APPENDIX A:

Review of alternative solid waste management technologies and practices: feasibility, ESD, environmental impacts, barriers, economics and employment benefits.

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INTRODUCTION

In reviewing alternative waste management technologies and practices, it has become apparent that the Australian approach to waste management has been largely 'end-of-pipe' to date. This review highlights a need to move away from the waste removal and disposal mentality and towards a resource efficiency and services provision mentality.

The following review assesses technologies and practices for reducing the volume to landfill of four waste streams: organics (food waste), green waste, paper and plastics. These four waste streams have been chosen on the basis of their combined overall contribution to waste, they account for over 31% of all waste disposed to landfill in Greater Sydney Region (GSR)[1]. Additionally, these waste streams allow resource efficiency and resource recovery mechanisms to be explained using examples to illustrate the concepts involved. A more general review of technologies and practices appears in reference document A.

Various technologies and practices for paper, organics, plastics and green waste are reviewed, covering resource efficiency type measures (avoidance, reduction and reuse) and resource recovery (recycling). Case studies are provided to illustrate how alternative technologies or practices have been applied in Australia and overseas. Where available, actual economic and employment impacts of the various approaches are reported, otherwise estimates are made. Barriers are reviewed and comment is made on the ecological sustainability and environmental impacts of technologies and practices. Obviously these factors are strongly context dependent.

Many of the broader questions regarding assessment of different approaches to waste management relate to the scale at which technologies are implemented, site specific factors, and relative (subjective) valuations of benefits and costs. For example, transportation of organic waste to large scale, centralised recycling facilities may cause transport related environmental and social negatives (eg. CO_2 emissions, increased vehicle pollution and accident morbidity and mortality risk) while providing economic (eg. savings due to economies of scale) and employment benefits (eg. increased employment in transport and allied sectors). In a high unemployment area, employment and economic benefits may be seen to outweigh environmental and health impacts.

1 Based on 1996 waste production rates as per report one of this consultancy

SOURCE REDUCTION AND RECYCLING: INCENTIVES AND MECHANISMS

Source Reduction

Source reduction seeks to reduce waste generation at, or before, the point at which a useful product becomes a waste product. This approach corresponds with the first priorities of the waste hierarchy – avoid, reduce, reuse. Source reduction can be achieved through a wide range of mechanisms, for example: legislation for minimum packaging; education of the consumer (e.g. promoting purchase of non-disposable goods, ways of reusing waste products); and redesign of products for durability / repairability. In the following document, source reduction mechanisms are described in order to illustrate the wide range of measures which may be used to achieve reduced resource consumption in terms of raw materials and inputs associated with processing, and reduced waste generation. In general, source reduction mechanisms which promote avoidance or reduction are likely to lead to more efficient use of resources and reduced waste generation. Reuse of waste products needs to be examined in a case-by-case way to ensure that associated inputs (e.g. transport) do not outweigh the benefit of reuse over direct disposal to landfill.

Recycling

Recycling is the re-processing of a waste product to produce a different, useable product. Examples of mechanisms which encourage recycling include: landfill bans or increased levies for disposal of the target waste stream; incentives for research and development of new products from waste; extended producer responsibility; improved market value of the product (this may result, for example, from a relative increase in cost of virgin materials or consumer pressure for recycled content); and education of waste generators to divert recyclables from landfill. While recycling is usually preferable to disposal of resources, economic, social and environmental costs of re-processing need to be explored to ensure recycling is the more sustainable option.

ORGANICS

Source Reduction

Description of mechanisms

Mechanisms for source reduction of organic wastes include:

- Increased efficiency in the transport and storage of organics;
- Education about organics purchasing in both the domestic and commercial sectors (eg. catering and hospitality industries);
- Education about minimising waste during food preparation (domestic and commercial sectors);
- Cleaner production programs offering advice and support to the commercial food processing sector on minimising food wastes and finding suitable uses for material currently wasted;
- Promoting purchase of locally grown produce;
- An increase in decentralised and urban agriculture (both domestic and commercial);
- Promotion of spoilage resistant and seasonal produce;
- Financial incentives for householders to reduce the volume of municipal waste produced (e.g. pay by size of bin or pay by weight for waste collection);
- Reuse of waste organics (e.g. donation to charitable organisations, livestock feed);
- Appropriate 'product design' by the retail sector. Either unpacked product available or analysis of appropriate packaging size (e.g number of carrots per bag, number of rashers of bacon per pack) and size of produce (e.g. large cabbage vs mini cabbage) for a range of typical household sizes; and
- Decentralisation of retail outlets to allow more frequent small purchase of organics.

Examples of mechanism

To some extent the promotion of spoilage resistant food is currently reflected in the lower cost of these goods. Producers, wholesalers and retailers charge a premium for goods that spoil rapidly, to cover the cost of stock loss. While this mechanism may incorporate a cost for disposal of spoiled product, it is a hidden cost and unlikely to cover the true cost to the community of disposal.

The Earthworks community education program covers a number of waste streams including organics. For organics source reduction, participants are encouraged to buy only the organic produce that they need and to avoid buying pre-packaged organics (both to avoid the packaging and to avoid buying in excess of needs). A more detailed description of the Earthworks program appears in the *Plastics* section below.

Brumby's Bakery in Randwick and the Fast & Fresh pre-prepared sandwich shops in Sydney's CBD donate excess stock to charitable organisations such as the Sydney City Mission and the Salvation Army. The food is distributed by the charities to, for example,

under privileged, impoverished or homeless people. Fast & Fresh sandwich shops (two shops in the CBD) have donated over $1,000,000 (retail value) worth of stock to the Salvation Army since the business opened. While Fast & Fresh apparently over-produce in order to meet their community responsibilities, this suggests that donation of excess sandwiches to charity by two inner city sandwich retailers would represent a decrease in organics to landfill of around 20 tonnes per annum. Employment is generated in co-ordinating, transportation and distribution of food to recipients (currently most of these positions are filled by volunteers).

A number of community gardens operate in Sydney (e.g. Addison Road Community Garden, Marrickville; Angel Street Community Garden, Erskineville; Randwick Community Gardens, Randwick). Community gardens and backyard vegetable production are likely to reduce organic waste as residents may pick food as they need it and excess product can be stored (frozen, dried), distributed amongst the community or recycled (e.g. composted).

Commercial waste collection weight based fees were introduced in Florida in 1996. The resulting decrease in solid waste volumes lead to the city's refuse collection service saving just under $US1 million in less than two years. These savings resulted from cut backs in the number of trucks and crew employed in collecting waste, the number of job losses are not reported. The surplus was used to reduce rates to customers and the approach was reported to have increased recycling rates.

Recycling

Description of mechanisms

Mechanisms for increasing recycling of organic wastes include:

- A ban on organics to landfill, leading to: reduced organics disposal, stabilising of feedstock supplies for organics re-processors, and increased demand for re-processing activities. It has been suggested that markets for end-products of organics re-processing may not adjust rapidly enough for this approach to be viable on a large scale in the short term.
- Increased tipping fees for organics, reducing the cost differential between landfilling and re-processing;
- Education and technical advice for householders and commercial premises to re-process organics on-site;
- Provision of readily accessible facilities for re-processing organics (e.g. composting, vermicomposting, or biodigestion). Possible approaches are backyard, or decentralised facilities, or transport systems combined with centralised facilities;
- Collection and re-processing service for commercial and institutional food wastes;
- Collection and re-processing service for domestic sector food wastes;
- Research and development funding, or infrastructure development funding to evaluate, establish and promote technologically reliable organics re-processing facilities (decentralised home composting type, small scale municipal and centralised); and

- Tax breaks or transport subsidies for organics recycling businesses and products made from recycled organics.

Examples of mechanisms

Explanatory note:

Some technologies that recycle organic waste require source separated feedstock while others can recycle the organic fraction from mixed wastes . Recycling of organic waste is generally undertaken by composting, vermicomposting, biodigestion, or incineration for energy. Composting converts organic waste to soil conditioner or fertiliser through microbial (and sometimes mechanical) degradation. Vermicomposting produces soil conditioner or fertiliser, liquid fertiliser ('worm tea') and biomass (worms). Biodigestion is the anaerobic microbial breakdown of organics to produce methane and other combustible gases which are usually used for energy generation. Larvae composting is also currently in use in Australia[2].

A number of Councils in Sydney offer support to householders and organisations in their LGA who wish to compost or vermicompost organic wastes on-site. South Sydney Council has an Education Officer who conducts in-house training for employees who wish to run worm farms in the workplace. Botany Council has an Education Officer who has visited residents' homes to assist residents in establishing compost bins and worm farms. Randwick Council retails compost bins and worm farms to residents at a low cost (standard Reln worm farm approximately $20 lower purchase price than retailer Target[3]).

In 1987, Cherry Hill, New Jersey, USA (population 73,000) introduced mandatory recycling of corrugated cardboard and high grade paper for businesses operating in the town. Businesses were required to submit tonnages recycled for all wastes recycled to the town's Recycling Co-ordinator. In the following year, businesses in Cherry Hill reported recycling 503.4 tons of food waste even though food waste recycling was not mandatory and businesses had to arrange private recycling of organic waste. This represented approximately 1% of the towns overall commercial waste generation. Cherry Hill landfill tipping fees were $US53/ton in 1989.[4]

In 1989, Recycling Market Development Zones (RMDZ) were established in California to reduce waste to landfill by 50% by 2000. RMDZs provide low-interest loans and assistance for recycling businesses to increase uptake of recovered raw materials. Loans totalling $29 million have been made to businesses, many of which are recycling organics. It is estimated

2 Source: Richard Hughes, Perfect Worms, Lismore.

3 As at October 1998 when the author purchased a standard Reln worm farm from Target and one from Randwick Council.

4 Platt, B., Doherty, C., Broughton, C-A. and Morris, D. (1991) Beyond 40 Percent: Record-setting Recycling and Composting Programs. Institute for Local Self Reliance. Washington DC, USA.

that 2.3 million tons/year of solid waste will be diverted when all participating businesses complete capacity upgrades, and 721 jobs will be created[5].

The Earth Solutions Vertical Composting Unit is an in-vessel system for putrescible waste. It is a world patent that has been substantiated in the last 2 months. It has been 4 years in development and now operates commercially. The composter contains microbes that live at a temperature of 80-90^{0}C. These microbes degrade gases that are produced which results in an odourless process. The unit is currently operating at Long Bay Jail and the University of New South Wales (UNSW). The end product is a stabilised organic compost. At UNSW, 1 person is employed 2 hours a day to run the unit which produces 3 tonnes of stabilised compost each day.[6]

The offices of the Sydney Organising Committee for the Olympic Games (SOCOG), located in Ultimo, are vermicomposting some food waste and shredded paper produced on-site. A worm farm is maintained in the high rise office block's basement and wastes from the preparation of SOCOG's canteen food is source separated and transported to the basement. The farm processes approximately 120kg of food waste and requires approximately one hour maintenance each day. This suggests that one full-time employee operating a scaled up system could process around 250 tonnes of food waste per annum. The product is a good quality soil conditioner, which would be expected to have high retail value (up to $1/kg retail[7]).

Connecticut Department of Correction, USA, established composting in a prison that was generating 1,086 tons of MSW per year. Collection, transport and disposal of which cost the prison $US 106,833/a. With the exception of meat, bones, and grease, all plate scrapings and pre-consumption (prep) scraps were composted. The cost of establishing the composting facility and equipment was $US 130,000. In three months of operation the facility processed 73.6 tons and saved $US 4,784 in tipping fees alone (based on above quoted collection, transport and tipping fees, the total saving was around $US 7,200 and estimated annual saving $US 28,900). The project employed 30 inmates although the author suggests that free labour resulted in a system that was more labour intensive than would have otherwise been the case[8]

Stirling Council (WA) co-ordinates the ATLAS project, a municipal mixed waste sorting facility, which sorts wastes into organics, ferrous metals and residual waste. The facility took the City of Stirling's municipal residual waste (after source separation of recyclables). In the 1997/98 financial year, the ATLAS plant received 66,612 tonnes of waste and produced 46,600 tonnes of compost. This employed 12 people full-time. Disposal fees at the facility were the same as local landfill fees ($14/tonne). The ATLAS project was shut down

5 Block, D. (1999) Government financing and expertise boost recycling businesses. Biocycle. 40(2): 45-48. 1999 Feb.

6 Source: Peter Rutherford, Earth Solutions

7 Lotzof. M. (1999) The Wonder of Worms for Sludge Stabilisation. Water. Journal of the Australian Water and Wastewater Association. Jan/Feb: 38-42.

8 Block, D. (1997) Composting prison food residuals. Biocycle 38(8): 37-39. 1997 Aug.

due to a number of problems including resident resistance and regulatory difficulties, however operations will re-commence in December 1999 under a new set of conditions.[9]

The Port Stephens Council has been operating an aerobic co-composting system called the Bedminster System that takes in a mixture of mixed solid waste and sewage sludge (ratio: 2.5:1). The waste is primarily domestic waste (70-80%), however, construction and demolition, and green waste can also be put into the digester. It spends three days in a digester during which the temperature is taken to 55°C. The treated waste is then fed through a screening process at the end of three days to remove large contaminants. After 28 days on a maturation floor a final screening process removes anything with a diameter greater than 3mm. Usually about 10-20% of the material is landfilled at the end of the process. The final product is sold to the agricultural market. The aim is to produce 20,000 tons a year and to divert 90% of waste away from landfill by the end of 1999. The Port Stephens facility has 10 full time employees. Currently there is no financial benefit to the council. Council has signed an agreement whereby the site is leased, operated and maintained for 20 years. The council pays a fee at the gate of between $80-90 / ton.[10]

9 Source: Viet Nysen, Stirling Council (WA)

10 Source: Michael Skins, Port Stephens Council

Review of Organics Approaches

Mechanism	Jobs per tonnes diverted	Potential diversion GSR[11]	Economic Costs and Benefits	Environmental impacts and barriers
	positions : tonnes / year	tonnes / year		
Community education (e.g. Earthworks)	1:135[12]	16,100[13]	• Participants benefit from reduced purchase of organic produce • Potential foregone revenue for organic producers and retailers • Cost to councils of staffing courses (currently most courses are run through councils)	• Running of courses depends on community motivation (teaching and participation) • Response depends on behaviour change which may be transient • Results of minimisation activities are hard to quantify • Negligible negative environmental impacts • Course also offers training in minimising a number of other wastes and community waste minimisation outreach

11 Based on 1996 waste production rates as per report one of this consultancy

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

13 Assumptions as above

Mechanism	**Jobs per tonnes diverted**	**Potential diversion GSR[11]**	**Economic Costs and Benefits**	**Environmental impacts and barriers**
Food waste to charity (e.g. excess stock from food outlets)	1:20[14]	18,000[15]	• Reduced waste service charges to the commercial and institutional sector • Potential foregone revenue from the sale of food in localities of food distribution • Savings to recipients of food in purchase of food • Cost to charities of co-ordinating distribution and transporting food to distribution points	• Food supplies will fluctuate (e.g. weekends, rainy days) and not provide reliable sustenance • Potential environmental impact from food miles travelled unless food distributed locally

14 Assuming one person to collect and distribute approximately 400 meals daily
15 Assuming 20% of C&I food waste is edible and a 15% C&I sector participation rate

Mechanism	**Jobs per tonnes diverted**	**Potential diversion GSR[11]**	**Economic Costs and Benefits**	**Environmental impacts and barriers**
Large scale composting (e.g. windrow composting at Lismore)	1:3000	345,000[16]	Lismore Case Study[17]: TOTAL COSTS $62.15/tonne Infrastructure $ 6.60/tonne Operating $ 42.75/tonne Other $ 12.80/tonne TOTAL SAVING $30.00/tonne Avoided tip fees $ 30.00/tonne TOTAL INCOME $30.00/tonne Product $ 30.00/tonne NET COST $ 2.15/tonne	• Requires source separated feedstock • Transport of organics (particularly from municipal sources) could cause high environmental impacts • While the decomposition process is passive, energy inputs are required for loading windrows, aerating or turning compost and removal of finished product • Creates some leachate which must be contained • A reliable source of bulky (carbonaceous waste) is required • A reasonable level of expertise is required to successfully finish a large batch of compost

16 Assuming 25% municipal and 50% C&I organic waste is processed

17 Denlay, J. (1993) Lismore City Council Waste Minimisation Strategy: Organics Recycling Strategy. 25 August, 1993.

Mechanism	Jobs per tonnes diverted	Potential diversion GSR[11]	Economic Costs and Benefits	Environmental impacts and barriers
Vertical composting (e.g. VCU at UNSW)	1:2,000[18]	300,000[19]	• Infrastructure cost may be high (VCU, vacuum motor, and grinder) • Operating cost low (including low energy requirement) • Provides high value product (soil conditioner) • Reduced waste disposal fees (organics and green waste)	• Requires source separation and bulking agent (an advantage in the light of the green waste ban) • Creates some leachate which must be contained • Odour / air pollution is eliminated in the hot zone prior to venting • Non-passive (requires energy consumption for operation of motors and grinders) • Treats all organics (including meat and dairy)
Medium scale vermicomposting (e.g. SOCOG in Sydney)	1:250[20]	NK (depends on number of employees in Sydney high-rises)	• Low set-up costs • Provides high value product (soil conditioner) and there is potential for income from worm biomass • On-site, so minimises transport costs	• Source separation required • Excludes re-processing of some organics (meat, dairy, onion, citrus) • Takes up space which is often in demand for other uses (e.g. storage, parking) • Passive or low energy use technology • On-site, so minimises transport environmental impacts

18 For a nine tonne per day VCU (approx. 60 cubic meters)
19 Assuming 50% of C&I organics processed
20 See description of SOCOG's worm farm

Mechanism	Jobs per tonnes diverted	Potential diversion GSR[11]	Economic Costs and Benefits	Environmental impacts and barriers
Large scale vermicomposting (e.g. Vermitech style)	1:2400[21]	345,000[22]	• Income from castings $250 - $1000 / tonne[23], potential for income from worm biomass • Low operating expenses - administration, salaries, and machinery (fuel and maintenance) • Avoided tipping fees (however cost of treatment may outweigh this saving) • Collection and transport of organics (especially from municipal) may be expensive	• Large research and development costs associated with design and proving of technique • Establishment cost of infrastructure may be high • Ongoing energy requirements for application of waste to worm beds • Transport of organics to centralised treatment facility will cause transport related environmental and social impacts • Process uses green waste • Product may lead to a decline in use of fertilizers (e.g. superphosphate)

21 Assuming 3:1 organic waste to woody (green) waste

22 Assuming 25% municipal and 50% C&I organic waste were processed

23 Lotzof. M. (1999) The Wonder of Worms for Sludge Stabilisation. Water. Journal of the Australian Water and Wastewater Association. Jan / Feb: 38-42.

Mechanism	**Jobs per tonnes diverted**	**Potential diversion GSR**[11]	**Economic Costs and Benefits**	**Environmental impacts and barriers**
Mixed waste composting (e.g. Bedminster)	1:2,000[24]	0.9M[25]	• Infrastructure cost likely to be high • Operating cost may be high (Port Stephens Council pay an $80/tonne drop-off fee) • Product is resaleable • Cost from collection and transport of waste to centralised facility likely to be high	• Environmental impact from transport of waste to centralised facility • Product may be contaminated and of limited application • Residual waste is stabilised and less reactive in landfill

NK = not known

TABLE 1: Review of approaches to reduce and recycle organics from the waste stream.

24 Source: Michael Skins, Port Stephens Council

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

GREEN WASTE

Source Reduction

Description of mechanisms

- A ban on green waste to landfill;
- Education to avoid infringements of the green waste ban;
- Education of green waste producers in the domestic and professional sectors (eg. gardeners, primary producers of vegetables, landscape architects) on low waste gardening;
- Promotion of appropriate planting in the domestic sector (e.g. appropriate size trees leading to decreased lopping) and practice of this in municipal parks and gardens, and institutions; and
- Development control planning to reduce green waste (e.g. mandatory low waste garden design, increased density of dwellings, smaller lot sizes, reduced lawn area).

Examples of mechanisms

The NSW Government's green waste ban is a legislative source reduction mechanism which will inevitably lead to increased recycling of green waste. The ban is expected to come into effect in 2000. Resistance to the ban is apparent in both the residential sector and at local government level. This resistance is largely based on anticipated operational difficulties and increased handling costs.

Local government development control planning is likely to lead to a decrease in green waste production in the Sydney region. Decreasing lot size, larger houses and increasing density will minimise garden space in both residential and non-residential areas.

A number of organisations have produced educational material promoting low waste gardening[26] [27]. These encourage minimising lawn space to reduce production of grass clippings, planting slow growing plants and non-deciduous trees, and choosing plants of an appropriate eventual size thereby avoiding the need to cut back growth.

Recycling

Description of mechanisms

- Composting of green waste (this is widespread in the domestic sector and it is anticipated that green waste recycling will boom when the ban comes into effect although markets may take time to adjust);

26 Friends of the Earth (1997?) Low Waste Gardening fact sheets 1 – 4.

27 Sydney Water Corporation (1999) promotional material supporting residential demand management program.

- Chipping of green waste for mulch which can be on-sold; and
- Burning of green waste for energy production (see *RDF Fired Combustion Systems*) or used for biogas production (leading to energy generation).

Examples of mechanisms

Vermitech, a NSW based company, uses vermicomposting to produce a soil conditioner from municipal green waste and biosolids or abattoir waste. Green waste is used as a bulking agent. The company has operations in NSW and Queensland. Vermitech's biosolids product is sold in bulk as a soil conditioner for horticultural application. It wholesales for around $250/tonne[28]. The Redland Shire facility in Queensland processes around 400 tonnes per week and employs around 5 people. Intermittent technical expertise is required in overseeing operations and monitoring the quality of product[29]. It is estimated that one full-time employee is required per 100 tonnes per week of capacity. It is assumed the ratio of green waste to sludge is 1:4.

Many councils in NSW offer a green waste chipping service to residents, either at low cost or free of charge. The councils either return chipped green waste to the waste producer, sell the product as mulch (Randwick Council retails mulch at around $7 per 25kg or $30 for 2 tonnes) or use the mulch on council parks and gardens. The University of New South Wales and University of Technology, Sydney (Kuringai Campus), and other large institutions chip green waste and utilise it as mulch.

28 Lotzof. M. (1999) The Wonder of Worms for Sludge Stabilisation. Water. Journal of the Australian Water and Wastewater Association. Jan/Feb: 38-42.

29 Source: Peter Brooks, Vermitech

PAPER

Source Reduction

Description of mechanisms

Mechanisms for source reduction of paper wastes include:

- Delivery of programs offering education, advisory services and technical support to businesses, government and the community for minimisation of printing and writing paper use (e.g. double sided printing and copying, improved practices including electronic communication, web-based publishing);
- Code of Practice for broadsheet newspaper publishers facilitating increased consumer choice of purchase for separate newspaper sections;
- Industry co-operation between paper producers and paper goods manufacturers to decrease off-cuts. This would be through greater parity between dimensions of products produced by paper manufacturers and those required by paper goods manufacturers;
- Delivery of programs offering technical support and advisory services to businesses, government and the community for minimisation and reuse of paper (e.g. minimising use of handtowels through appropriate dispenser design, signage, user education and maintenance);
- Education about alternatives to disposable paper products and packaging (e.g. disposable hand towel vs reusable cloth hand towels);
- Education of business, institutional sector and industry about the use of grade appropriate to application, leading to establishment of paper quality cascades (e.g. one-sided A4 photocopy, write notes on other side, shred and use as parcel packing);
- Legislation and regulation governing source reduction (e.g. specific goals and government procurement and purchasing requirements and requirements for information provision and reporting);
- Commodity pricing of paper through, for example, environmental taxes leading to increased perceived value of paper;
- Economic incentives for implementation by businesses, government agencies and the community of practices, programs, policies or technology that reduces paper use in any category.

Examples of mechanisms

Reverse Garbage is a non-profit, financially self-sustaining organisation in Sydney that collects and retails industrial discards. The business retails a huge array of products and diverts approximately 1,000 tonnes of industrial discards from landfill each year. Many of Reverse Garbage's products are paper and cardboard off-cuts from paper using industries[30]. Reverse Garbage has 15 full-time and 6 casual employees.

30 Source: Felicity Stenning, Reverse Garbage

RMIT University maintains an environmental policy that was approved by the University Council in August 1994. This includes provisions for the promotion of the maximum recycling and reuse of goods used by and within the university and minimising the consumption of paper. The methods used in an attempt to attain these goals include promoting the use of double sided photocopying and recycled paper purchasing, using electronic communication, ensuring that new photocopiers can easily copy double sided, and dispensing with any requirements for student work to be submitted in double line spacing, single sided format.

The Earthworks program educates participants in minimising domestic and work place paper consumption, and encourages the reuse and recycling of paper. See *Plastics* for a detailed description of Earthworks.

In the US, Rhode Island requires businesses to submit source reduction (and recycling) plans to the state. This was phased in for larger (500 or more employees) to smaller businesses (100 or more employees) between 1989 and 1990, and for small business (less than 50 employees) businesses in 1991. This required the businesses to conduct a waste audit and submit proposals for effective reduction and recycling, and prepare an annual report to quantify results. Each business has 60 days to activate the plan before an inspection by the state. The most frequently used source reduction technique by 274 Rhode Island companies (52%) was double sided photocopying[31].

Recycling

Description of mechanisms

- Market development for recycled paper products;
- Research and development for improved recycling technologies and new products from recycled paper and cardboard feedstock;
- Improved compatibility between recycled paper products and equipment (e.g. printers, copiers);
- Decentralisation of paper recycling activities;
- Increased waste disposal and tipping fees for paper waste;
- Ban on waste paper to landfill;
- Education strategies and financial incentives to increase source separation in the municipal and C & I sectors;
- Legislation mandating recycled content of products;
- Education and technical assistance on purchasing of recycled products in the institutional and commercial sectors;
- Formal requirement for selective purchasing policies requiring the purchasing of recycled paper in the institutional and commercial sectors (e.g. universities); and
- Promotion of Australian paper and recycled paper products to avoid high transportation costs.

31 Source: US Environmental Protection Agency. (1995) Decision Maker's Guide to Solid Waste Management, Volume II, US EPA, Washington D.C.

Examples of mechanisms

The Shoalhaven Mills recycle waste paper to produce printing and writing paper. The plant sources wastes from manufacturers of paper products (off cuts) as well as post-consumer waste paper (approximately 15-20% of feedstock is post-consumer). Up to 45,000 tonnes of waste paper is processed annually at the plant which employs 320 people (260 in processing and 60 in maintenance). Recycled products are on-sold and, while the market has been strong, there is increasing competition from importers of cheaper, virgin paper[32].

The value of source-separated paper and cardboard is a reasonable incentive to recycle. Currently in Sydney, A4 paper attracts a re-sale value of around $45/tonne, clean cardboard around $50/tonne, and mixed paper and cardboard around $20/tonne. Some waste and recycling contractors in Sydney (e.g. Binky's) will collect source separated paper from large businesses at no cost to the waste generator. This represents a potential cost saving if residual waste collection services are on a pay by weight basis.

In the U.S the recycled paper market increased dramatically from 1970 to 1986. The American Paper Institute estimated that U.S. exports of waste paper increased from 408,000 tonnes to 3.75 million tonnes, in 16 years. In addition, laws mandating recycled content in newsprint, for example have been passed in at least 11 states requiring up to 50% recycled content[33].

A $US150 million paper recycling plant planned in Menominee, USA is expected to recycle mixed office waste paper to produce secondary fibre for new white paper products. The plant is expected to generate 100 permanent jobs and as many as 50 jobs in related industries such as chemical supply, waste supply and transportation[34].

Recycling initiatives, changes in technology and packaging practices and international trade liberalisation have impacted on employment patterns in paper-related industries. Americans consume approximately 2 pounds of paper per person per day. Employment in paper manufacturing, which historically has been volatile, has fluctuated less in recent years. Around 16,000 jobs have been lost in the paper manufacturing sector in the USA since 1990. However, employment in recycling collection and paper distribution have far outweighed these job losses in paper manufacturing. Employment in recycling collection is driven in part by changing regulations and consumer demands.

The labour requirements for producing recycled fibre are similar to those for producing virgin fiber, although the total costs of recycling are approximately 20 percent less. Production using recycled paper takes less energy than production using virgin paper. The

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32 Source: Ian Bain, Shoalhaven Mills.

33 Source: US Environmental Protection Agency. (1995) Decision Maker's Guide to Solid Waste Management, Volume II, US EPA, Washington D.C.

34 **Source: Power, C., and Halvorson, B. (1993) Upper peninsula of Michigan: U.P. economy welcomes Menominee paper recycling plant. Fedgazette. 5(1): 17. 1993 Jan.**

profitability of recycled products has caused some companies to replace pulp mills with deinking plants and to expand their use of recovered paper in existing mills. Companies are increasing domestic recycling capacity, as worldwide demand for recovered paper is expected to rise to 150 million tons by the year 2000, up from 110 million tons in 1993.
Paper-related employment is scattered among several industry categories. They are:

- manufacture of paper and allied products. This industry employs 681,000 people, down slightly from its peak employment of 697,000 in 1990;
- the paper and paper products component of wholesale trade. This involves distribution of paper products and employs around 259,000. Not included in this figure are another 130,000 jobs in recycling activities where a significant portion of labour is directly tied to paper recycling; and
- government transportation services and production of equipment, chemicals, and processes to be used in paper mills. This area supports the consumption and production of paper in the USA and is estimated to employ more than one million people[35].

35 Source: Engel, C. (1997) Taking note of the paper industry. Monthly Labor Review. 120(9): 32-40. 1997 Sep.

PLASTICS

Source Reduction

Description of mechanisms

- Extended Producer Responsibility (EPR). EPR exists when producers are responsible for the waste produced at the end of a products life and can be used to minimise waste and resource use. If producers were responsible for post consumer waste some of the costs would be built into the price of the products and consumers would pay for the waste management as consumers of waste generating goods rather than as tax or rate- payers[36];
- Use of reusable containers or packaging as opposed to disposable plastics (e.g. plastic shopping bags);
- Redesign of products away from plastic, lightweighting and increased durability of plastic goods (e.g. kids toys); and
- Education programs and financial incentives for the use of alternatives to plastic products (e.g. disposable nappies).

Examples of mechanisms

The Earthworks program initiated by the NSW EPA in 1996 was aimed at educating community members about waste avoidance, minimisation and recycling. Groups of between 15 and 50 participants were involved in 25 hours of guided discussion, field trips and promotion of waste minimisation in their community (eg. speaking at a school, instituting waste minimisation activities in their workplace). The course is evolving for more flexible delivery (to suit community needs). Earthworks courses have been run, largely through local councils. This has created some difficulties due to the need for courses to be offered after-hours. The Earthworks program educated participants in reducing their use of plastics, avoiding unnecessary packaging, lobbying manufacturers on their use of plastics, and on many aspects of plastics recycling.

One example of producer responsibility extending beyond the point of control is the requirement of the 1991 German Packaging Ordinance. This is a mandatory requirement for producers or distributors to take back packaging materials for the purposes of reusing or recovering it outside of the municipal waste stream. The Ordinance was in response to two-thirds of the plastic in household rubbish consisting of packaging[37].

In the US, Minneapolis established an "environmentally acceptable packaging" ordinance which banned non-returnable and non-recyclable packaging.

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36 Source: Friends of the Earth (Sydney). (1998). Demystifying EPR. Friends of the Earth, Sydney, Australia.

37 Source: Liu, X and Boyle,C.A. (1999). Current Management of Plastic Waste in New Zealand in *Australsian Environmental Engineering Conference*

In Switzerland in 1992 80% of drinks were bottled in reusable containers and 3,300 tonnes of PET bottles (53% of material used for beverage containers) were recycled. This was the effect of specific regulations aimed at stopping throwaway packaging, which had become the trend. In 1994 the Swiss collected 75% of the annual PET use (>9,000 tonnes) at 12,000 locations[38].

Recycling

Description of mechanisms

- Financial support for research and development into alternative products from recycled plastic feedstock;
- Market development and awareness programs for purchase of recyclable and recycled plastic goods;
- Education programs on plastic recycling and alternative products to plastic;
- Investigation and development of appropriate technologies and provision of infrastructure for plastics recycling (e.g. mechanical recycling for plastic bottles and flasks, thermal recycling for the recovery of film plastic and pouches, combined mechanical recycling and energy recovery for mixed plastics from cups and blister trays);
- Development of Statewide plastic use and waste reduction plans;
- Mandatory recycling ordinances and plastics to landfill bans;
- Extended producer responsibility for plastic goods (cradle to grave);
- Closed loop plastic products manufacture (minimising industrial plastic wasteage); and
- Energy recovery from plastic.

Examples of mechanisms

The New South Wales *Waste Minimisation and Management Act 1995* required the production of an Industry Waste Reduction Plan for the soft drink industry. In response to this the industry has agreed to support the development of more stable and efficient kerbside collection schemes for plastic recycling. Key strategies to achieve this include the development of a market intelligence program and to implement community education strategies[39]

Feedstock recycling (pyrolysis, hydrogenation, gasification and chemolysis) have been developed by the European plastics industry. They were designed to overcome limitations (ecological, economic and technical) associated with mechanical recycling. These processes break down plastics into their constituent molecules for reuse (e.g. refineries) or petro-chemical and chemical production. Germany is the major user of the process. In 1996, for example, 251,000 tonnes of plastics were recycled

38 Source: Liu, X and Boyle,C.A. (1999). Current Management of Plastic Waste in New Zealand in *Australsian Environmental Engineering Conference*

39 Source: Environment Protection Agency (1999). New South Wales Beer & Soft Drink Waste Reduction Plan. Environment Protection Agency: Chatswood: New South Wales.

Berlin Township, New Jersey has had its plastic recycling done at the Camden County Recycling Facility (CCRF) since it became operational in 1986. No tipping fees are charged at the facility. The CCRF was constructed to enable its towns to comply with the county wide mandatory recycling ordinance introduced in 1981. The CCRF was designed and built by Resource Recycling Systems, Inc., and cost $700,000. In 1988 the township collected 27 tons of plastic. This was approximately 10% of the total commingled recyclables that were collected. Berlin Township also runs a publicity and education program on recycling[40]

In an effort to support waste minimisation targets, create jobs and generate goodwill in local communities, Indiana Department of Correction (DOC) has started recycling operations at prisons throughout the state. Between mid-1997 and early 1998, Putnamville Correctional Facility recycling operations have saved over $US69,000 in waste disposal costs. Plainfield Correctional Facility recovered over 40 tons of recyclables between June 1997 and early 1998, resulting in a saving of more than $US 2,000 in tipping fees. Labour intensive hand sorting was selected and the program provides 32 jobs[41].

40 Source: Institute for Local Self-Reliance. (1991) Beyond 40%. Record-Setting Recycling and Composting programs. Island Press, Washington D.C, USA.

41 Cureton, W. Composting and recycling at Indiana prisons. Biocycle. 39(5): 76-80. 1998 May.

ESD ASSESSMENT

There are a number of principles or frameworks that can be used to evaluate the ecological sustainability of waste technologies and practices. Such as:

- The precautionary principle: 'where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation' (IGAE 1992: 13-14). When the principle is applied, public and private decisions should be directed by careful evaluation and a risk assessment of options, to avoid serious or irreversible damage to the environment.
- Intergenerational Equity: 'the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations' (IGAE 1992: 14).
- The conservation of biological diversity and ecological integrity should be used as a fundamental consideration to achieve ESD.
- Improved valuation, pricing and incentive mechanisms to include environmental factors in the valuation of assets and services. Incentives include:
- Polluter pays principle: 'those who generate pollution and waste should bear the cost of containment, avoidance or abatement' (IGAE, 1992: 14).
- User pays principle: the users of goods and services should pay for the full price of the life cycle cost of providing those services, including waste disposal.
- Environmental goals must be established and pursued in the most cost effective way by establishing incentive structures, including market mechanisms

Clearly the generation and management of waste is complex, and ESD assessment is truly meaningful only when it considers the context in which a technology or practice is applied. A broad assessment of the options described and the examples summarised in the previous sections is likely to show that they are broadly compatible with the many of the principles of ESD described above.

The ESD assessment below considers the resource efficiency approach, including source reduction and recycling, and examines the likely ESD implications of technologies and practices which favour these approaches ahead of waste treatment and disposal. The framework used corresponds with 1997 amendments to the *Local Government Act 1993* (Section 7(e)). Under the *Local Government Act*, ESD is defined as 'the effective integration of economic and environmental considerations in decision-making processes'.

- Intergenerational equity is strengthened through source reduction and reuse due to the reduction in the use of non-renewable resources, including fossil fuels, and the reduction in the amount of waste materials that are disposed of to landfill. The increasing costs and environmental and social impact of extraction and use of resources, and disposal of

wastes means that there this generation is using up opportunities. Reduction of materials use and waste disposal increases available opportunities for future generations in terms of the cost and environmental and social impacts of use of these resources and disposal of wastes.

- Improved valuation, pricing and incentive mechanisms are a key component of enesuring that source reductio and reuse options are implemented. The cost of using raw materials, and the costs of waste generation should reflect the total financial, environmental and social costs of the activity to all stakeholders. This is rarely achieved, and is often the domain of different levels of government, but must be pursued. The production of goods should then reflect the total costs of production, and through Extended Producer Responsibility (EPR) can be made to reflect the total life cycle costs of manufacturing a product, retrieving the waste and dealing with it, preferably through reuse.

- Increased reliance on Extended Producer Responsibility (EPR), would be a direct application of the ESD user pays and polluter pays principles. Currently, manufacturers have a limited responsibility for the environmental and financial costs of managing their product's waste through its life cycle from production to disposal or reuse, giving rise to reduced efficiency of materials use, increased waste generation and inappropriate product design, use or packaging. There are limited market signals (pricing, incentives) or regulatory measures (standards, covenants) to provide incentives for producers to improve this, and this means that other parts of the economy subsidise the increased resource use and waste generation (the environment, councils, the unemployment rate).[42]

- The technologies and processes that have been discussed in previous sections, while reducing materials use and waste generation, can have other impacts. For example, some options require increased energy consumption and therefore increased greenhouse gas emissions. Where possible, a life cycle analysis should be undertaken of different options, which means taking into account as many of the materials and energy inputs and the waste outputs and environmental and social impacts of options as possible, and seeking to find options which have, for example, greater energy efficiency than other options.

42 Source: Friends of the Earth (Sydney). (1998) Demystifying EPR. Friends of the Earth, Sydney, Australia.

LEAST COST PLANNING FOR SOLID WASTE MANAGEMENT

It is clearly possible to find and describe a number of examples of measures that can reduce waste generation and disposal to landfill through a combination of:

- Education (advisory services, community education, training, marketing);
- Economic instruments (taxes, charges, pricing, incentives, loans, rebates);
- Regulatory measures (performance standards, land use planning controls, covenants, licences, permits, development consent conditions, EPR requirements, deposit schemes)

These options then require a framework within which they can be implemented. Therefore, the fundamental question in seeking the most appropriate means of reducing waste to landfill, is:

'What is the least cost means of achieving the greatest reduction in waste to landfill?'

In this question, the word 'cost' refers to economic, environmental and social impacts that occur throughout the life of a product, from extraction of raw materials to reuse, recycling or disposal as a waste product. A framework which has been used successfully in examining similar questions in the electricity and water industry is Least Cost Planning (LCP), also called integrated resource planning. In LCP, a range of options for achieving reduction are evaluated and options are ranked, on the basis of levelised cost (taking into account both capital and operating costs), from lowest to highest, in For example) $/tonne/a reduction in waste generated. Ranking is dependent on the value or priority placed on each of the cost types and will reflect the local conditions in which options are to be applied. Table 2 below, is an example of some of the outputs which might be expected from an LCP study for reduction of organic waste to landfill in the Greater Sydney Region (GSR).

	Options	Est. reduction (tonnes/a)	Economic costs and benefits	Environmental costs and benefits	Social costs and benefits
1	Promotion and advisory support for home composting and worm farming leading to 20% uptake in GSR.	54,600[43]	Costs: $200,000 (one-off) [44] Benefits: $672,000 (ongoing)[45]	Decrease organics to landfill. Soil regeneration through application of product. Potential decreased use of garden fertilizer leading to decline in eutrophication of local water ways. Decreased transport of organics leading to lower transport impacts.	Employment - increase in community education, advertising and manufacture of bins; decrease in waste sector and, potentially in commercial manufacture of compost.
2	Give-away of home composting bins and worm farms leading to 65% uptake in GSR.	206,700[46]	Costs: $33 m (one-off)[47] Benefits: $2.6 m (ongoing)[48]	As above	Employment – increase in manufacture and distribution of bins, education of users; decrease in waste sector and, potentially in commercial manufacture of compost.
3	Free pick up service for organic waste from catering and hospitality venues with	90,000	Costs: $3.6 m (ongoing)[49]	Decrease organics to landfill. Soil regeneration through application of product.	Employment – increase in transport of waste and product, increase in organics processing;

43 20% of municipal organic (food and green) waste
44 Advertising and telephone hotline
45 Savings to the government sector assuming Councils spend $12.30 per tonne of municipal waste to landfill
46 65% of municipal organic (food and green) waste
47 1.6 million households receiving a compost bin or worm farm valued at $20
48 Savings to the government sector assuming Councils spend $12.30 per tonne of municipal waste to landfill

	20% participation rate.		Benefits: $1.1 m (ongoing)[50]	Potential decreased use of agricultural fertilizer leading to decline in eutrophication of water ways. Increased transport of organics leading to higher transport impacts.	decrease in waste sector.
4	Ban on organic waste to landfill from domestic and commercial premises (expectation of 90% compliance).	685,000	Costs: $5.3 m (ongoing) [51] Benefits: $3.9 m (ongoing)[52]	Large decrease in organics to landfill. Increased transport impacts if private contractors collected organics. Higher potential for illegal dumping. Environmental impacts from overloading of backyards and vacant space with organics.	Health and social impacts from overloading of backyards and vacant space with organics. Equity problems for those living in high density or with no time to maintain home compost or worm farms.

TABLE 2: Example of some outputs which might be expected from a Least Cost Planning study of organic waste minimisation.

49 Assuming cost of collection, transport and treatment is $30 / tonne

50 Ibid

51 Assuming 40% of individuals pay $80 per annum for collection and alternative treatment of organics

52 Savings to the government sector assuming Councils spend $12.30 per tonne of municipal waste to landfill

WASTE MANAGEMENT LABOUR MARKET TRENDS

In NSW in 1996/97:

- 5,299 people were directly employed in waste management (3,255 in the private sector and 2,044 in government organisations);
- Expenditure on salaries was $ 196.5m, $ 125.4m in the private sector and $ 71.7m in government organisations; and
- In the government sector, expenditure on waste collection, transport and treatment/processing/disposal of waste was $ 88.8m and expenditure on recyclables collection and transport of recyclables was $ 38.1m; and
- Approximately 7.2m tonnes of waste were received and disposed of at landfills in NSW and 0.5m tonnes of recyclables were recovered and on-sold.

These figures suggest that the government sector is spending $12.30 per tonne of waste sent to landfill and $76.20 per tonne recycled. While this is largely reflective of the municipal sector, these figures illustrate many of the difficulties inherent in changing the current waste management system:

- In most council areas, the financial cost of disposing of mixed waste to landfill is very low as: collection systems and infrastructure are already established; the current practice of landfilling is fairly technologically simple and can handle large volumes with minimal labour inputs; and environmental impacts (both of virgin material extraction due to disposal of resources and landfill impacts such as leachate and landfill gas) are not costed into the service.
- In comparison, the cost of collecting and transporting recyclables from residents is much higher, this would suggest that investment in new infrastructure and systems is being costed into collection and transport services (these may include: new bins, additional collections requiring more staff, sorting infrastructure and services, and reprocessing services and facilities). The private sector earns $114.40 per tonne for collection, transport and treatment, processing, sale of recyclables. Clearly the market value of sorted and reprocessed goods is reasonable but profits are remaining in the private sector.

Alternatives to landfilling wastes are often labour intensive but have been shown to be economically viable provided markets for recycled resources are available or rapidly become established. The following are examples of source reduction and waste recycling activities which have generated higher employment and economic prosperity:

An economic model developed by the Institute for Local Self-Reliance shows that a city of one million people could fully or partially sustain 30 facilities on secondary resources that would otherwise be burned, buried, or exported (assuming a comprehensive recovery and source reduction program, and a waste stream similar to national characteristics). In addition to diverting more than 635,000 tons of solid waste annually from local landfills and incinerators, thereby saving nearly $US10 million in disposal costs (assuming a moderate $US15 per ton tipping fee), the 30 facilities would add an average value of $US470 to each ton of previously discarded material. In the process, they would bring three-quarters of a

billion dollars and almost 2,000 manufacturing jobs to the community. An additional 2,550 jobs would be created in support of these manufacturing enterprises[53].

A study undertaken in North Carolina found recycling to be a significant job creator. In excess of 2,600 recycling jobs were created between 1989 (tabling of the Solid Waste Management Act) and 1995. A model based on changes in solid waste and virgin extraction material flows due to recycling, was developed. Using 1995 recycling rates, the model estimated that for every 100 recycling jobs created in North Carolina, 10 solid waste jobs were lost; less than 3 timber harvesting jobs were eliminated due to paper recycling, and less than one industrial sand extraction job was lost due to glass recovery. Of the 2,600 jobs created, 1,939 were established in the private sector, with 692 new recycling positions in the public sector. The job growth rate was expected to slow as recycling rates level off and diversion economies of scale are realised[54].

To date, three American states have exceeded a 40 percent recycling recovery rate, nine states are at or above 30 percent, eight states are at or above 25 percent, five states are at or above 20 percent, and 16 states between 10 to 20 percent. More than 45 percent of the American population is served by curbside recycling. Drop-off sites continue to grow, with more than 8,700 across the country (BioCycle magazine). There are more than 4,500 recycled content products that consumers can purchase. There are more than 3,000 businesses currently involved in processing recyclables and manufacturing recycled products. These businesses wouldn't be in business if it didn't make economic sense to manufacture with recycled feedstock[55].

A study in Iowa found that, as at December 1995, recyclable materials processing had created 1,290 jobs in the State and stimulated more than $US100 million in industrial sales. The largest contributor was processing of recyclables. More than 650 processing jobs existed in Iowa in 1995. Resulting product sales generated a total of more than 1,290 total jobs and $US100.3 million total industrial sales statewide. The 1995 fiscal benefits from processing were $US3.9 million in local governmental revenue and $US2.4 million in state governmental revenue. However, end-use manufacturers provide the greatest economic value to the State. In 1995, this value reached $US359.5 million in total income and supplied 8,800 jobs[56].

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53 Lewis, M., and Seldman, N. (1994) Scrap-based manufacturing sparks economic development. Biocycle. 35(4): 62-64. 1994 Apr.

54 Shore, M., and Ewadinger, M. (1995) Recycling impact on jobs. Biocycle. 36(4): 36-37. 1995 Apr.

55 Lichtenstein, M. (1996) Creating jobs and preserving resources. Biocycle. 37(8): 91. 1996 Aug.

56 Underwood, M. (1997) Iowa recycling industry raises revenue, creates jobs. World Wastes. 40(6): 8-11. 1997 Jun.

FOR FURTHER INFORMATION

The following websites hold a wealth of information for those interested in further investigating resource efficiency approaches to waste management:

http://www.profitfoundation.com.au
http://www.tellus.org/sw_group/sw_home.html
http://www.sustainable.doe.gov/efficiency/materials/mearttoc.htm
http://www.epa.gov/epaoswer/non-hw/payt/lessons.htm
http://www.yale.edu/jie/dissert1.htm
http://www.iclei.org/ecobudget
http://www.nwf.org/nwf/campus/yearbooks/index.html
http://www.srl.rmit.edu.au/enviro/
http://www.rachel.org