Opportunities and Constraints for Developing a Sustainable E-Waste Management System at Local Government Level in Australia.

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Abstract:

E-waste refers to both electronic and electrical wastes; that is, any items which rely on an electric current or electromagnetic fields in order to operate and contain a hard-drive or significant electronic components and/or a printed circuit board. According to UNEP, waste from electronic and electrical equipment (WEEE) is becoming a significant component of the waste stream, increasing at a rate of between three to five percent per annum, outstripping the general growth of the municipal waste stream. Increasingly, smaller and cheaper electronic items are being all too easily disposed of in municipal waste systems and this, coupled with an increase in the number of, and turnover of manufacturers and suppliers to the market, may see Local Governments assuming a key role in the future of e-waste management.

A survey of local councils across Australia was undertaken in order to determine the current level of understanding and action on e-waste, and to solicit key responses regarding the identification of areas where improvements could be made. For example, the rationalisation of preferred initiatives for future legislative and funding mechanisms. The survey achieved an overall local government response rate of 35%, across Australia. Survey results identified key barriers experienced by Councils regarding the collection and treatment of e-wastes as access to reprocessing facilities and the limited or complete unawareness by the public of the issues. With regards to who should pay for e-waste disposal at end-of-life, users/consumers and producers/manufacturers were most commonly cited, depending on the state with the preferred funding mechanisms being ARF and EPR. Overwhelmingly, 88% of respondents believed that federal legislation was required to manage e-waste. Overall, the results did not indicate differences in views between states for most questions.

***Keywords**:* Australia; E-waste; Local Government; Councils; survey.

1. Introduction

Electronic waste or e-waste is one of the fastest growing waste streams around the world, growing at a rate of 3-5% per annum or approximately three times faster than normal municipal solid waste (Schwarzer et al., 2005). One reason for this is the constant availability of newer technology and design, and an increasingly early obsolescence. For example, the average lifespan of a new model computer has decreased from 4.5 years in 1992 to an estimated 2 years in 2005 and is further decreasing (Widmer et al., 2005). A study completed recently by the United Nations University estimated that collectively the world generates around 40 million tonnes of WEEE every year (Huisman et al., 2007).

Despite the rate of computer and other equipment turn-over slowing, as individuals and businesses are holding onto their equipment for longer since new capacity and software exceeds predominant needs; there has been a simultaneous increase in the rate of multiple computer and electronic device ownership by individuals. The disposal of electronic wastes does not appear to show any signs of decreasing, coupled with smaller, cheaper and increasingly obsolete items, the issue of e-waste would appear to be a growing problem.

Local governments in countries around the world are increasingly getting involved with the management of used electrical and electronic equipment (EEE). In the absence of any national regulatory framework to deal with used EEE in Australia, the individual local councils are left to develop strategies to deal with the e-waste issue. The aim of this paper is to determine the current level of understanding and actions being

undertaken to deal with e-wastes by Local Councils across Australia, and to identify areas where future improvements to e-waste management practices could be made. For example, the rationalisation of preferred initiatives for future legislative and funding mechanisms, whilst further survey questions sought to identify the barriers and potential opportunities for the electronic waste stream

2 Australia

Australia has six states and two territories with an approximate population of over 21 million which is growing at over 1.7% per annum (Table 1).

Table 1: Population Distribution between States (Australian Bureau of Statistics , ABS, 2008)

	Population at end June 08 ('000)	Change over previous year (%)
New South Wales (NSW)	6 967.2	1.1
Victoria (VIC)	5 297.6	1.8
Queensland (QLD)	4 279.4	2.3
South Australia (SA)	1 601.8	1.1
Western Australia (WA)	2 163.2	2.7
Tasmania (TAS)	498.2	1.0
Northern Territory (NT)	219.9	2.3
Australian Capital Territory (ACT)	344.2	1.3
Total	**21 374.0**	**1.7**

This increase in population from natural increases and overseas migration is also linked to the increase in waste generation. In 2007/08, Australia generated approximately 40.3 million tonnes of solid waste equating to 1.89 tonnes of waste per capita (IBIS World, 2008). Of this 27% was from municipal sources, with Australians purchasing over 2.4 million PCs and one million TV's per year (IBIS World 2008).

From research during 2006, almost all households (99%) in Australia recycled and/or reused at home, compared with 91% of Australian households in March 1996 (Australian Bureau of Statistics; ABS, 2006). The increasing level of recycling over this period is due to increased environmental awareness by government and the community, which has led to new policies and initiatives promoting higher waste management hierarchy activities. Initiatives have included the introduction and increase

of landfill levies coupled with recycling and landfill diversion targets for various waste streams across most states, the provision of recycling services to residents and more stringent regulations on the disposal of waste.

The projected future disposal and recycling quantities in Australia for 2012-13 and 2022-23 (Table 2), predict an increase of over 74% in the current levels of municipal waste generated by 2012/2013 compared to 2003, yet recycling rates are assumed to remain constant at around 40% (Hyder Consulting, 2006). The increases are based on an average annual per capita GDP growth of 1.88% and a population growth of 1.13%, and assume that no changes in the proportion of materials recovered will take place over time, despite the trend for increasing recycling activity.

Table 2: Projected disposal and recycling quantities in Australia (Hyder, 2006)

Sector	2002-03 (million tonnes)			2012-2013 (million tonnes)			2022-23 (million tonnes)		
	Disposal	Recycling	Total	Disposal	Recycling	Total	Disposal	Recycling	Total
Municipal	6.045	2.408	8.451	8.148	3.246	11.392	10.984	4.376	15.357
C&I	5.308	3.837	9.144	7.155	5.172	12.326	9.645	6.972	16.615
C&D	5.918	7.417	13.331	7.977	9.998	17.971	10.753	13.477	24.225
Total	17.429	14.217	31.640	23.494	19.164	42.651	31.670	25.833	57.493

The degree of recycling in Australia for computers is low; and for printers and computer peripherals, and video and stereo electronic peripherals there is considered to be none (Hyder, 2006). Hyder (2006), also noted that resource recovery and waste minimisation behaviours where the benefits are not highly tangible and/or the participation costs are high, are less well supported both by individuals and local governments; including participation in the resource recovery of items through ‘take-back’ schemes.

The dissimilarity in the ratio of population to area across Councils and the remoteness of many communities has also led to a varied range of waste and recycling services; from more complex multi-bin schemes in urban areas, to some remote communities not receiving a waste collection service.

3. Scope of E-waste in Australia

During the past few years Australian businesses and households have experienced a significant growth in the use of computers and Internet access. According to the Australian Bureau of Statistics (ABS) during 2003, 85% of all businesses in Australia indicated use of a computer and 71% of them reported having access to the Internet, and 25% of all businesses had a web presence (ABS, 2005a). As for the household use, a survey conducted by ABS revealed that in 2005-06, 60% of all the Australian households had home Internet access and 70% of all households had access to a computer at home. This is a significant growth from 1998 data, where only 16% of all the households had access to the Internet and 44% had access to a home computer (ABS, 2005b). This data suggests that the need to access the Internet from home may be fuelling the purchase of home computers in Australia.

An IPSOS survey (IPSOS 2005), conducted across the major Australian cities, estimated that there are 92.5 million electrical and electronic items in households, averaging at 22 items per household (29 for households with children and 19 for those without). Of these items, around 93% were in working order, whilst 4% were working but in storage and 3% were stored in non-working order. The largest category of working equipment in storage related to computer monitors (9%) followed closely by computer box units (8%). The IPSOS survey also identified a number of trends including: a large amount of unbranded items, (in particular, PC box units were three times more frequently mentioned than the top PC brand); the percentage of householders acquiring new items is significantly greater than the percentage of

households disposing of them; and 51% of portable items are being disposed of via the normal garbage bin.

Currently, Australia either imports computers ready assembled or assembles them from imported components. There are also numerous 'white box' importers and manufacturers (unbranded products or products branded with the retailer as opposed to the manufacturer), which include the larger, well known electrical/electronic manufacturers who supply older and obsolete models to the market unbranded or specifically branded to retailers.

These trends may make it difficult to introduce product stewardship and producer responsibility schemes, as there are a high proportion of orphan products, (where the manufacturer cannot be identified, has ceased trading completely or withdrawn from the Australian market). Also, responsibility may not be accurately assigned due to differences between existing market share and previous market share; additionally overseas importers of equipment may not wish to cooperate.

The 'Computer and Peripherals Materials Project Report' released in October 2001, by Meinhardt Infrastructure and Environment Group for the Environment, Australia, stated that there was a range of possible options that could be implemented within Australia to achieve environmental gains with respect to computers and peripheral equipment. Opportunities for environmental improvement can be examined in three main areas (Meinhardt, 2001):

1. Actions initiated at manufacturing stage, which are focused on reducing the environmental footprint of production of the equipment;
2. Activities at the end of product life, involving extending product life and recovery of material resources; and
3. Education of users to encourage improvement across all stages of equipment life, including correct disposal.

Local Government could readily assume responsibility for the second and third areas as without any form of mandatory take-back by manufacturers and/or retailers the majority of e-waste finds its way into the municipal waste stream.

There are several e-recyclers specialising in the complete recycling of computers and the associated peripherals that are expanding the locations of their reprocessing plants into the State Capitals. The largest e-waste recycling facility in the Southern hemisphere, which opened in December 2008, is based in Sydney and operated by Sims Recycling Solutions, a subsidiary of Sims Metal Management. The plant has the capacity to process about 20,000 tonnes of e-waste every year. However, even at full capacity this is only a fraction of the 120,000 to 140,000 tonnes of e-waste produced by Australians every year. Sims opted to invest in this plant and smaller similar plants in Brisbane and Melbourne despite federal government's refusal to commit to a mandatory e-waste recycling policy, and the current recycling rate for e-waste in Australia limited to around only 4%.

The costs of their services, whilst acceptable to commercial organisations that need to ensure the complete destruction of computer hard drives and the information contained,

are prohibitive to local authorities and even individuals who can dispose of their items for free if they fit into their domestic wheeled bin.

The increase in consumption of smaller electronic items, such as PDA's and mobile phones, coupled with lowering purchase costs of new electronic equipment, is resulting in an increase in the overall volume of electronic wastes. The smaller sizes and perceived disposability and obsolescence of these items is making the tracking and quantification of electronic equipment within storage or those disposed of to the domestic waste stream more difficult. A further barrier to accurately quantifying the amount of e-waste globally is that Harmonised Tariff Codes fail to distinguish between used electronic, waste electronic and new electronic items (Puckett et al., 2005). The lower purchase price of new equipment is decreasing the market demand for used and refurbished items, particularly computers and peripherals.

The Australian Government's Productivity Commission Report on Waste Management (Commonwealth of Australia, 2006), highlighted the potential environmental impacts of batteries, phones and computers in landfill as "*sources of heavy metals and other toxic compounds that can be mobilised in leachate*".

3.1 Key Legislation

Although there are a number of Australian Commonwealth legislative items which may be applied to waste electrical and electronic equipment, such as the Hazard Status of Waste Electrical and Electronic Assemblies or Scrap, October 1999; and the Hazardous Waste (Regulation of Exports and Imports) Act 1989 (Environment Australia, 1989)

which fulfils Australia's obligations under the Basel Convention, and only applies to non-functional e-wastes being shipped to non-OECD countries.

There is currently no specific electronic waste legislation being considered and any national strategy would, most likely, be voluntary. Without strict regulation or mandatory legislation, there is little incentive for manufacturers and suppliers of electronic equipment to implement costly recycling or take-back schemes, and without the take-back schemes there is even less motivation to implement green-design principles or active design for disassembly. Except for the Australian Capital Territory (ACT), other States do not control the disposal of e-wastes to landfill and the accurate examination of the disposal of this waste stream is further hindered by the absence of any formal monitoring or reporting mechanisms (including weigh bridges) on many sites.

The National Environment Protection Council (NEPC) is currently developing a generic Product Stewardship National Environmental Protection Measure (NEPM). Their aim is to supplement a general NEPM with specific product schedules, to currently include televisions and tyres but could be extended to include computers. However, whilst the large computer manufacturers have been receptive to the idea and have been involved in on-going negotiations with the NEPC, a significant proportion of Australia's computer market (over 40%) is comprised of 'white-box' manufacturers and importers. This trend has led to a large amount of orphan products.

4. United States regulations and Activities Concerning E-Wastes

The United States is one of the largest producers of e-waste in the world. According to one estimate, 2.2 million tons (approximately 2.15 tonnes @ 1 ton≈1.02 tonnes) of e-waste was generated during 2000, including 859,000 tons of video products, 348,000 tons of audio products and 917.000 tons of information technology products (Gibson and Tierney, 2006). The United States Government Accountability Office (GAO) reports that over 100 million computers, monitors and televisions become obsolete in the United States each year and that amount is growing (United States Government Accountability Office 2005). The report also refers to United States Environmental Protection Agency (US EPA) data which indicates that less than 4 million computer monitors and 8 million televisions are disposed of in landfills each year and only 19 million computers were recycled in 2005 (United States Government Accountability Office, 2005). US EPA estimates that over 300 million electronics items became obsolete in 2007 (US EPA, 2008a). Further estimates suggest that around 500 million computers have become obsolete in the United States alone between 1997 and 2007 (Yu and Gao, 2006).

Concerns were raised in 2002 by the environmental groups estimating that between 50 to 80% of the e-waste collected in the United States for recycling is not recycled domestically but exported to developing countries such a China and India (Puckett et al., 2002). Although it appears that the situation has improved since 2002, GAO argues that there is still a lack of economic incentives to promote recycling and re-use of electronic equipment in the United States, which is also compounded by the lack of federal regulations that either encourage recycling or avoid their disposal in landfills (United States Government Accountability Office, 2005). It further argues that current federal laws allow hazardous used electronics to be disposed in landfills, do not provide

a funding system to support recycling and do not preclude e-waste being exported to developing countries.

In the absence of Federal legislation, the individual States have begun to address the issue by developing and adopting their own e-waste legislation covering areas such as e-waste landfill disposal bans and comprehensive recycling legislation. As of December 2008 18 States (California, Maine, Maryland, Washington, Connecticut, Minnesota, Oregon, Texas, North Carolina, New Jersey, Oklahoma, Virginia, West Virginia, Missouri, Hawaii, Rhode Island, Illinois, Michigan) and New York City have passed comprehensive E-waste legislation. Whilst California has also adopted an advanced recycling fee system, all the other States have settled for an extended producer responsibility system Electronics Takeback Coalition, 2008).

The Californian Advanced Recycling Fee (ARF) on all new computers and televisions purchased was launched in January 2005, effectively implementing the California Electronic Waste Recycling Act of 2003 (SB20). Depending on the size of the device, a ARF ranging from $6 to $10 is used to reimburse non-profit and commercial recyclers at a rate of 48 cents per pound. The recyclers, in turn, reimburse the e-waste collectors at a rate of 20 cents per pound providing them with an incentive to provide a free service to the community (Hileman, 2006).

One of the most recent developments in the regulation of e-waste in the United States is the framework released by the Electronics Industries Alliance (EIA) on 25 May 2007 which paves the way for Federal legislation establishing a national program for recycling household televisions and information technology products like computers

and computer monitors. It proposes a two-part financing approach, separating televisions from desktop computers, laptops and computer monitors, to reflect their divergent business models, market composition and consumer base. According to the framework, the television collection and recycling would be primarily conducted by an industry-sponsored third party organization and initially supported by a nominal fee paid by consumers at the point of purchase. The nominal fee would eventually expire, once a significant number of "legacy" sets are recovered. The manufacturers of information technology equipment would implement a program to collect and recycle its products in a manner that is convenient for household consumers and at no cost to them (Electronic Industries Alliance, 2007). They would have to offer such a program as a condition of conducting business. Furthermore, on 30 October 2008 US EPA announced it's first ever national guidelines for responsible recycling ('R2") practices for use in accredited certification programs which could be used to assesses environmental, health and security practices of electronic recyclers. The main purpose of this document is to develop a commonly accepted set of R2 practices for the electronic industry which is purely voluntary (US EPA, 2008b).

5 Survey Design and Delivery

The Local Government survey aimed to determine the current level of understanding and action on e-wastes, allowing them to identify the barriers to collection and processing, current best practice, and formulating Local Government perspectives for future legislative and funding developments. The survey was based on a detailed 38-question survey entitled "Survey of Selected Stakeholders on Recycling Used Electronics" created by the United States Government Accountability Office (2005).

The Griffith survey was targeted specifically to Waste Management/Recycling staff within Local Councils. Given the limited time resources of Local Council Officers and to achieve the best possible response rate, the survey was formulated to ask 25 questions (not including personal details), split into eight sections (Table 3).

Table 3: Summary of Survey Questions

1. Personal details	Name; Council; job title; contact details.
2. Background to general recycling	1. What materials are currently collected for recycling; 2. What is the frequency of recycling collections and form of container used; 3. What current promotional activities does the Council undertake/perform to promote recycling.
3. Background to e-waste	4. Definition of e-waste; 5. What is the Council's interest and role in managing e-waste; 6. Does the Council have a policy or strategy relating to e-waste (either formal or informal); 7. Does the Council (or Council contractor) collect any C&I waste which may include e-waste; 8. Does the Council have any data relating to the quantity of e-waste within domestic waste in your area; 9. Does the Council (or Council contractor) currently collect or provide facilities for e-waste collection/drop-off for residents; 10. Has the Council previously held any collection events for e-wastes; 11. Are there any collection or treatment facilities for electronic wastes within the Council's area; 12. Has the Council experienced the illegal dumping or incorrect disposal of wastes containing electronics.
4. Factors influencing recycling	13. In general, how aware do you feel the public is of the recycling options for e-waste; 14. Does the Council actively prohibit or discourage householders from disposing of e-waste to their domestic waste (i.e. to their wheeled bin); 15. What are the most important challenges to facilitating the collection of used electronics facing your collections infrastructure; 16. What are the most important challenges to facilitating the re-use and recycling of used electronics.
5. Finance and Regulation	17. Who should pay for the collection and treatment of e-waste;

	18. Who should pay for the collection and treatment of orphan e-waste; 19. Which finance system would be most effective for providing funding for recycling e-waste; 20. Should state or federal legislation be enacted to overcome the factors which currently discourage recycling of e-waste; 21. If legislation is enacted, which of the following provisions should national legislation include (list includes landfill bans; export restrictions, etc)
6. Perceived barriers	22. To what extent have the following factors hindered the Councils ability to encourage the collection and recycling of e-waste.
7. Perceived environmental/ health impacts	23. To what extent, if at all, are the following health and/or environmental problems associated with the disposal of e-wastes in Australia (leaching of toxic substances from landfill into surface and ground waters, toxic emissions from incinerators, etc); 24. Indicate which problem from the previous question, you feel is the most significant and why.
8. General	25. Any other comments

The survey link was sent via e-mail to all Councils within each state (except for the NT). The information on the number of councils and their contact information was obtained from the various Local Government Associations for each State. Additionally, the QLD, TAS and NSW surveys were promoted by the respective Local Government Association through their circulars. For the NT, only seven councils were approached to participate in the survey, essentially the six municipalities and the one 'special purpose town'. This was because approximately 80% of the territories population reside in these areas and the population density outside these areas is very remote. The ACT (who operates a single waste authority for the whole of the ACT) did not wish to participate in the survey.

Care was taken to expand any abbreviations, and brief explanations were included where appropriate, (for example, 'Advanced Recovery Fee', 'Individual Producer

Responsibility' and 'Extended Producer Responsibility'), so that respondents were clear about the different answer options. The questions comprised of a mixture of tick-box responses, open-ended questions and five point Likert scales (for question 22 and 23). For many of the tick-box response questions, additional space was provided for respondents to add comments. This approach discounted the use of a statistical modelling for many of the survey questions but allowed participants room to discuss the characteristics of their individual councils. The responses to open questions were grouped into related areas or recorded individually where appropriate.

The Councils were divided into six categories based on their population densities (ABS, 2006a) (Table 4): Major Cities; Cities; Inner Regional; Outer Regional; Remote; and Very Remote. The state responses were classified into area types so that any differences/variations could be identified.

Table 4: Frequency of Council Type by State

STATE			Frequency	Percent	Valid Percent	Cumulative Percent
QLD	Valid	inner regional	8	26.7	26.7	26.7
		city	4	13.3	13.3	40.0
		outer regional	5	16.7	16.7	56.7
		remote	5	16.7	16.7	73.3
		very remote	2	6.7	6.7	80.0
		major city	6	20.0	20.0	100.0
		Total	30	100.0	100.0	
NSW	Valid	inner regional	10	19.6	19.6	19.6
		city	6	11.8	11.8	31.4
		outer regional	7	13.7	13.7	45.1
		remote	11	21.6	21.6	66.7
		very remote	1	2.0	2.0	68.6
		major city	16	31.4	31.4	100.0
		Total	51	100.0	100.0	
VIC	Valid	inner regional	7	24.1	24.1	24.1
		city	2	6.9	6.9	31.0
		outer regional	8	27.6	27.6	58.6
		remote	2	6.9	6.9	65.5
		major city	10	34.5	34.5	100.0
		Total	29	100.0	100.0	

SA	Valid	inner regional	3	11.5	11.5	11.5
		city	1	3.8	3.8	15.4
		outer regional	4	15.4	15.4	30.8
		remote	9	34.6	34.6	65.4
		major city	9	34.6	34.6	100.0
		Total	26	100.0	100.0	
TAS	Valid	inner regional	9	60.0	60.0	60.0
		city	1	6.7	6.7	66.7
		outer regional	2	13.3	13.3	80.0
		remote	3	20.0	20.0	100.0
		Total	15	100.0	100.0	
WA	Valid	inner regional	1	2.7	2.7	2.7
		city	7	18.9	18.9	21.6
		outer regional	8	21.6	21.6	43.2
		remote	11	29.7	29.7	73.0
		very remote	3	8.1	8.1	81.1
		major city	7	18.9	18.9	100.0
		Total	37	100.0	100.0	
NT	Valid	inner regional	1	33.3	33.3	33.3
		remote	1	33.3	33.3	66.7
		very remote	1	33.3	33.3	100.0
		Total	3	100.0	100.0	

Statistical analysis was conducted on questions 22 and 23, which had used Likert scales and other selected questions (questions 12 and 17-20) to determine if there were any similarities between council types (i.e. city and very remote) and perspectives.

The survey was reviewed and edited by personnel within the Local Government Associations of Queensland and Central Queensland prior to distribution and, as such, the State of Queensland survey was undertaken first as a pilot study to the other states (Davis and Herat, 2008). The survey was then hosted on Griffith's e-waste web page (www.griffith.edu.au/ewaste) for ease, allowing respondents to print the survey or simply complete and submit on-line with the results being automatically posted to a designated e-mail address.

No individual survey responses were assigned to a council, as it is appreciated that the professional opinion of the Council Officer rather than the Council was reflected.

6 Results and Discussion

Table 5 details the frequency of survey response by state. Overall a significant proportion of Australia's population was covered within the survey responses, even though some of the state response rates were lower mainly due to the spatial distribution of inhabitants to the major cities and coastal communities.

Table 5: Survey response rate and population coverage by State (* Davis and Herat, 2008; # based on the seven councils contacted)

	Response rate for state (%)	Population covered by response (%)
QLD	**23***	**74***
NSW	**34**	**49**
VIC	**36**	**47**
SA	**38**	**46**
TAS	**48**	**64**
WA	**25**	**32**
NT	**43#**	**26**

All Councils were asked what their organisations interest and role was in managing used/waste electronics. 12% of respondents indicated that there was very little or no interest at present, whilst the most popular response (47%) was to limit or divert this waste stream away from landfill. This was reflected in that although over 24% of Councils who responded claimed to have a policy regarding the management of e-wastes, 78% of these 'policies' were informal and a significant 88% did not have any data relating to e-waste within their area/waste streams.

Over 74% of councils do not collect or provide facilities for the deposit of e-wastes, perhaps influenced by the fact that over 77% of Councils also do not have recycling facilities/organisation for e-wastes within their area so any targeted/specialised

collection may either result in large transport distances to reprocessors/recyclers or ultimately to landfill.

When questioned how aware the public is of the recycling options for electronic wastes, 27% of Councils indicated that they believed the public were ‘not at all aware’; 40% indicated that they were only ‘slightly aware’ and 11% ‘moderately aware’.

On examination of relationships between the states and their responses for questions 6-14, only question 12 (experience of illegal dumping) indicated a significant association between State and responses (Table 6). The relationships were explored using Chi Square contingency table test for independence (Table 7).

The significant association between State and response to question 12 (Table 6) clearly shows that for QLD there were significantly more saying No (80%) and significantly less saying Yes (20%) than what would be expected if State and response were independent. About 11 % variance in response is explained by State.

Table 6: Frequency of responses to Q12 Experience of Illegal Dumping by Local Council

			Q12_illegal_dump		Total
			no	yes	
State	QLD	Count	25	5	30
		Expected Count	16.0	14.0	30.0
		Std. Residual	2.2	-2.4	
	NSW	Count	21	30	51
		Expected Count	27.2	23.8	51.0
		Std. Residual	-1.2	1.3	
	VIC	Count	9	20	29
		Expected Count	15.5	13.5	29.0
		Std. Residual	-1.6	1.8	
	SA	Count	14	12	26
		Expected Count	13.9	12.1	26.0

		Std. Residual	.0	.0	
	TAS	Count	8	7	15
		Expected Count	8.0	7.0	15.0
		Std. Residual	.0	.0	
	WA	Count	23	14	37
		Expected Count	19.8	17.2	37.0
		Std. Residual	.7	-.8	
	NT	Count	2	1	3
		Expected Count	1.6	1.4	3.0
		Std. Residual	.3	-.3	
Total		Count	102	89	191
		Expected Count	102.0	89.0	191.0

Table 7: Chi-Square Test for Question 12.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.050*	6	.002
Likelihood Ratio	22.317	6	.001
Linear-by-Linear Association	.001	1	.980
N of Valid Cases	191		

* 2 cells (14.3%) have expected count less than 5. The minimum expected count is 1.40.

On the subject of finance, respondents were asked who should pay for the collection and treatment of waste electronics. Responses to questions 17, 18 and 19 were separated so that the first, second and third preferences could be clearly identified for all questions. An example of the frequency of responses by State is presented in Table 8 (question 17, first preference only).

Table 8: Frequency of response for each state to Q17 (who_pays) for the first preference

State			Frequency	Percent	Valid Percent	Cumulative Percent
QLD	Valid	Users/ Consumers	4	13.3	13.3	13.3
		Producers	25	83.3	83.3	96.7

		/Manufacturers				
		Local Authorities	1	3.3	3.3	100.0
		Total	30	100.0	100.0	
NSW	Valid	null	2	3.9	4.0	4.0
		Users/ Consumers	7	13.7	14.0	18.0
		Producers /Manufacturers	41	80.4	82.0	100.0
		Total	50	98.0	100.0	
	Missing	99	1	2.0		
	Total		51	100.0		
VIC	Valid	Users/ Consumers	4	13.8	13.8	13.8
		Producers /Manufacturers	24	82.8	82.8	96.6
		Local Authorities	1	3.4	3.4	100.0
		Total	29	100.0	100.0	
SA	Valid	Users/ Consumers	3	11.5	11.5	11.5
		Producers /Manufacturers	22	84.6	84.6	96.2
		Householders	1	3.8	3.8	100.0
		Total	26	100.0	100.0	
TAS	Valid	Users/ Consumers	2	13.3	13.3	13.3
		Producers /Manufacturers	11	73.3	73.3	86.7
		Local Authorities	2	13.3	13.3	100.0
		Total	15	100.0	100.0	
WA	Valid	Users/ Consumers	2	5.4	5.4	5.4
		Producers /Manufacturers	35	94.6	94.6	100.0
		Total	37	100.0	100.0	
NT	Valid	Producers /Manufacturers	3	100.0	100.0	100.0

Table 8 shows that councils in all states have nominated Producers/Manufacturers most frequently as first preference in response to question 17.

Between 82 and 100% of respondents then nominated Users/Consumers as their second preference nominated for question 17. Whilst the third preference ranged between Local Authorities (NSW, QLD, VIC, WA, NT) and Householders (SA and TAS) as their third preference.

Respondents were then asked who should pay for the collection and treatment of orphan electronic wastes (that is the waste electronics produced by manufacturers, who no longer exist or do not currently operate within Australia - question 18). Again, responses were separated so that the first, second and third preferences could be identified. QLD, VIC and TAS councils nominated Users/Consumers most often as first preference. NSW and SA councils nominated Producers/manufacturers most often as first preference, and WA councils nominated both with equal frequency as first preference.

As a second preference, all councils in all states nominated Users/Consumers most often in response to question 18; when a third preference was nominated in response, councils in each state selected local Authorities and/ or Householders.

When asked which finance scheme would be most effective for providing funding for electronic wastes (question 19), councils in QLD, VIC, and TAS nominated ARF most frequently as first preference. Councils in NSW and WA nominated EPR most frequently as first preference. Most councils across most states then nominated EPR as second preference; with few councils choosing a third preference.

Respondents were then surveyed about legislative regimes and if Federal Legislation should be enacted to overcome factors which currently discourage recycling of waste electronic items. Questions 20 and 21 had nominal response options (yes / no / no opinion) and so it was only possible to look at the frequencies of agree and disagree

responses for each state. Chi square contingency table analysis was also used to test whether the response was independent of State.

Overall, 87% indicated that federal legislation should be enacted to deal with e-wastes. The Chi square contingency table test for independence showed that there was a significant association between State and response to question 20. Councils in TAS responded 'No' significantly more often than what would be expected if state and response were independent. Overall 33% of respondents opted for 'No' in TAS, compared with under 18% in WA, 10% in QLD; 8% in NSW; 3% in SA and VIC; and none in NT. Approximately 7.3% of the variance in response was explained by state.

Question 21 then went on to determine what measures any federal legislation should include. 63% supported the inclusion of a disposal ban to landfill; 30% supported export restrictions; 65% supported restriction in toxic components; 75% supported product labelling; 74% supported subsidies to recyclers and 75% supported subsidies to manufacturers; 68% supported a certification scheme; 82% supported a green procurement system by government and, finally, 92% supported an education system to build e-waste awareness. Two sub-sections also asked about funding mechanisms, the use of IPR and EPR. These were included as an internal validation measure for question 19 (which finance system would be most effective for providing funding for recycling e-waste). Only 50% supported IPR whilst 78% supported an EPR system which supported previous responses. For question 21 there were no significant associations between State and response to the items under this question.

Question 22 then asked to what extent the following factors had hindered their Council's ability to encourage collection and recycling of used/waste electronic

equipment. As these items were responded to on an ordinal scale (Likert type scale response options from 1 *none* to 5 *very great)* it is possible to create a composite score for each case, which represents the sum of responses to the 10 items. A lower score reflects less of the characteristic, and a higher score reflects a greater degree of the characteristic (which, is based on preferences and may also indicate the respondent's knowledge in the area).

Prior to adding scores together to form the composite measure, the distributions of each item and correlations among all items were assessed. There was mild negative skew in the distributions of some items. However, as the direction of skew was consistent among all items, no transformations were conducted.

Bivariate correlations among all items were positive and, with two exceptions, all correlations were significant. Reliability statistics were computed to assess the internal consistency among the 10 items making up the scale.

Low public awareness, the 'lack of recycling facilities', 'no specific allocation of funds to deal with e-wastes' and 'the low market value of e-wastes' were all identified as key barriers which hindered their Council's ability to encourage collection and recycling of used/waste electronic equipment.

Independent groups ANOVA were used to determine if there were any significant differences among the states on question 22 scale values (Table 9). The results showed that there were no significant differences.

Table 9: ANOVA determination of differences between states for Q22

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	639.441	6	106.574	1.465	.193
Within Groups	13388.370	184	72.763		
Total	14027.812	190			

Respondents were also asked to what extent, if at all, are the following health and/or environmental problems associated with the disposal of waste electronic equipment in Australia (question 23). Analysis was conducted in the identical manner as for question 22. There was no problematic skew in the distributions of individual items. Correlations among all items were positive and significant and internal consistency was high and a one way ANOVA for independent groups showed that there were no significant differences among the states on question 23.

The leaching of toxins to ground/surface water, followed by concerns around releases from unregulated reprocessors were considered to have the greatest health and/or environmental impacts. The volume of e-wastes within landfill was also of concern. The lowest concern was for the illegal exports and worker exposure. The environmental and/or health problems associated with the illegal exporting of e-wastes generated the largest 'don't know' response for this question, indicating that individuals were very uncertain about the impacts associated with illegal exports.

Question 24 asked individuals to indicate which problem from question 23 they felt was the most significant. There were a number of differing frequencies of responses to this item for each state. Councils in four states (NSW, VIC, TAS, WA) most often nominated volume of waste to landfill whilst Councils in two states (QLD and SA) nominated leaching of toxic substances. Chi square contingency table test of independence showed there was no significant association between State and response. When looking at this question across all Australia councils, 'volume of waste to landfill' (36%) was most frequently nominated followed by 'leaching of toxic substances' (29%) and loss of natural resources (12%).

7 Conclusions

The survey results have highlighted a number of key knowledge gaps across Local Councils across Australia. For example, very little audit data relating to the composition of general wastes (including e-wastes) within the domestic waste stream exists. It is therefore difficult to plan for future infrastructure and treatment facilities where the composition and nature of a waste is unknown (Davis and Herat, 2008). There are also very few facilities which can handle the processing or recycling of e-wastes. This is further compounded by large geographical distances between many of the significant conurbations and the treatment points.

In rural areas, where demand for an e-waste collection and/or treatment service is low, it is unlikely that there will be any cost-efficiency or incentive for such a scheme. For

these areas, a life-cycle-analysis of the options (i.e. local landfill versus distant recycling) may indicate that e-waste reprocessing is only environmentally and economically viable in larger conurbations where demand is high (Davis and Herat, 2008). Further research in this area needs to be undertaken so that Local Councils have the tools to make sound decisions on e-waste treatment options for their particular region, based on current data.

It is not currently possible to determine the full costs associated with sustainably managing the e-waste stream within Australia as there is insufficient data regarding the composition and extent of the issues. This is compounded by low landfill prices in some states, which clearly do not take into account externalities such as the environment or social aspects. The purchase prices of cheap, high volume unbranded electronic items further impacts this.

The opportunity currently exists for all e-waste stakeholders to ensure the dissemination of information, and to work collaboratively to design a fair funding and legislative regime, which sustainably manages the current and future e-waste stream. It is commonly acknowledged that current costs associated with the purchase of electronic equipment do not embrace the waste management principles, as all costs associated with the use of a resource are not included in the price of goods and services developed from that resource. Additionally, the cost of disposal in many States does not accurately cover all externalities, such as environmental and social impacts. Also, the producers and/or importers of the electronic goods do not take all reasonable steps to minimise environmental harm from the production, use and disposal of the product in line with the "product-stewardship principle". The survey did show widespread support for both

ARF and EPR schemes. This is in-line with many of the US states preference to adopt EPR schemes (Solmer and Stoll, 2007), and the introduction of the Californian Advanced Recycling Fee.

Like the US, Australia needs to carefully manage the legacy sets and ultimately control the influx if new unbranded/white box electronic equipment to the market. Additionally, there are few examples of producer responsibility schemes within Australia, perhaps as their success is highly dependent on the amount of regulation and government involvement, and the threat of mandatory measures such as statutory recovery targets and other control measures. Currently, such regulation or threat of, is lacking at both state and federal levels for e-waste streams.

Despite the lack of government commitment for managing the e-waste stream, a private sector organisation (Sims Metals Management) has invested significant funds into infrastructure in the form of recycling facilities in some of the major cities across Australia, shown not least by the opening of its new Sydney plant capable of processing 20,000 tonnes per annum. In order for this plant to be financially viable it will need to operate close to this capacity. However these facilities only have capacity to treat a small component of the 120-140,000 tonnes of e-waste produced in Australia annually, and other companies are unlikely to invest in a market where there are no government drivers or targets.

Other Sims e-waste recovery plants around Australia, such as in Brisbane, rely heavily on commercial e-waste streams provided by large organisations, such as the banking and finance communities, where information security is the driver for the use of their

service. The resource recovery activity related to e-waste is labour intensive whether reconditioning a newer computer for re-use or stripping an older computer for straight resource recovery. Both of these activities, but particularly the former, often require higher labour skills and are highly labour intensive. Labour schemes which help source labour to this sector could assist e-waste recoverers to maintain access to appropriate labour and also that the recovered product was more cost competitive with the non-recovered alternatives.

The survey also highlighted overwhelming support for the introduction of legislative measures to manage e-waste with particular support for the introduction of a suitable funding mechanism and a consumer education programme. It has been widely anticipated that the legislative drivers in Europe and the US will encourage manufacturers to better-design and manufacture their equipment in order to comply with this legislation, which may result in a design-improvement to the equipment imported into Australia. However, it may also see Australia and other countries without import and legislative restrictions become a dumping ground for older and obsolete models, and for those companies who do not have the infrastructure or investment to upgrade existing product and manufacturing lines to conform to European and US standards.

In the absence of a formal legislative structure and the high level political resolve for any near future formulation, the management of e-wastes is increasingly going to fall upon Local Councils to administer. It is therefore essential that Local Councils consider strategy formulation to deal with this waste stream without delay. This approach should include a review of existing treatment and disposal options including the full range of costs. The development of a strategy may facilitate the recognition of opportunities

through raising the awareness of the issues both within the Council but also to external stakeholders (i.e. local businesses, residents).

Overall, there was a strong indication through all of the survey responses that more information is required and this needs to be joined with an overall increase in the levels of awareness, both by policy makers and public. The need for this information being regarded as urgent.

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Table 8: Correlations for Q22 responses

		q22a_lack_legislation	q22b_lack_data	q22c_lack_infrastructure	q22d_allocation_funds	q22e_lack_facilities	q22f_low_aware	q22g_low_pub_aware	q22h_priority	q22i_mkt_value	q22j_costs
q22a_lack_legislation	Pearson Correlation	1									
	Sig. (2-tailed)										
	N	189									
q22b_lack_data	Pearson Correlation	.531(**)	1								
	Sig. (2-tailed)	.000									
	N	189	190								
q22c_lack_infrastructure	Pearson Correlation	.378(**)	.498(**)	1							
	Sig. (2-tailed)	.000	.000								
	N	189	190	191							
q22d_allocation_funds	Pearson Correlation	.392(**)	.385(**)	.596(**)	1						
	Sig. (2-tailed)	.000	.000	.000							
	N	189	190	190	190						
q22e_lack_facilities	Pearson Correlation	.310(**)	.386(**)	.508(**)	.450(**)	1					
	Sig. (2-tailed)	.000	.000	.000	.000						
	N	189	190	191	190	191					
q22f_low_aware	Pearson Correlation	.282(**)	.489(**)	.440(**)	.302(**)	.298(**)	1				
	Sig. (2-tailed)	.000	.000	.000	.000	.000					
	N	189	190	190	190	190	190				
q22g_low_pub_aware	Pearson Correlation	.417(**)	.620(**)	.430(**)	.328(**)	.331(**)	.712(**)	1			
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000				
	N	189	190	191	190	191	190	191			
q22h_priority	Pearson Correlation	.276(**)	.439(**)	.286(**)	.334(**)	.271(**)	.455(**)	.531(**)	1		

	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000			
	N	188	189	189	189	189	189	189	189		
q22i_mkt_value	Pearson Correlation	.337(**)	.227(**)	.185(*)	.263(**)	.351(**)	.252(**)	.264(**)	.234(**)	1	
	Sig. (2-tailed)	.000	.002	.011	.000	.000	.000	.000	.001		
	N	188	189	189	189	189	189	189	188	189	
q22j_costs	Pearson Correlation	.267(**)	.147(*)	.210(**)	.272(**)	.130	.205(**)	.121	.219(**)	.637(**)	1
	Sig. (2-tailed)	.000	.043	.004	.000	.073	.005	.096	.002	.000	
	N	189	190	191	190	191	190	191	189	189	191

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).