REPORT 2

TECHNOLOGIES & PRACTICES: Review of ESD factors, costs, feasibility and environmental performance of alternatives

Prepared for

THE TOTAL ENVIRONMENT CENTRE

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1 STUDY BRIEF AND SCOPE OF REPORT

The Total Environment Centre (TEC) received funding to assist in the preparation of submissions by community groups to the NSW Government's Alternative Waste Technologies and Practices Inquiry. The governments call for submissions stated that:

> "The purpose of the public inquiry is to investigate current and emerging waste management technologies and practices, taking into account the principles of ecologically sustainable development.
>
> The Terms of Reference of the Inquiry are as follows:
>
> "Describe and assess current and emerging waste management technologies and practices in Australia and overseas. These technologies are to be assessed in terms of:
> 1. Potential impact on the environment in terms of local, regional and global air, land and waster impacts and amenity
> 2. Contribution to waste avoidance and beneficial reuse of resources
> 3. Contribution to waste reduction
> 4. Environmental and economic benefits and costs of the alternative technologies and expressed: per tonne of waste input: per tonne of waste diverted from landfill; per tonne of recovered secondary resources or recovered energy value
> 5. technical performance and operational reliability
> 6. factors effecting the capacity for accelerating the implementation of alternative waste management technologies and practices in NSW in the short, medium or long term"

Environment groups are particularly concerned about establishment of mega-tips (city and country) for Sydney's waste and are focusing on environmentally acceptable alternative technologies and policy tools.

To assist community groups develop responses to the Government's Inquiry the TEC sought assistance from consultants to prepare reports on:
1. The likely (segregated) waste streams in firstly, the Sydney / Newcastle / Wollongong region and secondly a "typical' coastal region over the next 5, 10, 20 years – assuming major landfill and inclusion of other management regimes reasonably anticipated by waste management authorities.
2. A brief review of alternative technologies and practices in terms of feasibility (short, medium, long term) and assessment against ecologically sustainable development (ESD) principles and the inquiry terms of reference and employment generation.
3. A practical alternative waste management plan for the segregated waste streams for the next 5, 10, 20 years for Sydney / Newcastle / Wollongong region and "typical" coastal region that minimises landfill and maximises reuse and waste minimisation with data on resulting employment and economic activity.
4. Removal of barriers to accelerated implementation of the alternatives.

In response to the terms of reference of the Government's Inquiry into alternative waste technologies and practices this report only deals with technologies and practices applicable to management of solid wastes that are regulated under the *Waste Minimisation and Management Act 1995* (WMMA). This report covers the issues in item 3 of the TEC brief described above.

1.1 Defining key terms

Throughout the waste planning and management field and literature in NSW there is a good deal of variation in terminology and its manner of use. As such following are definitions for terms used in this report.

ESD: *Ecologically sustainable development* is the principle under which development and activities in solid waste management should be undertaken as required by the *Waste Minimisation and Management Act 1995.* ESD:

Is considered to be the effective integration of economic and environmental considerations in decision-making processes, and can be achieved through the implementation of the following principles and programs:

(a) the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:
(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and
(ii) an assessment of the risk-weighted consequences of various options,

(b) inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations,

(c) conservation of biological diversity and ecological integrity—namely, that conservation of biological diversity and ecological integrity should be a fundamental consideration,

(d) improved valuation, pricing and incentive mechanisms—namely, that environmental factors should be included in the valuation of assets and services, such as:
(i) polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement,
(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and

services, including the use of natural resources and assets and the ultimate disposal of any waste,
(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

LCA: *Life cycle assessment* – a tool for studying, analysing and assess the environmental impacts of material and products use.

Recycled: The term "recycled" in this document is to be taken as a general description of a material that has been made available as material for re-manufacturing or further processing to ensure its remanufacture.

Recyclable: Materials that are potential materials for reuse or recycling are described as "recyclable".

Direct recycling: Direct recycling means the processing of material into a similar non-waste product. That is the recycling of plastic bottles into plastic bottles.

Indirect recycling: Indirect recycling means the recycling of a material into another product via a transformation process. For example the recycling of plastic bottles into plastic chairs or the combustion of plastic to produce energy.

Technology: We adopt the broad definition of technology as being the terminology of an art, science etc. Where necessary we define particular types of technologies, ie technical (hard) or sociological (soft) technologies.

Waste management: Any reference to waste or waste management throughout this report, unless otherwise stated, relates to non-hazardous solid waste and its management, (although we recognise household hazardous type wastes are important in planning and managing solid waste streams we do not consider these in any particular detail). Any reading of the term "waste" should therefore be read in reference to this context.

1.2 Study boundaries and focus

It is important to recognise the parameters for the current debate of "technologies" and "practices" in the area of waste management are not fixed within society. In fact there are many ways that persons, groups, governments, associations etc. perceive, relate to and or approach the topic of waste and waste management.

In recognition of this we define and present the study boundaries used in the reports.

Firstly, we take a "systems" approach in dealing with society management of wastes where a number of technologies and approaches (practices) occur within the waste management system shown in Figure 1-1.

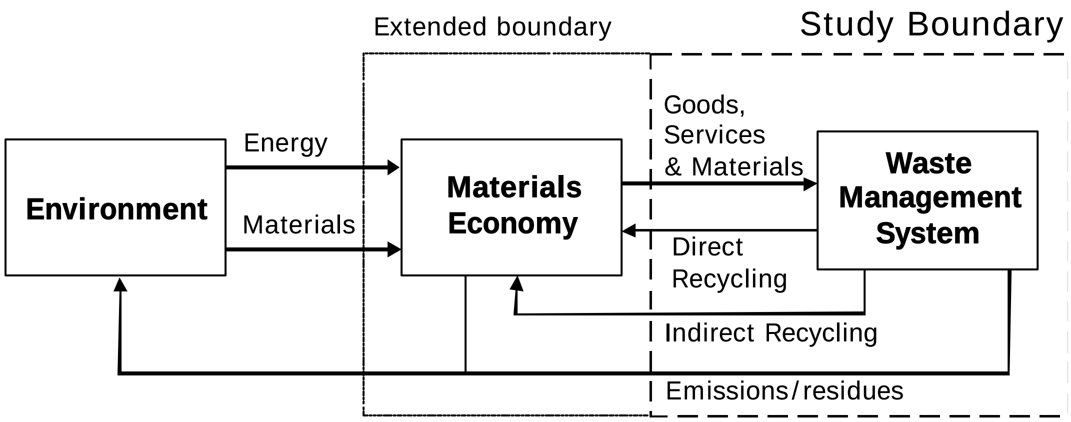


Figure 1-1: System boundaries under study

Within the materials-economy there are many and numerous complex relationships. These result from the many materials types chosen and used in the materials-economy and it involves the many and varied management styles and methods used to provide and move these through the materials-economy. This we can define as the waste management *problem*

It is not within the scope of this work to be able to explore, describe or evaluate all complexities within the *problem*. Our approach has been defined by the consultancy brief and terms of reference of the Inquiry and as such our view of the *problem* has needed to allow for a wide rather than narrow review and assessment of current and potential alternatives available within, the "waste management system" (Figure 1-1).

We have therefore developed our reports around materials (presenting as wastes) within the material economy and the management of these materials.

2 INTRODUCTION

2.1.1 Overview

The following report presents information to support element 2 of the TEC brief by:

1. Considering the potential impacts of a variety of alternatives to the existing management of wastes using the total waste flow from the Municipal and Commercial and Industrial sectors, and
2. Reviewing the feasibility of alternatives in regard to the Inquiry Terms of References

Although a substantial amount of quantitative information is presented this report it is not and cannot be considered a full quantitative assessment of current waste management systems in the Greater Sydney Region (GSR). This is stated to remind the reader of comments made in Report 1 that the current quality and availability of information on environmental and social factors and preferences for decision-making in waste management is inadequate and that it is outside the scope of this work to conduct those evaluations.

It is hoped the Waste Technologies and Practices Inquiry may fill some of these gaps.

This situation, although a barrier to detailed and proper integrated planning and management for development of a sustainable approach to waste management in the GSR, does not preclude preliminary and constructive consideration of alternatives and their potential to provide outcomes for a sustainable integrated waste management system.

Wastes generated in the GSR [1] have been used to examine a range of aspects of technologies and practices:

- Resource efficiency type measures (avoidance, reduction and reuse)
- Resource recovery (recycling)
- Where possible, case studies are used to illustrate how alternative technologies and or practices have been applied in Australia and overseas
- Where available, economic and employment impacts of various approaches are reported, otherwise estimates are made
- Barriers are reviewed and comment is made on the ecological sustainability and environmental impacts of technologies and practices

A number of key issues regarding assessment of different approaches to waste management are critical in determining feasibility of alternative technologies and practices. Some of the questions that are relevant here include:

- the scale at which technologies are implemented,

1 Based on 1996 waste production rates as per Report 1

- site specific factors, and
- relative (subjective) valuations of benefits and costs
- societal preferences

Our approach in this report is therefore to:

- highlight ability of technologies and or practices to perform with regard to waste prevention and or reduction in line with the preference for ESD adopted in the WMMA, and
- within the scope of the questions asked as part of the Inquiry Terms of Reference.

To achieve this and to prevent a long and complicated review of all possible alternatives and combination of alternatives we have grouped and focused our discussion of alternatives in broad classes of technologies and practices. The result of this however is that some sensitivity and detail is lost and because, as a category, practices fall within one grouping the amount of discussion provided in this area may create the appearance that practices have less applicability and coverage in alternative future waste management practice. This is not the case. Alternative practices are extremely important and should play an increasing role in integrated waste management and as such a detailed review of issues relating to feasibility is provided as an individual report in Appendix A.

3 PERFORMANCE & FEASIBILITY OF TECHNOLOGIES & PRACTICES

3.1 Introduction

Although ESD is a now a principle focus of waste planning and management in NSW very little work has been carried out to explicitly assess performance of waste management systems or practices against ESD principles. Performance has instead been focused on socio-political and economic outcomes and these usually target issues of waste volume. That is and the social preference used by bureaucrats primarily revolves around public health and environmental protection.

Broader evaluations as per the goals expressed for ESD and called up as being the guiding principles for planning in the *Waste Planning and Management Act 1995* have not been forthcoming. To date, two examples exist that are readily and publicly available which show Waste Board attempts to undertake decision-making for cross-sectorial (economic, social or environmental) outcomes:

- Western Sydney Waste Board's "Cost-benefit analysis of the Western Sydney Regional Waste Plan". The analysis although considering economic and flow on effects on the materials-economy did not evaluate environmental or social performance outcomes, and
- Southern Sydney Waste Board's "Stabilisation/ Pre-treatment Study" which included environmental and economic performance evaluations of alternative waste treatment systems in terms of ability to divert materials from landfill disposal.

ESD evaluations are generally not occurring. Reasons for this are seem to include:

- Planning of integrated solid waste management (ISWM) in Australia has, and remains, focused on treatment and disposal. Data currently generated (ie waste volumes and amounts, composition data current data) therefore does not serve or facilitate broader evaluation or more inclusive evaluations on environmental and social factors and impacts, and
- Current environmental impact planning and assessment has been similarly focused on economic and local environmental impacts and a narrow range of social impacts associated with environmental protection

Processes and tools that assist ESD evaluations have however been developed and these have been used successfully by a number of utilities in Australia, including the energy and water-supply utilities. These can provide guidance and a foundation for developing ESD assessment procedures in the waste management context. Discussion and recommendations on these issues will occur in Report 3 and 4.

It is widely accepted that ESD assessment requires integration and balancing of preferences of the social, economic and environmental held by society as part of decision-making. In Europe and North America both life cycle impact assessment and multi-criteria decision-making have been used to undertake some of the evaluations. These also stand as a base for future works in waste management in Australia. However to be conclusive these methods need to be considered in terms of our own context in regard to our particular industrial base, processes and environmental issues.

Report 1 reviewed both technologies and practices relevant to waste prevention and waste diversion from landfill. The following information builds on that information to outline the benefits and logic of utilising alternatives to improve waste diversion performance generally, whilst also obtaining environmental and social benefits.

4 COMPARISON OF TECHNOLOGY OPTIONS

The work developed in Europe on life cycle inventory assessment of integrated solid waste management systems is used as a basis for the following section. It outlines data generated from a modelling exercise to provide an environmental profile of some of the alternative technologies available for ISWM in the GSR.

4.1 Methodology

4.1.1 Environmental profile

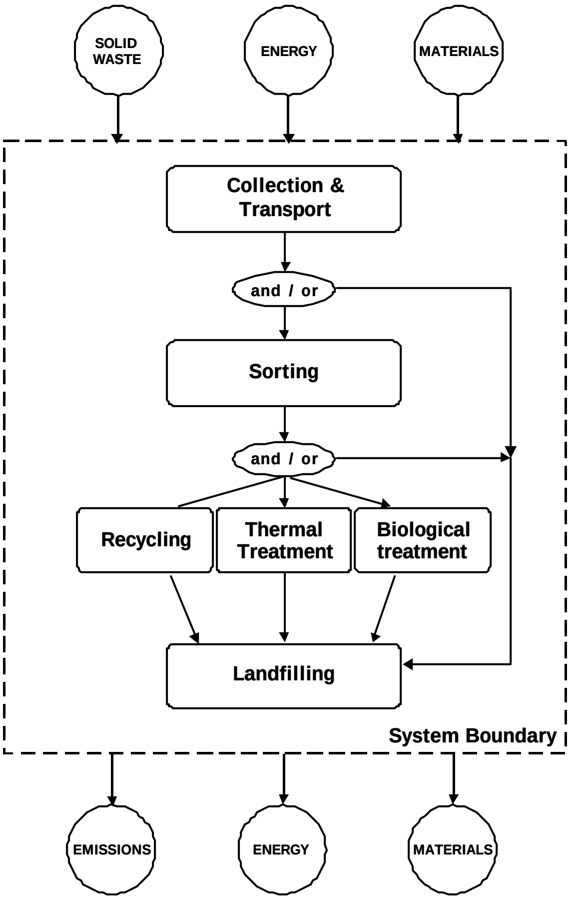
The life cycle inventory model developed by White et al (1997)[2] was used to model current landfill impacts and alternative technologies and mixes of these technologies that might be used in the GSR. The modelling was conducted to assess the potential of the technology to:

- divert materials from landfill disposal, and
- achieve better performance in terms of materials management outcomes of the technology

Comparisons are made by allocating proportions of waste from the total amount generated in 1996 in the Municipal and Commercial and Industrial sectors to one or a number of various alternative technologies. The results are therefore descriptions of the potential alternative outcome within the GSR but they are not real-world comparative technology assessments. These comparisons are useful because the results indicate the differences between technologies although, due to the limitations, these differences are more qualitatively than quantitative.

The system under study in the modelling is within the framework shown in Figure 4-1.

2 White, P.R., Franke, M., Hindle, P. (1997). *Integrated Solid Waste Management: A lifecycle inventory*. Blackie Academic & Professional. Glasgow.



Source: Adapted from White et al (1997)

Figure 4-1: Boundaries for lifecycle inventory of wastes

In lieu of available Australian based life cycle information for industrial processes, the profiles generated have been developed using the Western European data that are included in the model.

Waste material flow data for the GSR however is used for:
- Defining the total and sub-flows of wastes in the “system” within the modelled waste management system (Figure 4-1), and
- Waste composition.

A profile for a number of potential ISWM systems has been developed here to compare the performance of the potential alternatives. Each profile consists of:
- environmental impacts from air and water emissions,
- energy resources used and net energy outputs within the system, and
- residual solid waste outputs from the system under study.

The alternatives assessed are:

- Benchmark: Landfill; kerbside recycling [A] and no energy recovery (this is the current ISWM system, and used for comparison with alternative ISWM systems)
- Alternative 1: Landfill, kerbside recycling [A] and energy recovery at landfill
- Alternative 2: Mass-burn for energy recovery, kerbside recycling [A] and landfilling of residue from mass burn activity
- Alternative 3: Densified refuse derived fuel (dRDF) production and combustion for energy recovery, kerbside recycling [A] and landfilling residues from dRDF combustion
- Alternative 4: Organics composting for production of recyclable organic materials, dRDF production and combustion for energy recovery with residue landfilling and kerbside recycling [A]
- Alternative 6: Mixed waste composting for production of recyclable organic materials, wastes with landfilling of residues from composting process, energy recovery from landfill gases, and kerbside recycling [A]
- Alternative 5: Gasification for energy recovery with residues of processing to landfill and kerbside recycling [A]

Notes: A – recycling at 1996 rates and composition

To compare outcomes of the alternative systems, each data point has been turned into a ratio that is comparing the life cycle inventory result for the alternative against the Benchmark system. Table 4-1 provides the results and it shows the actual life cycle inventory output data for the Benchmark and the ratio for each other alternative compared to that number. Inventory data has been provided for the Benchmark and a ratio of the technology data to the Benchmark is provided for the alternatives. Environmental data has however been rated as either higher lower or the same as the Benchmark model data outputs. Table 4-2 provides the results expressed as a per tonne value of total waste managed.

4.1.2 Economic Profile

As outlined earlier proper ESD evaluations require the balancing of economic, social and environmental preferences for waste management planning. Economic data relating to decision making in waste management is presented. This includes costs for various waste management services and where available, related economic data such as employment in waste technologies

4.2 Results

Table 4-1 provides the results of the comparisons made between the technologies and groups of technologies against the current approach to waste management in the GSR. Broadly, the results can be summarised as follows.

4.2.1 Energy conversion/ recovery

Significant energy recovery potential exists within the waste streams being landfilled. Much of energy is sourced from organics that are a renewable resource within the wastes. A number of technologies individually or in combination have the potential to recover and convert the energy stored in wastes. The combination of dRDF and gasification shows on preliminary assessment the highest recovery potential of all technologies.

4.2.2 Final solid waste

The comparisons show all technology options can significantly deliver reduction effects in terms of weight and volume of materials currently disposed to landfill. Specifically the technologies for energy recovery, ie mass-burn, dRDF production and gasification show the greatest potential for benefits from reduction in mass and volume.

The benefits of reduction need however to be balanced against the potential lost benefits of recovering valuable resources that exist in waste streams that will be destroyed if combusted. Much of the energy potential comes from renewable organics, that is food, garden/ vegetation type wastes as all models assessed included recycling as a part of the management regime and this would have reduced significantly the total thermal value of mixed wastes.

Generally though the results indicate:

- a suite or mix of technologies could be developed to deliver a range of outcomes that provides for reduction in materials sent to landfill,
- recovery and utilisation of renewable energy sources can be developed within an ISWM system to reduce environmental impacts (see below), and
- Deliveries of secondary resources (eg compost products and dry recyclables) result from direct and or indirect recycling activities.

4.2.3 Environmental emissions

Initial examination of the data presented does not show the true environmental impacts of the emissions from air and water. To assess this further life cycle assessment is required to properly determine the scale and effect of the various pollutants in the environmental emissions occurring due to the alternative systems.

From the data shown however it can be stated that:

- generally all alternatives show increase in the amount of air emissions against reductions in water emissions and these. This is expected considering the change in process is from land disposal where the major route for discharge is water-leaching of materials within the landfill to combustion of materials for energy recovery with resultant emissions by the technology to air,

- particulate and smog pollutants (SOx, NOx) increase due to combustion, and
- water pollutants associated with eutrophication, oxygen depletion and metals decrease due to combustion.

Table 4-1: Results of lifecycle inventory assessment for ISWM alternatives

ENVIRONMENTAL IMPACTS		Landfill (no energy recovery) & Recycling	Landfill (energy recovery) & Recycling	Mass Burn for energy recovery & recycling	RDF, recycling & residue landfilled	RDF, composting, recycling & residue landfilled	RDF, gasification, recycling & residue landfilled	Composting, Recycling, Landfill with energy recovery	Gasification, Recycling & Residues to landfill
ENERGY									
Consumption	Diesel(transport) 000 litres	37,213.01	same	0.95	same	0.97	1.03	0.97	0.97
	TOTAL GJ Thermal	1,860,537.63	same	1.85	2.37	1.46	2.60	1.46	1.77
Recovery	NET ENERGY USE GJ th	475,887.25	-5.73	-20.77	-18.67	-7.66	-22.59	-7.66	-12.47
FINAL SOLID WASTE									
	non-hazardous (kt)	3,600.21	same	0.19	0.21	0.43	0.24	0.43	0.37
	hazardous (kt)	5.68	same	11.26	1.21	0.43	1.24	0.43	0.38
	TOTAL WEIGHT (kt)	3,605.88	same	0.21	0.21	0.43	0.24	0.43	0.37
	TOTAL VOLUME (000m3)	1,797.86	same	0.32	0.39	0.77	0.43	0.77	0.69
EMISSIONS									
Air emissions(kg)									
	Particulates	-983,277.42	higher	higher	higher	higher	higher	higher	higher
	CO	845,058.60	higher	higher	lower	lower	lower	lower	lower
	CO2	600,435,321.15	higher	higher	higher	higher	higher	higher	higher
	CH4	220,883,427.26	lower	lower	lower	lower	lower	lower	lower
	NOx	902,589.60	lower	same	lower	lower	lower	lower	lower
	N2O	-7,459.17	higher	higher	higher	higher	higher	higher	higher
	SOx	-34,553.75	higher	lower	higher	higher	higher	higher	higher
	HCl	36,458.04	lower	higher	higher	lower	higher	lower	lower
	HF	9,146.88	lower	higher	lower	lower	lower	lower	lower

ENVIRONMENTAL IMPACTS		Landfill (no energy recovery) & Recycling	Landfill (energy recovery) & Recycling	Mass Burn for energy recovery & recycling	RDF, recycling & residue landfilled	RDF, composting, recycling & residue landfilled	RDF, gasification, recycling & residue landfilled	Composting, Recycling, Landfill with energy recovery	Gasification, Recycling & Residues to landfill
	H2S	111,700.94	lower	lower	lower	lower	lower	lower	lower
	HC	800,188.55	lower	higher	higher	higher	higher	higher	higher
	Chlor. HC	19,678.56	lower	higher	same	lower	higher	lower	lower
	Dioxins/Furans (TEQ)	0.00	same	same	same	same	same	lower	lower
	Ammonia	-1,170.32	higher	higher	higher	higher	higher	higher	higher
	Total metals	435.59	lower	higher	higher	higher	higher	higher	higher
Water emissions(kg)									
	BOD	219,989.82	same	lower	lower	lower	lower	lower	lower
	COD	-924,502.47	same	higher	higher	higher	higher	higher	higher
	Suspended Solids	17,857.15	same	lower	lower	lower	lower	lower	lower
	Total Org. Compounds	16,880.02	lower	lower	lower	lower	lower	lower	lower
	AOX	163.39	same	higher	higher	higher	higher	higher	higher
	Chlorinated HCs	167.03	same	lower	lower	lower	lower	lower	lower
	Dioxins/Furans (TEQ)	0.00	same	lower	lower	lower	lower	lower	lower
	Phenol	1,473.53	same	lower	lower	lower	lower	lower	lower
	Ammonia	33,963.52	lower	lower	lower	higher	higher	higher	higher
	Total Metals	33,311.95	same	lower	lower	lower	lower	lower	lower
	Total Salts	83,073.95	lower	lower	lower	lower	lower	lower	lower

Note: Negative values indicate overall reductions in energy consumption or production of emissions

Table 4-2: Results of lifecycle inventory assessment for ISWM alternatives (Adjusted to per tonne of waste managed)

		Landfill (no energy recovery) & Recycling	Landfill (energy recovery) & Recycling	Mass Burn for energy recovery & recycling	RDF, recycling & residue landfilled	RDF, composting, recycling & residue landfilled	RDF, gasification, recycling & residue landfilled	Composting, Recycling, Landfill with energy recovery	Gasification, Recycling & Residues to landfill
		per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne
ENERGY	Diesel 000 litres	0.0103	0.0103	0.0098	0.0103	0.0100	0.0106	0.0100	0.0100
Consumption	Electricity MW h	0.0000	0.0000	0.0479	0.0495	0.0262	0.0609	0.0262	0.0436
	Natural gas ,000 cu m.	0.0000	0.0000	0.0001	0.0056	0.0000	0.0056	0.0000	0.0000
	TOTAL GJ Thermal	0.5161	0.5161	0.9547	1.2222	0.7515	1.3430	0.7515	0.9159
Recovery	Electricity MWh	0.0000	0.8890	1.8641	1.6746	0.1007	2.3129	0.1007	0.9005
	TOTAL GJ Thermal equiv.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	NET ENERGY USE GJ th	0.1320	-0.7570	-2.7418	-2.4649	-1.0106	-2.9824	-1.0106	-1.6461
FINAL SOLID WASTE	non-hazardous (kt)	0.9987	0.9941	0.1933	0.2118	0.4274	0.2369	0.4274	0.3737
	hazardous (kt)	0.0016	0.0016	0.0177	0.0019	0.0007	0.0019	0.0007	0.0006
	TOTAL WEIGHT (kt)	1.0002	0.9956	0.2111	0.2137	0.4281	0.2389	0.4281	0.3743
	TOTAL VOLUME (000m3)	0.4987	0.4987	0.1585	0.1934	0.3840	0.2128	0.3840	0.3423

		Landfill (no energy recovery) & Recycling	Landfill (energy recovery) & Recycling	Mass Burn for energy recovery & recycling	RDF, recycling & residue landfilled	RDF, composting, recycling & residue landfilled	RDF, gasification, recycling & residue landfilled	Composting, Recycling, Landfill with energy recovery	Gasification, Recycling & Residues to landfill
		per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne
EMISSIONS									
AIR EMISSIONS(kg)	Particulates	-0.2728	higher	higher	higher	higher	higher	higher	higher
	CO	0.2344	higher	higher	lower	lower	lower	lower	lower
	CO2	166.5563	higher	higher	Higher	higher	higher	higher	higher
	CH4	61.2714	lower	lower	lower	lower	lower	lower	lower
	NOx	0.2504	lower	same	lower	lower	lower	lower	lower
	N2O	-0.0021	higher	Higher	higher	higher	higher	higher	higher
	SOx	-0.0096	higher	lower	higher	higher	higher	higher	higher
	HCl	0.0101	lower	Higher	higher	lower	higher	lower	lower
	HF	0.0025	lower	Higher	lower	lower	lower	lower	lower
	H2S	0.0310	lower	lower	lower	lower	lower	lower	lower
	HC	0.2220	lower	higher	higher	higher	higher	higher	higher
	Chlor. HC	0.0055	lower	higher	same	lower	higher	lower	lower
	Dioxins/Furans (TEQ)	0.0000	same	same	same	same	same	lower	lower
	Ammonia	-0.0003	higher	higher	higher	higher	higher	higher	higher
	Total metals	0.0001	lower	higher	higher	higher	higher	higher	higher

		Landfill (no energy recovery) & Recycling	Landfill (energy recovery) & Recycling	Mass Burn for energy recovery & recycling	RDF, recycling & residue landfilled	RDF, composting, recycling & residue landfilled	RDF, gasification, recycling & residue landfilled	Composting, Recycling, Landfill with energy recovery	Gasification, Recycling & Residues to landfill
		per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne	per tonne
WATER EMISSIONS(kg)	BOD	0.0610	same	lower	lower	lower	lower	lower	lower
	COD	-0.2565	same	higher	higher	higher	higher	higher	higher
	Suspended Solids	0.0050	same	lower	lower	lower	lower	lower	lower
	Total Org. Compounds	0.0047	lower	lower	lower	lower	lower	lower	lower
	AOX	0.0000	same	higher	higher	higher	higher	higher	higher
	Chlorinated HCs	0.0000	same	lower	lower	lower	lower	lower	lower
	Dioxins/Furans (TEQ)	0.0000	same	lower	lower	lower	lower	lower	lower
	Phenol	0.0004	same	lower	lower	lower	lower	lower	lower
	Ammonia	0.0094	lower	lower	lower	higher	higher	higher	higher
	Total Metals	0.0092	same	lower	lower	lower	lower	lower	lower
	Total Salts	0.0230	lower	lower	lower	lower	lower	lower	lower

Note: Negative values indicate overall reductions in energy consumption or production of emissions

4.3 Economics of technology options

Financial costs are a key determinant of decisions and choices in waste management technologies and practices. Waste management costs in Australia and internationally are reviewed below to indicate the ability to take-up the technical options available and reviewed above.

Employment is a key aspect of technologies and it will be an important element of the economics of a particular waste treatment technology or practices. Although we provide some data on employment in later sections it is not possible to determine or indicate employment on a per tonne basis for all technologies. This is not possible because as we have already highlighted technologies will and are effected by the context and scale of their application. In other words technologies we review are although based on a similar process vary considerably from location to location and situation to situation depending upon their operational capacity / scale and specifications.

However what is generally known about the relationship with employment and technologies is that the higher the mechanisation the lower the employment and higher the operating costs. Where for example hand sorting of recyclables occurs there can be a number of jobs per tonne of waste sorted. Where mechanised system exists the number of employees will be likely to be significantly reduced and might approach zero employees per tonne processed.

4.3.1 Waste Management Costs in the GSR[3]

Nolan-ITU (1998) reported to the NSW Environment Protection Agency (EPA):

- the total cost for collection of Municipal Wastes in 1997 was $141 million or $86 per household for the 1.6 million households in the GSR, and
- 296,000 tonnes of the wastes generated was recycled at a cost of $67 million or $47 per household. This equated to an average cost of about $220 per tonne for collection and transport of materials to material-recyclers.

Table 4-3 shows commercial waste management charges at Waste Services NSW facilities, which are used for treatment and disposal of putrescible wastes in the Sydney Metropolitan area (SMA) and Table 4-4 indicates charges for Councils at these and other facilities.

Costs for Municipal recycling in the GSR can range depending upon the suite of systems integrated in to the waste management approach of a locality or area from $220 per tonne to $390 as identified by Wright Corporate Strategy shown Table 4-5.

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3 Nolan-ITU *Kerbside Recycling in NSW, May 1998.* Consultants report to the NSW EPA

Costs for landfill disposal and recycling compare similarly to costs of similar services/ systems provided in North America shown in Table 4-6 and Table 4-8.

Table 4-3: Commercial waste management charges [4]

Transfer stations

- $72/t containing food
- $72/t without food (except Chullora $58/t)
- Recycling free
- $55/t untreated timber and garden organics

Landfills

- Containing food: Belrose $72/t; Eastern Ck & Jacks Gully $55.95/t; Lucas Heights $57/t
- Without food: same as above
- Recycling free
- Untreated timber and garden organics: Belrose $55/t; EC $38 JG $40/t; LH $40/t
- Sorted construction & demolition wastes $15 EC, JG & LH only
- Mixed construction & demolition wastes $93 JG & LH only

Table 4-4: Municipal waste management costs in Western Sydney [5]

WASTE TYPE	CHARGES
• Mixed putrescible Disposal Charges	$39.50/ tonne to landfill $45.00/ tonne to transfer station
• Domestic Collection Costs	$0.60 – $1.00/lift at kerb for mixed wastes or greenwaste ($40-$60/ household/yr) *Average at $0.75 per lift*
• Compost:	$28.00 processors charge (average) $30.00 income at sale

4 Waste Service NSW: Recycling & Solid Waste Disposal Guide and Charges July 1999

5 WSWB , (personal communication)

Table 4-5: Processing costs for Municipal recyclables[6]

ARRANGEMENT	COSTS
• Kerb to re-processor	• **$220/t**
• Kerb consolidate to trade or re-processor	• **$270/t** - $220 + $50
• Kerb to MRF to Processing	• **$340/t** - $220 + $90 + $50
• Kerb to MRF – consolidate to trade or re- processor	• **$390/t** - $220 + $90 + $50 +

Table 4-6: Recycling and collection costs in the USA, (1994)[7]

	Collection Costs (dollars per ton collected)	
Percentage of waste recycled	Garbage collection costs ($US)	Recycling collection costs ($US)
0-9%	$42	$285
10-19%	$53	$102
20% +	$66	$93

4.3.2 Overview of Recyclables Supply and Demand

Supply, demand and market values for recyclables are shown in Table 4-7. The information shows a demand varies depending upon commodity with some above and some below demand. Considering that more recyclable materials exist in mixed waste streams currently disposed to landfill and that the economics of the delivery of services and sale of products are relatively stable it seems feasible higher recovery and reuse of recyclable materials should be possible.

6 Wright Corporate Strategy

7 Ackerman, F. (1997).

Table 4-7: Supply demand and market values for recyclables in GSR[8]

	Supply (tonne / annum)	Demand (tonne / annum)	Market Values ($ / tonne)
PAPER	70,000	120,000	- Newsprint ; $50
CARDBOARD	90,000	50,000	- Clean source separated; $50- $65 - General; $25- $50
GLASS	60,000	70,000	- $85; to specification
PET	>10,000	4,000	- $250; to specification - $300[9]
HDPE	>2,000	1,500	- $250 to specification - $300[3]
ALUMINIUM	Open	550	- $1,200[3]
STEEL	Open	3,000	- $50 - $70
LPB	Open	140	- $200

8 Nolan-ITU Kerbside Recycling in NSW, May 1998. Consultants report to the NSW EPA
9 WSWB, (1998).

Table 4-8: Case Studies of full cost accounting results from communities in the USA[10]

COLUMBIA PUBLIC WORKS DEPARTMENT ***(Population: 69,100 in 1990)***		
Activity	**$(US)/ton**	**Inclusive of:**
- Composting	$30.08	Administration, composting process, depreciation
- Recycling	$150.30	Administration; container repair; kerbside collection; drop offs; volunteer program; white goods; HHW; Yard trimmings; depreciation
- Residential wastes	$119.80	Administration; container repair; collection; depreciation
- Commercial wastes	$90.44	Administration; container repair; collection; depreciation
- Landfill	$22.94	Administration; container repair; landfill process; compost, drop-off and HHW re-allocation; interest expense; depreciation; debt retirement; closure and post-closure costs.
SOUTH EASTERN PUBLIC SERVICE AUTHORITY OF VIRGINIA ***(Population: 1,012,800 in 1990)***		
Activity	**$/ton**	**Inclusive of:**
- Regional Landfill	18.37	Direct: Operating, maintenance, transport. Indirect: transportation, environmental management maintenance, administrative debt service
- Transfer Stations	18.50	As above
- RDF Plant	25.31	As above
- Power plant	40.88	As above
- Landfill	15.05	As above
- Kerbside recycling	310.26	As above
- Ferrous metals recovery system	26.08	As above
- Compost facility	34.15 / cubic metre produced	As above
- Drop-off recycling facility	98.97	As above

4.3.3 Alternative technology costs

Operating costs for alternative waste treatment and management technologies have been considered and reported by the Southern Sydney Waste Board and are shown in Table 4-9

Table 4-9: Summary of Indicative Costs Ranges for Technology Categories[11]

Technology Category	Low Average ($/t)	High Average ($/t)
Solid Waste Class I Landfill	50	70
Solid Waste Class II Landfill	30	40
Inert Waste Class I Landfill	20	25
bioreactor landfill	60	80
MBT	65	90
MBT & RDF utilisation (residual waste splitting)	120	170
Incineration	170	250
New thermal treatment	160	280

4.3.4 Environmental profile results

While recognising that the example provided is an illustration only, it draws upon Western European experiences it is possible to conclude that alternative technologies exist that are capable of providing environmental and waste reduction outcomes.

The results should be considered as a general expression of alternative technology abilities to deliver real-world outcomes. More detailed assessment is needed to occur within a well-structured decision-making process (such as in the Inquiry if all data is available to it) before confidence in can be provided as to alternative technologies efficacy to operate in an ESD framework.

11 Table 8.4: Summary of Indicative Costs Ranges for Technology Categories - SSWB (1999) Stabilisation / Pre-treatment Study DRAFT, Nolan ITU report to the Southern Sydney Regional Waste Board

11 USEPA. (1998). Full Cost Accounting in Action: Case Studies of Six Solid Waste Management Agencies. United States protection Agency. EPA530-R-98-018.

Notwithstanding this it is considered:

- Together with economic and social information available in other sections of this and Report 1 it is possible to project potential future impacts of technology use in the GSR,
- It should be possible to do similar more detailed assessments for the GSR, but this would require considerable additional to inform policy intervention mechanisms,
- In order to engage with defensible decision making around environmental issues, it is necessary to translate life cycle emissions into considerations of environmental impact. Again, definition and selection of an appropriate technology or suite of technologies has to be supported by further detailed and inclusive examination of the performance criteria by which a technology(s) would be chosen and commissioned,
- Through formal decision analysis, it should be possible to explore trade-offs between economic, environmental and social objectives. Barriers exist in this regard in terms of policy and practice in current waste planning and management and these issues will be discussed in later reports, and
- Availability of viable proven technology for management of various (or mix) of waste materials is not seen as the limiting factor in alternative technology uptake. There are in fact many technologies and practices available for application and other non-technical (e.g. policy integration, coordination of strategy) issues are the significant barriers in regard to change in ISWM planning in the GSR.

5 FEASIBILITY

5.1 Introduction

The following section reviews technologies and practices in regard to the Inquiry Terms of Reference. Individual technologies and practices identified in this report and Report 1 have been described and examples as to how they might fit within a future integrated solid waste management (ISWM) system have been highlighted. The Inquiry terms of reference (ToR) state it is concerned with technologies and practices in regard to a technology or practices:

- "Potential impact on the environment in terms of local, regional and global air, land and water impacts and amenity
- Contribution to waste avoidance and beneficial reuse of resources
- Contribution to waste reduction
- Environmental and economic benefits and costs of the alternative technologies and expressed: per tonne of waste input: per tonne of waste diverted from landfill; per tonne of recovered secondary resources or recovered energy value
- Technical performance and operational reliability
- Factors effecting the capacity for accelerating the implementation of alternative waste management technologies and practices in NSW in the short, medium or long term"

Taking a materials management focus for developing future waste management strategies it becomes clear there are only two major classes of waste management technologies:

- those that manage wastes that have end-products that retain or return materials or energy to the materials economy, or
- those that remove materials and potential energy from the materials-economy

When comparing the ability of technologies the ultimate difference is the ability of the technology to achieve desired outcomes in terms of preferences made by society regarding:

- total environmental emissions, impacts of those emissions and trade offs- between environmental and social or economic preferences,
- economic cost of operating the technology, the economic cost or benefit to the materials-economy to produce the desired end-products of a particular technology, and trade-offs between economic costs and benefits and environmental and social preferences, and
- social costs or benefits of using the technology and trade-offs between social costs and benefits and environmental and economic preferences.

Technology comparisons are therefore exceptionally context-dependant including the elements discussed above. The feasibility of various technologies guided by the Inquiry's ToR do explicitly recognise this and this is a key concern if sustainable technologies and practices are to be evaluated by the Inquiry in terms of sustainability. The following however compares alternative technologies to landfill as the benchmark technology using the factors for consideration outlined in the Inquiry ToR.

5.2 Landfill

5.2.1 Potential impact on the environment

Many studies in Australia and worldwide and the data provided in Section 4.2 show landfilling waste can contribute substantially to the total transport of pollutants by society into the environment via the materials-economy and the built environment.

The main impacts occurring from landfill operations are:

- leaching of pollutants via water emissions,
- greenhouse gas impacts from landfill gases,
- contribution to local and regional smog production from smog causing chemicals emitted in landfill gas, and
- contribution to greenhouse warming through energy used in collection, transport and treatment.

Although there has been a trend toward collection of both leachate and landfill gases (both to varying efficiencies) and treatment of these, significant amounts of leachate and landfill gas are still emitted from existing and old landfills. The nature of landfills means also that these emissions will continue, although on a decreasing amount annually for the next 100 years or more.

When considering the allocation of environmental impacts as a result of the use of landfill to manage materials leaving the materials-economy it is clear further materials need to extracted from the environment, processed transported, used, and disposed as wastes. When the air, water and amenity impacts are allocated to landfill, as they are in the modelling work presented earlier, the impacts increase as they are additive. This is due to the linear relationship landfill has to the materials-economy, as it drains materials from the materials-economy and does not facilitate recycling and reuse of many materials.

On a per tonne basis the data presented in Table 4-2 indicates the types and expected ratio of impacts from various environmental emissions associated with collection, transportation and landfilling wastes in the GSR.

Impacts of landfilling on the environment in terms of local and regional air, water and amenity will have impacts in the immediate and longer term. This presents an inter-generational issue as these impacts will occur for periods over 100 years and hence are transferred to later generations.

5.2.2 Contribution to waste avoidance and beneficial reuse of resources

To consider this element all technologies need to be assessed in terms of the function provided to the materials economy and the waste management system.

Landfills as systems are not deigned to assist waste avoidance and therefore can not and do not provide these outcomes. The Western Sydney Waste Board, in terms of the materials-economy has stated landfills can work against waste avoidance as they provide a cheap method of waste disposal (when environmental costs are not incorporated in the cost of landfill development, management and post closure).

Beneficial reuse of the energy inherent in the organic materials landfilled by capture and combustion of landfill gases can assist in beneficial reuse of these components in the waste stream. The development of "bioreactor" landfills, which act as active energy recovery systems, has been a recent attempt to improve landfill environmental performance. This is still only an emerging research scale (thermal) treatment technology (see Section 5.3). Landfill energy recovery therefore remains a by-product of the existing function of landfills, that is , to dispose of materials no longer used by the economy.

Other than landfill gas and its combustion to provide a source of energy for non-renewable energy generation there are no other flow on effects to the materials economy available from use of landfill technology.

5.2.3 Contribution to waste reduction

This is not applicable as this issue is not related directly to landfill use.

5.2.4 Environmental and economic benefits and costs of the alternative

This is not applicable as this issue relates to comparison of alternative technologies to landfill itself.

5.2.5 Technical performance and operational reliability

This technology is already proven in regard to its use as part of the waste management system and is the benchmark for comparison for the Inquiry.

5.2.6 Factors effecting the capacity for accelerating implementation of alternative

This is not applicable in regard to this technology.

5.3 Thermal treatment technologies with energy recovery

Thermal treatment technologies include:

- Mass burn or incineration
- Gasification
- Pyrolysis
- Refuse derived fuels

Each of these technologies can be developed to operate with or without energy recovery. However, other than mass burn, these technologies are generally developed with energy recovery because it is a large factor in their operational viability.

Anaerobic digestion can also be considered a thermal treatment technology if it is used for energy recovery and generation.

5.3.1 Potential impact on the environment

The main impacts demonstrated to occur from use of thermal treatment technologies are:

- greenhouse gas impacts from the combustion of materials derived from wastes,
- contribution to local and regional smog production from smog causing chemicals emitted in landfill gas escape, and
- contribution to greenhouse warming through energy used to undertake the activity.

Comparative to the 100-year active life cycle of a landfill, emissions from thermal treatment of wastes will occur immediately as the full amount of waste material is processed immediately. In total the amount of total recoverable energy will also generally be greater for thermal treatment technologies as thermal treatment technologies will combust more efficiently a greater range of materials than within a landfill. For example, in landfills, materials such as plastics and rubber will not “give-up” their full energy value, where as in thermal treatment it will be recovered.

This greater and more immediate recovery of energy from wastes using thermal treatment will generally result in:

- increase regional and local emissions of greenhouse gases and regional and potentially locally significant air pollutants. Controls are usually used in these technologies to mitigate environmental emissions of pollutants. These impacts however need to be considered in terms of the net impact occurring and any credits for their substitution for energy that might otherwise have been generated using non-renewable sources such as fossil fuels,
- reduction in water emissions compared to landfill as landfill leachate will be avoided, and
- amenity of communities surrounding a properly commissioned and regulated thermal treatment facility due to greater control of the processes involved should generally be improved over that of a landfill facility.

5.3.2 Contribution to waste avoidance and beneficial reuse of resources

The major concern with thermal treatment is that it is not an avoidance technology and it has in many countries been used as waste reduction technology. Its use in this manner has the same effect as landfill, which is to facilitate a largely unsustainable one-way flow of materials through the economy, (although some trade off exists through the recovery of energy).

The main beneficial use of the technologies is for recovery of energy that can be substituted for energy generated from non-renewable fossil fuels. The benefit will be derived substantially from organic materials (about 40% of the total waste stream) which in the most part are renewable materials linked to the carbon cycle. Producing useful energy from materials that otherwise generate a net negative effect from greenhouse and landfill leachate will be the main flow-on effect of using these technologies. There are however no other material by-products that will be used by other elements of the materials economy.

Without consideration and strategic management of the flow of materials to and through a thermal treatment facility the technology has the same function within the materials-economy, as landfill. Therefore use of thermal treatments has to occur within a strategic materials management approach where materials that can be re-processed are.

5.3.3 Contribution to waste reduction

Thermal treatments have the potential for significant reduction impacts on the solid waste currently disposed to landfill.

In general the reduction potential could be as high as 80 percent of the total weight and 85 precent of the total volume of materials currently sent to landfill. Residual inert materials and ash represent the materials remaining after thermal treatments and these have to be landfilled. Very small quantities of the residues left from combustion in thermal treatments can be further used.

An important issue that needs to be considered in regard to thermal treatment is the ability to develop appropriate landfill for residual materials. The residual materials are potentially hazardous and the location and operation of a suitable facility or facilities could be as problematical as that for Class 1 solid waste landfill is now.

5.3.4 Environmental and economic benefits and costs of the alternative

If worlds best-practice thermal technologies are used and ‘subject to high standard environmental regulation there could be:

- reduction in water pollutants locally and regionally as landfill leachate generation will be avoided, and
- reduction in the amount of land contamination and area of land “sterilised” by avoiding the need for development and operation of putrescible landfill facilities at the current and future scale and number needed to deal with the GSR wastes.

These benefits of thermal treatment need to be considered against:

- the total amount of greenhouse gas emissions versus those reduced from coal-based electricity generation as a result of the energy substitution provided by the mass-burn,
- the total air pollutants emitted in the locality and region of thermal treatment facilities versus those saved from generation in the region of the equivalent amount of energy using fossil fuel technologies, and

- lost benefit to the economy through destruction of products and materials that have already been produced, generated and or value-added in the materials-economy.

5.3.5 Technical performance and operational reliability

A number of thermal technologies are proven technologies and many applications exist around the world. Many of these can be easily adapted to the Australian context and conditions.

Other than mass burn technologies, which is probably the least likely to easily fit into a sustainable materials-management framework, thermal treatment technologies are usually specific to certain waste streams where quality control of materials used in the process can occur. Many require very specific organic waste sources, for example gasification and pyrolysis has been most successful in the wood wastes sector. Methanogenic thermal treatment technologies have been especially suited to food scraps, food processing wastes and wastewaters.

Considering this it is estimated from our literature review and discussions with industry personnel that it is technically possible thermal technologies could manage the following amounts of materials from those generated in the GSR:

Table 5-1: Thermal treatment technology feasibility characteristics

Thermal technology	Tonne/ year (approx.)	Materials processed / outputs
• Mass burn	2,000,000+	• All: approx. 20-30% residual to landfill
• Gasification	600,000+	• Wood and vegetation; approx. 10% residuals landfilled. • Beneficial products are energy and digestates that might be recycled • Possibly food wastes but technology is not yet proven in large scale processing of these wastes.
• Pyrolysis	100,000+	• Wood and vegetation; approx. 10% residuals landfilled. • Beneficial products are energy are and digestates that might be recycled • Possibly food wastes but this is not proven technology • Mixed waste treatment via pyrolysis has been proven not to be viable •
• Anaerobic Digestion (when used explicitly to recover energy)	800,000+	• Preference for wet-organic wastes (food, sewage & some vegetation)

5.3.6 *Factors effecting the capacity for accelerating implementation of alternative*

Emanating from a lack of consideration of:

- the economic and environmental costs, benefits and trade-offs possible from use of thermal technologies, and
- a strategic role for thermal technologies in a materials-economy

there has historically been strong political and community resistance to thermal treatment technologies. This resistance is considered to be justified in the case of thermal technologies being used to dispose of wastes and where no proven benefits are designed into their application, eg energy recovery and utilisation.

Application of these technologies at a scale that can manage the waste volumes currently generated in the GSR will require a significant lead-time. This occurs because for each technology there are considerable scaling-up issues and factors to be managed. In regard to economies of scales there are also issues of limits to the size of individual facilities (for development costs and performance) relating to certain technologies that need to be considered.

For new large-scale facilities, and generally those above 50,000 tonnes per annum of mixed wastes, development lead times may range from 3 to 7 years depending upon the technology.

The result is that sustainably managing the volume of wastes currently generated in the GSR should require:

- use of a range of technologies to manage the range of materials presenting as wastes and to ensure that unsustainable mass-burn does not occur for the sake of waste reduction,
- a strategic development approach tom be taken that sees facilities come “on-line” over a period of time, and
- use of a range of technologies in parallel to increase overall treatment capacity over a shorter time period and to increase the diversity of beneficial products being derived from wastes.

5.4 Biological Treatment technologies

Biological technologies include:

- Bio-mechanical treatment (BMT)
- Composting (aerobic static-pile or active/ assisted composting)
- Vermi-composting (worm farming)
- Anaerobic digestion

5.4.1 *Potential impact on the environment*

Properly managed and regulated biological treatment technologies by nature are more inert with regard to environmental emissions of water and air pollutants.

As alternative technologies to landfill these can generally assist reduction of pollutants as they can reduce the amounts of putrescible wastes sent to landfill, thereby reducing the landfill emissions discussed above.

Considering this it is estimated from our literature review and discussions with industry personnel that it is technically possible thermal technologies could manage the following amounts of materials from those generated in the GSR:

Table 5-2: Biological treatment technology feasibility characteristics

Treatment technology	Tonne/ year (approx.)	Materials processed / outputs
• MBT	900,000+	• All mixed wastes: Approx. 30-50% residual to landfill • Some beneficial products can be derived, lower grade recycled organic materials (ROM) materials from mixed wastes typically suitable for horticulture, landscaping and land rehabilitation sectors
• Composting	300,000+	• Technically any organic waste however preference to wood, vegetation, paper and some food wastes; Approx. 10-30% residuals need to be landfilled • Beneficial products are a range of compost products of varying grades / contamination depending upon source and production activities
• Vermicomposting	100,000+	• As for composting above
• Anaerobic Digestion (when used explicitly to recover energy)	800,000+	• Preference for wet-organic wastes (food, sewage & some vegetation), energy predominant by product with residual digestate possibly suitable for blending with other organics as part of composting / vermicomposting processing

5.4.2 Contribution to waste avoidance and beneficial reuse of resources

Composting and vermicomposting technologies are specifically operated to produce recycled organic materials (ROM) that are then put back to use. Predominantly, ROM is marketed to the horticulture, agriculture landscape and land rehabilitation industries.

Biological treatment technologies will compete for some of the organic materials that thermal treatment technologies will target for processing, particularly premium quality (low level metal and physical contamination) organic wastes. To develop a sustainable ISWM approach it will be necessary to conduct detailed examination that balances the competing issues and trade-offs that occur between:

- energy generation and substitution via energy recovery and utilisation for organic wastes, and
- ROM production and substitution for fertilisers and or organic materials in industries utilising ROM materials.

5.4.3 Contribution to waste reduction

A range of biological treatment technologies can be used in an ISWM system to assist reduction goals. Table 5-2 indicates the scale of their ability to do this.

5.4.4 Environmental and economic benefits and costs of the alternative

Biological treatment technologies provide an alternative that can recycle significant amounts of organic materials back to the materials-economy thereby redistributing amounts of nutrients and organic matter to sectors from which these have originated.

This recycling may in part substitute non-sustainable nutrient/ organic matter use or provide benefit to production or rehabilitating eco-systems. Similar benefits have been shown by Sydney Waters' sewage sludge re-use scheme, which already supplies a number of primary production sectors for various uses.

The following case studies overview some GSR and Australia experiences in the biological treatment technologies.

Case Study: MBT

Estimates using the Port Stephens Waste Management Group MBT treatment facility indicates that the technology could provide:

- 1 job for each 2,000 tonne of waste diverted per annum [12]
- total annual diversion[13] using this technology might be 900,000 tonnes[14]

12 Source: Michael Skins, Port Stephens Council

13 Based on 1996 waste production rates as per Report 1

14 Assuming 50% of total municipal solid waste and 25% of total C & I waste treated and 30% residual solid waste to landfill

Case study: Vermicomposting
Estimates using the Vermitechs treatment facility indicates that the technology could provide:

- 1 job for each 2,400 tonne of waste diverted per annum [15]
- total annual diversion[16] using this technology might be 345,000 tonnes [17]
- Income from castings $250 - $1000 / tonne[18], potential for income from worm biomass

Case Study: Vermicomposting
Estimates using the University of New South Wales vertical composting unit indicates that the technology could provide:

- 1 job for each 2,000 tonne of waste diverted per annum [19]
- total annual diversion[20] using this technology might be 300,000 tonnes [21]

5.4.5 Technical performance and operational reliability

Biological treatment technologies using various wastes are proven.

A number of MBT technologies have been very successfully used in Europe and North America as a volume reduction technology. They have also been used to a lesser degree to beneficiate waste streams, possibly due to the higher development and operation costs compared to some composting and vermicomposting operations.

As with thermal treatment systems limitations would exist in regard to large-scale rollout of biological treatment systems to deal with the amount of mixed wastes generated in the GSR, as determined by market economics development costs and amortisation of facilities.

Some biological treatment systems may, like thermal treatment systems, better perform when used for treating a specific or a limited range of waste types. Application of biological treatment technologies such as composting and vermicomposting, might be best considered niche treatment systems that should be facilitated to develop high quality beneficiated products in a strategic ISWM system, which is aiming to recover and recycle organic materials.

15 Assuming 3:1 organic waste to woody (green) waste
16 Based on 1996 waste production rates as per Report 1
17 Assuming 25% municipal and 50% C&I organic waste were processed
18 Lotzof. M. (1999)
19 For a nine tonne per day VCU (approx. 60 cubic meters)
20 Based on 1996 waste production rates as per Report 1
21 Assuming 50% of C&I organics processed

5.4.6 *Factors effecting the capacity for accelerating implementation of alternatives*

A number of biological treatment systems are now being developed by commercial interests. The pay by weight pricing regimes now in place and some activities of Regional Waste Boards are attempting to refocus the fate of wastes by providing an environment to allow these companies to take advantage and develop new facilities.

Most developments in this technology area however are tending toward those that provide energy recovery. This may be in part due to the Sustainable Energy Development Authority's (SEDA) activities for stimulating such developments. As discussed however there is an opportunity arising from good to high quality beneficial ROM products that might provide better benefit than if used in energy production.

Waste Boards are attempting to assist development of markets for ROM materials. However, their activities are far from the type of similar work carried out by SEDA in the energy sector. There is no similar entity or body in the waste sector doing SEDA-type activities sector and therefore there is an opportunity for government to facilitate beneficiation of materials found in wastes for the materials-economy. Market forces and government waste policy alone would not be sufficient and horizontal, not vertical policy integration is needed if beneficiation of wastes is to occur.

5.5 Prevention and minimisation technologies

Prevention technologies are a broad range of "soft-technologies" such as policies, practices and activities that aim for outcomes where wastes are not generated or they are minimised at their point of generation in the materials-economy. These technologies usually aim also to divert materials from disposal through programs such as reuse and recycling.

Examples include:

- institutional and regulatory policy including examples such as extended producer responsibility,
- education, training and promotion,
- pricing mechanisms such as economic incentives and pricing policies including examples such as container deposit legislation, and
- waste avoidance and reuse programs and systems.

For a more detailed review of prevention and minimisation examples see Appendix A and Report 1.

5.5.1 Potential impact on the environment

There are negligible negative environmental impacts considered relevant to prevention technologies. In the case of recycling it has been shown in a number of studies that significant reductions in total economy-related environmental pollutants occur when recycling is conducted instead of replacement with new resources from the environment.

Reduction of consumer demand through prevention at points of purchasing or through environmental purchasing programs will lead to a corresponding and net benefit due to the avoided use of materials and associated production impacts.

5.5.2 Contribution to waste avoidance and beneficial reuse of resources

These programs have direct impacts on waste avoidance and it is our opinion that there are significant reduction impacts already evident but difficult to quantify from these activities. For example the construction and demolition industry has reduced its total amount of waste presented for disposal in response to increasing landfill costs and the availability of recyclable raw materials.

5.5.3 Contribution to waste reduction

This is difficult to quantify however desktop studies in the Unites States[22] and in Australia[23], generally point to potentially significant quantities.

22 Fishbein, B., and Gelb. C. (1992) .

5.5.4 *Environmental and economic benefits and costs of the alternative*

The following case studies indicate some examples.

Case Study: Community Education – *"Earthworks"*

Estimates using the University of New South Wales vertical composting unit indicates that the technology could provide:

- 1 job for each 135 tonne of waste diverted per annum [24]
- total annual diversion[25] using this technology might be 16,100 tonnes [26]

Economic costs and benefits might include:

- Potential foregone revenue for organic producers and retailers
- Cost to councils of staffing courses (currently most courses are run through councils)

Case Study: *Food waste to charity*

Estimates indicates that the technology could provide:

- 1 job for each 20 tonne of waste diverted per annum [27]
- total annual diversion[28] using this technology might be 18,000 tonnes [29]

Economic costs and benefits might include:

- Reduced waste service charges to the commercial and institutional sector
- Potential foregone revenue from the sale of food in localities of food distribution
- Savings to recipients of food in purchase of food
- Cost to charities of coordinating distribution and transporting food to distribution points

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23 EcoRecyle (Vic) numerous studies and reports are available, and NSW EPA "Solutions to Pollution" case studies in offices

24 With 0.4% participation rate (as in Lismore – EPA Earthworks Evaluation, 1997) and assuming impact of approximately 50% organic waste reduction in households of participants (EPA evaluation did not estimate the reduction in organic waste) and behaviour change effective for 5 years.

25 Based on 1996 waste production rates as per Report 1

26 Assumptions as above

27 Assuming one person to collect and distribute approximately 400 meals daily

28 Based on 1996 waste production rates as per Report 1

29 Assuming 20% of C&I food waste is edible and a 15% C&I sector participation rate

Case Study: *Medium scale vermicomposting*
Estimates using the SOCOG's office composting unit results indicates the technology could provide:

- 1 job for each 250 tonne of waste diverted per annum [30]
- total annual diversion[31] using this technology are not known and would depend on the number of employees in Sydney and Regional CBD areas.

Economic costs and benefits might include:

- Low set-up costs
- Provides high value product (soil conditioner) and there is potential for income from worm biomass
- On-site, so minimises transport costs

Case Study: *Reverse Garbage*
Reverse Garbage is a not-for-profit organisation that has been very successful in facilitating reuse and recycling of very significant amounts of waste materials in the GSR.

- Reverse garbage is financially self-sustaining with 15 full-time and 6 casual employees. The business collects and retails approximately 1,000 tonnes of industrial discards per year.

5.5.5 Technical performance and operational reliability

Waste prevention activities have been proven to varying degrees across Australia and internationally. Location and context specific programs are required for best effect and outcome. A number of small businesses have responded to opportunities in these areas and now provide services, eg waste prevention consultancy and training and waste management services such as organics composting / vermicomposting, collection repair, and retailing of reusable materials.

5.5.6 Factors effecting the capacity for accelerating implementation of alternatives

There has been much discussion on the impacts of soft technology approaches and many technically oriented governments have used the outcomes of many programs as evidence that they are not as effective as technical solutions. It is clear however that dollar for dollar comparisons show hard technology funding is significantly higher compared to soft technology programs.

30 See description of SOCOG's worm farm
31 Based on 1996 waste production rates as per Report 1

The earlier comments regarding the need for a body committed to the concept of materials management and which implements and facilitates activities to this end is also relevant here. Currently only add-on programs are implemented in government departments that have a specific program for waste reduction to landfill.

6 FUTURE ISWM

It is clear from the review of the technologies and practices that there are a range of viable and world proven options with positive environmental outcomes for future ISWM available to the GSR instead of landfill.

Various technologies have the potential to extend the life of existing landfill capacity in the GSR[32] significantly beyond their projected lifespan if the alternative technologies can be implemented in a relatively short term, say within the next 2 to 7 years.

What is very clear is that no one technology or practice will provide the "solution" to the GSR waste problem and that ISWM technologies alone cannot facilitate waste prevention.

Waste prevention in its various forms is also not the solution to waste problems in society. A number of examples of European and North American and unpublished Australian life cycle assessment studies[33] described in the international literature have shown sustainable product development and their use within closed-loop recycling systems is probably the only direction for achieving ESD.

To move in this direction, over the medium and long term, the use of ESD technologies and practices needs to be:

- studied and evaluated in terms of their role in a materials-economy,
- studied and evaluated in terms of their environmental, social and economic impacts in a materials-economy, and
- chosen in terms of their ability to perform to a set of determined preferences for the management and cycling of resources in a materials-economy.

To do this government needs to evolve the existing waste planning and management regime to develop and adopt an integrated strategic approach to:

- monitor and manage waste flows in the GSR,
- review and coordinate infrastructure development, and
- evaluate economy-waste management industry links and developing cross-sector policy and development activities that aim to create a) materials cycling, and b) improved material consumption and use patterns.

The structure of an alternative approach as outlined above and the barriers needing to be overcome to reach this will be discussed in Reports 3 and 4.

32 The same concepts are applicable to other regional areas therefore those areas landfill life could also be extended

33 RMIT / CRC for Waste Management and Pollution Control project on three packaging materials

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