14 April 2000

The Hon. R. Debus MP
Minister for the Environment
Level 25
59-61 Goulburn Street
SYDNEY NSW 2000

Dear Minister,


The availability of technologies, together with strong community support for waste reduction make the next five years a time of great opportunity for further waste management reform.

On behalf of the Waste Inquiry Panel, I hope this report will be helpful to the Government in further shaping strategic policy for waste management in New South Wales.

Yours sincerely,

[Signature]

A.G. Wright
Chairman
Acknowledgements

Many public, private and community sector organisations and individuals contributed to the Waste Inquiry through provision of formal submissions. The Panel is grateful for these contributions, and for the valuable discussions held to elaborate on submissions. Many public and private sector organisations generously facilitated inspections of facilities and practices both in Australia and overseas. The Inquiry benefited greatly from their cooperation and open exchange of information and ideas.

The establishment assistance and ongoing liaison provided by Graeme Head and his staff at the Environment Protection Authority, and Matthew Chesher from the Office of the Minister for the Environment is also gratefully acknowledged.

The Inquiry Panel was greatly assisted in the final stages by Paul Howlett who contributed an objective review of the draft report and valuable ideas based on expert knowledge of the waste management industry.

The Inquiry, and particularly the Chair, also greatly benefited from the able assistance of Judy Myers. As the Secretariat she provided excellent and patient support and assistance.
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Paul Fuller was seconded from the Environment Protection Authority of New South Wales to assist the Inquiry.
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Executive Summary

Why do some communities manage waste with alacrity while others seem overwhelmed by the task? Are some communities wise in seeking value from waste, or should they choose least-cost disposal options? The Waste Inquiry has sought to understand the potential contribution of waste management practices and technologies in seeking answers to these fundamental questions.

Waste is both diffuse and heterogeneous. It is difficult to handle and often complex to recover for beneficial uses. Many communities, however, now think of waste materials as potential resources, and they invest in systems and infrastructure to capture the benefits waste can bring. New technologies and management practices have been developed over the last ten years to meet the demands of this modern regard for waste.

The New South Wales community too has signalled a strong commitment to sustainable waste management. And the New South Wales Government, through the Minister for the Environment, established the Alternative Waste Management Technologies and Practices Inquiry (Waste Inquiry) in August 1999.

1. Purpose and Background

This report presents the outcomes of the Waste Inquiry. It comprises a review of conventional and emerging waste technologies and the management practices that drive the logistics and transformation of discarded materials to beneficial resources. In accordance with the Terms of Reference, the review has been framed on an ecologically sustainable development basis, emphasising economic, social and environmental dimensions. Technology viability also is a critical consideration.

The intent of the Government in establishing the Waste Inquiry was to inform decisions about future waste management infrastructure and practices in New South Wales. The Report will also provide input to a planned strategic policy review of the Waste Minimisation and Management Act (1995) scheduled to commence later this year.

A primary aim of the Inquiry Panel has been to demystify waste management issues and inform Government, business and citizens about how improved practices and technologies might contribute to sustainable waste management. The report also provides an accessible framework for considering waste management options.

The Waste Inquiry has received and considered 80 submissions during the course of the investigation. Hearings were conducted, and inspections and interviews were undertaken in various urban and regional centres of New South Wales. The Panel visited facilities in Victoria and Queensland and overseas to inspect emerging technologies and review waste management practices.

2. The Opportunity

The Waste Inquiry has been undertaken at a time when three related issues have coincided to bring waste management into special focus: favourable economic conditions are driving increased consumption and disposal; numerous pressures surround the availability of future landfill capacity; and promising new options are emerging for treatment and beneficial use of some waste resources.

This is a time of great opportunity to begin to change the paradigm of waste management in New South Wales. An abundant array of viable technologies exists to increase recycling and to gain value from various parts of the waste stream. No one technology offers a complete solution. Rather, each can form a part of an integrated management system.

Mechanical technologies and processes for recycling of plastics, glass and paper, are well developed and improving. Biological technologies are generally well proven and increasingly finding favour in European countries for production of high quality compost (and, in some cases, green energy or fuel).

The new thermal technologies are well regarded for production of green energy from specific wastes and are reaching commercial status for mixed residual waste applications. New landfill technologies accelerate waste degradation for early green energy gains and show promise in speeding waste stabilisation.

New waste management practices too are available for consideration. Integrated waste management, for instance, links markets with technologies, logistics and waste streaming to simplify the pathway from discard site to market. This philosophy is based on the idea of a systems approach in which technologies are used to serve designated purposes; to achieve market related outcomes as the servant of the management practice. A sound strategic framework can guide the choice of both practices and technologies.

3. The Approach

The foundation for the Waste Inquiry was a review of the current situation in waste management in New South Wales and the issues confronting the Government, business and citizens. This process was greatly assisted
by the submissions received, hearings, informal discussions with private and public sector participants in waste management, and facility inspections.

An important further step was to examine management practices and technologies overseas and in other parts of Australia. In this way the Waste Inquiry sought answers to the fundamental questions concerning the ingredients for success in deploying waste management practices and technologies.

The bulk of the effort, however, went into identifying appropriate technology classes and types, evaluating these technologies, and determining and assessing appropriate management practices.

The Waste Inquiry has focused on municipal waste, commercial and industrial (C&I) waste and construction and demolition (C&D) waste.

4. Toward a New Way of Managing Waste

The central issue faced by the Waste Inquiry revolved around the search for a set of appropriate waste management practices and technologies to play a crucial role in securing sustainable waste management. The report contains much detail and many conclusions on issues affecting successful take-up of alternative waste management technologies and practices. A few inter-related findings however have emerged as central themes. These are discussed below, ahead of the more detailed findings and recommendations on practices and technologies.

4.1 The Triple Manifesto

The Waste Inquiry has concluded that, in waste management, choices of State or regional technologies, practices and strategy are inextricably linked. Determinations in one leg of the tripod cannot be made without impact on the other legs, and all contribute to achieving sustainable waste management.

When the three legs are in balance, as they are in Frankfurt, Portland and Salzburg, communities can best manage waste as a potential resource; not necessarily to be saved at all costs, but neither to be squandered without consideration of the economic, social and environmental merits of reprocessing.

Balance, in this case, arises when the State’s strategic policy framework for waste management facilitates (and, to some extent, drives) the adoption of an array of creative waste management practices and an array of aligned technologies for treatment and disposal. It also implies that improvements in practices and technologies can influence the modification of strategy to achieve better outcomes.

The Waste Inquiry urges the Government to adopt this triple manifesto as the defining framework for waste management and Recommends that the Government move forward with its intended review of State waste management legislation and the strategic policy framework, based on moving the paradigm from waste disposal toward resource management.

4.2 The Marketplace

The second main theme concerns a much more deliberate inclusion of the marketplace for resources in the business of waste management. (See Chapters 7 and 8). The materials managed by the waste management industry (and business and citizens) can have value. But for many in the industry, the mind-set is tuned to the cost side of the business rather than the revenue side (ie, how best to efficiently manage the logistics process, in lieu of creatively building revenue by meeting market needs). This is not a balanced approach to building a viable business or industry.

The market perspective must move from its current position in the blurred background to a central focus in the business of waste management. Discovering end-market raw materials needs, and meeting those needs, ought to be the point of focus which drives adoption of innovative technologies and practices.

The Waste Inquiry Recommends that the Government lead actions to stimulate the market for recyclate:

• Reaffirm and drive the Government initiative for purchase of recycled materials as a matter of policy preference.

• Encourage and facilitate action by waste management companies to develop raw materials end-markets by facilitating innovative commercial linkages between markets, technologies and practices; for example, by ensuring a smooth path through the various planning processes.

• Ensure a consistent policy and regulatory philosophy so that material flow continuity is predictable, moderating project investment risks, and ultimately building confidence in recyclate products.

4.3 Waste Management Technologies

The third main theme is that an ample array of technologies exists to enable management of more New South Wales waste as a potential resource. (See Chapters 5 and 6). But no one technology is suitable for all waste streams. Each class and type of technology has characteristics which make it particularly suitable for specific waste streams. The Government should guide adoption of a portfolio, that comprises all classes of technologies, on the basis of end-market demands, waste streams available and regional circumstances.

The best way for the Government to provide technology portfolio guidance is to ensure that the strategic policy framework actually enables the achievement of the Government’s vision and intent. The commercial waste
management sector is best positioned to own and operate technologies, and manage associated business risks.

Progressive take-up of alternative technologies is highly dependent on the comparative costs associated with traditional disposal technologies. A key cost component of course is the Section 88 disposal levy. This important economic instrument should be struck carefully to ensure that the costs and benefits of non-market externalities (particularly environmental ones) are internalised and become an explicit part of market-based waste management “gate price” decisions.

The size of the levy, and the scope to refine its application to various classes of technologies, can have a powerful influence on everyday discard or recycle choices by business and citizens through comparative cost signals. Moreover it is fundamental in shaping investment decisions by firms in the commercial waste management sector.

All stakeholders in waste management seek clarity in future policy on waste disposal taxes. Specific considerations are: the absolute amount of the levy; the technologies to which it will in future apply; and the planned rate of change of the tax. These are critical strategic waste policy issues. Striking the right tax balance is fundamental to achieving continued waste management reform. Policy continuity provides a measure of certainty on which the waste management industry can base investment decisions.

The Waste Inquiry Recommends that Government policy and management initiatives be organised to:

- Guide and facilitate take-up and deployment by the commercial waste management sector of a portfolio of technologies through appropriate settings in economic instruments (including the waste disposal levy), voluntary industry agreements and regulations so that each waste stream is treated to best advantage.
- Provide enhanced investment and contract certainty by signalling policy intentions for the waste disposal levy in respect of amount, technology application and planned rate of change.
- Provide support where appropriate in the form of low interest loans to encourage investment in, and full commercialisation of, emerging technologies.


The fourth theme is that no single waste management practice, treatment technology and disposal technique can handle the full array of waste sources, types and recycling possibilities. Integrated waste management is based on the idea of an overall approach coordinating logistics, waste streams, recyclables streams, treatment technologies, and markets. (See Chapter 8).

The three components of integrated waste management practice are: waste streaming, where like materials are similarly classified and collated; system integration, where responsibility for sequential activities, waste streams and geographic areas is aligned and broadened; and industry arrangements where the roles and responsibilities of the institutions and private sector corporations involved in waste management are clearly focused.

Government agencies and the private sector waste management industry are well positioned to facilitate the implementation of integrated waste management, within a Government approved strategic framework. Collaboration by Governments, business, citizens, and the waste management industry is a vital ingredient to achieving integration.

The Waste Inquiry Recommends:

- Inclusion of integrated waste management as part of the strategic policy framework for waste management in New South Wales so that it becomes the accepted way of organising activities.
- Progressive adoption of integrated waste management practices which link each step in the supply chain and provide for a portfolio of reuse, recycling, reprocessing and disposal schemes to gain optimal value from waste as a potential resource.
- Government coordination of actions to achieve integrated waste management in Municipal, C&I and C&D sectors, in collaboration with business, local government, citizens and the waste management industry. Stakeholder involvement is critical to achieving beneficial outcomes.
- A short term Task Force of key Government, business and waste management industry participants, to guide planning and implementation of integrated waste management in the C&I sector. This sector has high potential for waste management and resource recovery, but waste diversion efforts to date have been limited and inconsistent.
- Voluntary action, financial incentives, and ultimately regulatory action to drive capture and processing of new waste streams (identified in this report), and marketing of derived products with collaboration by business, Government, citizens and the waste management industry.
- The EPA monitor implementation without delay of this program and take action to remove any roadblocks.

4.5 Costs of Potential Improvements

The fifth main theme is that improved and integrated management practices and technologies can bring about good waste reduction outcomes at moderate cost. The
report explores (Chapter 9) two scenarios for increased waste diversion over and above the carry-on-much-as-now scenario.

The Improved Scenario has an indicative system-wide cost of around 5 per cent more than now (around $29 million added to the current $571 million) but takes diversion from disposal from a current 38 per cent (municipal 25 per cent; C&I 24 per cent; and C&D 60 per cent) to 54 per cent (municipal 49 per cent; C&I 42 per cent; C&D 67 per cent).

The Aggressive Initiatives Scenario has an indicative system-wide cost of around 14 per cent more than now (around $78 million) but takes overall diversion to 69 per cent.

Achievement of such improvements is dependent on gains being made in the other themes discussed here, but would rely, as well, on a mix of policy and regulatory reforms, financial incentives and education initiatives.

The incremental costs associated with waste reduction initiatives, such as described in these scenarios, would logically be borne by State Government, Local Government, the business sector and citizens.

These indicative financial costs would be somewhat offset by reduced energy costs and indirect environmental benefits. Moreover, the analysis does not take account of the scope for efficiency improvement through integrated waste management.

**The Waste Inquiry Recommends that the Government take into consideration these order of magnitude benefits and costs in framing a new waste/resource management vision.**

### 4.6 Waste Management Strategic Policy Framework

The Waste Inquiry has not made specific recommendations on the various aspects of the strategic policy framework necessary to achieve the proposed new way of managing waste. That task is beyond the Terms of Reference of this Inquiry and will be addressed in the upcoming review of waste management legislation. But the new paradigm for waste management clearly requires some changes to the present strategic framework to enable the emerging array of practices and technologies to make their full contribution.

The foundations for such a strategy are: vision; objectives; role clarity; business and citizen involvement; funding availability, and legislation. Key ingredients are outlined below.

**Vision** is needed by Government and all stakeholders to complete the paradigm change to “waste as a potential resource”. The concept is now part of the waste management industry debate in New South Wales. Policy initiatives over the last five years are strengthening the resource perspective. The strategic framework for the next five years ought to entwine strategy, practices and technologies with markets for transformed materials.

**Objectives** are needed in order to communicate the Government’s purpose and principles in relation to waste management. Goals such as waste diversion targets should be applied to specific waste stream types.

**Role clarity** is critical to achieving step-changes in waste management practices and take-up of technologies. It is now opportune to consider public sector institutional structure and role options in respect of strategy, policy and management, and the role that might best be played by the commercial waste management sector. Role clarity is essential to getting the best from integrated waste management.

For example, it is the view of this Inquiry that the Government should frame the vision, strategy and policies to bring about reform; guide and facilitate sound practice and technology adoption; and allow the commercial sector to own and operate systems and manage business risks.

**Business and citizen** involvement in waste minimisation is crucial to achieving source separation and waste streaming, and to identifying creative opportunities for improvement. The framework particularly should consider options for engaging business to accomplish waste reduction. Industry image appears to be an important driver of waste minimisation actions.

**Funding availability** should encompass both private sector and public sector sources to maximise the economic efficiency of this system.

**Legislation** review should take into consideration the need for an integrated approach to waste management using a portfolio of financial incentives and economic instruments, voluntary planning and management agreements, education, and regulatory flow control measures.

### 5. Review of Current and Emerging Technologies

The Waste Inquiry assessed four separate classes, covering 14 types of waste management technologies as follows:

**Mechanical Separation Technologies**
- Material Sorting
- Waste Separation

**Biological Technologies**
- Land Application
- Open Windrow Composting
- Vermicomposting
- Enclosed Composting
- Anaerobic Digestion
- Fermentation

**Thermal Technologies**
- Incineration
EXECUTIVE SUMMARY

• Pyrolysis/Gasification
• Waste Melting

Landfill Technologies
• Conventional Wet Landfill
• Conventional Dry Landfill
• Bioreactor Landfill.

These technologies are described in summary form in Box 1. The key features of each technology type are set out at Table 1. (See page 17)

5.1 Evaluation

The technologies were evaluated using criteria developed by the Waste Inquiry to reflect technical performance characteristics and relevant ESD issues.

The evaluation criteria used in the review cover:

Technical Issues
• Technology maturity
• Input quality flexibility
• Input quantity flexibility
• Local availability of technology and expertise

Environmental Issues
• Resource conservation
• Solid residues
• Greenhouse gas emissions
• Risk of water emissions
• Risk of air emissions

Social Issues
• Community involvement/buy-in
• Public perception
• Amenity impacts
• Employment impacts

Economic Issues
• Net costs per tonne
• Cost/scale sensitivity
• Net benefits per tonne
• Market availability for products.

The evaluation was based on the terms of reference of the Inquiry. However, there are various issues which limit comparative assessment of technologies:

• Local variations such as socio-economic factors, transportation distances for wastes and recovered resources greatly affect economic, environment and social impacts.
• Project scale greatly affects impacts, so technology scores are somewhat related to optimal project scale.
• The risks of environmental impacts to air, land, water and amenity from a facility are largely governed by the types and volumes of waste handled and the quantum of potential impacts that must be managed.

• Each generic technology has application to specific operating tasks which overlap at boundaries but differ in the main. Moreover, technologies should logically be considered in the context of their specific waste stream design application, (eg, organic waste, mixed waste, inert waste etc).

The weighting factors used in the evaluation process were determined by the Inquiry Panel Members to reflect relative importance of key issues associated with implementing the technologies at present. A variety of alternative weighting patterns was considered, and the Panel is satisfied that the one adopted best represents a balanced perspective. The results obtained were not sensitive to modest changes to the weightings applied to key criteria.

5.2 Technology Evaluation Conclusions

No single technology class can offer a complete solution by treating and processing all waste materials. Each can form part of an integrated waste management system. Moreover, technology classes and types excel in varying performance dimensions: a measure of trade-off is invariably required to balance technical, environmental, social and economic outcomes.

The choice of a portfolio of technologies should be made on the basis of regional circumstances, waste streams available and market demand for the products of reprocessing. More specifically, technology selection ought to be driven by three critical principles:

• A firm understanding that the array of technologies selected as part of an integrated system must play a pivotal role in linking markets for resources and the system of waste management practices adopted.
• Investment and operating risk can be best managed if input supply can be reasonably predicted and product demand can be reasonably judged. The most efficient allocation of these and other risks is a key factor in controlling waste management costs.
• Current and evolving circumstances provide an important context for technology choices. The complex intertwining of waste types generated, local planning, social and environment considerations, industry resource demands and geographic circumstances (along with many other issues) can provide opportunities and influence choices.

The Evaluation Results, drawn together for each technology type in Table 2, allow the following Conclusions to be reached:

(a) Mechanical Technologies perform specific purposes which essentially precede other treatment processes. Material sorting technologies (sometimes known as MRFs) score very well due to their maturity and modest cost in sorting dry recyclables, which are then reprocessed to create new paper and packaging products or industrial materials.
Box 1 Technology Description

MECHANICAL SEPARATION TECHNOLOGIES

Material sorting
These schemes use automated and manual sorting to separate mixed recyclable materials to groups of specific materials. The outputs are suitable for reuse, recycling or reprocessing.

Waste Separation
These technologies use a variety of physical processes, such as drums and pulverisers, to separate mixed residual wastes. The aim is to recover specific waste streams for further processing or reduced volume disposal.

BIOLOGICAL TECHNOLOGIES

Land Application
These schemes involve direct injection of organic wastes to increase the availability of nutrients in farm soils. This increases soil sustainability and crop yields. Typical waste materials are sewage sludge, agriculture wastes and grease trap wastes.

Open Windrow Composting
These technologies involve decomposition of organic wastes through microbial activity under open, aerobic conditions. The compost product is stable and rich in nutrients and organic matter and is suitable as a soil conditioner.

Vermicomposting
These technologies use worms to consume organic wastes including sewage sludge, food and animal wastes. The product is high quality compost suitable for soil conditioning.

Enclosed Composting
Controlled atmosphere and moisture conditions are used in these technologies to improve the rate of organic waste decomposition (over open windrow composting) and control odours. Enclosed composting systems use drums, boxes, tunnels, silos or vessels as the core process technology. System controls provide for input of potentially odorous waste including food, sewage sludge and garden wastes, to produce good quality compost.

Anaerobic Digestion
Digestion involves controlled biological degradation of organic wastes by microbial activity in the absence of oxygen. Methane-rich gas is produced suitable as fuel for energy generation. A digestate sludge is also produced, which is suitable for enriching compost materials. Input preparation or source separation is required to ensure that waste is free of non organic contamination.

Fermentation
Fermentation technologies involve biological degradation of organic wastes to produce a chemical feedstock or liquid fuel (usually ethanol). Primary input application has been agriculture wastes, but recent developments take municipal organics including food waste and sewage sludge.

THERMAL TECHNOLOGIES

Incineration
These mature technologies recover the calorific energy contained in residual wastes. Heat and steam for electricity generation is produced through mass combustion of the input waste. The products can be used for local heating and for energy input to the grid.

Pyrolysis/Gasification
In this group of technologies, waste materials are heated in the absence of oxygen to produce a liquid fuel (pyrolysis oil) which can then be separately gasified in the presence of oxygen to produce a fuel gas (syngas). This pyrolysis oil or syngas can in turn be used to power industrial engines producing energy for input to the grid, or as a chemical feedstock.

Waste Melting
These technologies use high temperatures to oxidise or reduce waste, and melt the residual material. The output is heat and fuel gas which can be used to power industrial engines producing energy for input to the grid. A further product is recyclable metal, and inert slag remains.

LANDFILL TECHNOLOGIES

Conventional Wet Landfill
These mature technologies are used to facilitate waste decomposition in a controlled manner. As the process of biodegradation takes place methane and carbon dioxide are released and a good proportion is captured as gas suitable as fuel for electricity generation.

Conventional Dry Landfill
Dry landfills are feasible in low precipitation climates, where minimisation of infiltration inhibits the biodegradation of waste. This reduces or eliminates leachate and landfill gas formation because of the dry stable conditions.

Bioreactor Landfill
In these landfills the rate of anaerobic decomposition is accelerated by recirculation of leachate and, in some cases, addition of sewage sludge. The process aims to improve gas production and electricity generation, and reduce the time taken to achieve stabilisation.
**Box 2  Suitable Input Materials and Products**

<table>
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<th>Technology Class/Type</th>
<th>Input Waste Type(s)</th>
<th>Output Product(s)</th>
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<td><strong>Mechanical Separation Technologies</strong></td>
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<tr>
<td>Material Sorting</td>
<td>Mixed dry recyclables, including:</td>
<td>Reprocessable materials by type.</td>
</tr>
<tr>
<td></td>
<td>• Paper/cardboard</td>
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<tr>
<td></td>
<td>• Packaging plastics, paper, glass, metals.</td>
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<td></td>
<td>Industrial dry recyclables, including:</td>
<td>Reprocessable materials by type.</td>
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<td>• Paper/cardboard</td>
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<tr>
<td></td>
<td>• Metals, plastics, glass</td>
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<tr>
<td></td>
<td>• Timber, concrete, spoil</td>
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<td>High calorific material (RDF) for thermal processes or reduced volume landfill.</td>
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<td>Inert materials.</td>
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<td></td>
<td></td>
<td>Metals.</td>
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<tr>
<td><strong>Biological Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Application</td>
<td>Agriculture wastes, sewage sludge, gypsum.</td>
<td>Soil improvement.</td>
</tr>
<tr>
<td></td>
<td>Specific organic wastes including grease trap wastes.</td>
<td></td>
</tr>
<tr>
<td>Open Window Composting</td>
<td>Garden waste, sewage sludge.</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td>Vermicomposting</td>
<td>Sewage sludge, food waste, garden waste.</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td>Enclosed Composting</td>
<td>Mixed organic waste, including:</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preseparated residual waste.</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High calorific material (RDF) for thermal processes or reduced volume landfill.</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>Mixed organic waste, including:</td>
<td>Biogas fuel/green energy.</td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td>Digestate material for compost.</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Agriculture wastes:</td>
<td>Liquid fuel.</td>
</tr>
<tr>
<td></td>
<td>Mixed organic waste, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High calorific specific wastes.</td>
<td>Waste destruction.</td>
</tr>
<tr>
<td></td>
<td>Special wastes, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clinical waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hazardous waste</td>
<td></td>
</tr>
<tr>
<td>Pyrolysis/gasification</td>
<td>Sewage sludge, agriculture wastes.</td>
<td>Pyrolysis oil or Syngas/green energy.</td>
</tr>
<tr>
<td></td>
<td>Mixed organic waste, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Paper pulp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preseparated residual waste.</td>
<td></td>
</tr>
<tr>
<td>Waste Melting</td>
<td>Metal wastes, hazardous waste.</td>
<td>Syngas/green energy.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal residue.</td>
</tr>
<tr>
<td><strong>Landfill Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioreactor Landfill</td>
<td>Mixed residual waste.</td>
<td>Methane/green energy.</td>
</tr>
</tbody>
</table>
Waste separation technologies score moderately for their ability to segregate mixed residual wastes so that various fractions can then be processed using specific biological or thermal technologies.

(b) The main recognised **Biological Technologies** score well on an aggregated criteria basis. The composting technologies in this group produce a moderate to high quality soil conditioner with strong market acceptance. They are mature technologies with moderate to good environmental characteristics and social impact and good economic viability.

A further biological technology, anaerobic digestion, scores slightly less on the criteria, but has energy as its main product along with organic material. Fermentation technology has not reached the same level of commercial maturity as its counterparts but can be used to produce a chemical feedstock at moderate cost. It scores moderately well on the criteria.

(c) **Thermal Technologies** are a mixed bag. Incineration, despite its maturity and input materials flexibility, scores poorly overall due to economic and social issues and low resource conservation capabilities.

The new thermal technologies, pyrolysis/gasification and waste melting technologies, are proven in specific materials applications and some pyrolysis/gasification technologies are reaching commercial status for mixed waste treatment. These technologies produce energy, at moderate cost, as their main output product.

This group of technologies scores moderately on the criteria.

(d) **Landfill Technologies** score moderately on the criteria, mainly due to their maturity (providing favourable operating performance), flexibility and low costs per tonne of input. These factors somewhat balance their poor performance in resource conservation, moderate environmental risk characteristics and low social acceptability. Bioreactor landfills and conventional wet landfills produce energy as their main product.

Each of the above technology classes should be used in a portfolio of technologies as part of an integrated waste management system that aims to maximise resource conservation at a cost acceptable to the community as a whole. Thus a technology portfolio might reasonably include a mix of:

- material sorting technologies geared to recovering high volumes of recyclable materials;
- biological and new thermal technologies (after waste separation) aimed at beneficial use of organic materials;
- landfill technologies for the inevitable remaining mixed residual waste that cannot be separated and processed at reasonable overall cost to the community.

It is not appropriate to distinguish between technology classes without reference to the waste stream to be treated. The adage: “garbage-in, garbage-out” is highly relevant. Some compost is of a quality suitable only as landfill cover, whilst some energy recovery systems are inefficient. Further, the scale of differences between the various technology types within each class is so great that it is entirely inappropriate to lump them all together, eg. thermal and biological technologies.

Moreover, care needs to be taken with the terminology “waste to energy”. Technologies that create energy from waste can take several forms. Some biological technology systems produce energy as the primary product, and some thermal technology systems can produce chemical feedstock in lieu of energy. The new landfill technologies too are able to win energy from the decomposition process. It is clear that this overlapping and blurring of technologies and products will become more profound over the next five years, as suppliers seek to improve and differentiate their technologies.

**The Waste Inquiry Recommends:**

- Adoption of purpose-specific emerging technologies into waste management operations in the municipal, C&I and C&D sectors on a planned commercial basis with private sector funding, but with general facilitation as necessary by the Government through economic and regulatory instruments, financial incentives and institutional arrangements.

- Project delivery and financing for technologies should be organised so that the private sector takes process, project and business risks.
Table 2: Technology Evaluation Table

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Technical</th>
<th>Environmental</th>
<th>Social</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluation Criteria Weighting (%)</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Mechanical</td>
<td>Material Sorting</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Waste Separation</td>
<td>4.5</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Biological</td>
<td>Land Application</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Open Window Composting</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Vermicomposting</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Enclosed Composting</td>
<td>5</td>
<td>2.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Fermentation</td>
<td>3.5</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Thermal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incineration</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Pyrolysis/ Gasification</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Waste Melting</td>
<td>2.5</td>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Landfill</td>
<td>Conventional Wet Landfill</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Conventional Dry Landfill</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Bioreactor Landfill</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Indicative assessment based on broad technology classes and types, not brands.

The practices adopted in managing discarded materials are fundamental to both protecting the environment, and using waste as a resource. The Waste Inquiry has found that sustainable waste management should be guided by a clear strategy which employs simple but sound practices. These practices must be in touch with the community psyche, market-based where possible, and underpinned by a robust strategic policy framework.

The waste management practices adopted should lead selection of the array of technologies employed in the solution, rather than the reverse.

The Waste Inquiry assessed three separate classes, covering nine types of waste management practices as follows:

Waste Minimisation Practices
- Material recycling
- Product reuse
- Waste avoidance

Integrated Waste Management Practices
- Waste streaming
- System integration
- Industry arrangements

Market Development Practices
- Alternative recyclate uses
- Quality standards
- Market intervention.

The main features of each practice type are set out at Table 3. Box 3 presents a description of the focus and drivers of the various practices. (See page 18)

The management practices were broadly assessed against operational, environmental, social and economic criteria, similar to the ones used in reviewing the technologies.

6.1 Management Practices Assessment Conclusions

The Waste Inquiry has found that effective management practices are driven by three major principles:

- Minimising the amount of waste inappropriately disposed of by “enabling” the practices described in the waste hierarchy, with priority accorded to waste avoidance.
- Viable end-markets for discarded resources. They need to be founded on economic good sense as well as resource conservation goals.
- Integrated waste management aimed at efficiently supplying consistent quality resources to the highest value end-markets.

6.1.1. Waste Minimisation Practices

(a) Achieving More Recycling and Reprocessing

There is strong community support for recycling, and it is based on a well developed sense that the practice is both good for the environment and is an accessible way of making a personal contribution. Ample capacity and goodwill exists for an increased contribution by business and citizens to the general recycling effort. Creative management practices can be deployed to encourage and facilitate easier recycling.

It is technically feasible to recover and recycle most discarded materials. Technical system barriers to significantly increased recycling relate to the cost of recovering, sorting and reprocessing of recyclate. Entrepreneurial action and technology innovations are leading to cost savings in each of these activities.

The market issues concern recyclate product consistency and market price stability. Both are tackled in Europe and North America by specification of various graded quality standards and development of local and international recyclate markets.

The C&I sector in particular warrants special attention. Although significant volumes of glass and paper are already captured, more is readily available and other materials could be recycled in greater volume.

Many small/medium enterprises (SMEs) have a waste stream that is up to 95 per cent commercial/industrial recyclables and only 5 per cent food or other contaminants. A smart system would make it easy to keep the real waste out of the mixed recyclable stream by providing collection technology geared to intercepting and capturing waste before it becomes mixed and uneconomic to recover. One way forward is to bring about collaborative recycling for industrial estates, shopping centre tenants and other business clusters.

Changing the price structure for C&I waste management to provide financial incentives to reduce residual waste capacity and use recycling bins is an important tactic to bring about increased recycling in the C&I sector. This is done overseas by relating charges more to weight or volume, and less to a “per lift” basis.

The current technology and pricing arrangements result in high costs for many SMEs that seek to participate in recycling.

Social and community barriers to greatly increased recycling relate to convenience and message reinforcement. The opportunities for public place recycling in New South Wales are minimal and therefore non-reinforcing: public place streaming technology is limited and colour coding is inconsistent.

Financial incentives too can make a contribution to greater municipal recycling when used in combination with strong communication of the benefits of recycling. European and North American cities have successfully differentiated pricing for recyclables from mixed residual waste, and provide distinguishable incentives for reduced volumes of residual wastes.
# Table 3  Key Features of Waste Management Practices

<table>
<thead>
<tr>
<th>Technology Class&gt;Type</th>
<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste Minimisation Practices</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Material Recycling | • Good resource conservation (virgin material avoidance, energy savings).  
• Emissions reduction.  
• Net benefit on sustainability benefit/cost analysis.  
• Strong community support and goodwill. |
| Product Reuse | • Excellent resource conservation and economic benefits.  
• Community involvement with minimal awareness of benefits.  
• Traditional concept, partly supplanted by lightweight packaging and recycling. |
| Waste Avoidance | • Clean production.  
• Sustainable consumption. |
| **Integrated Waste Management Practices** | |
| Waste Streaming | • Source separation of wastes to various nominated organic, municipal recyclable, industrial recyclable and hazardous waste streams.  
• Enables material recovery and reduces need for (later) waste separation.  
• Facilitates integrated waste management by reducing the mixed residual waste stream. |
| System Integration | • Links markets, technologies, logistics, waste streams and geographic areas.  
• Facilitates discovery and exploiting of opportunities for recycling and reprocessing. |
| Industry Arrangements | • Organisation of waste management geared to innovation in technology and management practices.  
• Public sector and private sector waste management industry are well resourced and skilled. |
| **Market Development Practices** | |
| Alternative Recyclate Uses | • Diversification of end use applications can strengthen and stabilise demand.  
• Specifications and regulations need to be geared to accommodate recycled alternative materials. |
| Standards | • An appropriate array of standards can act to improve recycled product marketability.  
• Confidence and trust can be enhanced through adherence to established quality standards. |
| Market Intervention | • Intervention through economic instruments, subsidies and grants, and risk sharing can be crucial in developing markets for recycled materials.  
• Product/market development through business and Government commitment to purchase recycled materials and products. |
The Waste Inquiry Recommends that the following reforms should be adopted by Government and the waste management industry:

- Organise on-site recycling and collection systems, and pricing for the C&I sector to match the physical circumstances and discard streams of each business and its cluster setting. The C&I sector can be tackled successfully by a Task Force comprising Government, waste management industry, and business sector representatives.

The Government could contribute to this process by establishing appropriate targets for business waste reduction for C&I sub sectors, and working with business leaders from each sub sector to develop sub sector “business waste reduction plans” eg. food supermarkets, retail shopping centres etc. The Task Force referred to in Section 4 (d) above and could be used to establish the collaborative process.

- Provide a universal colour coding system to encourage and reinforce recycling. The coding system ought to feature a standard colour depicting each recyclable material, predictable (if not standard) bin shapes in public places (including footpaths and train stations), and a standard cluster of material discard opportunities at each public location (eg, plastic, glass, metal, paper – food might be a later addition).

- Introduce a “Waste-Not” DCP requirement in relation to all Local Government approvals.

- Progressively change waste management pricing arrangements for the municipal sector: to provide real financial incentive for smaller residual bin size (or, ultimately, less frequent collection); and to shift ratepayer charges more to residual waste and less to recyclables collection.

(b) Achieving More Product Reuse

Product reuse accrues powerful environmental benefits, but more could be done to encourage the practice given its elevated position in the waste hierarchy. A key issue is how best to unite buyers and sellers when the value of the reusable products is low. Europe and the United States have successfully established “drop-off” centres to capture end-of-first-life bulky household and commercial products and promote extended producer responsibility/product stewardship. These highly successful centres are conveniently located and attractive to visit.

A pilot drop-off centre is currently proposed by Western Sydney Waste Board as a full-scale trial to prove the viability of the concept. It appears to be viable on commercial and economic grounds.

The Waste Inquiry Recommends support for the proposed drop-off centre pilot trial through Government and (if possible) business funding, and, if successful, private sector participation in future drop-off centres.

(c) Commitment to Recycling

Most communities don’t count the benefits of waste minimisation, and particularly recycling, in narrow economic terms. However, the existence of strong private sector participants in the market does indicate that recycling can be profitable in the right circumstances. This Report demonstrates that the economic and environmental benefits of recycling go close to covering direct and indirect costs. Logistics efficiencies, improved technologies and developed markets can consolidate economic, environmental and social sustainability.

Moreover the marginal cost of increased recycling is considerably less than the marginal benefits given the infrastructure in place.

The Waste Inquiry Recommends that the Government reassert its commitment to material recycling in the strongest terms, to provide community confidence and encourage increased participation by business and citizens.

6.1.2. Integrated Waste Management Practices

(a) System Integration

Waste management activities in New South Wales are organised as sequential steps in which management and materials ownership shifts from one participant to the next. For the municipal streams, four and sometimes five specialist organisations play a part in the journey from discarding to disposal or reprocessing organisations. Adding the C&I and C&D discard streams brings further participants into the business of managing waste. At present each participant in the management process logically seeks to optimise their own position, which works against the interests of overall system optimisation. This way of managing is inefficient and limits potential for discovering and exploiting new opportunities for recycling and reprocessing materials.

Waste management and recycling practice could be greatly improved by adoption of a more integrated approach which strengthens the links between steps in the supply chain, various waste streams, processing technologies, and geographic areas.

Integrated waste management practice, widely adopted overseas, is based on the idea of an overall approach. It is a central plank of the recently developed waste management strategy for England and Wales, and is routine practice in many other parts of Europe and the USA. It involves moving beyond the current fragmented but evolving approach, to synergistically link and combine sequential activities, and various types of waste streams, and wider geographic areas, together with appropriate processing technologies. This practice can not only increase the scale and efficiency of operations, but can also provide rewards for action to support diversion of resources from disposal to reuse, recycling and reprocessing.

System integration implies an approach that incorporates in single contracts and/or agreements:

- increased value chain activities, including collection, transfer, transport, MRF sorting, treatment, selling, and/or disposal;
The complexity and cost of recycling and reprocessing demand. The more universal integration will require collaboration between the private sector waste management industry, Government, Local Government and public sector interests.

(b) Waste Streaming at Source

The Waste Inquiry Recommends that the Government initiate a detailed examination of how best to bring about the structural reforms needed to bring about the structural reforms needed to implement the practice of integrated waste management. Achievement of effective integration will require collaboration between the private sector waste management industry, Government, Local Government and public sector interests.

The Waste Inquiry Recommends Government/waste management industry collaboration to drive adoption of principles and measures which lead to waste streaming at the point of discard. These include:

- Contract arrangements that enable business clusters to pool waste management arrangements to maximise streaming.
- Provision of services and facilities to capture separately the main municipal discard streams in a controlled expansion of supply to match increasing market demand.
- Government leadership in changing the business waste management paradigm from waste collection/disposal to resource management: total waste management rather than fragmented transport services. This will require coordination, education, economic instruments and appropriate regulatory action.

(c) Industry Arrangements

New South Wales is well positioned to achieve further waste management reform through its public sector waste policy and management agencies and private sector waste management and recycling industry. The resources and skills available to the community, operating in a competitive framework, provide a favourable basis for the development of greatly improved management practices and the uptake of innovative technologies to efficiently transform wastes to resources.

The Waste Inquiry believes that innovation in waste management practice and technology development is best served by the existence of a competitive market framework in the waste and recycling sector. An adequately resourced and skilled commercial waste management industry exists in New South Wales. This sector should take responsibility for the commercial risks associated with the delivery, ownership and management of new technologies and practices.

Regional waste planning and management has been considerably strengthened by the creation of the Waste Boards, but greater coordination is necessary (particularly across the Sydney Metropolitan Area). Further, the role of the Boards should be clarified and defined in terms of regional outcomes to be achieved.

A properly independent advisory body with expertise in waste strategy, management and operations is needed to provide the Government with strategic advice on significant waste management issues.
The Waste Inquiry Recommends that the Government:

• Adopt the proposed institutional reforms to improve Waste Board performance.

• Establish a body of waste management stakeholders to provide an alternative source of waste management policy and strategic advice to Government.

• Engage the commercial waste management industry to manage investment and operating risks associated with adoption of innovative practices.

(d) Research and Development

Research and Development is poorly funded throughout Australia in relation to the scale of the opportunity available for innovative technologies and practices. There is a clear need for increased research to:

• assist in developing and commercialising Australian technologies, and demonstrating these to global markets;

• further develop and apply Life Cycle Analysis to inform policy and operating decisions;

• trial and demonstrate the viability of alternative waste management practices.

The Waste Inquiry Recommends development and funding of a broad-based five year R & D program, with priorities established by the Task Force referred to at Section 4 (d) above.

6.1.3. Market Development Practices

Market barriers to greatly increased recycling are associated with demand; key factors are resistance to using recyclate in new products, price fluctuations and quality consistency. The German response to these issues involves legislative recyclate content specification; the UK and North America have opted for promotion and persuasion. Many see global markets as a key to increased demand. Development of new, high value uses for recyclate, beyond traditional sectors, is now seen as critical for market stability.

Overseas experience has shown that a substantial coalition of effort by Government, business and citizens is essential to creating viable stable markets for recycled materials. A package of market stimulation measures and quality standards remains an imperative to building sustainable markets.

Five issues are important in market development:

• use of economic instruments based on the financial incentive principles employed in the Government’s successful Load Based Licensing program.

• review of the size and application of the Section 88 waste levy;

• action to stimulate alternative uses of recyclate in order to diversify end-market applications;

• development of an array of appropriate quality standards for each recyclate type, so that broader market choice opportunities are created;

• direct intervention by Government (such as extending the policy preference for recycled products) in order to strengthen market demand.

The Waste Inquiry Recommends a specific review by Government of market development initiatives for recycled materials.

7. Scenario Development

Illustrative scenarios were developed to demonstrate what might be achievable by integrating improved management practices and compatible technologies. These cover each waste generating sector: municipal, commercial and industrial and construction and demolition. The three scenarios compared encompass plausible and reasonably efficient options to gain progressively more value from waste.

Scenario 1.

Carry on much as now.

• based on current systems of waste minimisation and management.

Scenario 2

Improve current initiatives

• based on increased recycling and streaming of various wastes.

Scenario 3

Aggressive initiatives

• incorporating a variety of initiatives to capture and beneficially use waste streams.

The illustrative outcomes, taking account of indicative financial costs and revenues are set out at Table 4. The main conclusions from this scenario analysis are:

• Significant further gains can be made in waste minimisation at modest cost. Based on the waste flow plans associated with each scenario (See Box 4), the following indicative total cost estimates can be derived:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$571 million</td>
</tr>
<tr>
<td>2</td>
<td>$600 million</td>
</tr>
<tr>
<td>3</td>
<td>$649 million</td>
</tr>
</tbody>
</table>

• The net incremental cost increases between scenarios arise from specific waste diversion initiatives covering each waste sector.

• The incremental cost of moving from Scenario 1 to Scenario 2 is thus an indicative $29 million, distributed as follows:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>$13 million</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>$9 million</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>$7 million</td>
</tr>
</tbody>
</table>

• The incremental cost of moving from Scenario 1 to Scenario 3 is an indicative $78 million, made up as follows:

<table>
<thead>
<tr>
<th>Sector</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>$31 million</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>$31 million</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>$16 million</td>
</tr>
</tbody>
</table>
• The C&D sector offers good scope for further recycling without major overall cost impost, though already some 60 per cent of this waste is recycled or reused (a proportion of it as landfill cover).

• There are immediate opportunities for further waste minimisation in the C&I sector to Scenario 2 level without major overall financial cost impost.

Numerous caveats in relation to this modelling are described in the report. One is important to note here. Technology types are deliberately left unidentified in the scenario modelling. Moreover, other technology classes could be substituted for the ones nominated. For example:

• A variety of technologies could be used effectively in lieu of composting technologies to process garden waste and organic waste and produce beneficial products (eg, anaerobic digestion, pyrolysis/gasification and fermentation).

• A variety of treatment technologies suitable for residual waste processing could be used to divert, treat and recover a measure of residual waste modelled to landfill (eg, biological technologies and thermal technologies, in association with varying levels of waste separation).

Table 4 Scenario indicative financial outcomes

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MUNICIPAL</th>
<th>C&amp;I</th>
<th>C&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent Diverted</td>
<td>25</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td>$139.23</td>
<td>$81.43</td>
<td>$59.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MUNICIPAL</th>
<th>C&amp;I</th>
<th>C&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent Diverted</td>
<td>49</td>
<td>42</td>
<td>67</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td>$146.33</td>
<td>$85.63</td>
<td>$62.72</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MUNICIPAL</th>
<th>C&amp;I</th>
<th>C&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cent Diverted</td>
<td>66</td>
<td>63</td>
<td>76</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td>$156.40</td>
<td>$95.97</td>
<td>$66.35</td>
</tr>
</tbody>
</table>

**Box 4 Scenario Resource Flows**

**SCENARIO 1 FLOW PLAN**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Streamed, Recycled (% of total)</th>
<th>Streamed, Recycled (mtpa)</th>
<th>Residual (mtpa)</th>
<th>Total (mtpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>25</td>
<td>0.450</td>
<td>1.350</td>
<td>1.800</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>24</td>
<td>0.500</td>
<td>1.600</td>
<td>2.100</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>60</td>
<td>1.500</td>
<td>1.000</td>
<td>2.500</td>
</tr>
<tr>
<td>Total</td>
<td>38</td>
<td>2.450</td>
<td>3.950</td>
<td>6.400</td>
</tr>
</tbody>
</table>

**SCENARIO 2 FLOW PLAN**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Streamed, Recycled (% of total)</th>
<th>Streamed, Recycled (mtpa)</th>
<th>Residual (mtpa)</th>
<th>Total (mtpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>49</td>
<td>0.886</td>
<td>0.914</td>
<td>1.800</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>42</td>
<td>0.888</td>
<td>1.212</td>
<td>2.100</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>67</td>
<td>1.682</td>
<td>0.818</td>
<td>2.500</td>
</tr>
<tr>
<td>Total</td>
<td>54</td>
<td>3.456</td>
<td>2.994</td>
<td>6.400</td>
</tr>
</tbody>
</table>

**SCENARIO 3 FLOW PLAN**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Streamed, Recycled (% of total)</th>
<th>Streamed, Recycled (mtpa)</th>
<th>Residual (mtpa)</th>
<th>Total (mtpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>66</td>
<td>1.188</td>
<td>0.612</td>
<td>1.800</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>63</td>
<td>1.319</td>
<td>0.781</td>
<td>2.100</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>76</td>
<td>1.900</td>
<td>0.600</td>
<td>2.500</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td>4.407</td>
<td>1.993</td>
<td>6.400</td>
</tr>
</tbody>
</table>
Table 1  Main Features of Technologies

<table>
<thead>
<tr>
<th>Technology Class/Type</th>
<th>Main Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical Separation Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Material Sorting</td>
<td>• Mature technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of municipal and commercial dry recyclable materials.</td>
</tr>
<tr>
<td></td>
<td>• Good resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Main product is recyclate for further reprocessing.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Waste Separation</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept mixed residual waste as input.</td>
</tr>
<tr>
<td></td>
<td>• Main products are specific separated resource streams for further processing.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td><strong>Biological Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Land Application</td>
<td>• Simple technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Controls needed to avoid nutrient runoff.</td>
</tr>
<tr>
<td></td>
<td>• Good soil improvement.</td>
</tr>
<tr>
<td></td>
<td>• Moderate/good benefit/cost position.</td>
</tr>
<tr>
<td>Open Windrow Composting</td>
<td>• Simple, mature technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Best performed at commercial scale.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input contamination.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Vermicomposting</td>
<td>• Simple technologies, at commercial operating status.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input material.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Enclosed Composting</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Good environmental features.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input contamination.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Products are both energy and compost input.</td>
</tr>
<tr>
<td></td>
<td>• Moderate/good benefit/cost position.</td>
</tr>
<tr>
<td>Fermentation</td>
<td>• Reaching commercial status for mixed organic wastes.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Main product is ethanol for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
</tbody>
</table>

continued
### Table 1  Main Features of Technologies (continued)

<table>
<thead>
<tr>
<th>Technology Class/Type</th>
<th>Main Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thermal Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Incineration</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept wide variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Poor/moderate resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Require considerable air emission control equipment.</td>
</tr>
<tr>
<td></td>
<td>• Products are both energy and heat.</td>
</tr>
<tr>
<td></td>
<td>• Poor benefit/cost position.</td>
</tr>
<tr>
<td>Pyrolysis/Gasification</td>
<td>• At commercial operating status for specific wastes, reaching commercial status for preprocessed residual waste.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Main product is syngas or oil used for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
<tr>
<td>Waste Melting</td>
<td>• Commercial operating status for metal wastes, not yet commercial status for mixed residual waste.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited (but possibly expanding) variety of wastes.</td>
</tr>
<tr>
<td></td>
<td>• Main products are heat and syngas used for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Poor to moderate benefit/cost position.</td>
</tr>
<tr>
<td><strong>Landfill Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Conventional Wet Landfill</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept wide variety of waste types.</td>
</tr>
<tr>
<td></td>
<td>• Poor resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Main product is methane, used for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
<tr>
<td>Conventional Dry Landfill</td>
<td>• Mature, robust technologies</td>
</tr>
<tr>
<td></td>
<td>• Accept wide variety of wastes.</td>
</tr>
<tr>
<td></td>
<td>• Poor resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
<tr>
<td>Bioreactor Landfill</td>
<td>• Robust technologies, at commercial status.</td>
</tr>
<tr>
<td></td>
<td>• Accept wide variety of wastes.</td>
</tr>
<tr>
<td></td>
<td>• Poor resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Main product is methane, used for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
</tbody>
</table>
### Box 3 Focus & Drivers of Waste Management Practices

<table>
<thead>
<tr>
<th>Practice System</th>
<th>Product/Market Focus</th>
<th>Facilitators</th>
<th>Key Drivers</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste Minimisation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Households.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Households.</td>
<td>commitment</td>
<td></td>
</tr>
<tr>
<td>Material Recycling</td>
<td>Reprocessing of mainly paper/board, packaging, organics, metals, building</td>
<td>Business</td>
<td>Business and citizen</td>
<td>Participation and support, based on suitable quality standards and clarity of materials. requirements.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Households.</td>
<td>commitment</td>
<td></td>
</tr>
<tr>
<td>Waste Streaming</td>
<td>Resource market focus with planned streaming.</td>
<td></td>
<td>Waste management practice leadership</td>
<td></td>
</tr>
<tr>
<td>System Integration</td>
<td>System synergy by linking markets, process steps, waste streams and geographic areas.</td>
<td>Waste Boards</td>
<td>Waste management practice leadership</td>
<td>Management improvement, cost reduction.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industry Arrangements</td>
<td>Sustainable management of discarded resources.</td>
<td>Waste mgt. industry.</td>
<td>Waste management practice leadership</td>
<td>Clarity of objectives, roles and authority.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Standards</td>
<td>Array of specifications providing user choice</td>
<td>EPA.</td>
<td>Market perspective.</td>
<td>Linkage between market needs and resource availability.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RECOMMENDATIONS: A New Way of Managing Waste

A consolidated list of all Recommendations is set out below.

The Triple Manifesto

Recommendation 1

The Waste Inquiry urges the Government to adopt this triple manifesto as the defining framework for waste management and Recommends that the Government move forward with its intended review of State waste management legislation and the strategic policy framework, based on moving the paradigm away from waste disposal toward resource management.

The Marketplace

Recommendation 2

The Waste Inquiry Recommends that the Government lead actions to stimulate the market for recyclate:

2.1 Reaffirm and drive the Government initiative for purchase of recycled materials as a matter of policy preference.

2.2 Encourage and facilitate action by waste management companies to develop raw materials end-markets by facilitating innovative commercial linkages between markets, technologies and practices; for example, by ensuring a smooth path through the various planning processes.

2.3 Ensure a consistent policy and regulatory philosophy so that material flow continuity is predictable, moderating project investment risks, and ultimately building confidence in recyclate products.

Waste Management Technologies

Recommendation 3

The Waste Inquiry Recommends that Government policy and management initiatives be organised to:

3.1 Guide and facilitate take-up and deployment by the commercial waste management sector of a portfolio of technologies through appropriate settings in economic instruments (including the waste disposal levy), voluntary industry agreements and regulations so that each waste stream is treated to best advantage.

3.2 Provide enhanced investment and contract certainty by signalling policy intentions for the waste disposal levy in respect of amount, technology application and planned rate of change.

3.3 Provide support where appropriate in the form of low interest loans to encourage investment in, and full commercialisation of, emerging technologies.

Integrated Waste Management Practices

Recommendation 4

The Waste Inquiry Recommends:

4.1 Inclusion of integrated waste management as part of the strategic policy framework for waste management in New South Wales so that it becomes the accepted way of organising activities.

4.2 Progressive adoption of integrated waste management practices which link each step in the supply chain and provide for a portfolio of reuse, recycling, reprocessing and disposal schemes to gain optimal value from waste as a potential resource.

4.3 Government coordination of actions to achieve integrated waste management in Municipal, C&I and C&D sectors, in collaboration with business, local government, citizens and the waste management industry. Stakeholder involvement is critical to achieving beneficial outcomes.

4.4 A short term Task Force of key Government, business and waste management industry participants, to guide planning and implementation of integrated waste management in the C&I sector. This sector has high potential for waste management and resource recovery, but waste diversion efforts to date have been limited and inconsistent.

4.5 Voluntary action, financial incentives, and ultimately regulatory action to drive capture and processing of new waste streams (identified in this report), and marketing of derived products with collaboration by business, Government, citizens and the waste management industry.

4.6 The EPA monitor implementation without delay of this program and take action to remove any roadblocks.
Costs of Potential Improvements

Recommendation 5
The Waste Inquiry Recommends that the Government take into consideration these order of magnitude benefits and costs in framing a new waste/resource management vision.

Current and Emerging Technologies

Recommendation 6
The Waste Inquiry Recommends:

6.1 Adoption of purpose-specific emerging technologies into waste management operations in the municipal, C&I and C&D sectors on a planned commercial basis with private sector funding, but with general facilitation as necessary by the Government through economic and regulatory instruments, financial incentives, and institutional arrangements.

6.2 Project delivery and financing for technologies should be organised so that the private sector takes process, project and business risks.

Waste Management Practices

Achieving More Recycling and Reprocessing

Recommendation 7
The Waste Inquiry Recommends that the following reforms should be adopted by Government and the waste management industry:

7.1 Organise on-site recycling systems and pricing for the C&I sector to match the physical circumstances and discard of each business and its cluster setting. The C&I sector can be tackled successfully by a Task Force comprising Government, waste management industry, and business sector representatives.

The Government could contribute to this process by establishing appropriate targets for business waste reduction for C&I sub sectors, and working with business leaders from each sub sector to develop sub sector “business waste reduction plans”. eg, food supermarkets, retail shopping centres etc. The Task Force referred to in Section 4 (d) above and could be used to establish the collaborative process.

7.2 Provide a universal colour coding system to encourage and reinforce recycling. The coding system ought to feature a standard colour depicting each recyclable material, predictable (if not standard) bin shapes in public places (including footpaths and train stations), and a standard cluster of material discard opportunities at each public location (eg, plastic, glass, metal, paper – food might be a later addition).

7.3 Introduce a “Waste-Not” DCP requirement in relation to all Local Government approvals.

7.4 Progressively change waste management pricing arrangements for the municipal sector: to provide real financial incentive for smaller residual bin size (or, ultimately, less frequent collection); and to shift ratepayer charges more to residual waste and less to recyclables collection.

Waste Management Practices Achieving More Product Reuse

Recommendation 8
The Waste Inquiry Recommends support for the proposed drop-off centre pilot trial through Government and (if possible) business funding, and, if successful, private sector participation in future drop-off centres.

Waste Management Practices Commitment to Recycling

Recommendation 9
The Waste Inquiry Recommends that the Government reassert its commitment to material recycling in the strongest terms, to provide community confidence and encourage increased participation by business and citizens.

Waste Management Practices System Integration

Recommendation 10
The Waste Inquiry Recommends that the Government initiate a detailed examination of how best to bring about the structural reforms needed to implement the practice of integrated waste management. Achievement of effective integration will require collaboration between private sector waste management industry, Government, local government, and public sector interests.
RECOMMENDATIONS

Waste Management Practices
Waste Streaming at Source

Recommendation 11
The Waste Inquiry Recommends Government/waste management industry collaboration to drive adoption of principles and measures which lead to waste streaming at the point of discard. These include:

11.1 Contract arrangements that enable business clusters to pool waste management arrangements to maximise streaming.
11.2 Provision of services and facilities to capture separately the main municipal discard streams in a controlled expansion of supply to match increasing market demand.
11.3 Government leadership in changing the business waste management paradigm from waste collection/disposal to resource management: total waste management rather than fragmented transport services. This will require coordination, education, economic instruments and appropriate regulatory action.

Waste Management Practices Industry Arrangements

Recommendation 12
The Waste Inquiry Recommends that the Government:
12.1 Adopt the proposed institutional reforms to improve Waste Board performance.
12.2 Establish a body of waste management stakeholders to provide an alternative source of waste management policy and strategy advice to Government.
12.3 Engage the commercial waste management industry to manage investment and operating risks associated with adoption of innovative practices.

Waste Management Practices Market Development

Recommendation 13
The Waste Inquiry Recommends development and funding of a broad-based five year R & D program, with priorities established by the Task Force referred to at Section 4.4 above.

Recommendation 14
The Waste Inquiry Recommends a specific review by Government of market development initiatives for recycled materials.
CHAPTER 1 Introduction

Why do some communities manage waste with alacrity while others seem overwhelmed by the task? Are some communities wise in seeking value from waste, or should they choose least-cost disposal options? The Waste Inquiry has sought to understand the potential contribution of management practices and technologies in seeking answers to these fundamental questions.

This report presents the outcomes of the Alternative Waste Management Technologies and Practices Inquiry. Established by the Minister for the Environment in August 1999, the Waste Inquiry has conducted a review of the technologies and practices that can create viable products from discarded materials.

In accordance with the Terms of Reference, the review has been framed on an ESD basis, emphasising economic, social and environmental dimensions. Technology viability too is a critical consideration.

The Waste Inquiry has been undertaken at a time when three related issues have coincided to bring waste management into special focus: favourable economic conditions are driving increased consumption and disposal; numerous pressures surround the availability of future landfill capacity; and promising new options are emerging for treatment and beneficial use of some waste resources.

The Inquiry Panel has attempted to provide an objective assessment of waste management practices and technologies. A primary purpose has been to demystify waste management issues and inform citizens, business and government about how we all might contribute to tackling the growth of waste.

An important purpose also has been to provide an accessible framework to guide others in considering waste management options. The framework is straightforward and, no doubt, could be developed further as new technologies press for recognition.

The Inquiry has received and considered 80 submissions during the course of the investigation. Hearings were conducted and inspections and interviews were undertaken in various urban and regional centres of New South Wales. The Panel also visited facilities in Victoria and Queensland, and in overseas countries, to inspect emerging technologies and review waste management practices.

The Report comprises nine main sections. The Terms of Reference for the Inquiry are at Chapter 2. Chapter 3 is a survey of the current waste management situation in New South Wales.

A review of overseas waste management strategies, practices and technologies is included at Chapter 4. This provides important input to later chapters which consider management practices and technologies.

Chapter 5 introduces and describes the various technologies which are more fully evaluated in Chapter 6. This chapter presents a comparative perspective, as far as possible, of technologies which perform a variety of functions. The classes reviewed include mechanical separation, biological technologies, thermal technologies and landfill technologies.

Products and markets are covered in Chapter 7. Resource markets are critical if more waste materials are to be diverted for beneficial use.

Waste management practices are described and assessed in Chapter 8. These cover waste minimisation processes, integrated waste management practices and market development practices.

The threads are drawn together in Chapter 9, which presents three scenarios for future waste management.

The Report concludes that New South Wales can gain more value from waste resources. This can be achieved by significantly increasing recycling and reprocessing of discarded materials. There are clever technologies and creative practices available now, and some promising ones emerging, which provide the tactics to create viable products from waste materials.

This Report has not addressed the strategic policy changes needed to give impetus to waste management reform. That task is beyond the Terms of Reference of the Waste Inquiry. This Report will provide input to a planned review of the Waste Minimisation and Management Act (1995), scheduled for later this year. That review will provide the basis for future strategic policy framework for waste management in New South Wales.
The following advertisement announcing the Waste Inquiry and calling of submissions appeared in the Sydney Morning Herald of 31 July, 1999.

Call for Submissions

Minister for the Environment, Bob Debus, has established the Alternative Waste Management Technologies and Practices Inquiry. The purpose of this public inquiry is to investigate current and emerging waste management technologies and practices, taking into account the principles of ecologically sustainable development. The findings of this inquiry will be used to inform decisions of Government, Waste Boards and the waste industry about future waste management infrastructure and practices in New South Wales.

The inquiry’s terms of reference 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 water impacts and amenity.
  - (2) Contribution to waste avoidance and beneficial re-use of resources.
  - (3) Contribution to waste reduction.
  - (4) Environmental and economic benefits and costs of the alternative technologies 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 affecting the capacity for accelerating the implementation of alternative waste management technologies and practices in NSW in the short, medium or long term.

CHAPTER 2 Terms of Reference of the Waste Inquiry
Waste management, the world over, is still largely a logistics business, based on minimising handling, transport and disposal costs. The system is designed around logistics efficiency rather than efficient and effective resource management.

This Chapter sets the scene by outlining the way waste is currently managed in New South Wales. As a background description, it covers industry arrangements, waste flows, logistics, landfill capacity and briefly describes some of the main national waste minimisation initiatives.

The section on logistics introduces a series of diagrams to illustrate flows of waste and recyclables in each waste sector. Good data is notably absent from the Australian waste management scene, particularly in the C&I and C&D sectors. New South Wales has made significant advances in recent years, and estimates for this Chapter have been made by the Inquiry by integrating data from the Environment Protection Authority, Waste Boards and private sector sources. 1998 has been adopted as the base period for data analysis. It is recognised that more recent data show gains in recycling over this period.

3.1 Waste Management Legislation and Regulation

Waste management in New South Wales is governed by the Waste Minimisation and Management Act, 1995. The Act established a stretch goal for waste reduction, a waste management options hierarchy, and an institutional framework for managing waste.

The Act also created the State Waste Advisory Council, with a widely representative membership, to advise the Minister and the Environment Protection Authority of New South Wales (EPA) on planning and policy issues (see description at Section 3.2.5.). It also created eight Waste Boards, responsible for planning and managing waste at a regional level, with membership drawn from constituent local councils (see description at Section 3.2.2.).

An important object of the act was to ensure an appropriate measure of industry responsibility for managing waste. The vehicle for this is the development of Industry Waste Reduction Plans, for which the act sets out the basis and requirements. Waste disposal regulation in New South Wales is facilitated by the Protection of the Environment Operations Act 1997 (the POEO Act), and the Regulations made under the act.

Under this act, waste generating, transporting and disposal operations are in two classes:

- **scheduled activities** – those which are subject to environment protection licences; and
- **non-scheduled activities** – those for which environment protection licences are not required.

Licence conditions for scheduled waste activities require measures to regulate pollution and to prevent environmental harm. Non-scheduled waste activities are regulated by generic environmental protection requirements set out in the POEO Act Regulations.

The EPA’s regulation and enforcement capacity is based on:

- the POEO Act, which clarifies the responsibilities of owners of waste;
- regulations which control non-licensed generators and transporters in relation to waste tracking;
- licence conditions which require state-wide monitoring and reporting for hazardous, industrial and some liquid wastes;
- a National Environment Protection (Movement of Controlled Wastes between States and Territories) Measure, to enhance the tracking of controlled wastes moving between NSW and other States.

The POEO Act consolidates and establishes a range of offences dealing with wastes.

“...**Tier 1 offences:**
- willfully or negligently disposing of waste in a manner that harms or is likely to harm the environment;
- willfully or negligently causing any substance to leak, spill or otherwise escape in a manner that harms or is likely to harm the environment.

**Tier 2 offences:**
- transporting of a waste to a place that cannot lawfully be used as a waste facility for that waste (applies both to the transporter and the owner of the waste);
- unlawfully permitting any land be used as a waste facility (applies to the occupier or owner of the land);
- provision of false or misleading information to the EPA by the holder of the licence;
- failure to comply with a condition of a licence;
- failure to notify a pollution incident causing or threatening material harm to the environment (this places obligations on the person carrying on the relevant activity, employees and agents, occupiers of premises, employers and principals). ...”

3.2 Institutional Arrangements

3.2.1 Environment Protection Authority of New South Wales

The EPA is responsible, under the Protection of the Environment Administration Act, to:

- protect, restore and enhance the quality of the environment, having regard to the need to maintain ecologically sustainable development; and
- to reduce risks to human health and prevent the degradation of the environment.
The EPA administers the Waste Minimisation and Management Act and the Protection of the Environment (Operations) Act. Waste management policy and regulation is managed on a unified basis within the Authority. This is designed to ensure a comprehensive response on waste issues and strengthen the Authority’s ability to regulate waste management.

3.2.2 Waste Planning and Management Boards

Eight regional Waste Boards were created in 1997 to cover the Sydney Metropolitan Region, Hunter, Central Coast and the Illawarra. These Boards are responsible for planning and managing domestic waste, commercial and industrial waste, and construction and demolition waste. The directors of each Waste Board are drawn from constituent Councils within each Waste Board region and from the community. They are appointed by the Minister for the Environment.

Each Waste Board is required to prepare and implement a Regional Waste Plan, and may direct constituent Councils to comply with a plan which is approved by the Minister for the Environment. The second round of planning by the Waste Boards, for the period 2000-2003, is nearing completion.

The Waste Boards have tackled regional waste planning and facilitation, resulting in improved practices, and are doing pioneering work on a wide array of cross-regional projects. They have forged collaborative relationships with constituent Councils through an essentially facilitating role.

The Minister for the Environment has recently established a further Waste Board in South East New South Wales. In those parts of the State where no Waste Boards exist, Government funding and cooperation between local councils has created successful unofficial waste management groupings.

3.2.3 Local Government

Local Councils are responsible for managing domestic waste and recyclables collection services. They also manage periodic garden waste collection services, clean-up services and public place waste facilities. These activities are undertaken within the framework of the regional waste plan, which councils are able to directly influence through Board membership of regional Waste Boards.

Local Councils outside Greater Sydney, Hunter and Illawarra regions are responsible for waste planning and infrastructure as well as operations.

3.3.4 Waste Service NSW

Waste Service NSW is a government trading enterprise which owns and manages Greater Sydney’s seven waste transfer stations and six putrescible landfills. Waste Service also owns and manages two specialised materials recovery facilities (MRFs) (Chullora and Jacks Gully).

Operations are contracted to the private sector, so that the key role of Waste Service is infrastructure ownership and management.

The near monopoly position enjoyed by Waste Service in greater Sydney for putrescible waste transfer and disposal is now open to competition. This has most potential impact in relation to putrescible landfills. It is now possible for private sector contractors to own, manage and operate such facilities under the general direction of a supervisory licence holder which is a public authority.

3.2.5 State Waste Advisory Council

The State Waste Advisory Council (SWAC) has the role of advising the Minister for the Environment and the EPA on strategic aspects of waste management policy issues. This includes waste reduction priorities and State-wide programs, changes to legislation, R&D priorities, and industry waste reduction programs.

The Council comprises nine members, appointed by the Minister for the Environment, and representing local government, NGOs, consumers, industry, waste management contractors, and the EPA.

3.3 The Waste Management Industry

The private sector waste operators have traditionally focused activities on waste collection and transport. Collex Waste Management, Rethmann Australia Environmental Services, Thiess Environmental Services, Cleanaway, Pacific Waste Management, URM, and others compete for market share and strive for differentiation.

As the corporate names imply, these firms have moved beyond collection and transport, to now offer a broad array of waste management services. At the basic level, these services include operation of MRF processing sites, operation of landfill facilities and supply of direct recycling operations. New technologies for waste treatment are either being introduced or are under consideration by some of these traditional industry participants. Collex, Rethmann, Thiess and others now offer waste minimisation advisory services to business clients.

Other participants have recently entered the market with specific innovative waste treatment technologies in New South Wales. Notable projects include:

Bedminster Bioconversion (Australasia) Pty Ltd has established a facility to produce compost with input of mixed metropolitan waste, sewage sludge and garden waste. This facility is at Raymond Terrace and provides contracted services for the Port Stephens Council.

Brightstar Environmental Pty Limited has established landfill gas to energy projects at three existing landfills in New South Wales.

Brightstar Environmental is currently establishing a combined pyrolysis/gasification system located at Wollongong based on contract arrangements with the Wollongong City Council.

EarthPower Technologies Sydney Pty Ltd is planning a food waste processing system using anaerobic digestion for development in Camellia, near Parramatta.
3.4. Drivers of Waste Generation

Waste generation is related to population size, lifestyle activities (notably affecting domestic waste quantities) and by the economic cycle (affecting each of the key waste generating sectors). Waste minimisation on the other hand relies on a combination of business and consumer choices and actions to avoid waste creation, and reuse or recycle materials.

There is an important contrast between the sweeping drivers of waste generation and the deliberate drivers of waste minimisation.

Waste generation results from a decision to discard a commodity at some point in its lifecycle. Discard
### Table 3-1 Estimated Waste Disposed and Recycled Sydney Metropolitan Area (tonnes per annum)

<table>
<thead>
<tr>
<th></th>
<th>Municipal Disposed</th>
<th>Municipal Recycled</th>
<th>Commercial and Industrial Disposed</th>
<th>Commercial and Industrial Recycled</th>
<th>Contraction and Demolition Disposed</th>
<th>Contraction and Demolition Recycled</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper/Cardboard</td>
<td>390,000</td>
<td>195,000</td>
<td>210,000</td>
<td>300,000</td>
<td>Nil</td>
<td>Nil</td>
<td>1,095,000</td>
</tr>
<tr>
<td>Plastic</td>
<td>100,000</td>
<td>10,000</td>
<td>150,000</td>
<td>20,000</td>
<td>Nil</td>
<td>Nil</td>
<td>280,000</td>
</tr>
<tr>
<td>Glass</td>
<td>150,000</td>
<td>90,000</td>
<td>30,000</td>
<td>40,000</td>
<td>Nil</td>
<td>Nil</td>
<td>310,000</td>
</tr>
<tr>
<td>Ferrous</td>
<td>30,000</td>
<td>5,000</td>
<td>50,000</td>
<td>40,000</td>
<td>20,000</td>
<td>40,000</td>
<td>185,000</td>
</tr>
<tr>
<td>Garden</td>
<td>240,000</td>
<td>150,000</td>
<td>60,000</td>
<td>70,000</td>
<td>30,000</td>
<td>Nil</td>
<td>550,000</td>
</tr>
<tr>
<td>Food</td>
<td>280,000</td>
<td>Nil</td>
<td>160,000</td>
<td>Nil</td>
<td>30,000</td>
<td>Nil</td>
<td>440,000</td>
</tr>
<tr>
<td>Timber</td>
<td>Nil</td>
<td>Nil</td>
<td>210,000</td>
<td>10,000</td>
<td>100,000</td>
<td>50,000</td>
<td>370,000</td>
</tr>
<tr>
<td>Soil/Rubble</td>
<td>Nil</td>
<td>Nil</td>
<td>150,000</td>
<td>10,000</td>
<td>360,000</td>
<td>800,000</td>
<td>1,320,000</td>
</tr>
<tr>
<td>Concrete</td>
<td>Nil</td>
<td>Nil</td>
<td>50,000</td>
<td>10,000</td>
<td>160,000</td>
<td>460,000</td>
<td>680,000</td>
</tr>
<tr>
<td>Other</td>
<td>160,000</td>
<td>Nil</td>
<td>530,000</td>
<td>Nil</td>
<td>330,000</td>
<td>150,000</td>
<td>1,170,000</td>
</tr>
<tr>
<td></td>
<td><strong>1,350,000</strong></td>
<td><strong>450,000</strong></td>
<td><strong>1,600,000</strong></td>
<td><strong>500,000</strong></td>
<td><strong>1,000,000</strong></td>
<td><strong>1,500,000</strong></td>
<td><strong>6,400,000</strong></td>
</tr>
</tbody>
</table>


Note: Waste avoided by onsite reprocessing or reuse is not covered in the “disposed” or “recycled” data.
Garden waste is typical of the municipal stream, but also a feature of the commercial and industrial stream.

Commodity type is relevant to waste minimisation initiatives. Food and kitchen waste, garden waste, and to some extent paper and wood, make up the organic fraction of the disposed waste stream. Concrete and rubble and metals are an inert component; plastics are a chemical synthetic component. A large quantity (some 25 per cent) of the overall disposed waste is classed as “other” across all waste streams.

The regional variation in waste is an important consideration in waste minimisation. Regional Waste Plans indicate that waste quantities and flows for inner city, outer city, and rural/regional areas differ. For example, in Sydney city, waste composition is:

- Municipal 1 per cent
- C&I 69 per cent
- C&D 30 per cent.

In contrast, the outer Sydney area of Sutherland Shire has a stream of:

- Municipal 52 per cent
- C&I 38 per cent
- C&D 10 per cent.

In contrast, the Central Coast has a ratio of:

- Municipal 42 per cent
- C&I 37 per cent
- C&D 21 per cent.

### 3.6 Waste Reduction Performance

#### 3.6.1 Municipal Waste Reduction

Municipal waste disposal has declined steadily over the decade, to be some 16 per cent below 1990 gross tonnage and 22 per cent below per capita disposal levels (ie, after normalisation) by 1998. Currently some 1.350 million tonnes is disposed to landfill annually.

Kerbside recycling has been a key contributing factor in waste reduction over the decade. Some 0.450 million tonnes is recycled annually. The main types of materials subject to recycling/disposal are shown at Table 3-2.

**Table 3-2**

<table>
<thead>
<tr>
<th>Main municipal materials recycled and disposed (tonnes per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Paper/Cardboard</td>
</tr>
<tr>
<td>Food</td>
</tr>
<tr>
<td>Garden</td>
</tr>
<tr>
<td>Glass</td>
</tr>
<tr>
<td>Plastics</td>
</tr>
<tr>
<td>Ferrous</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

*Source: Compiled by the Waste Inquiry from various data sources.*

#### 3.6.2 Commercial and Industrial Waste Reduction

This sector comprises a diverse array of business and public sector establishments. The main subsectors contributing to the waste-sector are:

- manufacturing;
- wholesale and retail trade;
- community services; and
- tourism and recreation.

Waste disposal rates are well correlated with economic activity, and a sharp decline in the early nineties was followed by a moderate increase to current disposal levels. Waste disposal in the sector has decreased since 1990 according to the EPA by around 25 per cent (after normalisation); or around 9 per cent in actual terms. Currently some 1.6 million tonnes is disposed to landfill annually.

Data on reuse and recycling of C&I resources is apparently not collected. The Inquiry estimates that around 0.5 million tonnes is recycled annually.

The main types of materials subject to disposal in the sector are set out at Table 3-3. Also shown is a rough estimate of the amounts recycled.

**Table 3-3**

<table>
<thead>
<tr>
<th>Main C&amp;I materials recycled and disposed (tonnes per annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
</tr>
<tr>
<td>--------------------</td>
</tr>
<tr>
<td>Paper/</td>
</tr>
<tr>
<td>Cardboard</td>
</tr>
<tr>
<td>Timber</td>
</tr>
<tr>
<td>Food</td>
</tr>
<tr>
<td>Soil/Rubble</td>
</tr>
<tr>
<td>Garden</td>
</tr>
<tr>
<td>Glass</td>
</tr>
<tr>
<td>Ferrous</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

*Source: Compiled by the Waste Inquiry from various data sources.*

Much C&I waste collection is undertaken from on-site skips which are not partitioned to provide for a recycling component. The level of waste mixing mostly precludes reasonable MRF separation activities except where dedicated recyclables skips or bins are made available.

Paper reprocessors have made specific arrangements to collect cardboard from numerous major retail establishments and commercial kerbside locations. This material mostly travels direct to preprocessors’ facilities.

Commercial office cleaning firms are moderately well geared to recycling.

#### 3.6.3 Construction and Demolition Waste Reduction

Waste disposal in the Construction and Demolition sector has increased by around 14 per cent since 1990 (after normalisation) or around 58 per cent in actual terms. The EPA points to increased construction activity in recent years, reduced illegal dumping and improved data collection.

Statistics on reuse and recycling of C&D resources are extremely scant, but the Inquiry has made the following estimates on the basis of discussions with Waste Board, industry and EPA.

- Approximately 1.5 million tonnes recycled pa.
- Approximately 1 million tonnes disposed to landfill pa.
These estimates indicate a strong sector interest in reuse and recycling. On-site reuse is largely driven by convenience factors (eg, relocation of excavated material in road construction). Off-site recycling is partly driven by price incentives, reduced transport costs and the development of innovative construction uses for recovered and reaggregated resources.

The main types of materials subject to recycling/disposal in the sector are set out in Table 3-4.

Table 3-4
Main C&D materials recycled and disposed (tonnes per annum)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Recycled(est)</th>
<th>Disposed to Landfill est)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil/Rubble</td>
<td>800,000</td>
<td>360,000</td>
</tr>
<tr>
<td>Concrete based</td>
<td>150,000</td>
<td>160,000</td>
</tr>
<tr>
<td>Clay based</td>
<td>50,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Timber</td>
<td>40,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Garden</td>
<td>Nil</td>
<td>30,000</td>
</tr>
<tr>
<td>Other</td>
<td>Nil</td>
<td>170,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,500,000</strong></td>
<td><strong>1,000,000</strong></td>
</tr>
</tbody>
</table>

Source: Compiled by the Waste Inquiry from various data sources.

Four types of waste separation techniques are being increasingly employed:

- multiple-bin site separation/reaggregation for material use on-site or off-site;
- C&D recycling facilities using loaders, conveyors and sieves to reaggregate materials for sale into markets;
- drop-off separation bins and other facilities at Waste Service Transfer Stations;
- separation bins and other facilities at landfills.

The Government’s Construction and Demolition Waste Action Plan (November 1998) sets out an array of initiatives to reduce waste disposal to landfill. These include:

- the Waste Not initiative which requires a waste management plan to be lodged with Development Applications to Local Councils;
- significantly increased research, education and information diffusion;
- consideration of landfill bans;
- project design with waste minimisation as a key priority;
- waste management initiatives associated with NSW Government Projects.

A key issue for the sector is the development of recycling facilities in strategic locations to boost supply and minimise transport costs from demolition site to potential reuse site. Development of markets for timber and clay-based materials is also important.

3.7 Waste Management Logistics

The management of waste and recyclables has at its core the physical distribution or logistics of getting resources to disposal, treatment facilities or markets. This covers the collecting, handling, consolidating, sorting, storing and transporting processes.

In marketing of traditional products, the cost of logistics is around 30 per cent of sales; in recyclables management, logistics cost exceeds revenue gained from sales, and in waste disposal, logistics costs claim 70-80 per cent of the total disposal bill (physical distribution plus landfiling).

Those responsible for waste planning and management in NSW (both government agencies and the waste management industry) have recognised the importance of logistics efficiency. They have moved, over the last ten years, to greatly improve the technologies and infrastructure used in waste and recyclables logistics. Australian collection technology, for instance, has been adopted for use in Europe by German companies; New South Wales MRFs are amongst the best in the world; as are the latest generation of transfer stations.

On the other hand, some logistics practices adopted in NSW prevent the development of highly efficient logistics. Collection contracts in NSW are usually geared to small geographic areas (based on local council boundaries); cover only a single resource type (dry recyclables, garden waste, residual waste); and cover only one or two processes in the whole logistics chain.

Many European and North American cities, for instance, have adopted logistics systems which cover:

- a considerably larger geographic area;
- a more comprehensive array of resources (recyclables, garden waste and residual waste); and
- more processes in the logistics system than is adopted in NSW waste management (collection, sorting, consolidation, processing and disposal).

The disparate management of system parts leads to sub optimal decision making as each manager has responsibility for only a small part of the value chain, and each naturally seeks to gain the best outcomes in terms of their own contract provisions. The NSW Waste Boards are considering how best to achieve greater efficiency in managing municipal waste. This could provide scope for geographic and resource type amalgamations for collection and transport. Sorting, consolidation and disposal should ultimately become available as an integrated part of the value chain.

3.7.1 Scope and Parts of the Logistics System

Discussions on waste management logistics are often hampered by the complexity of the system and the jargon used in the waste management industry. A simple conception of the entire waste/recyclables logistics system has been developed by the Inquiry and is shown at Figure 3-1. In order to aid communication several points of minor detail are omitted from the diagram.

Seven different activities or processes are depicted between the act of waste generation and either disposal or creation of new products. The whole
Figure 3.1 Waste Management and Recycling Current Situation

- Waste Generation
- Site Sorting
- Collection & Transport
- Site Mixing
- Aggregation
- MRF Sorting
- Transfer Station
- Reprocessing & Manufacture
- New Products
- Waste Disposal - Landfill
system centres on the mixing/sorting decision made at the site at which waste is generated. This decision seals the fate of the discarded material, so it is important that the opportunity for a decision to reuse or recycle is available.

A decision to discard newly created waste in the general, or residual, waste bin will result in Collection and Transport direct to landfill. Disposal or via a Transfer Station, for consolidation and subsequent long haul transport, to landfill.

On the other hand, a decision to sort the newly created potential recyclate according to logistics arrangements prescribed by the local council will result in specialised collection and transport to an MRF for sorting to type, then for the transport for Reprocessing and ultimate inclusion in manufacture of New Products. A variation on this path is where sorting to type is accomplished by the recyclate discarder, allowing for MRF processing to be skipped in favour of Aggregation and transport for Reprocessing and ultimate inclusion in manufacture of New Products.

The generalised value chain is common to the three waste management source streams: Municipal, Commercial and Industrial; and Construction and Demolition. Unfortunately, data limitations prevent a full analysis. However, estimates of the (Sydney Metropolitan Area) volume of waste and recycling flows for each sector is shown in Figures 3-2 to 3-4.

Municipal waste generation in Australia is very high by world comparison: the Economist newspaper ranks Australia second only to the United States in terms of municipal solid waste generated per head of population.

The Municipal waste logistics chain is characterised by high use of Transfer Stations for residual waste consolidation prior to long-haul transport of some 1.35 million tonnes to landfill. Some 25 per cent of the general waste flow is recycled/reprocessed, and much of this is sorted to type at MRF facilities before transport to reprocessors. Municipal kerbside recycling has increased by around 10 per cent per year from 1990.

In 1998 some 450,000 tonnes of recyclate was processed: around 195,000 tonnes of paper/cardboard; 150,000 tonnes of garden waste; 90,000 tonnes of glass; 10,000 tonnes of plastics; and 5,000 tonnes of metals. Figure 3-1 shows the recycling penetration and potential for each resource type. Clearly there is scope for further improving recycling performance.

Commercial and Industrial waste generation in NSW also appears to be high by world standards, though statistics are less comparable than for municipal waste generation. The logistics chain is characterised by:

- a significant proportion of the (mostly inert) waste generated being transported direct to privately owned landfills rather than via publicly owned Transfer Stations to publicly owned landfills;
- predominantly private sector ownership, management and operation of infrastructure and activities;
- significant recycling of paper, cardboard and ferrous metals, moderate recycling of glass, but only modest recycling of other dry recyclables and low levels of recycling of other resources.

Some 1.6 million tonnes of waste was disposed of to landfill, and an estimated 500,000 tonnes were recycled in 1998. This includes significant quantities of paper/cardboard, garden waste, ferrous, plastic and glass. See Table 3-1.

Construction and Demolition waste generation has been at very high levels in NSW since 1997 when a surge in building activity took disposal to around one million tonnes per year. This waste is largely bulky, inert and of relatively high mass.

The logistics chain is characterised by:

- high levels of on-site reuse and recycling of materials such as soil/rubble and bricks;
- moderately high levels of site-sorting and (specialised) MRF sorting of demolition materials for on-selling;
- predominantly private sector ownership, management and operation of infrastructure and activities.

Some 1.0 million tonnes of waste was disposed of to landfill and an estimated 1.5 tonnes were recycled in 1998.

3.8 Landfill Infrastructure Capacity

The main infrastructure stock which is part of the waste management logistics chain performs the functions of consolidating, sorting, treating, reprocessing and disposing of waste and recyclate. This section examines the adequacy of the existing landfill infrastructure in order to compare the relative impact of this constraint with the impact of diversion targets.

Much has been written over the last 20 years about the diminishing Sydney availability of putrescible waste landfill space. New South Wales currently disposes of 75 per cent of municipal waste to these Solid Waste Class 1 landfills (25 per cent is recycled). This mixed residual waste stream comprises around 50 per cent truly putrescible waste, 25 per cent potential dry recyclate and 25 per cent inert materials.

Solid Waste Class 1 landfills also receive around 60 per cent of commercial and industrial waste (after 10 per cent is recycled and 30 per cent is dispatched to other landfills). The residual waste in this case comprises about 40 per cent truly putrescible waste, 35 per cent potential dry recyclate and around 25 per cent inert materials.

Estimated waste disposal to these putrescible waste landfills in 1996 is set out below:

Sydney metropolitan: 1.750 million tonnes
Hunter region: 0.260 million tonnes
Central coast: 0.220 million tonnes
Illawarra region: 0.120 million tonnes.
Figure 3-2 Municipal Waste and Recycling Flows (approx. million tonnes per annum)
Figure 3-3 Commercial and Industrial Waste and Recycling Flows (approx. million tonnes per annum)
Figure 3.4 Construction and Demolition Waste and Recycling Flows (approx. million tonnes per annum)
Putrescible waste landfill capacity (at 1998) is set out below:

Sydney
metropolitan: 21 million tonnes
Hunter region: 8 million tonnes
Central coast: 5 million tonnes
Illawarra region: 6 million tonnes.

Sydney has eight putrescible waste landfills, six of which are owned by Waste Service, with two owned by Hawkesbury Council.

The most notable capacity squeeze is in the Sydney Metropolitan Area. At current disposal rates, some 11 years of capacity is available. On the basis of this generalised analysis, limited breathing space exists in which to provide alternative disposal technology, supplementary landfill capacity and/or reduce disposal rates.

This macro-analysis does not take account of two issues of considerable importance:

(a) limitations on waste inputs to Lucas Heights landfill based on geographic restrictions and agreements, which will reduce the amount of waste accepted from 2001.

(b) the future impact of current initiatives aimed at further reducing waste disposal.

The effect of the limitations issue would be to place a constraint on SMA putrescible waste disposal of approximately 1.35 million t/yr. This translates to a shortfall of capacity by 2001 and therefore an immediate need for waste minimisation action, and/or additional landfill capacity and/or alternative treatment/disposal technology.

A more complete (but rough) analysis of the permutations is set out at Table 3-5.

3.9 Main National Waste Minimisation Initiatives in Currency

3.9.1 The National Packaging Covenant

Packaging material is estimated to be 20 per cent of the municipal discard stream. Because of its public visibility, and potential for reduction, packaging waste has received a great deal of attention over the past decade. There is little doubt that the volume of waste can be reduced substantially, by design for waste avoidance and ease of recycling.

Rather than develop product-specific regulations governing reduction of packaging material, a cooperative agreement between government and industry has emerged to address the problem.

Signed by environment ministers and representatives of industry and local government in mid 1999, the National Packaging Covenant is a cooperative effort to be undertaken over the next five years to minimise the environmental impacts of packaging waste. The objectives of the Covenant are to:

- Establish a framework based on the principle of shared responsibility for the effective lifecycle management of packaging and paper products including their recovery and utilisation.
- Establish a collaborative approach to ensure that the management of packaging and paper throughout its lifecycle and the implementation of collection systems including kerbside recycling schemes, produces real and sustainable environmental benefits in a cost effective manner.
- Establish a forum for regular consultation and discussion of issues and problems affecting the recovery, utilisation and disposal of used packaging and paper, including costs.

(The National Packaging Covenant, ANZECC, August 1999).

The Covenant is based on the principle of product stewardship, implying that all parties in industry and government share responsibility for the lifecycle of products with respect to their area of activity. According to the Federal Environment department (Environment Australia),

the focus is on members of the packaging supply chain, including suppliers of raw goods, fillers, brand owners, wholesalers and retailers.

It is expected that Covenant signatories will take action in design, production, distribution, disposal, research, market development, education, labelling and manufacturing and retailing.

Many interested parties are optimistic that the Covenant will allow the industry flexibility to develop and then deliver waste reduction outcomes that would have been difficult to achieve through more traditional and prescriptive “command and control” regulations. Others, however, are concerned that the lack of specificity in the Covenant will encourage little or no forward progress on minimising waste and encouraging innovation in recycling. Although it is too early to make a judgment, if significant progress is not apparent within 12 months of the Covenant signing (ie August 2000), alternative means for achieving waste reduction from the “consumer packaging” chain should be investigated.

<table>
<thead>
<tr>
<th>Table 3-5 Demand/Capacity Trade-off. Surplus Versus (Shortfall)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Acceptance Rate</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Increased Disposal Rate 5 per cent</td>
</tr>
<tr>
<td>90,000 tpa</td>
</tr>
<tr>
<td>Current Disposal Rate</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Reduced Disposal Rate 5 per cent</td>
</tr>
<tr>
<td>90,000 tpa</td>
</tr>
</tbody>
</table>
3.9.2 Extended Producer Responsibility

The OECD defines Extended Producer Responsibility (EPR) as ‘The principle that manufacturers and importers of products should bear a significant degree of responsibility for the environmental impacts of their products throughout the product lifecycle, including impacts [from] ... the selection of materials, the ... production process, and ... from the use and disposal of products.’

Many consider Germany’s 1991 packaging take-back ordinance to be the embodiment of EPR. German industry developed the Duales System Deutschland to operate its now-famed “Green Dot” program that guarantees to consumers that recycling of the packing will take place. Industry pays a fee to DSD for use of the ‘green dot’ logo and the fees pay for the collection and recycling. The system is credited with reducing packaging waste substantially (including a plastics reduction of 100,000 tonnes to 823,000 tonnes between 1991 and 1995). Some contend the program has been too costly, others hail its success at encouraging waste minimisation and job creation.

But EPR is not limited to Germany or to ‘take-back’ schemes for packaging. Ten OECD countries have legislation that provides for regulations, ordinances, covenants or other government instruments for imposing EPR for certain product categories. In addition to packaging, these include tyres, batteries, waste oil, CFCs, printed matter, electrical and electronic products, office equipment, cars, furniture, building products and agricultural plastics (RMIT).

Policy tools commonly used include voluntary agreements or covenants with the industry, deposit refund schemes, product disposal charges, and end-of-life product take-back requirements. Table 3-6 describes the [current] schemes operating in various countries and which products are targeted.

It seems clear the EPR has been a significant force in increasing industry attention to waste issues during the 1990s. The jury is still out over relative cost-effectiveness of the various methods for implementing EPR. The programs will likely need another 12-24 months of operation in order to get to a stage of legitimate comparative assessment. While some contend that industry will meet ambitious waste reduction goals on a voluntary basis, the Netherlands experience does not fully support that case: for batteries, tyres and agricultural plastics, legislation was required after voluntary industry agreements failed.

3.9.3 Cleaner Production

Cleaner production is an approach to business management that minimises the pollution associated with delivering particular goods or services while ensuring businesses are competitive. In his internationally acclaimed book *Factor 4: Doubling Wealth, Halving Resource Use*, Amory Lovins illustrates how pollution is an indicator that resources are being wasted, and therefore so is money. He cites dozens of examples in which companies engaging in cleaner production techniques also strengthened their bottom lines.

The benefits of cleaner production include improved efficiency, reduced environmental impacts, increased profits, and improved employee morale. Cleaner production means that use of packaging, energy, water and other resources is reduced. Thus, it is an important contributor to waste avoidance. The United Nations Environment Program (UNEP) defines cleaner production as ‘the continuous application of an integrated preventive environmental strategy applied to processes, products, and services to

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Table 3-6 Product Stewardship Programs

<table>
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<tr>
<th>Deposit-refund schemes</th>
<th>Denmark, Switzerland, Sweden</th>
<th>Small consumer batteries</th>
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<tr>
<td></td>
<td>Austria</td>
<td>Fluorescent lights, tyres</td>
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<tr>
<td></td>
<td>Korea</td>
<td>Beverage containers, batteries, tyres, televisions, washing machines and lubricating oils</td>
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<tr>
<td></td>
<td>Taiwan</td>
<td>PET bottles</td>
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</tbody>
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<tr>
<th>Advanced disposal fees</th>
<th>Austria</th>
<th>Refrigerators</th>
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<tr>
<td></td>
<td>Sweden</td>
<td>Automoblies</td>
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<tr>
<td></td>
<td>US (Florida and Hawaii)</td>
<td>Containers</td>
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<td></td>
<td>US (21 states)</td>
<td>Tyres</td>
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<td></td>
<td>US (10 states)</td>
<td>Beverage containers</td>
</tr>
<tr>
<td></td>
<td>Germany</td>
<td>Refrigerators</td>
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<td></td>
<td>Canada</td>
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<tr>
<th>Voluntary agreements/ covenants</th>
<th>UK</th>
<th>Various</th>
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<tr>
<td></td>
<td>Netherlands and Australia</td>
<td>Packaging</td>
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<table>
<thead>
<tr>
<th>Product take-back schemes</th>
<th>Germany</th>
<th>Packaging</th>
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increase eco-efficiency and reduce risks for humans and the environment.‘

Cleaner production has virtually universal application because it requires closely managing inputs (costs) to maximise outputs that are sustainable (profits).

Most companies that have undertaken Cleaner Production programs have improved their competitive positions. Examples in many sectors abound: dry cleaning, paints, hospitality, printing, and oil refining are just a few. Much of the success can be attributed to cleaner production techniques in four categories: improved housekeeping, materials substitution, process or technology change, and reuse or recycling of materials onsite.6

3.9.4 Strategic Issues and Implications of Current Direction

There is little doubt that waste avoidance practices can be enhanced in NSW. While there are local examples of progress, statistics on waste generation suggest that waste avoidance is not a concept firmly entrenched in business and community psyches at present. It is likely that improvement will be achieved through a variety of mechanisms some voluntary and some regulatory, some through education and persuasion, others through pricing instruments.

With waste management under reform in many countries valuable insights can be gained by observing the unfolding of strategy in the main centres of reform.

This Chapter examines waste management practices in Germany, United Kingdom, United States of America and Japan. The purpose is to highlight and demonstrate how some other countries are approaching the challenge of sustainable waste management.

Planning, management and operations practices are largely shaped by national or state waste strategy, as described in legislation, policy, agreements and broad institutional arrangements. Accordingly this chapter provides a brief survey of both waste strategy and practices adopted by various nations/states. Valuable insights emerged from the successes and difficulties of others, and these provide an important input to consideration of creative practices for adoption in New South Wales.

(Waste treatment/disposal technology adoption is of course driven by in turn by the practices adopted and to some extent by the strategy adopted).

4.1 Germany

4.1.1 Waste Strategy

Germany has adopted a Waste Avoidance Recycling and Disposal Act (September 1994) aimed at resource conservation and environmentally compatible disposal of waste. The Act prescribes that “…waste must, primarily, be avoided … must, secondly, (a) be subjected to recycling, or (b) used to obtain energy (energy recovery).” The Act further requires that “… high quality recycling appropriate for the type and nature of the waste in question is to be pursued”. Recycling in this case includes reprocessing of bio waste to produce compost. Recycling in Germany is to be undertaken to the extent that is “… technically possible and economically reasonable, especially when a market exists or can be created for an extracted substance or for extracted energy”.

Priority between recycling and energy recovery is governed by relative “environmental compatibility” for the specific type of waste, with the following to be taken into account:

- emissions;
- conservation of natural resources;
- energy to be consumed and yielded; resulting increased concentrations of pollutants in outputs.

However, subject to statutory ordinance, energy recovery is permissible only when the base thermal value of the subject waste is at least 11,000 kJ/kg and a combustion efficiency of at least 75 per cent is achieved and the resulting heat is used productively. In private discussions with officers of the Federal Environment Agency, Thermal Treatment Group, the logic of this provision was further clarified using holistic energy analysis:

- Product creation consumes approx. 30 MJ/kg; recovery and recycling of discarded material consumes 12 MJ/kg, thus the act of recovery and recycling saves 18 MJ/kg.
- The average calorific value of waste is approx. 8.4 MJ/kg, but due to contamination and combustion efficiency factors, only some 1 to 2.5 MJ/kg is actually usefully recoverable to energy.

A measure of product responsibility accrues to parties who “… develop, manufacture, treat or sell products …” The Act prescribes that products “… must be so designed, if at all possible, that waste production is reduced within their production and use, and that environmentally compatible recycling and disposal of the waste resulting from their use is assured.”

Product responsibility urges that products be designed and manufactured to facilitate reuse, preferably, or highest quality recycling or, as a last resort, environmentally compatible disposal.

Product responsibility also comprises acceptance of post-consumption discards by relevant parties for subsequent recycling or disposal.

4.1.2 Implications for Waste Planning and Management Practices

The language of the Federal Act precisely establishes a vision and a set of principles to be adopted for waste management. The States are responsible for strategy development through ordinance (regulation) and (broad) waste management planning. Specific responsibility for the practice of waste management is delegated to cities and towns.

(a) Waste Streaming

The Federal Act has been powerful in promoting a national waste streaming scheme. It is based on a uniform colour coding for four recyclate containers plus residual waste, viz:

- Packaging: yellow container
- Paper: green container
- Glass: blue container
- Biological material: brown container
- Residual waste: red container.

This scheme is universally applied in public places, business premises and at domestic level. It results in good waste streaming with moderate contamination of recyclate streams. The residual waste stream does however contain a significant proportion of potential recyclate, particularly food waste, paper and cardboard. Informal estimates were that municipal residual waste contained about 20 per cent of each recyclate fraction. This tends to indicate that the German public is not as compliant as generally thought, but the sheer dominance of the
segregation scheme appears to have had a high educative and reinforcement value.

This streaming practice gives direct effect to the Act provision requiring pursuit of high quality recycling appropriate for the type and nature of the waste. The outcome has been initial strong growth in incineration capacity (with energy recovery) followed by, more recent, growth in composting plant capacity (currently 550 plants in operation) and very recent moves to combined mechanical/biological pretreatment to render waste inert, followed by landfilling.

(b) Integrated Management

The institutional arrangements established in German cities provide for strongly integrated management of municipal/commercial waste minimisation and disposal activities. In Frankfurt, for example, a single public/private joint venture company is responsible for all municipal and commercial (but not restaurant) waste management. This includes:

- collection, transport and sorting recyclate streams plus residual waste;
- selling of paper, packaging materials and glass as recyclate;
- reprocessing of bio waste and selling as compost;
- collection and disposal of bulky household waste;
- incineration of residual waste; and
- disposal of residues to landfill.

Moreover, the contract covers the whole of Frankfurt, a city of over one million people.

The scope of this contract provides considerable vertical and horizontal integration presenting opportunities for both logistics efficiency and market strength in relation to recyclables.

4.1.3 Trends in Waste Minimisation Practices and Technologies

The German system places recycling and waste to energy incineration at an equal rank, subject to “environmental compatibility” with the specific waste stream. Community support for mass burn incineration however is apparently declining in favour of technologies which are efficient and/or which conserve natural resources. Several factors are important:

- According to a recent consumer survey 77 per cent of the community gave preference to recovery and recycling, compared with 17 per cent in favour of incineration and 4 per cent in favour of landfilling.
- Detailed life cycle analysis is increasingly used to determine relative environmental compatibility between recycling/reprocessing and waste to energy actions. With greater availability of relatively low cost energy (in environmental and economic terms) the scientific balance is moving in favour of recycling.
- Waste streaming to recyclable materials facilitates biological, physio-chemical and mechanical treatment tuned to specific waste types. On the other hand, the German system favours incineration as the most proven technology for treating residual (mixed) wastes, which of course contain diffuse hazardous material.
- As the proportion of municipal/commercial waste that is source separated increases the amount available for incineration is reduced. At 1996/97 the amount of recovered and recycled high-volume recyclate materials (packaging, biowaste and paper/cardboard) almost matched the amount of residual waste (256 kg/capita versus 268 kg/capita).

4.2 United Kingdom (England & Wales)

4.2.1 Waste Strategy

The UK Government has adopted a sustainable waste management strategy (1999) aimed at gaining increased value from waste and managing it in an environmentally responsible way. It has the status of Government policy under the Environmental Protection Act (1990) (as amended).

The document describes overwhelming community agreement with a new vision which embraces environmental, economic and social objectives. It comprises:

- reduction in the quantity and hazard of waste arisings
- higher levels of reuse
- increased recycling and composting
- increased energy recovery
- further development of alternative recovery technologies
- greater public participation in the decision making process, and,
- protection of human health and the environment...

This national waste strategy is based on adoption of three key principles:

- Best Practicable Environmental Option.
- A waste hierarchy.
- The proximity principle.

These are supplemented by adoption of integrated waste management practices.

Each of these concepts is described briefly below:

(a) Best Practicable Environmental Option is the outcome of analysis which seeks “... the most benefits or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term.”

The procedure is not yet developed to a standard suitable for general use, but is intended to comprehend:

- protection of the environment;
- conservation of resources;
- economic growth and employment;
- social progress.

(b) The Waste Hierarchy is used as a guide to the priority which should be accorded to waste options. It comprises:

- Reduction
- Reuse
- Recovery
  — Recycling
  — Composting
  — Energy
- Disposal.
The strategy explicitly states that "... recycling and composting should be considered before recovery of energy from waste."

(c) The Proximity Principle is based on the idea that "... waste should generally be disposed of as near to its place of production as possible." This recognises:

- costs and environmental impacts of transport;
- the case for regional self-sufficiency;
- the need to "... raise awareness in local communities that the waste they produce is a problem with which they must deal."

There are clearly important links and tradeoffs implied by consideration of all three principles. And they form the backbone of the strategy, with integrated waste management as the flesh.

(d) The Integrated Waste Management Practice approach emphasises the importance of a symbiotic relationship between the multiple activities, practice options and people’s contributions through:

- decision making which recognises each step in the waste management value chain as part of the whole (collection, transport, sorting, recovery/disposal, reprocessing, and selling to markets);
- a mixture of waste management options, each appropriate to the characteristics of the specific waste stream;
- involvement of all participants who have a contribution to make.

4.2.2 Waste Minimisation Targets

As a member of the European Union, the UK is bound by directives, but also able to play an influential role in shaping EC policy. In response to EC Directives, the following goals have been established in the waste strategy:

- Municipal
  - to recover 45 per cent of municipal waste by 2010 (intermediate target 40 per cent by 2005),
  - to recycle or compost 30 per cent of municipal waste by 2010 (intermediate target 25 per cent by 2005).
  - The above targets imply diversion of 15 per cent to waste to energy recovery by 2005 and 2010.
  - to reduce household waste arisings by a target yet to be set.
  - The current situation is that some 14 per cent of municipal waste was recovered in 1997/98, of which 8 percentage points was subjected to recycling or composting.

- Commercial and Industrial Waste
  - to reduce C&I waste to landfill to 85 per cent of 1998 levels.

4.2.3 Landfill Taxes

A key instrument in achieving the nominated targets is a landfill tax which has an “... explicit environmental objective”. This is currently £10 per tonne (A$25) for active wastes and £2 (A$5) for inactive waste. Both categories are to be increased by £1 (A$2.50) per year, with review in 2004. These clearly signalled increases provide a margin of certainty on which to base the investment in alternative waste management technologies.

There is discussion of the idea of a tax on virgin raw materials in order to encourage greater use of secondary resources. This is apparently unlikely to proceed pending progress toward the targets.

4.2.4 Implications for Waste Planning and Management Practices

The comprehensive scope of the waste strategy has been driven to a large extent by the reality of European legislation. Implementation of this strategy is through waste planning authorities, borough councils and district councils, working with the private sector waste management industry under long term contract arrangements.

(a) Waste Streaming

Attention to waste streaming is delegated to local level, and results in terms of recovery have been highly variable. Recyclate collection, sorting and reprocessing infrastructure is patchy, largely because recyclate markets are not well developed.

As a result, total household recycling is about 8 per cent. A significant contribution to paper recycling is made by the commercial sector.

(b) Integrated Management

Institutional arrangements are described under the Environmental Protection Act (1990) and the Waste Minimisation Act (1998). County Councils and London Borough Councils are responsible for waste planning. District Councils have responsibility for waste collection and recycling, and Waste Disposal Authorities (usually County Councils) are responsible for safe disposal.

The Waste Strategy recognises that current arrangements do not facilitate integrated waste management practice. Plans are currently being drawn up by the Government to bring about full cooperation and collaboration by all participants to ensure sustainable waste management. This is critical to the success of the integrated waste management concept.

4.2.5 Action to Promote Waste Minimisation Practices

In order to meet the EU driven targets, the Government’s strategy focuses sharply on reuse, recycling and composting as practices to be encouraged. Energy recovery schemes are to be “... sensitively designed, to avoid ‘crowding out’ of recycling”, recognising that substantial additional incineration capacity will be required in order to meet the requirements of the Landfill Directive.

This program includes:

- Landfill tax increases (described above).
- Recyclate market development, with market stabilisation, quality standards and recycled content agreements at the forefront.
- Research and development into alternative, high value uses for recyclate, product design and development of new technologies for creating and using recyclate.
• Information and advice of efficient and effective waste minimisation and management practices, including logistics, avoidance and reuse, technology, and applications for recyclate.
• Special action to promote and develop composting, including preparation of various standards for differing applications.
• Education and awareness programs to bring about changes in behaviour in respect of resource consumption and recycling.
• Producer responsibility actions when recovery and recycling rates are below optimal for specific waste streams, "... reflecting market failure".

4.2.6 Trends in Waste Minimisation Practices and Technologies

As indicated above, the UK strategy distinguishes recycling, composting and energy recovery in order of preference. But it recognises that substantial action needs to take place in each practice. Current overall waste minimisation outcomes lag Australian and are well behind German achievements.

The Government’s targets place significant expectation on composting as a practice to divert disposal of biodegradable waste from landfill.

4.3 United States

4.3.1 Waste Strategy

Solid waste management is largely the responsibility of state and local governments, with the federal government providing policy analysis, leadership (eg with the US EPA’s 1989 solid waste policy statement “Agenda for Action”) and now acting primarily as a collector and disseminator of information.

During the 1980s and early 1990s it was perceived throughout much of the US that landfill space was running out and that a crisis was imminent. The waste hierarchy (same as that used in NSW) was articulated and drew wide public and government support.

In response, many states have passed broad-based legislation that specifies waste reduction targets. Development of strategy and programs to achieve strategic goals is usually done cooperatively between state environmental regulators and local and regional authorities. This spurred the commencement of many local recycling initiatives and a variety of “container deposit” laws.

Overall, waste management is undertaken by many players in the public and private arenas. Governments develop legislation and policy guidance and then allow many players in the free market to find the most cost-effective solutions for fulfilling the policy directives. This differs somewhat from the European model of “integrated waste management” that might codify more specifically who must do what.

(a) Waste Minimisation Targets

As mentioned above, many states have legislated targets for diverting waste from landfills. Progressive states like California, Washington, New Jersey, Colorado, Massachusetts, Minnesota, and Oregon often call for 50 per cent waste diversion. Last year the US EPA published a report called “Cutting the Waste Stream in Half: Community Record-Setters Show How”. The report details the efforts of 18 communities across the US that have successfully diverted between 40 per cent and 65 per cent of residential waste from disposal.

4.3.2 Implications for Waste Planning and Management Practices

Because waste management is undertaken at a local level it is difficult to generalise about the US in its entirety. Programs are very diverse. Like NSW, each locality has developed a system conducive to its own needs in terms of demographics, waste composition, geography, institutional requirements and costs. However, for jurisdictions that are taking waste reduction seriously there are probably a number of common threads worth noting.

(a) Municipal

The vast majority of effort to date has been on residential kerbside recycling programs. Officials commonly cited that 70-80 per cent of time and resources in the past decade had focused on developing, managing and evaluating kerbside programs for the domestic sector.

Householders are asked to stream a wide variety of materials, usually including glass, two types of plastic, aluminium, newsprint, cardboard, and mixed paper.

• In jurisdictions with leading programs, residents have historically been required to source separate to a much greater extent than in NSW (eg often only two types of plastic are accepted; eg each of 5-6 streams must be bagged separately). Much effort was put into public education and interestingly, this effort by and large met with great success.

• In cases in which residents hadn’t separated according to the proper local regimen, “behaviour modification” was achieved through non-collection of improperly sorted materials accompanied by a kerbside notice physically resembling a parking or speeding ticket.

• Only recently has there been a move toward increased co-mingling of recyclables. This has required education as well, as the public has indicated concern that their co-mingled recyclables might end up in a landfill.

Garden waste collection and/or composting schemes are well developed and often account for more than half of waste diverted from landfill. There is a market demand for as much compost as is made available through recycling. The composting facilities are run by private enterprises that develop a variety of soil enhancement products.

Cost structures are set to reward recycling and minimisation relative to disposal. Officials cite demonstrable consumer responses to “Pay as you throw (PAYT)” rates in which large and transparent price differentials are charged for sorted recyclables versus
mixed garbage, small versus large bin sizes, and collected versus backyard composting being cited.

Markets for recycled materials have developed well over time, with few citing any examples of “warehouse stockpiling” of recycled commodities. Sometimes materials are processed locally and regionally, other waste streams are shipped offshore to Asian countries that use them as feedstock in other manufacturing processes.

Recycling programs receive widespread public and political support. Market research suggests that recycling is firmly ensconced in the hearts and minds of householders, that recycling more is better, and that there is unlikely to be any public movement to roll back the recycling programs underway. If anything, consumers want to be able to recycle MORE of their garbage, not less.

Program cost data suggest that recycling programs are sometimes less expensive than alternatives. This varies widely depending on the jurisdiction. Interestingly though, even in places in which recycling programs are not “cost effective” in the traditional sense, there is no apparent movement to roll them back. As stated above, the community wants to participate in recycling and it is incumbent upon the government agencies at all levels to meet that need as efficiently as possible.

By and large, the focus is on PRACTICES, not technologies. Discussions and research about “alternative” technologies revealed the following:

- Waste to energy is viewed in many localities as “incineration” which is vehemently opposed by local residents. Further, it is believed that once adequate pollution control technologies are added to waste-to-energy equipment, it is much cheaper to recycle and/or transport residual mixed waste to landfills (even to great distances away from the localities – see Seattle and Portland).
- New thermal technologies (eg pyrolysis and gasification) tend to be viewed with some scepticism, both in terms of performance with mixed residual waste and cost-competitiveness.
- Reports of bad experiences with mixed residual waste composting have dampened enthusiasm for new investment in this technology. However, new technologies for mechanising the sorting of recyclables are widely embraced. These technologies can both decrease costs of collection and sorting and improve participation and diversion rates (as they require householders to go to less trouble at home).

In addition, new technologies for composting organics are being trialled widely as programs mature and volumes increase.

(b) Commercial and Industrial (C&I)
C&I waste has received much less attention than the residual sector. Most current programs are still in their infancy.

For the most part, C&I waste is managed by the private sector, with contractual arrangements made on a business-to-business basis.

Generally, politics inhibits development of regulatory waste reduction mandates to the business sector. More common are voluntary programs which focus on government assistance through auditing and information sharing. An interesting exception to this is the City of Portland, whose efforts in C&I are groundbreaking and receive wide support from the business community (see Box 8-3 at Chapter 8).

(c) Construction and Demolition (C&D)
In leading cities programs in the C&D sector are generally well developed with large builders and developers. Efforts are underway to increase participation rates by smaller construction entities.

Markets for recycled construction materials are strong, with the possible exception of wood waste (a large part of the residential construction sector waste stream). A number of jurisdictions cited programs to help develop this market.

4.3.3 Trends in Waste Minimisation Practices and Technologies

Improve efficiency of residential kerbside. Most of the leading US programs are engaged in a program of “continuous improvement”, the focus of which is on increased diversion and reduced costs through greater co-mingling of dry recyclables, adding waste streams eligible for recycling (eg margarine tubs), making yard waste recycling easier and development of schemes to increase participation of multi-family apartment dwellers. In addition, there are several pilots for collection of food waste underway.

Continue outreach to C&I to raise participation. Most jurisdictions realise that much potential in the C&I sector remains untapped. As such, localities continue to refine what are primarily voluntary programs to increase diversion rates from the business sector. Technical assistance through audits and waste management plan development, as well as awards programs recognising and promoting high achievers are common undertakings. Portland’s model waste audit and management plan “forms” for different business types are a notable contribution.

Gain participation in the C&D sector.
Some programs are linking building and construction approvals to waste management success. These areas are collecting a “recycling deposit” from builders as a condition of receiving a building approval or development approval. This deposit can be refunded only when the builder demonstrates that waste was either recycled directly or taken to an MRF for recycling.

Develop product stewardship and EPR programs as appropriate. This area remains somewhat vague in leading US cities. Product stewardship and extended producer responsibility as mechanisms to encourage waste minimisation are viewed favourably, but not a great deal of concrete action has been taken other than container deposit legislation in some places. Voluntary efforts are afoot in dealing with tyres and some electronic equipment, but they are in the early stages.
Government officials seem to hope that as more and more corporations adopt robust environmental management plans that best practice in waste minimisation will unfold.

San Francisco’s Food Waste Recycling Program being undertaken in both the commercial and residential sectors (in which all organics are combined in one bin for weekly collection), organics are transported more than ~100 km and processed and sold to farmers. In addition, the major grocery chain, Safeway, has undertaken a program to backhaul its organics in standard Safeway trucks to privately operated composting facilities outside the urban setting.

Seattle’s Geographic Information System built into Collection Trucks. With the launch of its “new and improved” kerbside recycling program, Seattle’s waste collection trucks will be equipped with Geographic Information Systems (GISs) that allow drivers to immediately record extra waste and non-compliance at each address. This facilitates record-keeping and communications back to ratepayers about costs and opportunities in waste management.

4.4 Japan

Japan is a country currently committed to incineration as the predominant waste disposal practice. However national concerns over dioxin contamination in air, land and food, together with a persistent shortage of land for waste disposal, including incineration ash, has led to a new strategy for waste minimisation. This strategy has evolved at the national level, with passage of several significant waste minimisation laws in the 1990s, at the prefectural level where ordinance development and reporting activities occur, and at the city and local level where domestic collection, waste management, and disposal responsibility resides.

Separate domestic and industrial policy areas can be distinguished in Japan. The domestic sector generates some 51 million tonnes per annum of waste. Approximately 70 per cent of this waste is incinerated, 10 per cent Landfilled (with 25 per cent overall being ultimately landfilled as waste or incinerator ash), 10 per cent composted, and 10 per cent recycled. Industry generates some 400 million tonnes per annum of waste with some 30 per cent being recycled. Certain industries in Japan have extremely effective waste minimisation programs.

4.4.1 Waste Strategy

In modern Japan domestic waste management traditionally has been the responsibility of local cities and industrial waste the responsibility of the company and contractors. Legislation was directed at waste disposal with crude sorting of domestic and other waste into combustible and non-combustible streams. Ash was landfilled together with some non-incinerated wastes. Non-combustibles were crushed and landfilled.

(a) Legislation

From around 1984 onward a change occurred in the Japanese approach to waste management. Landfill space is rapidly decreasing, with some 8-9 years predicted capacity remaining in Japan on current usage projections. The national government from early 1980 has required municipal government to stream waste with basic kerbside recycling including cans, bottles and paper. Since 1997 increased emphasis on the 3R Hierarchy: reduce, reuse and recycle has seen a shift of responsibility to producer obligation.

In 1995 a “Law for Promotion of Sorted Collection and Recycling of Containers and Packaging” was promulgated. This legislation has the objective of “contributing to the maintenance of the living environment and the healthy development of the national economy through the proper disposal of waste and effective utilisation of resources”. It requires prompt collection of waste containers and packaging and the recycling of items with the aim of achieving a reduction in the volume of general wastes and utilisation of recycled resources.

In 1998 the national government issued a “Directive Specifying the Enforcement Date of the law for Promotion of Sorted Collection and Recycling of Containers and Packaging”. Additionally, in 1998 the “Specific Household Appliance Act” was passed with regulation to be introduced from 2001. That legislation requires that steps be taken to secure the proper disposal of waste and effective utilisation of resources through introduction of collection, transportation, and recycling of specific household appliance waste by retail traders and appliance manufacturers of specific household appliances.

Prior to the regulation enforcement date, compliance for these acts has been largely voluntary. Industry has been expected to comply. Peak industry and regional associations have contributed through data recording and encouragement of member participation. The recycling of steel cans, aluminium, glass, paper, tetrapak and to some degree textiles and PET have been effective. Recycling of other plastics has been ineffective. Overall some 67 per cent of glass, 80 per cent of steel cans, 76 per cent of aluminium cans, 20 per cent of PET, and 54 per cent of paper have been recycled.

The containers and packaging recycling law aims to increase recycling by some 20 per cent in around 3 years. Some half of this projected improvement is to be done by reduction and half by recycling. Kerbside separation will be further encouraged at a municipal level. Packaging materials and containers are to be returned to the producer under a mandatory process. A levy on disposal of recyclable materials has been applied to big business, and from 2000 will apply to small business. The levy is calculated using a scaling factor for the particular industry involved and a unit cost for the type of recyclable.

The Home Appliance recycling law will require domestic users to pay for collection. Delivery to the retailer will require local government management. The producer who is responsible for final recycling.

(b) Targets

National waste minimisation targets were established around 1996 with projected delivery at 2005 and 2010. For the domestic sector, a reduction in total waste of some 3 per cent is projected with a doubling of recycling by 2005 and further improvement by
2010. This would be accompanied by halving of the amount of waste disposed to landfill by 2010, with a commensurate 14 per cent reduction in incineration. For the industrial sector, total waste disposal is anticipated to increase by around 12 per cent, however it is to be accompanied by a 28 per cent increase in recycling, a 70 per cent increase in waste reduction, and a halving of waste finally disposed to landfill. Industry incineration levels are predicted to remain roughly constant.

(c) Costs
The costs of waste management in Japan are high. Nagoya Region collection costs are some A$400.00 per tonne, incineration A$300.00 per tonne, crushing some A$580.00 per tonne and landfill A$160.00 per tonne. The average cost of waste management is some A$800.00 per tonne.

Overall, at both the national and individual city levels, Japan appears to have stabilised the previous increase in waste disposed, based upon an intensive effort to initiate waste minimisation and recycling.

4.4.2 Implications for Waste Planning and Management Practices
The Japanese experience has three immediate implications for waste management:

- Incineration as a preferred disposal method has clear limitations due to associated air pollution impacts and land availability constraints, including effective containment of hazardous ash. These constraints are only overcome at extremely high cost to society in dollar terms, with modern Japanese incinerators requiring extremely costly air pollutant equipment. In Japan, energy can be derived from waste incineration, which somewhat reduces the cost of that particular disposal technology.

- Clear national legislation, reflected into prefectural and local government ordinances, has been fundamental in initiating integrated domestic and industrial waste management. Industrial and community peak-body involvement in the overall effort has been important. Nevertheless, domestic comprehension of waste management activities remains limited in Japan. Industrial awareness is high.

- The most effective procedure for recycled material value retention, and for achieving efficient waste minimisation, is early streaming of waste types together with individual worker and citizen responsibility for waste minimisation and management. A spectacular example of this procedure is the “zero-waste” approach achieved by several Japanese industries, for example Kirin Breweries as set out at Box 4-1

4.4.3 Trends in Waste Management Practices and Technologies
Several important trends in waste minimisation practices and technologies were evident in Japan in response to the pressure for minimising landfilling of municipal wastes, industrial wastes and incinerator ash.

These were:

(a) High Temperature Melting Of Municipal Non-Combustible Waste
This process, evident at Tokai City adjacent Nagoya, is a method for combining waste incinerator ash from municipal waste burning with non-combustible municipal waste (with white goods and CFC-containing materials removed) in a blast-furnace-type process at 1700 degrees Centigrade. The method is used on some 100,000 tonnes per annum of municipal waste and incinerator ash and results in an inert granular product, which is used for making pavers, and a globular low-grade metallic product, which is used in making counter weights for industrial machinery.

The method immobilises toxic materials from municipal incinerator ash. It is very cost intensive, costing some A$300 million for capital equipment and A$300 per tonne of waste in operating costs.

(b) Industrial Re-Utilisation Of Process Waste Materials
A number of companies are now using processing wastes for development of new products. Nippon Steel uses blast furnace slag and oxygen furnace slag for production of a sand-substitute in cement production, and for fill material in the construction industry, respectively. The sand substitute is sold on the commercial market and has been used for a number of bridge and other construction projects. While slower-drying than normal cement, it produces a robust product, particularly suitable for marine and chemical and insult applications, and not requiring high temperature curing.

Nippon Steel is also an example of industry success in general waste minimisation, with most metal wastes produced being converted to computer floppy disc magnetic media.

(c) Emerging Approaches
Several examples of emerging practice and technology which will have important implications for waste management were evident in Japan. These include:

(a) Processes for depolymerisation of plastics and repolymerisation into new plastic materials.

Research publications describing these processes were observed in the laboratory of Dr. Akira Oku at the Kyoto Institute of Technology. These include;

(i) A method for chemical recycling of PET.

This involves retro-polymerisation to monomers by cutting of PET products (such as drink bottles), depolymerisation by alklyolysis at 180°C for 15 minutes in the presence of chemical additives, separation of terephthalic acid by filtration, drying, and reconstitution of dry terephthalic and into new PET products.

(ii) Chemical Conversion Of Polycarbonate To Monomer Form

This method recycles polycarbonate (from computers and other products) into a diol monomer using highly efficient Alklyolysis and co-solvents.
In line with the United Nations Policy for zero waste production, and consistent with a company policy to assure consumers that Kirin Brewery is clean and environmentally responsible, the Kirin Brewery Company in December 1998 obtained ISO14001 certification to international standards of environmental management at eight of its breweries. The remaining four achieved certification a year later.

Several broad approaches to environmental protection have been implemented, including maintaining the refillable bottling system and reducing the weight of aluminium cans as much as possible. The weight of large bottles has also been reduced. Large bottles are being replaced with new light weight models.

Since 1996 Kirin have been publishing annual environmental reports, reviewed by independent institutions to ensure credibility and clarity. One of these independent reviewers of the 1999 annual report was a beer making competitor. This indicates a clear commitment to waste minimisation at the industrial level. In addition to these broad environmental achievements and approaches, individual Kirin plants have effectively achieved 100 per cent waste diversion from disposal. For example, the Nagoya Plant has achieved 100 per cent recycling since December 1997 and has complied with national legislation since 1998. The keys to the Nagoya Plant achievement are:

(a) Early streaming of materials for waste minimisation and recycling.

(b) A well-organised system or classification of wastes (into 19 legally defined types).

(c) Monitoring of individual departmental performances in waste minimisation.

(d) Attention to disposal of the final few percent of difficult wastes in order to achieve an overall 100 per cent record (eg. for mixed plastic and metal separation and streaming).

(e) Environmental auditing as part of ISO14001 has also been an important component.

The importance of ISO14001 achievement to environmental improvement cannot be under emphasised. The Kirin Plant undertakes full auditing correction/prevention programs for updating its environmental management system practices. The ISO14001 document effectively acts as a contract for plant operations.

Wastes at the Kirin Brewery are categorised into “valuable” and “valueless” wastes based on profitability at sale and on legal definitions. Various waste products have different fates:

The hops recovered from beer making, some 30 per cent of total site waste, is de-watered and utilised for cattle feed by local farmers after processing. Various sludge materials are used as cement constituents, and occasionally as garden composting material. Yeast residue after drying is used for production of high starch noodles, biscuits and fortified cheese.

Bottle labels are washed, dehydrated, and used for egg-carton production. Cans and bottle tops are compacted and reused for new can making. Various plastic residues are reconstituted into water filtration equipment. Plastics are used as reduction agents in steel blast furnaces. Food residues from the cafeteria are broken down by micro-organisms, and the waste water processed in the waste water treatment plant.

Fluorescent tubes and batteries are separated and recycled by specialist contractors into basic constituents including glass, metals and mercury. Some other materials such as computer circuit boards are broken by hand on the site in order to achieve overall 100 per cent recycling.

Office materials are separated in the office into six or seven streams of material including paper, wood, rubber, and metals. Individual office departments are responsible for appropriate separation. Reporting of inadequate separation is undertaken at the organisational level in order to improve performance.

Overall, the advantages identified by the organisation for the 100 per cent recycling (“zero waste”) program include:

(a) An extremely good corporate image which is advertised at the national level.

(b) Improvement of worker morale.

(c) Cost effectiveness, with market returns exceeding costs for recycled materials, excluding plant, energy and labour costs (Table 4-2.)
Application of these processes to recycling of plastics is currently under development in Japan, and merits the attention of Australian waste minimisation bodies with an aim to optimising royalty discussions with the Japanese. It is anticipated in Japan that the chemical recycling of plastics would be at the third level of plastics recycling. At the first level, plastics should be returned and refilled in order to maximise reuse of the embodied energy contained within plastics after manufacture. Secondly, remoulding of plastics (which requires less energy than chemicalisation), is energy and cost-effective. Finally, chemical recycling may be used for depolymerisation and reprocession of the plastics. The costs of this latter process is currently comparable with reformation of plastics from virgin materials, however this situation may improve with increasing costs of oil.

The current expected use of plastic as an alternative for coke in steel making blast furnaces, as is occurring in Japan, works against the concept of re-utilising the intrinsic energy contained in plastic materials. It is a low grade end use of plastics.

(b) Composting of Commercial Separated Food and Other Organic Wastes at Site of Production

A number of hotels (such as the New Otani Hotel in Tokyo) are composting food on site prior to sale of nutrient rich compost materials to farmers. This process minimises transportation costs in waste management. Other hotels are entering into undertakings with farmers. Food waste is delivered to a processing plant, composted products utilised on farms, and vegetables resold back to the hotels.

(c) Alternative design and reuse Several design and reuse approaches in Japan have potential for waste minimisation. In particular, a cardboard material has been produced which does not use vinyl coating for the paper, and therefore renders the cardboard product more recyclable. Secondly, cooking oil used for food has been purified and recycled for use in motor vehicle fuel.

(d) Other Approaches Some attention has been given in Japan to conversion of plastic materials to oil. Several pilot plants have undertaken such research and development projects however, the process, while feasible, is proving very cost intensive at some A$1000 per tonne of plastics.

Table 4-1  Amount of Waste From Japanese Main Industries & its Recycle Ratio

<table>
<thead>
<tr>
<th>Industry</th>
<th>Amount of industrial waste (kt)</th>
<th>Recycle ratio (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food manufacturers</td>
<td>17,250</td>
<td>11.6</td>
</tr>
<tr>
<td>Fibre industry</td>
<td>8,680</td>
<td>2.5</td>
</tr>
<tr>
<td>Paper pulp manufacturers</td>
<td>26,120</td>
<td>7.7</td>
</tr>
<tr>
<td>Chemical industry</td>
<td>22,500</td>
<td>14.6</td>
</tr>
<tr>
<td>Iron &amp; steel manufacturers</td>
<td>56,900</td>
<td>70.4</td>
</tr>
<tr>
<td>Vehicle manufacturers</td>
<td>7,270</td>
<td>64.7</td>
</tr>
<tr>
<td>Electrical industry</td>
<td>6,020</td>
<td>52.2</td>
</tr>
<tr>
<td>Kirin Brewery</td>
<td>519</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: “Environmental Review 1996” from the Ministry of Trade and Industry statistics from the Ministry of Health & Welfare (June 94, Sep 95, Aug. 96, Sept 97; Feb 99)

Table 4-2  Annual Cost of Precessing of Valuable & Valueless Waste

<table>
<thead>
<tr>
<th>Profitables</th>
<th>Unprofitables</th>
<th>Total balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried yeast</td>
<td>52,126</td>
<td>Wasted kieselghur</td>
</tr>
<tr>
<td>Bottle carat</td>
<td>33,858</td>
<td>Brew spent</td>
</tr>
<tr>
<td>Concentrated water</td>
<td>3,796</td>
<td>Waste plastic bottle cases</td>
</tr>
<tr>
<td>From brew spent</td>
<td>3,796</td>
<td>Burnt ash</td>
</tr>
<tr>
<td>Aluminium cans</td>
<td>2,965</td>
<td>Wasted plastics</td>
</tr>
<tr>
<td>Stainless steel kegs</td>
<td>216</td>
<td>Steel cans</td>
</tr>
<tr>
<td>Label spent 76 Crowns</td>
<td>252</td>
<td>Corrugated board</td>
</tr>
<tr>
<td>Others</td>
<td>1,068</td>
<td>Others</td>
</tr>
<tr>
<td>+93,533</td>
<td>60,886</td>
<td>+32,647</td>
</tr>
</tbody>
</table>


1. FES is a joint venture between the City of Frankfurt and Rethmann Co.
An ample array of technologies exists to enable management of more New South Wales waste as a potential resource. But no one technology is suitable for all waste streams. Each class and type has characteristics which make it suitable for specific waste streams.

The purpose of this Chapter is to introduce and describe the main technology classes and types that form the focus of this report. The aim here is to provide an accessible description of the array which is evaluated in full at Chapter 6.

Readers who are familiar with the operating principles of the technologies might profitably skip to Chapter 6. On the other hand, readers who want to skip the detailed evaluation discussion can gain a reasonable overview of the technologies by reading this Chapter in lieu of the next.

Four technology classes and 14 generic types of technologies are described, as follows:

**Mechanical Separation Technologies**
- Material Sorting
- Waste Separation

**Biological Technologies**
- Land Application
- Open Windrow Composting
- Vermicomposting
- Enclosed Composting
- Anaerobic Digestion
- Fermentation

**Thermal Technologies**
- Incineration
- Pyrolysis/Gasification
- Waste Melting

**Landfill Technologies**
- Conventional Wet Landfill
- Conventional Dry Landfill
- Bioreactor Landfill

The key features of each technology type are set out at Table 5-1. Table 5-2 outlines preferred and suitable input waste types and the main products for each technology type.

### 5.1 Mechanical Separation Technologies

Waste separation is an important part of resource recovery because separation can lead to increased value of materials, and because appropriate location of separation facilities can bring advantages of scale and local market access to recovered materials.

The relevance to waste separation technologies depends on the extent to which the waste stream is prevented from mixing at source. This “unmixed” status depends upon waste practices adopted and can vary across municipal, commercial and industrial, and construction and demolition streams. Source separation opportunities are affected by the waste type.

#### 5.1.1 Material Sorting Technologies

These technologies use automated and manual sorting to separate mixed recyclable materials to groups of specific materials. See Figure 5-1. The outputs are suitable for reuse, recycling or reprocessing. The main technology types, Material Recovery Facilities (MRFs), perform two key functions in waste separation: consolidation of pre-sorted collected materials for transport to reprocessors; and sorting of co-mingled waste streams to aggregate specific commodities.

---

**Figure 5-1: Material Sorting Flow Chart**

![Material Sorting Flow Chart](image-url)
Table 5-1  Main Features of Technologies

<table>
<thead>
<tr>
<th>Technology Class/Type</th>
<th>Main Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical Separation Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Material Sorting</td>
<td>• Mature technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of municipal and commercial dry recyclable materials.</td>
</tr>
<tr>
<td></td>
<td>• Good resource conservation.</td>
</tr>
<tr>
<td></td>
<td>• Main product is recyclate for further reprocessing.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Waste Separation</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept mixed residual waste as input.</td>
</tr>
<tr>
<td></td>
<td>• Main products are specific separated resource streams for further processing.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td><strong>Biological Technologies</strong></td>
<td></td>
</tr>
<tr>
<td>Land Application</td>
<td>• Simple technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Controls needed to avoid nutrient runoff.</td>
</tr>
<tr>
<td></td>
<td>• Good soil improvement.</td>
</tr>
<tr>
<td></td>
<td>• Moderate/good benefit/cost position.</td>
</tr>
<tr>
<td>Open Windrow Composting</td>
<td>• Simple, mature technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Best performed at commercial scale.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input contamination.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Vermicomposting</td>
<td>• Simple technologies, at commercial operating status.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input material.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Enclosed Composting</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Good environmental features.</td>
</tr>
<tr>
<td></td>
<td>• Compost quality related to input contamination.</td>
</tr>
<tr>
<td></td>
<td>• Good benefit/cost position.</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>• Mature, robust technologies.</td>
</tr>
<tr>
<td></td>
<td>• Accept limited input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Products are both energy and compost input.</td>
</tr>
<tr>
<td></td>
<td>• Moderate/good benefit/cost position.</td>
</tr>
<tr>
<td>Fermentation</td>
<td>• Reaching commercial status for mixed organic wastes.</td>
</tr>
<tr>
<td></td>
<td>• Accept moderate variety of input waste types.</td>
</tr>
<tr>
<td></td>
<td>• Main product is ethanol for energy production.</td>
</tr>
<tr>
<td></td>
<td>• Moderate benefit/cost position.</td>
</tr>
<tr>
<td>Technology Class/Type</td>
<td>Main Features</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>Thermal Technologies</strong></td>
<td></td>
</tr>
</tbody>
</table>
| Incineration | • Mature, robust technologies.  
• Accept wide variety of input waste types.  
• Poor/moderate resource conservation.  
• Require considerable air emission control equipment.  
• Products are both energy and heat.  
• Poor benefit/cost position. |
| Pyrolysis/Gasification | • At commercial operating status for specific wastes, reaching commercial status for preprocessed residual waste.  
• Accept moderate variety of input waste types.  
• Main product is syngas or oil used for energy production.  
• Moderate benefit/cost position. |
| Waste Melting | • Commercial operating status for metal wastes, not yet commercial status for mixed residual waste.  
• Accept limited (but possibly expanding) variety of wastes.  
• Main products are heat and syngas used for energy production.  
• Poor to moderate benefit/cost position. |
| **Landfill Technologies** | |
| Conventional Wet Landfill | • Mature, robust technologies.  
• Accept wide variety of waste types.  
• Poor resource conservation.  
• Main product is methane, used for energy production.  
• Moderate benefit/cost position. |
| Conventional Dry Landfill | • Mature, robust technologies  
• Accept wide variety of wastes.  
• Poor resource conservation.  
• Moderate benefit/cost position. |
| Bioreactor Landfill | • Robust technologies, at commercial status.  
• Accept wide variety of wastes.  
• Poor resource conservation.  
• Main product is methane, used for energy production.  
• Moderate benefit/cost position. |
### Table 5-2 Suitable Input Materials and Products

<table>
<thead>
<tr>
<th>Technology Class/Type</th>
<th>Input Waste Type(s)</th>
<th>Output Product(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mechanical Separation Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Sorting</td>
<td>Mixed dry recyclables, including:</td>
<td>Reprocessable materials by type.</td>
</tr>
<tr>
<td></td>
<td>• Paper/cardboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Packaging plastics, paper, glass, metals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Industrial dry recyclables, including:</td>
<td>Reprocessable materials by type.</td>
</tr>
<tr>
<td></td>
<td>• Paper/cardboard</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Metals, plastics, glass</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Timber, concrete, spoil</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>High calorific material (RDF) for thermal processes or reduced volume landfill.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inert materials.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metals.</td>
</tr>
<tr>
<td><strong>Biological Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Application</td>
<td>Agriculture wastes, sewage sludge, gypsum.</td>
<td>Soil improvement</td>
</tr>
<tr>
<td></td>
<td>Specific organic wastes including grease trap wastes.</td>
<td></td>
</tr>
<tr>
<td>Open Window Composting</td>
<td>Garden waste, sewage sludge.</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td>Vermicomposting</td>
<td>Sewage sludge, food waste, garden waste.</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td>Enclosed Composting</td>
<td>Mixed organic waste, including:</td>
<td>Compost, soil conditioner.</td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preseparated residual waste.</td>
<td>Compost, low grade.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High calorific material (RDF) for thermal processes or reduced volume landfill.</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>Mixed organic waste, including:</td>
<td>Biogas fuel/green energy.</td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td>Digestate material for compost.</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Agriculture wastes:</td>
<td>Liquid fuel.</td>
</tr>
<tr>
<td></td>
<td>Mixed organic waste, including</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td><strong>Thermal Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>High calorific specific wastes.</td>
<td>Waste destruction.</td>
</tr>
<tr>
<td></td>
<td>Special wastes, including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Clinical waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Hazardous waste</td>
<td></td>
</tr>
<tr>
<td>Pyrolysis/gasification</td>
<td>Sewage sludge, agriculture wastes.</td>
<td>Pyrolysis oil or Syngas/green energy.</td>
</tr>
<tr>
<td></td>
<td>Mixed organic waste, including</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Food waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Garden waste</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Paper pulp.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preseparated residual waste.</td>
<td></td>
</tr>
<tr>
<td>Waste Melting</td>
<td>Metal wastes, hazardous waste</td>
<td>Syngas/green energy.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metal residue.</td>
</tr>
<tr>
<td><strong>Landfill Technologies</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioreactor Landfill</td>
<td>Mixed residual waste.</td>
<td>Methane/green energy.</td>
</tr>
</tbody>
</table>
New South Wales has many sophisticated MRF sorting technologies for mixed recyclables, whereby co-mingled paper and packaging materials may be effectively sorted to type as recyclate streams.

### 5.1.2 Waste Separation

These technologies use a variety of physical processes, such as drums and pulverisers, to separate mixed residual wastes. See Figure 5-2. The aim is to recover specific waste streams for further processing or reduced-volume disposal.

Examples of such technologies are:
- the German Loesche refuse mill (see Photograph 5-2), which is rapid (~1 hour) ball mill process adopted from mineral processing practice where friction provides the heat source;
- the Australian Brightstar “autoclave” process, in which the waste is heated with steam and rotated in batches then separated through screening and sorting;
- various tunnel systems in which the waste is fed into a rotating drum for 1 to 3 days, with heat being generated through friction and biological action. See for example Photograph 5-3.

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

Several fractions are recovered from the waste. Typically these are:
- an organic rich fraction (40-50 per cent by mass) that can be used as a feedstock for further biological processes (usually anaerobic digestion) or converted to energy or chemical feedstocks using pyrolysis/gasification. This material is generally not composted due to contamination levels;
- a high calorific fraction (20-30 per cent by mass) consisting primarily of plastics, which can be recycled, used as an RDF or landfilled;
- an inert fraction (~10 per cent by mass) consisting of bricks, stones, glass, etc that is landfilled;
- a ferrous scrap fraction (~5 per cent by mass) recovered using a magnetic separator.

### 5.2 Biological Treatment Technologies

A variety of biological treatment technologies is now available for processing organic materials from C&I, and municipal waste sources. In
these processes decomposition is achieved by microbial activity within biologically degradable wastes.

5.2.1 Land Application
These schemes involve direct injection of organic wastes to increase the availability of nutrients in farm soils. See Figure 5-3. Typical waste materials are sewage sludge, agriculture wastes and grease trap wastes. Control is necessary during application to avoid excessive concentration of the material and to ensure that run-off does not occur in wet weather.

5.2.2 Open Windrow Composting
Composting involves the decomposition of organic materials by microbial activity under open, aerobic conditions to produce a stable organic material containing plant nutrients. Complex organic molecules are broken down by microorganisms in a moist, oxygen rich environment. This process releases nutrients and energy contained in the waste material. The material can be used beneficially as a soil conditioner with well recognised properties.

The simplest large scale composting process uses open windrows, which can be applied to garden waste, and which can also accommodate food waste and sewage sludge. See Figure 5-4. Piles need to be turned and watered intermittently in order to avoid anaerobic processes, and for control of moisture content. Variations on open windrowing are used throughout the world. One example is illustrated at Photograph 5-4.

Open windrow composting processes are relatively low-technology solutions. They are most effective in situations where the proportion of organic

Figure 5-6 Enclosed Composting Flow Chart

- Organic Wastes
- Enclosed Composting
- Screening
- Compost
- Biofilters
- Water Treatment
- Water for Reuse or Discharge
- Inert Residues
- Cleaned Air for Discharge
- Polluted Runoff
- Odours
- Inert Residues
- Water for Reuse or Discharge
- Odours
- Biofilters
- Enclosed Composting
- Screening
- Compost
material in the waste stream is high and markets for the product are readily available.

5.2.3 Vermicomposting

These technologies use worms to consume organic wastes including sewage sludge, food and animal wastes. See Figure 5-5. The product is high quality compost suitable for soil conditioning. The technology may be applied on a large or small scale. Garden waste is sometimes used as a bulking agent.

An example of commercial scale vermiculture is the Vermitech Redlands vermiculture facility outside Brisbane.

5.2.4 Enclosed Composting

Controlled atmosphere and moisture conditions are used in these technologies to improve the rate of organic waste decomposition (over open windrow composting) and to control odours. The technologies introduce the use of drums, boxes, tunnels, silos or vessels into the process. See Figure 5-6. System controls provide for input of potentially odourous waste including food, sewage sludge and garden wastes, to produce good quality compost.

The use of slowly rotating drums provides aeration and odour containment. Potential exists for filtration prior to release to the environment of air. In-vessel treatment may require from 1 to 12 days after which open windrowing, generally in a containment building to control odours, completes the composting process over some 6 to 12 weeks, with turning of windrows every few weeks.

A further enclosed composting scheme is “box composting”, where initial composting occurs in sealed boxes for seven to 12 days, with forced air and water spraying, followed by static pile windrowing for three to four months. “Tunnel composting” uses troughs with turning or air-forced disturbance of the bed for around three weeks to produce compost of fairly advanced maturity.

The number of aerobic composting plants used for bio-waste has increased in Europe in the past decade due to the introduction of source separated collections for organic materials from households. Photograph 5-5 shows a Brickolare press used for biowaste in Germany. A similar trend is evident in the United States where composting of source separated garden waste has become an accepted management method.

5.2.5 Anaerobic Digestion

Digestion involves the biological degradation of organic materials by microbial activity in the absence of oxygen. It takes place in digester tanks or reactors, which enable control of temperature and pH levels for optimising process control. See Figure 5-7 and Photograph 5-6. The technology produces methane suitable for energy.

Photograph 5.6 Biowaste Anaerobic Digestion Facility, Salzburg, Austria
for energy generation, and a nutrient rich organic digestate suitable for soil conditioning.

The overall process requires three to four stages involving mechanical processing, one or two distinct anaerobic decomposition phases, and an aerobic or other stabilising process. During digestion, the two different processes of acidification and methanogenesis require different temperatures and pH levels for optimal process control.

Pre-treatment of waste is required for preparation of organics and separation of dry recyclables. Following digestion, a composting stage is usually required for curing, as the anaerobic process does not necessarily destroy all pathogens.

5.2.6 Fermentation

Fermentation technologies involve biological degradation of organic wastes to produce a chemical feedstock or liquid fuel (usually ethanol). See Figure 5-8. Primary input application has been agriculture wastes, but recent developments take municipal organics including food waste and sewage sludge.

Fermentation processes utilising waste as a feedstock, have been under development, primarily in the USA, over the past decade. They are on the verge of commercialisation, with a 500,000+ per annum municipal solid waste and sewage sludge plant now being constructed in Middletown, New York.

5.2.7 Mechanical Biological Treatment (MBT)

Several forms of MBT allow composting-based processing of source-separated waste or mixed municipal waste. These include biological “inerting” and “dry stabilisation”.

Biological “Inerting”, also called mechanical/biological treatment, is a scheme which aims to reduce the carbon content and volume of waste prior to landfilling. The technique involves mechanical waste separation (shredding and fractionation), followed by a biological process (aerobic or anaerobic).

The composting procedure results in significant reduction of biologically decomposable substances. The product is low in gas formation potential, has a low carrying potential of pollutants, and subsequent methane generation is reduced. The mechanical processing stage optimises the biological processes of decomposition.

“Dry Stabilisation” techniques convert residual waste to a stable emission-free form, and to homogenise and stabilise the material to produce a fuel. Stabilisation involves reduction of water content to less than 15 per cent, thereby suppressing biological activity.

The process includes preparing waste material using a mechanical separation waste technology, drying it in an enclosed system by spontaneous heating and biological activity, conditioning the material and reducing metal content. The process is applicable to waste with between 30 per cent and 70 per cent organic materials. The product may be used as a starting material for production of refuse derived fuel (RDF).

5.3 Thermal Technologies

Thermal waste treatment technologies are well established in Europe and North America, with incineration the most widely used thermal process. Energy recovery is usually in the form of heat and electricity. Incinerators are generally regarded as only one treatment technology in an integrated waste management approach. A number of ‘new thermal’ technologies have emerged over recent decades which do not utilise direct burning or combustion of waste. These include pyrolysis and gasification technologies as well as oxidation or melting technologies.

In the United States the amount of waste incinerated declined between 1997 and 1999 from 10 per cent to 7.5 per cent, corresponding to increased recycling rates for organic materials and dry recyclables. In Europe the overall amount of waste requiring disposal has decreased in the past years, however the market for thermal treatment is expanding, largely as a result of EC directives limiting landfill disposal.

5.3.1 Incineration

These mature technologies recover the calorific energy contained in residual wastes. Heat and steam for electricity generation is produced through mass combustion of the input waste. See Figure 5-9. The products can be used for local heating and for energy input to the grid.

Conventional “mass burn” incinerators use reciprocating grates to move waste through the combustion chamber, usually at some 200 to 400 tonnes per day. The stages of combustion usually involve drying and pre-heating the solid waste, emission and combustion, and a burnout and removal stage. Solid combustible material is removed as a slag. It is generally landfilled or may be sorted by grain size for recovery as aggregate. The ferrous metals may be recovered by magnet and recycled. Wash water is often recycled for flue gas treatment. Flue gas from combustion contains water, combustion gases, oxygen and nitrogen. It may need to be reburned to ensure that any carbon monoxide is converted to carbon dioxide.

Steam may be super-heated to drive a turbine to generate electricity. Municipal waste has the capacity to generate power at about 3,000 kWh per tonne of waste, but the majority is lost as heat from the boiler and through loss of flue gas.

Air pollution control is critical in incineration because particulates and dust, NOx acid gases and dioxins, furans, polyaromatic hydrocarbons and heavy metals may be generated.

5.3.2 Pyrolysis/Gasification

Several new thermal processes, including gasification, pyrolysis and combinations of these have been adapted to municipal waste particularly in recent years. The technologies themselves are not new; they have been applied to coal since the turn of the century. Other
Figure 5-7 Anaerobic Digestion Flow Chart

- Organic Wastes
- Waste Preparation
- Anaerobic Digestion
- Digestate Dewatering
- Biofilters
- Heat and Electricity
- Biogas
- Exhaust Gas
- Inert Residues
- Water for Reuse
- Water Treatment
- Water for Discharge
- Digestate
- Chemicals for Sale
- Biogas
- Sludge Dewatering
- Water Treatment
- Water for Discharge

Figure 5-8 Fermentation Flow Chart

- Organic Wastes
- Waste Preparation
- Fermentation
- Sludge Dewatering
- Biofilters
- Chemicals for Sale
- Biogas
- Inert Residues
- Water for Reuse
- Water Treatment
- Water for Discharge

Figure 5-9 Incineration Flow Chart

- Residual Waste
- Combustion (>800°C)
- Boiler
- Low Pressure Steam
- Heat and Electricity
- Exhaust Gas Cleaning
- Cleaned exhaust gas
- Excess air
- Start up heat
- Ash residues
- Hot exhaust gas
- Excess air
applications are for sewage sludge, biomass in the form of crop residues, and motor vehicle tyres.

These technologies require a uniform, consistent input stream to ensure reliable operation. For mixed municipal wastes, some form of sorting/ separation pre-treatment is usually required, to remove unsuitable waste materials and ensure consistency. Unsuitable materials are usually aggregated as like streams, usually including metals, glass and plastics and can be recycled productively in separate processes.

**Pyrolysis**

Pyrolysis involves indirect heating carbon rich material. The aim is to achieve thermal degradation of the material at a temperature of some 500 degrees Centigrade in the absence of oxygen and under pressure. See Figure 5-10.

Useable energy of some 200 to 400 kWh/t of waste is generated by pyrolysis. Energy production and greenhouse gas production are lowered due to the starved air conditions. Less volatile heavy metal species remain in char, while volatile species need to be captured by gas cleaning systems and treated as hazardous materials. A liquid fraction is produced consisting of a tar or oil stream containing acetic acid, acetone, methanol and complex oxygenated hydrocarbons. This may be used, with additional processing, as a synthetic fuel oil.

A number of pyrolysis plants are in operation, mainly concentrating on processing consistent waste streams such as plastics or biosolids. An example of this is the ESI Enersludge process currently converting sewage sludge into a liquid fuel in Perth, WA. This process converts 15 tonnes of biosolids to 4,000 litres of pyrolysis oil for energy recovery per day.

**Gasification**

Gasification involves heating carbon rich waste in an atmosphere with slightly reduced oxygen concentration. The majority of carbon is converted to a gaseous form, leaving an inert residue from break down of organic molecules. See Figure 5-11. Relatively high temperatures are used, around 1,000 degrees Centigrade in air, or 1,200 degrees Centigrade in oxygen. Process descriptions vary for different specific technologies, and are generally patented.

Gasification is widely considered an energy efficient technique for reducing the volume of solid waste and for recovering energy. A combustible fuel gas (“Syngas”) is produced which is rich in carbon monoxide, hydrogen and some saturated hydrocarbons (methane).

Examples of gasification processes now being operated and commercialised include respectively the PKA process (see Photograph 5-7) and the Brightstar Environmental SWERF process.

Useable energy of some 500 to 600 kWh/t of waste is generated by gasification. Emissions from gasification are significantly less than from incinerators. The fuel gas can be used in internal combustion engines to produce energy; in a steam turbine or boiler; or as a raw material resource to produce methanol, hydrogen or methylacid. Syngas includes carbon dioxide, methane, carbon monoxide, hydrogen, nitrogen and ammonia. Small quantities of hydrochloric acid, hydrofluoric acid, hydrobaric acid, sulphur dioxide and nitrogen oxides and particulates are produced along with trace metals or heavy metals, notably cadmium and mercury.

5.5.3 Waste Melting

Waste melting refers to thermal technologies that operate at sufficiently high temperatures to completely oxidise or reduce the waste and produce an inert glassy slag, a recyclable metal matte and a minimal amount of waste (~1% of incoming waste). These processes can either be used to stabilise residuals from a thermal process, or be used to process the waste directly.

---

**Figure 5-10 Pyrolysis Flow Chart**

![Pyrolysis Flow Chart](chart)

- **Waste**
- **Reactors (400-800°C)**
- **Pyrolysis oil**
- **Cleaned pyrolysis oil**
- **Combustion in IC engine**
- **Electricity**
- **Exhaust gas**
- **Separated Waste**
- **Ash and char**
- **Residue recirculation**
- **External heat**
Two types of waste melting processes exist:

- Oxidation processes, where oxygen is introduced to oxidise out the carbon content and raise the temperature sufficiently to form a slag/metal melt that can be tapped and recovered. See Figure 5-12, and

- Reduction processes, where a plasma arc is used to reduce the carbon to syngas and form a slag/metal melt. See Figure 5-13.

Examples of oxidative processes are the Australian Ausmelt process and the melting process that can be installed at the back of the PKA gasification plant. The Ausmelt process utilises a submerged lance to inject air and/or oxygen directly into the molten slag, creating sufficient heat to melt the waste. This process has been used around the world for refining metal concentrates and metallic wastes such as aluminium pot linings and spent nickel-cadmium batteries, and has been trialled for incinerator ash.

Similarly plasma arc processes have been processing metal wastes and specialised industrial wastes, such as aluminium refinery scrap and hazardous waste.

5.4 Landfill Technologies

Landfill is defined in the Waste Minimisation and Management Act (1995) as “the disposal of waste to land”, and refers to the technology of depositing waste to land in a controlled manner to reduce impacts to water, air and human health. Landfill had traditionally been the primary end point for waste arisings in NSW, and in 1998 some 62 per cent of waste was landfilled in NSW.

Landfill technology is based on anaerobic decomposition, which depends on hydrolysis (breakdown of complex organics to monomers), acidification (acid formation) and methanogenesis (methane and CO2 formation) phases.

5.4.1 Conventional Wet Landfill

These mature technologies are used to facilitate waste decomposition in a controlled manner. As the process of biodegradation takes place methane and carbon dioxide are released and a preparation is captured as gas suitable as fuel for electricity generation. See Figure 5-14.

Conventional landfill technology has evolved over time beyond simply filling an excavated hole. Landfills now utilise a liner or a natural geological barrier beneath the waste, aimed at water protection, and improved local environmental amenity. Composite liners consisting of plastic membranes placed directly on top of a clay liner are not uncommon.
Landfill gas is usually collected from large-scale developments by a piped collection system. Gas may be combusted to convert methane to carbon dioxide, either in flares or in engines that recover useable energy. Chlorinated and fluorinated hydrocarbons are present in landfill gas, and these are also destroyed in the combustion process.

Research is being undertaken to examine the value of ammonia and other leachate contaminants as growth nutrients for agricultural or other applications, by dilution or mixing with water.

There is interest internationally in pre-treatment of waste to be landfilled in order to control long-term landfill behaviour and reduce residual volume. Thermal pre-treatment would require attention to the potential hazardous nature of ash, notwithstanding the value in reduced waste volumes. Landfilling of biologically pre-treated municipal waste may still require the use of liners, leachate and gas collection systems. Baling however may avoid leachate generation and to maximise space efficiency.

5.4.2 Conventional Dry Landfill

Dry landfills are feasible in low precipitation climates, where minimisation of infiltration inhibits the biodegradation of waste. This reduces or eliminates leachate and landfill gas formation because of the dry stable conditions.

5.4.3 Bioreactor Landfill

Bioreactor landfills rely on enhanced microbial decomposition and optimised process control of the degradation phases, and result in an accelerated process compared with conventional landfill. See 5-15.
In these landfills the rate of anaerobic decomposition is accelerated by recirculation of leachate and, in some cases, addition of sewage sludge. The process aims to improve gas production and reduce the time taken to achieve stabilisation.

Bioreactor landfill aims to rapidly develop a high concentration of methanogenic organisms to enhance the rate of decomposition of waste and enable the pollutant and gas flow to be optimally captured. These processes are currently at the experimental stage in Australia, but used with success in USA.

The process control associated with the bioreactor and the ability to capture and treat emissions and leachate offer the potential for significant environmental improvement compared with traditional landfiling. Bioreactor landfill requires a high standard of design and operations control. Benefits over conventional landfill include more predictable landfill performance, more rapid stabilisation of waste, controllable and increased short term gas yields, and better leachate control.

5.5 Emerging Situation

The development and uptake of emerging technologies overseas has been driven by national circumstances expressed in practical terms through waste management policy and practices. Environmental concerns in particular have prompted development of alternative treatment/disposal systems to landfill and incineration.

In the last ten years many different proprietary technologies have become available. Most are in fact established technologies adapted for
use with (often mixed) waste inputs rather than uniform consistent materials.

The next five years will be a critical proving period for the new applications entrusted to biological and thermal technologies. Issues of importance will be:

• relative long term cost compared with traditional solutions;
• continuing performance reliability;
• the success of pre treatment waste separation systems;
• innovative financing arrangements;
• government policies which influence flow control;
• pricing, differentiation and other competitive market positioning moves.
Technology classes and types excel in varying performance dimensions: a measure of trade-off is invariably required to balance technical, environmental, social and economic outcomes and achieve best overall performance for specific waste streams.

This Chapter presents multi-discipline evaluation of the main generic waste and recyclate processing technologies, as described in Chapter 5. The objective here is to test each technology, within its operating context, against technical, environmental, economic and social criteria.

It must be emphasised that none of these technologies offer a complete solution. Rather, each can form a part of an integrated waste management system. In such a system specific technologies may be utilised to process different waste streams, or may be used as different unit processes at the one waste facility.

It is important to note that the technology systems evaluated are not directly comparable. This is essentially because they are designed to perform different functions, both within and across class boundaries. For example, landfills are capable of taking a wide variety of wastes, while anaerobic digesters are geared to food wastes. Consistent with the message throughout this report, the implication is that an integrated portfolio of technologies (and practices) will provide best results.

Technology selection ought to be driven by three critical principles:

- A firm understanding that the array of technologies selected as part of an integrated system must play pivotal roles in linking markets for resources and the system of waste management practices adopted.
- Investment and operating risk can be managed most easily if input supply can be reasonably predicted and product demand can be reasonably judged. The most efficient allocation of these and other risks is a key factor in controlling waste management costs.
- Current and evolving circumstances provide an important context for technology choices. The complex intertwining of waste types generated, local planning and environment considerations, local industry resource demands and geographic circumstances (along with many other issues) can provide opportunities and influence choices.

Although comprehending a wide array of ESD and technical performance issues, the evaluation is necessarily a little more general than might in the future be possible. There are numerous obstacles to the total system analysis which might comprehend every conceivable impact:

- The technique of Life Cycle Analysis is often cited as desirable, but the technique and the data base are yet to be developed to the stage where it could provide reliable manageable results on a State-wide basis.
- As mentioned above, direct comparison of technology classes and types is largely inappropriate: each generic technology has application to specific operating tasks which overlap at boundaries but differ in the main. Moreover, technologies should logically be considered in the context of their specific waste stream design application, (eg, organic waste, mixed waste, inert waste etc).

The Inquiry has chosen not to report on specific technology brands, but rather on classes and types of technology systems. A systems approach has been adopted, which considers the waste treatment technology complete with any waste pre- or post-processing and pollution control equipment that would normally be associated with the technology.

Technology Classes and Types

The technologies under consideration can be summarised as follows:

- **Mechanical Separation Technologies**
  - Material Recovery
  - Waste Separation

- **Biological Technologies**
  - Land Application
  - Open Windrow Composting
  - Vermicomposting
  - Enclosed Composting
  - Anaerobic Digestion
  - Fermentation

- **Thermal Technologies**
  - Incineration
  - Pyrolysis/Gasification
  - Waste Melting

- **Landfill Technologies**
  - Conventional Wet Landfill
  - Conventional Dry Landfill
  - Bioreactor Landfill

Evaluation Criteria

The evaluation criteria used in the review cover:

- **Technical Issues**
  - Technology maturity
  - Input quality flexibility
  - Input quantity flexibility
  - Local availability of technology and expertise.

- **Environmental Issues**
  - Resource conservation
  - Solid residues
  - Greenhouse gas emissions
  - Risk of water emissions
  - Risk of air emissions

- **Social Issues**
  - Community involvement/buy-in
  - Public perception
• Amenity impact
• Employment impact.

Economic Issues
• Net costs per tonne
• Cost/scale sensitivity
• Net benefits per tonne
• Market availability for products.

These criteria are defined and the scoring system is explained in Annex A.

The evaluation is based on the terms of reference of the Inquiry. However, there are various issues which limit comparative assessment of technologies:

• local variations such as socio-economic factors, transportation distances for wastes and recovered resources greatly affect economic, environment and social impacts;
• project scale greatly affects impacts, so technology scores are somewhat related to optimal project scale;
• the risks of environmental impacts to air, land, water and amenity from a facility are largely governed by the types and volumes of waste handled and the quantum of potential impacts that must be managed, thus the assumption is made that the environmental controls at the proposed facilities are in line with the concept of best available technology not entailing excessive cost (BATNEEC), and are therefore accounted for in terms of the capital and operating costs of the facility. The evaluation however considers the risks of adverse emissions associated with each technology.

The weighting factors used in the evaluation process were determined by the Inquiry Panel Members to reflect relative importance of key issues associated with the technologies at present.

A variety of alternative weighting patterns was considered, and the Panel is satisfied that the one adopted best represents a balanced perspective. The results obtained were not sensitive to modest changes in key criteria.

It is not possible to be precise about the capital and operating costs of the technology classes and types under analysis. Several issues prohibit precision:

• within each technology type under analysis several (or more) proprietary brands exist, and all vary slightly in process configuration;
• project circumstances vary considerably, particularly in terms of scale, input materials and output resource focus;
• project and process risks vary and the allocation of the various risk elements between the parties is fundamental to pricing;
• the introduction of new technologies, or technologies new to a region is often accompanied by intense competition and special pricing in order to secure an initial contact which would create a commercial scale demonstration plant.

Benefits too, defy precision. Price fluctuations around the various output products are high, and in one year, 1995, suffered a 50 per cent decrease.

6.1 Evaluation Results

The evaluation results indicate that each of the above technology classes can make a contribution in an integrated waste management system that aims for increased resource conservation. Technology classes and types excel in varying performance dimensions: a measure of trade-off is invariably required to balance technical, environmental, social and economic outcomes.

The evaluation results set out at Table 6-1 allow the following conclusions to be reached.

• Mechanical Technologies perform specific purposes which essentially precede other treatment processes.

Material sorting technologies (sometimes known as MRFs) score very well due to their maturity and modest cost in sorting dry recyclables, which are then reprocessed to create new paper and packaging procedures.

Waste separation technologies score moderately for their ability to segregate mixed residual wastes so that various fractions can then be processed using composting or gasification technologies.

• The main recognised Biological Technologies score very well on an aggregated criteria basis. The composting technologies in this group produce a moderate to high quality soil conditioner with strong market acceptance. They are mature technologies with moderate to good environmental characteristics and social impact and good economic viability.

A further biological technology, anaerobic digestion, scores slightly less on the criteria, but has energy as its main product. Fermentation technology has not reached the same level of commercial maturity as its counterparts but can be used to produce a chemical feedstock at moderate cost. It scores moderately well on the criteria.

• Thermal Technologies are a mixed bag. Incineration, despite its maturity and input materials flexibility, scores poorly overall due to economic and social issues and low resource conservation capabilities.

The new thermal technologies, pyrolysis/gasification and waste melting technologies, are proven in specific materials applications and some pyrolysis/gasification technologies are reaching commercial status for mixed waste treatment. These technologies produce energy, at moderate cost as their main output product.

This group of technologies score moderately well on the criteria.

• Landfill Technologies score moderately on the criteria, mainly due to their maturity, flexibility and low costs. These factors somewhat balance their poor performance in resource conservation, moderate environmental risk characteristics and low social acceptability.

Bioreactor landfills and conventional wet landfills produce energy as their main product.
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Notes: Indicative assessment based on broad technology classes and types, not brands.
6.2 Mechanical Separation Technologies

These technologies are based on physical processes that separate and prepare mixed recyclables or mixed waste for further processing. The separation of mixed recyclables (material sorting) is usually done at a material recovery facility (MRF). The separation of a mixed waste into several material and waste streams is usually done as a precursor to further treatment of the separated fractions at the same or other site.

6.2.1 Material Sorting

Material sorting refers to the recovery of recyclable materials from a mixed or “comingled” recyclable stream. The most commonly processed recyclables stream processed is kerbside collected dry recyclables, but there is an increasing push to recover recyclables from C&I and C&D sources.

For dry recyclables two different strategies are being pursued:

- Traditional sorting to standardised marketable grades of recyclate, such as newsprint, cardboard, clear/green PET, LDPE, clear/brown/green glass, steel and aluminium (ie, Waste Service Chullora).
- A two stage sort, where the dry recyclables are sorted into mixed paper, mixed plastic, mixed glass and metals for later separation using specialised sorting equipment such optical sorters (ie, Visy Recycling in Melbourne).

The proponents of the two-stage sorting system claim that it leads to efficiencies in the recovery of recyclables, and higher diversion rates at kerbside. But others are concerned that it is leading to an oligopoly with a few vertically integrated companies in the marketplace.

Australian material recovery facilities compared favourably with current overseas practice. One development that has emerged is the development in Germany by DSD of a fully automated MRF, where all the material is ground up and separated using magnetic, heavy media and filtration processes. At present only one demonstration plant exists using this technology. Issues of energy efficiency and optimal catchment size are yet to be clarified.

(a) Technical Issues

Material recovery facilities are designed to recover a specific set of recyclate, and the introduction of materials unsuitable for recovery (contamination) increases operating costs and can lead to penalties or rejection of the recovered materials. Thus these facilities usually rely on community education to encourage and direct the community to correctly separate recyclable materials. The input quality flexibility is rated as moderate (3).

The facilities are usually sized for a particular recyclables stream, but can generally be expanded or contracted by altering staffing levels, sorting equipment or operating hours, so in terms of input quality flexibility are rated moderate (3).

MRFs generally have reached a high level of technology maturity (5), and are a well established technology. They also consist of a number of independent processes so if one process fails the rest are often able to continue operating while un-processed materials are able to be stockpiled due to their relatively inert nature.

The local availability is also high (5), with Australian facilities comparable to those seen overseas.

(b) Environmental Issues

MRFs have limited localised environmental impacts, such as noise, dust and odour. These can be readily controlled through good housekeeping and enclosing operating equipment. A detailed study into the environmental impacts of MRFs in the USA concluded that they do not pose a significant threat to the environment. From a broader perspective MRFs are considered environmentally beneficial as they facilitate the recovery of recyclable materials necessary to achieve higher levels of resource utilisation.

Greenhouse gas emissions, risk of air emissions and risk of water emissions are all rated low at 4.5, 5 and 4 respectively. Minor amounts of solid residue will be generated from MRFs (4), but as the recovery of materials by MRFs reduces virgin resource use they rate highly in terms of resource conservation (5).

(c) Social Issues

MRFs generally have a good image with the community as they provide confirmation that the effort made in separating recyclables is being followed up.

MRFs have a moderate amenity impact (3) due to traffic noise and noise and dust from processing equipment. Community involvement in resource conservation associated with material recovery is very high (5). The practice fundamentally relies on community involvement in source separation and diversion of recyclables from the mixed waste stream. The outputs are quite clearly are used to create new products for everyday use which reinforces community involvement.

Public access through organised site visits is entirely possible to MRF facilities. Inspection of the next stage, of material beneficiation and processing, is also feasible.

Public perception and confidence in material recovery processes is moderately high (4), though occasional market downturns create community uncertainty about the benefits of recycling. The community is generally not aware that MRF technology is rapidly improving.

Employment impacts are high (5) in direct operations and process control. Indirect employment is moderate to high in onward processing, materials transport, selling and new product activities.

(d) Economic Issues

The net cost per tonne of waste input was assessed by the Inquiry to be between $80 and $120 (3.5), with the net benefit per tonne assessed as between $60 and $80 (4). The cost-scale sensitivity is moderate (3), with larger facilities being able to utilise more automated sorting technology.

Being internationally traded commodities, the markets for recovered recyclables is volatile, but generally believed to be becoming...
more stable as more industry moves to greater use of recovered feedstocks. The overall market availability is rated as good.

6.2.2 Waste Separation

These technologies are used to separate a mixed residual waste stream into a number of distinct streams that may be either directly recyclable, able to be used as feedstock for further processing, available for energy recovery or be disposed of to a more economic landfill facility. Waste separation is usually undertaken in two steps:

- a processing step where the waste is mechanically worked (usually through turning) and heated to homogenise the waste, tear open plastic bags, and soften the waste; and
- a separation step where the processed waste is segregated using screens, air blowers, magnets and other processes.

Several fractions are recovered from the waste. Typically these are:

- an organic rich fraction (40–50 per cent by mass) that can be used as a feedstock for further biological processes (usually anaerobic digestion) or converted to energy or chemical feedstocks using pyrolysis/gasification. This material is generally not composted due to contamination levels;
- a high calorific fraction (20–30 per cent by mass) consisting primarily of plastics, which can be used recycled, as an RDF or landfilled;
- an inert fraction (~10 per cent by mass) consisting of bricks, stones, glass, etc that is landfilled; and
- a ferrous scrap fraction (~5 per cent by mass) recovered using a magnetic separator.

Weight losses due to evaporation of water and some biological decomposition are in the order of 20 per cent.

When combined with on-site biological processing technologies (as is often the case), these schemes are collectively referred to as mechanical-biological treatment or MBT.

(a) Technical Issues

The technology maturity of these processes is high (4.5), with numerous processes operating overseas.

The input quality flexibility of waste separation processes is high (4), being designed to process a mixed residual waste stream. Like most processing operations they have moderate input quantity flexibility (3). The local availability is believed to be good, but expertise from overseas would probably be needed to optimise performance (4).

(b) Environmental Issues

The separated materials (except for ferrous scrap) usually have a marginal or negative value, and little is gained if these wastes are landfilled except for being slightly reduced in volume and mass. To avoid being landfilled additional processes have to be available to further transform the separated waste streams. If landfilled, it is unclear how separated waste streams from residual municipal waste would be assessed in NSW, although the WSWB is currently undertaking research in this area. Overseas studies indicates that additional biological treatment of residual municipal waste is necessary (MBT) to achieve significant reductions in landfill gas and leachate generation.

Due to this uncertainty, the solid residues and resource conservation scores are rated below that of MRFs, being (4) and (2) respectively.

Modern waste separation processes are usually enclosed and incorporate air and water emission collection and treatment, so environmental impacts are minimised. They do involve mechanical working of the waste to separate the different fractions, so are large noise generators and noise barriers or separation distances to sensitive receptors need to be considered.

Greenhouse gas impacts are rated as low (4), while the risk of water emissions and risk of air emissions are both rated as moderate (3) due to large amounts of wet waste being processed.

(c) Social Issues

Community involvement in resource conservation through activities associated with waste separation are very limited (1) as this is an industrial process usually involving noise and safety issues. The community of course can play an important part in source separating waste to minimise the need for residual waste separation.

Public perception and confidence is not an issue because waste separation technologies usually form part of a waste treatment system comprised of various processes, so is rated as moderate (3). The amenity impacts of waste separation are expected to be moderate similar to an MRF (3).

Employment impacts are low (2) in process operations due to the automation of the process and usually low in process control due to relative simplicity.

(d) Economic Issues

Waste separation is usually a unit process within a waste treatment facility, and as such the unit cost is incorporated into the overall waste processing costs. In submissions to the Inquiry the net cost per tonne of waste input for waste separation was around $30 (5), with net benefit per tonne input ranging from -$45 to -$10 (1). The cost-scale sensitivity of waste separation is moderate (3).

The separated waste streams (except for ferrous scrap) typically have a marginal to negative value and usually have a further processing step, so the output product market is poor.

6.3 Biological Technologies

These technologies utilise the biodegradable nature of organic wastes to recover nutrients and/or biogas for energy recovery. They can operate alone or in combination with other biological processes. As these processes only affect the organic fraction of the waste, any inorganic or intractable components will remain in the residue and may even be concentrated due to degradation and drying of the waste mass. Hence the product quality from biological processes is highly dependent on the
quality of the incoming waste stream. Six biological technologies are considered in this section:

- Land Application;
- Open Window Composting;
- Vermicomposting;
- Enclosed Composting;
- Anaerobic Digestion; and
- Fermentation.

6.3.1 Land Application

The scheme is based on the application of organic wastes to soils. The bacteria in the soil break down the wastes, releasing nutrients. This technology is only suitable for a limited range of organic wastes such as food waste and sewage sludge, with application under controlled rates and methods. The EPA is currently reviewing land application of wastes, with guidance to be developed on applicable waste types and application methods.

(a) Technical Issues

The technology for land application of wastes is largely agronomic, based on soil science and incorporation of the product into the soil. The technology for land application of wastes has largely been developed from the land application of manures and biosolids from sewage treatment plants.

The input waste flexibility is low (1), with only certain types of wastes suitable for land application. The input quantity flexibility is limited for any given application site, so changes in quantity depend on finding new application areas (3).

The technical maturity of land application is reasonable (4), but is highly dependent on the application method used. The local availability of the technology is good (4) but more research is needed for land application of various wastes under Australian conditions.

(b) Environmental Issues

The success of land spreading is dependent on the technique being limited to certain waste types, and applied at appropriate concentration. If inappropriate wastes are land applied, or appropriate wastes at an excessive rate or with poor incorporation into the soil, then soil degradation and water pollution can result.

With appropriate wastes and application rates and methods, the risk of air emissions and greenhouse gas emissions are considered to be low at (4) and (4) respectively. Until the wastes have broken down in the soil the potential water emissions are considerable (3), as land application distributes wastes over a large area. The solid residues from land application are negligible (5), assuming all the waste applied is biodegradable in the soil. Resource conservation is facilitated through the recovery of nutrients within the soil (4), with the energy balance considered to be neutral.

(c) Social Issues

Community involvement in resource conservation through land application is clearly limited by the specialised nature of the process. The broad community is essentially unaware of the process and plays no specific part in material separation or preparation (1).

Public perception and confidence is unclear in respect of waste, but positively in favour of land application of sewage biosolids (2).

The amenity impacts of land application are low (4) and localised to the active application site. Employment impacts are low to moderate (2) in process operations and waste preparation.

(d) Economic Issues

With active farming still practised in areas adjacent to urban areas, such as within the Sydney basin, land application of wastes is a viable proposition capable of providing nutrient enrichment to soils. Costs for land application of wastes vary, and include the following:

- analysis costs to characterise the wastes to be applied;
- costs associated with locating, testing and gaining approval for the land application site;
- application costs, including any waste storage or pollution control works required; and
- post application monitoring costs.

These costs would be offset by the disposal charge levied on the waste generator.

The net per tonne of waste input is estimated to be between $15 and $25 (5), while the net benefit per tonne of waste input is low at $0 to $5 (1). The cost-scale sensitivity is moderate (3) when dedicated subsoil injection equipment is used and a soil assessment is done at each application site.

The market availability is good (4), with a reasonable demand for soil improvement near urban areas of NSW.

6.3.2 Open Window Composting

This technology involves composting organic wastes in open air conditions. It is the least expensive composting technology, and is widely practised for composting garden waste, sometimes with the addition of animal wastes and sewage sludge. Other wastes can be processed to an acceptable compost product, such as food processing waste, and grease trap waste, but controlling the odours from composting these wastes is difficult.

One method used to reduce odour impacts is to use forced aeration. This technology involves placing the organic waste on a sealed surface, into which are installed a number of channels. These channels are used to draw air through to the base of the pile for treatment in a biofilter to reduce odours, as well as to collect any leachate generated. If the colder topmost layer is constructed from mature compost, the need to turn the pile can be eliminated.

Operational control is through selecting and preparing a suitable waste to be composted and maintaining optimal temperature, moisture and aeration conditions in the active windrows. This process is the most widely practised biological processing technique in Australia, where abundant garden waste and open space make it a viable option.

(a) Technical Issues

The input quality flexibility of open window composting is limited (2), being only able to process organic wastes.
Open windrow composting has a good input quantity flexibility (4) with the capacity of any facility limited to the land area of the facility. The technology maturity of open windrow composting is good (5), with large scale open windrow composting being done in NSW for many years. Similarly the local availability of open windrow composting is high (5), with some key technologies such as windrow turning equipment imported.

(b) Environmental Issues
The primary environmental impacts of open windrow composting facilities is from odours and leachate. Controlling these impacts requires operational controls, such as:

- creating a suitable feedstock for composting by creating a good carbon to nitrogen ratio and limiting fatty or high protein wastes;
- maintaining the compost in an aerobic condition through having adequate structure in the compost, adequate turning and/or forced aeration; and
- controlling the moisture content in the piles through drainage and irrigation.

Open windrow composting can produce significant risk of air emissions (2) due to being open facilities. Greenhouse gas emissions are moderately beneficial (3) through the recovery of soil conditioner that has horticultural and agricultural uses. The risk of water emissions is moderate (3) as a result of nutrient rich runoff from the large exposed area of waste. The amount of solid residues is dependent on the amount of inorganic contaminants in the input waste (3).

In resource conservation terms the technology is good, with most of the organic material being recovered (4).

(c) Social Issues
Community involvement in resource conservation through open window composting is reasonably high (4). Home composting is practised by thousands of households. The community is broadly aware that a sizeable proportion of the garden waste refuse haul is composted, the end products are readily available for sale. Despite this apparent knowledge, up to half the garden waste refuse in NSW is disposed as residual waste. Community access to composting activities is readily available without safety hazard.

Public perception and confidence in composting is generally positive and the product is well supported in the market place but local odour dispersion is significant and is a key factor in siting of facilities (3).

The amenity impacts of open windrow composting are considerable (2), with such facilities generating many complaints regarding odour and dust emissions.

Employment impacts are low (2) in the composting process but moderate in product sales and indirect activities including package development.

(d) Economic Issues
The net cost per tonne of input is estimated to be between $25 and $40 (5), while the net benefit per tonne of waste input is estimated as between $15 and $30 (2). The cost-scale sensitivity is moderate (4), with larger facilities able to purchase specialised turning equipment.

The output product market is very good (4.5), with compost from waste well established in NSW.

6.3.3 Vermicomposting
Vermicomposting is the production of compost using worms. Composting worms originally consumed manures, and thus this technology is useful for sewage sludge and some food wastes. It is widely practised at a small to medium scale, but is now being developed at a commercial scale for processing biosolids and animal wastes.

(a) Technical Issues
Although widely operated on a small scale vermicomposting is only now being practised on a commercial scale. It is a robust technology for selected feedstock wastes, such as sewage sludge and some food wastes.

The input quality flexibility is low (2), being limited to organic wastes of a suitable structure for worms. The input quantity flexibility is moderate (3), with expansion requiring worms to be bred up and beds to be established. The technical maturity of vermicomposting is good (4) and with operations at commercial scale being developed in Australia the local availability is high (5).

(b) Environmental Issues
The environmental impacts of vermicomposting depend on the configuration of the process and the wastes incorporated. If practised in the open it will have similar impacts to open windrow composting, but if enclosed as proposed for newer plants the impacts will be similarly reduced as in enclosed composting.

The risk of air emissions are considered to be significant (3) due to semi-enclosed operation, but this could be reduced with enclosed systems. For greenhouse gas it is taken to be moderately beneficial (4), as a soil conditioner is produced.

Risk of water emissions are considerable for an open operation, but could be reduced with enclosed facilities (3). Solid residues are dependent on the inert contamination in the incoming waste (3).

Resource conservation is assessed as good (4) as most of the nutrients are recovered, with the energy balance is considered to be neutral.

(c) Social Issues
Vermiculture is possibly the most well accepted waste technology after recycling, with people seen to identify with worms.

Community involvement in resource conservation through small scale vermicomposting is already high and the community has a good appreciation of the benefits of the scheme. Community access to a local commercial scale facility is feasible though it presents potential safety hazards in wet conditions. Odours may be an issue in municipal waste applications. It is entirely possible to purchase the product of commercial vermicompost schemes. The overall rating for vermicomposting is high (4).

Public perception and confidence in vermicomposting of biosolids is positive (4), but municipal applications would need to be proved.
The amenity impacts are significant due to the open nature of vermicomposting (3).

Employment impacts are moderate (2), and cover low to high skill levels involving physical and process control.

(d) Economic Issues

The economics of vermiculture at a commercial scale is still being established in Australia, but the Inquiry estimates net costs per tonne of waste input to be between $35 and $50 (5), and net benefit per tonne of waste input from the vermicast to be between $30 and $50 (3). The cost-scale sensitivity is expected to be moderate (3).

The market availability is good (3.5) with vermicast reported by some to be superior to compost.

6.3.4 Enclosed Composting

Enclosed composting is the production of compost within a facility in which atmospheric and moisture conditions are controlled. This offers a number of advantages over open composting facilities:

• total control of the airflow and temperature profile through the composting waste is gained, which allows for faster composting times;
• moisture content in the pile is controlled, reducing the generation of leachate from the compost; and
• all air and water emissions are able to be collected and treated prior to discharge.

Many configurations of enclosed composting systems exist, but they broadly fall into one of two categories:

• Continuous systems, where the waste is added and compost discharged on a continuous manner. These systems have a high throughput, but being a continuous system are not able to be readily changed in response to changes in feedstock. Examples include drum systems and vertical composting units.

• Batch systems, where the waste is loaded into a tunnel, silo or box and composted until maturity is obtained. It is claimed that these systems have better process controls, and allow flexibility as to when to cease the composting process.

The capital and operating costs of enclosed composting plants considerably exceed those of open windrow composting, but the potential environmental impacts such as odour and leachate from compost decrease during processing. To minimise costs many facilities utilise an enclosed composting system for the initial period when odours and leachate emissions are highest, then use open windrows to mature the compost.

The high level of process control in enclosed composting systems allows for the process to be used for alternative applications. One such application is the use of heat generated during composting with controlled air flow to dry out residual waste to produce a dry, stable RDF.

(a) Technical Issues

The technology for enclosed composting is well established, with many facilities operating in Europe and the USA. In particular, large amounts of combined food and garden waste (biowaste) is processed into marketable compost using enclosed composting facilities, where the marketability of the compost helps to offset the increased costs.

The input quality flexibility is low (2.5), being able to only process organic waste. The input quantity flexibility is moderate (3), as the facility is sized and amortised for a certain capacity. The technical maturity of these processes is high (5), with many facilities operating overseas. The local availability of the technology is high (4), with some leading technology providers in Europe and USA already entered into commercial arrangements with local companies.

(b) Environmental Issues

Given the collection and treatment of air and water emissions is standard with enclosed composting systems, the primary environmental impact of this technology is the compost produced. The quality of the compost is in turn dependent on the quality of the incoming waste and the efficiency of any processes to remove contamination from the compost product.

The risk of air emissions and risk of water emissions are low at (4) and (5) respectively, with all emissions being collected and treated before discharge. The greenhouse gas emissions are taken as moderate (4), and solid residues are dependent on inert contamination in the incoming waste stream (3).

(c) Social Issues

Community involvement in enclosed composting technologies is moderate to high (4). Communities are able to identify readily with the value adding processes undertaken with food and garden wastes. The products are generally of high quality and readily available in the marketplace. Many households participate in home composting using various organic wastes.

Enclosed composting facilities are accessible with little safety hazard or odour problems related to site visits.

Public perception and confidence in enclosed composting is positive and the product is well supported in the marketplace (4). Facilities are usually large and occasional odour problems are experienced.

Amenity impacts are low (3) due to the process being enclosed. The resource conservation is good (4), with the energy balance is considered to be neutral.

Employment impacts are moderate (3) in the composting process and moderate to high in product sales, supply of processing technology and maintenance and upgrading of facilities.

(d) Economic Issues

The net cost per tonne input is between $50 and $80 with organic waste only, and between $80 and $110 for residual waste (4). The net benefit per tonne of input from the compost is between $15 and $30 (2). The cost-scale flexibility is considered to be good (3).

The market availability for the compost is moderate (3).

6.3.5 Anaerobic Digestion
This technology has been adapted for residual organic waste from sewage sludge treatment. It is widely used as an alternative to or in parallel to enclosed composting for processing biowaste in central Europe. The process involves the anaerobic (without air) decomposition of a wet organic rich pulp to produce a methane-rich biogas fuel and a small amount of residual sludge that can be used for making compost.

(a) Technical Issues
Anaerobic digestion of biowaste or the mechanically separated organic fraction of residual municipal waste is well established in central Europe, with a number of technology suppliers in that region dominating the market. The core technology and intellectual property is however portable, as demonstrated in the Earthpower proposal in Parramatta that utilises technology from the German company BTA.

The input quality flexibility is low (2), being able to only process organic waste. The input quantity flexibility is moderate (3), as the facility is sized and amortised for a certain capacity. The technical maturity of these processes is high (5), with many facilities operating overseas. The local availability of the technology is good (3), being similar to anaerobic biosolids technology already used widely in Australia.

(b) Environmental Issues
Being an enclosed technology with collection and treatment of all air and water emissions the environmental impacts of this technology is low. The recovered biogas can be used to generate green power, and the residual sludge can be land applied, composted, or converted into fertiliser pellets.

The risk of air emissions and risk of water emissions are moderate at (3) and (2) respectively, with all emissions being collected and treated before discharge. The greenhouse gas emissions are taken to be moderate (4), and solid residues are dependent on inert contamination in the incoming waste stream (3).

(c) Social Issues
Community involvement in anaerobic digestion is moderate (3) due largely to their complexity and the process nature of their operations. Feedstock is generally supplied form a small number of food processing businesses, with little or no household involvement. The products are directly available for purchase, often in mixture with other materials, as a high quality compost. Plants are accessible for site visits, with little potential safety hazard.

Public perception and confidence in anaerobic digestion is unclear due to the minimal number of facilities operating in Australia, but is expected to be fair (3).

Amenity impacts are low (3) due to the process being enclosed.

A proposed facility to be located in Camellia, Western Sydney, has recently gained development approval by Parramatta City Council after minor community opposition.

Employment impacts are moderate (3) in process operations due to the capital intensity of the operations, but moderate in process control and asset management.

(d) Economic Issues
The net cost per tonne of waste input is between $70 and $150 (3.5), and the net benefit per tonne of waste input from the biogas and sludge is between $20 and $30 (2). The cost-scale sensitivity is estimated to be significant (3) due to the large capital costs of such facilities.

The market availability for the biogas and digestate compost is good (4).

6.3.6 Fermentation
Fermentation technologies use biological methods to produce an industrial feedstock, such as ethanol. These processes have been under investigation for several decades, with the amount of research peaking during high oil price episodes. A commercial sized fermentation facility is now under construction in Middletown, New York. This facility, which is expected to be completed in late 2000, will process 200,000 tonnes of residual municipal waste and 45,000 dry tonnes of biosolids per year, producing 27 million litres of ethanol.

(a) Technical Issues
Fermentation of agricultural products to produce industrial feedstocks has been practised on a large scale for the past century, but the use of an impure and varying feedstock such as organics derived from residual wastes is not yet well established. A pilot plant processing up to 200 tonnes per day has been operating since the early 90s, but the Middletown proposal is the first commercial scale operation to be attempted, and the technical feasibility of this technology would need to be evaluated when it is fully operational.

It is assumed that the fermentation process can only handle organic waste, so the input quality flexibility is low (2). The input quantity flexibility is estimated to be moderate (3).

The technical maturity at commercial scale is yet to be proven (3.5), and as almost all the technology would need to be imported the local availability is low (2).

(b) Environmental Issues
Fermentation is an enclosed industrial process, and as such would have limited emissions to air and water. It is claimed that no toxic emissions will be generated, and that only a small solid residual (>10%) will be generated.

The risk of air emissions and risk of water emissions are both low (3), with all emissions being collected and treated before discharge. The Greenhouse gas emissions are taken to be moderate (4), and solid residues are dependent on inert contamination in the incoming waste stream (3).

The resource conservation is good (4), with a valuable product being produced from organic waste.

(c) Social Issues
The waste-to-ethanol facility currently being constructed in New York was selected after the community rejected proposals for a new landfill and demanded more sustainable waste.
management options. It is claimed that the facility will generate up to 200 permanent jobs in the area.

Community involvement in activities associated with fermentation is limited (3), due to their complexity and the process nature of their operations. Feedstock is generally supplied from a small number of businesses, and products are not directly available for purchase.

Plants are accessible for site visits, with moderate potential safety hazard.

Public perception and confidence in fermentation technologies is due to the lack of facilities operating throughout the world. The one commercial facility being constructed followed the community rejecting other options, so is expected to be fair (3).

Amenity impacts are low (3) due to the process being enclosed.

Employment impacts are low to moderate (3) in process operations due to the capital intensity of the operations, and moderate in process control and asset management.

(d) Economic Issues
The economics of waste fermentation are not known, and will be dependent on the price obtained for the industrial chemicals generated, which is in turn dependent on agricultural commodity and oil prices.

The net cost per tonne of waste input is around $120 (3), while the net benefit per tonne of waste input is estimated to be between $10 and $20 (2). Being a capital-intensive facility the cost-scale sensitivity is moderately high (3).

The output product market is good (5), with the process producing a refined chemical feedstock.

6.4 Thermal Technologies
Thermal technologies are designed to recover the calorific energy contained within residual wastes, and to produce a small, stable residual for disposal. Residual municipal wastes contain 8 to 10 MJ of calorific energy, and the recovery of this energy can reduce the unit economic cost of processing waste to a reduced volume. In oxidation processes this calorific energy is recovered as low pressure steam and hot water, which are usually respectively used for generating electricity and district heating. Pyrolysis and gasification processes recover pyrolysis oil and syngas, which can be cleaned and used for generating electricity or industrial feedstocks.

6.4.1 Incineration
Incineration refers to the combustion of waste solely as a solid waste reduction and stabilisation process, with or without energy recovery. Energy is recovered as low pressure steam from the exhaust gas, which can in turn be used directly in nearby industrial processes or used to generate electricity for sale, and hot water for district heating, which has a poor market in NSW. Incineration was in the past a popular alternative disposal method to landfill when municipal waste incinerators existed in Sydney, with the last closing in 1997. The only incinerators of any significant capacity are for destroying clinical waste.

It is considered by the panel that incineration without energy recovery will only exist for specialised waste streams such as clinical waste, and that no incinerator would be built that did not incorporate energy recovery.

Incineration facilities are the dominant form of residual waste processing in Japan and much of Europe.

(a) Technical Issues
Incinerators can process any combustible feedstock, and can tolerate fairly high levels of incombustible materials within the feedstock. However, when processing more toxic or varying feedstock the environmental controls, particularly air emission controls, must be upgraded. These air emission controls can be up to 50% of the capital cost of the facility, as well as a major portion of the operating cost. The input quality flexibility is therefore rated as high (4).

Incinerators are generally built to a certain capacity, with operational flexibility limited to operating two or three incinerators in parallel that can be taken off line when feedstock is low or for maintenance. The input quantity flexibility is rated as moderate (3).

The technical maturity of incinerators is high (5), with incinerators (with or without energy recovery) processing a large portion of municipal waste in Europe and Japan. Any large incineration units would have to be imported from these countries where continuing development of incineration units has continued.

The local availability of incinerator technology and expertise is low (2.5).

(b) Environmental Issues
A number of environmental issues associated with incineration. These include:

- toxic air emissions, particularly dioxins, furans and heavy metals;
- disposal of ash and other solid residues;
- greenhouse gas emissions; and
- being large capacity and capital intensive they provide a disincentive for recycling.

The risk of air emissions from incinerators is moderate to high (1), with modern incinerators meeting all the emission levels for all toxic air emissions by incorporating large, expensive air emission control equipment. The reliance this equipment provides low probability, but high consequence of emission release.

The greenhouse gas emissions from incineration are moderate (3), assuming they have high efficiency energy recovery systems in place.

Risk of water emissions from incinerators is low (4), with modern incinerators operating dry air emission control equipment.

Solid residuals, consisting of ash, soot and inert particles, vary depending on the feedstock but are low (4) at about 20% of the incoming waste stream for residual municipal waste. This residual waste is generally treated as a hazardous waste due to leachable heavy metals and salts. It can be further reduced to ~1% of the incoming waste stream with recovery of metals and an inert aggregate through an additional waste melting process.
Incinerators rate as poor to moderate in terms of resource conservation (2), as only minor amounts of material are recovered as well as moderate amounts of energy.

(c) Social Issues
Community involvement in resource conservation activities associated with incineration technology is very limited (1) because of their scale and propensity to crowd out recycling.

Public perception and confidence in incineration technology has never been high in Australia (1). Although the devices are prolific in Europe, USA and Japan, there are strengthening views that conventional incineration is not appropriate for the entire residual waste stream. These views are most firmly held in USA West Coast States, where new incineration projects would not easily gain development approval. Germany and UK communities regard incineration as a progressively less important part of waste management.

Amenity impacts of incinerators are considerable (2), with people objecting to the large visual impact due to their size and presence of tall emission stacks.

Employment impacts of incineration facilities are low (2) due to the capital intensity of the facilities. Indirect employment in process control and asset management activities is available at medium to high skill levels.

(d) Economic Issues
The net cost per tonne of input for incinerators is between $180 and $260 (1.5), down from over $400 several years ago due to cost reduction in pollution control technologies. The net benefit per tonne of output is between $15 and $25 (2), mainly from energy sales. The cost-scale sensitivity is high (1), with large scale operations necessary to achieve reasonable costs.

The product recovered from incinerators is energy in two forms, electricity and heat/hot water. There is a large and relatively stable market for electricity, but given NSW’s temperate climate the demand and hence viability of hot water for district heating is limited. The overall output product market is rated as good (4).

6.4.2 Pyrolysis/Gasification
In this range of technologies carbon-rich waste is heated in the absence of oxygen to produce pyrolysis oil or a syngas that can be used as a fuel or as a chemical feedstock. Although the technologies are less proven for mixed residual wastes they are seen to offer a number of advantages over conventional incineration. These include:

- they produce a product (pyrolysis oil or syngas) which can be cleaned, stored, and used as a chemical feedstock or energy recovery, and are hence more aligned with recycling processes;
- when used for energy recovery the overall efficiency is higher than incineration; and
- are able to operate at a smaller or modular scale, mitigating against the claim that the large scale of incinerators inhibit waste minimisation and recycling.

In pyrolysis the waste is heated to 400 to 800°C in the absence of oxygen, and produces a liquid hydrocarbon or pyrolysis oil that can be utilised as a fuel or purified and used a chemical feedstock. With gasification the waste or the pyrolysis oil is heated to over 1000°C in the presence of limited oxygen which breaks down or “cracks” the complex molecules to produce a gas called syngas. This syngas contains carbon monoxide and hydrogen, which can be used as fuel or as a chemical feedstock.

Gasification technologies have been operating for over a century for coal producing “town gas”, and have long been promoted as being a viable, cleaner alternative to incineration for residual municipal wastes. Extensive research into gasifying waste has been undertaken over several decades. For example, a pilot gasification plant was being operated in Sydney in the early 70s. These processes have however failed to live up to their promise due to waste variability and material handling problems. Several newer processes are overcoming these problems through extensive pre-processing of the feedstock wastes, and are on the verge of commercialisation.

(a) Technical Issues
The technology maturity of the various waste pyrolysis and gasification processes is considered to be moderate (3.5), with some systems having reached commercial status and many more under development.

The input quality flexibility of pyrolysis/gasification is considered to be good (3), with some pre-processing of input waste required. The input quantity flexibility is good to very good (3.5), with the potential for the process to work on a modular basis. Local availability is considered to be moderate (3.5) due to development of this technology in Australia.

(b) Environmental Issues
The risk of air emissions in pyrolysis and gasification processes is consistent with other thermal processes at (2).

Greenhouse gas emissions, risk of water emissions and solid residues are considered to be similar to incineration at (3), (2) and (4) respectively. The resource conservation of pyrolysis/ gasification is moderate (3) as there is a potential for the recovery of chemical feedstocks from the pyrolysis oil and syngas, though worldwide trends are for direct use for electricity generation. The energy balance of the process is good with some pyrolysis/gasification process claiming higher energy recoveries than incineration.

(c) Social Issues
Reinforcement of community involvement in resource conservation activities is facilitated by their relatively small scale and consequent ability to align with other community infrastructure (3). The (energy) product can be indirectly purchased at regional level.

Public perception and confidence in Gasification/Pyrolysis technology is still in the formative stages. Australian operations are apparently viewed by the informed public as very promising, based on community and business reactions to systems in Brisbane, Illawarra and Perth. Some, however, perceive gasification as a form of incineration and regard the
6.4.3 Waste Melting

These processes have established very high (>1500°C) temperatures, simple gases and inorganic residues that are still to be widely proven at commercial scale. The amenity impacts are moderate (3) due to the smaller scale of plant reducing the visual impact of the facility.

Employment impacts are moderate to high (3) due to the multi-staged systems which vary in complexity and offer direct and indirect opportunities in process control and asset management.

(d) Economic Issues

The net costs per tonne of input vary between $80 and $170 (3), but this is still to be widely proven at commercial scale. The net benefit per tonne of input is estimated at between $15 and $25 based on direct electricity generation. The cost-scale sensitivity is moderate (3), but may be lower if modular units prove reliable.

The output product markets are similar to that of incineration (4).

6.4.3 Waste Melting

Two types of waste melting processes exist:

• oxidation processes, where oxygen is introduced to oxidise out all of the carbon and raise the temperature sufficiently to form a slag/metal melt that can be tapped and recovered (see Figure 5-12); and

• reduction processes, where a plasma arc is used to reduce the carbon to syngas and form a slag/metal melt. See Figure 5-13.

Waste melting refers to an emerging group of technologies that operate at very high (>1500°C) temperatures, reducing organic components to simple gases and inorganic components to recyclable metals and slag. Energy recovery is either recovered from the exhaust gas or from a syngas similar to gasification.

(a) Technical Issues

These processes have established themselves for processing metal and other industrial wastes, but have not yet been operated on a mixed waste stream at a commercial scale. They are high rate processes, and thus require a small footprint and capital costs.

Waste melting processes operate at very high temperatures and can process all types of waste, so the input quality flexibility is high (5). They have moderate input quantity flexibility (3) as they are very high rate processes.

The technology maturity of melting processes for waste is largely unproven (2.5), and is mainly based on successful operation in the mineral processing and scrap metal industries. The local availability is also considered to be good (3) with some local development of the technology taking place.

(b) Environmental Issues

The environmental impacts of waste melting processes are not yet fully quantified, as they are not operating at commercial scale. It is likely however that this technology would produce the least residual waste of any process, produce no water emissions and due to their high operating temperature and origin in processing metal wastes toxic air emissions would be low.

The risk of air emissions, greenhouse gas emissions and risk of water emissions are estimated to be similar to those of pyrolysis/gasification at (2), (3) and (4) respectively. The solid residues are negligible (5), with most of the solids being recovered as metal for recycling or an inert slag that can be used as an aggregate.

The resource conservation from waste melting is moderate (3) due to the recovery of energy, recyclable metals and inert slag aggregate.

(c) Social Issues

Community involvement in resource conservation activities associated with these systems is limited (2) by their newness for waste applications and consequent pilot plant scale. The energy products will ultimately be available for indirect purchase at regional level. Public access to facilities is presently limited, however, when commercial scale is attained access should be feasible.

Public perception and confidence in melting technologies is entirely unformed but is expected to be moderate (3). These technologies are not in commercial operation for waste applications.

The amenity impact of waste melting would be moderate (3), as they are relatively small enclosed processes.

Employment impacts are low (2) at present due to the high unit throughput predicted for these technologies.

(d) Economic Issues

The economics of these processes is largely untested, but it is widely suggested that they will be considerably cheaper than conventional incineration due to the reduced plant and air pollution control equipment size and minimal solid residue requiring disposal. The energy recovery efficiency of these processes is also untested, but it is claimed that it would be superior to conventional incineration processes.

6.5 Landfill Technologies

As landfill is the primary management option for wastes in NSW operational controls are well known and are outlined in the EPA Environmental Guidelines: Solid Waste Landfills (EPA, 1996). Wastes in NSW are categorised in legislation largely according to the potential environmental impacts of the waste when landfilled. Hence in the EPA Environmental Guidelines: Solid Waste Landfills operating requirements are split into a number of categories as follows:

• Solid Waste Class 1 – municipal and commercial waste including putrescible

• Solid Waste Class 2 – municipal and commercial waste excluding putrescible

• Inert Waste Class 1 – construction and demolition waste including mixed wastes

• Inert Waste Class 2 – construction and demolition waste excluding mixed wastes

There is however continuing development of landfill technology, mainly in terms of reducing the time period for which landfills pose a threat.
to groundwater and air quality. Three approaches to this problem predominate at present:

- Conventional Wet Landfill
- Conventional Dry Landfill; and
- Bioreactor Landfill

These three approaches are examined below.

### 6.5.1 Conventional Wet Landfills

These landfills utilise conventional operating systems including leachate barriers and collection, compaction and covering of waste, and collection of landfill gas if present. This type of “sanitary” landfilling has been practised for most of the 20th century. An important issue with conventional landfills is the extended period over which biodegradation of waste occurs, and hence the time span to reach stabilisation and negligible risk to the environment. This extended life means that leachate and landfill gas emissions must be collected and treated for decades after the closure of the facility.

**(a) Technical Issues**

The technology is developed to a mature stage (5). Being largely a civil engineering operation the operational reliability of a landfill is impacted by factors such as inclement weather, or waste handling issues (fires or hazardous materials in the waste, etc). Well operated landfills have measures in place to deal with these issues and have minimal downtime, so operational reliability is generally good.

The **input waste quality flexibility** at conventional landfills is high (4). They are able to receive a wide range of non-hazardous wastes if operated with appropriate environmental controls such as liners and/or natural barriers, daily compaction and covering of waste and leachate and gas collection.

The **flexibility of waste input quantity** is similarly high (5) and as most of the operational equipment at landfills is mobile plant, there is high flexibility to adapt to a wide range of incoming waste flows. Some research has indicated that an optimal size of landfill occurs for a given waste flow.

The **local availability** of landfill technology and expertise is high (5), with landfill being the most established waste management technology in Australia, with a large number of different sized operating sites in NSW.

**(b) Environmental Issues**

Landfills rate poorly in terms of **resource conservation** (1), as very little of the resource contained in the waste is recovered. Energy balance of landfills is poor as relatively little of the energy contained in the waste is recovered from the landfill gas.

The **solid residues** remaining after landfilling waste are very high (1), as they are themselves the ultimate destination of any residual solid waste in the waste management system. Some breakdown of the solid material into either the leachate or landfill gas, but a high proportion of the waste mass will remain in the landfill.

The **greenhouse gas** emissions from landfill are high (2), with landfill gas contributing almost 4% of the total greenhouse gas emissions in NSW. These emissions can be reduced by burning the methane to carbon dioxide, which reduces its greenhouse impact by a factor of 21. For larger landfills energy recovery is economic, and if electricity is produced it can be accredited as a “green power” generator. It has been claimed that as most of the carbon in the biomass remains in the waste and is not released in the landfill gas, landfills act as a carbon sink. However, as methane is a potent landfill gas and is never totally captured, landfills retain an overall negative greenhouse gas impact.

There is an environmental risk from **water emissions**, arising from contaminated water generated from surface or groundwater contacting the landfillled wastes or from the breakdown of the wastes. With modern leachate barriers and collection systems this is largely prevented from polluting the environment.

Another potential source of water emissions is turbid stormwater that can be generated from a landfill facility due to a landfill being an earthworks site. The unvegetated and unsealed areas such as new disposal cells, recently completed cells, stockpiled soil and roads have a high potential to release sediments into stormwater, and significant sedimentation and erosion controls have to be constructed to minimise this risk.

**Significant air emissions** can be generated from the degradation of biodegradable waste within landfill facilities. These primarily consist of the greenhouse gases methane and carbon dioxide, and a range of non-methane organic compounds (NMOCs) of varying toxicity. These NMOCs can cause localised concentration of toxic gases, and can contribute to regional air quality problems such as summer smog. Under EPA Guidelines for landfills any landfill gas flare or combustion equipment is required to have a 99 per cent destruction efficiency for NMOCs. Overall, the risk of emission is moderate and the capacity of collection systems to capture emissions is moderate (3).

**(c) Social Issues**

Community involvement in **resource conservation** activities associated with landfill is limited (2). The community is aware that a high proportion of discarded materials are despatched to landfill, and this may possibly inspire increased recycling.

Community access to landfill sites is available, but working face access is limited for safety reasons.

**Public perception and confidence** in landfilling varies with proximity to the operations (2). Recent protests in regional centres about proposed siting of new landfills indicate considerable displeasure when local communities are faced with the prospect of landfill impacts including traffic, vermin and odours.

The potential for **amenity** impact of landfills is high (1), consisting of traffic and equipment noise, dust, odour, and visual amenity. Traffic noise is directly related to the amount of waste being brought to and materials and wastes being exported from the facility, so is largely unavoidable. The number of people affected can be minimised by planning haulage routes to and from the facility avoiding heavily populated
areas, ensuring haulage vehicles are well maintained, and the locating the facility in an appropriate area.

Operation noise, dust and odour can be controlled through good operating practices, but are difficult to eliminate at landfill facilities as they are operated in the open. Noise emissions can be reduced through fitting and maintaining silencing on equipment, and with noise mounds and separation distanced between active areas and sensitive receptors. Large landfill sites will inevitably lead to noticeable odours in the adjacent area due to the volume of waste being deposited in the open, despite best practice operations. Dust emissions are related to operational practices at the site, and can be controlled through normal civil works practices of watering roads, providing windbreaks and reducing traffic speeds.

The visual impact of landfills is significant as they cover a large area of land, although screening mounds and vegetation (that often double as noise barriers) can reduce this impact.

Employment impacts are low in respect of direct operations, but moderate in terms of indirect associated activities such as transport, monitoring and development of improvements (2).

(d) Economic Issues

The net cost per tonne of waste input has been estimated by the Inquiry to be between $30 and $45 per tonne for putrescible waste and $15 to $20 per tonne for inert waste. (Both costs are exclusive of levy) (5). This figure may be higher for smaller landfills or for landfills located in sub-optimal locations, thereby requiring more environmental controls, but is still a relatively low cost technology.

The net benefit per tonne of waste input is low (1), with landfill gas collection systems not significantly offsetting capital and operating costs.

The cost-scale sensitivity of landfills is relatively low (5), as they are largely civil construction operations that are able to be operated at small or large scale and may be staged according to changing demand.

Landfill, once stabilised, can rehabilitate disturbed or extractive industry sites, leading to an improvement in local amenity.

6.5.2 Conventional Dry Landfills

The discussion in this section supplements the material above in describing conventional wet landfills. These landfills are operated such that moisture is excluded from the waste through siting the landfill in an area of low rainfall and intercepting any rainfall before it enters the waste. This inhibits the biodegradation of the waste, which in turn reduces or even eliminates leachate and landfill gas formation and leads to dry stable waste.

Criticism of this technology stems from attempts to apply this process in temperate regions, where rainfall and/or groundwater infiltration mitigate against attempts to keep the waste dry and landfill gas and leachate is inevitably generated. If the landfill plan relied on the fill remaining dry and the facility was not fitted with leachate and gas collection systems, considerable water and air pollution could result.

This technology is only suitable for dry climates, such as west of the Dividing Range in NSW. In these regions the dry climate and lack of, or depth to, groundwater means that landfills more generally are dry and produce minimal amounts of leachate and landfill gas. These landfills do however need adequate environmental controls and safeguards such as leachate collection systems and regular landfill gas monitoring in place in case the landfilled waste becomes wet through excessive rainfall, flooding or groundwater infiltration.

(a) Technical Issues

The technical issues in relation to dry landfills are similar to conventional landfills.

(b) Environmental Issues

The environmental benefit of dry landfilling is that the emission of landfill gas and leachate is minimised, thereby reducing the threat of air and water emissions from the landfill. Although dry landfills forgo any benefits that could be obtained from landfill gas, the small size of most landfills in inland NSW means that it is unlikely that the potential for generation of electricity from landfill gas in this region is low. Also the emission of greenhouse gases is greatly reduced.

The risk of air emissions from dry landfills is reduced (3), as are the greenhouse gas emissions (3). Similarly, the risk of water emissions is also reduced (5). Other scores on environmental criteria remain the same as for wet landfills.

Social Issues

One concern commonly expressed regarding dry landfills is that they pose a continuing threat to future generations if they become significantly wet at some time in the future. If however the landfill is adequately capped and the cap is maintained, and the waste is well above historic groundwater levels, the risk of this event is low. The social issues are rated the same as for wet landfills.

(c) Economic Issues

As dry landfills generally require leachate collection systems and gas monitoring in place as a contingency measure, the economic gains of this technique are limited to reduced costs for leachate and gas treatment. The small size of landfills in suitable regions negate any relative economic gains these landfills would have over larger conventional or bioreactor landfills in urban NSW.

The economic ratings remain the same as for wet landfills. It is however possible that a large rollout landfill in a dry area of NSW with negligible groundwater could realise savings from a dry landfill operation. As negligible landfill gas is produced in conventional dry landfills, the market availability for the products is low (1).

6.5.3 Bioreactor Landfills

In these landfills, the anaerobic degradation of biodegradable waste is accelerated through a combination of leachate recirculation, controlled infiltration of rainwater and/or groundwater into the waste, and cosidispal with digested biosolids. The ideal is to rapidly degrade the waste to a stable form with maximum
methane recovery, with a possibility of later mining the stabilised waste to recover a "compost" and recyclables. Landfills then become a waste processing technology of in situ anaerobic digestion rather than a disposal technology.

Despite some development difficulties, many landfills have been fitted with bioreactor technology features such as leachate reinjection and controlled infiltration to enhance biodegradation of the waste. These improve landfill gas production rates, which suggests that enhanced biodegradation is occurring, but it is as yet too early to determine to what extent bioreactor technology will reduce the time required to stabilise waste and degraded sites. The Delaware Solid Waste Authority (USA) has had a large scale bioreactor landfill in operation for many years.

Considerable research into bioreactor landfill technology has and is being undertaken in Australia. An important trial of landfill bioreactor technology in Australia was conducted by the CRC for Waste Management and Pollution Control using a series of test cells at the Waste Service Lucas Heights landfill. However this trial indicated difficulty in recirculating through the landfilled waste the large volumes of leachate required to replicate the laboratory scale results and overseas practice.

(a) Technical Issues

As noted above the bioreactor landfill ideal has yet to be realised at commercial scale, and the benefits of the bioreactor landfill features are yet to be fully quantified and demonstrated. The adoption of these features is technically feasible, and is not believed to introduce significant technical risk to the landfill operation (4).

For enhanced biodegradation to occur, care has to be taken to exclude wastes that may inhibit desired biological activity or the recirculation of leachate, so the input quality flexibility is reduced (5). The flexibility of waste input quantity remains high (5). The technical maturity of bioreactors to achieve enhanced gas production and reduced waste stabilisation times is not yet fully proven, but is believed to be similar to conventional landfills (4). The local availability of bioreactors is high (4), with world class research and development being undertaken in NSW.

(b) Environmental Issues

A landfill adopting bioreactor technology would have generate enhanced flows of leachate and landfill gas, and the collection and treatment systems would have to be capable of handling this increased load. If however this technology led to major faster stabilisation of the landfilled waste this would be a significant environmental improvement over conventional landfill so the risk of water emissions is less than that of a conventional wet landfill (3).

(c) Social Issues

While the reduction in time when landfills pose a threat to the environment may have some appeal, the social issues associated with bioreactor landfills are believed to be similar to those of conventional landfill, with or slightly reduced amenity impacts due to reduced stabilisation time (2).

(d) Economic Issues

The extended life cycle period of landfills means that considerable uncertainty exists regarding the benefits of bioreactor landfills over conventional landfill. For example, some studies have indicated that bioreactor landfills offer a US$1 to $2 per tonne economic advantage over conventional landfills, while other information received by the Inquiry claimed that bioreactor technology requires additional cost to implement. Given the uncertainty, the economic ratings therefore remain the same as conventional landfills.
CHAPTER 7 Products and Markets

Progression towards sustainability in waste management requires that products are derived from waste in an economically viable manner. It is therefore critical that viable and preferably stable markets exist for the full range of products derived from waste.

This Chapter examines the current and potential markets for products derived from waste, and explores the factors that could influence demand.

The products under examination are:

- Dry recyclables – paper and cardboard, plastics, metals, glass, textiles, rubber.
- Compost, mulches and soil conditioners.
- Recycled construction materials – concrete, brick, timber, gravel, sand, soil.
- Energy (as electricity, gas, steam or heat) and feedstock.

7.1 Dry Recyclables

7.1.1 Paper and cardboard

This is a major component of waste, comprising around 33 per cent of the municipal waste stream and 24 per cent of the C&D waste stream. Although paper and cardboard are amenable for energy recovery and composting, from a life-cycle viewpoint recovery of the fibre content for recycling back into new paper and cardboard products is the preferred option. In addition, manufacturing recycled paper and cardboard from recovered paper and cardboard fibre offers considerable economic advantages over the use of virgin fibre. One Australian company, Visy Recycling, has developed world-class expertise in using recovered fibre in new paper and cardboard, and has used this knowledge to expand operations within and outside Australia against users of primarily virgin fibre.

An issue with recycling paper and cardboard is that with each new cycle, the fibres can become shorter and weaker, leading to degradation of the recycled product quality. This is overcome by introducing a portion of virgin fibre to be added to the pulp during manufacture. It is not however expected that the proportion of virgin fibres required would exceed recovery losses, and continuing research into paper and cardboard recycling will mitigate this problem from reducing recovered paper and cardboard prices.

Paper and cardboard has historically been recovered and marketed as baled lots, in a large number of grades, such as old newsprint (ONP), bond (office) paper, cardboard, etc. These grades are internationally traded as a commodity, so prices fetched by paper and cardboard recovery operations are subject to the unpredictable price fluctuations characteristic of such markets. Several factors are however leading to improved stability for recovered paper and cardboard in Australia:

- increasing capacity for paper and cardboard recycling in Australia, driven by lower capital and operating costs for paper production from recycled fibre than for virgin fibre;
- limited import and export of waste paper due to local recovery operators having lower transportation costs; and
- a desire for companies to monitor the recycling of their wastes for public perception purposes.

7.1.2 Plastics

Plastics are often the most visible portion of the waste stream due to their extensive use for packaging and films, but due to their low density, make up less than 10 per cent of the municipal solid waste stream. They are manufactured from a large and increasing number of incompatible polymers, which require separation prior to recycling.

The main advantage of plastic packaging comes from its stability and reduced weight per package, which means a high material efficiency is obtained. Consumer demand has pushed the recovery and recycling of commonly used packaging polymers such as PET, LDPE and HDPE, but other packaging polymers and non-packaging plastics are not recycled to any great extent. In Germany the compulsory collection of a wide range of polymers under the “green dot” program has led to uneconomic recycling of some types of plastic, particularly LDPE films and multilayer packaging. In the USA demand for these types of plastic has increased due to the expansion of “plastic lumber” manufacturing creating a demand for these plastics at prices that make recovery via kerbside recycling and MRFs viable. It is preferred in NSW that market pull be created for these extra plastics rather than to recover these plastics without having a market.

7.1.3 Glass

Packaging glass is declining in relation to plastic and aluminium, but due to its weight still makes up 13 per cent of the municipal waste stream. Significant amounts of glass also appear in the C&D waste streams.

Most glass in Australia is manufactured by ACI who have undertaken to purchase clear, green and brown packaging glass at prices comparable to international levels.

Packaging glass in Australia is mostly collected comngled with other recyclables and the separation at MRFs of glass into the three colours has been uneconomic. In Germany the “green dot” program has led to uneconomic recycling of some types of plastic, particularly LDPE films and multilayer packaging. In the USA demand for these types of plastic has increased due to the expansion of “plastic lumber” manufacturing creating a demand for these plastics at prices that make recovery via kerbside recycling and MRFs viable. It is preferred in NSW that market pull be created for these extra plastics rather than to recover these plastics without having a market.

To overcome this problem in some places such as Germany and the UK glass is excluded from kerbside recyclables and all glass is collected from three colour bottle banks. To
achieve acceptable recovery rates these bottle banks must be within walking distance from all residences. This option may not be as viable in low density outer suburban areas of NSW.

7.1.4 Metals
The recycling of metals has a long history in Australia, with a large number of scrap metal yards buying scrap metal from commercial and domestic sources. The scrap metal market in Australia is dominated by Simsmetal and Metalcorp, who sort scrap metal received into a number of grades for recycling within Australia or export.

The price of metal scrap is set by its internationally traded metal value minus the cost of recycling. Consequently these prices are sometimes volatile, but increasing numbers of metal refiners are changing their refining plant to be able to process recovered scrap due to public image concerns and cost savings. The underlying market is strong, particularly for metals with a high virgin production cost such as aluminium.

7.1.5 Other Dry Recyclables
Other dry recyclables include textiles and rubber. Textiles make up about 4 per cent of the municipal waste stream, but less than half is estimated to be recovered. This recovery is usually through charitable clothing bins, which sort the textiles for reuse, cleaning rags or remaking into new products. Potential also exists for recovering fibre from carpets, but the viability of this is now being investigated.

Although rubber and other elastometric materials make up a small portion of the waste stream, the failure of a number of used tyre recycling schemes has focused attention on this material. Large markets exist for recycling rubber crumb, but the high cost of grinding waste rubber to crumb inhibits large scale recycling. Increased disposal costs and larger scale grinding facilities may make the economics of rubber recycling more favourable in the future.

7.2 Composts, Mulches and Soil Conditioners
These can be produced from a wide range of green wastes. Significant amounts of green waste are already produced, and are continuing to increase.

There has been concern expressed regarding the ability to find markets for the increasing amounts of compost being produced. However, studies into markets have indicated the potential for markets to increase in proportion to increasing production. This has occurred in the USA, where greatly increased amounts of compost from biowaste collection have been able to be absorbed without excessive stockpiling if adequate product quality is maintained.

One large market that is often raised is the broad acre farming. Many Australian agricultural areas have very low organic content within the soil (<1 per cent), and the addition of compost would add nutrients and improve soil structure. However, due to the transportation costs involved in getting the compost out to farms a subsidy in the order of $1 to $5 per tonne is needed to make compost competitive with chemical fertilisers (Biala & Wynen, 1998).

Another key marketing issue is product quality. Strong markets can be found in domestic and landscaping applications for composts produced to meet the Australian Standard AS4454, and for products meeting “organic” certification such as from the proposed Earthpower facility at Parramatta.

Potential exists for the production of composts that do not meet the contamination limits of AS4454. These criteria are in two types:

- inert contaminants, which have been set based on public rejection of visible levels of plastic and glass in domestic potting mixes; and
- chemical and biological contaminants, which have largely been adopted from the “unrestricted use” criteria NSW Biosolids Guideline.

Composts generated form source-separated organic waste with appropriate education of operators can pass both types of contamination limits. For this reason source separation is the NSW Government’s preferred strategy for green waste collection. This is also similar to Europe, where compost from the municipal sector has been almost totally replaced by composting of source-separated biowaste (food and garden waste).

Composts generated from a mixed waste stream typically have levels of inert and chemical contaminants above those specified in AS4454.

Low levels of inerts do not always affect the performance of the compost, but affect marketability in the high-value domestic and landscaping markets. Composts with higher levels of inerts may be acceptable for bulk applications such as minesite rehabilitation, but as the compost breaks down the inert contaminants will be concentrated in the soil. The acceptable level of inert contaminants for these applications would need to be established for local conditions.

Similarly composts with higher levels of chemical contaminants may be suitable for different applications with certain controls. Sewage sludge products with chemical contaminants higher than “unrestricted use” are permitted for minesite rehabilitation and other uses, so some precedent exists for this application. These criteria may however need to be modified to consider any additional contaminants present in compost from mixed wastes that would not be found in levels of concern in biosolids.

7.3 Recycled Construction Materials
These recyclates consist of inert materials that can be recovered and recycled from construction and demolition activities. Currently 60 per cent of this waste stream is recycled, predominantly as crushed concrete and bricks as an aggregate and excavated material as fill material. The rate of generation and use of these materials in NSW is currently high due to the high level of construction activity in Sydney. Opportunities for increasing recovery of recyclables exist in separating mixed C&D waste at specialised
MRFs, and through increasing the range of materials separated on-site for recycling to include additional recyclables such as timber, steel, glass, plaster board, etc.

7.4 Energy

Energy can be derived directly from waste by a number of technologies in a variety of forms. These include:

- Low pressure steam for electricity generation or industrial use.
- Pyrolysis oil and syngas for electricity generation or chemical feedstocks.
- Syngas.
- Hot water for district heating.
- Biogas for electrical generation or industrial use.
- Refuse derived fuel (RDF).
- Cement kilns/power stations.

7.4.1 Electricity

Electricity is the most common energy product derived from waste. It offers a number of advantages over other forms of energy such as:

- it has a widespread distribution network, which facilitates supplying the product to market;
- the product quality standards are well known;
- it is a commodity with a large market compared with the amount potentially available from waste;
- if the electricity was generated from renewable sources it can be sold at a premium as “green power”.

For processes that produce electricity directly from exhaust gas heat (via low-pressure steam), electrical generation is the only viable option for energy recovery if no industrial user of steam is located adjacent to the facility. These processes thereby generate electricity whenever they are operating, which does not always allow for generation during peak demand (and therefore peak price) periods.

Processes that produce a liquid or gaseous fuel, such as pyrolysis oil, syngas, or biogas have the advantage that the fuel can be cleaned, stored and selectively used during peak demand periods. These fuels can also be marketed as fossil fuel replacements or industrial feedstocks, but electricity operation in a dedicated plant at the facility is usually chosen on economic grounds.

An alternative method of utilising the pyrolysis oil and/or syngas from pyrolysis/gasification processes is as a feedstock in the production of chemicals. Examples include the use of syngas from organics and plastics in the production of ethanol, and the use of pyrolysis oil to produce waxes. In these uses they replace the use of agricultural crops and petroleum hydrocarbons.

Another energy product from waste is obtained by capturing or separating out a solid high calorific fraction. This material, known as refuse derived fuel or RDF, can be separated from a number of waste streams:

- fluff (plastic, waxed paper, etc) separated from municipal waste;
- unf recyclable C&D wastes such as painted timber and carpet;
- treated organic liquid waste;
- contaminated green waste; and
- difficult to recycle wastes such as tyres.

This RDF can be used as a substitute fuel in a number of processes, such as cement kilns and power stations, without leading to significantly increased emissions while displacing fossil fuels. This would however require retrofitting existing cement kilns and power stations to handle RDF and/or pelletising the RDF, which adds significant costs. As in Europe and the USA significant amounts of RDF could be used by industry, but RDF is expected to fetch a low or negative price (ie, in Germany cement kilns are paid up to 50DM/t to use RDF).

CHAPTER 8 Description & Assessment of Waste Management Practices

The practices adopted in managing discarded materials are fundamental to both protecting the environment, and using waste as a resource. The Waste Inquiry firmly believes that sustainable waste management must be guided by a clear strategy which employs simple but sound practices. These practices must be in touch with the community psyche, market-based where possible, and underpinned by a robust strategic policy framework.

The waste management practices adopted should lead selection of the array of technologies employed in the solution, rather than the reverse. Waste management practices in high performing States and cities are driven by three major principles:

- Minimising the amount of waste inappropriately disposed of by “enabling” the practices described in the waste hierarchy, with priority accorded to waste avoidance.
- Viable end-markets for discarded resources. They need to be founded on economic good sense as well as resource conservation goals: sustainable management recognises the economic system in which waste recycling and disposal operates.
- Integrated waste management aimed at efficiently supplying consistent quality resources to the highest value end-markets.

These principles in fact form the basis for the main practices required for sustainable management of waste as a resource. The key management practices can be summarised by class and type as follows:

**Waste Minimisation Practices**
- Material recycling
- Product reuse
- Waste avoidance

**Integrated Waste Management Practices**
- Waste streaming
- System integration
- Industry arrangements

**Market Development Practices**
- Alternative recyclate uses
- Quality standards
- Market intervention

This Chapter presents the case for increased adoption of these management practices. Assessment of the practices is undertaken in terms of operational, environmental, social and economic issues. The Inquiry’s observations of successful practices in Europe, North America and Japan are cited as a basis for consideration of alternative arrangements.

The assessment procedure covers:

**Operational Issues**
- Technical impacts
- Market issues
- Technical and market barriers.

**Environmental Issues**
- Environmental impacts
- Resource conservation impacts
- Transport impacts.

**Social Issues**
- Citizen and business involvement
- Local employment generation
- Social and community barriers.

**Economic Issues**
- Cost impacts
- Benefit/effectiveness impacts.

These issues form the broad basis for assessing the nominated management practices. As the practices under consideration are complementary, the assessment is discussion/analysis based rather than quantitative. The aim here is to consider impacts of current practices and postulate options for improvements.

The analysis of **Operational Issues** covers technical and market aspects, and barriers to improved performance.

**Environmental Issues** are considered by reference to reputable studies which provide indicative estimates of environmental performance of (mainstream) practices.

The environmental performance of some practices, such as System Integration, is less well studied and only indicatively quantifiable.

The analysis of **Social Issues** is limited by the research undertaken in this field. The objective, but non-quantitative analysis is limited to indicative scope for community involvement and local employment.

Analysis of **Economic Issues** is feasible for the mainstream practices by reference to studies and research as well as operating data constructed by the Inquiry. This provides a generalised perspective of costs and benefits of various waste management practices.

The Chapter is organised to deal with each Class and Type of practice in turn. The broad features of these practices are summarised in Table 8-1. The key focus and drivers are set out at Box 8-1.

**8.1 Waste Minimisation Practices**

These are aimed at reducing the amount of waste created (avoidance) and disposed of (reuse and recycling). The multiple objectives of waste minimisation are:

- resource conservation, through reduced need for virgin materials;
- pollution prevention/reduction;
- greenhouse gas abatement;
- diversion of resources to other productive uses.

The key facilitators of waste minimisation are businesses and households. Each has a somewhat separate role to play in recycling and reuse. Waste avoidance, however, is strongly facilitated when a dynamic interaction exists between producers and consumers: expressions of customer concern about waste can
## Table 8-1 Key Features of Waste Management Practices

<table>
<thead>
<tr>
<th>Technology Class/Type</th>
<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste Minimisation Practices</strong></td>
<td></td>
</tr>
</tbody>
</table>
| **Material Recycling**           | • Good resource conservation (Virgin material avoidance, energy savings).  
  • Emissions reduction.  
  • Net benefit on sustainability benefit/cost analysis.  
  • Strong community support and goodwill.                                                                                                           |
| **Product Reuse**                | • Excellent resource conservation and economic benefits.  
  • Community involvement with minimal awareness of benefits.  
  • Traditional concept, partly supplanted by lightweight packaging and recycling.                                                                  |
| **Waste Avoidance**              | • Clean production.  
  • Sustainable consumption.                                                                                                                                                                                 |
| **Integrated Waste Management Practices** |                                                                                                                                                                                                            |
| **Waste Streaming**              | • Source separation of wastes to various nominated organic, municipal recyclable, industrial recyclable and hazardous waste steams.  
  • Enables material recovery and reduces need for (later) waste separation.  
  • Facilitates integrated waste management by reducing the mixed residual waste stream.                                                                 |
| **System Integration**           | • Links markets, technologies, logistics, waste streams and geographic areas.  
  • Facilitates discovery and exploiting of opportunities for recycling and reprocessing.                                                                                                                     |
| **Industry Arrangements**        | • Organisation of waste management geared to innovation in technology and management practices.  
  • Public sector and private sector waste management industry are well resourced and skilled.                                                                                                               |
| **Market Development Practices** |                                                                                                                                                                                                            |
| **Alternative Recylcate Uses**   | • Diversification of end use applications can strengthen and stabilise demand.  
  • Specifications and regulations need to be geared to accommodate recycled alternative materials.                                                                                                          |
| **Standards**                    | • An appropriate array of standards can act to improve recycled product marketability.  
  • Confidence and trust can be enhanced through adherence to established quality standards.                                                                                                              |
| **Market Intervention**          | • Intervention through economic instruments, subsidies and grants, and risk sharing can be crucial in developing markets for recycled materials.  
  • Product/market development through business and Government commitment to purchase recycled materials and products.                                                                                      |
### Box 8.1 Focus & Drivers of Waste Management Practices

<table>
<thead>
<tr>
<th>Practice System</th>
<th>Product/Market Focus</th>
<th>Facilitators</th>
<th>Key Drivers</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Waste Minimisation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Integrated Waste Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System Integration</td>
<td>System synergy by linking markets, process steps, waste streams and geographic areas.</td>
<td>Waste Boards</td>
<td>Waste management practice leadership</td>
<td>Management improvement, cost reduction.</td>
</tr>
<tr>
<td>Industry Arrangements</td>
<td>Sustainable management of discarded resources.</td>
<td>Waste mgt. industry.</td>
<td>Waste management practice leadership</td>
<td>Clarity of objectives, roles and authority.</td>
</tr>
<tr>
<td><strong>Market Development</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality Standards</td>
<td>Array of specifications providing user choice</td>
<td>EPA</td>
<td>Market perspective.</td>
<td>Linkage between market needs and resource availability.</td>
</tr>
</tbody>
</table>
send powerful messages to motivate optimised product and package design.

A fundamental driver of good waste minimisation performance is community and business commitment to the practice. The way this commitment is engaged varies from environmental concern, through local leadership, financial incentives to regulatory sanctions.

The Inquiry has studied waste minimisation practices in various international settings. The highly successful strategies are characterised by the common features set out at Table 8-2.

### 8.1.1 Material Recycling Practices

Recycling involves four primary activities: collection and transport; sorting and separation; marketing; and reprocessing. These activities are broadly sequential in the value chain, with sorting and transport often undertaken at several points in the journey from discard to rebirth.

Value is added repeatedly and built up in performing each of these primary activities. The process creates a chain of economic activity and environmental benefits which have captured the imagination of governments, citizens and business throughout the world.

Two groups of functions are relevant. Primary functions are those directly involved with operations, as described above. Support functions provide indirect, but driving inputs: people, technology, market frameworks etc.

There are four principal points of value:

- the (voluntary) participation of businesses and householders in the recycling program;
- the logistics process involving capturing used materials, transporting, consolidating, sorting to type and on-transporting to buyers’ premises;
- the selling/buying activity in which supply sources and demand sources trade;
- the materials transformation process which allows recyclable materials to be used beneficially in order to conserve virgin resources.

Value is also created for the recycling industry through the support functions. The potential value-adding contributions here are:

- progressively declining input costs through technology developments;
- improved streamlining of transactions through continuously improving protocols and increasing maturity of relationships;
- increased workforce competency through experience and training;
- ordered market arrangements through product standards, market development and action for integrated management.

#### (a) Operational Issues, Material Recycling

It is technically feasible to recover and recycle most discarded materials. It can be costly, however, to remove contaminants from the recyclate stream and render the resource suitable for processing. Dry recyclables such as paper/board, glass, plastics, metals etc are the traditional candidate materials.

Organics, including food waste and garden waste are now finding an important place in the recovery agenda. The technical issues associated with the practice of household and business recycling revolve around the trade-offs associated with separating recyclable materials to specific streams suitable for reprocessing.

Options include maximising source separation with consequent collection cost penalties, versus comingled storage with consequent increased sorting requirements. The issue is complicated by the continuing development of improved sorting and reprocessing technologies. The creation too of new products, which take mixed resource streams, confuses the issues of how best to collect dry recyclables. Moreover the “best” practice for one recyclate stream may be inferior for others.

The waste management industry is progressively coming to grips with these issues through initiatives including improved collection technologies and multi stage sorting facilities.

The technical system barriers to significantly increased recycling relate to the cost of recovery, sorting and reprocessing of recyclate. Entrepreneurial action and technology innovations are leading to cost savings in each of these activities.

The market issues concern recyclate product consistency and market price stability. Both are tackled in Europe and North America by specification of various graded quality standards and development of local and international recyclate markets.

But market demands are shifting. New uses for polymers are diverting some recyclate streams, and Visy for instance is building market demand for composite polymer products.

### Table 8-2 Common Characteristics of Successful Waste Minimisation Strategies

<table>
<thead>
<tr>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication of a burning imperative founded on reality beyond a political message to drive community participation in waste minimisation with sustainability as a goal.</td>
</tr>
<tr>
<td>Recognition that some waste streams have value as a commodity.</td>
</tr>
<tr>
<td>A waste management industry able to offer an array of service, treatment and disposal options which facilitate regard for waste as a resource.</td>
</tr>
<tr>
<td>Systems and guidance which make conservation of resources easy and compelling.</td>
</tr>
<tr>
<td>Business grasp of the benefits of clean production.</td>
</tr>
<tr>
<td>A logical connection between an array of markets and an array of suitable technologies and practices.</td>
</tr>
<tr>
<td>Options include maximising source separation with consequent collection cost penalties, versus comingled storage with consequent increased sorting requirements. The issue is complicated by the continuing development of improved sorting and reprocessing technologies. The creation too of new products, which take mixed resource streams, confuses the issues of how best to collect dry recyclables. Moreover the “best” practice for one recyclate stream may be inferior for others.</td>
</tr>
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<tr>
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</tr>
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</tr>
<tr>
<td>But market demands are shifting. New uses for polymers are diverting some recyclate streams, and Visy for instance is building market demand for composite polymer products.</td>
</tr>
</tbody>
</table>
The market barriers to greatly increased recycling are associated with demand; key factors are resistance to use recyclate in new products, price fluctuations and quality consistency. The German response to these issues involves legislative content specification; UK and North America have opted for promotion and persuasion. Many see global markets as a key to increased demand. Development of new, high value uses for recyclate, beyond traditional sectors, is now seen as critical for market stability.

A study by the combined Waste Boards recently found that local demand for all dry recyclates except newspaper is likely to exceed supply.

(b) Environmental Issues, Material Recycling

The environmental issues associated with recycling relate to conservation of energy and virgin resources, and reduction of environmental impacts associated with acquiring and processing virgin resources. Reduction of environmental impacts resulting from avoided disposal of packaging recyclables, which are largely inert, is not an issue, though it is often cited in support of recycling.

Analysis of the issues and impacts is at the formative stage with the development of Life Cycle Assessment (LCA) techniques. LCA studies in Europe and North America have demonstrated the substantial environmental benefits of recycling, and pointed to the relatively modest environmental impacts of collecting, sorting and transporting recyclate. A recent study undertaken for EcoRecycle, Victoria has validated these findings in Australia for recycling of some packaging discards. The materials covered were PET, Glass and Steel.

One of the key factors in these life cycle assessments is energy consumption and its associated greenhouse gas emissions. Various studies have examined life cycle impacts of materials including aluminium, and steel cans, plastic bottles, paper and glass. In all cases, virgin materials require more energy input, with the greatest difference in aluminium cans and the least difference in glass containers.

(c) Social Issues, Material Recycling

There is strong community support for and participation in the recycling program, with the community placing recycling only behind waste avoidance as a priority for waste management. Householders in fact are the final consumers of most manufactures. They play a crucial role in recycling and create considerable value in the system by their willing participation in waste sorting at no cost to the recycling system. The majority of community members want to and do make an active contribution to resource conservation. The EPA's community survey (1997) found that 91 per cent of respondents participated in recycling.

This citizen participation is rewarded in a broad sense by the creation of community capital in the form of:

- involvement in an enterprise that is widely regarded as worthy;
- generation of paid employment in the recycling value chain;
- opportunities to leverage the effort by purchasing recycled products.

Citizen and business involvement is the critical spark to drive effective recycling. Professor Frank Ackerman, in “Why Do We Recycle?” sheds light on the practice. See Box 8-2.

Social and community barriers to greatly increased recycling relate to convenience and message reinforcement. Cities that have reached 50 per cent diversion rates have successfully combined action to make recycling easy with clear information about the contribution recycling makes to the environment and the economy. Seattle, for instance, has a public information budget of more than $1 million each year.

---

Box 8-2 Professor Frank Ackerman on Recycling

“We recycle because we consider it worthwhile to conserve landfill space, or save energy and materials. In short, we recycle because we believe it is the right thing to do, because it is good for the environment...

“... In one sense, altruistic public behaviour seems out of step with the 1990s, an era when individualistic, selfish voices have increasingly shaped the contemporary discussion of economic policy. But the misstep may be the interpretation of recycling as solely an economic policy. In another sense, the commitment to recycling echoes the tenor of the times, as moralism and professions of faith have become more and more prominent in social and political debate. If ‘family values’ are now acknowledged to be a vague but powerful force in public life, why not recognise a similar role for ecological values?

“... Recycling as religion arises from shared values; it provides public rituals that reaffirm those values; the faithful organise aspects of their lives around it, even at noticeable cost and inconvenience to themselves. But the ecological values that form the basis for this behaviour are complex and multi-faceted. What accounts for the emphasis on recycling in particular?... What distinguishes recycling is not its importance, but rather the ease with which individuals can participate, and the visibility of actions taken to promote the common good. You may care passionately about the threat of global warming or the destruction of the rain forests - but you can’t have an immediate effect on these problems that is perceptible to yourself or others...

When a 1990 Gallup poll asked people what they had done in connection with environmental problems, 80 to 85% answered that they or their households had participated in various aspects of recycling. no other steps had been taken by a majority of respondents.”
year. San Jose has similar promotional activities and in addition has an effective program for “negative” reinforcement: “Non-Collection Notices (NCNs)”. If a resident has not separated refuse appropriately the collectors not only leave the materials at the kerbside, they also leave a non-collection notice, which closely resembles a speeding or parking ticket in appearance, detailing what was wrong and how it ought to be rectified for the next collection. Currently San Jose distributes more than 500 NCN admonishments per week on average, and maintains the response is changed behaviour and thus expects the number to decline over time. While there is some evidence that mass incineration may crowd-out increased recycling, the Inquiry found no evidence that the existence of landfill disposal for residual waste had any negative effect on recycling commitment. On the contrary, cities with highly successful recycling programs, like Seattle and Portland, make use of long haul transport to distant landfill sites for residual waste. The employment generating effects of recycling appear to outweigh the employment opportunities foregone by reduced virgin material extraction and processing. Recycling today is by and large more labour intensive than virgin material based manufacturing. Several US studies have suggested that recycling leads to a net increase in jobs, taking account of reduced need for disposal personnel as well as virgin materials handlers. Massachusetts for example, estimates a job creation impact (direct and indirect) of 8.9 jobs for every 1,000 tons diverted from disposal.8

(d) Economic Issues, Material Recycling

Although much has been written about the environmental benefits of recycling paper and packaging materials, only limited definitive work has been done to estimate the economic value of the practice. LCA work in Australia has largely focused on defining and quantifying environmental benefits but not on valuing them in an economic sense. This is largely due to the uncertainties associated with valuing indirect impacts, like avoided costs, and with estimating the value of non-market benefits, such as reduced pollution. Even revenue from sale of processed materials is subject to fluctuation and considerable uncertainty. The cost side of the recycling equation is relatively uncomplicated: collection and transport is a key factor, sorting at MRF, or aggregation to bulk loads is important, and MRF residuals are usually disposed to landfill. Further transport to the reprocessing facility is usually necessary though this is excluded as materials are usually sold ex-MRF. The aggregation of the estimated costs associated with these activities is set out at Table 8-3.

Table 8-3 Estimated average cost of recycling

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection &amp; Transport</td>
<td>$140</td>
</tr>
<tr>
<td>MRF sorting (average)</td>
<td>$100</td>
</tr>
<tr>
<td>MRF Residual Disposal</td>
<td>$5</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$245</strong></td>
</tr>
</tbody>
</table>

Source: As referenced in text and/or estimated by Waste Inquiry.

Benefits arise in multiple ways. When material is collected for recycling, savings result because those materials are not collected, transported and disposed of as part of the residual waste stream. Many argue about the extent of these savings. Some economists argue that waste management costs are large and lumpy, and therefore minor changes in recycling quantities result in changes only in marginal costs at least for collection and transport.

The alternative view is that over the long run the aggregation of modest local changes will result in step changes to capacity. Moreover, there are substantial collection and transport costs that can be avoided when materials are diverted from residual waste to the recycling bin. Following the approach of Skumatz and Morris 9, the Inquiry has adopted an avoided cost of 33 per cent of the estimated total collection and transport cost of $66 per tonne (ie, $22 per tonne). The full value has been adopted for avoided disposal cost (ie, $57 per tonne), and for transfer and transport $15 per tonne.

Manufacturing costs are reduced by the use of recycled materials and it is reasonable to account for this impact reduction. But the market price that manufacturers are willing to pay for recycled materials should reflect a proportion of this benefit. In particular energy savings and emission control technology should ultimately be reflected by market price. These have not been used in the analysis due to the double counting effect. An interesting consideration is the extent to which market price for recycled materials does in fact equate to net manufacturing cost savings.

Non market factors include the impact of emissions which are below environmental standards and greenhouse gas emissions. The latter has been estimated at $21 per tonne based on the Massachusetts study. The low level emissions avoidance benefit has been based on a conservative 25 per cent of the total estimated manufacturing emissions reduction benefit used in the same study. This amounts to $20 per tonne.

Finally, the sale of recycle to reprocessors provides a direct benefit. The Inquiry has estimated revenues as averaging $70 per tonne in a range fluctuating between $60 and $80.

The aggregation of these estimated average benefits is set out at Table 8-4.

Table 8-4 Estimated average benefits of recycling

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided Waste Collection &amp; Transport Cost</td>
<td>$22</td>
</tr>
<tr>
<td>Avoided Waste Disposal Cost</td>
<td>$57</td>
</tr>
<tr>
<td>Avoided Transfer &amp; Transport Cost</td>
<td>$15</td>
</tr>
<tr>
<td>Sales Revenue</td>
<td>$70</td>
</tr>
<tr>
<td>Reduced Manufacturing Pollution</td>
<td>$20</td>
</tr>
<tr>
<td>Reduced Greenhouse Gas Emissions</td>
<td>$21</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$205</strong></td>
</tr>
</tbody>
</table>

Source: As referenced in text and/or estimated by Inquiry.
In addition to the above costs and benefits, two other less tangible environmental issues warrant consideration: the transport issue; and the benefit to future generations of virgin natural conservation.

The transport issue is complex. Post-MRF materials are often transported long distances to second stage beneficitation or reprocessing, eg, paper for recycling travels from Sydney to Albury. Although the transport cost is logically reflected in the market price, the environmental impacts are unlikely to be fully comprehended. On the other hand, the environmental impact of post-transfer bulk transport may not be fully reflected in prices. The variations are so enormous as to prohibit serious evaluation. This is borne out by the fact that the Inquiry has been unable to locate an LCA study of recycling that has considered post MRF transport versus post transfer transport. Accordingly a rough balance has been assumed.

The value in ESD terms of conserving virgin materials is unquantifiable. But it is clear that the community willingly subsidises recycling, and this may to some extent reflect a collective community valuation of the practice. Again the Inquiry was unable to locate a serious evaluation of the benefits of conserving the array of virgin materials comprising the dry recyclables stream.

Does recycling make sense when viewed in the ESD context? The answer is a reasonably clear yes, within the limitations of the estimates and (particularly) assumptions noted above. With the inclusion of community subsidy, the benefits roughly equate to the costs. And the position will improve if recycling volumes can be increased, because the infrastructure is largely in place and marginal costs are low. Moreover, the emerging global market place for recyclate should ensure a more stable demand/price position than has been evident over the last five years.

Accepting the widespread citizen enthusiasm for recycling (for reasons discussed above), many localities have moved on from the “to recycle or not” debate and have pushed headlong into the arena of driving down costs through improved program efficiencies. The City of Portland is a prime example. It concerns itself less with cost competitiveness of recycling versus alternatives (they accept prima facie that the community expects recycling services), and more with driving down costs of their programs.

This is important because the costs of recycling collection and sorting are not only high, but are highly variable with collection system and frequency. Variations of 50 per cent have been cited in a recent study of kerbside collection costs.

8.1.2 Product Reuse Practices

Packaging product reuse has traditionally been an important part of the waste minimisation agenda. Over the last decade however, there has been a global move to recyclable packaging in the face of uncertainty about the financial and environmental costs associated with reusing containers. Health issues too have curbed some reuse initiatives.

- Most reuse activity now involves:
- finding new, often innovative uses for used products, such as household bin liners from plastic shopping bags;
- extending the life of products, such as furniture, electronic goods etc;
- using components from electronic and mechanical products as spare parts and for active rebuilds (see Photograph 8-1);
- household and industrial rechargeable products, such as spray units and laundry detergents.

These reuse applications are not new, but the concept is worthy of special attention because it can be accomplished without the need for reprocessing and often without transport. This distinguishes reuse, which is product oriented, from recycling, which is material oriented.

The dimensions of the product reuse achievement and potential in NSW are uncertain because the practice can never be fully recorded. The following indicative estimates serve to illustrate potential for reuse.

EU data reveal disposal potential of around 30 kg/household/year in electrical goods. The addition of furniture, clothing, household bric-a-brac, and other household reusables yields a rough total of around 100 kg/household/year. This would sum to a NSW total of around 250,000 tonnes per year. Possibly 10-20 per cent of this is currently reused, and

Photograph 8-1: Used refrigerators being disassembled to recover components for reuse, Lünen, Germany.
the potential capture might be 30-50 per cent, say 100,000 tonnes per year.

The C&I waste stream is much more difficult to disaggregate. Informal estimates put the potential reusables at around 200,000 tonnes per year, of which, again, 10-20 per cent (or 20,000 to 40,000 tonnes) might currently be reused. The realisable potential for reuse in the C&I sector is probably around 40 per cent or 80,000 tonnes.

In the C&D waste stream significant reuse of doors, windows and internal fittings is undertaken. Industry participants estimate that this amounts to around 20,000 tonnes per year.

(a) Operational Issues, Product Reuse

The scope for small scale product recharge applications, mentioned above, is technically uncomplex and has been addressed in part by market and household innovation. The technical barriers to greatly increased product reuse are essentially tied to the willingness of manufacturers to innovate to gain corporate competitive advantage using environmental performance as a key selling point.

Reuse of white goods, electronic goods and components has been addressed in two main ways in Europe; extended producer responsibility initiatives, and application of high disposal costs. In Germany this has resulted in component stripping of some 80 per cent of electrical and electronic goods: a technically feasible proposition which is highly automated but costly in terms of transport.

The NSW market has long been active in facilitating reuse of clothing, furniture and household bric-a-brac. And white goods after end of first life were previously traded-in on new products, then refurbished and brought back into a further useful life. Electronic goods are more recently finding applications for a second life. Most used product is exchanged through local markets, garage sales, newspaper columns, second hand shops and charitable organisations. The market is reasonably efficient for municipal products, and the exchange is effective in extending the life of unwanted products. It is much less effective for C&I products.

However, many in the community are reluctant to part with potentially reusable products, largely because they over-rate intrinsic residual value. Data from IBM indicate that in North America the active life for a home PC is three to five years, after which 79 per cent of PCs are stored for long periods, 15 per cent reused in a second life, 5 per cent landfilled, and 1 per cent recycled.

The accessibility of the market to sellers (or discards) is an issue of some concern. For some people, the Council clean-up or the local Transfer Station offer convenience which outweigh potential financial returns of garage sales and “for sale” columns.

Europe has taken this concept to the next logical step with development of “drop-off” centres. These are usually conveniently located, staffed by people expert in second hand values, and provide either a free or low cost service. Drop-off centres serve both C&I and municipal markets and focus on reusable products, but also take dry recyclables, timber and garden waste. All discards must be sorted at unloading to stream type. Used products and materials are often refurbished on-site and are available for purchase. Photograph 8-2 shows reusables and recyclables drop-off centre at Salzburg, Austria.

Similar operations exist in the USA. In Berkeley, California a company called “Urban Ore” serves as a for-profit, commercially-operated drop-off centre, in which employees accept (and pay for!) items they feel confident can be resold to others. Having grown to 25 employees, the site covers a hectare, with an internal sales floor of almost 2,000 m² divided into sections covering hardware, arts and media, furniture, general merchandise and the largest: building materials (including toilets, timber, doors, iron railings, etc). Turnover last year was some A$2m.

A good, low-scale drop-off, refurbish and resale facility has been established by Orange City Council. The principal market barrier to wider uptake of the drop-off concept has been the need to demonstrate the benefits of the scheme. A pilot drop-off centre is currently proposed by Western Sydney Waste Board as a full scale trial. The Waste Board considers that following successful demonstration, drop-off centres will be commercially viable at various locations in the Western Sydney region.
(b) Environmental Issues, Product Reuse

Product reuse accrues powerful environmental benefits, mainly arising from resource conservation, avoided manufacturing emissions and avoided disposal impacts. Energy savings are substantial. When effective, reuse initiatives ought to be superior to recycling because the preparatory step of reprocessing is omitted. Transport activity is also reduced.

Despite its elevated position in the waste hierarchies of western nations, little analysis of the relative environmental impacts of reuse has been completed.

(c) Social Issues, Product Reuse

The reuse market in New South Wales reaches to all parts of the community: individuals drive the process, but the social sector is highly involved and the practice provides an income for many small businesses.

Most citizens don’t view their routine reuse activities in the same resource conservation sense as recycling; although 86 per cent of people surveyed in NSW claimed to have reused products within the last 12 months, the vast bulk place recycling ahead of reuse in their personal waste minimisation hierarchy.

Increased product stewardship could bring about increased involvement and impact awareness in reuse activities by large and medium sized businesses.

(d) Economic Issues, Product Reuse

The economics of product reuse make sense when buyers and sellers can be efficiently united. The cost and benefit profile is similar to recycling. Costs are associated with logistics and marketing to make products available for reuse. These vary from zero to considerable depending on the product and the circumstances.

Benefits accrue from avoided collection, transport and disposal costs which would have been incurred had the product been disposed of rather than reused. Benefits also may accrue from avoided manufacturing impacts. These include energy savings, reduced manufacturing emissions and reduced Greenhouse gas emissions. Some argue however against the full valuation of these benefits. The grounds are that the act of reuse does not confer new life on a product, but merely extends the life of the product, and sometimes not by much. The competitive market for product reuse appears to recognise these limitations in the equilibrium at which prices settle.

Just how good reuse is compared with recycling can only be settled in regard to specific products and materials. The view of the Inquiry is that reuse has an important position in the economics of waste minimisation.

8.1.3 Waste Avoidance

Sitting at the top of the waste hierarchy, waste avoidance is the ultimate goal in the waste management regime. One of the pillars of sustainability is conservation of resources for future generations – avoidance of waste generation epitomises this aim.

Waste avoidance is about doing more with less, it is the underlying issue of the international initiatives, Factor 4 and Factor 10.

Increased product stewardship could bring about increased involvement and impact awareness in reuse activities by large and medium sized businesses.

Financial instruments – Evidence is mixed over whether financial instruments actually improve waste avoidance in the domestic sector. Ackerman reports that the impacts of “unit pricing” (volume based user pays) must not be overstated:

“Today more than 2,000 communities have instituted unit pricing for garbage collection, and the number continues to grow. As unit pricing programs have spread across the country, economists studying them have not been far behind. Although the tone of the studies is optimistic about the potential for price incentives, the empirical results provide grounds for pessimism. The problem is that people just do not respond very well to moderate prices for garbage collection. The initial introduction of unit pricing causes a modest reduction in waste disposal; small price changes thereafter have almost no additional effect, while large price increases might lead to unacceptable levels of illegal dumping.” (Ackerman, 1997).

However, it is important to note that according to the US Center for Local Self-Reliance (which prepared the USEPA study on the most successful community waste management programs), the majority of US communities with leading recycling programs have unit pricing for waste. These “Pay As You Throw (PAYT)” tariffs charge per-bag or per-can volume-based waste fees. Officials in Seattle, Portland, San Jose and San Francisco (among others) report that when customers pay by the bin or pay differential prices for larger or smaller waste bins the response is immediate. While the sums of money may be significant in relative terms, the absolute figure may only amount to around $4 each month, or the cost of a couple of cups of coffee. Yet the consumer response has often been
overwhelming: officials say that most customers move to smaller bins and take steps to limit the amount of mixed waste they generate.

The Inquiry identified what may be another key factor in US program success – the manner in which households are billed. In leading cities, customers usually receive a bill dedicated to waste services. Often the bill is itemised for mixed waste, recycling and organics. This may be a critical factor in the purported strong consumer response to PAYT mechanisms.

In an effort to encourage source separation and reduce waste, many localities have instituted regulatory bans on certain materials in mixed waste bins. Seattle, for example, prohibits householders from putting garden waste into the residual waste bin. It either must be composted in the back yard or separated into the waste container for municipal collection (which carries a fee). Evidence is inconclusive, however, over whether such bans are effective at encouraging waste avoidance, or whether they are more effective at redirecting waste into recycling and reuse.

Overall, The US EPA cites that PAYT tariffs in concert with mandatory source separation ordinances are keys to success in recycling programs. What is not entirely clear is the extent to which these mechanisms encourage waste avoidance. When recycling is mandatory and easy some argue that the incentive to avoid waste generation in the first place is eliminated entirely.

(a) Operational Issues, Waste Avoidance

Waste avoidance is a technical issue to the extent that as a society we are not using all of the processes available in our manufacturing systems to minimise waste. Cleaner production is a concept for businesses to apply in which each step of the commercial process is analysed to identify ways in which wastes of all types could either be avoided or reused. This can apply to a steelworks, a medium-sized printing outfit or a local dry cleaner. For example, almost a decade ago the compact disc (CD) industry moved to reduce its packaging (virtually cutting it by half). The large packaging had been deployed to inhibit retail theft. Instead, however, the industry substituted alternative inventory tracking methods to achieve the same end with far less material.

While a smattering of firms have engaged in cleaner production programs in Australia, much remains to be done.

(b) Environmental Issues, Waste Avoidance

Resource efficiency is the overarching goal from the perspective of sustainability and environmental protection. And pollution is an indicator of resource inefficiency, as it is usually a byproduct of achieving something else – whether it occurs in the form of solid waste or air and water emissions. The smoke from our car exhaust pipes is a byproduct of us needing to get from Point A to Point B. The effluent entering a river may be the byproduct of the factory making durable and brightly coloured paints. And the skips full of rubbish at a retail outlet arise as a byproduct of leftover and damaged inventory and product packaging. This pollution signals, then, that resource efficiency has not been optimised.

The environmental benefits of waste avoidance are immense, starting with reduced demand on resources in the first place, reduced energy in manufacture and less product manufactured and wasted and less emissions.

(c) Social Issues, Waste Avoidance

There are major social challenges associated with increasing waste avoidance. In the last half century of “post-scarcity” consumerism, we have become a ‘disposable society’ in which, for many, acquisition of more material goods has become measure of success. There is also clearly a component of convenience related to waste generation. From disposable nappies to throw-away coffee cups to extra food at home and in restaurants, most people find it easier to throw away what we no longer need than plan for avoiding that waste in the first place. One good example of a turnaround, however, has been the choice of landscaping; by using native plants in domestic and commercial settings the volume of garden waste can be substantially reduced (with conservation of water occurring as well).

A key social issue with waste avoidance is that the community has a poor understanding of what is meant by sustainable consumption. Emphasis has been placed on sustainable production but the second half of the equation remains poorly defined and even less understood. Yet sustainable consumption practices will be a key factor in the success of waste avoidance.

(d) Economic Issues, Waste Avoidance

Economic impacts of waste avoidance mirror those of environmental impacts: reduced demand for resources, less energy, less emissions. We do more with less and still achieve the life style and economic growth we desire.

8.2 Integrated Waste Management Practices

No single waste management practice, treatment technology and disposal technique can handle the complex array of discarded material types, sources, locations, and product types from which waste arises. Integrated waste management practice is based on the idea of an overall approach, coordinating value chain activities with waste streams, recyclables streams, treatment technologies, and markets.

The three components for integrated waste management practice are: waste streaming, where like materials are similarly classified and collated; system integration, where waste and resource recovery activities are linked; and industry arrangements where the roles and responsibilities of the institutions involved in waste management are brought into focus.

This section examines the main practices that contribute to integration, with a view to assessing the merit of further New South Wales moves in favour of integrated waste management.

The imperatives of integrated waste management constitute a mindset that is not present in many of the
participants in the system. The focus of most participants is on their own part of what is a long and complex chain. Protecting and upgrading established positions is a reasonable and logical pursuit, but a durable outcome ultimately requires the cooperation of participants in the interests of a higher-order goal.

Even a sub system of waste management, the recycling system, is not balanced to maximise overall efficiency. Rather, organisations operating at each activity in the chain have invested in systems and technology to improve their own efficiency. In other words, their focus has been on their own activity optimisation rather than total system optimisation.

The position is compounded by the existence of a proliferation of different sorting and handling systems at each activity point. The outcome to date is a sub optimal, excessively costly, recycling system. Entrepreneurial companies have seen the opportunity of improved system integration and some have moved to establish their own systems to bypass the many steps in the chain. These splendid moves have shown that recyclables management can be profitable.

8.2.1 Waste Streaming

Waste streaming can be thought of at various levels. The most obvious macro level source classification is:

- Municipal
- Commercial and Industrial
- Construction and Demolition

This classification can be further subdivided by current main stream type, viz:

Municipal
- Residual waste: mainly mixed food; paper; and packaging materials discarded for disposal.
- Dry recyclables: predominantly paper/cardboard; and packaging plastics, glass and metals.
- Bulky waste items: which are infrequently generated and usually too large for the residual waste bin. They comprise unwanted furniture, white goods, electronic equipment, building and decoration materials, clothing and household bric-a-brac.
- Hazardous wastes: mainly paints; batteries; pharmaceuticals; and chemicals.
- Garden waste: essentially lawn, tree and plant clippings; generated in plentiful supply in warmer months.

Commercial and Industrial
- Residual waste: largely food; paper; packaging and industrial materials and products, including timber, metals, plastics, textiles and organics. These are discarded for disposal in small to large containers, in various states from homogeneous to mixed.
- Common recyclable materials: predominantly paper/cardboard; packaging plastics, glass and metals; and industrial metals.

Construction and Demolition
- Residual waste: largely mixed spoil; rock; concrete; timber and metal products and materials.
- Recyclable materials: usually source separated construction materials, often reused within the construction industry (eg, spoil and concrete).

Well organised practices are in place to manage each of these broadly defined waste streams. However the streams are so well defined in the public psyche that great difficulty is encountered in recruiting specific materials from one stream to another or to create new streams. Thus, much material that is perfectly suitable for recycling is despatched to residual waste because it does not fit our often arbitrary community and institutional ideas of what constitutes the potential recyclable stream.

The notion that some waste might have value is not new. But the concept has been diminished in the post-scarcity era. As a throwaway society our waste management practices and recycling behaviour are geared to convenience.

The complexity and cost of recycling and reprocessing discarded materials is strongly related to the extent to which they are mixed with unlike materials. Waste mixing occurs for two reasons:

- it makes post-discard recovery of specific materials costly and difficult;
- it nurtures the dominant view that all material arbitrarily designated as waste ought to be disposed of, usually to landfill.

Practices to achieve greater streaming of discarded materials are discussed in detail at Chapter 9.

(a) Operational Issues, Waste Streaming

The technical issues of greater waste streaming relate to providing convenient ways for households and businesses to source separate beyond current practices. The current generation of dry recyclables collection technologies well serve their purpose, essentially at the household level. A step change in resource recovery may require innovative investment in source separation and collection technologies, especially for the commercial sector.

Effective streaming would see standardised technologies, coded to specific waste streams in all business locations and all public places. The existence of discard options confronts the disposer with a choice between waste and beneficial use. The more
CHAPTER 8

and leisure activities, the more the message of resource recovery is reinforced. The multi-purpose recycling bin is shown at Photograph 8-3.

The opportunities for public place recycling in New South Wales are minimal and therefore non-reinforcing; public place streaming technology is limited and colour coding is inconsistent.

Business recycling and waste streaming opportunities are sporadic and depend on the environmental commitment of business leaders, and the responsiveness of waste management companies. Technical system barriers are associated with source separation technology availability, work space layout and employee education. These barriers can be addressed in large measure by seeking manageable commitments from business; for example, facilitating source separation of only the single dominant waste material at a specific business location.

Market issues are intertwined with the technical aspects of recycling and reprocessing. The market logic of streaming is that it maximises the probability that specific materials discarded will be recoverable at critical mass and will be reprocessed and used for their highest resource value. This logic is the core of the submission to the Inquiry by the combined Waste Boards. The Boards proposed a system of integrated waste management “... providing a use for materials that cascade from the highest resource value to the lowest ...”.

Effective resource streaming requires a dynamic relationship between waste management practices and technologies. The organisation of waste management and recycling in NSW has acted, until recently, as a barrier to the uptake of new practices and technologies. Strategic policy changes introducing Waste Boards in a regional planning and management role, and allowing scope for private sector management of putrescible waste, have already had an impact on the uptake of new practices and technologies which recognise some waste materials as a potential resource.

In its submission to the Inquiry Western Sydney Waste Board points out that “... Opportunities for processing these homogeneous resource streams will arise through market forces ...” and the assured, continuing availability of resource streams will provide investment confidence in appropriate technologies.

The challenge is to bring about practices that capture specific material streams before they become mixed as part of the residual waste stream.

(b) Environmental Issues, Waste Streaming

The environmental issues associated with waste streaming as a practice should be considered separately from the broader issues associated with the practice of recycling. Increased, targeted streaming facilitates recycling and reuse because it makes processing activities more efficient and should provide higher quality recyclate. The concomitant improvement in market advantage for the recycled product over the virgin alternative has discernible, though intangible, resource conservation impact.

Further, streaming enables greater opportunities for accumulating and appropriately managing hazardous wastes. It is likely that the current system allows too much hazardous material to “slip” into the mixed residual waste stream. As such, the increased streaming of dry cell batteries, for instance, is best managed outside the residual waste system.

The environmental benefits of increased streaming are associated with facilitating the capture of more waste material and diverting it to be effectively reused or recycled, thus preserving virgin materials and reducing disposal impacts.

(c) Social Issues, Waste Streaming

There are potentially significant social issues associated with greatly increased waste resource streaming. The “hassle factor” for some communities may discourage participation and unwittingly lead to less diversion rather than more. Interestingly, however, US cities like Seattle and Portland have, until recently, had programs which required more than six disaggregated streams of recyclables for the municipal kerbside programs and through robust community education secured both high public participation and enthusiasm.

The key social issue with waste streaming is the reinforcement that the activity provides to heighten citizen and business awareness to resource consumption and disposal. The act of streaming one’s wastes – whether for environmental or economic reasons – brings into close scrutiny the amount of resources that we discard and which we consider surplus to our needs. Over time, most reasonable citizens and cost conscious businesses will begin to look for effective ways to minimise the amount of discarded resources.

(d) Economic Issues, Waste Streaming

Increased streaming may in many circumstances result increased costs – more collection bins, more time for collection, and/or transport costs, etc.

Portland, USA found an innovative way to get business involved in waste streaming. See Box 8-3.

8.2.2 System Integration Practices

Integrating the waste and recycling value chain involves moving beyond the current piecemeal approach to
synergistically link and combine sequential activities, waste streams and geographic areas. This practice can not only increase the scale of operations, but can also provide rewards for action to support diversion of resources from disposal to reuse, recycling and reprocessing.

System integration implies an approach that incorporates in single contracts and/or agreements:

- scope for increased value chain activities, including collection, transfer, transport, MRF sorting, treatment, selling, and/or disposal;
- inclusion of recyclables, special collections, such as garden waste collection, and residual waste;
- scope for increased waste streaming and various treatment technologies;
- scope for larger geographic areas than a single local council collection zone – possibly two or three per Waste Board region;
- scope for capture by the contractor of C&I and C&D waste and recyclables from these streams within the relevant geographic area.

These activities are presently better integrated in rural cities than in Sydney. For instance, Orange City Council and its waste contractor work in collaboration to cover many of the above activities. Waste management in German and some US cities is similarly integrated and provides flexibility and cost containment.

(a) Operational Issues, System Integration

The technical issues of system integration relate to both the infrastructure available and required for sustainable waste management, and the scope and organisation of waste management contracts.

A mix of public and private infrastructure is used for collecting, transporting, transferring, MRF sorting, reprocessing and disposing of waste and recyclable resources. Substantial investment in new infrastructure will be required to greatly increase recycling and reprocessing, and consideration of how this infrastructure ought best be funded and managed is critical to system integration.

New South Wales (and Australia) is at world class in waste and recyclables collection, transfer and MRF technology. But this largely applies to municipal waste and recylcate streams.

Commercial and Industrial waste infrastructure is similarly sophisticated, but the technical systems to bring about C&I recycling leave considerable scope for improvement. System integration practice would provide the basis for substantial investment in new infrastructure to bring about C&I recycling.

Box 8-3 City of Portland, Oregon, USA Commercial Industrial waste management Program

Portland is among America’s leading jurisdictions for its success in domestic recycling programs. It is, however, an unusual standout in its innovative approach to the business sector. With 20,000 businesses generating about 75 per cent of the city’s waste, Portland realised that more needed to be done in C&I and proposed extending its area-based collection program to the business sector. Contractors were doing collection, recycling and diversion well for households, so city officials believed that business could benefit.

Businesses immediately objected, arguing that they needed to be able to competitively tender for their waste management services to get the best financial deal. Government and business then struck a deal that satisfied both objectives: businesses would agree to an ordinance requiring businesses to divert at least 50 per cent of waste from disposal in exchange for being able to gain competitive bids for their waste services.

How does it work? Businesses seek competitive bids from the waste management industry on the basis of those tenderers being able to provide the most cost effective program to meet the 50 per cent target regulations. The details of the programs are proprietary between the business and the waste service provider.

If, though, the Government officials identify that a business is not actively engaged in a waste management program to meet the target they take action. They first issue a notice warning a firm that they have a 60 day grace period to demonstrate to the city that they have taken the steps necessary to rectify the situation. In this warning the city officials also offer to provide assistance in development of a business plan. The Portland Government has developed simplified “short forms” covering most sectors (e.g., manufacturing/wholesale; hotels/institutions; medical facilities; retail businesses; offices; restaurants, and automotive businesses) to assist SMEs with development of appropriate waste management plans.

If after the grace period the business has made no progress, the city can fine the company. After several years of operation and hundreds of warning notices sent, only two fines have had to be issued. Generally, officials say, businesses want to do the right thing in waste management and if given the tools will get going.
necessary to facilitate vertical and horizontal integration of activities, materials and geographic scope. This work has pointed to significant economic, environment and social benefits from system integration.

The market issues concern the ability of the environment management industry to respond to a wider brief. System integration is routinely practised in Europe and USA, and industry has responded with progressive diversification. The portfolio approach is also a key part of the UK sustainable waste management strategy developed in 1999.

The waste management companies that presented submissions to the Inquiry (Collex, Rethmann, Thiess) made clear their commitment to broad portfolios of environmental services, reaching far beyond collection and transport.

In the Sydney, Newcastle, Wollongong conurbation, around 20 contracts covering municipal waste and recyclables are envisaged in lieu of more than 100 that presently cover these activities.

(b) Environmental Issues, System Integration

High level environmental outcomes are generated when systems are integrated – not competing. Under current systems, the majority of municipal contracts within one Council area are allocated to separate service providers. Thus, increasing diversion from the mixed waste stream to garden waste or recycling, represents a potential benefit to the mixed waste service provider, whilst at the same time presents a threat to the resource recovery service provider.

These benefits and threats arise through respectively the lesser or greater amounts of materials collected per household serviced, and the contractual payment system of fees per household serviced. Under current contracting arrangements, there are few, if any mechanisms for adjusting contract rates for these shifts. Thus there is little incentive for contractors to pro-actively promote diversions.

Awarding all contracts within a geographic region to the one service provider would eliminate this dilemma and permit the contracting body (Council, Waste Board etc.) the opportunity to introduce financial incentives for greater diversions on the part of the service provider.

In the C&I sector, resource conservation opportunities are regularly lost through the current fragmented services infrastructure. Within any one geographical area multiple service providers offer collection services – sometimes to the extent of two or more service companies collecting from the one industrial site. This high level of free market competition mitigates against resource conservation and reduces waste disposal to “lowest cost” choices.

System integration is a mechanism to reduce costs for resources management and to provided enhanced logistics within any region. With multiple service providers operating in the one region, for either municipal or C&I services, there is bound to be over-servicing and excess transport impacts including local traffic impacts, greenhouse gas emissions, excess fuel consumption and poor transport fleet efficiencies.

(c) Social Issues, System Integration

The current separation of systems, management and services presents barriers to higher levels of community involvement.

Clear messages cannot be passed on to citizens and business through a fragmented system for managing wastes and resource recovery. To achieve the requisite behavioural changes from the waste generating community it is essential that the services offered are uniform in approach and presentation, that each element of the services is supportive of the others, and that community members can see the impact of their involvement and efforts.

System integration can lead to higher levels of community participation, less inconvenience for the community, greater linkages between consumers and suppliers, and more balanced equity in sharing costs and responsibilities associated with resource recovery and residuals disposal.

(d) Economic Issues, System Integration

Three issues warrant critical attention: flow control; pricing structures; and sub optimisation. These are discussed below.

Control over the movement of wastes and resources is currently only possible to a limited degree – primarily through Local Council contracts and EPA regulation. These flow controls achieve local economic outcomes for Councils and State-wide environmental outcomes. There remains the opportunity for regional optimisation of flows of wastes and recovered resources, which can only be achieved through system integration and regional contracting.

The work of the Waste Boards in regional recycling initiatives is a first step in developing the necessary relationship models and evaluating the benefits.

The current pricing structures for waste services do not work in favour of either system integration or good environmental outcomes. In municipal contracts, payments per household are predicated on a “status quo” situation pertaining throughout the term of the contract with regard to arisings in collections – which is obviously not the intent of diversion and minimisation initiatives.

In the C&I sector, service providers charge “per lift” of bin, irrespective of the tonnage involved. On face value this should provide an incentive for waste generators to seek alternative payment arrangements based on arisings. However, the system in-place does not facilitate such arrangements and the right messages are not being pushed through to waste generators.

The service differences and the pricing differences between the municipal and the C&I sector have been allowed to widen to the extent that it now requires a major effort to bring them into some alignment. The alignment that system integration can bring will result in uniformity in service and uniformity in messages to waste generators through the charging regimes.
One of the failings of current piece-meal arrangements is that each party in the value chain seeks individual result, yielding a sub-optimal outcome for the overall system. In systems that are not integrated it is often the intermediate technologies that drive the linkages between waste sources and the markets for the recovered resources. This again yields results that are not optimised for the overall system.

Three issues warrant critical attention: flow control; pricing structures; and sub optimisation. These are discussed below.

Conversely, with integrated systems, the markets for recovered resources are linked with the sources of those resources. This permits a better appreciation of the handling and logistics approaches that are required to convert the at-source resources to the form most desirable for the at-market reprocessors. In an integrated system, appropriate technologies are selected to effect the required transformations.

Typical of the benefits that can be derived from system integration are lower total costs, financial surety and stability, larger contracts, links markets with sources and ensures clarity in purpose across all participants. These all translate into beneficial economic impacts for the system.

### 8.2.3 Industry Arrangements

Review of waste management institutional arrangements is not within the terms of reference of the Inquiry and is not part of this report. However, some industry arrangements and issues critically affect the uptake of innovative management practices and technologies. These arrangements and issues are described and assessed below in terms of their impacts on waste management performance. Waste management in New South Wales is organised within a complex structure comprising public sector and private sector participants. (See Chapter 3 for details). In summary the roles outlined in Box 8-4 apply.

These participants have important roles to play in shaping the practices to make greater resource use of waste. Important progress has been made since the introduction of new industry arrangements with the 1995 Waste Minimisation and Management Act.

### Policy and Regulation

The EPA has the lead role in developing waste management policy and managing the strategic framework and regulation. The State Waste Advisory Council was established to provide a further policy perspective to the Minister for the Environment. The concept of an alternative source of policy and strategy advice has merit, but the body that provides it ought to have the capabilities, independence and agenda to make an outstanding contribution to the further development of waste management practice. The following features are important:

- Expertise in waste management at the strategic, management and operation levels.
- Independent Chair so that the body is positioned as distinctly separate from the EPA and a source of good strategic, but pragmatic advice.
- Membership based more on contribution than on representation.
- An agenda and focus that requires the body to produce valuable outcomes within the strategic policy framework for waste management.

### Planning and Management

Regional Planning and Management is now led by the Waste Boards of New South Wales. They have developed momentum and are now playing a role in questioning the status quo and initiating reform in the ways waste is managed with a main focus on municipal waste.

The introduction of regional planning and facilitation has added significantly to the knowledge base, debate and intellectual capacity that is now focused on waste minimisation and management initiatives. Although there are disparate views across the eight Boards, a refreshing degree of new thinking has emerged, though it does need better coordination.

A great deal of valuable management planning has been undertaken, during 1998 and 1999, that is now at the early stages of implementation: eg, kerbside recycling strategy, food streaming and reprocessing, garden waste collection and processing, and initial attempts to influence waste management in the C&I and C&D sectors.

Most importantly, the Waste Boards have brought about much-needed regional approaches to waste management in the main centres of New South Wales. The following specific achievements are notable:

- The Waste Boards have been effective in achieving wide stakeholder input to the

### Box 8-4 Waste Industry Roles

<table>
<thead>
<tr>
<th>Policy and Regulation</th>
<th>NSW Government, EPA, SWAC</th>
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<tr>
<td>Planning and Management</td>
<td>Waste Boards and Local Councils</td>
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<tr>
<td>Infrastructure Ownership</td>
<td>Waste Service, NSW, Local Councils and private sector waste management industry</td>
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<td>and Management</td>
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<td>Research and Development</td>
<td>EPA, CRC for Waste Management and Pollution Control, private sector waste management</td>
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<td>industry and CSIRO and</td>
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<tr>
<td>Recycling Operations</td>
<td>Private sector waste management industry, Local Councils and Waste Service(NSW)</td>
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<tr>
<td>Recyclables Processing</td>
<td>Private sector, Waste Service NSW</td>
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<tr>
<td>Recyclate Selling</td>
<td>Private sector, Local Councils and Waste Service NSW</td>
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development of Regional Waste Plans. The bottom-up approach that has been successful in gaining broad-based regional concurrence with the Boards’ second round regional plans.

- The relationship between the Waste Boards and constituent Local Councils is still forming, but showing signs of becoming an effective mechanism for waste reduction initiatives. Local Government has authority to require changes to practices in land use applications through instruments such as Development Control Plans and Local Orders Policies. The Waste Boards have been supporting Local Councils in the introduction of waste avoidance and waste minimisation obligations through Council consent processes.

- In the area of kerbside recycling the Waste Boards have developed commercial relationship principles for implementing regional flow control on recyclates to overcome the current high degree of market fragmentation. This work is progressively being accepted by both the waste management industry and Councils. Three Boards are in the process of facilitating regional contracts. The Waste Boards overall have been influential in seeding innovative approaches. There is, of course, scope for improvement and some considerations include:

  - Consideration of the most appropriate role for Waste Boards.
  - Consideration of the capacity and powers of Waste Boards, particularly in respect of: authority to enter into contracts on behalf of constituent councils as facilitator; and authority to work with industry to facilitate improved management of C&I waste and C&D waste streams.
  - Consideration of whether Waste Boards should play a more active role in facilitating community and business initiatives at the upper part of the waste hierarchy, with a particular focus on sustainability initiatives.

- More formal coordination, at an appropriate bureaucratic and governance level, of Waste Board planning and management activities so that maximum broad-based value is gained from the efforts of each Board. This mechanism should also ensure that the collective Waste Boards have a seat at the policy table, and, where appropriate, that consistent practices are adopted.

- Consideration of the appropriate number and deployment of Waste Boards.

- Consideration of ways to support the informal waste management coordination approaches in rural regions; Netwaste, which covers the Orana and Central Waste regions, incorporating 29 Local Councils is a highly successful, but low cost coordinating mechanism.

### Infrastructure Ownership and Management

Putrescible waste management and infrastructure is largely under the control of Waste Service, NSW. The corporation owns and manages the dominant putrescible waste management transfer, recycling and disposal infrastructure in Sydney. This has enabled timely development and advance in waste management infrastructure in keeping with sound public health and pollution control management. The private sector waste management industry, however, claims the virtual monopoly that Waste Service has enjoyed for many years has limited competition and scope for technology innovation based on alternative perspectives of the value of waste resources.

The Inquiry believes that innovation in waste management practice and technology development is best served by the existence of a competitive market framework in the waste and recycling sector. An adequately resourced and skilled waste management industry exists in New South Wales. Moreover the array of waste treatment and disposal options available now and on the horizon negates the possibility of any one or two large operators gaining control of the State or Sydney market. A measure of flow control through institutional arrangements and policy instruments could ensure critical mass aggregation to specific markets.

### Research and Development

Waste management R&D throughout Australia is poorly funded and the priorities are not well conceived. A recent study of Federal Government spending on R&D found that funding is being spread too thinly to support developing industries. The field of waste management received $6.4 million in 1996/97 for the whole of Australia (and this covers waste water management as well as solid waste management). Apparently the focus of funding in general was on basic research, neglecting the importance of practical applied applications and commercial development of embryo technologies.

The main research effort in New South Wales is being undertaken by the CRC for Waste Management and Pollution Control. This research establishment is funded by 15 member organisations including three NSW Government agencies. Important work is also being done by the CSIRO.

There is a clear need for increased research to:

- assist in developing and commercialising Australian technologies, and demonstrating these to global markets;
- further develop and apply Life Cycle Analysis to inform policy and operating decisions;
- trial and demonstrate the viability of alternative waste management practices.

#### (a) Operational Issues, Industry Arrangements

The relationships between the various parties involved in the management of wastes and recovered resources are somewhat complex and fragmented. The complexity is a result of the structural systems in place, while the fragmentation stems from the contractual systems employed.

In considering regional based recycling, the Combined Waste Board’s Recycling Task Force identifies three relationship models and generic commercial principles for
the management of the interactions between the parties. Consideration of such arrangements are outside the terms of reference for the Inquiry, but a similar methodology could be implemented for each aspect of waste management and resource recovery.

Two most important aspects for successful operation of industry arrangements are clarity in purpose and appropriate allocation of risk. With fragmented systems there is no single purpose that captures the desired outcomes for the system, and with current contracting arrangements a major focus is risk-shifting rather than best practice risk minimisation and management.

In a free market environment no commercial operator will assume risks or purpose of business that is markedly out of touch with the market and their competitors. Thus it is unreasonable to expect that leadership should or will come from the service providers. Change is needed from the planners and managers, as was the case with the Recycling Task Force.

(b) Environmental Issues, Industry Arrangements

Each waste Board region has particular circumstances that are likely to limit initiatives in industry arrangements that cover the whole of the greater metropolitan area of Sydney, Newcastle and the Illawarra. However, regional solutions are likely to deliver regional industry improvements, which, in-turn, should deliver regional environmental benefits.

In addition, the cross-regional project program of the Waste Boards is considered likely to work favourably with industry structures in development of “horizontal” initiatives that address specific industry sectors across the metropolitan area. These initiatives will deliver environmental improvements within the industry sectors and complement the industry waste reduction plans being implemented through the EPA.

(c) Social Issues, Industry Arrangements

The structures, roles and responsibilities of the various participants in waste minimisation and management are unclear to many businesses and citizens. This is a significant gap in planning and management given the vital task expected of the waste generating community in streaming, and recycling on-site.

Clarity of purpose and consistent and effective communication to the whole community will significantly enhance participation levels.

(d) Economic Issues, Industry Arrangements

Economic benefits to the system, the community and the service providers can be enhanced when enlightened approaches are taken to the formal contractual arrangements within industry and between the other participants.

Part of the current fragmentation comes from traditional adherence to the adversarial contract structure. Waste management and resource recovery operations require more sophisticated contractual relationships that the historical models, including alliance based contracts and public/private partnerships.

Box 8-5 outlines the public/private partnership established in Frankfurt, which has resulted in reduced operating costs and recycling performance of 30 per cent.

8.3 Market Development Practices

Market factors in many countries have received second order consideration in the management of recyclables. Demand/supply equilibrium has often been assumed, possibly due to the long term strength of markets for industrial waste materials such as steel and copper. Markets for household recyclate however have proved unstable during the last ten years, and prices have rarely matched costs of collecting, transporting and reprocessing recyclable materials. This is at least partly because pricing of virgin materials does not fully comprehend non-market factors such as non-renewable resource depletion and greenhouse gas effects.

The challenge of achieving significantly increased recycling requires not only attention to supply side practices and technologies, but also a substantial and supportive effort to create markets and stabilise demand. The development and expansion of markets for recycled materials requires a coalition of effort by government, business and the broader community.

City officials in Europe and North America suggest that the growing quantities of recyclate over the past decade have now firmly led to established markets for these products, both locally and internationally. They characterise the early experiences with stockpiling of excess recyclate streams as inevitable growing pains of a young industry. The comparatively tiny Australian market may need greater stimulus to take up newly available supply.

This section describes and assesses market development practices without general reference to the assessment criteria.

8.3.1 Alternative Recyclate Uses

Traditional dry recycling is founded on the loop concept of feeding recycled materials into like-product development. The quest for alternative uses for recyclate is based on the idea that diversification of end-use applications can help to strengthen and stabilise demand.

The issues are explored below.

(a) Operational Issues, Alternative Recyclate Uses

The key technical issue involves actually achieving open consideration of the recycled material option in industrial applications. Too often, specifications are written in such a way that only virgin materials (or in some cases closed-loop recycled materials) are able to comply: the recycled alternative material is excluded on a technicality. Governments can take action to ensure that agencies open specifications to the scope for recycled materials. This may require accommodation of variations to specifications for items such as road-base materials.
The general aim is to discover innovative uses which are diverse (to absorb economic fluctuations) and high in value (to increase returns). The challenge is to achieve the highest value overall portfolio for each resource stream. Several examples of alternative uses are worth considering:

- In glass recylcate, for example, highest value for uniform cullet is in reprocessing, but mixed cullet, of relatively low value, is finding applications in building and construction industries.
- Recovered plastic film is being recycled in North America for use in composite plastic/timber decking products. Current costs are around US$0.014 per pound against current revenues of around US$0.040 per pound\(^6\).
- Excess PET is being used successfully in clothing manufacture.
- Recovered liquid paperboard is used in manufacture of industrial sheet/board products.
- Significant recycling takes place in industrial manufacturing, where off-cuts, product over-runs and out of specification products are reused as feed stock.
- Rail track ballast is being recycled successfully by Rail Services Australia, a New South Wales Government trading enterprise, to manufacture aggregate for use in concrete and road base. This alternative use arises because used ballast is technically inferior in closed-loop recycling.

The market issues concern the location and development of new applications and markets. In Australia both Tetra and Visy are exploring alternative use recycling by developing new, composite materials, then creating lead products and stimulating market demand. This market creation strategy is commercially risky, but potentially rewarding in environmental and financial terms.

The general aim is to discover innovative uses which are diverse (to absorb economic fluctuations) and high in value (to increase returns). The challenge is to achieve the highest value overall portfolio for each resource stream. Several examples of alternative uses are worth considering:

- In glass recylcate, for example, highest value for uniform cullet is in reprocessing, but mixed cullet, of relatively low value, is finding applications in building and construction industries.

There has been review of crushed concrete suitability as a road base material, and of the performance of blends of crushed brick and concrete material to meet RTA road making specifications.

(b) Environmental Issues, Alternative Recyclate Uses

The environmental benefits of creating a broad array of uses for recylcate accrue mainly from increased energy and resource conservation. On the other hand, the environmental impacts associated with collection, transport and processing may in specific cases outweigh the environmental benefits of alternative uses. This issue should be assessed closely for each recycling stream, rather than being assumed to be a reason for eschewing recylcate. Alternative transport and management approaches may overcome problems in those few cases.

(c) Social Issues, Alternative Recyclate Uses

There is need for significant business entrepreneurship in finding and developing new uses and alternative markets for recycled materials. Job creation should follow and citizen action will be mobilised if further high value alternative uses can be found for recylcate.

In Japan there is keen competition between some firms, notably in food, beverage and hospitality, to demonstrate maximal effort in funding alternative uses for waste materials. A very successful “Zero Waste” program in Japanese breweries is addressed at Chapter 4.

(d) Economic Issues, Alternative Recyclate Uses

The economic benefits of developing non-traditional recylcate markets accrue mainly from increased market stability resulting in increased revenue, energy savings, landfill costs avoided, and any transport costs saved. Revenue losses resulting from market failure are also significant considerations.

8.3.2 Standards

Market realities demand that recylcate must compete with virgin materials. The broad concept of best value for...
money is applied by product manufacturers as a long run issue. Price, utility, quality and delivery are the critical mix that manufacturers seek to optimise.

Manufacturers are continually confronted with the alternative of using virgin raw materials. Consistent adherence to whatever quality is required is necessary to win reprocessor and end-user confidence. The Inquiry received considerable anecdotal evidence of quality variations in recyclate streams.

The quality framework is fundamental to winning the confidence of the various purchasers engaged in the product value chain. Although business supplier to business buyer specifications exist, there is no broad system of Australian standards for end products comprising inputs of recycled or reprocessed materials. Moreover, if NSW recyclate is to compete in an increasingly global marketplace, then formal quality standards will be a requirement.

Quality standards are not only appropriate at end product stage. There is a need for greater transparency and an array of choices of various stages in the value chain:

- recyclable materials supplied to MRF for sorting;
- material supplied to reprocessor (eg mixed polymer, single polymer streams etc);
- material supplied to manufacturers.

It has traditionally been difficult for processors and manufacturers to minimise contamination, adhere to product specifications, and meet buyer expectations. This problem can be compounded by many new collectors and processors that produce recyclable materials in small quantities of variable quality.

In New South Wales there is some work underway in standards development for recycling, including organics and construction demolition materials. Just prior to closure, the former Local Government Recycling Cooperative produced standards for kerbside recyclables. In organics, there is an Australian Standards for compost but not for a range of products. Research is underway into the question of whether high generic standards necessarily are required for other uses such as broadacre farming.

(a) Operational Issues, Standards

Standards establish the benchmarks of performance for the participants in waste minimisation and management. Without standards it is not possible to oblige, reward and/or penalise parties for performance.

In resource recovery and recycling the trading of commodities cannot operate effectively without exchange protocols and standards. The value chain approach used by the Recycling Task Force of the combined Waste Boards, highlighted the important need for capabilities in the support area for development, implementation and enforcement of standards and exchange protocols.

Without standards, industry does not operate effectively, and the outcomes expected by the community are not delivered.

(b) Environmental Issues, Standards

There is clear evidence that the performance standards required by the New South Wales EPA in the design and management of waste facilities is leading to significantly enhanced environmental outcomes. In the process, the EPA has established a uniform set of standards for industry, a “level playing field” for all service providers if they want to continue in business.

In the management of wastes and resource recovery, similar performance standards are needed to ensure environmental expectations are met.

(c) Social Issues, Standards

Standards reflect the values and outcome expectations of the community with respect to environmental performance and interaction with the community. If these are not clearly expressed and enforced, it is unreasonable to expect delivery of expected outcomes.

(d) Economic Issues, Standards

All parties in the specification and delivery of services associated with waste minimisation and resource recovery seek surety in order to minimise uncertainties and to confidently invest in the future. Standards underpin surety and thus are an essential platform on which economic stability and benefits can be delivered.

It is important that the price framework comprehends not only the material cost, but also the comparative manufacturing cost for using recyclate versus virgin material.

8.3.3 Market Intervention

Government intervention in markets for recycled products has had demonstrated success at catalysing these markets. This intervention may be in the form of financial assistance, legislative reform or procurement guidelines.

Financial Assistance

Direct financial assistance may take several forms:

Tax incentives. Relief or exemptions from various taxes and levies is a possibility worthy of consideration.

One mechanism used overseas to stimulate the use of recovered resources is a consumption tax credit. This is similar in concept to an investment tax credit, and is intended to encourage the use of recycled products in the same way as investment tax credits are intended to encourage the installation of recycling equipment. A consumption tax credit scheme would allow firms using recycled products in manufacturing to apply a portion of the price paid for those materials as a credit against income taxes owed. This is equivalent to a reduction in the price of recycled products, making them more cost competitive with products manufactured from virgin material.

Subsidies and Grants. Financial assistance programs often involve low-interest loans and grants that may be offered to recycling processors and end-users of recycled material generally for capital expenditure. These programs provide aid to business enterprises and non-profit organisations that are expanding their markets in these areas. Many North American States and Provinces have used general business assistance programs. Grant and loan
programs specifically aimed at recyclers are operated in the following States:

<table>
<thead>
<tr>
<th>State</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>(grants)</td>
</tr>
<tr>
<td>Illinois</td>
<td>(grants and loans)</td>
</tr>
<tr>
<td>Michigan</td>
<td>(grants)</td>
</tr>
<tr>
<td>New Jersey</td>
<td>(loans)</td>
</tr>
<tr>
<td>New York</td>
<td>(loans)</td>
</tr>
<tr>
<td>Ohio</td>
<td>(grants)</td>
</tr>
<tr>
<td>Ontario</td>
<td>(grants)</td>
</tr>
</tbody>
</table>

In general, financial assistance programs such as grants and low-interest loans are similar to tax incentives in that they provide direct cost reduction to selected activities. Like tax credits, the cost reduction can be as large as the program permits. However, the benefits are more directly controlled by government. Unlike tax credits, the benefit is set in advance, and can be applied over a specified period.

**Financial Risk Sharing.** The successful program for municipal kerbside recyclables collection in Seattle, USA, which achieved 45 per cent recycling, used a risk-share approach to stabilise contractor risks and to nurture new dry recyclable markets. The regional recycling initiative investigated by the Combined Waste Boards involved careful assessment of risks and consideration of appropriate and efficient risk allocation to the party best placed and qualified to manage and assume each risk. This model is one which should be considered for general application in all waste management practices.

**Product Procurement**

Government procurement of recycled products is important to the success of recycling programs. Government demand can be substantial and can mean the difference between survival and closure of business for a recycler because it provides a measure of flow certainty. Moreover, Government leadership encourages other industries to use recycled products and should encourage consumers to support recycling of their waste.

The New South Wales Government’s Waste Reduction and Purchasing Policy covering all Government agencies is a fine initiative which warrants continued support. North American jurisdictions have approached a procurement program from three directions: review of specifications; price preferences; set-asides.

Review of Specifications. In the 1990s many States in North America established specifications and procedures for procuring recycled materials. Passive specifications ensure that recycled products are not excluded from consideration on irrelevant grounds. Active specifications require the goods to contain specified percentages of recycled material.

The most common recycled commodities targeted for review of standards in North America included:

- Paper
- Lubricating oil
- Tyres (retreaded)
- Asphalt (contained recycled rubber)
- Concrete (containing fly ash)
- Cellulose insulation.

Paper is the most common product for which North American States have developed specifications. Over 30 States have such policies. Nine other States have laws encouraging procurement of the other recycled products listed above.

**Price Preference.** In order to enable recycled products to compete many North American jurisdictions have established price preferences. In 1990 five States used price preferences for the purchase of paper produced from recycled fibres. California, Oregon and Rhode Island offered a 5 per cent preference while New Jersey and New York provided a 10 per cent preference.

Experience shows that the additional cost of purchasing recycled products is nowhere near the size of the price preference. Recycled paper products can compete with paper made from virgin material, particularly for large purchases. For other products, where recycling is less developed, a price preference is likely to be necessary, particularly until markets and industries have been increased. This appears a worthwhile temporary impost to stimulate the recycling industry.

**Set-asides.** A set-aside is a stipulation that a specific portion of purchases consists solely of products with recycled content.

In 1990 five States and many other local authorities had in North America established set-asides, primarily for paper, but also for other products. For example, Virginia, by law, reportedly purchased a minimum of 40 per cent of government paper requirements as recycled products.

Set-aside policies are unpopular with procurement officials. They claim that limiting competition solely to manufacturers of recycled material frequently reduces the level of competition, may reduce the quality available and increases prices.

**Industry Responsibility**

Many participants in the waste management chain have recognised that while recycling programs have improved substantially, sheer waste volumes have not declined as many had hoped. Some argue that this will not occur until the original generators of the material that becomes waste are responsible for managing it until its full life cycle is complete. Formally termed “cradle to grave” and now called “cradle to cradle” because of the implicit eye toward reuse, a number of programs are underway that put responsibility for a product’s waste management onto the original manufacturer. Examples include:

- Germany’s well-publicised Duales System Deutschland (DSD) “Green Dot” program for packaging materials.
- British Columbia, Canada’s Product Stewardship program for household hazardous materials. See Box 8-6.
- Netherlands’ program for batteries, tyres and agricultural plastics.
- US programs in white goods, computers, photocopiers and carpets.
- UK activities in mobile telephones and automobiles.

Some nations are legislating for “extended producer responsibility” (eg, Germany), others are adopting
primarily voluntary approaches (eg. USA). Either way, effective programs are stimulating innovation in production and distribution for participating sectors. Companies like BMW, Bosch, Miele, Whirlpool, IBM and Fuji-Xerox demonstrate that product stewardship can be accomplished in a context of maintaining or enhancing a firm’s competitive position.

(a) Operational Issues, Market Intervention
Intervention in markets by governments and agencies has often been less successful than intended, sometimes due to market participants taking advantage of weaknesses in the intervention mechanisms used.

In New South Wales, the EPA and other Government agencies have implemented examples of successful intervention strategies that have corrected and directed markets very effectively. Typical of these are the waste levy on disposal, and load based licensing in water and air discharges.

These sorts of instruments affect the performance and operations of both waste generators and waste service providers by creating a financial imperative for change – the cost of disposal increases, whilst the hurdle for alternative technologies falls.

The Inquiry considers that there is further scope for effective financial tools to be introduced to foster change in behaviour and encourage further innovation in operations.

(b) Environmental Issues, Market Intervention
Market interventions in resource recovery and waste management without expectation of enhanced environmental outcomes should not be considered. Those introduced in recent years by the New South Wales Government have had a clear environmental objective and outcomes are being delivered.

There is opportunity now to use more sophisticated economic instruments in waste management. Incorporating concepts such as those associated with load based licensing is likely to have some very influential impacts on the waste generating community that are more targeted and sector specific than the more general waste levy.

(c) Social Issues, Market Intervention
Market interventions are targeted at behaviour change and by their very nature have significant social ramifications. In waste minimisation and management, a driving tenet of the Act is the principles embodied in ESD, yet these are not clearly articulated to the community and often “taken as read”.

At the Waste Boards’ EMIAA workshop in 1999 that discussed issues pertaining to the Waste Inquiry, a paper was presented that related some of the core principles of ESD to the management of wastes and resources. This paper provides a rationale for alignment of regulatory
and other intervention initiatives with ESD principles, and a basis for the message to the community at large.

**(d) Economic Issues, Market Intervention**

Along with environmental issues, this is the area where intervention has the most significant strategic importance. The tools and mechanisms available all have economic and environmental ramifications – legislation, financial and product procurement.

Of these, product procurement is one which is least likely to distort free markets, yet at the same time stimulate the emerging markets for recycled goods. Government is a major purchaser of goods that can be supplied from either virgin or recycled resources, and whilst there is a directive for agencies to implement “buy recycled” initiatives, there is not significant evidence of government procurement favouring recycled products.

Two issues considered to contribute to this shortcoming are the traditional approaches to materials specifications, and a preference by many government agencies to use financial (rather than economic) evaluations for government purchases.

In the area of regulation, there is ample evidence of the financial impacts that appropriate mechanisms can inject and outcomes in behaviour that can be influenced. There is a good and continuing development in the application of such instruments in NSW.

Direct financial support and assistance has been effectively utilised by the Government in a number of sectors, including waste reform. The Government has committed to continued utilisation of significant funds generated through the waste levy. The Inquiry believes that some of these funds should be directed to fostering research and development toward commercialisation of new technologies as well as the development and implementation of high performance waste management practices.

3. Ibid.
6. Ibid.
9. Personal communication, IBM to Chair of Waste Inquiry.

### Current Industry Product Stewardship Programs

<table>
<thead>
<tr>
<th>Material</th>
<th>Solvents/ Flammable Liquids, Gas, Pesticides, Pharmaceuticals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paint</td>
<td>Post-Consumer Residual Stewardship Program Regulation</td>
</tr>
<tr>
<td>Beverage Containers</td>
<td>Post-Consumer Paint Stewardship Program Regulation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supporting Regulation/ Legislation</th>
<th>Post-Consumer Residual Stewardship Program Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding Mechanism</td>
<td>Industry “eco-fees” and/or internalised by industry</td>
</tr>
<tr>
<td>Collection System</td>
<td>35 industry depots (drug stores for pharmaceuticals)</td>
</tr>
<tr>
<td></td>
<td>103 industry depots</td>
</tr>
<tr>
<td></td>
<td>Retailers and over 160 industry depots</td>
</tr>
</tbody>
</table>

Considerable improvement in waste management outcomes can be brought about at moderate cost by seamless integration between various specific resource markets, a portfolio of suitable technologies, and an array of source separated waste streams.

This Chapter builds on the previous one to identify candidate waste streams and appropriate, targeted practices to efficiently divert these streams for treatment and beneficial use. The survey identifies only primary candidates for increased waste streaming. These are outlined below, and Section 9.2 presents three illustrative scenarios depicting the improvements that increased waste streaming can bring about.

9.1 Primary Candidates for Increased Waste Streaming

There are some clear primary candidates for consideration in facilitating increased streaming. These are discussed below:

9.1.1 Municipal Sector

Garden waste which comprises an average of some 18 per cent of the municipal waste stream. Collection practices and technologies are highly variable across local boundaries and views on potential market demand for garden waste products are diverse.

The Regional Waste Boards report that widespread garden waste collection services have been provided over the last two years and the market has absorbed the additional product. Notably, where garden waste is widely collected and composted in the US, there is no glut of material. All the organic waste composted has a market. Despite increased garden waste collections, the Inquiry estimates that in 1998 some 190,000 tonnes were recycled compared to total estimated garden waste discards of 600,000 tonnes. Although the outcome will be improved in 1999, there is clear scope for greater capture and streaming of garden waste. The options are:

- Upgraded household collection, with focus on optimal collection frequency for the situation (location, season, supply, demand) and appropriate collection technology.
- Increased home composting with on-site usage in appropriate locations.
- There is a place for both options though most consistently good results are obtained with the scientific approach used in commercial scale composting.

Care is needed however to ensure that expansion of supply matches the potential to increase market demand. A blanket move to immediately collect all garden waste for instance could result in a damaging oversupply situation. A more appropriate strategy is staged increase in supply, together with action to stimulate demand.

Food Waste which comprises around 27 per cent of the municipal waste stream, or 480,000 tonnes. Very little food waste is captured and reprocessed save for the small amount which joins the home compost stream. As a rich source of organic matter this resource can produce a highly beneficial compost product. Trials facilitated by Southern Sydney Waste Board show little contamination in domestic source separation.

The options are:

- Household separation of food waste and addition to the garden waste stream as a combined biowaste kerbside bin.
- Increased home and precinct composting with on-site usage in appropriate locations.
- Greater use of in-sink food waste disposal units in high density neighbourhoods with a proportion of solid organic material captured as sewage sludge. (A life cycle analysis of this concept is currently being undertaken by the CRC for Waste Management and Pollution Control).

Biowaste collection and processing is a feature of German waste management. Biowaste collection has been undertaken successfully in Lismore, NSW for almost a year. It is based on weekly collection of the biowaste bin and fortnightly collection of the residual waste bin, resulting in a diversion rate of 54 per cent including recyclables.

Home composting has both proponents and opponents. The municipality of Dilbeek in Belgium has had outstanding success with voluntary home and precinct composting. About 60 per cent of households are now actively composting and the regional government is planning to extend the scheme to other cities.

The cases for and against in-sink food waste disposal units have been argued to date in Australia on emotive rather than scientific grounds. Given the current landmark LCA work the Inquiry refrains from venturing an opinion on the merits of these devices as part of an integrated waste management scheme.

San Francisco, California too has now commenced a biowaste collection system.

Household Bulky Waste made up largely of discarded furniture, white goods, electronic equipment, clothing, building materials and household bric-à-brac is a significant material stream. It comprises reusable products and materials which, in aggregate, provide valuable additions to the various recycled materials.

This broad group amounts to around 5 per cent of the municipal waste stream by weight, but probably 10 per cent by volume. Much of this stream is despatched to landfill via Council cleanup, charity collection, Transfer Station deposit, or sale, reuse and rejection. The options for beneficial streaming are:
• A network of conveniently located drop-off facilities geared to repairing and selling reusable products, and aggregating like-materials for recycling. The Western Sydney Waste Board is presently evaluating the merits of a “Drive Through Recycling Centre” (DTRC) concept. An important feature of the drop-off facility plan is the scope for the scheme to facilitate product stewardship or extended producer responsibility actions by manufacturers. The Waste Board has gained considerable industry interest in supporting the DTRC plan.

• Separate collection of kerbside sorted bulky wastes with streaming and aggregation for despatch to recycling applications appropriate to the material type. Many Local Councils offer fee-based household bulky waste collection services, but few bother to sort the discards.

• Increased direct product stewardship/producer responsibility for end of life consumer durables.

Each of these streaming options has a place in an integrated scheme to capture and beneficially assign these resources. Drop-off centres and streamed kerbside collection offer near-term potential to divert more materials away from disposal.

**Dry Recyclables** collection warrants further serious attention given the environmental benefits, the potential for increased diversion of recyclables from the residual stream, and the low marginal cost of increased collection transport, sorting, and selling.

Participation in recycling has captured the imagination of a significant group of Enthusiastic Adapters. These strong participants have internalised recycling behaviour into their lifestyle and household systems and contribute greatly to the activity.

The next group is Committed Partial Participants. These people accept the environmental benefits of recycling and participate in the scheme within individual limits of personal convenience. They are strong contributors to recycling. They may have established household recyclables separation systems, but when the moderate capacity of the system reaches its limit, the residual waste stream provides a convenient alternative despatch point. This group needs assistance with household system innovation as well as positive reinforcement to strengthen participation and tighten quality control.

The Uncommitted Partial Participant group is willing to participate in recycling to the extent necessary to prevent overloading the residual waste bin. Some of this group may have established rudimentary household separation systems but the group has only moderate interest in quality control and avoidance of contamination.

The Laggard group is essentially made up of people who have no interest in participating in recycling and some who are opposed to the practice on grounds of intrusion.

More can be done to recruit both groups of partial participants to greater endeavour. And to secure a measure of participation by the laggards.

A great deal of thinking and analysis on recycling behaviour has been undertaken by and for the NSW Waste Boards, and throughout the world. The inescapable conclusions are that:

- there is a great deal of community goodwill toward the concept of recycling; recycling has become the local proxy for citizen environmental stewardship;
- recycling participation must be made easy and convenient;
- consistent opportunities for public place recycling can reinforce recycling behaviour;
- price signals in concert with participation mandates increased success;
- participation must be rewarded with positive feedback so that individuals are assured that their contribution counts;
- the message of choice in the destination of discards should be reinforced by standard colour coding and universal availability of multiple-stream recycling receptacles.

**Household Hazardous Waste** should be kept out of the residual waste stream and aggregated for recycling where possible or appropriate separate disposal. The options for consolidation of these materials are:

- Voluntary take back by retailers. This is particularly relevant for dry cell batteries and pharmaceuticals, which are already covered by a take-back scheme.

- A network of convenient drop-off facilities at which household hazardous material wastes can be deposited. This would especially cover paints, chemicals and batteries. The proposed Drive Through Recycling Centres and the existing Transfer Station network could act as the consolidation vehicle for voluntary take-back from retailers.

- Frequent Local Council collection of household hazardous waste by establishing bin-type drop-off facilities at key locations.

### 9.1.2 Commercial and Industrial Sector

The C&I sector comprises diverse organisations and the sector discards a wide array of (mostly) mixed materials. Thus only two main waste streams can be readily identified: common recyclable materials; and residual waste. Data on waste and recycling flows in this sector is poor and there are immediate financial penalties for business in separating waste.

The Inquiry however has identified great potential for increased streaming in the C&I sector. Obvious areas include packaging from retail outlets, organics from the food service providers, and increased paper collection from offices. One model of particular interest is the City of Portland’s business program, in which sector participants have a 50 per cent diversion target and get waste service providers to competitively bid for the most cost-effective schemes for achieving that target.

This sector presents important scope for increased waste streaming with several key candidates.

Common Recyclable Materials for this sector are mainly packaging glass and commercial paper/cardboard. Recycling of plastic packaging
Refocusing the Industry Waste materials is practised to a lesser extent. Recycling of general industrial materials including metals, timber and glass is at low to moderate levels. The options for a step-change in streaming and recycling participation are:

- **Shopping Centre Wastes** including paper/cardboard and commercial plastics. Work undertaken by Southern Sydney Waste Board has shown that these recyclable materials dominate the waste stream for 60 per cent of the trading space at shopping centres. Yet there is little streaming undertaking by these small to medium sized shopping centre traders.

- **Strong focus on paper/cardboard from commercial offices** by dramatically changing the logistics of recyclables collection in office locations.

- **Achieving increased streaming of industrial metals, timber and glass** through encouragement of business recycling plans, in collaboration with the waste management industry.

- **Food Waste** streaming provides an accessible resource, which when uncontaminated by mixing can be easily handled and homogenous. The key opportunity for this material is:  
  - Capture and reprocessing of food wastes from the supermarkets and main food traders at shopping centres. Around 160,000 tonnes of commercial food waste is disposed each year, plus a further 200,000 tonnes of food in mixed waste.

- **Further Options** beyond waste management practices warrant policy consideration:
  - the waste disposal levy to reflect non-market externalities, which should provide a financial incentive for business to separate and stream materials that can be reused, recycled or reprocessed for beneficial value.
  - Collaboration between government, business and the waste management industry to find opportunities to greatly increase business recycling.
  - Refocusing the Industry Waste Reduction Plan concept from the single industry perspective to a logical cluster perspective on a geographic and waste vertical integration basis.

- **Introduction of a “zero waste” policy and award program for NSW industry, commencing with beverage and food industries, and hospitality industries.** A successful “zero waste” program in Japanese breweries is discussed in the chapter on international approaches in this report.

- A requirement for industries to develop an Environment Management System, with accreditation under ISO14001, including an appropriate waste management policy. Environment management systems have driven effective minimisation of commercial and industrial wastes in other countries, notably Japan.

### 9.1.3 Construction and Demolition Sector

The building and construction sector is increasingly taking opportunities to stream and recycle waste materials. Spoil, rubble and concrete are the primary materials receiving attention, but brick and timber recycling is reported to be increasing. At 1998, around 1.5 million tonnes were recycled, while around 1.0 million tonnes were disposed.

The key is site streaming during the demolition phase. The selective demolition technique focuses on initial removal of hazardous materials, to avoid contamination with recyclable materials and ensure appropriate disposal. Concrete and masonry recycling is important due to the availability of aggregate markets. The other main candidate streams are glass, timber and metals.

California has initiated a “Waste Deposit” program for the C&D sector in which builders put up a bond to the local DA/BA authority, refundable only upon presentation of proof at the end of a job that construction materials were either recycled directly or sent to a MRF for recycling. A “Waste Not DCP” has been adopted by several councils in NSW for more effective design and assessment of waste management space and methods in commercial and industrial, construction and demolition, and municipal development applications. Adoption of such a planning instrument by all councils would represent a serious attempt to minimise waste.

### 9.2 Scenario Development

**Commencing with the current base, the Inquiry has developed three scenarios to encompass plausible and reasonably efficient waste streaming and treatment options.** They involve a progressively greater effort to efficiently gain value from waste resources. The scenarios are:

**Scenario 1**
- **Carry on much as now**  
  - based on current systems of waste minimisation and management.

**Scenario 2**
- **Improved current initiatives**  
  - based on increased recycling and streaming of special wastes.

**Scenario 3**
- **Aggressive initiatives**  
  - incorporating a variety of initiatives to capture and beneficially use resources.

These scenarios cover the three main waste sectors: municipal, commercial and industrial, and construction and demolition.

This Section first describes the scenarios and their impact on waste flows. The various activities are then modelled so that their impacts can be assessed and compared in financial cost and flow terms.

The modelling is intended to be illustrative rather than definitive. The scheme is simplified in several ways for ease of comparison of the main focus of the analysis:

(a) Waste avoidance and product reuse are held constant in all these scenarios, though improvements are entirely feasible and opportunities have been described in Chapter 8.

(b) Costs and revenues are broad estimates, and do not necessarily include all steps in the value chain. Moreover, marginal costs are not assessed, and efficiencies brought about by improved practices are not comprehended.
c) Technology types are deliberately left unidentified. Moreover, other technology classes could be substituted for the ones nominated. For example:

- a variety of technologies could be used effectively in lieu of composting technologies to process garden waste and organic waste and produce beneficial products (e.g., pyrolysis/gasification, anaerobic digestion and fermentation).
- a variety of treatment technologies suitable for residual waste processing could be used to divert from landfill the measure of residual waste modelled (e.g., biological technologies and thermal technologies, in association with varying levels of waste separation). These options are illustrated in Figure 9-1.

(d) Environmental benefits including energy conservation have been omitted due to the generalised basis of the evaluation.

(e) Waste flow data used covers the Sydney Metropolitan Area 1998 estimates used throughout this report.

9.2.1 Scenario Descriptions

Scenario 1: Carry on Much as Now

This base case scenario involves continuation of the current rate of waste avoidance, reuse, recycling and disposal in each of the three waste streams. The outcomes are summarised in Table 9-1 below:

Scenario 2: Improve Current Initiatives

This scenario involves improvements in municipal and C&I sector recycling participation, improved source separation, streaming and collection of garden waste, C&I dry recyclables and C&I food waste. Further improvements in C&D recycling are also included. The outcomes are summarised in Table 9-2 below.

The main initiatives taken in bringing this scenario to fruition are:

- A mix of regulatory, financial incentives, education and proposed C&I task force initiatives to increase diversion from disposal.

Municipal

- Collection of garden waste from all relevant areas on a frequent basis, using appropriate containers (a further 150,000 tpa from current level).

C&I

- Targeted food waste collection with focus on main producers currently disposing of food as mixed residual waste (a further 130,000 tpa from current organic waste collection level).

- Increased source separation by SMEs of dry recyclable materials: paper, industrial packaging plastics (a further 175,000 tpa from current level).

C&D

- Encouragement of further source separation initiatives (a further 182,000 tpa from current level).

Scenario 3: Aggressive Initiatives

This scenario involves dramatic improvements in recycling, source separation, streaming and collection in all sectors. The outcomes are summarised in Table 9-3.

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### Table 9-1 Scenario 1 Resources Flow Plan (million tonnes per annum)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Dry Recycling</th>
<th>Organic Recycling</th>
<th>Construction Recycling</th>
<th>Residual Reprocessing</th>
<th>Disposal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>0.300</td>
<td>0.150</td>
<td>0</td>
<td>0</td>
<td>1.350</td>
<td>1.800</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>0.405</td>
<td>0.045</td>
<td>0.050</td>
<td>0.614</td>
<td>1.600</td>
<td>2.100</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>0</td>
<td>0</td>
<td>1.500</td>
<td>1.500</td>
<td>0</td>
<td>2.500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.705</strong></td>
<td><strong>0.195</strong></td>
<td><strong>1.550</strong></td>
<td><strong>0.300</strong></td>
<td><strong>3.950</strong></td>
<td><strong>6.400</strong></td>
</tr>
</tbody>
</table>

### Table 9-2 Scenario 2 Resources Flow Plan (million tonnes per annum)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Dry Recycling</th>
<th>Organic Recycling</th>
<th>Construction Recycling</th>
<th>Residual Reprocessing</th>
<th>Disposal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>0.369</td>
<td>0.300</td>
<td>0</td>
<td>0.217</td>
<td>0.914</td>
<td>1.800</td>
</tr>
<tr>
<td>C&amp;I</td>
<td>0.580</td>
<td>0.175</td>
<td>0.050</td>
<td>0.083</td>
<td>1.212</td>
<td>2.100</td>
</tr>
<tr>
<td>C&amp;D</td>
<td>0</td>
<td>0</td>
<td>1.682</td>
<td>0.083</td>
<td>0.818</td>
<td>2.500</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0.949</strong></td>
<td><strong>0.475</strong></td>
<td><strong>1.732</strong></td>
<td><strong>0.300</strong></td>
<td><strong>2.944</strong></td>
<td><strong>6.400</strong></td>
</tr>
</tbody>
</table>
The main initiatives taken in bringing this scenario to fruition are:

• A mix of regulatory, financial incentives, education and proposed C&I task force initiatives to increase diversion from disposal.

Municipal

• Collection of food with garden waste at a frequency to match seasonal demand (a further 300,000 tpa from current level).

• Increased collection of recyclable materials through expansion of public place collection systems (a further 150,000 tpa from current level).

• Treatment and reprocessing of a portion of the residual waste steam (some 288,000 tpa).

C&I

• Expansion of food waste collection to SME food waste generators (a further 205,000 tpa from current organic waste collection level).

• Increased capture of industrial recyclables and sorting through C&I specialist MRFs (a further 495,000 tpa from current level).

C&D

• Best practice demolition activities featuring source separation for local reuse or sale (a further 400,000 tpa from current level).

9.2.2 Scenario Modelling

The scenarios were modelled for flow quantities and cost/revenue effects. Four value chain activities are covered: collection, transfer and transport, resource processing or disposal, and product sales. The illustrative outcomes, taking account of indicative financial costs and revenues are set out at Table 9-4. Activities and flows are shown diagrammatically in Figures 9-2 to 9-10.

Based on the Scenario Flow Plans at Tables 9-1 to 9-3, the following indicative total cost estimates can be derived:

Scenario 1: $571 million
Scenario 2: $600 million
Scenario 3: $649 million.

The incremental cost of moving from Scenario 1 to Scenario 2 is thus an indicative $29 million distributed as follows:

Municipal sector: $13 million
C&I sector: $9 million
C&D sector: $7 million.

The incremental cost of moving from Scenario 1 to Scenario 3 is an indicative $78 million, made up as follows:

Municipal sector: $31 million
C&I sector: $31 million
C&D sector: $16 million.

The conclusions from this modelling are:

• Significant further gains can be made in waste minimisation at modest cost.

• The net incremental cost increases between scenarios arise from specific waste diversion initiatives covering each waste sector.

• There are immediate opportunities for waste minimisation in the C&I sector to Scenario 2 level without major overall financial cost impost.

• The C&D sector offers good scope for further recycling without significant overall cost impost, though already some 60 per cent of this waste is recycled or reused (a proportion of it as landfill cover).

• Additional moderate financial costs are likely to result from the improved and aggressive initiative scenarios in the municipal sector.

Cost estimates and assumptions are set out at Table 9-5.

### Table 9-4 Scenerio Financial Outcomes

<table>
<thead>
<tr>
<th>Scenario</th>
<th>MUNICIPAL</th>
<th>C&amp;I</th>
<th>C&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1 (Current)</strong></td>
<td>25</td>
<td>24</td>
<td>60</td>
</tr>
<tr>
<td>Per cent Diverted*</td>
<td>$139.23</td>
<td>$81.43</td>
<td>$59.95</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario 2 (Improved)</strong></td>
<td>49</td>
<td>42</td>
<td>67</td>
</tr>
<tr>
<td>Per cent Diverted*</td>
<td>$146.33</td>
<td>$85.63</td>
<td>$62.72</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Scenario 3 (Aggressive)</strong></td>
<td>66</td>
<td>63</td>
<td>76</td>
</tr>
<tr>
<td>Per cent Diverted*</td>
<td>$156.40</td>
<td>$95.97</td>
<td>$66.35</td>
</tr>
<tr>
<td>Cost per tonne</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Excludes recovery of landfill gas.
### Table 9-5 Cost estimates and assumptions

#### Municipal

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual collection:</td>
<td>$66/tonne</td>
</tr>
<tr>
<td>Recycling collection:</td>
<td>$140/tonne</td>
</tr>
<tr>
<td>Garden/organic waste collection:</td>
<td>$80/tonne</td>
</tr>
<tr>
<td>Residual transfer and transport:</td>
<td>$15/tonne</td>
</tr>
<tr>
<td>Landfill:</td>
<td>$57/tonne</td>
</tr>
<tr>
<td>MRF processing:</td>
<td>$100/tonne</td>
</tr>
<tr>
<td>Compost processing:</td>
<td>$33/tonne</td>
</tr>
<tr>
<td>Enclosed compost processing:</td>
<td>$65/tonne</td>
</tr>
<tr>
<td>Residual reprocessing:</td>
<td>$105/tonne</td>
</tr>
<tr>
<td>Landfill gas revenue:</td>
<td>$100/tonne</td>
</tr>
<tr>
<td>Recyclate revenue:</td>
<td>$70/tonne</td>
</tr>
<tr>
<td>Compost revenue:</td>
<td>$25/tonne</td>
</tr>
<tr>
<td>Residual product revenue:</td>
<td>$10/tonne</td>
</tr>
</tbody>
</table>

#### C&I

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual collection:</td>
<td>$50/tonne</td>
</tr>
<tr>
<td>Recycling collection:</td>
<td>$85/tonne/$95/$105</td>
</tr>
<tr>
<td>Organic waste collection:</td>
<td>$85/tonne</td>
</tr>
<tr>
<td>Residual transfer and transport:</td>
<td>$12/tonne</td>
</tr>
<tr>
<td>Landfill:</td>
<td>$35/tonne</td>
</tr>
<tr>
<td>MRF processing:</td>
<td>$50/tonne</td>
</tr>
<tr>
<td>Compost processing:</td>
<td>$33/tonne</td>
</tr>
<tr>
<td>Enclosed compost processing:</td>
<td>$65/tonne</td>
</tr>
<tr>
<td>Residual reprocessing:</td>
<td>$105/tonne</td>
</tr>
<tr>
<td>Recyclate revenue:</td>
<td>$60/tonne</td>
</tr>
<tr>
<td>Compost revenue:</td>
<td>$25/tonne</td>
</tr>
<tr>
<td>Residual product revenue:</td>
<td>$10/tonne</td>
</tr>
</tbody>
</table>

#### C&D

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residual collection:</td>
<td>$30/tonne</td>
</tr>
<tr>
<td>Recycling sort/collection:</td>
<td>$45/tonne/$50/$55</td>
</tr>
<tr>
<td>Landfill:</td>
<td>$35/tonne</td>
</tr>
<tr>
<td>MRF processing:</td>
<td>$20/tonne</td>
</tr>
<tr>
<td>Fill material processing:</td>
<td>$10/tonne</td>
</tr>
<tr>
<td>Recyclate revenue:</td>
<td>$10/tonne</td>
</tr>
</tbody>
</table>
Figure 9-1 Residual waste treatment options

Residual Municipal Waste

- Externally heated rotating drum
- Biologically heated rotating drum

Processed Waste

- Screening
- Organic Pulp

Ferrous scrap for recycling

Oversize for RDF or landfill

- Rotating Mill

Pyrolysis

- Gasification
- Plasma Arc Reduction

Pyrolysis Oil

- Syngas
- Recyclable Metal and Slag
- Low Pressure Steam
- Biogas
- Anaerobic Sludge

Recycling as metal and aggregate

Energy recovery or industrial use

Energy recovery

Composting or land application

Ethanol/Methanol for sale

Mine rehabilitation

Chemical products

Low grade compost
Figure 9-2 Scenario 1 Municipal - Current

Collection Activity
- Residual: 0.731t @ $66/t = $48.24
- Recycling: 0.189t @ $140/t = $26.46
- Garden Waste: 0.080t @ $80/t = $6.40

Transfer & Transport Activity
- Transfer: 0.731t @ $15/t = $10.96

Resource Processing Technology
- Landfill: 0.750t @ $57/t = $42.75
- MRF: 0.189t @ $100/t = $18.90
- Composting: 0.080t @ $33/t = $2.64

Product Sales Activity
- Landfill Gas: 0.038t @ -$25/t = -$0.95
- Recyclates: 0.170t @ -$70/t = -$11.90
- Compost: 0.056t @ -$25/t = -$1.40

Total Cost: $139.23/tonne of waste arising
Disposal Diversion = 25%
Figure 9-3 Scenario 2 Municipal - improved

Collection Activity
Residual: 0.605t @ $66/t = $39.93

Transfer Activity
Transfer: 0.605t @ $15/t = $9.08

Transfer & Transport Activity
Residual: 0.605t @ $66/t = $39.93
Recycling: 0.228t @ $140/t = $31.92
Garden Waste: 0.167t @ $80/t = $13.36

Resource Processing Technology
Reprocessing: 0.150t @ $105/t = $15.75
Landfill: 0.508t @ $57/t = $28.96
MRF: 0.228t @ $100/t = $22.80
Composting: 0.167t @ $33/t = $5.51

Product Sales Activity
Products: 0.120t @ -$10/t = -$1.20
Landfill Gas: 0.025t @ -$100/t = -$2.50
Recyclates: 0.205t @ -$70/t = -$14.35
Compost: 0.117t @ -$25/t = -$2.93

Evaporation & CO₂ Gas
0.050t

Total Cost: $146.33/tonne of waste arising
Disposal Diversion = 49%
Total Cost : $156.40/tonne of waste arising
Disposal Diversion = 66%
CHAPTER 9

Figure 9-5 Scenario 1 C&I - Current

Total Cost: $81.43/tonne of waste arising
Disposal Diversion = 24%
Total Cost: $85.63/tonne of waste arising
Disposal Diversion = 42%
**Figure 9-7 Scenario 3 C&I - Aggressive**

**Total Cost : $95.97/tonne of waste arising**
**Disposal Diversion = 63%**
Figure 9-8 Scenario 1 C&D - Current

Total Cost: $59.95/tonne of waste arising
Disposal Diversion = 60%
Chapter 9

Figure 9-9 Scenario 2 C&D - Improved

Total Cost: $62.72/tonne of waste arising
Disposal Diversion = 67%
Residual: 0.210t @ $30/t = $6.30

Concrete & Timber: 0.300t @ $55/t = $16.50

Soil & Rubble: 0.490t @ $55/t = $26.95

Collection Activity

Transfer & Transport Activity

Residual: 0.210t

Concrete & Timber: 0.300t

Soil & Rubble: 0.490t

Resource Processing Technology

Landfill: 0.240t @ $35/t = $8.40
Processing: 0.300t @ $20/t = $6.00
Fill Material: 0.490t @ $10/t = $4.90

Fill Material: 0.030t

Product Sales Activity

Products: 0.270t @ -$10/t = -$2.70

Total Cost: $66.35/tonne of waste arising
Disposal Diversion = 76%
This Annex sets out the method and scoring basis used to evaluate the technology systems nominated. The assessment of technology classes and types is based on four issues:

- **Technical Issues**;
- **Environmental Issues**;
- **Social Issues**; and
- **Economic Issues**.

These four issues are broken down further as described below. Where possible a quantitative score (out of 5, with 5/5 being the most favoured) is allocated against each criterion on the basis of actual field performance. This is not always possible due to the early stage of development of some of the technologies.

### A1. Technical Issues

The technical/operational issues of the systems under review are considered from four aspects:

- Technology maturity.
- Input quality flexibility.
- Input quantity flexibility.
- Local availability of technology and expertise.

#### A1.1 Technology maturity

**Technology maturity** is an assessment of the relative development of the technology in terms of the reliability of the technology in treating waste, which is also indicative of operational risk. The scoring system for this issue below is based on the scoring system used by the German Federal Environmental Agency. The following scoring system is used:

- **5/5** Used successfully for purpose at commercial scale for many years with at least 80% annual operational time.
- **4/5** Used at commercial scale over a one to two year period (~10,000 hours operation) with expert assessment of environmental, technical and economic issues.
- **3/5** Successful operation of pilo plant over several months using waste with some analysis of environmental, technical and economic issues.
- **2/5** Operation of all parts of an experimental or pilot plant with waste.
- **1/5** Concept of a new process structured in a logical order prior to operation of a pilot plant, testing of some process components.

#### A1.2 Input quality flexibility

**Input quality flexibility** is the ability of the technology system to treat varying waste streams, which is important as waste is a heterogeneous feedstock. This measure covers both immediate heterogeneity/ homogeneity requirements of the technology, and the ability of the technology to process successfully waste inputs which may vary in composition over time. No direct quantitative score could be developed for this issue, so a scoring system was developed as below:

- **5/5** Technologies applicable to all waste streams including hazardous materials.
- **4/5** Technologies applicable to all waste streams except hazardous materials.
- **3/5** Technologies applicable to treating or recovering value from the bulk of waste.
- **2/5** Technologies applicable to treating only one waste stream (eg, organics).
- **1/5** Technologies applicable to only one waste type (eg food waste, biosolids).

#### A1.3 Input quantity flexibility

**Input quantity flexibility** refers to the adaptiveness of the technology to input quantity variations over time. Considerations include technical, financial and employment implications of swings in supply of resource for processing. The assessment is based on the following scoring:

- **5/5** Able to handle large variations in waste input quantity (100%) rapidly with little capital expenditure/overcapitalisation.
- **4/5** Able to handle moderate variations in waste input quantity (50%) with little capital expenditure/overcapitalisation.
- **3/5** Able to handle moderate variations in waste input quantity (25%) with moderate capital expenditure/overcapitalisation.
- **2/5** Able to handle some variation in waste input quantity (10%) with moderate capital expenditure/overcapitalisation.
- **1/5** Unable to handle variations in waste input quantity.

#### A1.4 Local availability

**Local availability** of technology and expertise is an assessment of the ability for the technology to be adopted for use in Australia, including the extent to which expertise and specialised equipment would need to be imported to support the use of the technology.

- **5/5** Australia has world class expertise in development, construction and operation of the technology.
- **4/5** Local expertise and operational experience, but leading edge development work or critical equipment would need to be imported.
- **3/5** Some local expertise or experience, but expertise and equipment would need to be imported.
- **2/5** Limited local expertise, most expertise and/or equipment would need to be imported to support operation.
- **1/5** No local expertise or operations, all would need to be imported.
A2. Environmental Issues

The assessment of the environmental impacts covers issues that can be assessed at various levels. These levels include **localised** impacts such as toxic air emissions, odour, dust and noise; **regional** impacts such as water use, summer smog and residual solid waste disposal; and **global** impacts such as greenhouse gases and material sustainability. It is however not practical or sensible to compare these impacts to each other.

Some life-cycle assessments (LCAs) have attempted to reduce all impacts to monetary values, but the more common approach is to aggregate the impacts into a number of categories, to which different weighting criteria may be applied. For example, the Southern Sydney Waste Board Residual Waste Treatment Study considered environmental performance under four categories:

- **emissions to air**, which was based on volume of air needed to dilute the emissions from processing one tonne of waste to meet the environmental emission standards combined with an expert assessment of the technology;
- **emissions to water**, which was based on volume of water needed to dilute the emissions from processing one tonne of waste to meet the environmental emission standards combined with an expert assessment of the technology;
- **solid waste**, based on weight of residual waste per tonne of input; and
- **greenhouse gases**, based on CO2 equivalent emissions minus any emission credits per tonne of waste processed.

Another Australian LCA study being undertaken for EcoRcycle Victoria uses a different list of environmental impacts when assessing the impact of recycling a number of materials. These are:

- greenhouse;
- summer smog;
- acidification;
- energy;
- eutrophication;
- solid waste; and
- water use.

The inquiry has not undertaken a further ground-up quantitative environmental assessment of the various technologies, as considerable uncertainty exists regarding the results of these assessments. For example, full emission inventories do not yet exist for newer technologies, but this should not form a barrier to the development of new technologies. Also considerable uncertainty exists regarding the actual emissions of pollutants from some technologies. Even landfills, which will vary widely depending on the nature of the waste and the amount of moisture allowed to infiltrate into the landfilled waste.

Newer enclosed waste facilities usually incorporate extensive air and water collection and treatment systems, which can make up to 50 per cent of the capital cost of the facility. With these systems the environmental impacts of the facility is minimised by increasing the capital and operating costs. Beyond prescribed emission limits the tradeoff between environmental impact and pollution control is an economic and social decision, but some processes are intrinsically cleaner than competing processes and hence this environmental expense is lower.

Moreover, the inquiry is conscious that resource conservation impacts and energy efficiency are critical environmental issues. Although only indicative impacts can be assessed due to data limitations, these have been included in the array of environmental criteria.

For this assessment the environmental issues have been classified into five main areas:

- Resource conservation;
- Solid residues;
- Greenhouse gas emissions;
- Risk of water emissions;
- Risk of air emissions.

A2.1 Resource conservation is a critically important environmental consequence of waste treatment and processing. Recycling and reprocessing substitutes previously extracted, refined and processed materials for virgin raw materials. Many studies have shown that the resultant conservation of resources is a significant environmental benefit. Greatest benefit accrues in treating and reprocessing finite resources and elaborately transformed materials. It must be stressed that both the technology and the accompanying waste management practices must be regarded as a “system” in order to achieve these benefits. However in this analysis each technology is considered in isolation and for application to the resource it is best suited to treat. The assessment is based on the following scoring:

- 5/5 High potential savings in terms of materials and/or energy.
- 4/5 Moderate potential savings in terms of materials and/or energy.
- 3/5 Small or neutral savings in terms of materials and/or energy.
- 2/5 Moderate potential loss of resource materials and/or energy.
- 1/5 High potential loss of resource materials and/or energy.

A2.2 Solid residues are the residual solid wastes that require disposal at the completion of a waste processing or disposal operation. These vary widely depending on the level of contamination in the incoming waste, so the level of source separation practiced has a large influence. The amount and nature of the solid residues is an important measure of the sustainability of the process and where it fits in the waste management hierarchy, as a process that produces large amounts of solid residue has poor sustainability and would be at the bottom of the hierarchy.

The assessment of solid emissions by the inquiry is as follows:

- 5/5 Negligible residues – residual wastes are low (land application, new oxidation).
- 4/5 Minor residues – minor residual wastes, less than 20% of incoming waste (incineration, pyrolysis/gasification, material sorting).
• 3/5 Significant residues – residues dependant on level of contamination in input waste being processed (enclosed composting, open window composting, anaerobic digestion, fermentation, vermicomposting).

• 2/5 Considerable residues – large amounts of residues of marginal value (waste separation).

• 1/5 Major residues – very little reduction of solid waste through process (landfill).

ANNEX A

A2.3 Greenhouse gas emissions include carbon dioxide and monoxide, methane, non-methane organic compounds (NMOCs), fluoro carbons and nitrogen oxides (NOx). Greenhouse gases are aggregated according to “CO2 equivalent” greenhouse effect, with gases such as methane having a claimed 21 times the greenhouse impact of CO2. Except for fluoro carbons, the emission of these gases is not always directly regulated, but their minimisation is discouraged through economic measures such as green electricity being sold at a premium, and requiring landfills to flare landfill gas to convert methane to produce the less harmful greenhouse gas carbon dioxide.

Greenhouse gas emissions are of concern in relation to the sustainability of various waste management options. In 1997 it was estimated that waste management activities contribute almost four percent of Australia’s total greenhouse gas emissions, mainly consisting of methane emissions from landfills (3.3 per cent). In larger landfills the recovery of landfill gas for generating electricity is economically viable, and most of the viable landfill gas potential is believed to be currently utilised in NSW.

Drawing these results together the Inquiry rated the greenhouse impacts of various waste technologies as below:

• 5/5 Beneficial.
• 4/5 Moderately beneficial.
• 3/5 Negligible.
• 2/5 Moderately detrimental.

A2.4 Air and Water Emissions It has been assumed by the Inquiry that any proposed technology would be installed with appropriate air and water emission collection and treatment systems, sufficient to meet NSW emission standards. These systems can comprise a significant portion of the capital and operating costs, and have been reflected in the economics of the technologies assessed.

Some studies have sought to assess air and water impacts by quantifying the fugitive air and water emissions below these limits, but these largely reflect the amount of resources used for emission control systems. The Inquiry however believes that a more productive approach was to make an expert assessment of the risk of air and water emissions based on the relative emission probability and consequence. These have been assessed according to the probability/consequence matrix outlined in the Australian risk assessment standard.

A3 Social Issues

This covers the social issues associated with the waste processing or disposal technology. These issues are broken down into four areas:

• Community involvement in resource conservation;
• Public perception;
• Amenity impacts; and
• Employment impacts.

A3.1. Community involvement in resource conservation refers to the extent to which the community is able to become associated in some way with activities associated with the technology and the broader practice involved. This reflects the importance accorded by the community making a contribution to the recycling of waste resources and, to some extent, to comprehend and identify with the fate of disposed materials.

It is a measure of the extent to which citizens relate to closed-loop recycling. For example, people readily support waste separation and can see the outcome of a composting facility through being asked to purchase the finished product (i.e., the Waste Service “Garden-to-Garden” program).

The assessment of citizen and business involvement potential uses the following scoring:

• 5/5 High involvement by the community providing a contribution to local or regional community capital.
• 4/5 High involvement by the local community, but modest involvement at a regional level.
• 3/5 Modest involvement at local and regional community levels.
• 2/5 Minor scope for community involvement and participation.
• 1/5 No scope for community involvement and participation.

A3.2. Public perception is an assessment of the broad community attitude to the technology. Such attitudes are usually formed through a combination of lengthy operating experience, pollution control record and technology complexity; a complex amalgam of perceived risk and benefit. Although no direct polling of waste technologies has been conducted by the Inquiry, an indication can taken from:

• public opinion surveys on environmental issues such as the EPA Who Cares about the Environment in 1997?
• public reaction to existing or proposed waste technologies in NSW;
• public reaction to waste technologies examined overseas.

These indicate that the community support initiatives for waste avoidance and recycling, followed by reuse and then reducing the environmental impacts associated with waste facilities.

In addition, careful note has been taken of current and emerging overseas attitudes to various types of waste management facilities. Cultural differences prevent direct application of overseas attitudes. These observations are therefore to inform rather than develop the evaluation.

The assessment of public perception/confidence is based on the following scoring:
• 5/5 High public confidence in the technology.
• 4/5 Moderate public confidence in the technology.
• 3/5 No clear attitude to the technology, mostly due to newness.
• 2/5 Poor perception of the technology by some sections of the community.
• 1/5 Broadly based hostility towards the technology.

A3.3. Amenity impacts from waste facilities occur from a number of activities associated with facility operation. These include:

• Traffic noise which is directly related to the amount of waste being brought to and materials and wastes being exported from the facility, so are largely unavoidable. The number of people affected can be minimised by planning haulage routes to and from the facility can be planned to avoid populated areas, ensuring haulage vehicles are well maintained, and locating the facility in an appropriately zoned area (usually medium industry).

• Operation noise, dust and odour which are dependant on whether the facility is an open facility such as an open window composting facility or a landfill or is an enclosed facility with appropriate controls. An enclosed facility with appropriate environmental controls will have similar impacts to a transfer station handling the same amount of waste, and is generally suitably located in a medium industrial area, or rural area with appropriate buffer distances.

• Visual impact is related to the scale of the facility and the architectural design of the facility. Facilities that cover a large area of land such as landfills and open windrow composting facilities the visual impact will be unavoidable if the facility is located in an exposed area, although screening mounds and vegetation can reduce the impact. For some facilities the visual impact of the air emission stacks can galvanise concern regarding toxic air emissions, and this is one of the reasons that much attention is paid to the architectural design of newer incinerators in Europe.

In conclusion the amenity impacts of a facility are largely determined by the nature of the technology.

• 5/5 Negligible impacts – impacts are low and localised to point of generation and extra truck movements.
• 4/5 Minor impacts – impacts localised to application point.
• 3/5 Significant impacts – impacts of noise, dust, and visual amenity due to handling of waste within an industrial process.
• 2/5 Considerable impacts – as above, but also with stacks for air emissions and electrical generation and transmission infrastructure or chemical storage.
• 1/5 Major impacts – impacts unavoidable due to the nature of the operation being handling waste outdoors.

A3.4. Employment impacts refers to the scope for job creation directly and indirectly as a result of engagement of the technology. It is often used as a partial justification of waste processing over disposal. This measure has been assessed using the number of people directly employed times a multiplier of 1.5 at a facility processing 100,000 tpa.

The assessment of local employment potential is based on the following scoring:

• 5/5 Significant direct/indirect employment opportunities involving a variety of skill levels and opportunities for further development.
• 4/5 Moderate direct/indirect employment opportunities involving a variety of skill levels.
• 3/5 Moderate direct/indirect employment opportunities.
• 2/5 Low direct and indirect employment opportunities.
• 1/5 Very low employment opportunities.

A4. Economic Issues

Economic issues consider the economic feasibility of the technology in a number of key areas. These areas are:

• Net cost per tonne.
• Cost/scale sensitivity.
• Net benefits per tonne.
• Market availability for products.

A4.1 Net cost per tonne of waste input is estimated from the capital and operational figures supplied from the technology providers and obtained by the Inquiry from independent sources.

The assessment of net cost/tonne of waste input is based on the following scoring:

• 5/5 Less than $50.
• 4/5 $50 > $100.
• 3/5 $100 > $150.
• 2/5 $150 > $200.
• 1/5 More than $200.

A4.2 Cost/scale sensitivity examines the sensitivities of costs to variations in the scale of the facility, and the extent to which the technology is driven to require large scale operation in order to achieve the necessary economies of scale.

The assessment of cost/scale sensitivity is based on the following scoring:

• 5/5 May be small, medium or large scale operation, with little variation in processing cost.
• 4/5 May be small, medium or large scale operation with moderate variation in processing cost.
• 3/5 Medium to large scale operation best for economies of scale.
• 2/5 Large scale operation necessary to achieve economies of scale.
• 1/5 Large scale operation is the only feasible configuration.

A4.3 Net benefits per tonne of waste input has been developed from Australian and International estimates of revenue from sale of resources, on a net tonne of input basis.
The assessment of net benefits per tonne of waste input incorporates the following scoring:

- **5/5** More than $70.
- **4/5** $50 > $70.
- **3/5** $30 > $50.
- **2/5** $10 > $30.
- **1/5** Less than $10.

**A4.4 Market availability for products** is a measure of the maturity and stability of the markets for products produced from waste, and the relative position of the products in these markets. For example, energy recovered from landfill gas has a large proven market as “green power”.

- **5/5** Products with a large proven market.
- **4/5** Products with a varying market.
- **3/5** Products with a marginal market.
- **2/5** Products now waste with some potential for future markets.
- **1/5** Products with marginal or negative value.

ANNEX B Submissions to the Waste Inquiry

Charles Macfarlane
Australians for an Ecologically Sustainable Population Inc

Singapore Ministry of the Environment

AWS Clinical Waste

Brentwood Recycling Systems

Rethmann Australian Environmental Services Pty Ltd

Gosford Wildlife Conservation Society

AIRVAC Vacuum Collection Systems

EENEE Designs

Ms Lyndall McCormack

Cairncross Tip Action Group

Phoenix Technology Corporation Limited

Friends of the Earth Spartel Pty Ltd

Geo-Eng Australia Pty Ltd

Pittwater Flora & Fauna Society

Waste Contractors and Recyclers Association of NSW

Colt Engineering Corporation, Canada

Australian Council of Recyclers

Telegraph Point Community Association Inc

Thiess Environmental Services

Carl R. Sinclair

Natures Wonder

Monash University - Centre for Environmental Management

Wastewater Management Authority, Ministry of Science, Technology and Environment, Thailand

Toshiba International Corporation Pty Ltd

Enecon Pty Ltd

Energy Developments Limited (now Brightstar Environmental)

J. M. Holmes

Herhof-Umwelttechnik, Germany

Dolocrete Environmental Solutions

Sustainable Development

Technological Sciences and Engineering

Singleton Environment Group

Recyclit Technologies Pty Ltd

Judith Anderson

NSW Department of Urban Affairs and Planning

Singleton Environment Group

Dr William B. Gara

Ms Liesbeth Ramzan

Eli Eco Logic Aust. Pty Ltd

EarthPower Technologies Sydney Pty Ltd

Australian Biomass Taskforce

Commercial Organics

Friends of the Earth

IGL Iggulden

Colin Hill

In-Sink-Erator

My Nguyen

Darren Bragg

People Against Ardlethan Landfill Inc.

Roderick Holcombe Environmental Services

Bedminster Bioconversion (Australasia) Pty Ltd

Atlas Group Pty Ltd

Pymont Raw Materials

Wollongong City Council

GeoFlora Life Science Pty Ltd

Waste Works World Limited

World Oasis Australia Pty Ltd

Total Environment Centre

Monaro Regional Recycling Service Pty Ltd

Australian Industry Group

Ausmelt Limited

CRC for Waste Management and Pollution Control Limited

Sustainable Energy Development Authority

Nature Conservation Council of NSW Inc

Waste Education Strategic Directions Writing Group

Local Government and Shires Associations of NSW

Penta-Link Pty Ltd

City of Sterling, Western Australia

Waste Service NSW

Hornsby Shire Council

Combined NSW Waste Boards

D. J. Sasson-Gubbay

Collex Waste Management Pty Limited

Western Sydney Waste Board

NetWaste

Dowmus Pty Ltd

NSW Environment Protection Authority

Environmental Solutions International Ltd

Inner Sydney Waste Board