Demolition Waste Recycling: Technology Profile

Table 3-3: Key characteristics of C&D waste recycling

Characteristic	Description
Waste stream	Builders' rubble (soil, concrete, asphalt, ceramics, bricks, wood and recyclables)
Typical capacity	50k– 500k tonnes per annum
Typical outputs	Various crushed aggregates, sorted by material and grain size
Indicative capital cost	c. 25-35 million ZAR for a 100 ktpa C&D recycling facility
Equipment	Waste crushing and sorting equipment such : excavators for separating large pieces of material, hydraulic hammers for crushing large pieces of materials, ball mill crushers with magnetic separators, a variety sieves for sorting different particle sizes, feed-in equipment and containers for sorted materials
Technology restrictions	Inputs are often contaminated, restricting the possible use of outputs. Maintenance and repair is one of the most important operational costs as equipment is subject to significant wear and tear. Need for separate storage areas for various aggregates. Economies of scale and enabling policies (landfill tax on C&D waste, tax on virgin aggregates etc.) are needed to achieve a profitable business.
Range of full specific cost	< 300 ZAR/t
Investment cost (estimated % of full cost)	50%
O&M cost (estimated percentage of full cost)	50%
Human resource requirement	Low and mostly unskilled workers, manual sorters.
Factors influencing revenue	• Amount of contamination in recyclate • Additional processing cost associated with contaminates • Disposal costs for rejected material • Composition of recyclate • Market value of recyclate • Distance to market for recyclables • Ratio of technology to manual separation

Figure 3-5: Horizon Farm Dormitory Unit (Rambrick 2016)

Figure 3-5: Rambrick production, Giba Gorge (A Use-It Initiative, 2016)

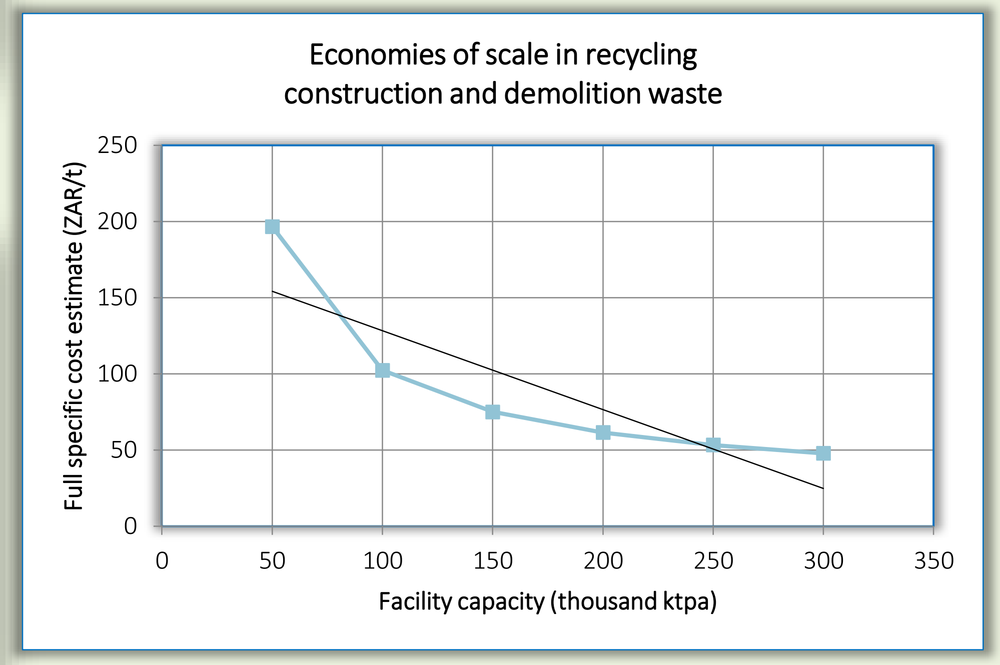

Figure 3-3: Economies of scale in recycling facilities for C&D waste

1.3 Materials Recovery Facilities: Technology Profile

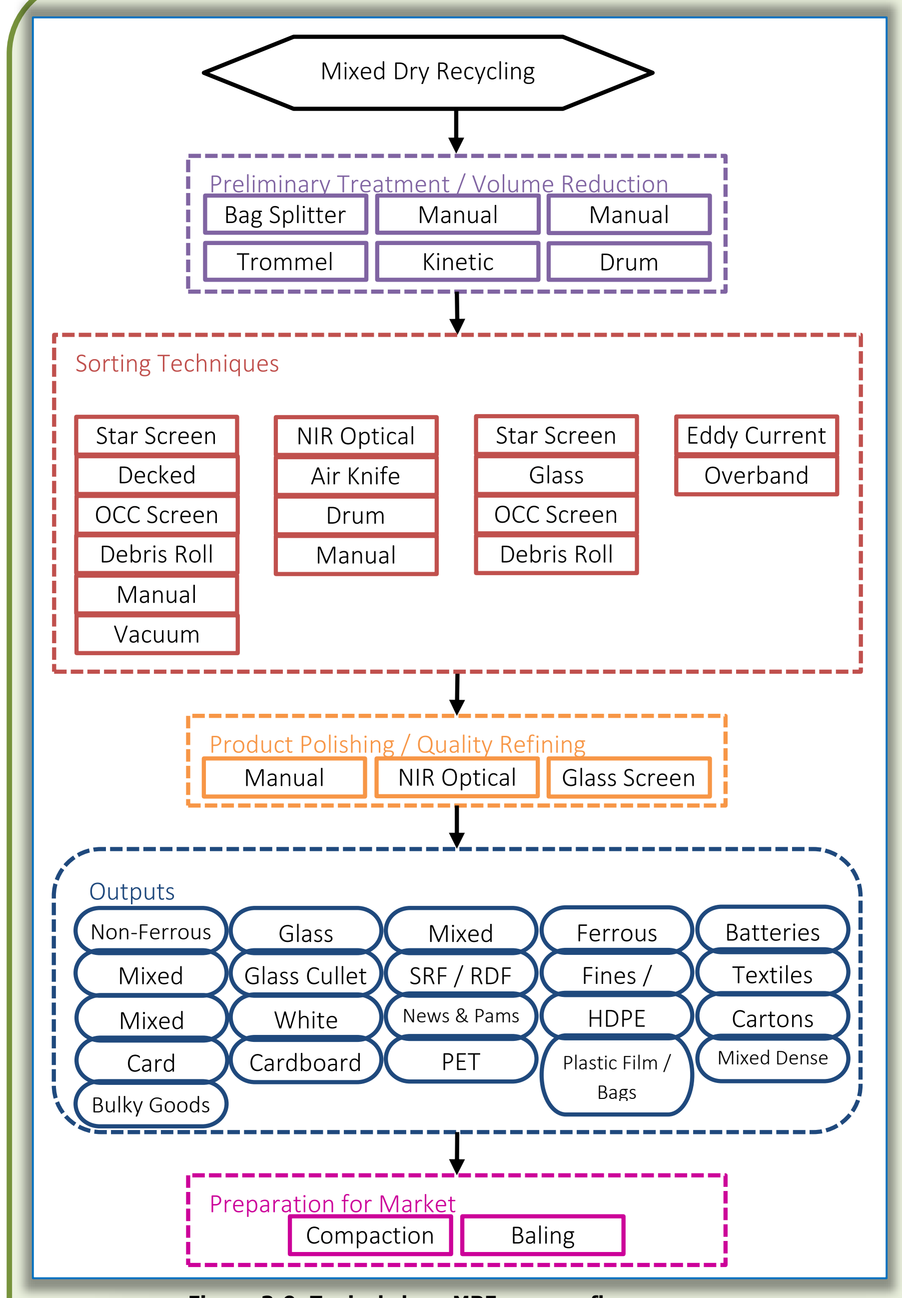

Figure 3-9: Typical clean MRF process flow

Figure 3-7: Kraaifontein Integrated Waste Management Facility, Cape Town ("Clean MRF")

Table 3-4: Factors influencing revenues - MRFs

Technology Heading	Outline Description	Factors Influencing Revenue
Clean MRF	Mixed dry recyclables are separated into fractions by a mechanical and manual segregation techniques and conveyors. Fractions can be targeted depending on value, with different levels of purity achievable as the end-market dictates.	• Amount of contamination in recyclate • Additional processing costs associated with contaminate • Disposal costs for reject material • Composition of recyclate • Market value of recyclate • Distance to market for recyclables • Ratio of technology to manual separation
Dirty MRF	A facility employing a number of separation techniques to recover recyclable materials from mixed waste, usually of a relatively low grade. The remaining residual can be processed into a fuel (refuse derived fuel (RDF)) for use in cement plants or energy recovery facilities. Small quantities of recyclables may be extracted and sold.	• Quality of compost • Cleanliness of recyclables • Disposal costs for reject • Market value of recyclate • Market cost for fuel • Market/facility availability for RDF • Distance to market/outlet for recyclables, fuel and rejects

Table 3-5: Key characteristics of MRFs

Item	Description	
Purpose	Clean MRF (cMRF) - to separate different recyclate streams by material and then by grade (where appropriate) ready for sale to reprocessors and the material commodities market	Dirty MRF (dMRF) - to recover recyclables from a mixed solid waste stream and produce an RDF from remaining residuals
Waste streams accepted	cMRF - Mixed dry recyclable materials from domestic and commercial	dMRF - Residual waste, C&I waste, C&D waste
Typical capacity	1k– 500k tonnes per annum for cMRF	10k – 500k tonnes per annum for dMRF
Typical outputs	Recyclate, aggregate, RDF	
Indicative capital cost	c. ZAR 45m – 80m for a 25ktpa cMRF	c. ZAR 60m – 110m for a 50ktpa dMRF
Human resource requirement	Low and mostly unskilled workers, manual sorters.	

Figure 3-6: Athlone Material Recovery Facility, Cape Town ("Dirty MRF")

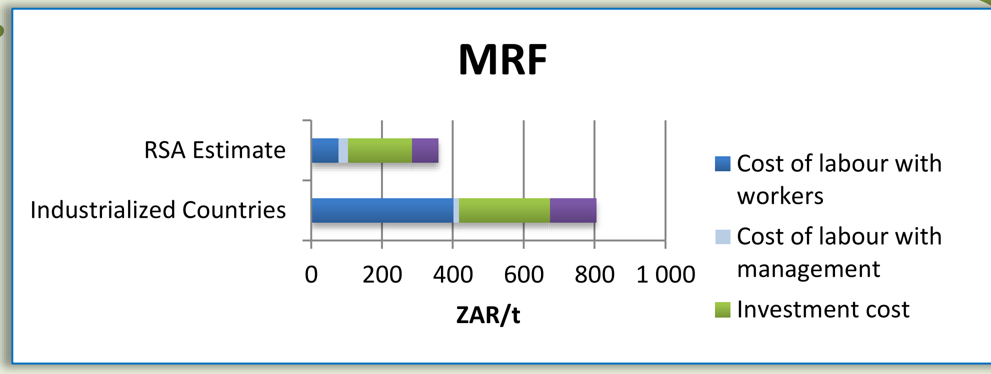

Figure 3-4: Full specific cost breakdown for MRFs

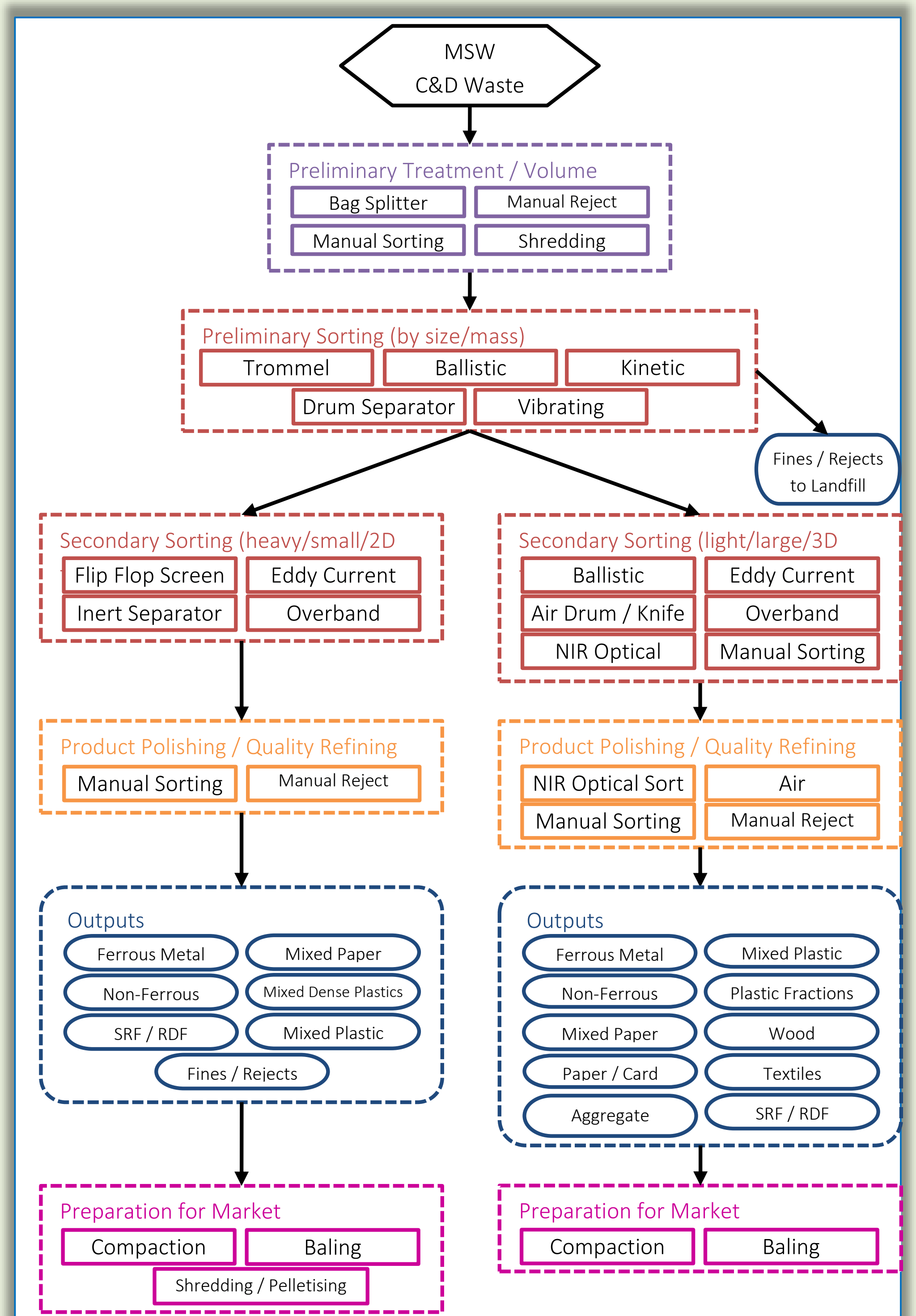

Figure 3-5: Typical dirty MRF process flow diagram

1.4 Mechanical Biological Treatment: Technology Profile

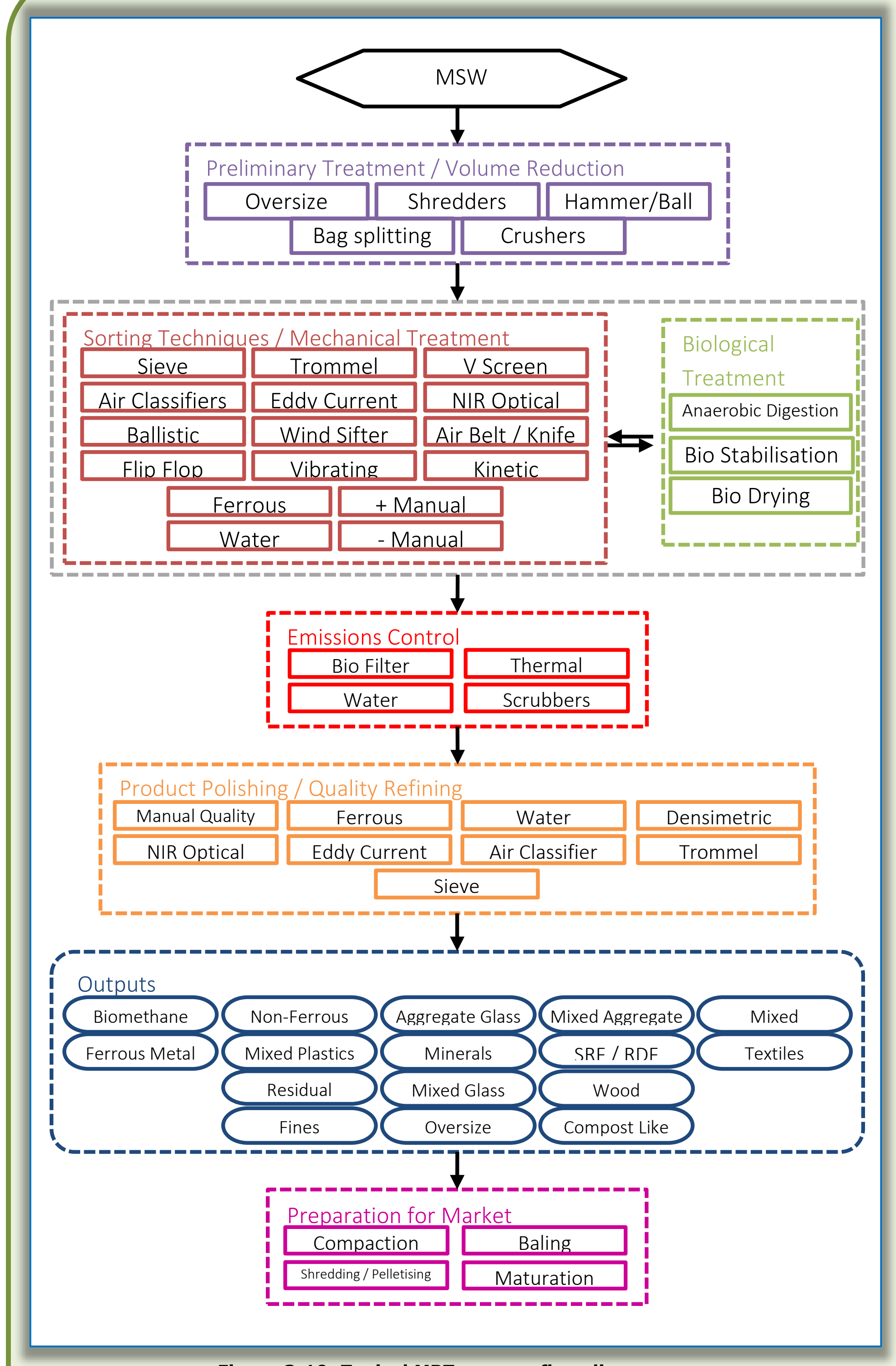

Figure 3-10: Typical MBT process flow diagram

Table 3-6: Labour intensity of the different options

Item \ Option	Open windrows passively aerated	Open/Covered windrows actively aerated	In-vessel actively aerated biological decomposition	Aerobic Biological drying	Combined anaerobic wet (low solid) digestion for organic waste	Combined anaerobic dry (high solid) digestion
Number of skilled workers	8	10	12	8	12	12
Number of general workers	15	15	12	6	10	10
Total number of workers	**23**	**25**	**24**	**14**	**22**	**22**

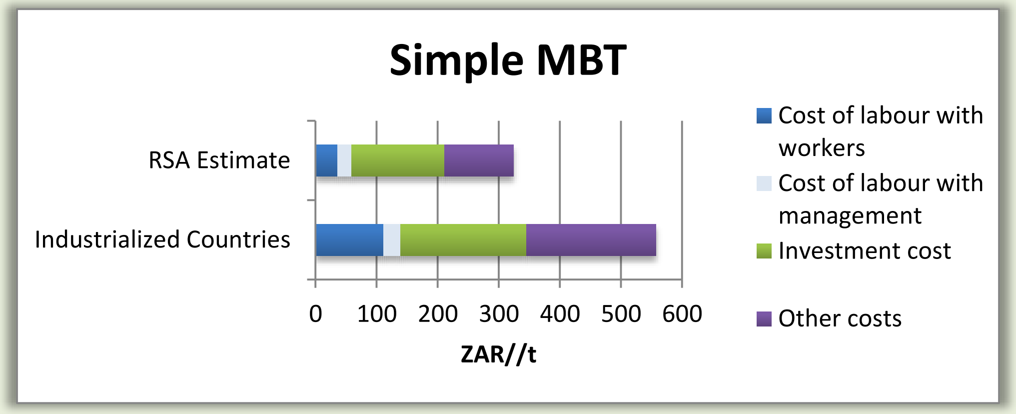

Figure 3-12: Full cost breakdown for simple MBT with windrow composting

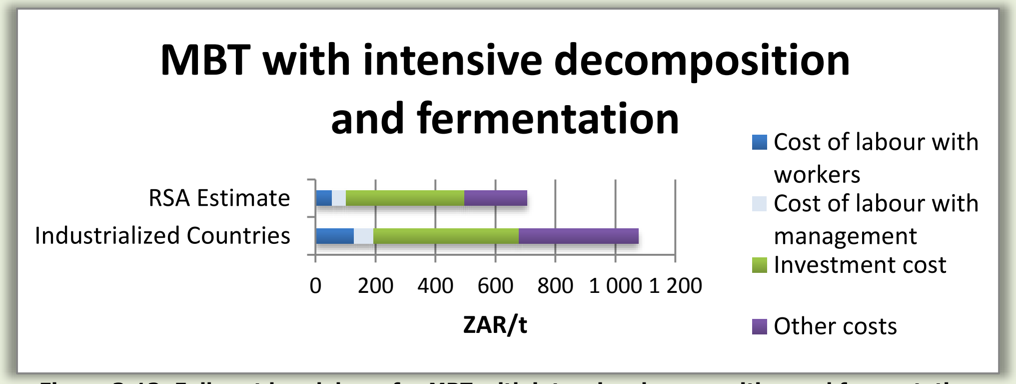

Figure 3-13: Full cost breakdown for MBT with intensive decomposition and fermentation

Table 3-8: Key characteristics of mechanical biological treatment

Item	Description
Purpose	To stabilise non-hazardous waste, producing useable recyclable and organic products in the process. Potential to produce energy either through AD or production of RDF
Waste streams accepted	MSW, wet type C&I
Typical capacity	50k – 500k tonnes per annum
Typical outputs	Energy, recyclate, fines, stabilised material
Indicative capital cost	c. ZAR 850m – 1.160m for a 100ktpa facility
Human resource requirement	Includes engineers, skilled workers, mechanics, unskilled workers and drivers.

Figure 3-11: Anaerobic digestion and gas storage (Viridor)

Table 3-9: Factors influencing Revenue - MBT

Technology Heading	Outline Description	Factors Influencing Revenue
MBT (with Composting/Bio-drying)	A facility combining mechanical separation techniques with biological treatment to either stabilise or dry the organic fraction of the waste. Mechanical separation is used to recover relatively low grade recyclable materials in much the same way as a dirty MRF. The organic fraction can be used as a RDF (bio-drying) or stabilised compost-like output with reduced volume.	• Market value of recyclate • Quality requirements of compost like output • Distance to market/outlet for recyclables, RDF, compost-like output and rejects • Quantity of contaminant and subsequent screening costs • Reliability of some technologies/maintenance requirements
MBT (with Anaerobic Digestion)	A facility combining mechanical separation techniques with biological treatment to derive energy from the organic fraction of the waste. Mechanical separation is used to recover relatively low grade recyclable materials in much the same way as a dirty MRF. The organic fraction can be subject to anaerobic digestion to recover biogas / generate electricity.	• Electricity/Bio-methane revenue • Any Government incentives for low carbon energy/other energy recovery incentives • Revenue/cost of digestate product in market • Quality requirements/dewatering of digestate • Quantity of contaminant and subsequent screening costs • Opportunity and value to utilise waste heat from process • Market value of recyclate/fuel • Quality requirements of compost-like output • Distance to market/outlet for recyclables, fuel, digestate and rejects • Quantity of contaminant and subsequent screening costs

Table 3-7: Specific treatment cost for different MBT options

Item \ Option	Open windrows passively aerated ZAR/t	Open/Covered windrows actively aerated ZAR/t	In-vessel actively aerated biological decomposition ZAR/t	Aerobic Biological drying ZAR/t	Combined anaerobic wet (low solid) digestion for organic waste ZAR/t	Combined anaerobic dry (high solid) digestion ZAR/t
Wages and salaries	22	26	30	17	67	67
Repair and maintenance	26	51	106	145	194	234
Variable cost/ consumables	7	20	39	38	60	65
Depreciation of investment	55	131	266	319	453	524
Total costs	**110**	**229**	**441**	**519**	**774**	**890**

1.5 Anaerobic Digestion: Technology Profile

Table 3-10: Key Characteristics of AD

Characteristic	Description
Purpose	To recycle biodegradable waste into a digestate for land application/ soil improvement and recover energy as either gas or heat and power
Waste streams accepted	Putrescible/ organic waste, garden/ food waste collections, slurries, energy crops
Typical capacity	5k – 150k tonnes per annum
Indicative capital cost	c. 120m –220m ZAR for a 25ktpa wet AD process c. 300m – 350m ZAR for 160 ktpa (620 t/day) (New Horizons Plant)
Human resource requirement	Engineers, chemists, environmental managers, skilled workers, mechanics and drivers

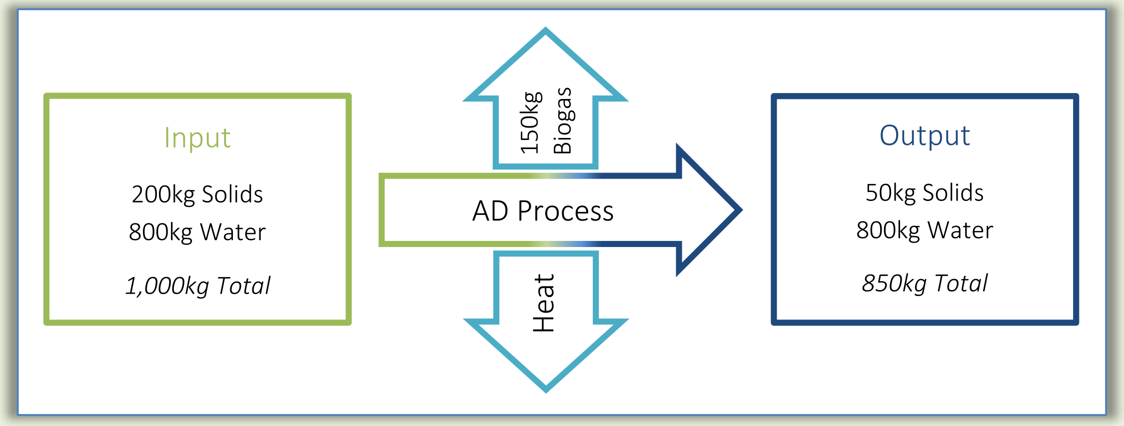

Figure 3-18: Example anaerobic digestion mass balance

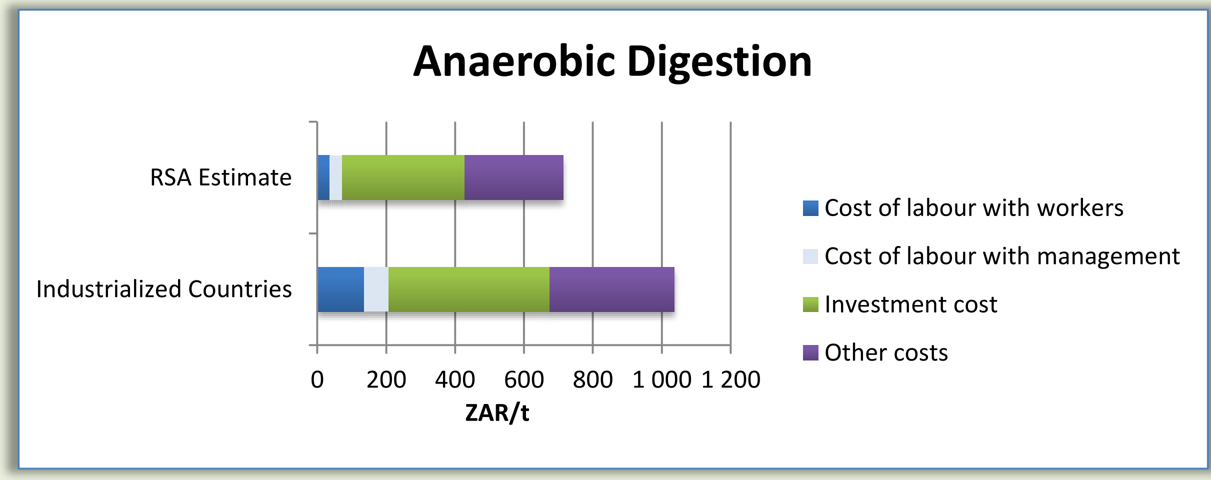

Figure 3-17: Full cost breakdown for anaerobic digestion

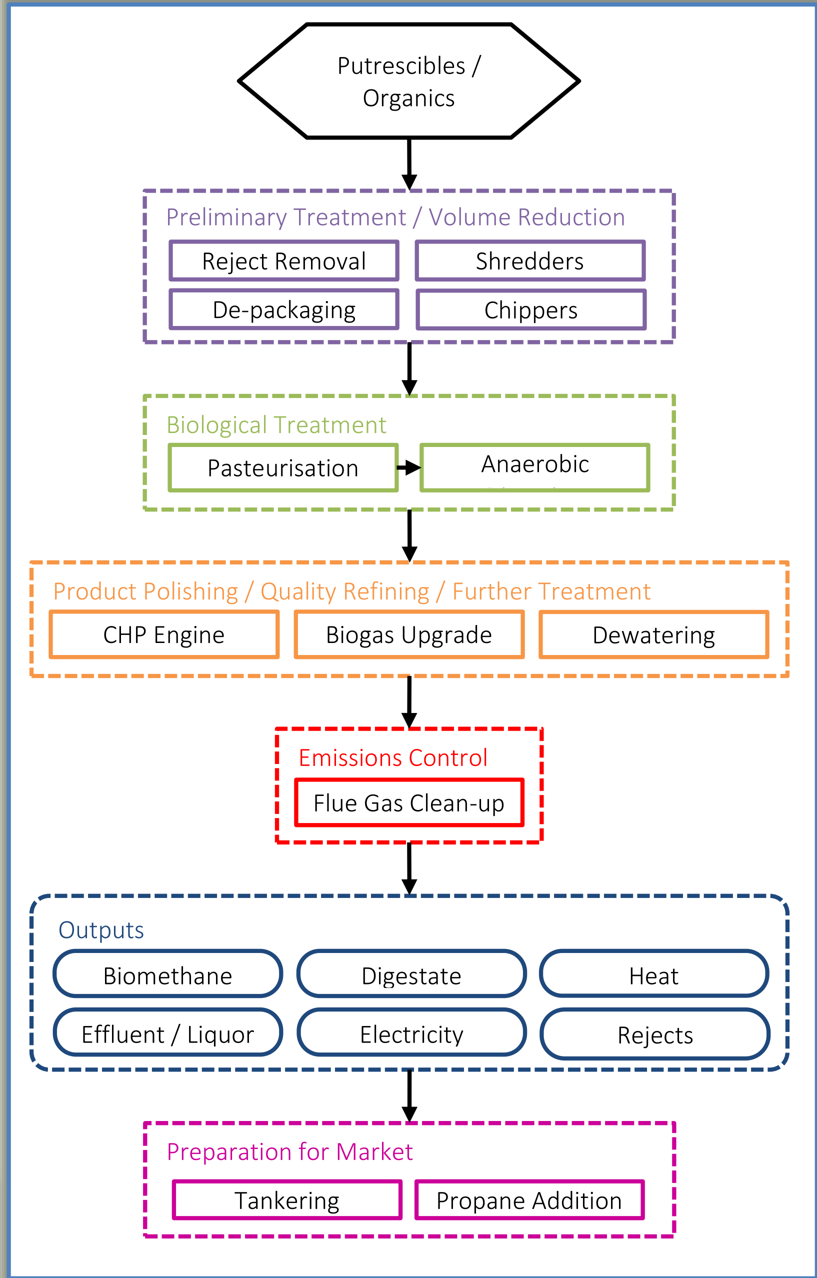

Figure 3-16: Typical anaerobic digestion process flow diagram

Figure 3-15: Biogas CHP engine and cleaning equipment (image courtesy of WolfeWare Ltd)

Table 3-12: Factors influencing AD revenues

Technology Heading	Outline Description	Factors Influencing Revenue
Anaerobic Digestion (AD)	Anaerobic digestion utilises natural microbes to digest and decompose food wastes (including animal products) in an anaerobic environment to produce biogas (suitable for use in CHP engines or clean-up for use as a replacement for natural gas) and nutrient rich digestate. The digestate can be spread on the land either in its output state if allowed by regulations, or after dewatering (more suitable if no immediate end user is available). Food waste has higher moisture content than mixed organics and is therefore most suitable for 'wet' AD systems.	• Electricity/bio-methane revenue • Government incentives for low carbon energy or other renewable energy incentives • Revenue/cost of digestate product in market • Distance to outlet for digestate • Quality requirements for dewatering of digestate • Quality requirements for biogas and related treatment costs • Quantity of contaminants and subsequent screening costs • Opportunity and value to utilise waste heat from the process • Appropriate feedstock availability, composition and consistency

Figure 3-14: Anaerobic digestion tanks (image courtesy of WRAP)

Table 3-11: Comparison of mesophilic and thermophilic anaerobic digestion

Operating parameter	Mesophilic	Thermophilic
Temperature	30-40˚C	50-60˚C
Digester residence time	15-30 days	10-20 days
Advantages	More robust and tolerant process. Less energy input required.	Higher gas production. Faster throughput (lower residence time). Separate sanitisation stage may not be required.
Disadvantages	Lower gas production rate. Requires larger digestion tanks. Requires a separate sanitisation stage	Greater energy input required. More sensitive to environmental variables. Needs effective control.

1.6 In-Vessel Composting: Technology Profile

Table 3-14: Key characteristics of IVC

Item	Description
Purpose	To recycle biodegradable waste into a compost for land application / soil improvement
Waste streams accepted	Putrescible / organic waste, garden / food waste collections
Typical capacity	10k – 150k tonnes per annum
Indicative capital cost	c. ZAR 60m – 95m for a 30ktpa facility
Typical outputs	Compost
Human resource requirement	Low and mostly unskilled workers, drivers and mechanics

Table 3-13: Revenue Factors – In vessel composting

Technology Heading	Outline Description	Revenue Influencing Factors
In-Vessel Composting (IVC)	In-vessel composting decomposes the feedstock in an enclosed aerobic environment to produce compost suitable for application to agricultural or horticultural land. Mixed organics, contain food (and other potentially hazardous or nuisance materials) require treating in-vessel.	• Revenue / cost of compost product in market • Distance to outlet for compost • Quality requirements / bagging of compost • Quantity of contaminant and subsequent screening costs • Disposal costs of contaminant

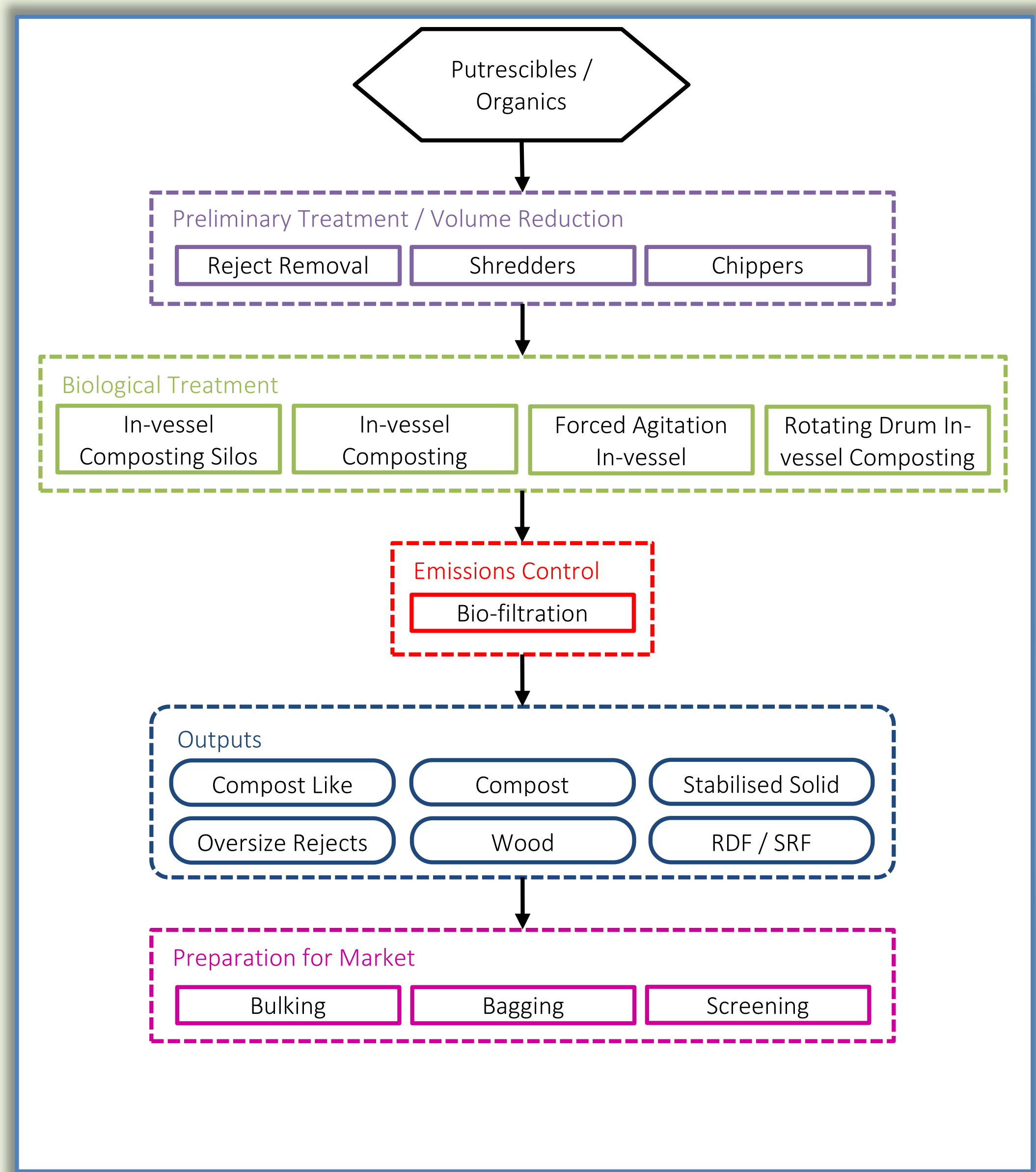

Figure 3-21: Typical in-vessel composting process flow diagram

Figure 3-19: Inside a tunnel method IVC facility (image courtesy of Viridor)

Figure 3-20: IVC compost (image courtesy of Sita)

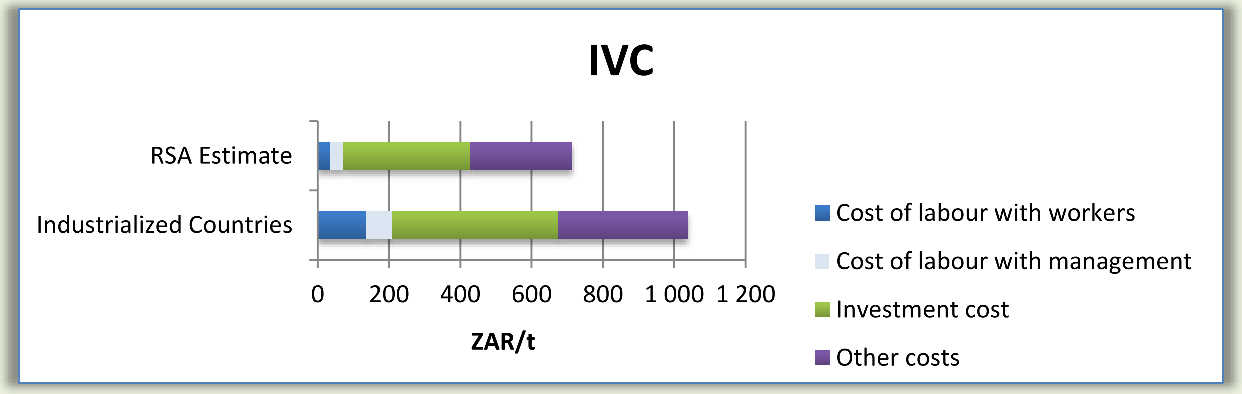

Figure 3-22: Full cost breakdown for IVC

1.7 Incineration with Energy Recovery: Technology Profile

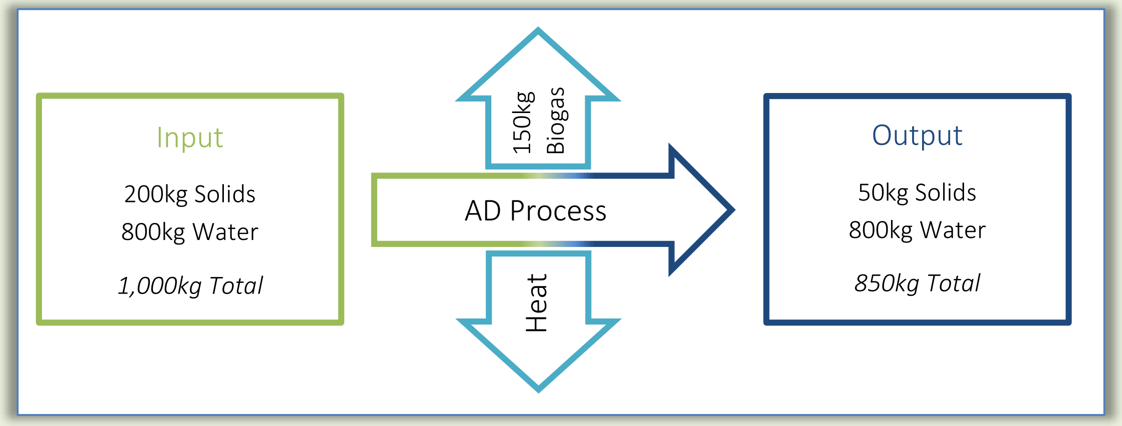

Figure 3-25: Example anaerobic digestion mass balance

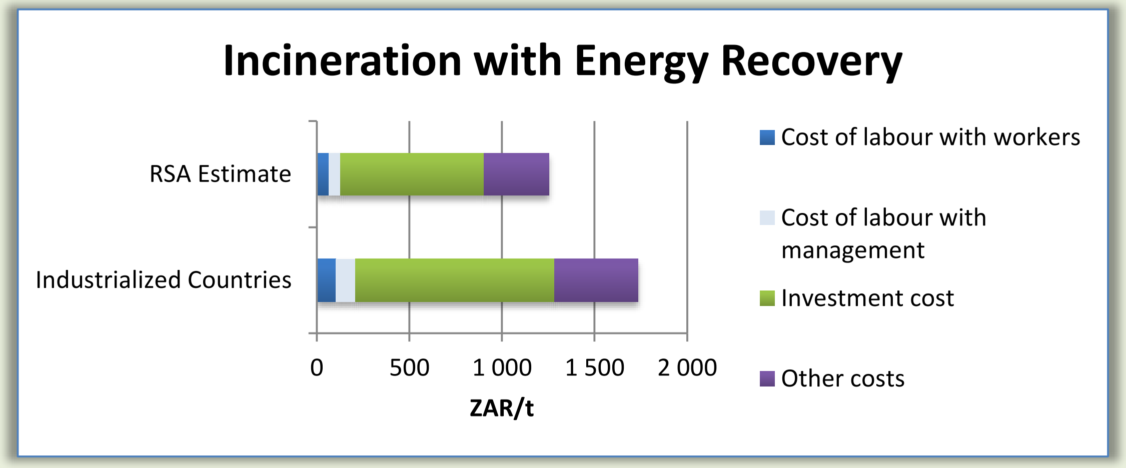

Figure 3-26: Full cost breakdown for incineration with energy recovery

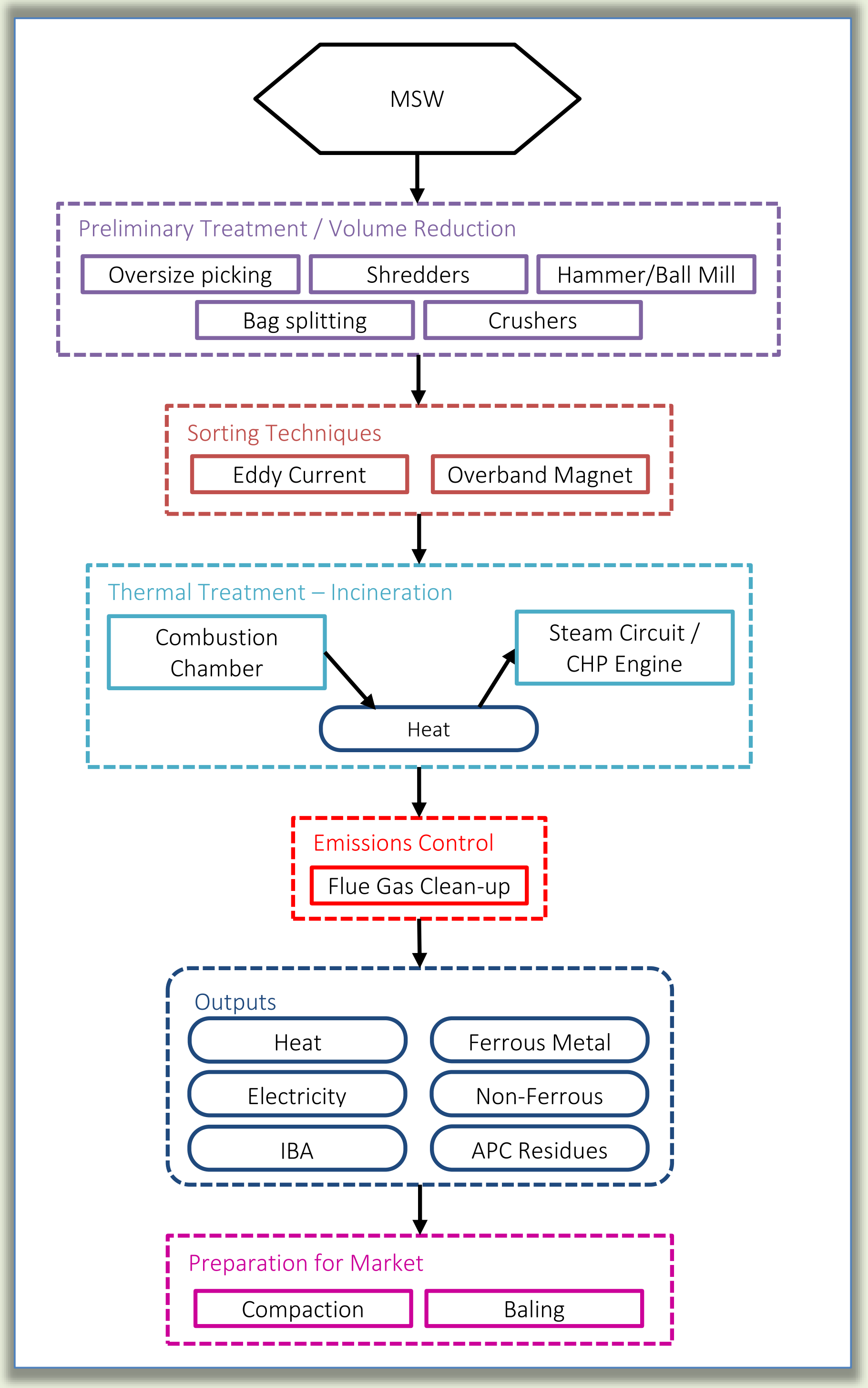

Figure 3-24: Typical incineration process flow diagram

Table 3-16: Key Characteristics of Incineration with energy recovery

Characteristic	Description
Purpose	To recover energy from non-recyclable mixed waste streams
Waste streams accepted	Residual waste, C&I waste, certain fractions of C&D waste, RDF
Typical capacity	60k – 600k tonnes per annum
Indicative capital cost	c. 1,400m – 1,900m ZAR for a 100ktpa facility.
Human resource requirement	Engineers, chemists, environmental managers, skilled workers, mechanics and drivers.

Table 3-15: Factors influencing Revenue for Incineration with energy

Technology Heading	Outline Description	Factors Influencing Revenue
Incineration with Energy Recovery	MSW or RDF is thermally treated by combustion for a minimum of 2 seconds above 850ºC in a natural oxygen environment. The steam created by this process is used to generate energy (heat and/or power) in a steam circuit. Flue gases are treated to remove harmful pollutants from output emissions. Incinerator Bottom Ash (IBA) can be treated to create a stable construction material or deposited to landfill.	• Electricity revenue • Any Government incentives for low carbon energy / other energy recovery incentives • Distance to outlets of bottom ash/fly ash if not recovered • Revenue from metals • Opportunity and value to utilise waste heat from process • Revenue from fly ash if utilised in cement industry

Figure 3-23: Pelletised RDF from heat non-pressurised heat vessels (Orchid Environmental)

1.8 Mechanical Heat Treatment: Technology Profile

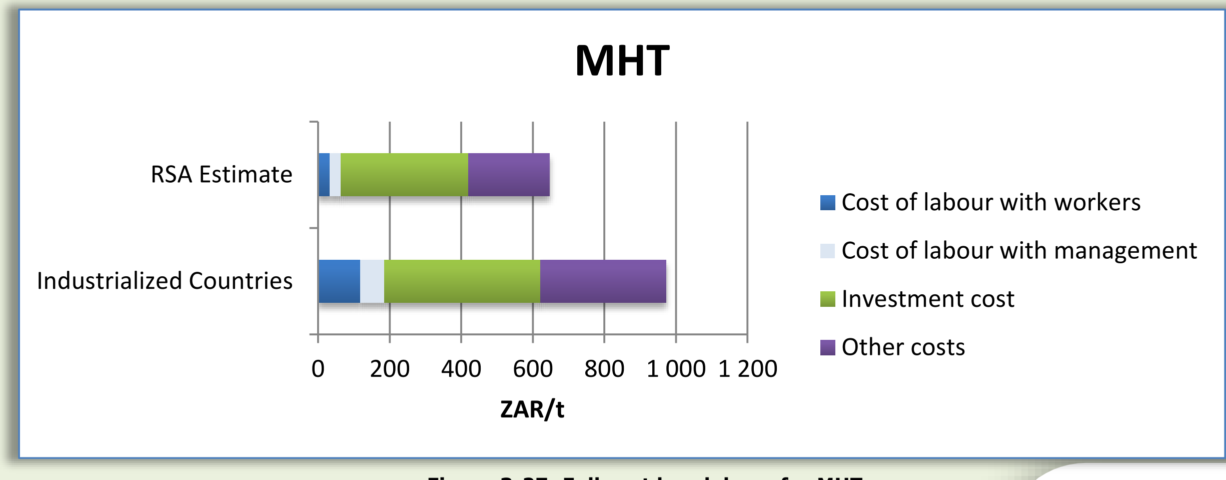

Figure 3-27: Full cost breakdown for MHT

Table 3-17: Key characteristics of MHT

Item	Description
Purpose	To stabilise waste, producing useable recyclable and organic products in the process. Potential to produce energy either through AD or production of RDF
Waste streams accepted	MSW, C&I, certain C&D, Clinical / Hazardous wastes
Typical capacity	50k – 500k tonnes per annum
Indicative capital cost	c. ZAR 180m – 550m for a 100 ktpa MHT facility
Typical outputs	Recyclate, fines, stabilised material, RDF
Human resource requirement	Medium to high, includes engineers, chemists, an environmental manager, skilled workers, mechanics and drivers.

Table 3-18: Factors influencing Revenue - MHT

Technology Heading	Outline Description	Factors Influencing Revenue
Mechanical Heat Treatment (MHT)	MHT facilities combine mechanical and thermal treatment techniques, often with the prime aim of extracting either relatively high quality recyclables and/or fuel fractions (RDF) from the waste. In addition, and dependent on the technology employed, they may: reduce the volume of waste; derive an organic fibre for use as a raw material/substitute fuel.	• Market value of recyclate • Distance to market/outlet for fibre, recyclables, fuel and rejects • Lack of a market for the organic fibre as raw material or substitute fuel

Figure 3-28: (from top down) Non-pressurised heat vessels (Orchid Environmental); end of process / emptying of an autoclave vessel; autoclaved waste (Orchid Environmental)

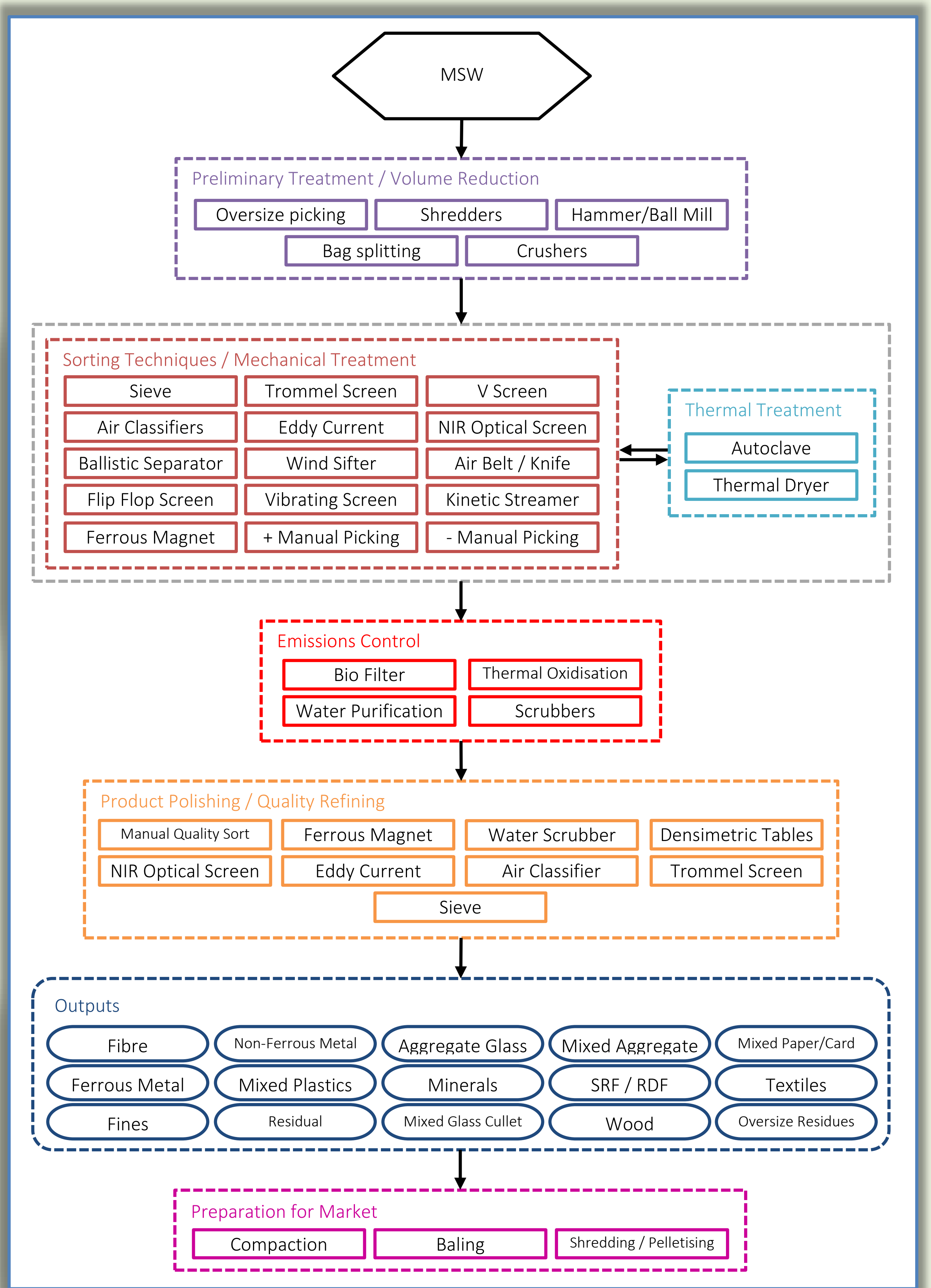

Figure 3-29: Typical MHT process flow diagram

1.9 Operator Models

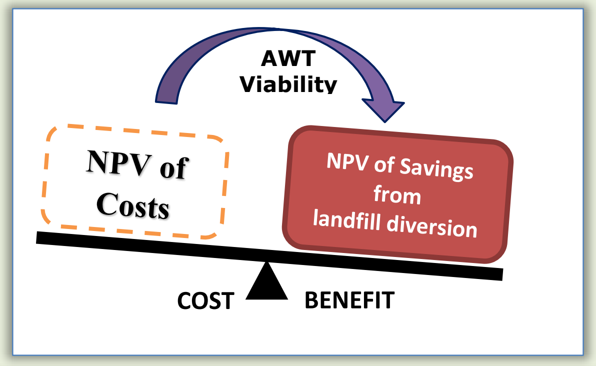

Figure 3-36: Financial cost-benefit assessment for AWT technologies.

Financing AWT Infrastructure

There are, traditionally, two important aspects to be considered in the financing of AWT infrastructure, namely:

1. **How capital investment expenditures (capex) are to be financed; and**
2. **How recurrent costs (opex) are to be financed.**

The financing of capital investment usually attracts most focus internationally because a shortage of capital funds is commonly viewed as a principal impediment to development. However, the financing of recurrent costs is probably the more critical issue, because this is typically upon the source upon which the financial sustainability of AWT technologies depend.

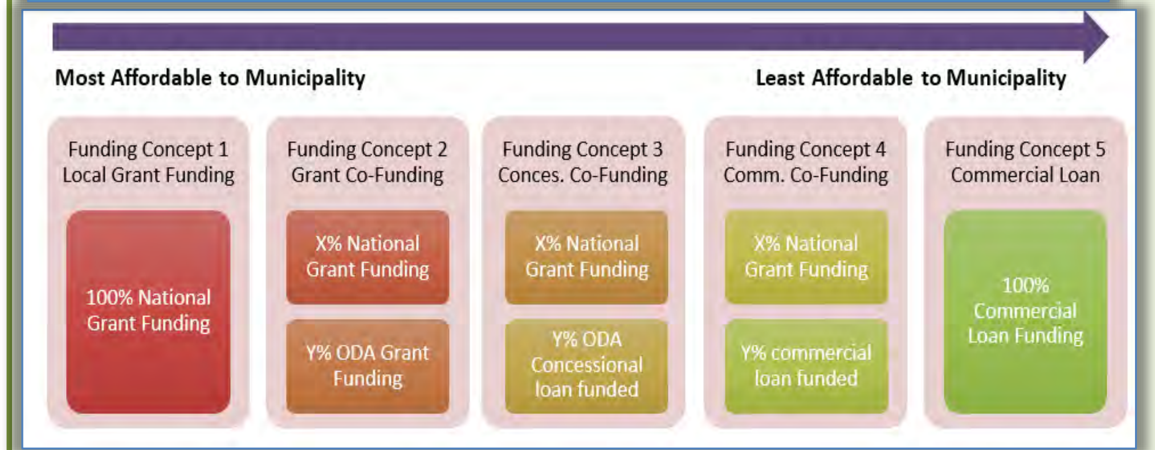

Figure 3-32: Possible CAPEX funding concepts available to municipal authorities.

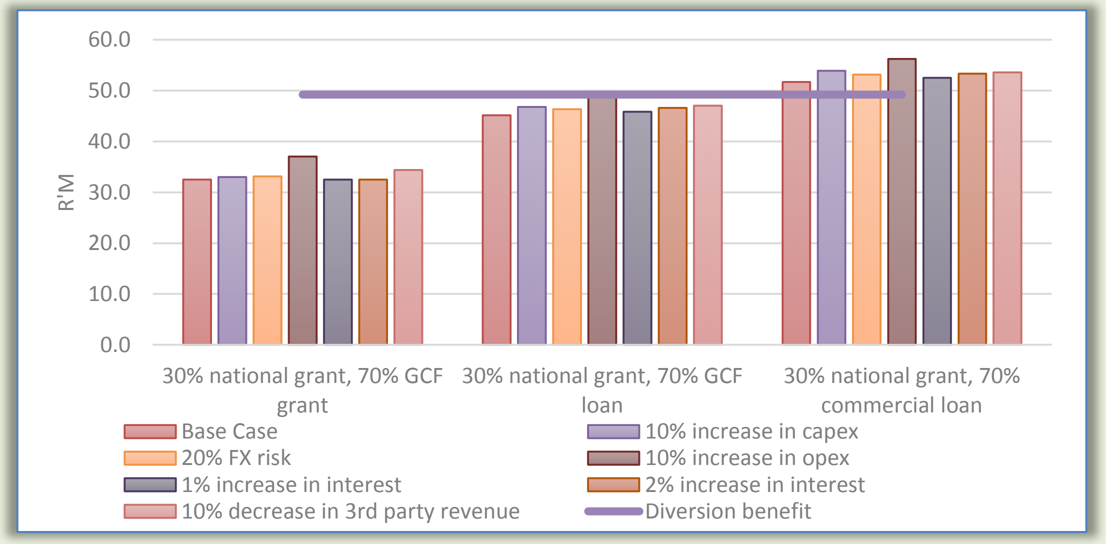

Figure 3-33: Example of OPEX surplus/(gap) as an expression of Government's net benefit/(cost).

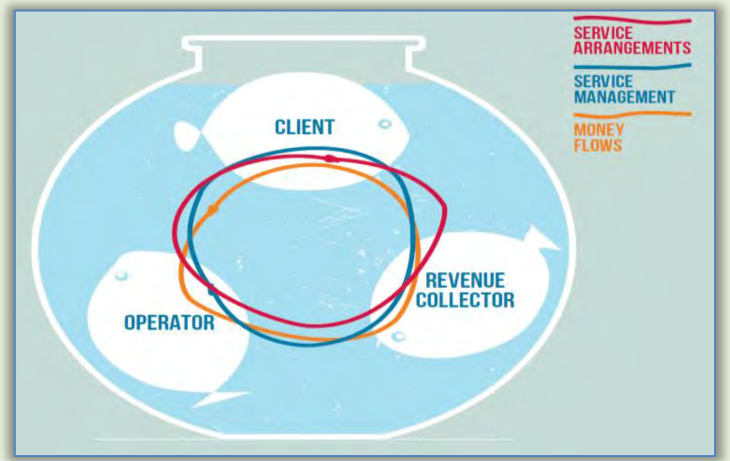

Figure 3-34: Components of an Operator Model

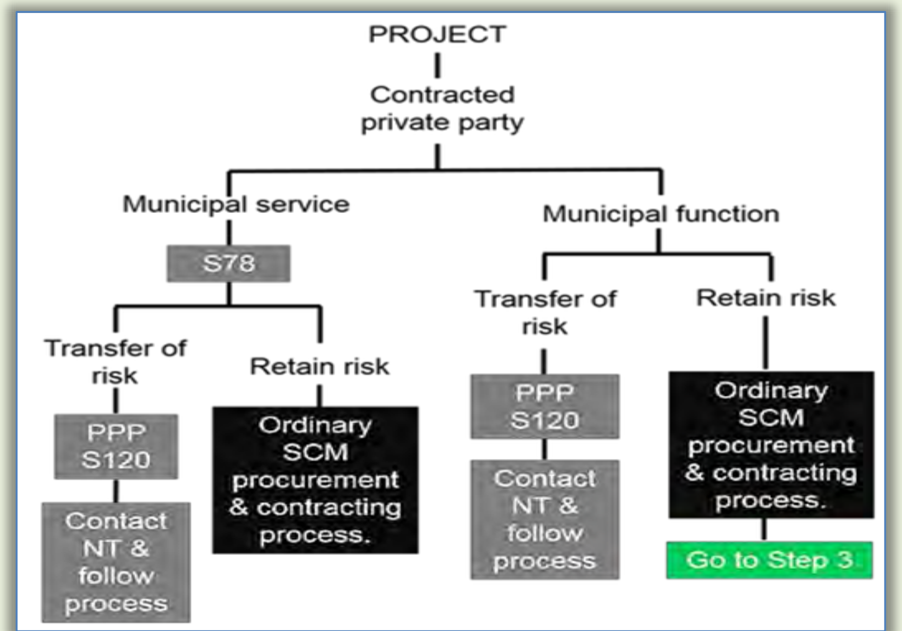

Figure 3-31: General procedure to be followed to set up an appropriate contract with a private sector entity (DEA, 2015).

Table 3-22: Key sensitivities and their likely impacts on municipal authorities

Sensitivity	Impact on municipality	Impact on National Government
Adverse change in Foreign Exchange Rates (FX)	Increased subsidy and loan repayments	Additional grant funding required from government, municipality's operational costs increase
Capex overspend	Increased loan repayments	Additional grant funding required from government, municipality's operational costs increase
Higher than forecast OPEX	Increased subsidy	Municipality's operational costs increase
Decrease in third party revenues	Increased subsidy	Municipality's operational costs increase
Increase in interest rates	Increased loan repayments	Municipality's operational costs increase

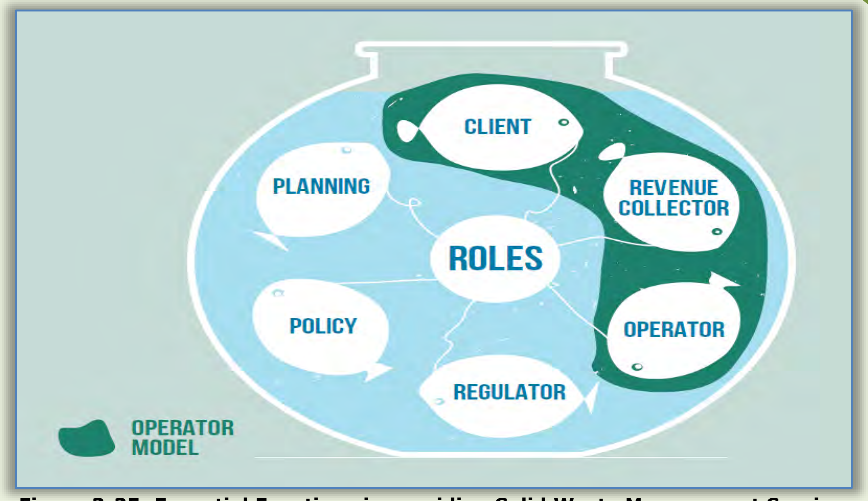

Figure 3-35: Essential Functions in providing Solid Waste Management Services (Wilson et al., 2001)

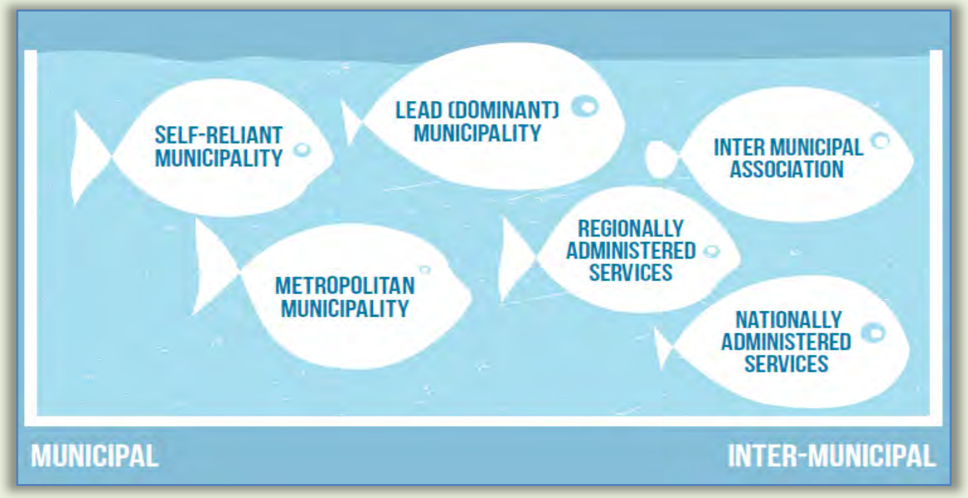

Figure 3-30: The Continuum between Operator Models for Self-Reliant Municipalities and Nationally Administered Services.

Table 3-21: Types of service delivery contracts between private and public entities (DEA, 2015).

Type	Description	Duration
Service	Service provider being paid a fee by the municipality to provide operational services.	1-3 years
Management	Municipality pays service fees to service provider assuming all responsibility for operation and maintenance of delivery service.	5 years
Lease	The service provider rents facilities from municipality for operations and maintenance.	10 years
Concession	The concessionaire will lease assets owned by the municipality for period of concession. The focus will be on operating, maintenance and financing of existing fixed assets.	15+ years
Build-operate-transfer (BOT)	This is a standalone capital project for which a concession is granted and where the municipality may or may not receive profits or fees.	15+ years

4 Conclusions

The public sector in liaison with private sector embarked on several planning activities to jointly address waste management in South Africa. Standards of waste disposal, tightening of environmental regulations, land use constraints, and social policies are progressively being addressed as alternative (landfill diversion) approaches and techniques become available.

This Advanced Integrated Solid Waste Management (AISWM) series of publications profiles globally established waste treatment technologies, in considering the implications from different perspectives.

The series of publications addresses the technical aspects of all major waste treatment technologies currently established on the international waste management market. It groups these technologies into categories of short, medium and long term, reflecting their prospect for implementation in the South African context.

The financial and economic implications of these technologies have been addressed, with international cost benchmarks adapted to the South African context. The outcome illustrates technologies which are increasingly becoming viable in the domestic market, also emphasizes the importance of a 'gate fee', to the financial sustainability of all treatment technologies. The price competitiveness of waste treatment technologies drives the business case for investors. The most important 'tipping' point in a business case analysis, is the local cost of landfill. As such feedstock security is key to ensure investor confidence in the establishment and operation of such facilities.

From a social perspective, implementing a policy of landfill diversion is job creation positive. Significant opportunity exists to create employment opportunities in an improved, South African resources and waste management sector. Existing informal livelihoods need to be understood and built into the new systems. Implementing AISWM requires political will, relevant human and financial support, vision, innovation and determination. The landscape of technology uptake across the South African waste management market will be more diverse as obstacles to progress are overcome, and more rational resource use is ensured in the medium to long term.

Notes

Notes

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