Chapter 4

COSTS AND REVENUES OF AWT OPTIONS



4. Costs and Revenues of AWT Options

Key aspects on costs and revenues of AWT options that are generic for all the AWT options is presented in this knowledge product. Collection and transfer also influence the overall cost of the integrated waste management system when an AWT is introduced and a change is made from a linear model to application of a multi-dimensional system.

4.1 Cost Benchmarking

It is challenging to identify meaningful cost benchmarks for implementing AWT in South Africa. Therefore based on a review of international literature, one particular source herein referred to as the *"Pfaff-Simoneit Study"* covers the needs of this KP comprehensively.[22]

The *Pfaff-Simoneit Study* includes estimations of costs for four income categories, including upper middle-income countries (the income category in which South Africa can be placed). Benchmarks for South Africa are comparable to those in upper-middle income countries, but, are adjusted based on the review of South African case and feasibility studies.

The cost benchmarks presented in this KP should be regarded as indicative and not definitive. The purpose of the benchmarks is to aid in the scoping of AWT projects, and to help readers understand the costs (both in terms of magnitude and type) generally associated with different types of AWT facilities.

Cost breakdowns have been presented that show the relative influence of capital and operating costs associated with each technology. In adjusting the international cost benchmarks to South African market conditions, focus has been placed on understanding how the local supply of equipment and spare parts and local maintenance may influence costs, as well as to reflect the costs of labour, fuel and other utilities in the South African context.

4.2 Typical Cost Structure of AWT

AWT technologies present a somewhat similar cost structure in terms of the balance between investment and operational costs, and in terms of equipment required for the actual treatment or pre-processing of waste and operational requirements. Specific cost structures associated with different AWT technology are described, together with case studies from South Africa.

A key component of the methodology used in this KP includes analysing data from feasibility studies developed within the South African context. Although adjustment to costs, expenditure, and revenues to obtain current uniform data does pose a threat.

Considering the earlier-mentioned constraints, unadjusted data has been presented in this knowledge product.

The typical cost structure in the project preparation, investment and operational phase for the AWT technologies is presented in Table 4. The transaction costs are costs that are incurred during preparation and prior to the commencement of the investment phase. If transaction costs are too high, they may impede otherwise viable projects.

22 *Pfaff-Simoneit W., 'Entwicklung eines sektoralen Ansatzes zum Aufbau von nachhaltigen Abfallwirtschaftssystemen in Entwicklungsländern vor dem Hintergrund von Klimawandel und Ressourcenverknappung' [Developing a sectoral approach to establishing sustainable waste management systems in developing countries in the context of climate change and resource scarcity], PhD Thesis, Rostock University, Faculty of Agro-Environmental Sciences, 2012*

Table 4: Transaction cost structure in the project preparation phase

Cost category	Notes
Feasibility study and technical design	5 to 10% of the total investment costs. The most expensive phase is the detailed technical design.
Permitting (including environmental impact assessment (EIA) and technical documentation needed for permitting, site selection and specialist studies)	3 to 5% of the total investment cost, depending on the difficulty of procedures and compliance.
Market research	Regularly part of the feasibility study. This merits special attention. Market research may be omitted at times for waste management tenders by public authorities, but is crucially important for AWT outputs.
Setting up the financing scheme	Often the source of financing is a combination of public and private funds in the case of AWT. Putting together options for the financing scheme becomes part of the feasibility study.
Contracting and negotiations	Since municipal waste is municipally owned, setting up AWTs will almost always involve public tendering procedures. Public procurement (tendering) can be a lengthy and expensive process, as professional advice is likely to be involved. Initiating public private partnerships adds additional complexity to the procedures.
Construction supervision	Along with the construction, contracting a separate construction supervision contract is needed to monitor and control the construction works. This may be tendered and allocated together with the detailed design.

Table 5 and Table 6 provide the typical cost structures for investment and operation respectively. The most important cost categories are listed and may be used as a checklist to verify if all costs were included when considering AWT investments.

Table 5: Typical investment cost structure

Investment phase	Description and notes
Land acquisition	Planning of waste management facilities can be a significant cost. However, industrial land is relatively cheap. The land footprint required for the different facilities is presented in the subchapters to follow.
Site infrastructure	• Paved areas, concrete works • Water supply, access to utilities • Effluent disposal/storing facilities • Road infrastructure
Supporting infrastructure	• Buildings • Weighbridges • Offices • Fencing and security systems
Equipment	Equipment needs depend on the type of AWT technology implemented. Typical equipment that will be necessary for most technologies include various vessels, sieves, separators, loaders, conveyors, temperature monitoring and control and in some cases odour control equipment, blowers, fans and filters, etc. Some of the equipment is locally produced and available, whilst other equipment needs to be purchased from outside the country.
Regulatory compliance	Includes all necessary permits and approvals.

Table 6: Typical operation cost structure

Operational phase	Description and notes
• Labour • Fuel • Energy and utilities • Maintenance and repairs • Disposal of rejects • Feedstock costs • Additives and consumables • Overhead (office supply, communication, etc.) • Advertising, promotion, awareness raising • Taxes and insurance • Monitoring and reporting to environmental and public health agencies	Labour costs include normal salaries and wages, bonuses, overtime costs, allowances, fringe benefits and social contributions, etc. Some technologies may have the need for highly specialised personnel; various technologies can include phases/departments that can be either labour intensive or fully mechanised, depending on local factors. Typical labour requirements may include heavy equipment operators, maintenance personnel, instrumentation/computer operators, administrative support and management. Overhead costs and recurring hidden costs are part of operations and often left unaccounted for. This list shows the cost categories and budget lines that belong to operation costs but sometimes get lost in other municipal budget lines. Private operators do not always incur all of these costs. Depending on the service contract between the municipality and operator, these may be with the municipality or the operator[23].

Operation costs are more challenging to estimate than capital costs, but need the same degree of rigour in order to inform decision-making. It is essential to ensure that the chosen technology can be sustained by revenues and gate fees.

4.3 Typical Revenue Structures of AWT

Revenues from AWT have a series of influencing factors, from the types of outputs of different technologies to local policy and market conditions.

The outputs of the AWT technologies described in KP2 and analysed from an economic point of view in this KP include: Compost and compost-like outputs, aggregates, different recyclables, refuse-derived fuel (RDF), biogas/ biofuel and energy (heat and/or electricity).

One of the factors that most influences the revenues from AWT is the existence of a market for the outputs and their market prices and fluctuations. Other factors influencing revenues from AWT include: Quality requirements, levels of contamination, additional processing costs for outputs, opportunity for use of by-products (such as residual heat from some AWT options), disposal costs for rejects, distance to market for outputs, the availability of feedstock for technologies and government incentives, as examples.

Some outputs, such as compost of good quality and minimum contamination, can be a turning point in obtaining revenues, as there is a high demand in South Africa for good quality compost for organic crops. Compost and compost-like outputs are a result of composting, anaerobic digestion or MBTs. However, good quality compost is much more likely to be obtained (and at a lower overall cost) from simple composting of source-segregated green garden waste than from other technologies. This is a clear example of how the market conditions may deem a type of AWT as being ‘promising’ over another.

Carbon financing is widely used internationally and is linked to the greenhouse gas (GHG) emissions reduction impact of the investments. Financing is allocated when the GHG emissions reductions are achieved, monitored and verified. South Africa has benefited from carbon financing through project-based initiatives and a Nationally Appropriate Mitigation Action, which may contribute to revenues.

Specific revenue-influencing factors for each type of AWT are provided under the technology subsection of this KP (Chapters 5-7).

23 *Technology Fact Sheet, In-Vessel Composting of Biosolids, EPA 832-F-00-061; Costs for municipal waste management in the EU, Final report to Directorate General Environment, European Commission, Eunomia Research & Consulting Ltd. EPA US, Biosolids*

4.4 Collection and Transfer

Advanced waste treatment technologies have specific feedstock requirements in terms of quantity and quality. As shown in Figure 4: An illustration of AWT options, costs and non – tariff revenues per waste stream and collection types, for example, recycling and composting is best done from source-segregated waste streams, thus separate collection systems need to be in place. For some thermal treatment options, mixed waste is acceptable as feedstock but where economies of scale are required, regionalisation of waste collection and the introduction of transfer stations may be required.

Case Study 1: Source segregation and separate collection of recyclables adds costs to the collection system in Cape Town

The City of Cape Town has drop-off centres that divert recyclables. During 2012, 2 000 t of recyclables were diverted through these centres. The costs of developing new drop-off centres has been estimated at approximately 5 million ZAR as investment costs, and approximately 8 million ZAR per year for operational costs depending on the size of the facility. The example highlights that setting up collection systems for source-separated recyclables will require investment.

The opportunity for collecting dry recyclables separated at source, was studied both in formal and informal settlements in Cape Town and piloted in the city centre. Studies indicated that this type of collection is not easy to implement as a stand alone service, capture rates are low, and the waste streams in the informal settlements do not contain such high amounts of recyclables, and the cost of the collection is high. The conclusion of the study was that outsourcing collection of source-separated recyclables as a single activity is not sustainable as it increases the additional costs to the City for collection significantly, and, does not have a major diversion impact due to the low capture rates. This also may be the reason why Cape Town decided to pilot outsourcing separate collection together with operation of an MRF at Kraaifontein. Other municipalities could also explore such options for implementation, given cost implications.

The Council for Scientific and Industrial Research (CSIR) study on the cost of collection for source-separated materials provides an in-depth study that considers different solutions for collection, taking into account current trucking capacities and actual distances. The preliminary results of the study indicated that the cost of collecting source-separated materials is cost efficient when it is organised through small and medium-sized enterprises, using labour intensive methods[24]. The initial set of results were favourable and added to the financial attractiveness of AWT options. The findings of the study are expected to assist in identifying solutions that are sustainable and the type of conditions needed in place for introducing the collection of source separated waste.

The costs of both direct hauling of waste to landfill and hauling to a transfer station should be compared in determining the feasibility. A site-specific calculation has to be conducted to establish the minimum distance beyond which introducing a transfer station is cost-effective for certain planned/estimated waste quantities. Therefore, the cost of the transfer station, the direct haul payload, the transfer haul payload and the trucking costs need to be known.

Once these values are known, the following formulas can be used to roughly calculate cost at different distances:

$$\text{Cost of direct haul (without the use of transfer station)} = \left(\text{Distance (km)} \times \text{Trucking cost (ZAR/km)} \right) / \text{Direct haul Payload (tonnes)}$$

Figure 7: Calculating cost of direct haul

24 *Personal communication between authors and CSIR*

As the calculation in Figure 8 shows, the costs (ZAR/t) of hauling waste to landfill depends on the total distance, costs of transport, and the capacity of the trucks.

$$\text{Cost of transfer haul} = \left[\left(\text{Distance (km)} \times \text{Trucking cost (ZAR/km)}\right) / \text{Transfer haul Payload (tonnes)}\right] + \text{Transfer station cost (ZAR/t)}$$

Figure 8: Calculating cost of transfer

Once the costs of direct haul and potential economic use of a transfer station are calculated, these can be plotted on a graph to see where the break-even point is and thus what the lowest cost option would be depending on the distances involved. An example is shown in Figure 9.

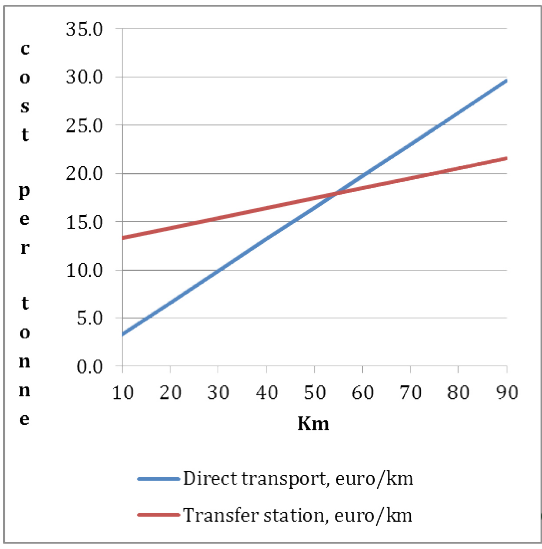

Figure 9: Example break-even point for the necessity of transfer station[25]

Figure 9 illustrates that building a transfer station may be financially justified if the haulage distance is longer than 55 kilometres for the specific case studied and for the amount of waste to be handled in the specific geographical project boundary. In other instances, this may be as low as 15-20 km, depending on the cost efficiency of the collection and transport equipment and the specific costs of the transfer station.

25 Courtesy of RWA Group, 2014 South Region of the Republic of Moldova

Case Study 2: Analysis of the feasibility of a transfer station at Linbro Park, Johannesburg

Table 7: Cost comparison among transfer station technologies[26]

	Unit	Static compactor	Open top	Baling
Specific investment cost	ZAR/tonne	561	480	411
Specific transport cost	ZAR/tonne	86	95	64
Specific Operation & Maintenance cost	ZAR/tonne	87	100	98
Total	**ZAR/tonne**	**734**	**675**	**573**

The conclusion on the preferred method for transfer needs to take into account a variety of significant factors, such as operation, maintenance and capital costs of each option. Also, the impact that the chosen technology may have on landfilling, and the sensitivity of the technology to economies of scale are amongst other considerations. Table 8 summarises the advantages and disadvantages of the solutions considered for the Linbro Park feasibility study.

Table 8. Advantages and disadvantages of the static compactors, open top containers and baling[27]

Technology	Advantages	Disadvantages
Static compators	Lowest operating cost for large quantities of waste Lowest total life cost for haul distances less than 40 km	Highest capital cost Containers need to be replaced Control of payload can be difficult
Open top containers	Rather low operating cost in case low quantities of waste are handled Low capital cost Well suited for smaller volumes No impact on operation of landfill	High operating cost in case large quantity is handled, due to lower payloads Highest total life cost Containers need to be replaced more regularly than reinforced containers More regular repairs required on containers
Baling	Low capital cost Optimised payload Lowest total life cost for haul distances greater than 40 km	High operating cost Changes the way the landfill is operated Difficult to use on existing landfill (i.e. requires dedicated cells) Leachate generation quantities at landfill are unknown; leachate needs to be treated Impact on gas generation likely to be negative

The feasibility study concluded that the further away the destination landfill, the greater the financial savings and shorter the payback period of the capital investment for the Linbro Park regional transfer station. The annual savings on transport costs from the initiative was projected between 30 million ZAR and 60 million ZAR depending on the location of the final disposal landfill, implying a saving of between 170 to 340 ZAR per tonne of waste.

The considerations related to changes in collection and transfer of waste and the cost of these elements are often coupled with the introduction of AWT in the process flow. Cost changes for source-separated collection of waste may not be significant in South Africa and longer hauling for large capacity plants may be optimised through transfer stations.

26 *Calculated from Jeffares & Green Pty (Ltd), 'The Feasibility Study, Project Appraisal and Definition and Preliminary Design of a Waste Transfer Station and Materials Recovery Facility at Linbro Landfill site', for Pikitup Johannesburg Ltd., Contract No. PR114/2011, July 2011 (page 107)*

27 *Idem, page 112*

4.5 Cost Benchmarks for AWT Technologies

Benchmarking costs and revenues can be helpful in assessing AWT projects and guiding the business scoping process. In general, it can be assumed that AWT facilities can be implemented in South Africa at lower costs to those in Europe and other industrialised countries. However the extent to which this is the case depends on the type of technology.

Table 9 summarises expected cost ranges for the AWT options. The information provides an indication for the budgeting requirements of proposed AWT options, and may be helpful in benchmarking tenders and proposals. **The table should, however, be interpreted as indicative rather than definitive.** The costs presented take into account the existing case study experiences, levels of income, wages, availability of equipment, and options for maintenance and repair locally or abroad for the various necessary equipment.

Table 9: Summary of expected cost ranges for treatment options in short, medium and long term

Technology	Range of full specific cost ZAR/t	Investment cost as estimated % of full cost	O&M costs as estimated % of full cost
Business as usual			
Landfilling	200 – 400	67[28]	33
Promising technologies – short-term			
Windrow composting	300 – 400	40	60
Construction and demolition waste recycling	<300	50	50
Materials recovery facilities	300 – 400	50	50
Potential technologies – medium-term			
Simple mechanical biological treatment (MBT)	300 – 500	50	50
MBT with intensive decomposition and fermentation	700 – 900	60	40
Anaerobic digestion	700 – 800	50	50
In-vessel composting	>600	50	50
Potential technologies – long-term			
Incineration with energy recovery	1,200 – 1,500	62	38
Mechanical and heat treatment	600 – 700	55	45
Advanced thermal treatment - gasification	1,300 – 1,700	62	38
Advanced thermal treatment - plasma gasification and pyrolysis	1,300 – 1,700	62	38

Table 9 summarises the benchmarks that are likely to be expected for the different technologies in South Africa. The promising technologies, the potential technologies – medium-and long-term will be discussed each in turn in Chapters 5, 6 and 7. The detailed description will give information on typical capacity, labour intensity, specific costs, cost breakdown and factors influencing revenue for each technology in turn.

Each technology was individually reviewed within a global context and adjusted to the South African situations. In the frame of a Section 78 Assessment Report for Cape Town a range of AWT technologies for the geographic scope of the city were analysed and the results are presented in Table 10.

28 *This includes all capital costs of phased site development, closure and aftercare*

Table 10: Findings of the MSA Section 78 Assessment Report for the City of Cape Town[29]

- Direct and indirect costs per tonne diverted are lowest for the C&D/builders' rubble, net savings of 50 – 75 ZAR/tonne can even be achieved, followed by;
- Organic waste management at an additional cost 750 – 960 ZAR/tonne;
- Waste recovery 1,380 – 1,470 ZAR/tonne;
- Co-mingled waste treatment 1,350 – 1,660 ZAR/tonne,
- The most expensive treatment, the household hazardous waste, 2,900 – 3,500 ZAR/tonne.

Table 10 reflects on cost ranges for similar AWTs as those included in the scope of KP4. The lowest cost options include builders rubble (construction and demolition waste) treatment and the treatment of the organic fraction of waste. These are adopted in KP4 as 'Promising technologies for the short-term'. Co-mingled waste treatment (MRF, MBT) are mid-range in terms of cost and may be attractive depending on market conditions and enabling environment are included in this KP4 as 'Potential technologies for the medium-term'. Other, thermal, waste treatment options such as incineration with energy recovery, mechanical heat treatment, pyrolysis and gasification are classified as 'Potential technologies for the long-term'.

The conclusions of the MSA Section 78 Assessment Report for the City of Cape Town presented in Table 10 are similar in terms of cost ranges to the ranges presented in KP4 (Table 9). The findings reinforce each other.

4.6 Concluding Remarks

The chapter has introduced a common language for investment costs, operation costs and revenues in waste management. Some of the costs described are hidden in different departments of a municipality and are not immediately obvious but are going to be important to consider once a service is outsourced or new investments are made. The cost structures presented in this chapter can be followed as a checklist for benchmarking purposes.

The revenues for AWT are diverse, and depend on the specific outputs. Most AWT facilities will need to complement revenue sources from economic incentives, grant financing, public financing or gate fees. Carbon financing is a revenue source that is gaining importance.

Whenever a new technology is introduced, the need to adapt the collection system should also be reviewed at. Organising collection of source-separated materials and/or introducing transfer stations may be required depending on the technology selected.

The cost benchmarks presented are a summary and a guide to reading the following chapters that provides details on costs and revenues of each subgroup of technologies; Promising technologies – short term (*Chapter 5*), Potential technologies – medium-term (Chapter 6) and Potential technologies – long-term (Chapter 7).

29 Akhile Consortium, MSA Section 78(3) to Assess Alternative Service Delivery Options, RFP No. 554C/2008/09, Consolidated Report, Solid Waste Management Department, Cape Town Municipality, May 2011, Executive Summary