Development of the Waste Economy in the Western Cape: A Decision Support Tool for Integrated Municipal Waste Management

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ABSTRACT

Municipalities are under pressure to divert waste from landfill as required by the National Environmental Management: Waste Act (NEM:WA, Act 59 of 2008). The implementation of alternative waste management thus far has been largely on an *ad hoc* basis. This comes as a result of the challenges associated with, among others, high cost, and limited capacity to evaluate the technical feasibility and financial viability of waste related projects. NEM:WA (59 of 2008) and the National Waste Management Strategy (NWMS, 2011) both require municipalities to develop Integrated Waste Management Plans (IWMPs). These should be developed in line with other municipal, provincial and national plans and strategies. However, many of the IWMPs still lack technical and financial substance, providing limited guidance in terms of both future infrastructural and operational requirements. This paper outlines the development of a decision support tool aimed at assisting municipal waste departments in the Western Cape to adopt a systems-based approach for the implementation of integrated waste management.

Keywords: Integrated Waste Management, Municipal Waste Management, Decision Support Tool.

1. INTRODUCTION

1.1 Background and overview of municipal waste management challenges in South Africa

Municipalities in South Africa are faced with a number of waste management challenges (DEA&DP, 2013), including increasing volumes of waste generated, escalating costs of management, decreasing landfill airspace, land availability for new landfills and increasingly stringent legislative requirements to adopt the waste management hierarchy based on the National Environmental Management: Waste Act (NEM:WA, 59 of 2008). The National Waste Management Strategy (NWMS, 2011) sets goals that municipalities should meet in terms of waste management, and these include:

- Promoting waste minimisation, re-use, recycling and recovery;
- Ensuring the effective and efficient service delivery of waste services;
- Achieving integrated waste management planning; and
- Ensuring sound budgeting and financial management for waste services.

In order to meet these goals, municipalities have to integrate alternative waste management technologies into their waste management systems. This in turn has brought about an influx of offers from a large number of parties, including entrepreneurs, technology vendors and proponents of climate mitigation projects, offering a range of technologies to assist municipalities with waste management. Many of these offerings are stream specific, and/or address specific areas of the municipal waste management system without necessarily taking into account the waste management system as a whole. In order to avoid poor decision making in terms of waste management infrastructure, municipalities need to adopt a full systems approach to address their challenges and implement alternative waste management practices.

1.2 Municipal planning and decision making structure

There are multiple levels of planning and decision making within a municipality that must be taken into account in order to implement sustainable waste management practices. Moreover, the different levels need to be aligned for the successful implementation of waste related initiatives. Key stakeholders in solid waste management include, but are not limited to, solid waste managers, technical/utility managers, municipal managers, chief financial officers, mayors, councillors and the public at the local municipal level. The criteria each of the stakeholders use for decision making is not necessarily the same and includes considerations such as technical feasibility, capital and operational expenditure, funding availability etc.

Key to the operations of any municipality is the Integrated Development Plan (IDP). This is a mandatory requirement as stipulated by the Municipal Systems Act (MSA, No. 32 of 2000). The MSA (32 of 2000) describes the IDP as a single, inclusive and five-year strategic plan for a municipality. Once adopted by the municipal council, the IDP becomes the principal strategic planning instrument which guides and informs all planning and development over the next five years, as well as all decisions with regard to planning, management and development, in the municipality. In summary, the MSA (32 of 2000) stipulates that the IDP must:

- link, integrate and co-ordinate plans and take into account proposals for the development of the municipality;
- align the resources and capacity of the municipality with the implementation of the plan;
- form the policy framework and general basis on which annual budgets must be based;
- be compatible with national and provincial development plans and planning requirements binding on the municipality in terms of legislation.

For implementation of integrated waste management, a number of steps have to be followed and decisions have to be made at various levels. At the core of the decision making are the technical aspects of waste management, including the assessment of the different waste treatment options available. This assessment then forms the basis for the selection of the most appropriate solution(s) per municipality. The technical assessment informs the Integrated Waste Management Plan (IWMP). The IWMP is called for by NEM:WA (59 of 2008), and is just one of the sector plans that is both guided by, and feeds into the IDP.

The IWMP addresses amongst other things, the practical aspects of waste management within a municipality and includes the challenges and plans of a municipality in terms of waste management. The NEM:WA (59 of 2008) states that the IWMP must:

- align with the Integrated Development Plan of the municipality;
- align with plans strategies and programs of local, provincial and national government;
- present the status quo of the municipality – in terms of population profile, waste generation and management; and importantly,
- provide for the implementation of waste minimisation, re-use, recycling and recovery targets and initiatives in line with NEM: WA (59 of 2008) and the NWMS (2011).

Although the IWMP is mandated by the NEM:WA (59 of 2008) and the NWMS, it needs - due to municipal process - to be necessarily aligned with the IDP for the implementation of any waste management initiatives. Municipalities in South Africa voluntarily developed 1st passes at integrated waste management plans following the drafting of the 1999 National Waste Management Strategies and Action Plans (DEAT, 1999), which were then referred to as 1st generation IWMPs. The development of IWMPs became a statutory requirement with the enactment of the Waste Act (NEM:WA, 59 of 2008) and indeed, most of the Western Cape municipalities have drafted what have become to be known as 2nd generation plans. However, there is still a big gap with regards to future planning and integrated waste management as a whole, and alignment of the IWMP with local, provincial and national strategies and plans.

Figure 1 below shows a schematic of the decision making stages within a municipality with regards to waste management, highlighting how the IWMP must feed into the IDP for budget to be allocated for both infrastructural and operational spending. However, the technical content is still lacking in many of the municipal IWMPs, ultimately contributing to the absence of waste management projects in the IDPs and limiting waste related development. An additional level –DST- has been included in figure 1, highlighting where a decision support tool (DST) as described in this paper can feed into and add value into the IWMP.

1.3 Objective

The objective of this paper is to discuss the development of a decision support tool aimed at assisting Western Cape municipalities to develop a systems-based approach to integrated waste management planning. It is proposed, as depicted in Figure 1, that such a tool will assist the municipalities to critically assess the different waste management options available and feed into the development of the next generation of IWMPs. This will in turn inform the next level of planning -the IDP, and ultimately lead to the unlocking of a streamlined systems-based approach to municipal waste management. This paper discusses the process being followed for the development of such a tool for the Western Cape context. This includes the rationale used for the selection of the specific tool to be used as a foundation to be customised to the South African municipal context, the process being used for this adaptation, and the challenges being encountered in this tailoring process.

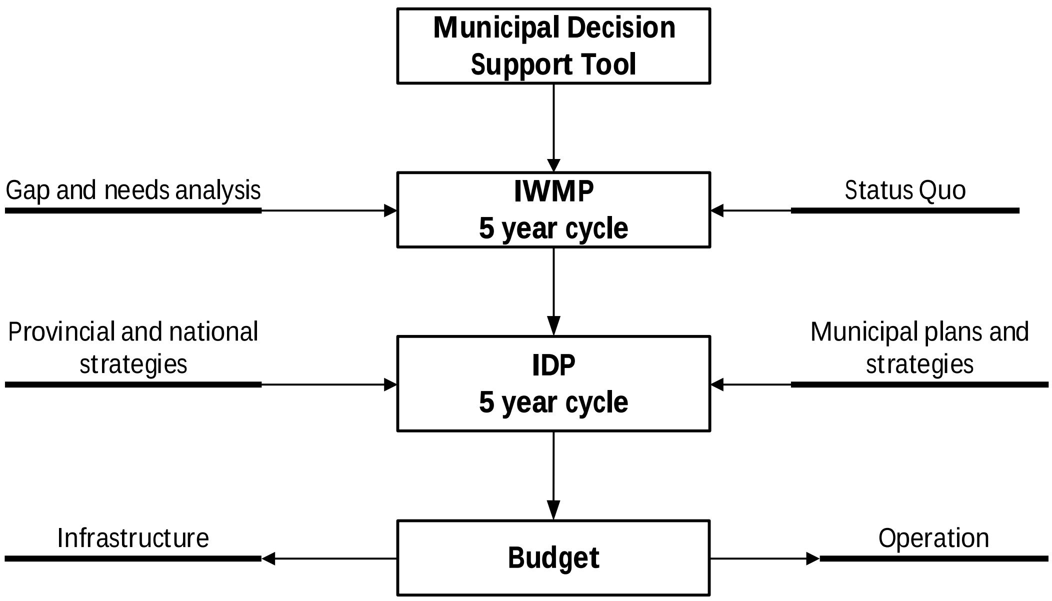

Figure 1: Municipal planning structure

2. A SYSTEMS-BASED APPROACH TO INTEGRATED MUNICIPAL WASTE MANAGEMENT

2.1 Basis for integrated municipal waste management

Due to the pressing need to divert material from landfill, municipalities may be ready to accept technologies or services without being able to evaluate whether the offering is a sensible path for a particular waste stream in the long run, or what the full impact on municipal systems may be. Figure 2 illustrates the various waste streams and the equally wide range of waste treatment options that a municipality may take into consideration when deciding on the best method for waste management for individual waste streams. Unforeseen impacts on municipal systems due to *ad hoc* implementation of alternative waste management technologies may include additional infrastructure and management requirements, substantial life-time costs, and changes to quantity and/or distribution of municipal revenue. That said, many of the offers do provide genuine opportunities to bring innovative solutions for municipal solid waste, some especially for distributed and uncollected wastes and these opportunities need to be identified and capitalised upon.

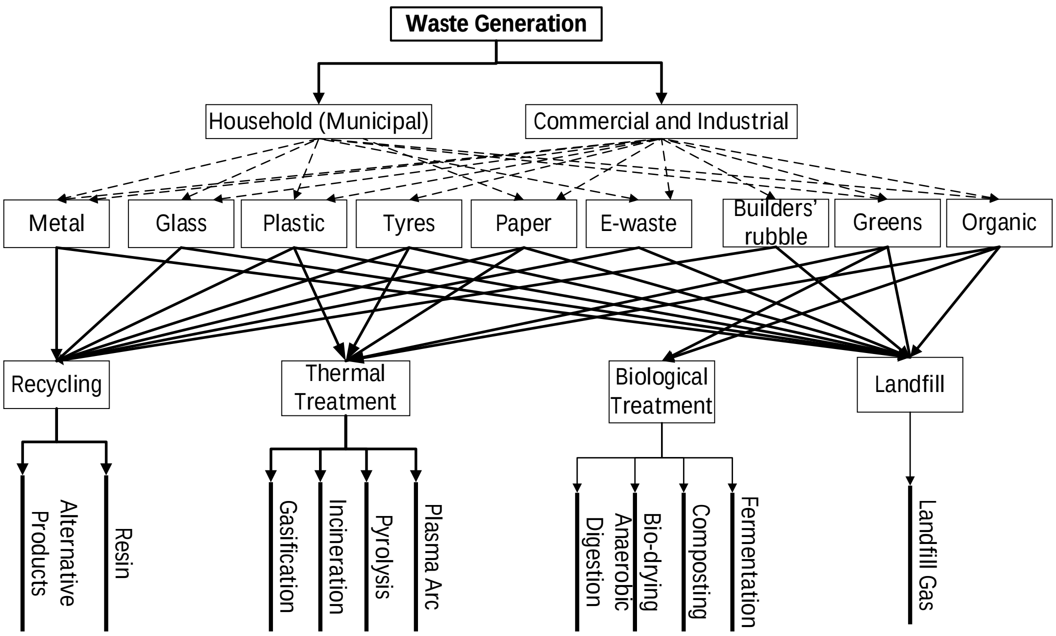

Figure 2: Different technology options available for different waste streams

The complexity due to the number of options available per waste type brings about the need to holistically evaluate the different possible routings, and this leads to a systems-based approach in evaluating the different treatment options. The NEM:WA (Act 59 of 2008) sets the basis for integrated waste management at municipal level. This in itself encourages a systems-based approach to waste management that considers the complete waste management system (from generation to collection, sorting, recycling, treatment of organic and residual waste and final disposal of remaining waste) in an integrated manner, thereby showing how changes in one aspect affects requirements or performance elsewhere. This approach helps to avoid the selection and development of projects and activities based on the influence of particular interest groups or based on simple heuristics that may not be sustainable when considered on a life cycle basis (i.e. from “cradle-to-grave”). This would be achieved by providing an evidence base for the financial, economic, social and environmental implications of different municipal solid waste management system configurations and technology choices on a life cycle basis. Figure 3 illustrates how a systems-based approach enables the municipality to evaluate the impact of a complete waste management system.

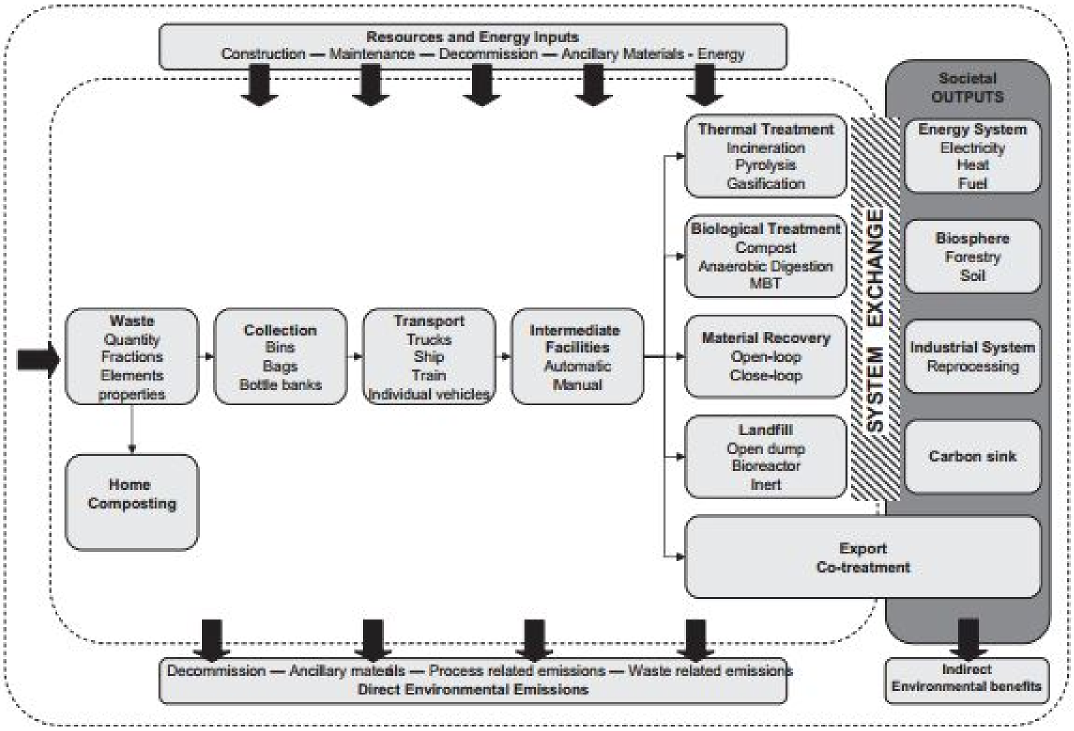

Figure 3: Generic integrated waste management system (Gentil *et al*, 2010)

2.2 Decision support tools for integrated waste management

As a result of the increasing adoption of life cycle thinking, a large number of decision support tools for municipal solid waste management systems have been developed since the early 1990s. These evaluate the different possible system configurations and enable life cycle costing and environmental life cycle assessment of waste management systems. Although these were primarily based on environmental impacts, the scope has gradually expanded to include multiple criteria such as financial (capital expenditure, operational cost, maintenance etc) and social (including noise, visual and job creation impacts) criteria.

The core component of the decision support tools is a model of the waste management system representing all stages including temporary storage, collection, transport, recycling, recovery and disposal, and typically equations/models that provide information on decision making criteria, such as costs and environmental impacts as typically on a life cycle basis. The use of a life cycle framework goes beyond the traditional focus on production site and manufacturing processes to include the complete environmental, social, and economic impact of a process or product over its entire life cycle.

3. APPROACH

This section presents the approach being used to develop the decision support tool. Figure 4 below shows the planned approach for the development of a municipal decision support tool and each step is discussed in turn below.

Figure 4: Approach for development of decision support tool

3.1 Characterisation of Waste Management Landscape

An overview of the municipalities in the Western Cape was conducted so as to determine:

- decision making criteria with particular emphasis on waste management;
- the status quo of their waste management, including waste data (type and quantity);
- current and planned initiatives within the different municipalities.

The overview was conducted via a desktop study (including analysis of IWMPs) as well as interaction with the different municipal waste management officers to identify the current challenges they are facing as well as any opportunities/initiatives being planned. From these interactions, it was quickly established that the goals for municipalities in terms of decision making included minimum capital and operating expenditure, job creation as well as landfill diversion. However, there is still a general paucity of waste information, with only seven weighbridges in the entire Western Cape to cover more than 150 facilities (including licensed and unlicensed landfills, transfer stations and material recycling facilities).

Although most of the municipalities in the Western Cape have approved 2nd generation IWMPs, many of these still lack concrete planning and strategic information, including lack of reliable waste data. The research conducted showed that unlike the Cape metro and a few other municipalities, many of the municipalities that were engaged are still battling basic issues – such as achieving basic service delivery (collection and disposal) as well as legislative and compliance issues – licensing of landfills, remediation of old landfills etc. This provides an extra challenge in terms of priorities for municipalities – whereas the NEM:WA (Act 59 of 2008) and the NWMS (2011) compel municipalities to adopt the waste hierarchy, many of the municipalities still need to meet the minimum requirements in terms of compliance of their waste management facilities and meet their service delivery targets before they get to a stage where they can implement alternative waste management projects.

3.2 Analysis of existing international decision support tools

Gentil et al. (2010) did an extensive review of nine models (out of a possible 50) that could be used for life cycle assessment of waste management systems. The goal of the review was specifically to understand differences in methodologies and technical assumptions used in the various parts of the selected models. The review concludes that significant differences exist, including those related to the technologies included (both what is included and how technologies are modelled), the system boundaries selected for the evaluations and other methodological assumptions made as part of the life cycle assessment. Models developed in later years tend to be more comprehensive particularly in their modelling of environmental impact potentials. What is also strongly evident is how sensitive results can be dependent on local context and hence how strongly geographically specific information can affect results. From the review as well as examination of more detailed publically available information on the specific models, the follow observations can be made:

- The majority embody comprehensive life cycle thinking i.e. the whole system from waste collection, material and energy inputs, crediting for recovered materials and energy inputs;
- The majority focus on environmental performance, principally greenhouse gas emissions (GHG);
- Some have been used as part of a multiple criteria decision analysis (MCDA) process;
- There is great variation in the technologies considered and the end-points used for impact assessment.

Based on the review, Table 1 below was compiled, and shows a summary of the features of the different tools. The selected tools reflect the influence of the fractional and elemental composition of the waste on system, financial and environmental performance and showed consistency with established life cycle assessment principles and practice, such as crediting the waste management system for "avoided burdens" if useful products (e.g. fuels, electricity, re-useable materials) are produced.

Table 1: Summary of available decision support tools*

	DST	WISARD	ISWM	IWM-2	ORWARE	EASEWASTE/ EASETECH	WRATE	LCA-IWM	WASTED	WARM
	USA, 1994	UK/Fr/Nl 1994	Canada, 1998	UK, 1995	Sweden, 1997	Denmark, 2003/2013	UK, 2002	EU, 2001	Canada	USA
Generation	X					X				X
Collection	X	X	X	X	X	X	X	X	X	X
Transport	X	X	X			X	X	X	X	X
Separation	X		X	X		X	X	X	X	
Treatment	X	X	X	X	X	X	X	X	X	
Burial	X	X	X	X	X	X	X	X	X	X
Criteria										
Financial	X	X						X		
Environmental	X	X	X	X	X	X	X	X	X	X
Economic			X	X		X*				
Energy		X			X			X	X	X
Social				X						
Extent of Life cycle analysis										
Life cycle inventory	X			X						
Full LCA		X	X		X	X	X	X	X	X
Technologies										
Anaerobic digestion		X	X		X	X	X			
Composting	X	X	X	X	X	X	X	X	X	
Energy recovery			X		X	X				
Gasification		X			X		X		X	
Incineration	X	X			X	X		X	X	X
Landfill		X	X			X		X		X
Pyrolysis		X					X			
RDF	X			X						
Recycling		X	X	X	X	X	X	X	X	

*Based on report by The Green House for GreenCape, 2013)

In summary a decision support tool will need to be developed/tailored to:
- have the correct figures for impact calculations, including the right energy mix;
- allow for small scale, distributed technologies;
- allow for innovative and novel waste treatment options that may be relevant locally;
- take into account the differences in waste and waste infrastructure due to the wide gaps in socio-economic conditions.

3.3 Selection of and tailoring of EASETECH as the preferred platform for South Africa/Western Cape

EASETECH was selected for development and tailoring into the South African context. EASETECH was developed by the Denmark Technical University (DTU). A number of reasons influenced the selection of EASETECH for adaptation into the South African context and include:
- the model takes a full waste value chain approach;
- it allows for multi-criteria assessment;
- it is predominantly LCA based, with a cost model under development;
- it has multiple waste treatment options available, and also allows for simple setup and addition of additional (local) technologies;
- tool was supplied free subject to training, with additional access to DTU resources for tailoring.

Figure 5 shows a generic schematic for such a decision support model, highlighting the main inputs required, the outputs generated -based on environmental, social, financial and economic criteria- for the information of decision making processes. In all cases, substantial tailoring to South African conditions would be required, mainly to provide appropriate information for the crediting of the systems for avoided burdens and differences in the receiving environment.

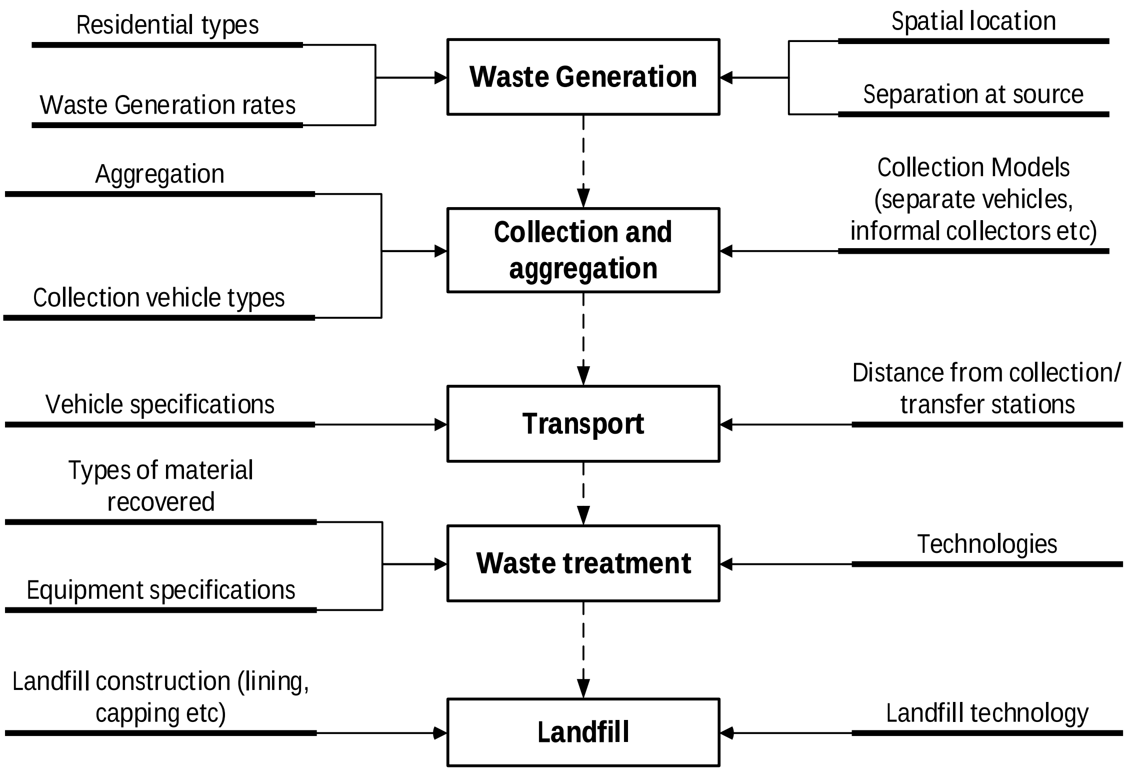

Figure 5: Input summary for a decision support model

However, more significantly most of these models make provision for larger scale, more centralised waste management solutions. Waste collection is not seen as problematic in the context of these systems, and the systems represented are typically less variable (more homogeneous) than the South African context leading to simpler, and possibly more manageable models of the waste management system. Technologies modelled tend to be well established, in contrast to the South Africa context where it is expected that novel distributed technologies may play an important role especially in currently unserviced or poorly serviced areas. This suggests that the models to be developed for the South African context may need to have a level of adaptability and agility to enable the (regular) consideration of novel (small scale) technologies. Table 2 shows what is available in EASETECH, and what modifications will be needed for the South African context.

Table 2: Information needed for tailoring to South African context

	EASETECH	NEEDED FOR SA
Material/waste generation	Danish/Euro defaults	· IWMP data · DEA&DP/SAWIC/case studies for more accurate data
Collection and transport	Euro spec vehicles	· Identification of local vehicle specification · Import data from other databases or manually source vehicle data · Alternatives models (communal waste facilities and informal collection etc · Investigate rail for transport
Treatment	Biological- AD, Composting	· Small scale and local options (e.g. Bokashi) · Compare with local case studies
	Recycling – glass, metal, paper, plastic: Danish/Euro data	· Information on local recycling (types of waste, processes, including energy and water usage)
	Thermal – Incineration	· Pyrolysis · Gasification
Landfill	Landfill gas emission Leachate generation	

3.4 Application to case study municipalities

The case studies will follow a two-phased approach. In the first phase, the selected case studies will assist in the development and tailoring of EASETECH to the local context. This will involve working with municipalities that are more advanced in terms of their alternative waste management planning, and preferably those that have already collected plausible waste information. The second phase will involve working with municipalities that are in the initial phase of the 3rd generation of their integrated waste management planning and inform their IWMP and assist them in working towards their waste management targets.

3.5 Deployment strategy and housing of decision support tool

Ultimately, the tool will be available for municipal decision making in waste management and can be used, for example, in the review of IWMPs at the end of each planning cycle. The initial form has been envisaged possibly as a central service housed under the Provincial Government of the Western Cape.

4. OUTLOOK

Diverting waste from landfill and supporting the development of the waste economy is strongly linked to municipal waste management worldwide. The development and implementation of a systems approach way of thinking is an essential part of bringing about the change in the way waste has been managed historically. This paper highlights the need for technology assessment on a systems basis, and the role decision support tools can play to enable the development of technically sound IWMPs, which then inform the planning and budgetary processes of a municipality, leading to availability of funding for implementation of sustainable waste management practices.

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